3.3.2 Number of books and chapters in edited volumes/books published and papers published in national/ international conference proceedings per teacher during last five year (1st June 2021-31st August 2022)

Dept.	Civil	CSE	EEE	ECE	Mech	AI & DS	S&H	Total
No. of Projects	10	4	7	46	21	2	27	**117**

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
Civil Englineering										
1	Mr. T. Chockalingam	-	A Review on Permeability of Pervious Concrete	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
2	Mrs.C.Subha	-	Surface Water Analysis and Water Purification System for Korampallam Lake in Tuticorin	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
3	Mrs.C.Subha	-	Microbial Fuel Cell for Treating Sea Food Processing Wastewater	Proceedings of International Conference on Recent Trends in Applied Sciences and Computing Engineering (RTASCE 2021)	International Conference on Recent Trends in Applied Sciences and Computing Engineering (RTASCE 2021)	International	2021		VIT Bhopal University	
4	Mrs.C.Subha	-	Investigation on Industrial Effluent Treatment Using Dual Chamber Microbial Fuel Cells	Proceedings of Second International Conference on Advances in Management and Technology (ICAMT 2021)	Second International Conference on Advances in Management and Technology (ICAMT 2021)	International	2021	978-93-5426-863-2	Sadabai Raisoni Women's College Nagpur, Maharashtra (India) & Mazedan International Research Academy Okhla, New Delhi (India)	

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
5	Mrs. A. Leema Margret	-	Numerical Study on Flexural Behavior of Reinforced Concrete Beam using MATLAB	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
6	Mrs. A. Leema Margret	-	Investigation on Corrosion behaviour of geopolymer concrete using DMS and M-Sand as a fine aggregate under ambient curing conditions	Proceedings of International Conference on Materials Science and Manufacturing Technology (ICMSMT 2022)	International Conference on Materials Science and Manufacturing Technology (ICMSMT 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	IOP
7	Mrs. A. Leema Margret	-	Investigation of Mechanical Properties of High Performance Concrete using Industrial Waste with Well Graded Aggregates	Proceedings of International Conference on Materials Science and Manufacturing Technology (ICMSMT 2022)	International Conference on Materials Science and Manufacturing Technology (ICMSMT 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	IOP
8	Mrs. A. Leema Margret	-	Fly-Ash and GGBS Based Geo-Polymer Concrete with Granite Powder as Partial Replacement of M-Sand for Sustainability	Proceedings of International Conference on Materials Science and Manufacturing Technology (ICMSMT 2022)	International Conference on Materials Science and Manufacturing Technology (ICMSMT 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	IOP
9	Mrs.D.Darling Helen Lydia	-	Performance Study on Damaged Cylinder with SFRP Under Various Loading Conditions using Abaqus	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
10	Dr.M.Indhumathi	-	An Experimental Investigation on Strength Properties and Flexural Behaviour of Ternary Blended Concrete	Proceedings of Fourth International Conference on Material Science and Manufacturing Technology	Fourth International Conference on Material Science and Manufacturing Technology	International	2022		Ramco Institute of Technology, Rajapalayam	IOP

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
Computer Science and Engineering										
1	Divyapandian K M, Sasi Rekha M and Dr.M.Gomathy Nayagam,	-	Webapp for Plant Disease Detection Using Deep Learning	In. the proc.of 1st International Conference on Social Work, Science and Technology	First International Conference on Social Work, Science and Technology	International	2021	Nil	RIT	Srinidhi Devkunvar Nanalai Bhatt Vaishnav College for Women, Chennai in
2	Ms.S.Manjula	-	Deep Learning Algorithm for detecting Cyber Attacks	In the Proc. of International Conference on Recent Innovations in Science and Engineering (ICRISE-2022)	International Conference on Recent Innovations in Science and Engineering (ICRISE-2022)	International	2022	Nil	RIT	P.S.R Engineering College, Sivakasi
3	M.SwarnaSudha	-	Location Prediction using Machine Learning	In the Proc. of International Conference on Recent Innovations in Science and Engineering (ICRISE-2022)	International Conference on Recent Innovations in Science and Engineering (ICRISE-2022)	International	2022	Nil	RIT	P.S.R Engineering College, Sivakasi
4	B.Vijayalakshmi & N.Nithya	-	Intelligent Personal Assistant (IPA) for Senior Citizens	In the Proc. of International Conference on Agriculture, Healthcare and Green Computing Perspective of Communication Technologis- ICAHGCT-2022	International Conference on Agriculture, Healthcare and Green Computing Perspective of Communication Technologis- ICAHGCT-2022	International	2022	Nil	RIT	Sona College Technology, Salem

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
Electrical and Electronics Engineering										
1	T. R. Alagarsamy Yaswanth, S. Arun Kumar and K. Karthikeyan	-	An embedded controller based train control system	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2022		Ramco Institute of Technology	Ramco Institute of Technology
2	S. Arunkumar, R. Chandru, P. Kasirajan and Ms.S.Sharmila Kumari	-	Solar Powered Smart LED Street Light With Auto Intensity	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2023		Ramco Institute of Technology	Ramco Institute of Technology
3	A. Arun Kumar, M. M. Muthu Rani, M.I. Rohini, V. Divya Jeyashree, S. Jeyanthi	-	Smart Garbage Detection System	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2024		Ramco Institute of Technology	Ramco Institute of Technology
4	S. Jeyanthi, B.V. Manikandan	-	Performance Analysis of Boost Converter by Comparing with Different Switching Techniques	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2025		Ramco Institute of Technology	Ramco Institute of Technology
5	E. Thangam, B.V. Manikandan, S. Kannan	-	Studies on the Planning of Generation Expansion in a Renewable Dominated Power System	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2025		Ramco Institute of Technology	Ramco Institute of Technology
6	D. Citharthan, M. Varatharaj, M. Arumuga Babu, S. Kannan	-	Field Oriented Control of Permanent Magnet Synchronous Motor with D-Q Axis Decoupling Using Feed Forward Compensation	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2025		Ramco Institute of Technology	Ramco Institute of Technology

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
7	S. Meenakshi Sundaravel, B.V. Manikandan	-	Analysis of Cascaded H-Bridge Multilevel Inverter Using Various Pulse Width Modulation Strategies	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	11.03.2022 to 12.03.2025		Ramco Institute of Technology	Ramco Institute of Technology
Electronics and Communication Engineering										
1	Mrs.S.Jeeva, R.Anushya, R.Dhanushya and T.Dhivya muthachi	-	2D Plotter Simulation and Prototype using NI LabVIEW and NI myRIO kit	Proceedings of nternational Virtual Conference on Emerging Trends on Artificial Intelligence in industry 4.0	International Virtual Conference on Emerging Trends on Artificial Intelligence in industry 4.0 (IVCETAI'21)	International	2021	Nil	Ramco Institute of Technology, Rajapalayam	Loyola Institute of Technology, Chennai
2	Mrs.R.Ramalakshmi, Dr.S.Tamil Selvi	-	System Model for Spectral and Energy Efficient Massive MIMO System	Proceedings of IEEE International Conference on "Emerging Technologies and Applications for a Smart and Sustainable World	IEEE International Conference on "Emerging Technologies and Applications for a Smart and Sustainable World (ICEmTASS '21)	International	2021	Nil	Ramco Institute of Technology, Rajapalayam	National Engineering College, Kovilpatti
3	Dhanusha P.B, Muthukumar A, Dr.Lakshmi A	-	A Novel approach for Early Invention of Retinal Disorders using Machine Learning	Proceedings of virtual 6th International Conference on Inventive Systems and Control (ICISC 2022) (SPRINGER)	virtual 6th International Conference on Inventive Systems and Control (ICISC 2022) (SPRINGER)	International	2022		Ramco Institute of Technology, Rajapalayam	JCT College of Engineering and Technology, Coimbatore,
4	Muthuvel A, Arun Prasath. T, Dr.Lakshmi A, Pallikonda Rajasekar M	-	CNN based classification of brain Abnormalities in MRI using Adaptive Deep Wavelet Encoder (ADWE)	Proceedings of virtual 6th International Conference on Inventive Systems and Control (ICISC 2022) (SPRINGER)	International Conference on Communication and Computing Technologies for Sustainable Development (ICCCTSD 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
5	Mrs.S.Jeeva , Dr.S.Anand	-	Qualitative Improvement in Wireless Capsule Endoscopy Images Using Single Scale Retinex Function with Un sharp Filtering	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
6	Ms.S.Harini Shriram,Dr.K.Ragavan	-	Fruits Recognition Classifier Implementation using Convolutional Neural Network	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
7	Mrs.G.Gnana Priya, P.Nisha, K.Vishnupriya	-	A Review on Spectrum Sharing Techniques in 5G Communication Networks	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
8	Dr.R.Rajalakshmi , Dr.P.Sivakumar,Dr.D.Devarajan, Mrs.G.Subhashini, Ms.S.Vasundaraa	-	Analysis of power in Logic circuits using various clock gating Techniques	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
9	Mr.S.Vijayakumar, Mr.D.Gopinath, Mr.A.Ramesh Babu A	-	Analysis of Memristor based Pass Transistor Logic	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
10	Dr.A.Lakshmi, Mrs.N.Bhuvaneswary, Mr.Aenike Umesh Chandra Reddy, Mr.Kakanuru Muralidhar Reddy, Mr.Sandeep kumar	-	Artificial Intelligence based Smart Electricity Billing Management System	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
11	Mrs.N.Thenmoezhi, Dr.B.Perumal, Dr.A.Lakshmi	-	Reduction of Noise in PET Brain Image Using Filtering Techniques	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
12	Mrs.R.Ramalakshmi, Ms.L.Nirmala & T.Vidhula	-	IoT based Requisite Usage of Welfare Equipment for Alcohol and Accident Detection	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
13	Mrs.G.Subhashini, Dr.R.Rajalakshmi, Mr.S.Jegadheeshwaran, Mr.Selvadurai	-	Development of Gyro Stabilized Electro-Bot	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
14	Mr.G.Sivakumar, Mr.R.Deivanayagam,Ms .Bala Kiruthika,Ms.S.Mirra	-	IoT based Drug Delivery System for Pulmonary Lung Disorders	Proceedings of International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
15	Dr.D.Devarajan, k.s.swetha, Dr.A.sundar Raj,Dr.R.Rajalakshmi	-	Brain Tumor Detection From MRI Image Using K-Means Clustering	Proceedings of International conference on communication,VLSI and signal processing	International conference on communication,VLSI and signal processing	International	2022		Ramco Institute of Technology, Rajapalayam	J.J.college of Engineering and Technology, Trichy
16	R.Narmadha, Pradeep Kumar Rangi, A.Azhagu Jaisudhan Pazhani, Prajval V	-	Analysis of the digital trends and IoT procedural scheme on traditional banking system	Proceedings of International Conference on “Contemporary Innovations in Mechanical Engineering	International Conference on “Contemporary Innovations in Mechanical Engineering	International	2022		Ramco Institute of Technology, Rajapalayam	RGM College of Engineering and Technology, Andrapradesh

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17	A.Bhagyalakshmi, K.Sasirekha, P.Gunasekaran, Ashok Kumar Koshariya	-	Smart agriculture system monitoring by IoT	Proceedings of International Conference on “Contemporary Innovations in Mechanical Engineering	International Conference on “Contemporary Innovations in Mechanical Engineering	International	2022		Ramco Institute of Technology, Rajapalayam	RGM College of Engineering and Technology, Andrapradesh
18	S.Jeeva, A.Deepika, R.Gayathri	-	Wireless capsule Endoscopybleeding image classificationusing SVM based mode	International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering	International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering	International	2022		Ramco Institute of Technology, Rajapalayam	I Business Institute, Greater Noida,Uttar Pradesh
19	S.Jeeva, P.Praveen Kumar,M.Raajasekar,V. Shriram	-	Deep Learning Model for Brain Tumor Segmentation and Classification	ISTE Sponsored National Level conference on Emerging Trends in Engineering Design and Manufacturing 'ETEDM-22'	ISTE Sponsored National Level conference on Emerging Trends in Engineering Design and Manufacturing 'ETEDM-22'	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology, Chennai
20	Vairaprakash S, Anu Lakshmi K S, Anusuya R	-	Lossless Cryptographic Techniques for Images using Discrete Rajan Transform’	1. First International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering ICAMESE’2022.	1. First International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering ICAMESE’2022.	International	2022		Ramco Institute of Technology, Rajapalayam	

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
21	N.Bhuvaneswary, J.Deny, A.Lakshmi	-	Exploration of Reusability of Universal Verification Technology	IEEE Second International Conference on Advances in Computing and Innovative Technologies in Engineering (ICAECT 2022)	IEEE Second International Conference on Advances in Computing and Innovative Technologies in Engineering (ICAECT 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	1. Department of Electrical and Electronics Engineering, Galgotias of College of Engineering & Technology, Greater Noida on 28.04.2022 & 29.04.2022.
22	Dr.A.Lakshmi, Ramasuresh M, Vishnu T		Sentimental Analysis On Review Comments Of Social Media Post Using Machine Learning	International Conference on Engineering and Innovation research ICEIR '2022	International Conference on Engineering and Innovation research ICEIR '2022	International	2022		Ramco Institute of Technology, Rajapalayam	Kathir College of Engineering, Coimbatore
23	Dr.A.Lakshmi, Balaji Raja. K, Dinesh. R		" IOT based milk monitoring system for detection & Milk Adulteration	in 2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022	in 2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022	National	2022		Ramco Institute of Technology, Rajapalayam	Kurinji college of Engineering and Technology, Tiruchirappalli
24	Mr.B.Kannan,		Tumor edge detection from brain MR Image using hybrid edge detector	International Conference on Recent Advances in Fog and Edge Computing,	International Conference on Recent Advances in Fog and Edge Computing,	International	2022		Ramco Institute of Technology, Rajapalayam	Sri Krishna College of Engineering and Technology
25	Mr.B.Kannan		Ambinet Dust Detection and Control System	National Conference on Emerging Trens in Engineering Design and Manufacturing	National Conference on Emerging Trens in Engineering Design and Manufacturing	National	2022		Ramco Institute of Technology, Rajapalayam	1. Hindusthan Institute of Technology, Coimbatore.

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26	Mr.B.Kannan,		Rs485 Based PLC Mogule for Industries using LORAWAN Tecgnology	National Conference on Emerging Trends in Engineering Design and Manufacturing	National Conference on Emerging Trends in Engineering Design and Manufacturing	National	2022		Ramco Institute of Technology, Rajapalayam	1. Hindusthan Institute of Technology, Coimbatore.
27	Mr.D.Gopinath		Design and Analysis of Circular Cross Sectional T- Shaped Antenna for Wireless body area network	International Conference on Advancements on Management, Entrepreneurship,Sciences & Engineering ICAMESE'2022	International Conference on Advancements on Management, Entrepreneurship,Sciences & Engineering ICAMESE'2022	International	2022		Ramco Institute of Technology, Rajapalayam	1. Business Institute, Greater Noida, Uttar Pradesh, India & Global Conference Hub, Coimbatore, Tamilnadu, India .
28	A.RameshBabu,Ms.M .Apineya Sri, Ms.A.BalaKiruthika		Implementation of High Speed Vedic Multiplier Using Pass Transistor Logic	First International Conference on Advancements on Management, Entrepreneurship, Sciences & Engineering ICAMESE'2022	First International Conference on Advancements on Management, Entrepreneurship, Sciences & Engineering ICAMESE'2022	International	2022		Ramco Institute of Technology, Rajapalayam	I Business Institute, Greater Noida, Uttar Pradesh
29	Mr.G.Sivakumar, G.Sridhar, R.Santhosh,K.Yaswanth		An IoT Security framework for Cloud Storage using Hybrid Cryptography	2 nd National conference on Recent trends in Engineering ,Science and Management	2 nd National conference on Recent trends in Engineering ,Science and Management	National	2022		Ramco Institute of Technology, Rajapalayam	1. Kurinji College of Engineering and Technology,Manapparai

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
30	A.Azhagu Jaisudhan Pazhani, R.Anitha Ram and N. Kohila Priya,		Ground Water Level Identification and Its Impact on Rural Locations	International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering, Coimbatore	International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering, Coimbatore	International	2022		Ramco Institute of Technology, Rajapalayam	International Conference on Advancements on Management, Entrepreneurship, Sciences and Engineering, Coimbatore
31	G. Subhashini, R.Karthik , R.Jebish Robin, K.J.Harish Kalyan		Energy Efficient and Secure Routing Protocol in WSN based on Block Chain Technology	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	National	2022		Ramco Institute of Technology, Rajapalayam	Kurinji College of Engineering and Technology
32	Dr.R.Rajalakshmi, R. Sai Siddharth,K. Saratth		Design of Approximate adder using QCA	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	National	2022		Ramco Institute of Technology, Rajapalayam	Kurinji College of Engineering and Technology
33	Dr.R.Rajalakshmi, S.Shanmuga siva Chidambaram,N.Venkatasubbu		Contactless ATM monitoring system with theft detection	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	National	2022		Ramco Institute of Technology, Rajapalayam	Kurinji College of Engineering and Technology
34	Mrs.V.SrirengaNachiyar , M.Kaliprakash, R.Kathir ,M.Mohanasudhan		Energy Efficient node deployment in Heterogeneous two-tier Wireless Sensor Networks using Neural Training	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	National	2022		Ramco Institute of Technology, Rajapalayam	Kurinji College of Engineering and Technology

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35	N.Manimala, S.Jayalakshmi, V.SrirengaNachiyar		Design and Development of Animal Detection System to Avoid Collision"	3rd National Conference on Communication& System Design (NC2SD)	2nd National Conference on Recent Trends in Engineering, Science and Management (RTESM-KCET 2022)	National	2022		Ramco Institute of Technology, Rajapalayam	by PSG Institute of Technology and Applied Research, Coimbatore
36	Harini Shriram S, Narmadhadevi M, Swetha K		Tomato leaf diseases detection using YOLO	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology, Coimbatore
37	Mrs.G.Gnana Priya, K.Jayamadan, P.Madhav		Raw Water Monitoring and Control System	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology, Coimbatore
38	R.Ramalakshmi, L.Nirmala, T.Vidhula		Multipurpose Embedded Based Hand Gesture Application for Physically Disabled People	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology, Coimbatore
39	R.Ramalakshmi, M.Sathis Kannan, S.Uvasri		An Accurate Prediction of Bitcoin Price Using Data Science and Deep Learning”	International Conference on Engineering and Innovative Research ICEIR 2022	International Conference on Engineering and Innovative Research ICEIR 2022	International	2022		Ramco Institute of Technology, Rajapalayam	Kathir College of Engineering, Coimbatore
40	Ragavan K, Venkatesh Permal M, Harinidurga I, Kiruthika T		Synthesis and Low Temperature Sintering of Copper Nanoparticle Pastes for Microelectronic Packaging”	National level conference Emerging trends in engineering design and manufacturing (ETEEDM-22)	National level conference Emerging trends in engineering design and manufacturing (ETEEDM-22)	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
41	Mr.R.Deiva Nayagam, K.Aarthi, S.Mirra		Colon cancer Classification on Histopathological Images using Deep Learning Techniques	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22),	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology
42	V.SrirengaNachiyar, S.Lingesh, R.Kavin kumar, C.M.Kesava Mugesh Kumar, K.Ragavan,		Advanced Mobile Application for Effective Communication of Deaf and Dumb people	3rd ACE International Conference on Applied Science, Engineering, Technology and Management	3rd ACE International Conference on Applied Science, Engineering, Technology and Management	International	2022		Ramco Institute of Technology, Rajapalayam	Alpha College of Engineering, Thirumazhisai
43	Mrs.G.Gnana Priya, P.Nisha, K.Vishnu Priya		AI based Spectrum Prediction in Cognitive Radio Network	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22)	ISTE Sponsored National Level Conference on Emerging Trends In Engineering Design & Manufacturing (ETEDM - 22)	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology, Coimbatore
Book / Book Chapter										
1	V.Nagaraj, T.Lalitha, B.Sampath Kumar, L.K.Balaji Vignesh	Antenna Design for Narrowband IoT: Design, Analysis and Applications	Dual-Band Helical Reflect Array Antenna for High Power Microwave Applications	IGI Global Publications		International	2022	Chapter No.14, Page No. 192-200 DOI: 10.4018/978-1-7998-9315-8.ch014	Ramco Institute of Technology, Rajapalayam	IGI Global Publications
2	T.V.Ramana, Alok Kumar, Binda M B, A.Azhagu Jaisudhan Pazhani	Computer Architecture		Scientific International Publishing House (SIPH)		International	2022	ISBN NO:978-93-94002-30-2	Ramco Institute of Technology, Rajapalayam	Scientific International Publishing House (SIPH)
3	B. Vijayalakshmi,M. Kaliappan,K. Ramar,K. Vijayalakshmi and S. Vimal	EAI/Springer Innovations in Communication and Computing Book Series	Forecasting Using Deep Learning Approaches	EAI/Springer Innovations in Communication and Computing Book Series	-	International	2021	2522-8609	Ramco Institute of Technology, Rajapalayam	Springer

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
Mechanical Engineering										
1	M. Ashok Kumar, S.Rajakarunakaran	-	Performance Evaluation of Heat Pump Dryer in Specific Moisture Evaporation Rate for Various Herbal Leaves	Emerging Trends in Engineering and Technology (ICETET2021)	Emerging Trends in Engineering and Technology (ICETET2021)	International	2021		Ramco Institute of Technology, Rajapalayam	
2	S.Godwin Barnabas, S.Rajakarunakaran, V.Sivakumar, S.Valai Ganesh, T.Selva Sundar	-	Application of Pedagogy Tools and Learning Management System in Higher Education-Case Study	International Virtual Conference on Interdisciplinary Approaches to education research and language Teaching – ICERLT 2021	International Virtual Conference on Interdisciplinary Approaches to education research and language Teaching – ICERLT 2021	International	2021		Ramco Institute of Technology, Rajapalayam	
3	S. Valai Ganesh, S. Rajakarunakaran, T. Selva Sundar, S. Godwin Barnabas	-	Automatic Latching of Door by Sensing Physiognomic Data Using Deep Face Recognition Techniques	35th National Convention of Production Engineers and National Conference on Emerging Technologies for Sustainable Manufacturing	35th National Convention of Production Engineers and National Conference on Emerging Technologies for Sustainable Manufacturing	National	2021		Ramco Institute of Technology, Rajapalayam	
4	G.Prabu ram	-	Prediction of Temperature Distribution in Three Dimensional Solid Objects using COMSOL and Python	International Conference on Advances in Materials Research 2021 (ICAMR 2.0)	International Conference on Advances in Materials Research 2021 (ICAMR 2.0)	International	2021		Ramco Institute of Technology, Rajapalayam	
5	M. Ashok Kumar, S.Rajakarunakaran, V.Sivakumar	-	Performance Comparison of Closed Loop Heat Pump Dryer with Bed, Tray and Bed-Tray Dryer for Curry Leaves	36th National Convention of Mechanical Engineers and National Conference on Innovations in Thermal Science and Engineering	36th National Convention of Mechanical Engineers and National Conference on Innovations in Thermal Science and Engineering	National	2021		Ramco Institute of Technology, Rajapalayam	

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
6	S. Valai Ganesh	-	Augmentation Studies on Manipulators in Solid Waste Management with Deep Learning based Machine Vision System		Doctoral Symposium organized by Machine Intelligence Research Labs, United States of America	International	2021		Ramco Institute of Technology, Rajapalayam	
7	T. Selva Sundar	-	AI-based Studies on Smart Trash Bot using Deep Learning Techniques		Doctoral Symposium organized by Machine Intelligence Research Labs, United States of America	International	2021		Ramco Institute of Technology, Rajapalayam	
8	J.Jabinth, N.L.Sujin, J.Jerold John Britto, V.Sivakumar, M.Vinoth, Ram Praksash	-	IoT Based Smart Door-To-Door Segregation and Prediction of Solid Waste Collection System using LABVIEW and Google Firebase	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
9	V.Sivakumar, R.Arun Kumar,R.Palani Bharathi,M.Selva Balaji,J. Jabinth, S.Rajakarunakaran	-	Energy and Exergy Analysis of Single Slope Passive Solar Still with Atomizer	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
10	S.Valai Ganesh, T.Selva Sundar, S.Godwin Barnabas, R.Dinesh, S.Rajakarunakaran, V.Suresh	-	Building Smart Bot Design For Library Assistance	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
11	T.Selva Sundar, V.Suresh, Soumya Souvik Khuntia, S.Jehaveerapanndiyan, S.Godwin Barnabas, V.Suresh	-	Smart Waste Trash Bot Monitoring System	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	

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12	K.Amudhan, R.Prabhakaran, R.Venkatesh, J.Jerold John Britto	-	Intensive Study on Additive Manufacturing for Biomedical Applications	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
13	R.Arun Kumar, V.Sivakumar, N.Veereswaran, R.Vishnu Sankar	-	Progress in Improving the Productivity of Solar Still – A Review	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
14	P.Pavithran, M.Nalliraj Madhavan, S.Keerthana, P.Krithika, M.I.Rohini, S.Sridharan, S.Rajakarunakaran	-	Implementation of Statistical Process Control in Meteorological Department by Using MATLAB	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
15	P.Pavithran, V.Sabarisha,T.Udhaya, S.Vijay anandh, N.Yuvapriya, S.Rajakarunakaran	-	Comparative Study Analysis of Daily Load Curve on Different Tariffs using MATLAB	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
16	S.Godwin Barnabas, S.Sridharan, G.R.Ragul, S.Valai Ganesh,S.Rajakarunakaran	-	A Review on Implementation of Kanban System in Various Process Industries	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
17	M.Ramar,M.Lakshmanan, H.Kanagasabapathy, S.P.Cheran,K. Gokul, R.Prasanna Gobi Ram	-	Mechanical Characteristics and Microstructure Evolution on SS316L via SLM	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	
18	M.Lakshmanan, M.Ramar,S.Saravanakumar,T.K.Vijay Akash,S.Ajay Rajappan	-	Mechanical and Tribological Performance of 18Ni350 Maraging Steel	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022	978-93-5593-352-2	Ramco Institute of Technology, Rajapalayam	

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19	S.Rajakarunakaran, J.Jabinth	-	Effective Teaching Learning Process	24th Annual Engineering Staff Convention on " A New Pedagogy in Engineering Education Challenges in Teaching and Learning"	24th Annual Engineering Staff Convention on " A New Pedagogy in Engineering Education Challenges in Teaching and Learning"	National	2022		Ramco Institute of Technology, Rajapalayam	
20	R Venkatesh, K Vignesh Saravanan, VR Aswin, S Balaji, K Amudhan, S Rajakarunakaran	Book Chapter	Detection of Cracks in Surfaces and Materials Using Convolutional Neural Network				2022		Ramco Institute of Technology, Rajapalayam	Springer, Singapore
21	P Pitchipoo, A Muthiah, A Manikandan, S Rajakarunakaran	Book Chapter	Tribological Behaviour of Hybrid Natural Fiber Polymer Composites with Novel Fillers				2022		Ramco Institute of Technology, Rajapalayam	Functional Composite Materials: Manufacturing Technology and Experimental Application
Artificial Intelligence and Data Science										
Book Chapter										
1	Janmenjoy Nayak, H.S. Behera, Bighnaraj Naik, S. Vimal, Danilo Pelusi	Computational Intelligence in Data Mining				International	2022	ISBN: 978-981-16-9447-9 ISSN: 2190-3018	Ramco Institute of Technology, Rajapalayam	
2	A. Suresh, S. Vimal, Y. Harold Robinson, Dhinesh Kumar Ramaswami and R. Udendhran	BIOINFORMATICS AND MEDICAL APPLICATIONS : Big Data Using Deep Learning Algorithms				International	2022	ISBN-13: 978-1119791836 ISBN-10: 1119791839	Ramco Institute of Technology, Rajapalayam	

Sl. No.	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Year of publication	ISBN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher
Physics										
1	Vigneswari.T, Kanthimathi.G, Senthilkumar.O, Sankar.C	-	Green Synthesis and Antibacterial activity of Iron Oxide Nanoparticles Using Vitex negundo leaf extract by Sol-gel method	Proceedings of International Conference on Solution Grown Crystals and their Useful Applications	International Conference on Solution Grown Crystals and their Useful Applications	International	2021		Ramco Institute of Technology, Rajapalayam	SSN College of Engineering, Chennai
2	K.Jeyapappa	-	Spectral and Mechanical Properties of Glycine Doped L-Tartaric Acid Crystal	Proceedings of International Conference on Solution Grown Crystals and their Useful Applications	International Conference on Solution Grown Crystals and their Useful Applications	International	2021		Ramco Institute of Technology, Rajapalayam	SSN College of Engineering, Chennai
3	T.Vigneswari, G.Kanthimathi and P.Sivaranjana	-	Green synthesis of CuO Nanoparticles with Hibiscus rosa-sinensis and Phytochemical Screening	Proceedings of International Conference on Smart Technologies and Applications-2022	International Conference on Smart Technologies and Applications-2022	International	2022		Ramco Institute of Technology, Rajapalayam	Ramco Institute of Technology, Rajapalayam
4	P.Thiruramanathan, T.Vigneswari, O.Senthilkumar and S.M. Senthil Kumar,	-	JANA2006 Refinement Analysis of Nickel Doped Copper Ferrite Nanoparticles For Photocatalytic Applications	Proceedings of the 3rd Indo-Korea Virtual Conference On Development Of Advanced Materials For Future Technologies,	3rd Indo-Korea Virtual Conference On Development Of Advanced Materials For Future Technologies,	International	2022		Ramco Institute of Technology, Rajapalayam	Vellore Institute of Technology, Chennai
5	K. Jeyapappa, P. Selvarajan,		Second and Third order NLO properties of L-asparagine L-tartaric acid Crystal doped with Ammonium Sulfate	Proceedings of International Conference on Functional Materials and Nanotechnology (ICFMN-2K22)	International Conference on Functional Materials and Nanotechnology (ICFMN-2K22)	International	2022		Ramco Institute of Technology, Rajapalayam	Nehru Institute of Technology, Coimbatore
6	T.Vigneswari, G.Kanthimathi and Lakshmanan Muthulakshmi		GREEN Synthesis of Silver Nanoparticles Using Azadirachta Indica and its Enhanced Antibacterial Activity	Proceedings of International Conference on Functional Material and Nanotechnology (ICFMN-2K22)	International Conference on Functional Material and Nanotechnology (ICFMN-2K22)	International	2022		Ramco Institute of Technology, Rajapalayam	Nehru Institute of Technology, Coimbatore

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Chemistry										
1	O. Senthilkumar, G. Kanthimathi, C. Revathi, S. Soundeswaran	-	Sodium Alginate Based Nanocomposites and Their Applications in Waste Water Treatment	Proceedings of International Conference on Smart Materials Chemistry	International Conference on Smart Materials Chemistry	International	2021		Ramco Institute of Technology, Rajapalayam	St. Joseph's College
2	G.Kanthimathi, T.Vigneswari, O.Senthilkumar and C.Sankar	-	Synthesis of Iron Oxide Using AzadirachtaIndica	Proceedings of International Conference on Solution Grown Crystals and Their Useful Applications	International Conference on Solution Grown Crystals and Their Useful Applications	International	2021	Nil	Ramco Institute of Technology, Rajapalayam	SSN Research Centre, SSN Institutions, Chennai
3	Dr. N. Revathi	-	Green Synthesis, Spectral Characterization and Antibacterial activity of Manganese Dioxide Nanoparticles	Proceedings of Indo-Malaysian Two Day International e-Conference	Indo-Malaysian Two Day International e-Conference partially funded by RUSA Phase-II Scheme	International	2021	Nil	Ramco Institute of Technology, Rajapalayam	School of Chemistry, Madurai kamaraj University, Madurai, Tamil Nadu,
4	Dr. N. Revathi	-	Synthesis, Spectral Characterization, Antimicrobial and antioxidant activity of Mixed ligand Co(II) complex using pyrimidine derivative	Proceedings of International Virtual Conference on Chemical Research for Sustainable Development	International Virtual Conference on Chemical Research for Sustainable Development	International	2021	Nil	Ramco Institute of Technology, Rajapalayam	Department of Chemistry, SRM Institute of Science and Technology, Ramapuram, Chennai
5	Dr. O. Senthilkumar	-	Synthesis and Characterization of Dibromobis (dimethylgloxime)cobalt(II) Complexes	Proceedings of 2nd International Web Conference on Advanced Material Science & Nanotechnology	2nd International Web Conference on Advanced Material Science & Nanotechnology	International	2021	Nil	Ramco Institute of Technology, Rajapalayam	Department of Physics, Vinayak Vidnyan Mahavidyalaya, Nandgaon Khandeshwar, Amravati

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6	Dr.G.Kanthimathi and M.Venkatesh Perumal	-	Green Synthesis of Metals and their Oxide Nano Particles-Sol Gel Method	Proceedings of National Virtual Conference on Sustainable Chemistry and Renewable Energy	National Virtual Conference on Sustainable Chemistry and Renewable Energy	National	2022	Nil	Ramco Institute of Technology, Rajapalayam	Universal Intellectuals Trust (UIT)Villupuram
7	Dr. N. Revathi	-	Synthesis, Spectral Characterization, Antimicrobial and Antioxidant Activity of Mixed ligand Zn(II) complex using pyrimidine derivative	Proceedings of Virtual International Conference on Multidisciplinary Research - 2022	Virtual International Conference on Multidisciplinary Research - 2022	International	2022	Nil	Ramco Institute of Technology, Rajapalayam	Association of Indian Biologists, Tamil Nadu
8	Dr.M.Venkatesh Perumal, Dr.K.Ragavan, Ms. I.Harinidurga, Ms. T. Kiruthika	-	Synthesis and Low-Temperature Sintering of Copper Nanoparticle Pastes for Microelectronic Packaging	Proceedings of ISTE SPONSORED NATIONAL LEVEL CONFERENCE ON EMERGING TRENDS IN ENGINEERING DESIGN & MANUFACTURING	ISTE SPONSORED NATIONAL LEVEL CONFERENCE ON EMERGING TRENDS IN ENGINEERING DESIGN & MANUFACTURING	National	2022		Ramco Institute of Technology, Rajapalayam	Hindustan Institute of Technology, Coimbatore
9	Dr.G.Kanthimath, Dr.T.Vigneswari L.Muthulakshmi and O.Senthilkumar	-	Green synthesis of silver nanoparticles using Vitex negundo and its enhanced antibacterial activity against Bacillus sp	Proceedings of 2nd International Conference on Sustainable Materials & Technologies for Bio & Energy Applications	2nd International Conference on Sustainable Materials & Technologies for Bio & Energy Applications	International	2022		Ramco Institute of Technology, Rajapalayam	SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING, KALAVAKKAM

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10	M. Muralisankar, G. Kanthimathi, T. Vigneswari and O. Senthilkumar	-	Undoped and Ag doped TiO2 Nanoparticles by Sol-Gel Method for Dye Effluent Treatment	Proceedings of 2nd International Conference on Sustainable Materials & Technologies for Bio & Energy Applications	2nd International Conference on Sustainable Materials & Technologies for Bio & Energy Applications	International	2022		Ramco Institute of Technology, Rajapalayam	SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING, KALAVAKKAM
11	C. Revathi, S. Soundeswaran and O. Senthilkumar	-	Synthesis and Characterization of Dibromobis (dimethylglyoxime)cobalt(II) Complexes	Proceedings of Third International Conference on, Advances in Physical Sciences and Materials	Third International Conference on, Advances in Physical Sciences and Materials	International	2022		Ramco Institute of Technology, Rajapalayam	Coimbatore,
Book Chapter										
1	C. Revathi, O. Senthilkumar, and S. Soundeswaran	Solid Waste Management	Energy and Environment Management Audits	-	-	National	2021	978-93-91538-26-2	Ramco Institute of Technology, Rajapalayam	AkiNik Publications, New Delhi
2	Dr.O.Senthilkumar, Dr.G.Kanthimathi, C. Revathi and S.Soundeswaran	Recent Innovations In Engineering, Science and Management	Current Trends in Sodium Alginate Based Nanocomposites for Wastewater Treatment	-	-	National	2021	ISBN : 978-81-950236-2-2	Ramco Institute of Technology, Rajapalayam	Association of Global Academicians and Researchers Publications
3	N. Revathi, M. Sankarganesh and J. Dhaveethu Raja	Natural Products and Their Bioactive Compounds as Chemotherapeutics	Natural Products to Prevent Drug Resistance in Cancer Chemotherapy	-	-	International	2022	ISBN13: 9781799892588, ISBN10: 1799892581, EISBN13: 9781799892601	Ramco Institute of Technology, Rajapalayam	IGI Global Publications

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4	C. Revathi, O. Senthilkumar, and S. Soundeswaran	Modern Trends in Chemical Sciences (Volume - 2)	Biomedical Waste and Their Disposal Techniques	-	-	National	2022	ISBN:978-93-5570-183-1	Ramco Institute of Technology, Rajapalayam	AkiNik Publications, New Delhi
5	Dr.G.Kanthimathi, Dr.M.Venkatesh Perumal and Dr.O.Senthilkumar	Science Of Environmetn (Volume-1)	Drinking Water Contaminants and Health Implications", in the Book "Science of Environment	-	-	National	Published	ISBN :978-81-95557-9-6	Ramco Institute of Technology, Rajapalayam	Scieng Publications
Mathematics										
1	Dr. G. Selvaraj	-	Solving Fuzzy Quadratic Programming Problem by Fuzzy Neural Network		6th International Conference on Advanced Computing and Intelligent Engineering	International	2021	---	Ramco Institute of Technology, Rajapalayam	Bhuvaneswar Institute of Technology, Bhuvaneswar
2	Dr. L. Sathikala, Mr. K. Subramaian, Dr. K. Basari Kodi	-	Dominator Neighbourhood Sum of a graph	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	
3	Mr. T. Selvaganesh, Dr. T. Manimaran	-	A Note on strongly Gorenstein X - flat modules	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	
4	U. Kumaran	-	On connectednesss of the Hausdroff Fuzzy Metric space	International Conference on Smart Technologies and Applications (ICSTA 2022)	International Conference on Smart Technologies and Applications (ICSTA 2022)	International	2022		Ramco Institute of Technology, Rajapalayam	
5	Subasree R	-	On Generalized bω-Closed Sets in Ideal Topological Spaces	Proceedings of Virtual International Conference on Multidisciplinary Research-2022	Proceedings of Virtual International Conference on Multidisciplinary Research-2022	International	2022	ISBN: 978-93-94198-04-3	Ramco Institute of Technology, Rajapalayam	Association of Global Academicians and Researchers (AGAR)

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CIVIL-030

SURFACE WATER ANALYSIS AND PURIFICATION SYSTEM FOR KORAMPALLAM LAKE IN TUTICORIN

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Water is the basic amenity of human life. The most important concern is providing safe and ample quantities of water to the rural and urban communities for the department responsible for public services. A proper formulated water strategy is vital for the health and wellbeing of humans. Impurity of water is inevitable and analysis of water to alleviate the water quality and eliminate all the toxic substances becomes imperative. Most of the ailments in humans are because of untreated impure water which makes water treatment a vital subject. To analyze the physical, chemical and biological properties of the water from the Korampallam lake. To identify the source of pollution and pollutants present in the Korampallam Lake. To analyze the test results and compare it with the general guidelines according to the Bureau of Indian Standards (BIS). To design an appropriate water purification system for the Korampallam lake. The overview of the water quality according to the physio-chemical and biological analyses of water body is obtained. Improvised water quality with respect to the source of pollution and pollutants present in it. The surface water quality conforming with the guidelines of BIS is ensured. The appropriate design of water purification system for safe and treated water is prepared. The surface water of Korampallam lake is analyzed for its surface water characteristics and the results are obtained and hence compared with the guidelines given by BIS. Thus, based on the comparison a proper means of treatment is suggested for each characteristic and a proper design of water treatment plant is comprehended.

Keywords: *Surface Water Analysis, Water Treatment and BIS Limits.*

CIVIL-031

NUMERICAL STUDY ON FLEXURAL BEHAVIOR OF REINFORCED CONCRETE BEAM USING MATLAB

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The analysis of flexural behavior of RC beam is carried out by using Graphical User Interface GUI) developed in software called MATLAB. MATLAB is algorithmic software that will be used to simulate the problem statement using an algorithm. MATLAB is a high-performance numerical computation and visualisation software package. Shear force and bending moment diagrams are more important for beam analysis because they serve as the foundation for studying developed stresses and deflections in beams. MATLAB is a software package with sophisticated computational and graphic representational capabilities that can be used as a convenient tool for beam analysis by generating SF and BM diagrams for any beam with given loading and supporting conditions. In the present study, a MATLAB Graphical User Interface (GUI) has been developed that can be used to produce and analyze the SF and BM diagrams for simply supported beams loaded with concentrated and uniformly distributed loads. This study is also concerned with conducting non- linear finite element analysis on reinforced concrete beam by developing MATLAB code to find stress distribution, damage behavior and load displacement response. The

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GUI in MATLAB code is used to develop a quick and efficient method of analysing the reinforced concrete beam.

Keywords: *Finite Element Analysis, Bending Moment, GUI, MATLAB and Shear Force.*

CIVIL-032

PERFORMANCE STUDY ON DAMAGED CYLINDER WITH SFRP UNDER VARIOUS LOADING CONDITIONS USING ABAQUS

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Numerous concrete structures have reached the end of their service life, either due to deterioration of the concrete caused by environmental factors or due to being functionally obsolete. Most of them are in serious need for restoration, retrofitting and rehabilitation. Steel Fibre Reinforced Polymers can be used in cylinders as they have high strength to weight and stiffness to weight ratios, corrosion resistance, light weight and potentially high durability. Their application has been rapidly growing in civil engineering field and is becoming a promising solution for strengthening the deteriorated structures. This work presents the results related to the behavior of cylindrical concrete specimens reinforced by external wrappings made of Steel fibre Reinforced Polymers. The specimens have been subjected to both compression and tensile loadings with and without SFRP wrappings terminated prior to failure of the cylinder in ABAQUS software. The results obtained shows that SFRP wrapping provide a significant increase in ultimate compression stress compared to concrete cylinder without SFRP wrapping in ABAQUS software. The damage mechanisms of the concrete cylinder strongly depend on the SFRP wrapping provided.

Keywords: *Compressive Strength, Concrete Damage, Steel Fibre Reinforced Polymer and Tensile Strength, Wrapping Material.*

CIVIL-033

WELDED TUFF AS CEMENT REPLACEMENT MATERIAL FOR CONCRETE PRODUCTION – A CASE STUDY

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The demand of concrete is increasing rapidly with the growth of construction industries, in turn, leads to huge usage of binding materials (especially, cement) in Ethiopia. The depletion of natural sources due to the extraction of aggregates is a major environmental problem affecting the eco-system. The cement industries in Ethiopia face many transformation challenges to overcome the environmental degradation and thus finding the suitable alternatives become mandatory for them. Welded tuff is a pyro-clastic type of rock and it is a cementation of volcanic ash or dust, unruffled volcanic ejecta. It can be used as a substitute for cement in the construction sectors to attain the optimum binder content. The porous structure of the welded tuff is an added advantage to lower the freezing temperature and act as the insulation material. In the current study, the characteristics of welded tuff as well as its effects on the property of concrete have been examined to check its suitability as a partial alternative of cement for the production of C-25 concrete. The Welded tuff was oven-dried and sieved by 150 µm to remove the coarser particle. The percentage of replacement of cement with Welded tuff was varied from 0% to 20% with respect to the cement in incremental steps of 5%. The experimental program was designed to explore the behavioral tendency of Welded-tuff over the setting time of cement, workability, density, and compressive strength of concrete. The workability of each sample was measured before the specimens cast and

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cured at a standard temperature and the test was accomplished on it for 7 and 28 days respectively. A total of thirty (30) 150 x 150 x 150mm concrete test cubes were cast using coherence mix of 1:2:3 applied a constant W/C ratio of 0.6. The result clearly indicated the adding of Welded tuff in adhesive cement glue as partial replacement of cement increase both the initial setting time and final setting time of cement. However, the workability and density of concrete diminish with the augment in Welded-tuff content of the mix. Regarding the limit state of compressive stress, increasing the Welded-tuff content (upto10%), there is a continuous enrichment in compressive strength of concrete mixes. Upon the completion of minimum curing period (7 days), the concrete containing 5% and 10% Welded tuff as cement, gained 6.3% and 1.09% of strength while at 15% and 20% replacement level concrete loosed 10.18% and 18.91% of strength respectively. Although the replacement of 10% of Welded tuff still boost up the compressive strength of special concrete in comparison with the control concrete, for obtaining accuracy on results, the 5% of Welded tuff was taken as the optimum replacement level. Eventually, the results encourage the use of Welded tuff as pozzolonic material for partial cement substitution in producing conventional concrete and to reimburse the impacts of cement production towards environmental factors as well as the technical and economic factors.

Keywords: *Cementitious Matter, Compressive Strength, Pyro-Clastic Rock, Ultra High Strength Concrete, Welded – Tuff and Workability.*

CIVIL-034

STATE-OF-ART REVIEW OF MECHANICAL PROPERTIES OF PERVIOUS CONCRETE

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Due to its nature friendly property, the pervious concrete has been able to attract researchers' attention despite having limitations in durability and strength. In this paper, the mechanical properties of pervious concrete and its applications, advantages, and limitations in implementation of pervious concrete were extensively reported. It will also focus on material structure, constituents of pervious concrete such as cement, fine aggregate, coarse aggregate and dosage of admixture. Further, physical properties of pervious concrete such as compressive strength, flexural strength, density, porosity, permeability were influenced by size of aggregate, aggregate-to-cement ratio, water-cement ratio, cement content and dosage of mineral and chemical admixtures. Regression relationship between mechanical properties and the proportions of materials used in pervious concrete for prediction of important parameters from established data and information might be helpful for researchers to accelerate their process of investigation in this area.

Keywords: *Pervious Concrete, Compressive Strength and Mechanical Properties.*

CIVIL-035

A REVIEW ON PERMEABILITY OF PERVIOUS CONCRETE

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Pervious concrete is a high-porosity concrete used for flatwork applications that allows water to flow through directly from precipitation and other sources, reducing site runoff and allowing groundwater recharge. Permeability is the key factor of pervious concrete. In this review paper, permeability of pervious concrete, its influence on effect of compaction, role of

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supplementary cementitious materials, experimental setup used in the past research studies were extensively reported. It will also focus on the relationship between permeability and mechanical properties, permeability and aggregate/cement ratio, permeability and porosity of pervious concrete. The new methodologies available for predicting the permeability of pervious concrete also reported. Researchers may find this information useful in accelerating their investigation in this area.

CIVIL-036

NUMERICAL STUDY ON FLEXURAL BEHAVIOR OF REINFORCED CONCRETE BEAM USING MATLAB

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Glass from a light bulb is a waste product that cannot be utilized in a traditional way. This study looks into the possibilities of using lamp borosilicate glass powder as a cement replacing admixture in conventional concrete. Finely grounded Borosilicate Glass Powder of particle Size 4 Micrometer shows good performance and properties towards partial replacement of cement in Concrete. Durability of the Concrete after partly replacing cement with Borosilicate Glass Powder for 20% was examined and the results were compared with conventional concrete in order to assess the suitability of usage of Borosilicate Glass Powder as a partial cement replacing material.
Keywords: Borosilicate Glass Powder, Concrete Durability.

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due to non-uniform buffer power in the soil. Also, it is observed that the increase in water flux in the soil leads to reduction in non-uniformity of phosphate concentration around the root.

Keywords: Soil; Buffer power; Water flux; Phosphate; Maize root; Infinite element method.

AS-52: Finite Summation Formulae for Multivariable H̆-Function

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Abstract

In this present paper, an attempt has been made to derive finite summation formulae for the H-Function introduced by H.M. Srivastava and R. Panda. Since the multivariable H-Function includes a large number of a special functions of one and more variables as its particular cases. Therefore, the results established here serve as key formulas giving as a large number of new and interesting results by specializing the parameter involved

AS-53: Microbial Fuel Cell for Treating Seafood Processing Wastewater

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Abstract

Microbial Fuel Cells are treatment technologies that utilizes the microbial metabolic activity for treatment of simple to complex wastewaters. They can simultaneously generate electricity in addition to wastewater treatment efficiency. Sea food processing wastewater with high COD and salinity is being treated with Microbial Fuel Cells. In the current study a dual chambered upflow MFC was employed. Carbon veils were used as electrodes. Nafion 117 is used as proton exchange membrane separating the lower cathode and upper anode chamber. Hydraulic retention time varied from 45 hrs to 5 hrs gradually varying the duration. The solids removal efficiency peaked a value of 68% and COD as 72%. The performance of MFC was measured in terms of power density and Coulombic efficiency. Peak power output was 105 mW/m^2 and coulombic efficiency was 40%.

Keywords: Microbial Fuel Cell, Power Density, Coulombic Efficiency, Sea food processing wastewater.

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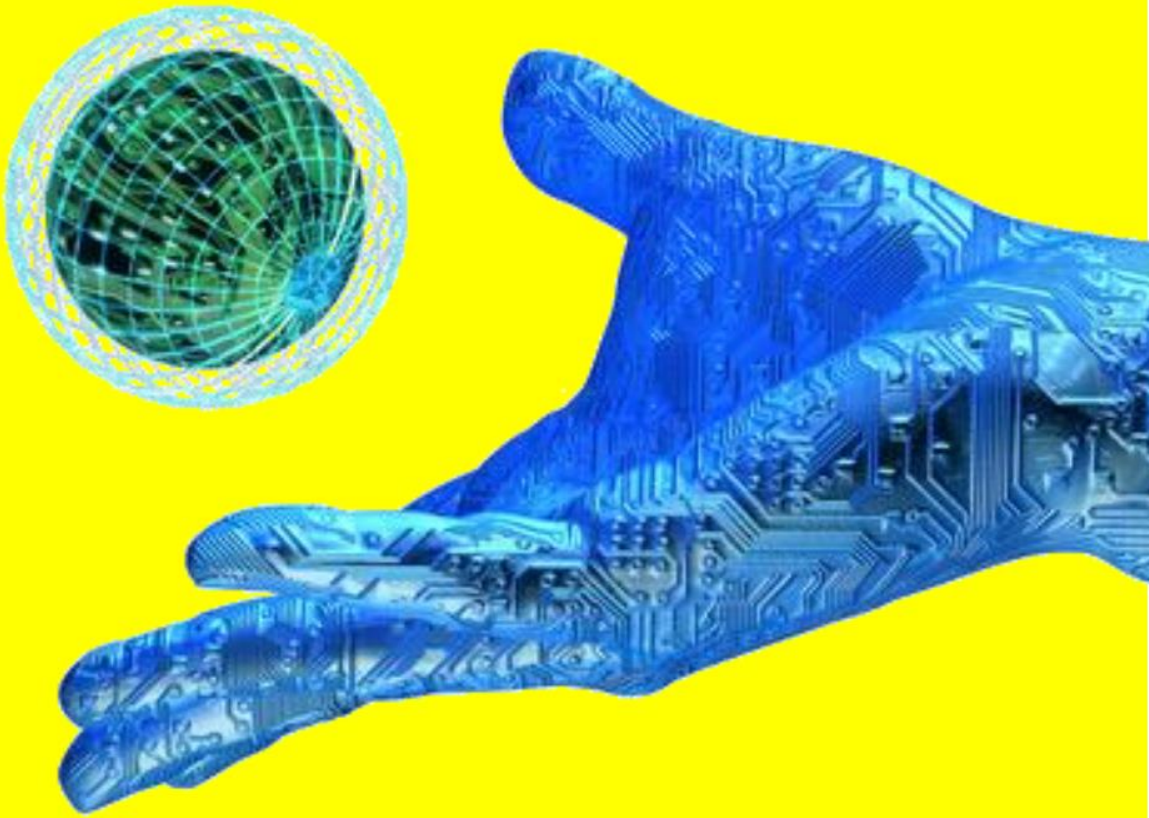

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Investigation on Industrial Effluent Treatment Using Dual Chamber Microbial Fuel cells

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Abstract

Energy crisis is one of the main problems in current scenario due to rapid urbanization and industrialization. Hence it becomes important to find alternate energy sources than the non-renewable energy sources. In addition to the energy crisis, industrialization and changing life style of people are generating a huge quantity of domestic and industrial wastewaters. All the wastewaters must be treated effectively before being discharged into the surface water bodies or ground surface. Else they may cause a huge deterioration to the environment and human health. A variety of wastewater treatment technologies are adopted in the recent times to meet out these problems. Microbial Fuel cells are one such novel technology used for treatment of wastewater simultaneously with the generation of electricity. Because of its dual benefits many researches are being carried out in recent times for its up scaling and implementation. Microbial fuel cells are bio-electro chemical systems capable of treating wastewater with the help of microbial communities as the catalyst. Few microbes called as exaelectrons have the capacity to transfer the electrons produced in them during metabolism to the outside world. In dual chambered microbial fuel cells, the main parts are a cathode chamber, anode chamber and a proton exchange membrane. The cathode and anode will be housed inside separate chambers which are separated by a proton exchange membrane. Activated carbon is used a cathode and anode. The sweet candy manufacturing wastewater is discharged in the anode side. It will get oxidized by the microbes' releasing protons and electrons. The protons reach cathode through a proton exchange membrane. The liberated electrons travel through an external circuit. The electrons get reduced in the cathode by the protons and the external terminal electron acceptor, the oxygen. In current study the removal efficiency of Chemical Oxygen demand was around 78% with a power density of 632 mW/m^2 and coulombic efficiency 33%. Hence from the studies Dual Chambered Microbial Fuel Cells are identifies as one of the promising technologies for treatment of complex industrial wastewaters.

Keywords

Dual Chamber Microbial Fuel Cell, COD Removal Efficiency, Coulombic Efficiency, Power Density

Student Feedback Application

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Abstract

The process used to collect the student's feedback is manual and takes more time to complete its analysis and report generation. As technology is changing at a fast rate, maximum numbers of android applications are available for educational purposes. In recent years the android technology with web services has brought many drastic changes in the mobile application development field. In this paper, we proposed a system that provides a simple interface for the collection and analysis of student's feedback. It can be used by educational institutes or colleges to maintain the records of student's feedback. Valuing and asking for feedback has recognized benefits for both faculty and students. For faculty to develop and improve teaching skills. Using this application, students can fill in their feedback through any android based mobile. Once they submit it, their feedback will be analysed quickly and a feedback report can be generated within a very short period.

Keywords

Student Feedback Application, Online feedback, Android, Mobile Application.

Investigation on Corrosion behaviour of Geopolymer concrete using DMS and M-Sand as a fine aggregate under ambient curing conditions.

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Keywords: Fly ash, GGBS, DMS, M-Sand, Ambient curing, Corrosion behavior.

Abstract. Finding an alternative to cement concrete has become critical for the long-term sustainability of the environment. Because of its lower carbon footprint, geopolymer concrete has shown to be an excellent substitute for traditional concrete. Fly ash, GGBS, metakaolin, red mud, and other raw materials for geopolymer concrete are high in silica and alumina. Geopolymer matrix is created when these raw materials are mixed with alkaline solutions. Fine and coarse aggregates, as well as superplasticizers, are all essential ingredients in geopolymer concrete. The goal of this study is to see if fly ash, GGBS, Manufactured Sand (M-Sand), and Dredged Marine Sand (DMS) can be used to make geopolymer concrete. In terms of corrosion resistance, carbonation and alkalinity, DMS could easily replace the typical scarce material (River Sand) in the manufacturing of geopolymer concrete under ambient curing conditions.

1. Introduction

In terms of sustainable building, geopolymer concrete has emerged as a possible alternative to cement concrete. The need of the hour is to preserve the environment from carbon footprints that are too large. In the manufacturing of traditional binding materials, such as cement, carbon dioxide emissions are disturbing. Cement manufacture accounts for around 80% of CO2 emissions. Furthermore, the creation of it will necessitate a significant amount of energy. (Approximately 3.5 times the energy required for Geopolymer Concrete.) Geopolymer is an inorganic polymer that uses silica and alumina-rich earth source materials as a binder in combination with an alkaline solution. The mixture, which includes source material (fly ash, GGBS, metakaolin, rice husk ash, and so on), alkaline liquids, fine aggregates, coarse aggregates, and super plasticizer, will be exposed to steam curing, hot air curing, and ambient curing conditions.

Geopolymer concrete technology has shown to be an excellent alternative binder and a vital factor in fostering a cleaner environment by lowering CO2

emissions. Furthermore, the strength and durability of the material are comparable to that of traditional concrete. Even Geopolymer concrete outperforms cement concrete in terms of durability in some situations. As the demand for cement grows, it's more important than ever to look at alternative binding materials. Furthermore, due to a scarcity of fine aggregate, such as river sand, researchers are investigating alternative materials for use as fine aggregate. The same is true for coarse aggregates. As a result, there is a lot of room for more study in the new Geopolymer technology. This paved the way for research into identifying appropriate source materials for various applications, attempting to replace scarce conventional fine aggregates with
alternate fine aggregates, exploring the possibilities of various coarse aggregates, recommending desired curing methods for specific applications, and proposing new curing methods.

In this investigation some efforts are taken to know the corrosion behaviour of geopolymer concrete using different fine aggregates.

1. Materials

1.1 Flyash:

Tuticorin, Tamilnadu, provided the fly ash used throughout the experiment. According to ASTM C618, fly ash is categorised as Class F (low calcium) or Class C (high calcium). The amount of calcium in low calcium fly ash is less than 10%, but it is more than 20% in high calcium fly ash. Low calcium fly ash is commonly recommended to speed up the polymerization process. Furthermore, Class F fly ash has a carbon content of less than 5% and Class C fly ash has a carbon content of less than 2%. In low calcium flyash, the composition of silica and alumina is higher than in high calcium flyash.

1.2 GGBS:

GGBS is a slag that is a by-product of the steel manufacturing sector. The use of GGBS in concrete can reduce chloride ingress by up to 50%. Furthermore, GGBS aids in improving concrete's early strength as well as its longevity. In this study, GGBS is utilised to aid ambient curing because one of the disadvantages of Geopolymer concrete is that it requires heat or steam to cure, making it unsuitable for cast-in-place applications. Because of the reduced chloride ingress and the improved alkali aggregate reactivity in geopolymer concrete, GGBS has an impact on corrosion.

1.3 Alkali Activator Solution (AAS):

AAS has been used to react with silica and alumina to produce the polymerisation process during the creation of geopolymer concrete. It is widely available in commercial form as Sodium Hydroxide (96 wt percent purity) and Sodium Silicate A53 ($SiO_2/Na_2O = 2$). Sodium Hydroxide is accessible in pellets or flakes , while sodium silicates is available in gel form.Alternate AAS will be potassium hydroxide and potassium silicates. From an economic standpoint, sodium hydroxide and sodium silicates are recommended. For the entire experiment, sodium hydroxide with a 14 molarity concentration and A53 grade sodium silicate solution were used.

1.4 Fine aggregates:

M-Sand and DMS were the fine aggregates employed in the study.M-Sand is extracted from granite quarries in the form of cubically formed crushed aggregates with grounded edges. Due of the high demand for traditional fine aggregates, such as river sand, it is critical to investigate the usage of alternative fine aggregates. Furthermore, M-Sand's availability and low transportation costs led to its widespread use at construction sites in place of rare river sand. The M-Sand utilised is zone II compliant, as determined by sieve analysis in accordance with IS 383-1970.

1.5 Coarse Aggregates:

As suggested by Rangan and Hardjito, coarse aggregates in different grades 7mm, 14 mm and 20 mm were arrived as per mix design and adopted.

1.6 Superplasticizer:

To improve workability, Master Glenium Sky 8233, a high-water reducer, was utilised as a super plasticizer. It's a high-durability polycarboxilic ether-based superplasticiser that's free of chloride and alkali. It has a brown tinge to it and is widely available. At the time of casting, it is mixed with the alkaline solution in a proportion of 1 percent superplasicizer to the binder mass.

2. Experimental programme

2.2 Mix Design

The material proportions were calculated using the Rangan and Hardjito method. Table 3.1 shows the mix proportions for geopolymer Concrete.

Table 3.1 Mix proportions for concrete - G40

S. No.	Mix ID	Fly ash (70%) (kg/m^3)	GGBS (30%) (kg/m^3)	NaOH (14M) (kg/m^3)		Na_2SiO_3(kg/m^3)		M-Sand (kg/m^3)	DMS (kg/m^3)	Coarse Aggregates(kg/m^3)		
				Solids	Water	Solids	Water			7 mm	14 mm	20 mm
1.	D20	297.87	127.66	20.17	29.68	54.69	69.66	432	108	630	360	270
2.	D40	297.87	127.66	20.17	29.68	54.69	69.66	324	216	630	360	270
3.	D60	297.87	127.66	20.17	29.68	54.69	69.66	216	324	630	360	270
4.	D80	297.87	127.66	20.17	29.68	54.69	69.66	108	432	630	360	270
5.	D100	297.87	127.66	20.17	29.68	54.69	69.66	--	540	630	360	270
6.	M100	297.87	127.66	20.17	29.68	54.69	69.66	540	--	630	360	270
7.	R100	297.87	127.66	20.17	29.68	54.69	69.66	540		630	360	270

Table 3.11 Mix identity for mortar

S. No.	Mix	M-Sand (%)	DMS (%)	River Sand (%)
1.	M100	100	0	-
2.	T20	80	20	-
3.	T40	60	40	-
4.	T60	40	60	-
5.	T80	20	80	-
6.	T100	0	100	-
7.	R100	0	0	100
M – M-Sand, T – DMS obtained from Tuticorin, R – River Sand				

3. Problem description:

3.1 Depth of carbonation Test:

All proportions were cast in 150mm x 150mm x 150mm cubes. Within 24 hours of casting, the specimens were demoulded. Specimens were examined in a 1000kN compression testing equipment after 28 days of ambient curing. The shattered surfaces were cleaned and treated with phenolphthalein pH indicator. 1 g phenolphthalein was mixed with 90 mL ethanol solution and then dilute with 100 mL distilled water to make the phenolphthalein indicator. The colourless area of the specimen was measured from three average sides. Following IS:516-2019 criteria, the measurement was performed immediately after spraying the phenolphthalein indicator on the surface of the specimens.

3.2 Alkalinity Test:

At the age of 90 days, 10 grammes of crushed material from all tested specimens in all proportions was mixed with 50 ml of distilled water and thoroughly agitated. After 72 hours, the pH values were checked, and a ph metre was placed in the solution to check the pH value of the samples, which reflected the alkalinity of the specimens.

3.3 Corrosion Test:

Because DMS was utilized as an alternative fine aggregate, corrosion testing was required, despite the fact that geopolymer concrete is a corrosion-resistant material. Normally, chloride attack is followed by reinforcing corrosion in concrete. Reinforcement corrosion has a bigger impact on the concrete structures' durability and serviceability. Due to the reduction in cross sectional area, the tensile strength of reinforcement is diminished, as is the link between steel and concrete. To investigate the corrosion behaviour of geopolymer concrete, cylinder specimens with a diameter of 100mm and a height of 200mm were formed, each containing a steel bar with a diameter of 10mm. in accordance with ASTM C876. Specimens were subjected to alternate soaking and drying operations after 28 days of cure. During the wetting cycle, the specimens were dipped in a 3 percent Nacl solution for 15 days.

They were then placed in a drying cycle for 15 days. The procedure was carried out four times. Corrosion potential, polarization resistance, Tafel

constants, and corrosion current density were studied after that. There are four electrodes in the experimental setup: a working electrode (red), a platinum electrode (blue), and two reference electrodes (white and black). In a 3 percent Nacl concentration solution, the saturated specimens were immersed. The rebar was used to connect the working electrode. Nacl solution was kept in contact with the platinum electrode and one reference electrode. As indicated in Figure4.1, the other reference electrode was left free. During the experimentation, the EC-lab V11.12 software interface was employed to measure corrosion. The specimens were exposed to an open circuit voltage ranging from -2.5V to +2.5V. For 200 seconds, the specimens were subjected to accelerated corrosion. In open circuit potential, the maximum and minimum voltages were recorded. The insert technique parameter for LPR was set to electrochemical application, and the corrosion rate was measured.

Figure 4.1 Corrosion test set up

3 Results and Discussions:

3.1 Depth of carbonation Test:

A phenolphthalein indicator is sprinkled on the material to determine carbonation. Alkalinity is indicated by the depth of carbonation. Cube specimens were cast and then cured for 150 days at room temperature before being evaluated for carbonation. The color shifts were measured from the surface's edges. Figure 5.1 depicts the tested specimens, while Table 5.1 lists the carbonation depth data.

Table 5.1 Carbonation depth

S. No.	Mix Id	Depth of carbonation in mm
1.	D20	6.5
2.	D40	6.8
3.	D60	7.2
4.	D80	7.5
5.	D100	8.3
6.	M100	7.9
7.	R100	8.1

Figure 5.1 Carbonation test

The carbonation data clearly show that increasing the amount of DMS increases the carbonation depth in the specimens. Control specimens have the same carbonation depth as the test specimens.

3.4 Alkalinity Test:

Using a pH metre, the alkalinity of each and every mix was determined. The pH values indicate the likelihood of reinforcement corrosion occurring in the concrete. Because geopolymer is high in alkalinity, adding DMS to concrete may improve its alkalinity. Table.5.2 shows the pH values measured for all mix proportions.

Table 5.2 pH values

S. No.	Mix Id	pH value
1.	D20	>14
2.	D40	>14
3.	D60	>14
4.	D80	13.6
5.	D100	>14
6.	M100	13.5
7.	R100	>14

The observed pH values show that the majority of the samples had a pH value more than 14, indicating that the likelihood of reinforcement corrosion is quite low.

3.5 Corrosion Estimation:

The LPR (Linear Polarization Resistivity) method and an open circuit potential test were used to estimate corrosion.

3.5.1 Linear Polarization Test:

This test entails calculating the corrosion current density (Icorr), for which two constants must be found first: the anodic Tafel constant (a) and the cathodic Tafel constant (c). These constants should be extrapolated to produce Ecorr from the slopes of the anodic and cathodic branches of the polarisation curve. The "intersection" or "Tafel extrapolation" method is the name given to this method. Curve fitting analysis might be used to obtain both Tafel slopes and Icorr simultaneously by plotting log I versus over potential(E-Ecorr). The

transition of the polarisation curve from a passive to an intermediate to a highly active state must be represented. The infinite anodic Tafel slope for corroding samples was observed because the anodic Tafel slopes of active samples would eventually reach infinity. After that, the corrosion current density (Icorr) will be calculated using the Stern-Geary Equation (5.1).

$$I_{corr} = \frac{(\quad + \quad)}{2.3}.$$

The corrosion rate observed for all mixes upto 4 cycles are given in Table 5.3. and also shown in Figure 5.2

Table 5.3 Corrosion rate observed

Sl.No	Samples	I Cycle	II Cycle	III Cycle	IV Cycle
1.	M100	0.032	0.0148	0.0178	0.0291
2.	R100	0.061	0.020	0.0315	0.00215
3.	D100	0.012	0.0098	0.061	0.0355
4.	D20	0.289	0.016	0.019	0.0021
5.	D40	0.080	0.0107	0.0186	0.0198
6.	D60	0.034	0.0083	0.014	0.0387
7.	D80	0.038	0.0130	0.0085	0.0401

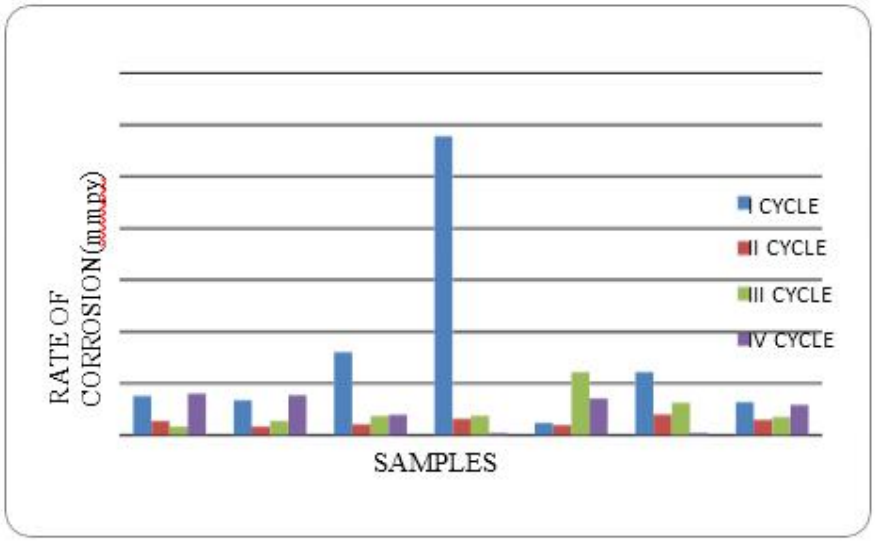
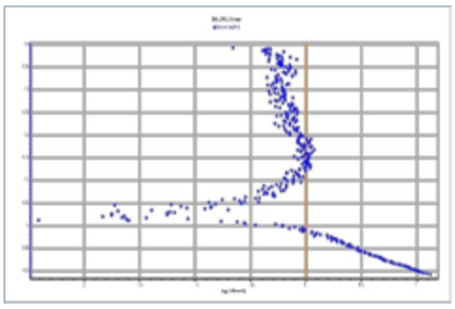


Figure 5.2 Rate of corrosion

The Tafel plots of uncorroded specimens are shown in Figure 5.3.



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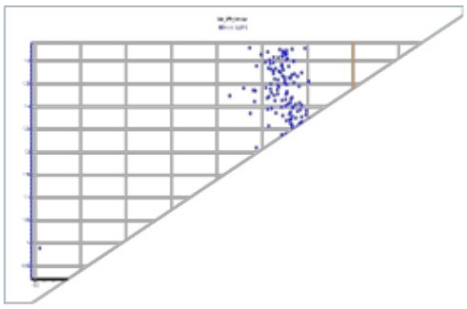

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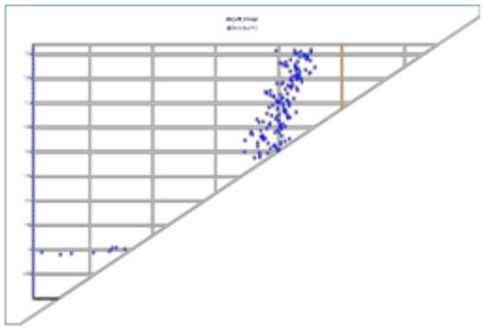
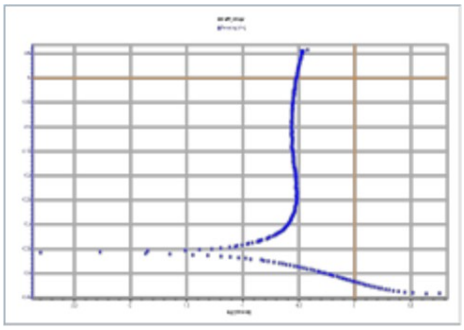


(c)



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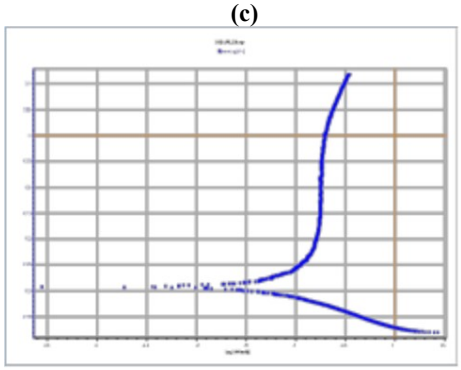

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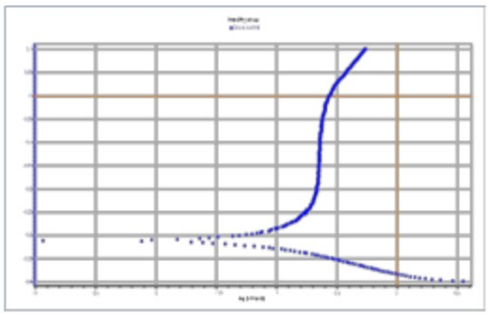

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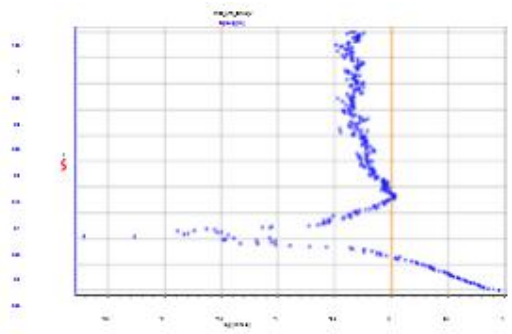
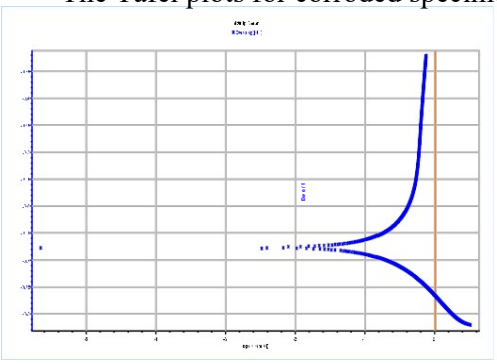


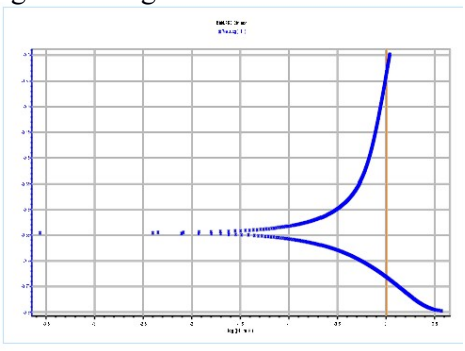
(g)

Figure 5.3 Tafel Plots for uncorroded specimens (a) D20, (b) D40, (c) D60, (d) D80, (e) D100, (f) R100 and (g) M100

The Tafel plots for corroded specimens are given in Figure 5.4.



(a)



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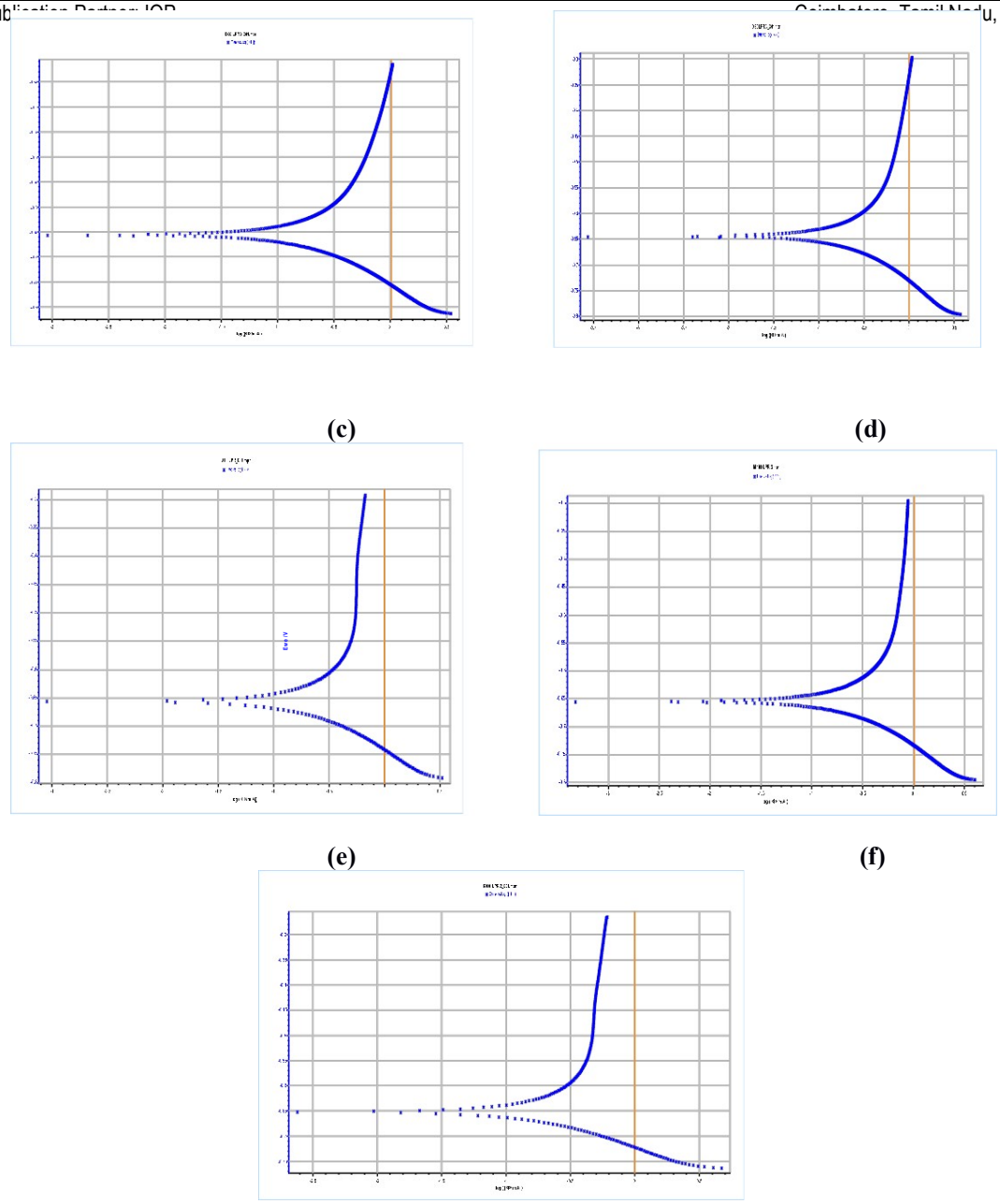


(c) **(d)**

(e) **(f)**

(g)

Figure 5.4 Tafel plots for corroded specimens (a) D20, (b) D40, (c) D60, (d) D80, (e) D100, (f) M100 and (g) R100

According to the results and graphs, a significant quantity of corrosion occurs in D60, indicating that the geopolymerisation process has completed at the fourth cycle of corrosion. Despite this, all specimens performed admirably in the corrosion test.

3.5.2 Open Circuit Potential Test:

Corrosion potential (Ecorr), a commonly used corrosion index, will be determined in this test. With increasing chloride contamination, the average value of the measured open circuit corrosion potentials rises dramatically. For converting AgCl electrode to Copper sulphate electrode, utilise Equation (5.2) from ASTM Standards C876 (CSE)

$U_{cu} = (U_{Ag} - 120 - 1.1(T - T1)) / 1000$ (5.2)

= (-0.29 -120-1.1 (24-25))

/1000 U_{cu}= -0.119 V

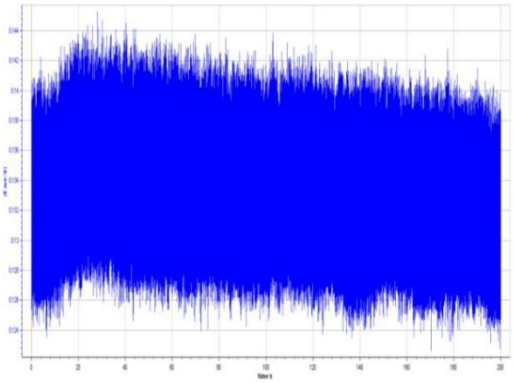
where,
U_{cu}=Half-cell potential of CSE. T = Ambient temperature
T1 = Constant temperature of 25ºC

Table 5.4 shows the corrosion potential for all combinations up to four cycles.

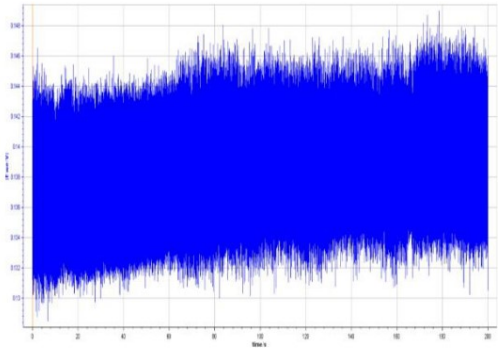
Table 5.40 Corrosion potential

SI.NO	Samples	I Cycle	II cycle	III Cycle	IV Cycle
1.	M 100	3.081	0.080	0.133	0.421
2.	R 100	1.30	0.014	0.299	0.383
3.	D 100	1.50	0.028	0.378	0.415
4.	D 20	1.301	0.013	0.015	0.440
5.	D 40	2.381	0.015	0.014	0.395
6.	D 60	1.581	-0.087	-0.119	-0.176
7.	D 80	0.900	0.076	0.141	0.426

The potential area measurements of uncorroded specimens are shown in Figure 5.5.



(a)



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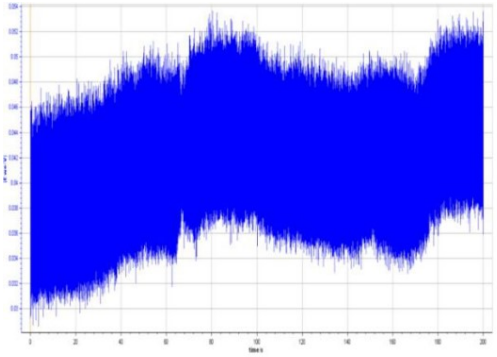

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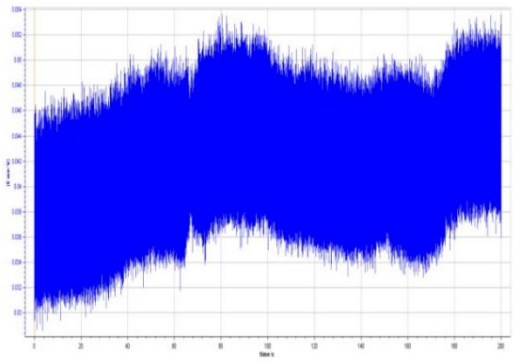
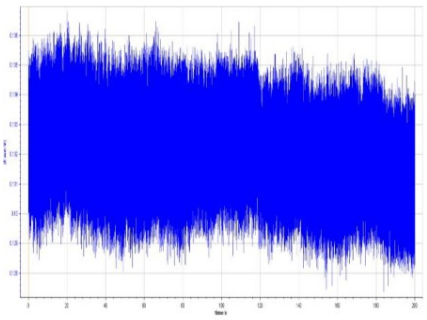


(d)



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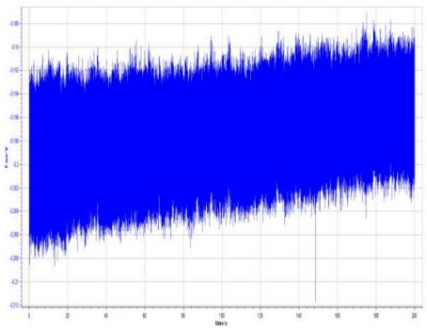

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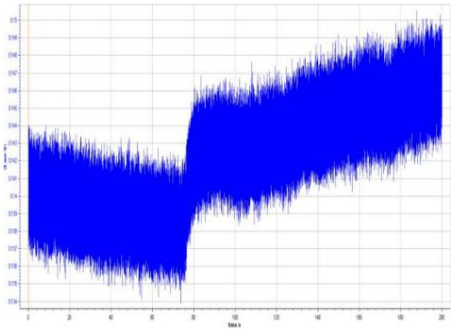
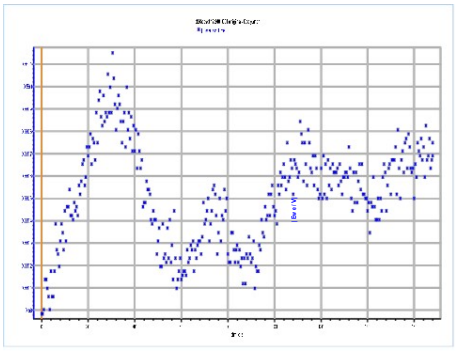


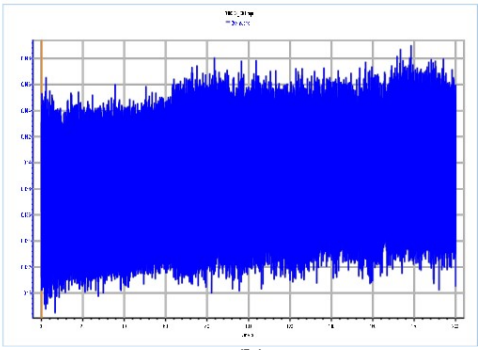
(g)

Figure 5.5 Potential area of uncorroded specimens (a) D20, (b) D40, (c) D60, (d) D80, (e) D100, (f) M100 and (g)-R100

The potential area measurements of corroded specimens are shown in Figure 5.6.



(a)



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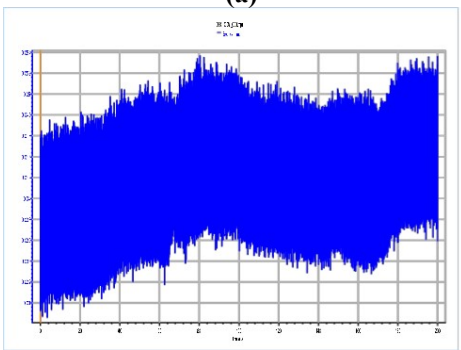

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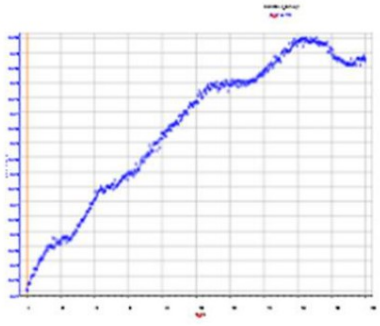
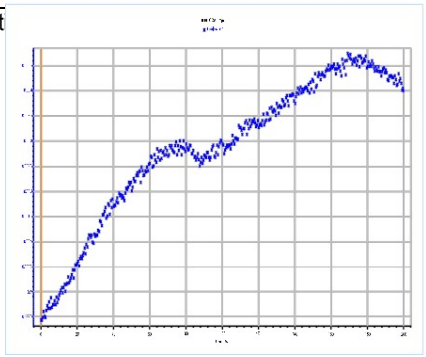


(d)



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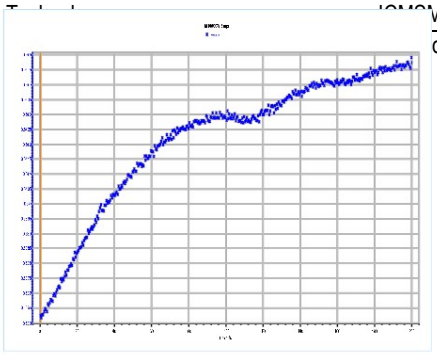
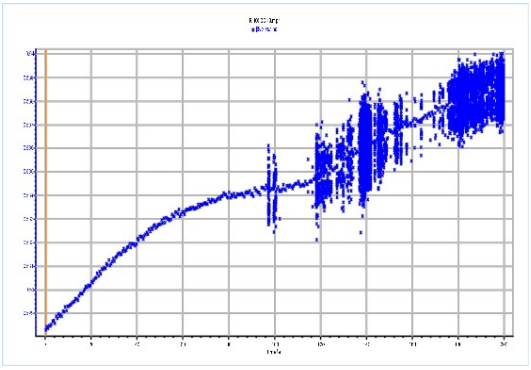


(f)



(g)

Figure 5.6 Potential area of corroded specimens

The collected results show that the region over an area has a positive value greater than 0.20 V. As a result, it can be assumed that there is a greater than 90% chance that no reinforcing steel corrosion occurs in that location. As a result, it will be found that geopolymer concrete made with M-Sand and DMS is more corrosion resistant than river sand-based samples.

7. CONCLUSION

1. From the above studies it is concluded that alkalinity tests that probability of reinforcement corrosion using DMS is very less.
2. The carbonation statistics clearly show that adding more DMS to the specimens enhances the carbonation depth. The carbonation depth of the control specimens is the same.
3. Corrosion monitoring also indicated that there is more than 90 % probability that no reinforcing steel corrosion occurs.

In terms of corrosion behaviour, DMS might very well be employed as a substitute for the traditional scarce material (River Sand) in the production of geopolymer concrete under ambient curing conditions**.**

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Investigation of Mechanical Properties of High Performance Concrete Using Industrial Waste with Well Graded Aggregates

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Keywords: High Performance, Nano Silica, Glasspowder, Polypropylene.

Abstract. Concrete is a breakable material and is made of cement, fine aggregates and rough aggregates with the addition of pozzolanic material such as microsilica, rice husk ash, bottom ash, glass powder, nanosilica, etc. In this paper, experimental studies for development of High Performance Concrete of M60 grade was carried out. Strength characteristics with supplementary cementitious material such as nano silica and glass powder where adopted. The optimum dosage of glass powder was 10% by mass of cement and that of nano silica and polypropylene were 1.5% and 0.1% respectively. Well graded aggregates were used. Used foundry sand of 30% was used as a partial replacement to fine aggregate. The percentage of super plasticizer used was 2.5% by mass of cement. The specimens were tested for Mechanical properties.

Introduction

Concrete is the most consumed global material after water due to its common usage in most of structural applications. The properties of the long-term concrete can be modifying by changing some of the fresh concrete properties, cement such as the amount of cement, the water/ ratio, dosage of admixtures in particular limits based on material properties. The concrete mix design creates complex concerns, and the accurate ways of performing its design can be finalized with expert information in the field with their experience. Over the last few years, efforts to improve the performance of concrete have suggested that cement substitute products, as well as mineral and chemical admixtures, will improve the strength and durability of concrete [4]. The concrete mixes thus produced will minimize carbon footprint and prevent the atmosphere from the pollution[8]. The environmental results indicate that replacing pozzolanic materials with Portland cement is not always beneficial to the climate[7]. To make high-strength and durability concrete, active mineral additives such as fly ash, blast furnace slag, rice husk ash and SiO2 nano particles have been added to the cement, aggregates and water in conventional concrete [9]. In this study attempts have been made to find out the scope for attainment of high strength concrete when industrial waste glass powder and silica flour are added in the concrete mixes to aim for the better mechanical properties of such concrete mixes.

Concrete is more economical, strong and durable. Tensile strength of the composite, related more to thestrain at which matrix develops a macro-crack, won't differ much for many Conventional

fibre reinforced cementations materials. Several fibre materials in various sizes and shapes are developed to be used in FRC. Among these fibers, the polypropylene has been one amongst the foremost successful [1-3]. The utilization of foundry sand in concrete improves the properties of concrete, making it more cost-effective and terminating the disposal problems [3-5].

The Glass powder, also known as factory-made sand, has been recognized as an artefact in developed countries. The level of glass powder utilization within industrialized nations has reached very hour of its total production as an outcome of sustained research process works undertaken with regard to growing application of this industrial any material un used[6-9]. A well-graded aggregate has a particlesize gradation that extends the size spectrum from fine to coarse. A silica sample from a centre of well-graded aggregate concrete exposes a closely packed mixture of particle sizes [10-11]. The S-Shaped inthe gradation curve characterizes it. In terms of proportion, well-graded aggregate can be tricky.

The goal of aggregate proportioning and sizing is to optimize aggregate volume in the concrete while retaining strength, workability, and finish. This preserves the proportions of scale such that there is just enough of each to fill all the voids while retaining the cast surface consistency and workability. High- performance concrete is a type of concrete with unique properties suited to a specific application and environment, ensuring that it performs well in the structure in which it is built [12-13].

Experimental Investigation

Physical Properties of Materials

OPC of 53 Grade was tested and it satisfies the IS Specifications. Fine aggregate was riversand passing through IS 4.75 mm sieve confirming to zone II as per IS: 383-1970 was used as fine aggregate having a relative density of 2.5 with FM 4.718. Aggregate having size 12mm and chips (4.75), relative density 2.7 and FM 5.27 was used as coarse aggregate. The used foundry sand havinga relative density 2.27 and FM 2.816. The Glass Powder was collected from Madurai, Tamilnadu, India. The Glass powder has the relative density of 2.733. NS used was of particle form with 99.9% SiO2 and specific surface area of 60 m^2 /g. It was produced by Astrra Chemicals and was used as received. The chemical ingredients of the NS are provided in the Table 1. Various types of short and chopped polypropylene fibers are available. This polypropylene fiber will get use in the sizes of 6mm,12mm, 15mm, 20mm, 24mm, 30mm, 40mm, 45mm, 60mm, 120mm.

Table 1. Mix Proportions

proportions	P.F %	N.S %	G.P %	F.S %	C.A 12.5mm	C.A CHIPS (<6mm&>4.75mm)	W/C ratio
GF 40/60	0.1	1.5	10%	30%	40%	60%	0.28
G 40/60	0.1	1.5	10%	-	40%	60%	0.28
F 40/60	0.1	1.5	-	30%	40%	60%	0.28
GF 70/30	0.1	1.5	10%	30%	70%	30%	0.3
G 70/30	0.1	1.5	10%	-	70%	30%	0.3
F 70/30	0.1	1.5	-	30%	70%	30%	0.3
C 40/60	-	-	-	-	40%	60%	0.28
C 70/30	-	-	-	-	70%	30%	0.3

Testing Methods

Properties of Concrete

Slump Test

As per IS 1159-1959, the slump test was carried out. Slump test is a method commonly used to measurethe consistency of the concrete. The 300 mm frustum cone mould was placed on a smooth levelled surface and filled with four equal thicknesses of concrete. Each surface was tamped twenty five times with sixteen mm diameter steel rod and top surface was struck with trowel. The mould was lifted slowly and decrease in height was measured.

Compressive Strength

The specimens were tested for 28 and 56 days as per IS 516-1959.Testing was carried out in the 2000 kN compression test machine. The specimens stored in the healing tank were removed after the healing period and wiped off to dry the specimen. The cubes were stored in CTM in such a way that the front part of specimen was right angles to the direction of compaction of the bearing sides and load applied centrally. At the time of testing, load was applied without shock and was applied up to the time that specimen reached failure .The allowed failure load was noted. The average of compressive strength was calculated considering average of three specimens.

Splitting Tensile Strength

The concrete specimen was tested at the age of 28 days as per IS 5816-1999.The test was carried out in a concrete cylinder specimen with a diameter of 150 mm and a length of 300 mm horizontally placed between the loading surface of the CTM. The load was applied to the nominal range at a rate of 1.2 N/mm^2 per minute until failure due to the vertical diameter split. The average of splitting strength was calculated considering average of three specimens.

Flexural Strength

The concrete specimen were tested at the age of 28 days as per IS 516-1959. The test machine bed wasequipped with two steel rollers of a diameter of 40 mm, on which the specimen was carried, and the centre distance between the rollers was 400 mm. The load was applied along 2 parallel rollers fixed atthird point of the supporting span, spaced at 133mm centre to centre and at the rate of 4 kN/min until specimen was broken and maximum load applied to the specimen was recorded. The average flexuralstrength of specimen was determined using an average value of three specimens.

Modulus of Elasticity

The modulus of elasticity was determined in accordance with IS 516-1959.Elasticity modules are mainly affected by the strength of the concrete, the properties of the cement and aggregates, the rate of loading, the type and size of the specimen (Pauw 1960). As specified in IS 516-1959, cylinder specimens with a height of 300 mm and a diameter of 150 mm were cast using control concrete and TUFS concrete to determine the modulus of elasticity of the concrete. It was determined by applying uniaxial compression to the cylindrical specimen and by measuring the deformation by means of dial gauges fixed between certain lengths of the gauge. The stress-stress curve was drawn on the basis of the calculated stress and the corresponding strains.

Result and Discussion

Table 2. Slump Test

S. no	Mix designation	Slump value (mm)
1	GF 40/60	32
2	G 40/60	30
3	F 40/60	31
4	GF 70/30	30
5	G 70/30	29
6	F 70/30	30
7	C 40/60	33
8	C 70/30	32

Compressive strength

Cubical specimen were prepared and applied for calculating the compressive strength carried out on cubes of size 100 x100 x100mm. The specimens GF 40/60, G 40/60, F 40/60, GF 70/30,G 70/30, F 70/30 which were got additional material such as 1.5% of Nano silica and 0.1% of Polypropylene fiber and 10% of glass powder and 30% used foundry sand as the replacement for cement and fine aggregate respectively for the water cement ratios of 0.28 & 0.3. And the specimen C 40/60& C 70/30 are the conventional concrete for 0.28 & 0.3 water cement ratio respectively were gone through the compressive strength. Comparing all the proportions the aggregate percentage of 70% of 12.5mm & 30% of Chips with the used foundry sand were gothigher compressive value which were shown in Table 3.

Table 3, Compressive strength

S.No	Mix designation	Compressive strength (N/mm^2)	
		28 days	56 days
1	GF 40/60	49.62	58.62
2	G 40/60	47.90	61.49
3	F 40/60	59.6	62.03
4	GF 70/30	60.53	62.80
5	G 70/30	61.24	64.09
6	F 70/30	72.92	76.05
7	C 40/60	59.2	61.77
8	C 70/30	61.1	64.52

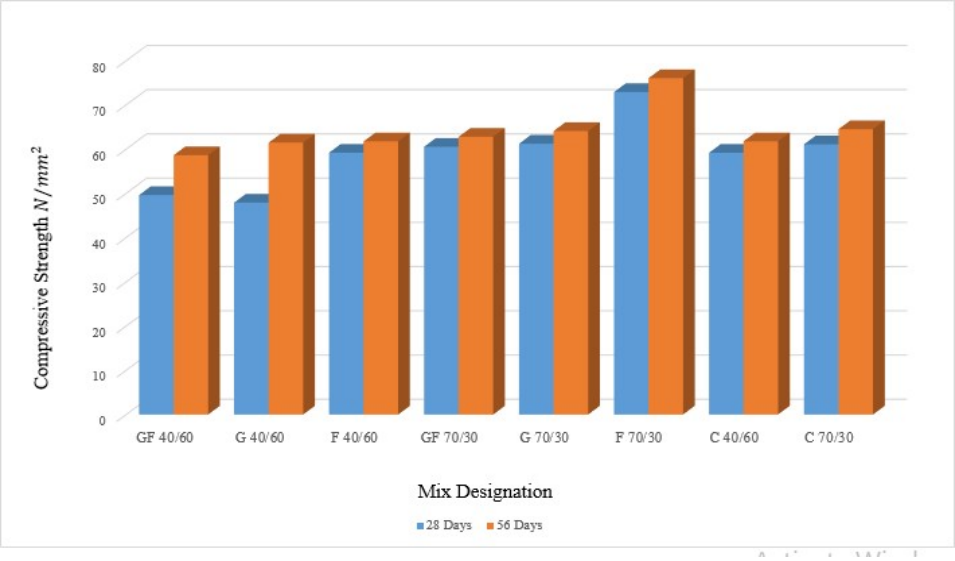

Fig 1. Compressive strength

Splitting Tensile Strength

The strength of concrete mixtures (GF 40/60, G 40/60, F 40/60, GF 70/30, G70/30, F 70/30, C 40/60 & C 70/30) was found out at 28 days only .The outcome areshown in Table 4.

Table 4. Split Tensile strength

S.No	Mix designation	Splitting tensile strength (N/mm^2)28 days
1	GF 40/60	3.6
2	G 40/60	4.1
3	F 40/60	4.45
4	GF 70/30	4.62
5	G 70/30	4.71
6	F 70/30	5.03
7	C 40/60	3.51
8	C 70/30	4.26

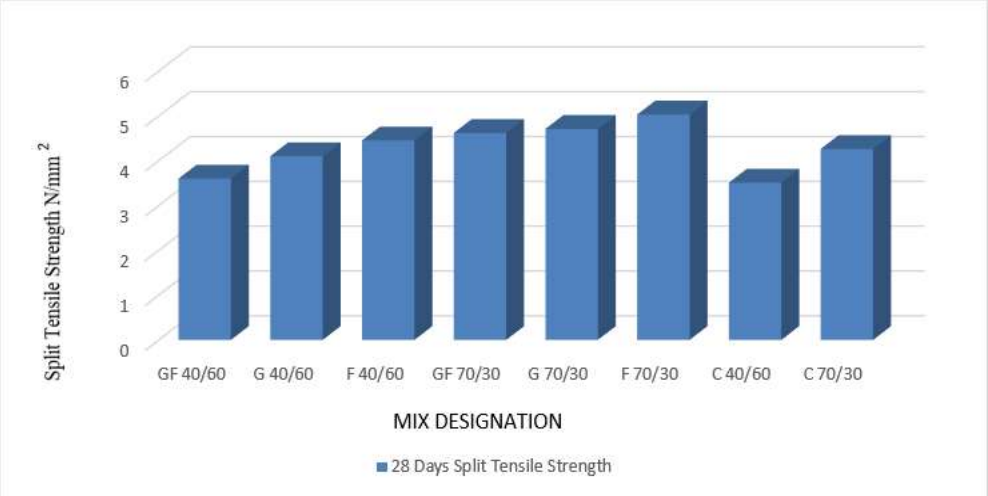

Fig 2. Split Tensile Strength

Flexural Strength Test

The flexural strength of concrete mixtures (GF 40/60, G 40/60, F 40/60, GF70/30, G 70/30, F 70/30, C 40/60 & C 70/30) was found out at the age of 28 days as per BIS 5816-1999. Flexural strength test result are shown in Table 5.

Table 5. Flexural strength

S.No	Mix designation	Flexural strength (N/mm^2)28 days
1	GF 40/60	6.21
2	G 40/60	6.75
3	F 40/60	7.02
4	GF 70/30	7.15
5	G 70/30	7.19
6	F 70/30	8.32
7	C 40/60	6.07
8	C 70/30	6.95

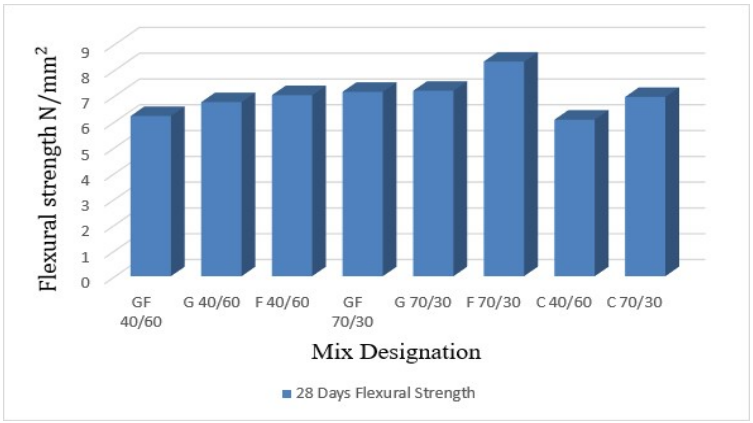

Fig 3, Flexural Strength

Modulus of Elasticity

The modulus of elasticity is mainly influenced by the type of cement, the aggregate, the water cement ratio of the mixture and the curing age. The values tested are taken from the average comparative values of the three specimens. The difference between the experimental result and the predicted values as per IS 456:2000 was evaluated and the results have been shown in the Table 6.

Table 6. Modulus of Elasticity

S.No	Mix designation	Experimental results (N/mm^2)	Predicted as per IS 456-2000 (N/mm^2)
1	GF 40/60	36102.8	35220.7
2	G 40/60	35533.9	34604.9
3	F 40/60	39511.4	38600.5
4	GF 70/30	40587.1	38900
5	G 70/30	41978.3	39128.6
6	F 70/30	44796.5	42696.6
7	C 40/60	37908.14	38470
8	C 70/30	38012.7	39083.2

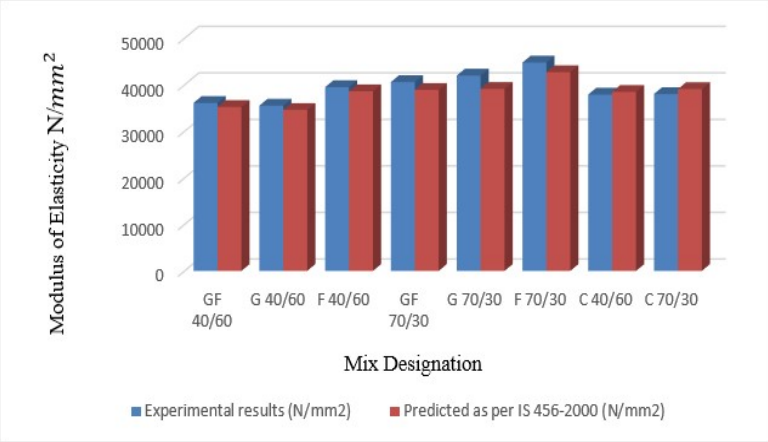

Fig 4. Modulus of Elasticity

Conclusions

The project work is mainly aimed at doing a lot of trial-and-error method which give some ideas about High Performance concrete. Tests were conducted to the properties on all materials. Mix design was formulated based on properties and requirements.

- The compressive strength got increased in the proportion of 70% of 12.5mm and 30% of chips (<6mm & >4.75mm) with the 30% replacement of Used Foundry Sand for fine aggregate with the additional material of 1.5% of nano silica and 0.1% of polypropylene fiber.
- Comparing all the proportions 40% of 12.5mm and 60% of chips (<6mm &>4.75mm) withthe 30% and 10% replacement of Used Foundry Sand andGlass Powder for fine aggregaterespectively with the additional material of 1.5% of nano silica and 0.1% of polypropylenefiber had got reduced in the mechanical properties.
- In most case, 10% replacement of Glass powder for fine aggregate with the addition of

1.5% of nano silica and 0.1% of polypropylene fiber were got slight reduction compared to other proportions.

- The modulus of elasticity of concrete with (GF 70/30, G 70/30 and F 70/30) mix is slightly higher than the control concrete.
- It is clear that the replacement of the glass powder reduces the strength of the hardened concrete, and the replacement of the fine-grained foundry sand gives better strength.

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Fly-Ash and GGBS Based Geo-Polymer Concrete with Granite Powder as Partial Replacement of M-Sand for Sustainability

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Keywords: Geo-polymer concrete, Fly ash, GGBS, Granite powder, Replacement level.

Abstract. The Strength characteristics of Fly-ash (FA) and Ground Granulated Blast Furnace Slag (GGBS) based Geo Polymer Concrete (GPC) incorporated with granite powder as partial replacement to fine aggregate M-Sand, has been discussed in this research study and presented with outcomes with valid conclusions for further studies. The production of ordinary Portland Cement (OPC) causes pollution to the environment which is due to the emission of Greenhouse gas, the Carbon Dioxide. Geo-polymer is an alternative material which is introduced in this study to replace and totally eliminate OPC in conventional concretes. An alkaline solution reacts with fly ash and GGBS to make an alumina silicate gel, which binds the aggregate and results in a harder concrete than standard concrete. Geopolymerization process occurs when an alkaline solution is added to geopolymer concrete dry mixes, causing fly ash and GGBS chemically activated to set and thus the Geopolymer Concretes get hardened. The mix design adopted with 10,12,14,16 different molarity values for alkaline solution was used in this study. Laboratory tests such as material property test and tests on fresh concrete to measure the workability of geo-polymer concrete mixes and strength tests on cubes and cylinders specimens were conducted to assess Compressive Strength and Split Tensile Strength and gain of strength on 7,14 and 28 days' age of Geopolymer Concrete mixes adopted in this study besides Stress versus Strain behavior under axial compression of various GPC mixes was also studied. The studies are also conducted on various mixes to ascertain the strength properties of geo polymer concrete which is cast with suitable mineral admixtures such as Flyash and GGBS used for improved workability and flowability with addition of super plasticizers. The study found that using granite powder as a partial replacement for fine aggregate M Sand increased the compressive strength of fly-ash GGBS based geo-polymer concrete. Among all GPC mixes the one cast with for 20% replacement level to M-sand and 16% Molarity alkaline solution had performed exceedingly well when compared to other replacement levels such as 0, 10 and 15 percentages.

Introduction

Geopolymer Concrete (GPC) is a high-tech concrete that uses industrial waste materials like Flyash and pozzolanic admixtures. Geopolymer concrete gains strength as a result of the polymerization process. Geopolymeric gel is formed when sodium silicate minerals are present in an alkaline media. According to literature, fly ash, Ground Granulated Blast-Furnace Slag (GGBS), Granite Powder, and other minerals should be utilised as raw materials for GPC manufacturing. Fly ash is the most frequent industrial waste byproduct material utilised in GPC casting and has outstanding technical features. In addition, GPC can help geopolymer concrete become less brittle.

As a result, the aseismic performance of geopolymer concrete (GPC) is improved. In this study, geopolymer concrete has been developed from Fly ash and GGBS,which is a new combination of blended GPC. GGBS is the byproduct obtained from steel industries and rock crushing plant respectively. Use of industrial by-products reduces the cost of construction as well as its disposal.

Research Significance

Granite powder is a waste product of the granite quarrying and polishing industries, produced by grinding granite stones and polishing granite slabs. M-sand, a fine aggregate used in concrete, can be partially replaced with granite powder. Granite powder has been demonstrated to dramatically boost the compressive strength and splitting tensile strength of concrete when added in the proper amounts, while also assuring high workability when compared to standard concrete. The mechanical qualities of GPC mixes improved when granite powder was employed as a partial substitute for fine aggregate M-sand at defined percentages, according to the experimental research done in this study. Furthermore, using these powders as a partial substitute for m-sand in the building industry would limit m-sand use, retaining more of these natural resources. Recycling these by-products and using them in concrete can minimize pollution-related health risks and their environmental effects**.**

Experimental Investigation

The testing programme included casting of test specimens such as GPC cubes and cylinders with replacement for M Sand and without replacement for fine aggregate Sand as substitute in GeoPolymer Concrete. Fly-ash and GGBS were used as alternate binder, M-sand as fine aggregate, Granite powder as a partial substitute for M Sand, coarse aggregate, super plasticizer, and chemical activator alkaline solution were all included in the concrete mix. The compressive strength of the cubes was determined, while the split tensile strength of the cylinders was determined, as well as the stress versus strain behaviour of Geo-Polymer Concrete (GPC) mixtures under axial compression.

Materials and mixing proportion of GPC

Materials

Fly-ash, coarse aggregates, fine aggregates (M-Sand), granite powder, GGBS, alkaline solution, and super plasticizers were employed in this investigation. To completely remove cement, fly ash and GGBS were employed as an alternative binder.The coarse aggregates were crushed into angular coarse aggregates with a size that ranged from 20mm to 10mm on the IS sieve. The fine and coarse aggregates have specific gravity of 2.72 and 2.68, respectively. The M-sand has a diameter of 4.75mm, a specific gravity of 2.74, and a fineness modulus of 2.3.

Granite powder has a specific gravity of 2.53 and a fineness modulus of 2.4 with a particle size of fewer than 90 micron. The typical chemical analysis of the granite powder is listed in Table 1.

Ingredient Materials for GPC Mixes

1) Fly ash
2) Coarse aggregate with size passing through 20mm and retained 10mm IS sieve
3) Fine aggregate(M-sand)
4) GGBS
5) Alkaline liquids as chemical activator
6) Granite powder (Replacement to M-Sand as fine aggregate)
7) Super plasticizer

Granite powder

Granite powder is used to partially replace fine aggregate in GPC mixes. The testing regime required finding test casting of GPC Test Specimens such as concrete cubes and cylinders with and without granite powder as a fine aggregate as substitute to M Sand fine aggregate in Geopolymer Concrete. Granite powder used in this study is shown in fig 1 and its chemical

composition is listed in Table 1. These products shall be used as a filler material (substituting sand) to reduce the void content in the concrete.

Fig 1, Granite Powder

Table 1, The Chemical composition of Granite powder

Chemical composition	Water (%)
SiO_2	64.5
TiO_2	0.67
Al_2O_3	12.01
Fe_2O_3	5.77
MgO	0.57
MnO	0.39
CaO	4.80
Na_2O	5.92
K_2O	5.26
P_2O_5	0.07

Fly-ash

In this research Fly ash which was collected form the source Mettur Thermal Power Plant, Tamilnadu, India was used. It has low calorific value and high ash content obtained as by-product from Coal burnt as fuel in the Thermal Power Plant. This industry produces huge quantity of fly-ash. When utilised in concrete, fly-ash has environmental advantages, making it a green building material. It reduces the amount of cement needed for the same strength, saving raw materials such as limestone, coal, and fuels used in cement production. Cement manufacturing uses a lot of energy and generates a lot of CO_2. During the manufacture of cement in the cement industry, one tonne of CO_2 was emitted into the environment at the same rate.. If the demand for cement decreases, then the amount of carbon dioxide emission will reduces thus resulting in a reduction in greenhouse gas emissions. This massive amount is being collected and disposed of in ash ponds. Wide swaths of fertile land are acquired by the ash ponds. The use of fly-ash decreases the amount of space required for a pond, saving valuable agricultural land. The Chemical composition of the fly- ash (Fig. 2) used in this study is listed in Table 2.

Figure 2. Flyash

Table 2. The Chemical composition of the Fly-ash

Chemical Constituents	% present
$SiO_2 + Al_2O_3 + Fe_2O_3$	90.5% Max
SiO_2	58% Max
CaO	3.6% Min
SO_3	1.8% Min
Na_2O	2% Max
LOI	2% Min
MgO	1.91% Min

M-sand

Manufactured sand (M – Sand) is a fine aggregate used for replacement to river sand in the production of sustainable concrete in construction industries. Crushing process in Crusher units is widely used to manufacture M Sand from hard granite stone. It's a building material with a cubical form and ground to have its sides to form a cube. It's washed and graded. It is conforming to zone II of IS 383-1970.Sand is used in the work which has the particle size less than 4.75mm.

Figure 3. Manufactured Sand (M-Sand)

Alkaline Liquid Solution- A chemical activator

The sodium hydroxide solution and sodium silicate solution are mixed at room temperature to make an alkaline liquid solution. When the solutions are combined, the resultant mixtures begin to react. Polymerization occurs, releasing a significant amount of heat; thus, it is recommended that to leave it for around 24 hours, allowing the chemical activator, alkaline solution, to prepare as a binder agent. The activator's job is to polymerize the GPC and harden it. The higher the NaOH content the higher will be the resultant compressive strength.

Preparation of Test Specimens

The granite powder was dried after being collected from a granite crusher and polishing quarry. In a dry condition, the fly ash and granite powder were fully blended. The m-sand and coarse aggregate were then added to the mixture. For few minutes, these ingredients were mixed to attain uniform dry mix condition. In a typical concrete mixer, the super plasticizer was added to the dry mix after all of the products had been thoroughly mixed. The resulting concrete mix was used to cast 150×150×150mm size cubes and 150mm×300mm size cylinders. The concrete was poured into the moulds and was compacted for 15 blows by a compaction rod. After that the moulds were left dry for 24hour. The specimens were then removed from the moulds and cured at normal room temperature for curing for the period of 7,14 and 28days respectively. GPC mixes were prepared with different percentages of GP dust as partial replacement to fine aggregate, M-Sand. The percentages of granite powder dust used were 10%, 15% and 20% respectively to replace for M-

Sand besides the GPC mix that was also cast without any replacement for M-Sand was used as reference mix for comparison purpose. A total of three mixes were cast with designations such as GPCGP10, GPCGP15 and GPCGP20 containing 10%, 15% and 20% of GP by weight of M-Sand respectively and tested in the concrete laboratory to assess the strength characteristics. Super Plasticizing admixtures are also added to a concrete mixture to make the mix workable without additional water especially for use in ready mixed concrete. The quantity of constituent materials for casting one Cube Test Specimen is listed in the Table 3.

Table 3. Material quantity for one cube

MATERIAS	10%	15%	20%
M Sand	1.686kg (90%)	1.592kg (85%)	1.498kg (80%)
Granite powder	188gms	280gms	375gms
Coarse Aggregate	1.745kg (20mm) 2.618kg (10mm)	1.745kg (20mm) 2.618kg (10mm)	1.745kg (20mm) 2.618kg (10mm)
Na_2SiO_3	532ml (1cube)	532ml (1cube)	532ml (1cube)
Fly as(90%)	1.198kg	1.198kg	1.198kg
GGBS(10%)	133gms	133gms	133gms
Extra water	199ml	199ml	199ml
Super Plasticizer	13.3ml	13.3ml	13.3ml

Mixing of Geo-Polymer concrete

In a dry condition, coarse aggregates, fine aggregates, and fly ash, as well as GGBS, were combined. Then, according to the water-to-geopolymer binder ratio, the produced sodium hydroxide and sodium silicate solution were added, along with water, and vigorously mixed for 3–4 minutes to form a homogenous mix..

Figure 4. Dry Mix of GPC with Granite Powder

Curing of Geo-polymer concrete

The experiments were carried out on fly ash-based geopolymer concrete with a variety of curing methods. For a resting time of 7, 14 and 28 days, fly ash was activated by alkaline solution at a set ratio of solution to binder. The compressive strength test was carried out and the test results showed a good improvement in Concrete compressive strength of GPC mixes with the age of curing for ambient cured specimens when compared to heat curing method from reference literature.

Testing of Geo-polymer concrete cubes and cylinders

Concrete cubes and concrete cylinders were subjected to compression and split tensile tests, respectively. The compressive strength of cubes was evaluated using an ASTM C39-compliant Compression Testing Machine (CTM) with a capacity of 2000kN, while the splitting tensile strength tests were performed using ASTM C496. For GPC mixtures, tests were conducted at 7 days, 14 days, and 28 days after curing. Totally nine cubes were cast and cured and then three cubes for each were tested at the age of 7day, 14 day and 28 days respectively. In a 2000kN Compressing Testing Machine, splitting tensile test specimens were tested. So nine cylinders were cast, cured, and three cylinders for

each age group were evaluated at 7, 14, and 28 days. The test results of concrete cubes and cylinders created using GP as a partial substitute for M-Sand were compared to the test results of reference concrete (control) specimens prepared without any M-Sand replacement.

Test results of granite powder (GP) concrete mixes and Discussions:

Compressive strength

The cubes' compressive strength was tested for control specimens and specimens bearing various amounts of granite powder. The compressive strength for the control cube is 35.8N/mm2. The granite powdered cubes had a higher compressive strength. The compressive strength of mixes GPCGP10 (10% GP), GPCGP15 (15% GP) GPCGP 20 (20%) respectively. A 15% partial replacement of m-sand with granite powder resulted in a significant improvement in compressive strength. The bar chart shows the compressive strengths of cubes formed with various percentages of granite powder replacing sand and for various molarity values such as 10,12,14, and 16 for alkaline solutions used for GPC mix activation..

The results presented in the Table 4 indicated that the replacement of M Sand by Granite powder in varied percentages viz. 10%, 15% and 20% plays a crucial effect in increasing the compressive strength of all GPC blends. And also noted that the molarity value of alkaline solution had contributed to the strength development of GPC mixes. In all mixes, a mix GPCGP 16 M with a 15 % replacement level for M-Sand by GP and a molarity value of 16 showed a good growth in Compressive strength above other mixes. It is observed that all the GPC mixes attained significant early strength at the age of 7 days and about 75% to 83.3% of 28 days strength was attained. The gain of high early strength due to presence of high content of $SiO_2$and Al_2O_3.

Fig 5,. Testing of GPC Cube Test in CTM

Table 4. Compressive Strengths of cubes with different proportion activated with different molarity alkaline solution

Mix	Granite Powder proportion	7^{th} Day (MPa)	14^{th} Day (MPa)	28^{th} Day (MPa)
GPCGP 10M	0%	31.1	37.2	40.4
	10%	32.3	37.6	40.8
	15%	32.8	38.2	41.4
	20%	31.4	37.6	40.6
GPCGP 12M	0%	34.2	39.6	41.8
	10%	34.9	40.1	42.5

	15%	35.3	40.8	42.9
	20%	34.6	39.8	41.0
GPCGP 14M	0%	35.1	39.9	42.9
	10%	35.6	40.6	43.6
	15%	36.1	40.8	44.0
	20%	35.9	40.5	43.8
GPCGP 16M	0%	36.4	41.3	43.6
	10%	36.7	41.6	43.9
	15%	37.1	41.9	44.5
	20%	36.8	41.5	43.6

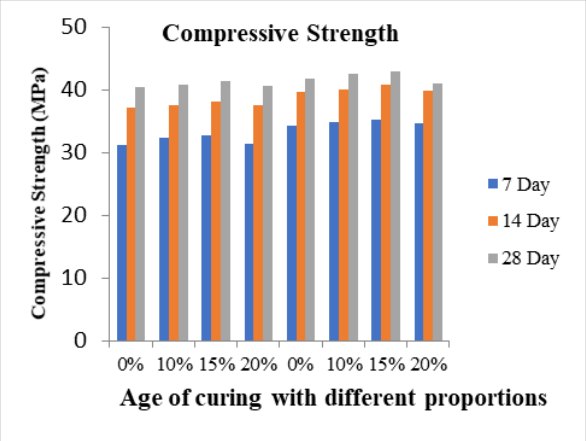

Figure 6. Compressive strengths of cube with different proportions and 10 & 12molarity (GPCGP10M,GPCGP12M)

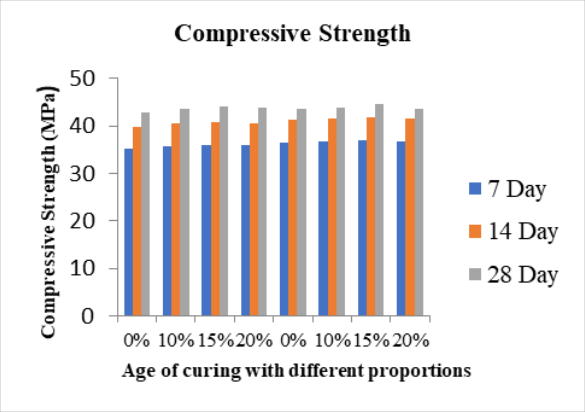

Figure 7. Compressive strengths of cube with different proportions and 14& 16molarity (GPCGP14M, GPCGP16M).

Split tensile strength

The CTM was used to test the Spilt Tensile Strength of Concrete. The Split Tensile Strength of Cylinder Test Specimens was determined in CTM. Because direct tensile tests are complicated and variable, the indirect test is a widely used method for measuring concrete tensile strength. The tensile strength of split cylinders was estimated using cylinders of 150 mm and 300 mm in diameter (6 in 12 in). Three cylinders were examined at different ages: 7 days, 14 days, and 28 days. The split tensile strength of the cylinders was determined for the control cylinders as well as the cylinders with various percentages of granite powder with different molarity concentration of alkaline solution used for chemical activation. After 28 days, the split tensile strength of the control cylinders was tested. The flexural strength of the cylinders with granite powder was greater than that of the control mixtures. The split tensile power of mix designs MG10 (10 percent GP), MG15 (15 percent GP), and MG20 is shown in Table No.8 (20 percent GP). According to the tests, the ideal proportion of granite powder to generate the greatest gain in split tensile strength was 15%, compared to an optimum value of 10% for compression. The split tensile strength was lower than the control cylinders when 20% of the M-Sand was replaced with granite powder. This discovery differed from others made during compression. The use of 20 percent granite powder resulted in a slight increase in compression strength. The maximum value of split tensile strength was 3.60 MPa for the Mix GPCGP14M

with a replacement quantity of 15% GP for M-Sand. Split tensile strength increased significantly when the proportion of Granite Powder and the concentration of Molarity were both increased.

Fig 8,. Testing of cylinder specimen using spilt tensile in compression

Table 5, Split tensile strengths of cylinder with different proportion and different molarity

Mix	Granite powder proportion	7th Day (MPa)	14th Day (MPa)	28th Day (MPa)
GPCGP10M	0%	2.70	2.80	2.95
	10%	2.74	2.86	3.14
	15%	2.90	3.05	3.20
	20%	2.80	2.90	3.00
GPCGP12M	0%	2.9	3 .0	3.20
	10%	3.05	3.10	3.35
	15%	3.16	3.22	3.40
	20%	3.0	3.05	3.25
GPCGP14M	0%	3.0	3.2	3.4
	10%	3.14	3.32	3.52
	15%	3.20	3.40	3.60
	20%	3.10	3.26	3.35
GPCGP16M	0%	3.10	3.3	3.50
	10%	3.25	3.36	3.53
	15%	3.30	3.40	3.55
	20%	3.20	3.32	3.46

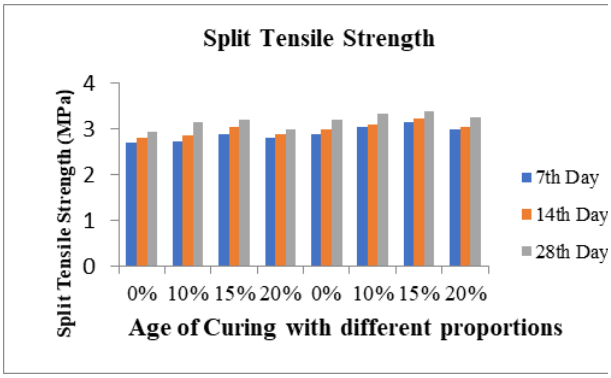

Fig 9, Split tensile strength of cylinders with

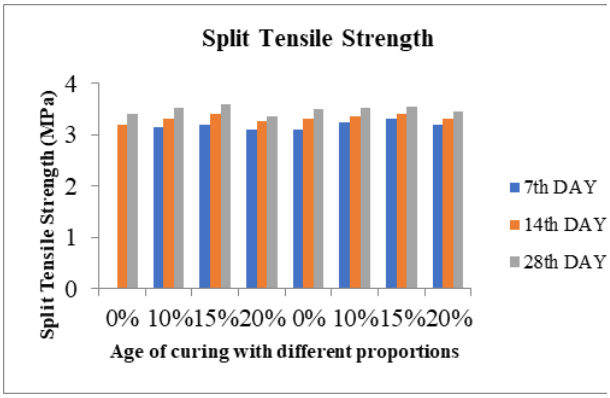

Fig 10, Split tensile strength of cylinders

different proportions and 10&12molarity (GPCGP10M, GPCGP12M)

with different proportions and 14 & 16molarity (GPCGP14M ,GPCGP16M).

Stress – Strain Behaviour

Work hardening is the process of reinforcing a metal by plastic deformation. Work hardening is also known as strain hardening or cold hardening. As the material is work hardened, it fills up quickly with new dislocations, and additional dislocations are prevented from forming. According to Neville (2000), loading in compression for 30 to 240 minutes causes a 15% drop in the observed compressive strength of tested cylinders.. The loading rate also influences the measured compressive strength of concrete (Zia et al. 1997).

Fig 11, Compression Test of Cylinder Specimens

Table 6, Stress Strain curve of cylinder with different proportion and different molarity

Mix	Diff proportion	Stress (Mpa)	Dial Gauge Reading	Strain (28th Day)
GPCGP10M	0%	39.10	79	0.00079
	10%	39.55	86	0.00086
	15%	40.25	91	0.00091
	20%	39.42	72	0.00072
GPCGP12M	0%	39.90	91	0.00091
	10%	40.04	97	0.00097
	15%	40.35	108	0.00108
	20%	39.77	87	0.00087
GPCGP14M	0%	39.95	95	0.00095
	10%	40.60	103	0.00103
	15%	41.22	108	0.00108
	20%	39.92	91	0.00091
GPCGP16M	0%	40.10	98	0.00098
	10%	40.65	106	0.00106
	15%	41.30	129	0.00129
	20%	40.18	97	0.00097

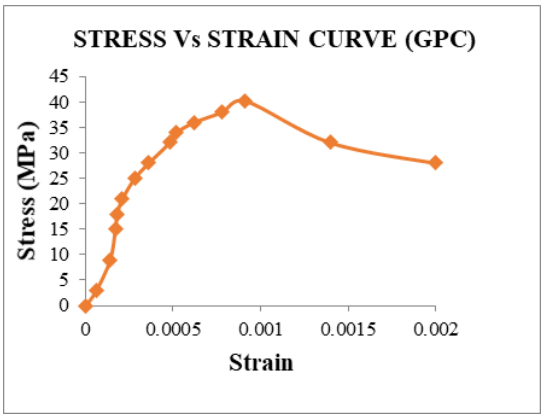

Fig 12, Stress strain curve of cylinders with 15%replacement and 10 molarity (GPCGP10M).

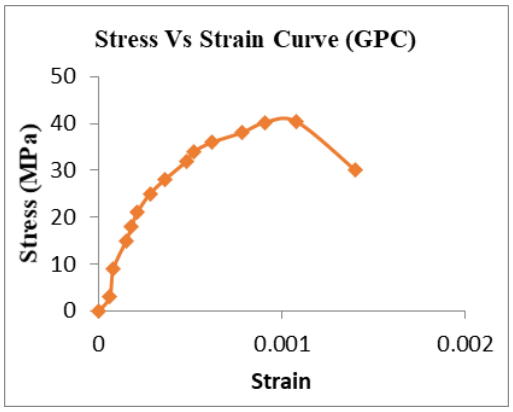

Fig 13, Stress strain curve of cylinders with 15% replacement and 12 molarity (GPCGP12M).

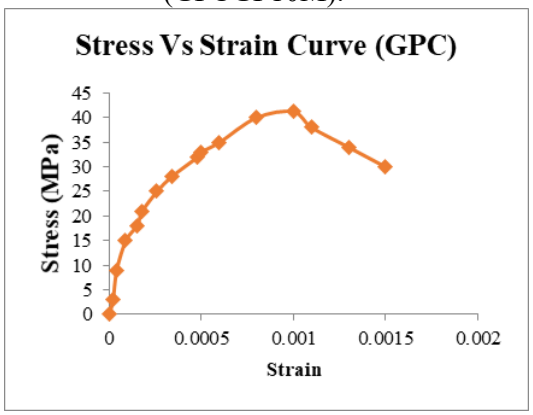

Fig 14, Stress strain curve of cylinders with 15% replacement and 14 molarity (GPCGP14M).

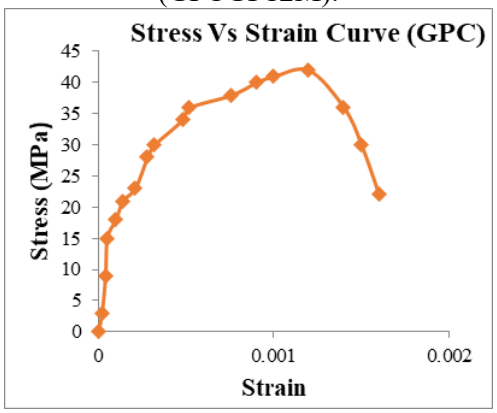

Fig 15, Stress strain curve of cylinders with 15% replacement and 16 molarity (GPCGP16M)

Summary and Conclusions

This paper investigated the Strength characteristics of fly ash- slag based Geo-Polymer Concrete mixes (GPC) with total elimination of OPC and the binder Fly ash and GGBS were chemically activated by alkaline solution. The fine aggregate M Sand was replaced by Granite powder with varied percentages viz.10%, 15% and 20%. The effects of granite powder on engineering properties of GPC including workability, setting time, compressive strength, split tensile strength and effect of molarity and percentage replacement of level of either Granite powder in M-Sand which was used as fine aggregate had very much influenced for better behavior of GPC both fresh and hardened stages. The chemical activator such as alkaline solution with different molarity concentration such as 10M, 12M, 14M and 16M were adopted in this study and the molarity vale also influenced on strength gain of GPC mixes.

Based on the experimental results, the following conclusions are drawn:

1. The GPC mix cast with granite powder (GD) for partial replacement of fine aggregate M-Sand in the flyash GGBS based Geopolymer concrete had fresh properties of concrete with good workability and fluidity when compared to conventional concrete with Cement is used as a binder.
2. An increased compressive strength and spilt tensile strength for flyash, GGBS based Geopolymer concrete with Granite Powder for partial replacement for M sand had good gain of

compressive strength when compared to conventional concrete.

3. A substantial increase of Compressive and split tensile strength is obtained with15% replacement of M Sand by GP for fine aggregate. Further increase in the proportion of GP more than 15% caused a decreases in the strength.
4. For both cases an increased compressive strength and split tensile strength was observed for15% of replacement level.
5. All test specimens with distinct (granite powder) used as fine aggregate shown with multiple cracking formation in the tests conducted to study the stress versus strain behavior.
6. From stress strain characteristic behavior is found the maximum strain value for GPC mixes are lower than the conventional Cement Concrete
7. The maximum value of strain was obtained in the GPC mix specimen with 15% replacement level for M-Sand by GP.
8. The compressive strength of concrete increased with the addition of granite powder (GD)as partial replacement of M- Sand due to increased content of SIO2 in GP. Using granite powder in concrete gave the best result compared to others.
9. There was a good development of early strength at the age of 7days and all the GPC mixes tested for compressive strength attained 75% to 83% of 28 days strength in 7 days. The gain of early strength was due to high percentage of silica and alumina in Granite Powder and in Fly ash .
10. From the limited studies conducted and the results, it is recommended that Fly ash, GGBS with GP as partial replacement to M Sand shall be used for construction application where the early gain of strength is recommended. Nevertheless, more studies have to be carried out for further conclusions in applications related to mixing at site, transportation and placement and compaction aspects of GPC mixes in the construction industries.

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An Experimental Investigation on Strength Properties and Flexural Behaviour of Ternary Blended Concrete

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Keywords: Silica flour, waste glass powder, TBC mixes, Compressive strength, Tensile strength, Flexural Strength and Ductility Index.

Abstract. Depletion of natural resource materials has resulted from an increase in the consumption of component materials in the manufacturing of concrete. On every year 12.6 billion tons of natural resources were consumed in the concrete industry across the world. Recycling is the most effective method for dealing with the effective management of waste for preservation of the environment. From available literature studies it is found that the silica flour when mixed with concrete had improved the strength characteristics and durability aspects of concrete. Recently researchers are being conducted to utilize industrial waste by product as an admixture in the concrete production. In this study silica flour which is a waste from silica industry and waste glass powder from glass industry are used for partial replacement of cement in the concrete mixes to get the higher strength of concrete. The concrete mixes were cast with replacement level such as 20%, 30% for Ordinary Portland Cement (OPC) in this study. As many as 8 mixes were cast to get the target compressive strength of M40 grade of concrete in this study and specimens such as cubes and beams were cast, cured and tested to find the characteristic compressive strength and flexural behavior of beams. The compressive strength at the age of 7,14 and 28 days of curing were determined in the compressive testing machine of 2000 kN capacity and the results were compared and also discussions are presented on the trend of strength gain for such Ternary Blend Concrete (TBC) mixes. The Reinforced Concrete (RC) Beams were tested in the loading frame of 500 kN capacity and the results obtained from the testing of beam, the load versus deflection pattern were drawn and compared for various beams cast with different TBC mixes. The ductility index of the beam was calculated from load versus deflection curve. The results obtained from the investigation compared with the test specimens cast with normal concrete tested in the laboratory. From the result it is found that the TBC shall be an alternative to the conventional cement concrete and found it will be used and suitable for structural applications.

Introduction

Concrete is the most consumed global man-made material after water due to its common usage in most of structural applications. The properties of the long term concrete can be modifying by changing

some of the fresh concrete properties, cement such as the amount of cement, the water/ ratio, dosage of admixtures in particular limits based on material properties. The concrete mix design creates complex concerns, and the accurate ways of performing its design can be finalized with expert

information in the field with their experience. Over the last few years, efforts to improve the performance of concrete have suggested that cement substitute products, as well as mineral and chemical admixtures, will improve the strength and durability of concrete. [4]. The concrete mixes thus produced will minimize carbon footprint and prevent the atmosphere from the pollution[8]. The environmental results indicate that replacing pozzolanic materials with portland cement is not always beneficial to the climate[7]. To make high-strength and durability concrete, active mineral additives such as fly ash, blast furnace slag, rice husk ash and SiO2 nano particles have been added to the cement, aggregates and water in conventional concrete[9]. In this study attempts have been made to find out the scope for attainment of high strength concrete when industrial waste glass powder and silica flour are added in the concrete mixes to aim for the better mechanical properties of such concrete mixes.

Ternary Blended Concrete

The concrete which contains more than three cementitious materials is known as Ternary Blended Concrete (TBC). The ternary mixture contains portland cement and two binder materials has been widely used in high-rise buildings due to its special fresh and hardened properties[13]. The materials included may be ground limestone or supplementary cementitious materials such as slag cement, fly ash, silica fume, or metakaolin[10-12].

The addition of supplementary cementing materials, which are industrial by-products, such as partial replacement of OPC in concrete which is widely practiced to reduce the carbon footprints and the global warming effect of the environment[6]. In addition, material selection should create reduction of calcium hydroxide content, increases the concrete's durability[14].

Objectives

The main goal of this research is to test the fresh and hardened properties of TBC with a variety of filler materials, as well as to understand the behaviour of silica fume and waste glass powder. The major objectives of the present investigation are

a. To determine the strength characteristics of the ternary blended concrete system.
b. To study the influence of the waste glass powder and silica flour in the ternary blended concrete.
c. To compare the test results of the strength and flexural behavior of test specimens casted with optimum ternary blended concrete mixes to that of nominal concrete mixes.

Literature Review

The addition of limestone powder improves the early age strength of concrete while fly ash improves the later age of concrete due to its pozzolanic properties in nature. The most selected mixture of constituents like cement, fly ash, and limestone is essential for material design of ternary blended concrete. This research presents a simulation program for evaluating the hydration process and strength characterization of TBC. Finally, the optimal combinations of cement, flyash and limestone with different age were determined based on the parameter studies[1]. The natural coarse aggregate which was partially replaced by 50 percentage recycled coarse aggregate. The third series is also similar to that of these series except the OPC which is partially replaced by 50 percentage of slag material [2].

The sustainability in manufacturing concrete industry is very important nowadays, it also shows its adverse effect in the environment. While selecting the raw materials for construction the eco-friendly materials should be taken. Alcofine which is the one of the by-product from steel industry and it possess cementitious properties and also it can be used as the replacement of cement, which are creating a set of pollution in the environment. The optimum

percentage of Ground Granulated Blast furnace Slag (GGBS) kept as constant, further placement of cement
with Alcofine was done with variations of replacement in the range of 8%, 10%, 12% and 14% [5]. The addition of limestone filler to portland cement causes an increase in the effect of hydration at early ages which induces a high early strength, but it can lower the later strength due to its dilution effect of the ternary blended concrete. On the other hand, the blast furnace slag in the hydration process after seven days improves the medium and later age strength in the ternary blends[4].

Studies on Material Properties

Materials Used

The following materials were used in this work

- Cement
- Silica Flour
- Waste Glass Powder
- Fine Aggregate
- Coarse Aggregate
- Water
- Superplasticizer

Mix Composition

The mix proportion of cement, silica flour and waste glass powder for the ternary blended concrete was given in Table 1.

Table 1. Mix Proportion

Mix Name	Cement %	Silica Flour%	Waste Glass Powder%
TBC (Normal Mix)	100	-	-
TBC 1	60	5	35
TBC 2	60	10	30
TBC 3	60	15	25
TBC 4	60	20	20
TBC 5	60	25	15
TBC 6	60	30	10
TBC 7	60	35	5

Experimental Program

Compression Strength

The compressive strength of concrete was determined by testing TBC specimens of size 150x150x150 mm cubes. The samples were prepared as per IS 516 -1959code. The compression test is carried out in concrete and highway engineering laboratory on a compression testing machine of capacity of 2000 kN. After the specimens have been casted for the requisite amount of time, they are removed from the mould and poured into water to cure. After that, the specimens

are removed from the curing tank after the necessary curing time has passed. All test specimens were taken out for testing after the curing period was completed. It was ensured that concrete specimen must be well dried before placing it on the compression testing machine. All the specimens then be loaded into the compression testing machine of capacity 2000kN. The test is then repeated to find out the average value to determine the mean compressive strength of the concrete test specimen for various TBC mixes. The compressive strength for different ternary blended concrete are given in the below Table 2, and Figure 1shows the tested image of cube testing at the age of 7,14 and 28 days.

Fig 1, Compression Test on Cube

Split Tensile Strength

The split tensile strength of TBC is measured using test specimen with a cylinder diameter of 150 mm and a length of 300 mm. The specimen is horizontally mounted between the loading surface of the compression testing unit, and the load is steadily applied until the specimen fails into two halves. The split tensile testing is carried out in concrete and highway engineering laboratory in a compression testing machine with a capacity of 2000 kN. The test is replicated three times on three separate specimens, with the average value being reported as the TBC's mean split tensile strength. The testing results as shown in Table 3 and Figure 2.

Fig 2, Split Tensile Test on Cylinder

Flexural Strength

A simple concrete beam is subjected to flexural loading (Third Point Loading) in the transverse direction to assess concrete beam flexural strength. Initially, 1500x200x150mm beam test specimens are cast, cured for 28 days and tested to measure the flexural strength of the concrete beam specimens. The casting of beam is done in a single stage. Modulus of rupture is another name for flexural strength. Bending strength, also known as tensile strength, is a material property that is characterized as the ability of a material to bend.

To check the strength of the ternary blended concrete and normal strength of the real structure, flexural strength test was conducted in loading frame under two -point loading with the capacity of 500 kN at advanced structural engineering laboratory. To calculate the load versus deflection, a Linear Variable Differential Transformer (LVDT) was placed under the base side of the specimen in the middle point of the beam. A hydraulic power pack system with jack was used to apply the loading. During the test, data from the load cell and LVDT was used with an automatic data acquisition system with a personal computer interface to record the deflection of the beam under the mid point. The geometry, loading pattern and testing of beam as shown in Figure 3, Figure 4 and Figure 5 respectively.

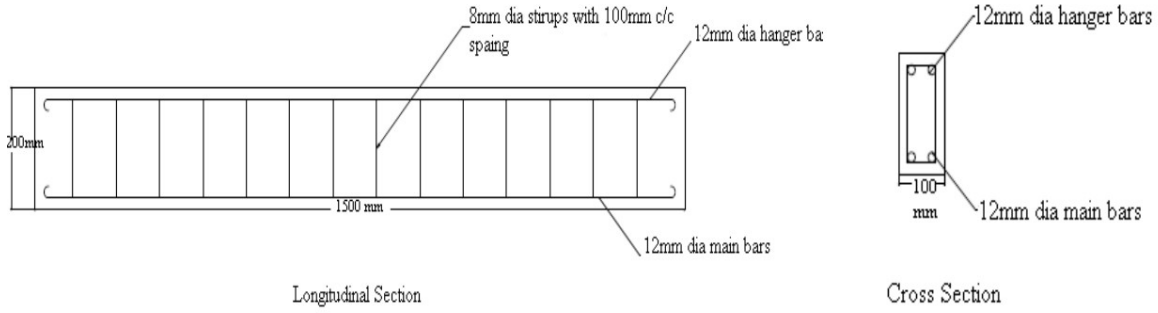

Fig 3, Geometry of the Beam

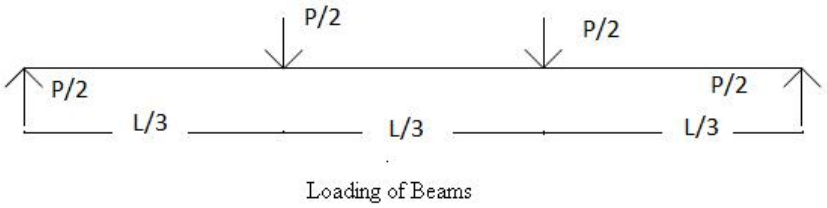

Fig 4, Loading of Beam

Fig 5, Testing of Beam

Results and Discussion

Test Results on Compressive Strength

The results for compressive strength, split tensile strength, and flexural strength are presented in the Table 2 given below. After 7, 14 and 28 days of curing period the partial replacement of OPC by silica flour and the waste glass powder designated with TBC mix had shown the optimum compressive strength.

Table 2, Compressive Strength Result of TBC

S.No	Mix	Compressive Strength at 7 Days (MPa)	Compressive Strength at 14 Days (MPa)	Compressive Strength at 28 Days (MPa)
1	TBC	25.89	30.4	54.89
2	TBC1	26.44	31.0	56.44
3	TBC2	26.00	30.8	56.00
4	TBC3	27.78	31.8	58.78
5	TBC4	26.22	30.9	56.22
6	TBC 5	25.56	30.6	55.56
7	TBC6	26.89	31.3	56.89
8	TBC7	25.4	31.1	55.11

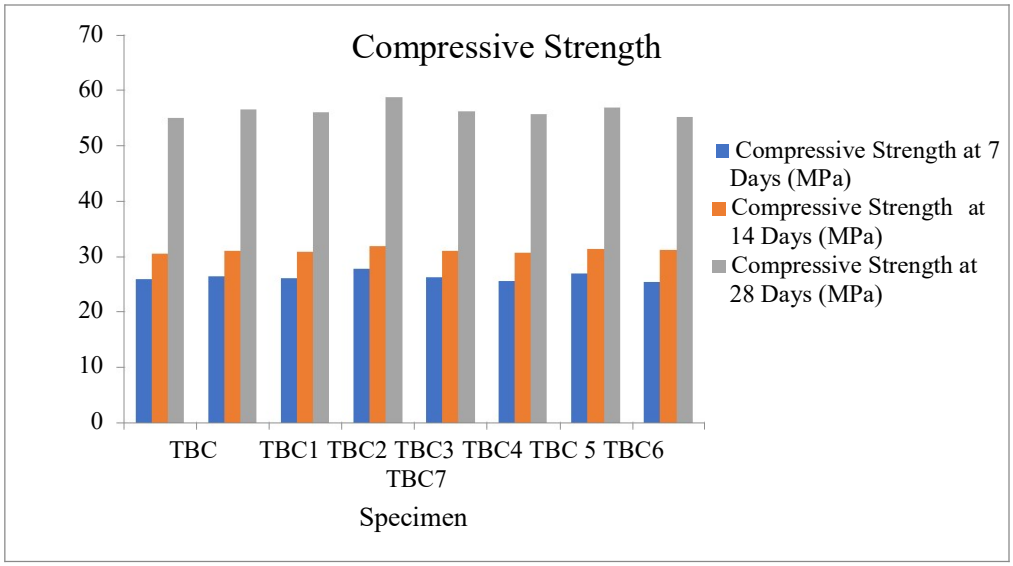

Fig 6, Compressive Strength Test Result for all TBC Mix

From the compressive strength test results, gigure 6 shows the optimum strength was obtained from the mix of TBC 3 which is having the proportions of 60% of the cement and 15% of the silica flour and the 25% of the waste glass powder. It was observed that all eight ternary blended concrete mixes contributes higher compressive strength gradually for 7, 14 & 28 days respectively. This could be attributed to the formation of stronger interfacial zones in ternary blended concrete mixes.

Test Results on Split Tensile Strength

The cylinder specimens were casted and tested to determine its split tensile strength and it is listed in the Table 3 as given below:

Table 3, Test Result on Split Tensile Strength:

S.No	Mix	Split Tensile Strength at 28 Days (MPa)
1	TBC	2.58
2	TBC1	2.68
3	TBC2	2.75
4	TBC3	3.46
5	TBC4	3.16
6	TBC5	3.03
7	TBC6	2.65
8	TBC7	2.41

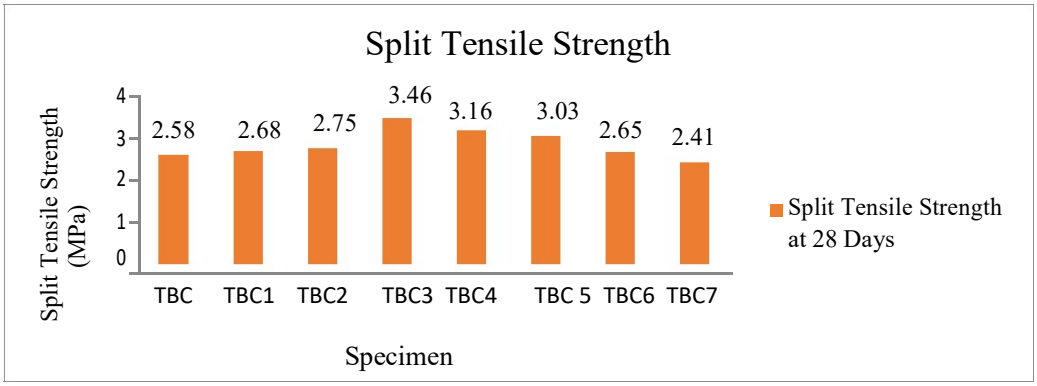

Figure 7, Split Tensile Strength Test Result for all TBC Mix

Test Results on Flexural Strength

The mix of TBC and TBC3 beam specimen were cast and cured for 28 days before tested in the loading frame. In this study TBC designated beam acted as a conventional beam whereas TBC3 which is having the proportions of 60% of the Cement and 15% of the Silica Flour and the 25% of the waste glass powder in concrete mix were cast cured for 28 days and tested in loading frame the behavior for flexural strength. The load versus deflection graph for TBC and TBC3 beam as shown in figure 8 and 9 respectively.

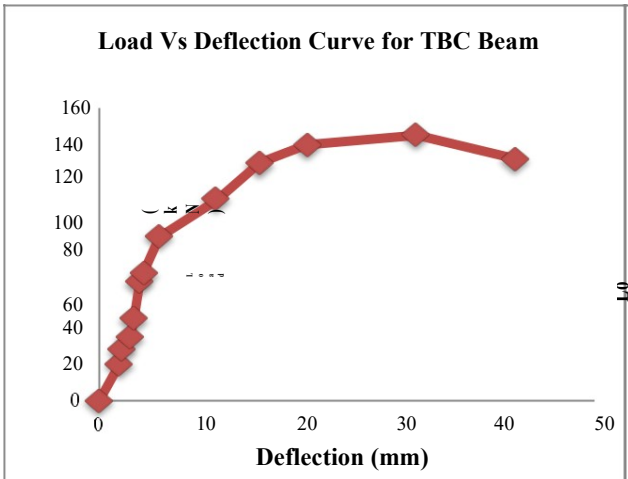

Fig 8, Load versus Deflection Graph for TBC

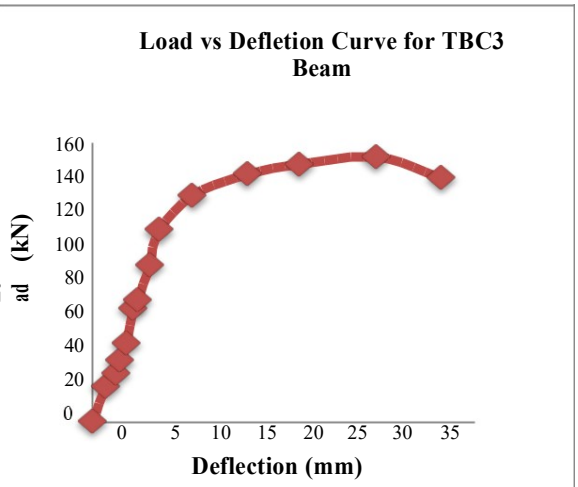

Fig 9, Load versus Deflection Graph for TBC3

From the above graphs, the flexural strength test, the load versus deflection behaviour for the specimen TBC and TBC3 results were illustrated. The above graph shows the load–defection curves at the mid-span of the beam specimens. Generally, there are two important stages of behaviour of beam were observed. The addition of silica fume and waste glass powder resist higher laod of the concrete. Therefore the deflection value of TBC3 beam is less as compare with TBC beam. In the first stage there was a linear branch with a steep slope, which represents the un- cracked condition of the beam. In second stage the cracking load was obtained, and a sudden decrease in load was observed because of the rapid cracking occurrences of the beam.

This sudden drop in the load which was more evident in load–defection curves, mainly for under reinforced beams. In this test the beam specimen of TBC and TBC3 were failed due to flexural failure.

At first, hair line cracks form appeared when the first crack load is reached. The cracks then expanded to vertical lengths as the load were increased, propagating from the bottom tension zone to the top compression zone. Furthermore, cracking has spread to the compression zone's and concentrated near load points. Concrete spalling took place in the compression region. The width of the crack is increased to a greater degree when the ultimate load is applied. The first crack often appeared near the midpoint of the beam's life.

The majority of the cracks on the surface of the beams are vertical, indicating flexure failure. With the help of loading frame the various points such as first crack, yield load and ultimate load were noted. The tested results of the beam on flexural strength along with load and deflection values are summarized in Table 4. Maximum load and maximum deflections of the tested beams also reported in Table 4.

Table 4. Test Results on Flexural Strength

S.No	Specimen	First crack Load(kN)	Maximum Load (kN)	Maximum Deflection (mm)
1	TBC	45	145	32
2	TBC3	65	152	26

A comparison was made and the result shows TBC3 beam reveals that it has 4.61% higher ultimate load than TBC beam. In TBC beam the first crack were obtained in 45KN and maximum deflection is 32mm when the applied load is 145 kN. For the beam specimen TBC3 the first crack occurred at 65 kN and maximum deflection of 26 mm were obtained at 152 kN.

Displacement Ductility and Energy Based Ductility

Ductility is considered as one of the important parameters for structural elements like beams. Ductility is generally measured by a ratio called ductility index (μ). The displacement ductility can be calculated by using the formula [5].

$$\mu = \frac{\Delta u}{\Delta y} \qquad \text{--------(a)}$$

Energy based ductility is another form of ductility determination. The energy ductility index(μE) is defined as the ratio between the energy of the system at failure(Eu) and the energy of the system at yielding load of tensile steel reinforcement at the centre of the support (Ey)[5].

$$\mu E = \frac{Eu}{Ey} \qquad \text{--------(b)}$$

The obtained value of ductility index value for TBC beam is 6.85 and for TBC3 beam is 5.62. The ductility value of TBC3 is lesser value and it implies the higher strength of concrete. The energy ductility index value for TBC beam is17.47 and 14.56. The corresponding values are tabulated in table 5.

Table 5. Values for Displacement Ductility and Energy Based Ductility

S.No	Specimen	Ultimate Load (kN)	μ (J)	μE (J)
1.	TBC	145	6.85	17.47
2.	TBC3	152	5.62	14.56

Conclusion

The industrial waste by products such as silica flour and waste glass powder were used in this study to replace OPC for producing concrete mixes. Eight proportions of TBC mixes were used to study the strength and flexural behavior with test specimens such as cubes, cylinders and beams were cast cured and tested in the laboratory.

- The optimum strength was found for the mix of grade 40 with designation of TBC3 shows 58.78MPa of compressive strength and 3.46MPa of split tensile

strength. The mix TBC3, which contains 60% of cement, 15% of Silica flour and 25% of waste glass powder in the ternary blended concrete. The presence of silica flour and waste glass powder fill the voids in the concrete, the density increases and also the strength of the concrete also gets increased.

- There is an increase of 7% in compressive strength and a significant increase of 34% in split tensile strength was obtained for TBC3 mix.
- In the flexural test conducted on simple beams the control beam designated as TBC beam the maximum deflection is 32mm at 145 kN and had a good ductile behaviour. For the beam specimen TBC3 the maximum deflection is 26 mm at 152 kN and behaved stiffer than the control specimen beam.
- The displacement ductility and energy-based ductility values represents the uniform elastic behavior of beam. It indicates the ductile manner for the beam is good and the energy released at a failure gets reduced. From the limited studies conducted on TBC mixes in the laboratory, it could be concluded that the industry waste bye products shall be used for construction activities which could reduce the burden on environment degradation and for sustainable concrete construction in future. Nevertheless, more researches are suggested to come for solid conclusion on structural aspects.

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Paper ID 101

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for presenting a research paper titled

INTELLIGENT PERSONAL ASSISTANT (IPA)
FOR SENIOR CITIZENS

at the International Conference on **Agiculture, Healthcare and Green Computing Perspectives of Communication Technologies - ICAHGCT - 2022** organised by Department of Electronics and Communication Engineering, Sona College of Technology, Salem - 5, held on 28th & 29th April, 2022.

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Sona College of Technology	Sona College of Technology	Sona College of Technology	Sona College of Technology

Department of Electrical and Electronics Engineering

Certificate ID: RIT-ICSTA22-315

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International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)

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Certificate of Presentation

This is to certify that Dr.KARTHIKEYAN K, RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "An Embedded Controller Based Train Control System" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

Organizing Secretary	Vice-Principal	Principal
Dr.K.Vijayalakshmi	Dr.S.Rajakarunakaran	Dr.L.Ganesan

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This is to certify that Ms.S. SHARMILA KUMARI, RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "Solar Powered Smart Led Street Light with Auto Intensity" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

Organizing Secretary	Vice-Principal	Principal
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This is to certify that Mr.A. ARUN KUMAR , RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "Smart Garbage Detection System" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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Certificate of Presentation

This is to certify that Ms.JEYANTHI S, RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "Performance Analysis of Boost Converter by Comparing with Different Switching Techniques" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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This is to certify that Mr.E. THANGAM, RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "Studies on the Planning of Generation Expansion in a Renewable Dominated Power System" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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This is to certify that Dr.S. KANNAN, RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "Field Oriented Control of Permanent Magnet Synchronous Motor with D-Q Axis Decoupling Using Feed Forward Compensation" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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This is to certify that Mr.S. MEENAKSHI SUNDARAVEL, RAMCO INSTITUTE OF TECHNOLOGY, RAJAPALAYAM has presented a paper titled "Analysis of Cascaded H-Bridge Multilevel Inverter using Various Pulse Width Modulation Strategies" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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CERTIFICATE OF APPRECIATION

This is to certify that Mrs.S.JEEVA of Ramco Institute of Technology has presented a paper on 2D Plotter Simulation and Prototype using NI labview and NI Myrio kit at *"International Virtual Conference on Emerging Trends on Artificial Intelligence In Industry 4.0"* in Association with Open POWER & IBM at *Loyola Institute of Technology* , Chennai on 21.06.2021.

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IEEE

CERTIFICATE OF APPRECIATION

This is to certify that Ms. R.Ramalakshmi of Ramco Institute of Technology, Rajapalayam has Won the Best Paper Award in the IEEE International E- Conference on *"Emerging Technologies and Applications for a Smart and Sustainable World"* **(ICEmTASS'21),** organized by the National Engineering College during 16.12.2021 to 18.12.2021.

Title of the Paper: System Model for Spectral and Energy Efficient Massive MIMO System

Authors: R.Ramalakshmi, S.TamilSelvi

Dr.B.PARAMASIVAN	Dr.M.A.NEELAKANTAN	Dr.K. KALIDASA MURUGAVEL	Dr.S.SHANMUGAVEL
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1. A Novel approach for Early Invention of Retinal Disorders using Machine Learning

Springer ICISC JCT

CERTIFICATE OF PRESENTATION

This certificate is awarded to

Dr. A Lakshmi

for successfully presenting the paper entitled

A Novel approach for Early Intervention of Retinal Disorders using Machine Learning Techniques

at the 6th International Conference on
Inventive Systems and Control (ICISC-2022)
organized by JCT College of Engineering and Technology, Coimbatore, India
on 6-7, January 2022.

Session Chair | Organizing Chair Dr. Jennifer S. Raj | Conference Chair Dr. K. Geetha

2. CNN based classification of brain Abnormalities in MRI using Adaptive Deep Wavelet Encoder (ADWE)

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This is to certify that DR. A. LAKSHMI of RAMCO Institute of Technology, Virudhunagar Presented a paper entitled CNN based classification of brain Abnormalities in MRI using adaptive Deep Wavelet Auto Encoder (ADWE) at the International Conference on Communication and Computing Technologies for Sustainable Development (ICCCTSD 2022) organized by the Department of Electronics and Communication Engineering, Sri Krishna College of Technology, Coimbatore, India During Feb - 25, 26 -2022.

Dr. K. Srinivasan, Organizing Chair | Dr. G.M. Tamilselvan, General Chair | Dr. V. Sreevidya, Principal

3. Artificial Intelligence based Smart Electricity Billing Management System

Certificate ID: RIT-ICSTA22-976

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Certificate of Presentation

This is to certify that Mrs.JEEVA S, Ramco Institute of Technology has presented a paper titled "Qualitative Improvement in Wireless Capsule Endoscopy Images Using Single Scale Retinex Function with Un sharp Filtering" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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Certificate ID: RIT-ICSTA22-968

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Certificate of Presentation

This is to certify that Ms.S.HARINI SHRIRAM, Ramco Institute of Technology has presented a paper titled "Fruits Recognition Classifier Implementation Using Convolutional Neural Network" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

Organizing Secretary	Vice-Principal	Principal
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Certificate of Presentation

This is to certify that Mrs.G.GNANA PRIYA, Ramco Institute of Technology has presented a paper titled "A Review on Spectrum Sharing Techniques in 5G Communication Networks" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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Certificate ID: RIT-ICSTA22-950

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International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)

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Certificate of Presentation

This is to certify that Mrs.G.SUBHASHINI, Ramco Institute of Technology has presented a paper titled "Analysis of Power in Logic Circuits Using Various Clock-Gating Techniques" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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Dr.K.Vijayalakshmi	Dr.S.Rajakarunakaran	Dr.L.Ganesan

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International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)

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Certificate of Presentation

This is to certify that Mr.VIJAYAKUMAR S, Ramco Institute of Technology has presented a paper titled "Analysis of Memristor based pass transistor logic" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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Certificate of Presentation

This is to certify that Dr.A.LAKSHMI, Ramco Institute of Technology has presented a paper titled "Artificial Intelligence based Smart Electricity Billing Management System" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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4. Reduction of Noise in PET Brain Image Using Filtering Techniques

Certificate ID: RIT-ICSTA22-890

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International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)
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Certificate of Presentation

This is to certify that Dr.A.LAKSHMI, Ramco Institute of Technology has presented a paper titled "Reduction of Noise in PET Brain Image Using Filtering Techniques" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

Organizing Secretary
Dr.K.Vijayalakshmi

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Dr.S.Rajakarunakaran

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5. Exploration of Reusability of Universal Verification Technology

Certificate ID: RIT-ICSTA22-933

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Certificate of Presentation

This is to certify that Mrs.R.RAMALAKSHMI , Ramco Institute of Technology has presented a paper titled "IOT BASED REQUISITE USAGE OF WELFARE EQUIPEMENT FOR ALCOHOL AND ACCIDENT DETECTION" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

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Certificate of Presentation

This is to certify that Dr.R.RAJALAKSHMI, Ramco Institute of Technology has presented a paper titled "Development of Gyro Stabilized Electro-Bot" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

Organizing Secretary
Dr.K.Vijayalakshmi

Vice-Principal
Dr.S.Rajakarunakaran

Principal
Dr.L.Ganesan

Certificate ID: RIT-ICSTA22-892

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International Conference on Smart Technologies and Applications-2022 (ICSTA 2022)

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Certificate of Presentation

This is to certify that Mr.G. SIVAKUMAR, Ramco Institute of Technology has presented a paper titled "IoT based Drug Delivery System for Pulmonary Lung Disorders" in the International Conference on Smart Technologies and Applications-2022 (ICSTA 2022) organized by Ramco Institute of Technology on 11th & 12th March, 2022 through online.

Organizing Secretary	Vice-Principal	Principal
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INTERNATIONAL CONFERENCE ON

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25th March, 2022

Organized by

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CERTIFICATE OF PARTCIPATION

This is to certify that Dr R Rajalakshmi, Asst. Prof., Ramco Institute of Technology has presented a paper entitled "Brain Tumor Detection and Segmentation from MRI Images using K-Means Clustering" in the International Conference on "Emerging Trends in Communication, VLSI and Signal Processing" held on 25 March, 2022 organized by the Department of Electronics and Communication Engineering, JJ College of Engineering and Technology, Trichy.

Conference Chair
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Principal
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CIME 2022

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IoT & Computational Techniques

22nd - 23rd April 2022

Paper ID: CIME-2022_paper_38

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Certificate of Presentation

This is to certify that **Dr. A. Azhagu Jaisudhan Pazhani**

Associate Professor, Department of ECE, Ramco Institute of Technology, Rajapalayam

has presented the Paper entitled

Analysis of the digital trends and IoT procedural scheme on traditional banking system

Authors: **R. Narmadha, Pradeep Kumar Rangi, A. Azhagu Jaisudhan Pazhani, Prajval V**

at the **International Conference on Contemporary Innovations**

in Engineering & Management in data Sciences IoT & Computational Techniques held in Blended mode (Offline / Virtual)

during 22nd - 23rd April 2022

Dr. Sunil Chawla	Dr. Shruti Aggarwal	Dr. D. Abhishek	Dr. K. Thirupati Reddy	Dr. T. Jayachandra Prasad
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International Conference on

CONTEMPORARY INNOVATIONS IN ENGINEERING & MANAGEMENT IN DATA SCIENCES
IoT & Computational Techniques

22nd - 23rd April 2022

Paper ID: CIME-2022_paper_37

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Department of Mechanical Engineering

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Certificate of Presentation

This is to certify that **P. Gunasekaran** of

Department of ECE, Ramco Institute of Technology, Rajapalayam

has presented the Paper entitled

Smart agriculture system monitoring by IoT

Authors: **A. Bhagyalakshmi, K. Sasirekha, P. Gunasekaran, Ashok Kumar Koshariya**

at the International Conference on Contemporary Innovations in Engineering & Management in data Sciences IoT & Computational Techniques held in Blended mode (Offline / Virtual)

during 22nd - 23rd April 2022

Dr. Sunil Chawla	Dr. Shruti Aggarwal	Dr. D. Abhishek	Dr. K. Thirupati Reddy	Dr. T. Jayachandra Prasad
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JEEVA S

AP. RAMCO INSTITUTE OF TECHNOLOGY

for attending & giving an Oral Presentation for the paper entitled

Wireless Capsule Endoscopy Bleeding Image Classification Using SVM Based Model

First International Conference on Advancements on Management, Entrepreneurship, Sciences & Engineering ICAMESE'2022 - (Online)
organized by I Business Institute, Greater Noida, Uttar Pradesh, India & Global Conference Hub, Coimbatore, Tamilnadu, India on 28th & 29th May' 22

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Department of Mechanical Engineering

Indian Society for Technical Education

certificate of participation

This is to certify that Mr/Ms/Dr JEEVA S
of Ramco Institute of Technology
has presented the technical paper
entitled Deep learning model for Brain tumor segmentation and
classification. in the **ISTE** sponsored two days
National Level Conference on "**Emerging Trends in Engineering Design and Manufacturing "ETEDM-22"** on 15th &16th June 2022.

Prof.M.Viswanath
CO-Ordinator

Dr.K.M ArunRaja
Organizing Secretary

Hindusthan Institute of Technology
Department of Mechanical Engineering
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Design, Analysis, and Applications

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ABSTRACT

A reflect cluster receiving wire (RAA) with a wideband high-power double branch helical reflect cluster is demonstrated. Two metal helical branches make up the reflecting component, and the movable pivot points allow for full 360o stage rotation. A 9 X 9 rectangular cross section X-band RAA model is imitated and estimated. The best get of 23.7 dB is achieved with the bar concentrated at (=20,=0) course at focus repeat of 9.3 GHz, and the 1-dB get a move on is more than 24.2%, according to full-wave reenactments. In the entire band, the intentional reflection coefficient is not exactly - 16.3 dB. The endeavored significant rate is under 2.3 dB from 8.4 GHz to 10.8 GHz. The attempted get at center rehash is 23.4 dB, and the differentiating opening helpfulness is 50.6%. The RAA's bar inspecting execution is endeavored inside 30o exactness in two balanced planes with a check trouble of under 1.5 dB and focus point degrees of under 1.4 dB. Under vacuum, the mirrored results provide the appearance that the RAA's force taking care of limit is approximately 358 MW.

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INTRODUCTION

The interest for high force microwave (HPM) imparting structures is filling really because of their wide applications in standard occupant and military frameworks (Taylor, 1994). The striking necessities of high force instruments place additional difficulties on radio wire plan. In high force conditions, the radio wire is acquainted with the radiation of high force sources. Therefore, the force overseeing limit of the radio wire changes into a gigantic issue that should be tended to. This shows up with the yield system for endless the HPM sources has azimuthal consistency (for example the TM01 round waveguide mode or the TEM coaxial mode), which conveys a donut formed model with a boresight invalid, whenever imparted straightforwardly. A few methodologies for HPM getting wire plans have been proposed in the piece. Mode change techniques are thoroughly used to change the vexatious azimuthally symmetric mode to one with a boresight top (for example the rectangular TE10 mode or the backhanded TE11 mode). (Li et al., 2008) Not with standing, these strategies have drawbacks for example, broadened structure difficulties, length, and weight. Valsov getting wire, COBRA radio wire, high force broadened line helical gathering radio wires, and high force microwave winding line opening radio wire are among the getting wire structures proposed for certain HPM applications. Obviously, the reflect display getting wires are planar developments in which a combination of insightful unit cells with fitting stage reactions is used to give an attracted or shaped shaft from an enlightening wave front. Reflect group getting wires have drawn in uncommon idea in later a long time inferable from their enchanting highlights like low profile, irrelevant expense, light weight, simplicity of headway, and managing. (Benford, 1992) This sort of radio wires are ordinarily framed from locally accidental plans in which unit cells of various shapes and advancements are utilized as spatial stage shifters of course spatial time-defer units. The reflect group unit cells are everything viewed as resounding or non-resonating squares and their stage or time surrender reaction can be constrained by changing the mathematical furthest reaches of portion, propelling the substrate attributes, turning the parts bearing, or stacking the unit cell with tuning fragments. (Lee et al., 2004) Many separated reflect bunches either have restricted power overseeing limit or are not reasonable for coordination with HPM structures. A tremendous piece of these improvements abuse metallic models in multi-facet game plans. Metallic associations, regardless, are tricky at high force, arcing happens at field focus focuses, and warming happens in view of ohmic difficulties experienced by solid streams in transmitters. Moreover, by ethicalness of direct radiation of the azimuthally symmetric yield methods for HPM sources, a donut framed model with a boresight invalid will be reradiated by the reflect display opening, which is bothersome for high force applications. (Courtney & Baum, 2000)

This paper portrays a dielectric reflect bunch that is equipped for understanding the directional radiation of azimuthally symmetric modes and has an excellent force overseeing limit. due to the hazardous impacts of metallic models at undeniable degrees of electromagnetic energy, a dielectric approach is embraced here to plan the reflect display unit cells. A variable broadness air-filled opening through a host dielectric material is used as a stage moving unit cell to plan a dielectric reflect show getting wire to work at X-band. (Vlasov & Orlova, 1974) The directional radiation of azimuthally symmetric mode is refined through remunerating the stage contrasts of enlightening wave front over the reflect show opening. Speculative assessment is utilized related to full-wave stimulations to take apart the radiation execution of the proposed reflect group getting wire. The outcomes depict the constraint of the proposed persuading wire to be utilized for HPM applications.

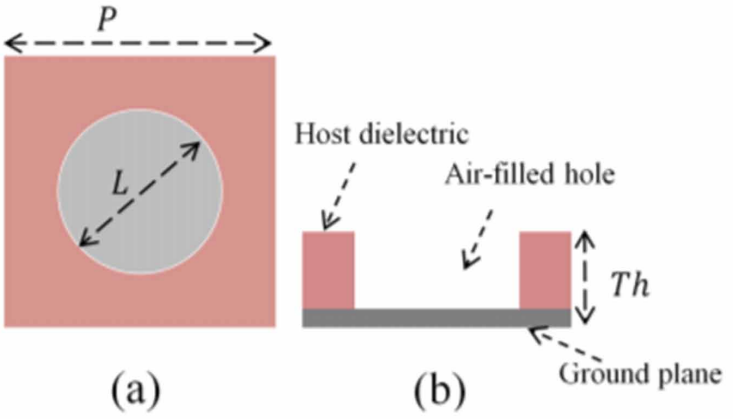
ANTENNA PRINCIPLE OF OPERATION

The reflect bunch opening is needed to be masterminded on the x-y plane and enlightened by a fixed horn radio wire. In our reference condition, the feed horn getting wire is straightforwardly constrained by the azimuthally symmetric TM01 round mode and a donut framed model with a bore sight invalid is sent toward the reflect show opening. (Li et al., 2010) Since the pushing toward wave front has azimuthal balance, there is a 90 stage contrast between transmits showing up at points of same curving distance and quadrupled azimuthal point at the space of reflect group opening. To give a boresight top after reflection, this stage separation should be assessed by the reflect bunch opening. To accomplish this, reflect show opening is detached into 4 tantamount point quadrants.(Li et al., 2010) By presenting a stage shift of 90 to unit cells of each quarter relative with the associating quadrant, directional radiation of the azimuthally symmetric wave front can be acquired by the reflect display opening. As per the above conversation, the stage delay from the feed horn stage focus to a unit cell masterminded at point C(r; ‘) on the reflect bunch opening is given by:

$$\varnothing\left(r,\varphi\right)=-k_0\sqrt{f^2+r^2}-\frac{\pi\left(n-1\right)}{2} \tag{1}$$

where k0 is the multiplication predictable of free space, (r; ‘) are the polar bearings of unit cell, n is the amount of quadrant wherein the unit cell is found, and F is the reflect array focal distance.(Peng et al., 2013)

Figure 1. Structure of Dielectric Unit Cell.



To achieve a collimated column at the boresight course, the time of reflection coefficient for different unit cells over the reflectarray opening should be picked with the end goal that total stage delay from feed stage center to a fixed opening plane before the reflectarray transforms into a reliable for all unit cells. (Berry et al., 1963) As necessities be, the necessary reflection stage appointment of reflectarray unit cells is settled as:

$$\varnothing_R(r,\varphi) = k_0\sqrt{f^2+r^2} + \frac{\pi(n-1)}{2} + 2k\pi \tag{2}$$

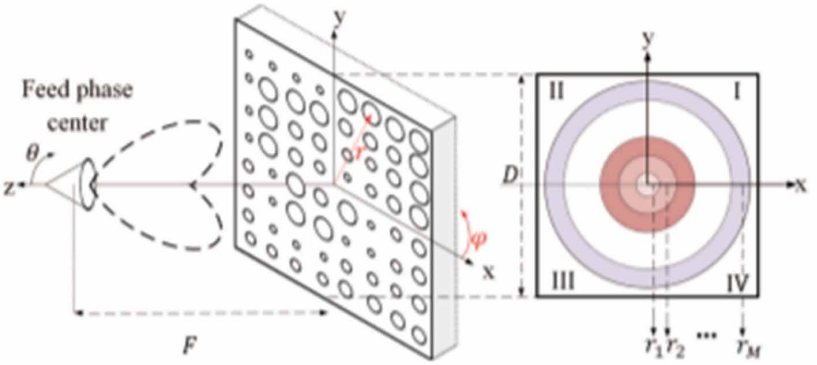
A X-band dielectric reflectarray getting wire working at 10 GHz is arranged, penniless down, and recreated to show the feasibility of the proposed approach. The dielectric unit cell is depicted in portion 3. In region 4, the reflectarray plan technique is presented, and the theoretical examination and reproduced results are inspected in portion 5.

REFLECTARRAY UNIT CELL

As alluded to as of now, dielectric approach is picked here to go without the risky impacts of metallic models in high force applications (Pottier et al., 2014). In dielectric-type unit cell, the conductive fix is taken out and the control of unit cell reflection stage is developed by changing the constraints of the dielectric. A

schematic model of the dielectric unit cell in our game plan is appeared (Peng et al., 2013). The unit cell is a square dielectric piece with permittivity of εr that in our course of action covers the entire unit cell surface. The thickness of the piece is Th, and the unit cell periodicity is P. To plan the proposed HPM reflect bunch, diverse likely gains of the reflection stage are needed for different unit cells over the reflect display opening. The reflection season of unit cell can be constrained by debilitating an air-filled opening that has a distance across L through the dielectric irregularity (Berry et al., 1963). The width of the opening is then changed to give the fundamental reflection stage on the fragment position. Additionally, considering the sagacious thought about the unit cell, a conductive ground plane has been added to the base side of the dielectric piece. There are three levels of opportunity to plan the depicted unit cell. These solidify the permittivity and thickness of dielectric piece, and the periodicity of unit cell. To consider the impact of these cutoff points on the unit cell reflection coefficient, a development of reenactments are done using the recurrent space solver of CST Microwave Studio (Huang, 2008). The unit cell is put inside a rectangular waveguide with TEM-mode augmentation limit conditions. The top and base dividers of the waveguide are picked as shocking electric channels, and its side dividers are picked as splendid appealing transmitters. These settings reenact an upward way animated plane wave that occasions generally on a boundless sporadic bundle of indistinct unit cells. After down to business full wave redirections, it is tracked down that a stage degree of about 360o could be refined with a unit cell having permittivity εr =10.2, thickness Th=7.62 mm, and periodicity P= 9 mm. Fig. 3 portrays the full-wave imitated reflection stage and sufficiency of the unit cell versus air-filled opening breadth at 10 GHz. It will overall be seen that the reflection affliction is under 0.3 dB at the course of action rehash, and a stage degree of around 360o is developed when the underlying broadness fluctuates from 0.1 to

Figure 2. Proposed HPM reflect array antenna



8.6 mm, which fulfills the significant stage degree of our dielectric reflect display plan (Al-Nuaimi & Wei Hong, 2014). The stage reaction of unit cell at various rate centers is moreover taken apart, and the outcomes are displayed in Fig. 4. As it very well may be seen, the stage reaction is steady for topsy-turvey occasion up to 30o

DESIGN PROCEDURE

The proposed approach portrayed in area 2 was followed to plan a HPM getting wire to work at an average rehash of 10 GHz. The reflect show has a square opening with side length of 252 mm (≈8.2λ0) and thickness of 7.62 mm (≈0.25 λ0), made out of a measure of 28×28 air-filled opening substrate through unit cells. Rogers 6010 dielectric substrate with relative permittivity εr = 10.2 and difficulty wandering tan = 0.002 was utilized for substrate layer (Peng et al., 2013). Aberrant waveguide (distance across = 27.8 mm) driven from one end by TM01 mode was picked as the feed of the reflect bunch. The distance across of the waveguide input opening was picked considering the take out rehash of the TM01 mode. The impedance coordinating between the free space and waveguide yield opening for this mode was refined through comfortable extending the helper assessment as shown. The imitated three-dimensional far-field radiation plan of the organized feed horn at the course of action rehash of 10 GHz is displayed in Fig. 5(b). The replicated return loss of the feed horn over the recurrent degree of 9.5-10.5 GHz also as the two-dimensional plots of upward and on a level plane animated radiation plans at the course of action rehash of 10 GHz. (Berry et al., 1963) The boresight nulls are obviously seen from this figure as we anticipated. The reflect group central length was picked to be 151.2 mm, giving a central length to isolate across degree F/D of 0.6. The worth of F/D was settled ward on the radiation representation of the feed horn getting wire and the reflect group opening feasibility assessments.

PERFORMANCE ANALYSIS AND RESULTS

Various strategies have been made to process the radiation illustration of reflectarray getting wires. The stage simply mix approach proposed was embraced here to characterize the issue as a result of its straightforwardness. (Huang, 2008) The far-zone electric field exuded by the reflectarray opening as a segment of the bearing cosines, u = sinθcosφ and v= sinθsinφis conveyed as follows:

$$\vec{E}(u,v)=\frac{jk_0e^{-jk_0r}}{2\pi r}\{\hat{a}_0[cos\varphi\tilde{E}_x(u,v)+\sin\varphi\tilde{E}_y(u,v)]+\hat{a}_\varphi cos\theta[-sin\varphi\tilde{E}_x(u,v)+\cos\varphi\tilde{E}_y(u,v)]\} \tag{7}$$

where (r,θ,φ) are the standard headings of round system. The terms Ẽ_x and (E_y) ˜ are the apparition parts of digressive sent field over the reflectarray opening, additionally, are approximated by:

$$\tilde{E}_{\substack{x\\y}}=(u,v)=\zeta\sum_{b=-\frac{B}{2}}^{\frac{B}{2}-1}\sum_{a=-\frac{A}{2}}^{\frac{A}{2}-1}\Gamma_{x/y}^{a,b}\frac{E_{feedx/y}^{a,b}}{\sqrt{F^2+x_a^2+y_b^2}}e^{j\Psi} \tag{8}$$

Where

$$\zeta=\frac{4\pi^2}{k_0^2uv}\sin\left(\frac{k_0ud_x}{2}\right)\sin\left(\frac{k_0ud_x}{2}\right), \tag{9}$$

$$\Psi=-k_0\sqrt{F^2+x_a^2+y_b^2}+\phi_{R,x/y}^{a.b}+k_0\left(uad_x+vbd_y\right) \tag{10}$$

accordingly, (x_a,y_b) are the headings of unit cell (a, b), d_x additionally, d_y are the equal components of unit cell, A and B are the finished number of unit cells along the x-and y-course, $\Gamma_{x/y}^{a,b}$ *and* $\phi_{R,x/y}^{a,b}$ are the plentifulness and time of unit cell reflection coefficient, and, and $\frac{E_{feedx/y}^{a,b}}{\sqrt{F^2+x_a^2+y_b^2}}e^{-jk_0}\sqrt{F^2+x_a^2+y_b^2}$ the event electric field at the unit cell, which is settled by the feed plan at the space of unit cell $E_{feedx/y}^{a,b}$,considering factors $\frac{1}{\sqrt{F^2+x_a^2+y_b^2}}$ for amplitude and $k_0\sqrt{F^2+x_a^2+y_b^2}$ with the expectation of complimentary space spread stage shift to the unit cell position.

The proposed approach depicted in locale 2 was followed to design a HPM getting wire to work at a typical repeat of 10 GHz. The reflect show has a square opening with side length of 252 mm (≈8.2λ0) and thickness of 7.62 mm (≈0.25 λ0), made out of a proportion of 28×28 air-filled opening substrate through unit cells. (Arrebola et al., 2009) Rogers 6010 dielectric substrate with relative permittivity εr = 10.2 and trouble meandering tan = 0.002 was used for substrate layer. Indirect waveguide (distance across = 27.8 mm) driven from one end by TM01 mode was

picked as the feed of the reflect bunch. The distance across of the waveguide input opening was selected considering the take repeat of the TM01 mode. The impedance planning between the free space and waveguide yield opening for this mode was refined through open to developing the associate appraisal as displayed. The copied three-dimensional far-field radiation plan of the coordinated feed horn at the game-plan repeat of 10 GHz is shown in Fig. 5(b). The recreated return loss of the feed horn over the repetitive level of 9.5-10.5 GHz similarly as the two-dimensional plots of vertically and on a level plane vivified radiation plans at the game-plan repeat of 10 GHz. The boresight nulls are obviously seen from this figure as we expected (Yu et al., 2010). The reflect bunch focal length was picked to be 151.2 mm, giving a focal length to seclude across degree F/D of 0.6. The value of F/D was settled ward on the radiation portrayal of the feed horn getting wire and the reflect pack opening sensibility assessments. In this way, tolerating as far as possible to be 3 MV/m, the power dealing with limit is comparable to $\left(\frac{3\times10^2}{1811}\right)^2 \approx 2.7$ MW.

CONCLUSION

In this paper, the reflect array thought was mauled to support an astounding radio wire which perceives the azimuthally symmetric yield methodologies for high force microwave sources unmistakably and sends a collimated light surge polarization at the boresight course. A 10 GHz test was organized and broke down to show the sensibility of the proposed approach (Al-Nuaimi & Wei Hong, 2014). The course of action mauled entered dielectric substrate as the stage moving unit cell to get out the risky impacts of metallic models at basic degrees of electromagnetic energy. The theoretical and reenactment results are in commendable understanding, which shows the capacity of proposed way to deal with oversee be utilized in irrelevant, high extension and high force radio wires plan for microwave system (Huang, 2008).

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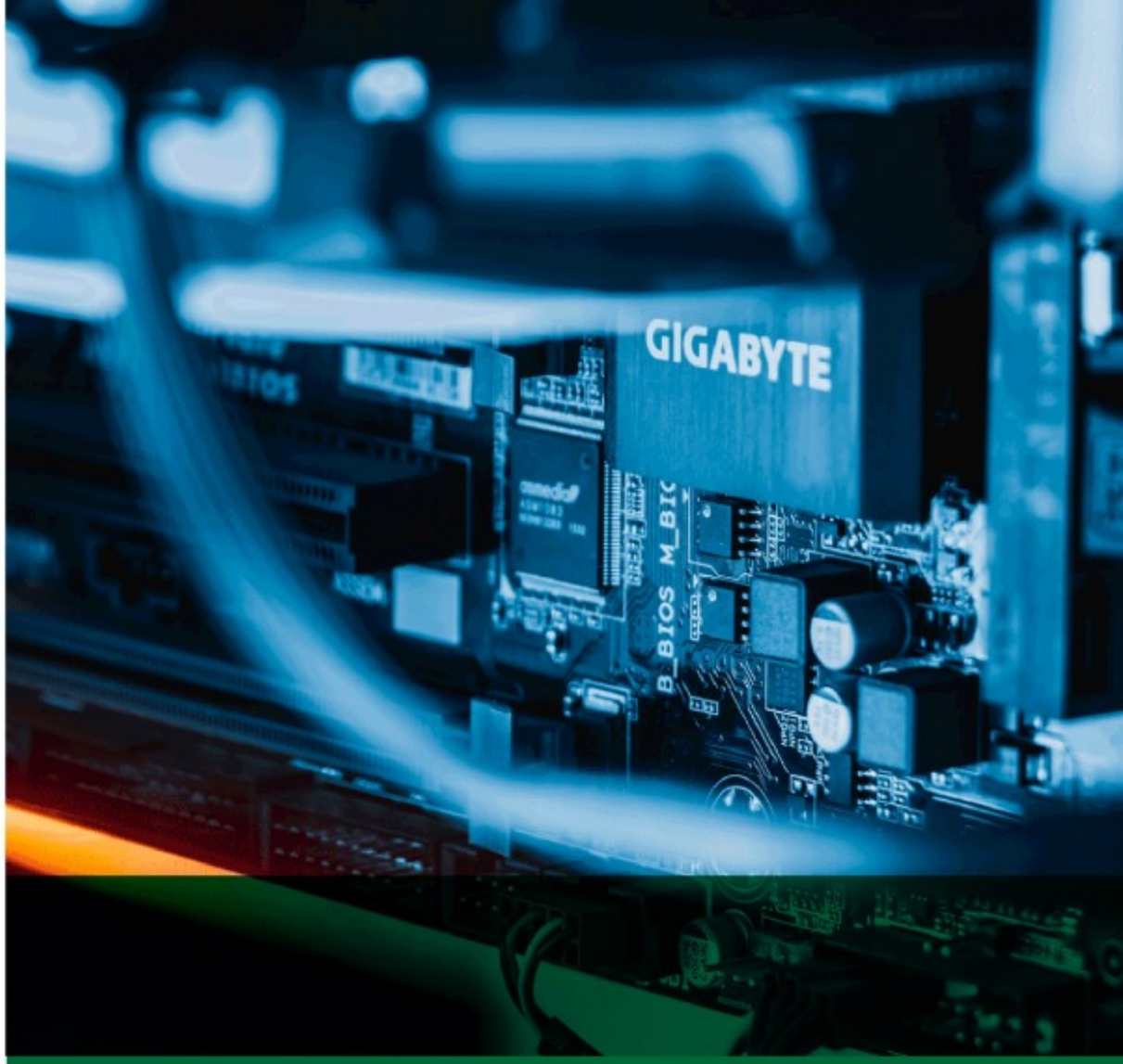

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Forecasting Using Deep Learning Approaches

B. Vijayalakshmi, M. Kaliappan, K. Ramar, K. Vijayalakshmi, and S. Vimal

1 Introduction

Nowadays, all are interested in knowing what may happen or what may be the trend in the future in the field of economy, politics, sports, marketing demands, and environmental factors. In such a case, forecasting is an important task to perform. The forecasting model predicts the future outcome based on the analysis of past historical data. The outcome may depend on the past value along with some other external factors which may influence the predicted value. People used various methods for prediction from the olden days itself. But the accuracy of those methods is not enough since the availability of historic data and the computing facilities are low at that time. But in the present situation, the data can be retrieved from plenty of sources in various forms, and also the high-performance computing facility supports the processing of a large volume and variety of data in a faster manner. It helps to design various efficient forecasting models that will improve the forecasting accuracy.

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1.1 Main Objectives of the Chapter

This chapter mainly focuses on different deep learning architectures such as fully connected neural networks (FCNN), convolutional neural network (CNN), recurrent neural network (RNN) such as long short-term memory (LSTM), gated recurrent unit, generative adversarial networks (GAN), and deep reinforcement learning to develop forecasting models with various parameters and reveal the applications of these methods.

1.2 Forecasting and its Need

In the current situation, forecasting plays a vital role in every field. Forecasting is a process of estimating the future value or trend based on the past and present data. This process analyzes a large volume of data to identify the trends followed in the previous data which helps to predict the future trend.

1.3 Forecasting Applications

In every field, everyone wants to forecast like whether some event will happen or not, what is the future trend. In the business field, it improves the decision of sales and production. In the field of healthcare, forecasting helps to predict the health status based on the health parameters. Economic forecasting helps to perform predictions about economic factors such as GDP and inflation. The trend in stock market prediction can be used to predict the stock values for investing in the future. The accurate forecasting of environmental factors like weather, storm, and other natural calamities helps to save valuable human life. In the sports field, it will predict the outcome of a particular match. In the transportation domain, forecasting helps to predict the number of users or vehicles that will use the particular transportation facility in the future to improve the traffic management system.

2 Time Series Forecasting

Time series is a series of data values that are collected over the even intervals time duration. Time series forecasting is the process of designing and using a model to predict the future value at a particular time point based on the observed value. This forecasting can be of single-step forecasting, i.e., predicting the value for the next time step, or multistep forecasting, i.e., predicting the value for the subsequent time interval.

(i) Univariate Forecasting.
Univariate time series forecasting model uses a single time series as a dependent variable. For example, if the traffic flow at a particular location depends on the past observation of traffic flow values only, then this model is referred to as univariate forecasting.

(ii) Multivariate Forecasting.
The multivariate time series forecasting model uses multiple dependent variables. For example, if the traffic flow at a particular location depends on the past observation of traffic flow values and also other factors like speed and weather conditions, then this model is referred to as multivariate forecasting.

2.1 Forecasting Models

Various models are proposed and used in the task of forecasting. The approach may of statistical- [1] or neural network-based [2] approaches. An evolving artificial neural network model along with a genetic algorithm is used for forecasting the time series. The paper [3] provided a review of various wind forecasting methods and its effectiveness which is useful for reducing the unpredictable situation of power generation. The deep learning approaches [4] provide the various machine learning models and the hybrid models used for forecasting the energy consumption value.

2.1.1 Naïve Forecasting Model

In this naïve model of forecasting, the forecast value is set to be the value of the last observed one. Similarly, in the seasonal naïve model, the forecast value will be set as the last observed value from the same season. It is the simplest method.

2.1.2 Linear Regression Model

It is an important tool for predicting future value. In a simple linear regression model, it finds the linear relationship between the forecast variable and the predictor variable. It doesn't consider any seasonality or cycles. It will produce a perfect result for linear data. It uses the least square method for fitting the value for the nonlinear model. The linear regression model can be of simple, multiple, and multivariate based on the number of predictor and response variables. In a naïve multiple linear regression framework for predicting the short-term load. It was used as a benchmark model for load forecasting. The multiple linear regression model proposed is used for predicting the short-term load value [6].

2.1.3 Exponential Smoothing Model

The exponential smoothing model is mainly used for data with no trend or seasonal pattern. This method is based on the weighted average of the past observations for predicting future value. But the weight values are decreasing exponentially as we move the observation values back in time. The recent observation gets a higher weight value and a lower weight will be assigned to the initial observation. In [5], a Holt-Winters exponential smoothing model was proposed which helps to adapt two different seasonalities. In [7], exponential smoothing method based on error, time, and seasonal is used for predicting the data traffic in the cellular network.

2.1.4 ARIMA

It is an autoregressive integrated moving average model. It is used to predict the next step value in the time series data based on the linear function of differenced observations and residual error at previous time steps. It combines AR and MA and also differencing of sequence value to create the sequence stationary. The variation of ARIMA is SARIMA which is also capable of modeling seasonal data. ARIMA model is used to forecast electricity prices [8] and sugarcane production [9] forecasting. The various approaches in deep learning used the SARIMA model for forecasting the price of cucumber and traffic flow value [10, 11].

2.2 Problems in the Classical Models

These models require the data to be in a complete form. It does not support effectively missing data. Most of these models are based on linear relationship and also they deal with univariate data. These models can handle a small volume of data. We are in the big data era, where data from multiple sources are generated in a large volume. These large data should be processed to find the patterns in the existing data for better prediction. The statistical models are not able to perform well in the case of big data. The accuracy of these models is not enough. Hence, a model should be designed to eliminate all the problems associated with the traditional forecasting methods.

3 Deep Learning

Deep learning is a subset of machine learning in which the machine learns itself from the example. It is based on the artificial neural network with the number of hidden layers that enable the learning process easier. The deep learning models learn the features from the input data automatically which helps to improve the

accuracy in the classification and regression task. The increase in the number of hidden layers helps to learn the complex features from a large amount of data efficiently. The deep learning model needs high computing power to train a large volume of data to improve accuracy.

3.1 Deep Learning Models for Forecasting

The availability of a large volume of data and computing power makes the machine learning-based models for forecasting as a popular one. During recent times, the deep learning-based approaches gained popularity in time series forecasting in various domains due to their nature of automatic feature extraction. Deep learning-based model can handle the missing values in data in a better way. They support both univariate and multivariate forecasting. This can handle the nonlinear relationship among the data by automatically learning the complex mapping from inputs to outputs. They perform multistep forecasting efficiently.

These models will deeply analyze the huge amount of data and produce better predictions in most of the domains. These are designed to perform the short-term and long-term forecasting of future events or trends. In [12], the review of the various deep learning-based models for financial time series forecasting was discussed. The comparison between the various models and their performance were discussed.

The models for forecasting such as multilayer perceptron (MLP), fully connected neural network, CNN, RNN, GAN, and reinforcement learning models are discussed below.

3.2 Fully Connected Neural Network (FCNN)

Fully connected neural network consists of a number of fully connected layers. It is a feed-forward neural network that contains one or more hidden layers. It is capable of learning nonlinear functions. It supports multivariate and multistep forecasting. It can be used to perform time series forecasting in which the input features are the observations at previous time steps and predict the future value at one or more time steps.

The input layer takes the feature as input and the output layer produces the predicted value. Here we will discuss how the fully connected neural network performs prediction for the time series forecasting. Figure 1 shows the sample FCNN which takes the four-time step's value of stock details as input. There are two hidden layers in this network. The first layer contains five neurons and the second hidden layer contains three neurons. Finally, the output layer contains one neuron for predicting the next time step stock value.

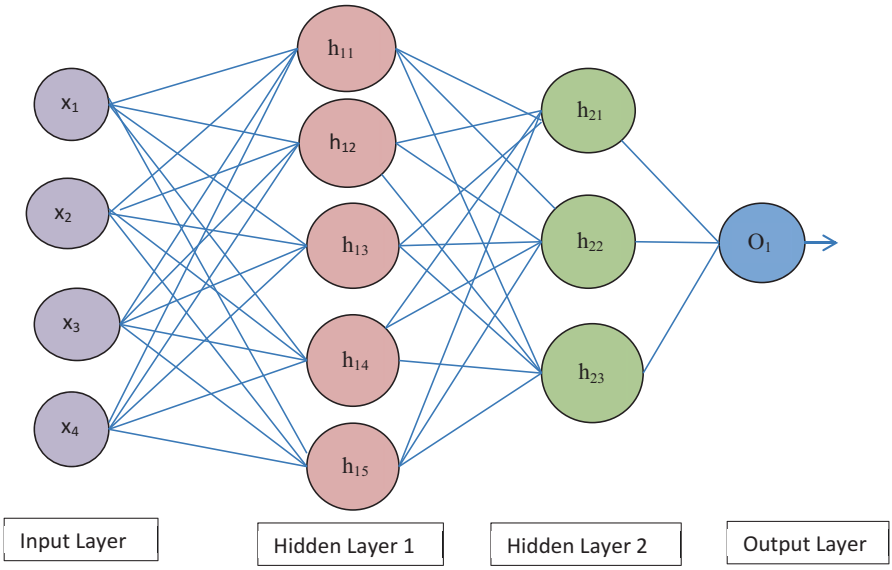


Fig. 1 Fully connected neural network

The training of the network is done in forward propagation. Here the input layer takes the input $x = (x_1, x_2, x_3, x_4)$ and it willgive the calculated value to the first hidden layer. The weights are assigned to the individual connections between the nodes. Y_i denotes the i^{th} output from the fully connected layer. The calculation that takes place at each node is given in Eq. (1):

$$Y_i = \text{sigmoid}\left(w_i * x_i + b\right) \tag{1}$$

The sigmoid activation function is used to introduce the nonlinearity to the data. W_i indicates the weight value and b denotes the bias value. The weight and input are multiplied and added with the bias value. Then the sigmoid activation function is applied to produce the output which is given as input of the first hidden layer. The calculation is repeated and the values are propagated until the output layer is reached. Finally, the output from the last layer $Y^{\wedge}$ which is the next time step prediction value is obtained.

Next, the predicted outcome is compared with the actual value to find out the errors. These error values will be propagated back to the layers to optimize the weights to reduce the error. This backpropagation calculates the gradient of the loss function. The gradient values are calculated and the optimization methods are used to update the weights in the network.

The activation function preferred at the output layer is the rectified linear unit (ReLU) which eliminates the problem of vanishing gradient. The loss function used in this FCNN for time series forecasting is mean squared error (MSE). The optimization function used in training the network is stochastic gradient descent (SGD).

It can be used for single-step as well as multi-step time prediction. FCNN can suffer from the problem of overfitting in which the network will not perform correctly on the new data even though it performs very well on the training data. This phenomenon can be avoided by using regularization techniques such as dropout and early stopping. Dropout refers that some nodes are randomly dropped from the network. These nodes are not considered for the particular iteration. It helps to reduce the interdependent learning among the nodes and learn more robust features. The model should be trained enough to learn the mapping from input to output but not so long which will degrade the performance. The training should be stopped when the performance of the model goes down. This is referred to as early stopping. In this way, the fully connected neural network can be used for solving time series forecasting problems.

3.3 Convolutional Neural Network (CNN)

Convolutional neural networks are a type of neural network which can learn and extract the features automatically from the input data. This makes CNN used frequently with image datasets. CNN can also be used for predicting time series information. The features are extracted from the input time series values which are treated as a one-dimensional image. These features represent the important features from past historic data which plays a major role in predicting future outcomes. The temporal order and the dependencies among the sequence data can be analyzed using CNN. It can able to perform univariate, multivariate, and both single-step and multistep forecasting effectively. A convolutional neural network-based deep learning model is proposed in [13] for predicting the foreign exchange rates. In [14] for predicting the stock price movement, the CNN model was proposed, and it predicts the Chinese stock market details efficiently. The convolutional neural network consists of a convolution layer, pooling layer, fully connected layer, and dense layer as shown in Fig. 2.

(i) Convolution Layer

The convolution layer extracts the features from the given input. Here in time series forecasting, the input sequence is considered as one-dimensional image from which the important features for the prediction are identified. The key points which play a vital role in predicting the next time step value are identified. The convolution operation is applied to the input sequence and the filter values. The output is a feature map which is the low-level features extracted from the input sequence. Multiple convolution layers are applied to extract high-level features.

After the convolution, the ReLU, sigmoid, and tanh activation function can be applied to introduce nonlinearity in the system. ReLU is preferred since it helps to eliminate the vanishing gradient problem during the backpropagation process. The gradient value decreases exponentially when moving on to the lower layer which reduces the learning capability of the neurons at the layer.

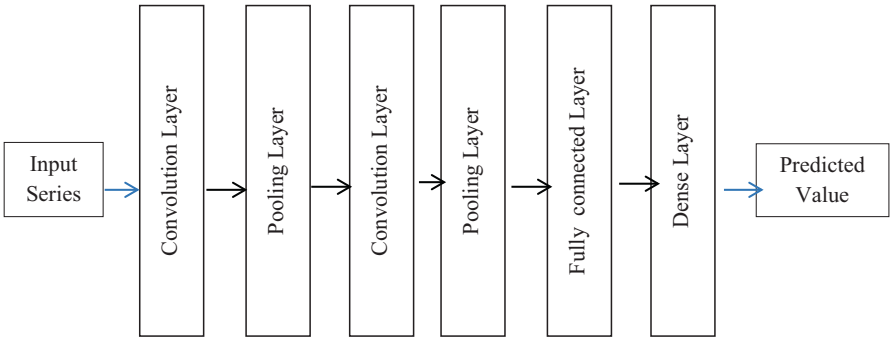


Fig. 2 Convolutional neural network

(ii) Pooling Layer

The pooling layer is used to reduce the spatial dimension of the input value. The pooling can be either max pooling or average pooling. In the case of max pooling, the maximum value from the set of values was considered. In average pooling, the average value will be taken.

(iii) Fully Connected Layer

After detecting the high-level features, a fully connected layer at the end of the network identifies the correlation of the feature in predicting the next time step value. Then it produces the corresponding next time step prediction value.

The network can be trained by a method known as backpropagation. The error value is calculated as the difference between the predicted time step value and the actual output. The error value should be minimized by updating the weight value of the filters which contribute the most in the loss value. Calculate the gradient value and that value is propagated to the entire network in a backward pass. Based on this value, the weights are updated for the next iteration. The process is repeated for a number of epochs until the model reaches the required accuracy.

CNN used in the forecasting of different entities such as, in [15], a deep learning-based short-term forecasting (DLSF) method proposed to predict the electrical load. It uses CNN to cluster the input and another neural network to perform prediction. In [16], GRU-CNN-based hybrid model proposed to support a large amount of data from smart sensors and smart meters which introduces complexity among the data. In this model, the temporal features were extracted from the time sequence load data by GRU, and CNN extracts other features. In [17], the electricity price forecasting problem was solved with the use of the CNN model along with PCA for feature extraction. Genetic approach used load balancing techniques [38] and cluster formation [39, 40] that are very much useful to solve load balancing problems.

3.4 Recurrent Neural Network (RNN)

RNN is a type of neural network suitable for solving problems involving a sequence of inputs. It can be defined as a network having loops and feedback which allows persisting information [41]. This recurrent connection adds memory to the neural network which helps to learn from the long input sequences. Fig. 3 shows the simplified RNN model.

RNN can be unfolded into a full network. X denotes the input sequence $<x_0,x_1,..x_t>$, S indicates the state vector, and O indicates the output. Training RNN is done in the following way.

x_t indicates input at time t. Each layer calculates the state S_t at time t based on the previous hidden state and the current input as given in Eq. (2):

$$S_t = A\left(WS_{t-1} + Ux_t\right) \tag{2}$$

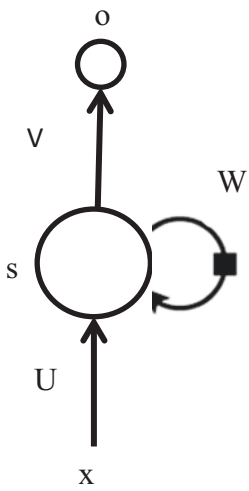
For time series problems, it is common to use a tan$h$ function for A. The current state becomes the S_{t-1} for the next time step. Repeat it for many steps as needed and combine all the information from previous states [42]. When the final state is obtained, the output can be produced using Eq. (3):

$$O_t = f\left(W * S_t\right) \tag{3}$$

The output obtained is compared with the actual output and find out the error value. The weight should be updated to reduce the error through backpropagation. Here we need to go back in time to adjust the weights of previous time steps.

A gradient-based method called backpropagation through time is used in RNN. The weights are the same at each time step. The gradient value is calculated for each time step based on the given weight value [43]. All time step gradient

Fig. 3 Simplified RNN



values are combined. Based on this value, the weights are updated. If the gradient value approaches zero, then all the value will become zero. Such a situation leads to the problem of vanishing gradient in which the network will not learn anything. RNN is very much suitable for time series forecasting problems such as household load forecasting [18].

3.5 Long Short-Term Memory (LSTM)

LSTM is a type of recurrent neural network which is capable of learning long-term dependency in a sequence of input. This solves the vanishing gradient problem of RNN by storing long-term information for making the decision [44]. Hence, it is suitable for time series prediction problems such as stock market prediction, weather forecasting, etc.

The internal structure of LSTM has a memory cell shown in Fig. 4 which helps to learn which data should be kept or discarded. The cell state carries relevant information during the processing of the input sequence [45]. The neural network structure is called gates that decide what information should be stored in a cell. LSTM consists of three gate structures, namely, input gate, forget gate, and output gate. Figure 4 described the various functionalities of LSTM cell.

The forget gate helps to decide what information should be stored in the cell or discarded from the cell. It takes the previous hidden state and current input and applies sigmoid function to decide whether to keep or discard data [46]. Next, one decides what information from the current input should be added to the cell state. For that, the input gate is used to decide which values to be updated. It takes the same input as that of the forget gate. The cell state ct can be updated with the values of it and the ct. The output value is calculated based on the cell state information. It is represented by Eqs. (4), (5), (6), (7), (8), and (9):

$$f_t = \sigma(W_f \left[x_t, h_{t-1}\right] + b_f \tag{4}$$

$$i_t = \sigma(W_i . \left[x_t, h_{t-1}\right] + b_i \tag{5}$$

$$C_t = f_t C_{t-1} + i_t \overline{C_t} \tag{6}$$

$$\overline{C_t} = \tan h(W_c . \left[x_t, h_{t-1}\right] + b_c \tag{7}$$

$$O_t = \sigma(W_o . \left[x_t, h_{t-1}\right] + b_o \tag{8}$$

$$h_t = O_t . \tanh\left(C_t\right) \tag{9}$$

The long-term dependencies in the input sequence can be easily identified with the help of LSTM. There are variations of LSTM that are available such as depth-gated RNN [19] and clockwork RNN [20] used to solve long-term dependency problem [47].

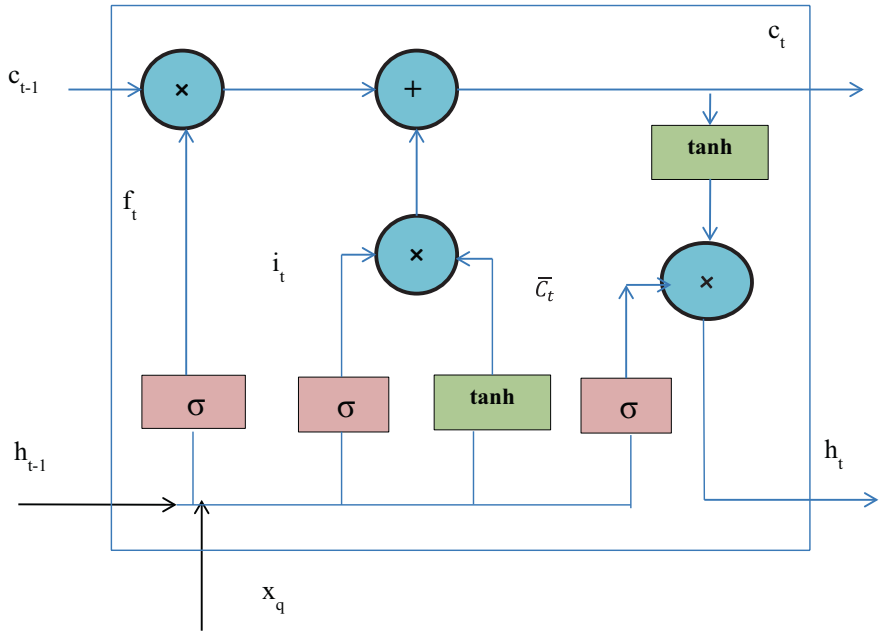


Fig. 4 LSTM cell

LSTM can be used in all types of forecasting such as stock price, oil price, flood value, electrical load value, fog, rain value, etc. In [21], LSTM-based attention model is proposed to forecast financial time series data. It uses wavelet transform to extract the features from the sequence data [48]. An ensemble empirical mode decomposition (EEMD) along with the LSTM model [22] is used to perform forecasting of crude oil price. In [23], LSTM-based attention mechanism known as the spatiotemporal attention long short-term memory (STA-LSTM) model is proposed. In [42], LSTM-based deep learning model is proposed to forecast the short-term load consumption. LSTM framework is proposed in [25] to forecast the short-term fog data.

3.6 Gated Recurrent Unit (GRU)

Gated recurrent unit is the simplified version of LSTM. It combines the input gate and forget gate into a single gate called update gate. It also combines the hidden state and cell state and it has fewer parameters than LSTM.

GRU shown in Fig. 5 uses two gates, namely, the update gate and reset gate, to decide what data should be passed to the output. The update gate helps to decide what information to discard and what should be added. The reset gate helps to

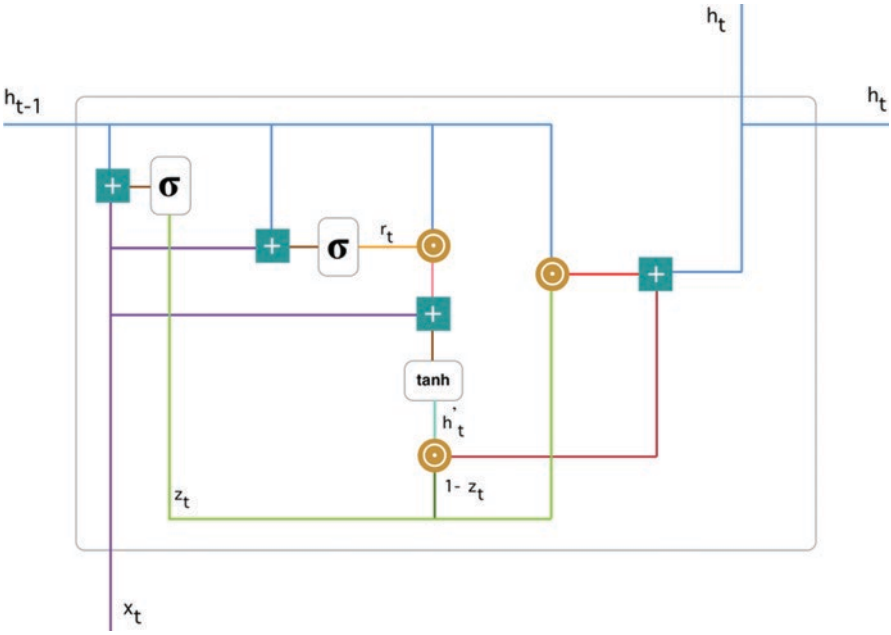


Fig. 5 GRU [26]

identify how much old data to forget [49]. The equations to calculate the values are given below.

x_t indicates the input at time step t. The update gate value z_t is calculated from the current input and the previous hidden state value s_{t-1}. Forget gate also calculates the same thing with the different weight values. Calculate the new memory content based on the reset gate value. Finally, calculate the value of s_t the current hidden state value which will be used for the next time step. It is represented by Eqs. (10), (11), (12), and (13):

$$z_t = \sigma(W_z \left[x_t, s_{t-1}\right] \tag{10}$$

$$r_t = \sigma(W_r . \left[x_t, s_{t-1}\right] \tag{11}$$

$$\overline{s_t} = \tan h\left(W . \left[r_t * s_{t-1}, x_t\right]\right) \tag{12}$$

$$s_t = \left(1 - z_t\right) * s_{t-1} + z_t * \overline{s_t} \tag{13}$$

The LSTM and GRU models can be stacked together to identify the long-term features in the input sequence data.

A multi-task learning based on GRU along with residual mapping and feature engineering is proposed in [27] to improve the forecasting accuracy of traffic state. In [28], CNN-GRU-based model is proposed for forecasting short-term busload.

The important factors are extracted and compressed using CNN to generate the feature vector, and multilayer GRU is used to perform forecasting. In [29], GRU combined with the wavelet soft threshold denoising model is proposed to perform wind speed prediction. WSTD was used to remove redundancy from the data, and GRU was used to learn the features and perform a multistep forecasting. In [30], a convolutional-based bidirectional gated recurrent unit (CBGRU) model was used to perform air pollution forecasting. This method used both CNN and GRU for prediction [50].

3.7 Generative Adversarial Network (GAN)

A GAN is a type of deep neural network which can be used in time series forecasting task. In a GAN architecture, there is a generative network and discriminative network and it is shown in Fig. 6. These neural networks perform the task of generating and evaluating samples [51]. The generator takes as an input of past times series data (x_0, x_1, x_2, ..., x_t) and generates the value at x_{t+1}, the next time step value. The discriminator evaluates the real value and the generated value and distinguishes the data by generator from the real data. It takes data from the generator and real value and classifies the data, i.e., whether the data is generated or real. In [31], the missing values in the multivariate time series data are generated with the help of a generative adversarial network. Along with gated recurrent unit, it is used to model the irregularity in the time series. Conditional GAN proposed in [32] is used to learn and model the economic time series data. The ability of CGAN helps to forecast the different types of data distributions. In [33], DNN-based approach of generative adversarial network was developed for modeling financial time series data. GAN generates data by learning the properties of data [52].

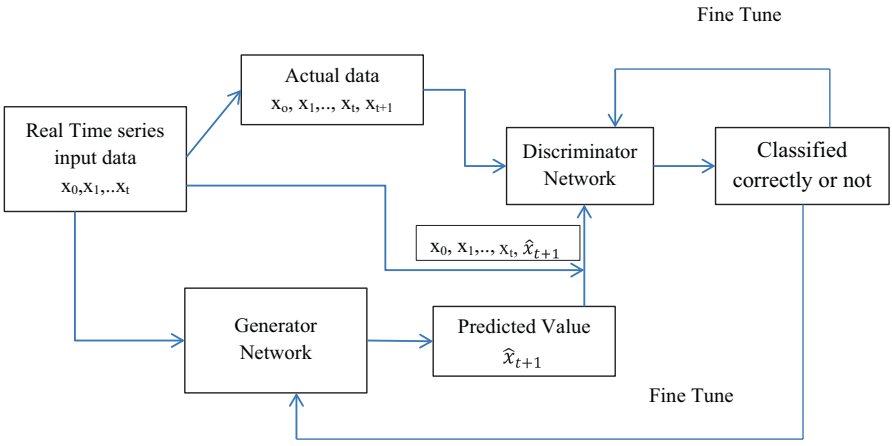


Fig. 6 GAN architecture

The goal of the generator is to maximize the error rate. The network is trained in a manner such that it should produce accurate predicted values by which the discriminator fails to classify the generated and real data. The discriminator is designed in a way such that the final classification error should be minimum. The backpropagation method is applied in both networks. In each iteration, the generator network weights are updated to increase the error and to decrease the error in the discriminator [53]. This can be considered as a minmax two-player game setting given in Eq. (14):

$$\min G \max DV(G,D) = E\left[\log D\left(X_{\text{real}}\right)\right] + E\left[\log\left(1 - D\left(X_{\text{fake}}\right)\right)\right] \tag{14}$$

The generator network can be designed using LSTM which will predict the next time step value effectively. LSTM performs well in the field of time series forecasting. In GAN, the LSTM is used for the generator network which takes input as a multivariate stock data to predict the price. The stock details of t days were taken as input $X = [x_1, x_2, ..,x_t]$. The LSTM will produce the output of $\hat{x}_{t+1}$.

The discriminator uses multilayer perceptron or CNN to classify the predicted data from LSTM and the actual data. It is trained with real data and the predicted data such that the classification error should be minimal. The output from the discriminator can indicate whether the input to the network is actual data or predicted data. Figure 6 shows the GAN architecture.

This will improve the performance of the forecasting model compared to the other methods. Both networks will try to defeat each other, hence performing better and better. Hence, the prediction accuracy gets improved.

3.8 Deep Reinforcement Learning

Deep reinforcement learning is a type of learning in which the agent learns by trial and error from the feedback received for its every action. In [34], the various algorithms in deep reinforcement learning and its applications in various fields are described. Here unlike supervised or unsupervised learning, the training dataset need not be a labeled or clustered one. It is based on the concept of learning in an interactive environment by using rewards and punishments as feedback to improve the model. The goal of this model is to find the best model which would maximize the total reward of the agent. The system is trained continuously by adapting the changes in the environment. It is based on the Markov decision process.

RL can be denoted with MDP using five tuples such as state which includes the set of states, actions, reward function, and state transition probability matrix ($p(s_0, r|s, a)$ which indicates the action a applied to state s gives the reward as r and moves to the next state s_0, discount factor (γ, the present value of future rewards). The major objective of this process is to maximize the total reward.

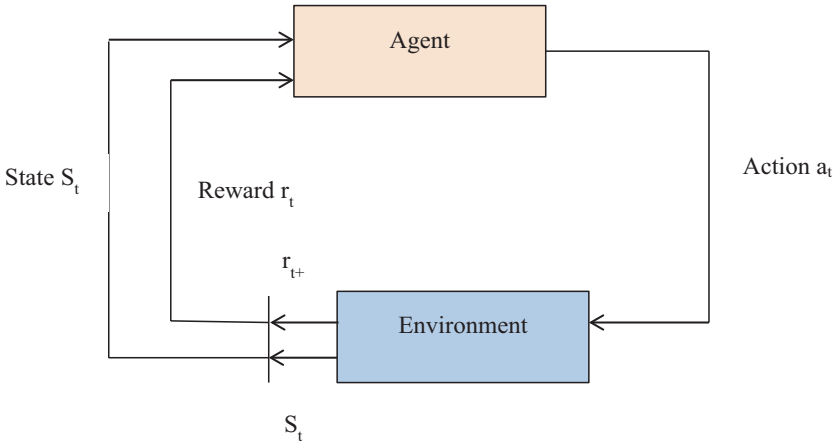


Fig. 7 Deep reinforcement learning representation

Initially, the neural network coefficients are assigned randomly. After obtaining the feedback from the environment for every action in terms of scalar value, the model can adjust its weights and improve the state-action values [24]. The system learns not only by the immediate rewards but also by the previous rewards that were returned before several time steps deeper. The deep reinforcement learning representation is shown in Fig. 7.

In [35], a demand forecasting methodology using clustering and reinforcement learning techniques is used for forecasting freight operation planning. It performs long-term freight demand weekly forecasting. A new ensemble deep reinforcement learning model was proposed in [36] to perform wind speed prediction. In this work, three kinds of deep neural networks are combined using the reinforcement learning method. In [37], the stochastic gradient ascent method of reinforcement learning approach is used for time series forecasting [39]. It was used in DBN with RBM for fine-tuning the network.

4 Experimental Results

The time series forecasting models such as fully connected NN, convolutional neural network, RNN-LSTM, and GRU model performance are compared using the stock market prediction data. The stock market details from the year 2006 to 2017 are considered for our experimental analysis. The attributes in the dataset are opening, closing, and the low and high value of stock details.

The performance measures used in the forecasting model are mean absolute error and root mean squared error. Mean absolute error (MAE) is the average of the absolute difference between the true values and predicted values. Mean squared

Table 1 Performance indicator values

Model	RMSE	MSE	MAE
FCNN	3.90	15.22	2.88
CNN	6.95	48.34	5.38
LSTM	3.52	12.45	2.43
GRU	3.24	10.55	2.21

error (MSE) is the average of the square of the difference between the true value and the predicted value. Root mean squared error (RMSE) is the root value of the mean squared error.

In the LSTM model, four LSTM layers with 100 and 50 neurons and a final output layer with a single neuron are designed. Dropout is applied after LSTM layers to discard certain neurons from the calculation in each epoch which will help to improve the learning. "RMSprop" optimizer is used here.

In the RNN-GRU model, four GRU layers with 100 and 50 neurons with tanh activation function are applied to each layer. Here also the dropout is applied. The stochastic gradient descendent optimizer is used and the learning rate is set as 0.01.

In a convolutional neural network, two convolution layers along with max-pooling layer are used. Convolution layer with 64 filters and "ReLU" activation function is applied. After that, the feature map is flattened into one-dimensional array followed by a dense layer to predict the output. In the fully connected neural network model, two dense layers with 100 neurons and a final output layer to predict the future stock value are designed.

The error values of these models are shown in Table 1. Figure 8 shows that the GRU model gives better results when compared to all other models for this stock prediction. The MAE and RMSE values are low compared to other approaches of the forecasting model. Based on the input and the seasonality and trend, the performance of every model may get varied. Every model is adapted based on the applications and its requirement.

5 Conclusion

Forecasting is an important research area in all domains. The prediction of future trends or events plays a vital role in enriching the business and identifying marketing demands. The accurate forecasting of the future needs helps to plan accordingly without delaying the service. For example, the traffic flow forecasting helps the passengers and transportation authorities to plan their travel decision and travel timing. The accurate forecasting is provided with the help of a deep learning method that learns the deep features from the large volume of past data along with the influencing factors. The recurrent neural network LSTM and GRU perform the time series forecasting very well. Many hybrid approaches such as "statistical" techniques along with deep learning techniques are also used to perform prediction. Recently,

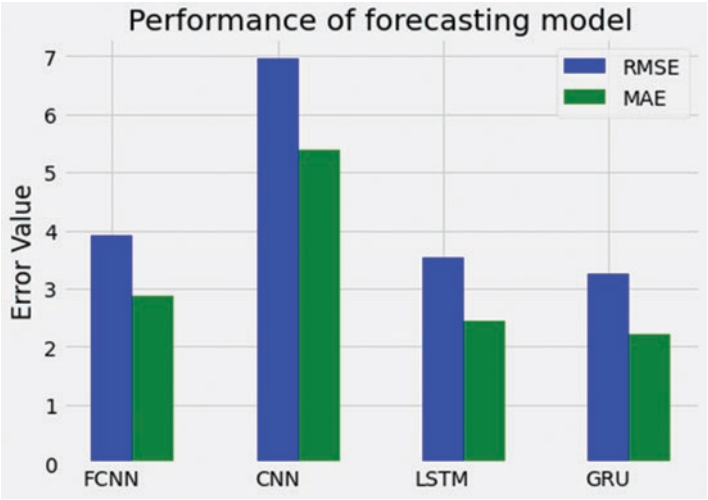


Fig. 8 Performance comparison of forecasting models

the generative adversarial neural network is also used to provide accurate forecasting value.

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Performance Evaluation of Heat Pump Dryer in Specific Moisture Evaporation Rate for Various Herbal Leaves

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***Abstract* - Drying is an important process followed in Siddha, Ayurveda, and Food processing industries for resisting the growth of Fungi and other germs. Heat pumping drying is one the promising technology where the drying is attained by the concept of refrigeration cycle to dry the herbal leaves with controlling the operating parameters like pressure, temperature, and humidity of the circulating air and without the influence of the atmosphere condition. In this proposed work a three-ton capacity heat pump dryer is designed and fabricated where R134a was used as a refrigerant with tray type drying chamber for testing the moisture removal rate of three different herbal leaves Tulsi (Ocimum tenuiflorum), curry leaves (Murraya koenigii), and Bermuda grass (Cynodon dactylon). The velocity, temperature, humidity, and pressure of circulating air are the predominant operating parameters that affect the Specific Moisture Evaporation Rate of the closed-loop heat pump dryer. The experiments were conducted at condition 2.5 m/s velocity, transient temperature, and humidity with an atmospheric pressure of circulating air, and the Moisture removal rate is evaluated for the given herbal leaves.**

Keywords - Heat pump dryer, Moisture removal rate, Food processing, leaf drying, Tulsi, Curry leaves, Bermuda grass

I. INTRODUCTION

Heat pump drying is one of the methods in which the drying of bio product can be prepared with no influence of atmospheric condition and the drying is achieved with less energy consumption. The medicinal plants have to be stored as dried products to avoid the development of fungi, yeasts, and bacteria. The relative humidity less than or equal to 60% is a suggested value to preserve the medicinal plant during storage for maintaining the good quality of the product [1]. A heat pump system under vacuum conditions is developed to dry the Moringa leaves and the moisture removal rate is increased by reducing the pressure of the circulation air significantly [2]. The integration of different drying technologies like a fluidized bed with the heat pump dryer [3], microwave drying and multi-flash drying, microwave and vacuum drying is produced a good result in dehydrating rate [4]. Ginger a medicinal product is dried in a tray-type dryer at different combination of slice size of the ginger, temperature, and the velocity of airflow, the result shows that the drying rate is affected by the properties of air like temperature, velocity, and the dimensions of the ginger slice [5]. Moringa oleifera which contains the higher quantity of micro and macronutrient content and the loss in nutrient content concerning the temperature was analysed, the better quantity of nutrients is attained at the drying temperature range of 40°C to 50°C, and the drying temperature for the Moringa leaves is maintained more than 50°C in the oven drying will cause for the unexpected nutrient loss [6]. The change in moisture content, hardness, antioxidant activity, and colour of kiwi fruit was investigated at the hot air and vacuum drying conditions for the vacuum pressure of 3kPa and the drying process temperature of 50, 60, and 70°C, the L-ascorbic acid is prevented better in vacuum drying compared to hot air drying [7]. The various drying technologies like Rotary drum dryer, Fluidized bed dryer, Pneumatic dryer, Agitated drum dryer, Solar dryer, Microwave dryer, and Far-infrared dryer, available in the conversion of biomass to biofuel are reviewed and the results were compared in the tabulated format, integrating the advanced system in the conventional dryer will promisingly increase the drying efficiency [8].

Drying the product cassava in a fluidized bed dryer at three different mass flow rate of air with the temperature range of 60°C to 160°C for the interval of 20°C is analyzed, from the experimental result it is concluded that the drying time is decreased with increase in air flow rate and the temperature of the drying air [9]. The combined heat pump vacuum-microwave dryer has a 50% shorter drying time compared to heat pump-assisted drying and convective vacuum-microwave drying for the drying product apple [10]. The solar-assisted heat pump dryer was developed to dry banana chips and the drying rate of the developed model is compared with simple heat pump drying, infrared-assisted heat pump drying, solar-assisted heat pump drying. The results indicate that the specific moisture extraction rate is observed higher in the solar-assisted heat pump dryer than the other methods [11]. The promising low Global Warming Potential (GWP) refrigerants were used as working fluid in

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AUTOMATIC LATCHING OF DOOR BY SENSING PHYSIOGNOMIC DATA USING DEEP FACE RECOGNITION TECHNIQUES

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Abstract:
Deep neural networks (DNNs) have been widely used in recent research works for deep face recognition. In this work, the OpenCV package will be used for the controlling of the doors using deep face recognition techniques. A security system for use on doors which have an electrically operated door locking mechanism is disclosed, this system is completely done by using the face recognition techniques. The Artificial Intelligence and the Deep Learning models and techniques were used to do this work. The visual input is given to the system, which converts the input to the signals and identified the person who arrived. The python 3.7 languages will be used for the programming of the project. The Anaconda3, Spyder, Jupiter notebook are the tools that were utilized for the programming.

Keywords:
Deep Neural Network; OPenCV; face recognition; Latching; Door Mechanism.

INTRODUCTION

A Face recognition technology is a process of recognizing the human faces by capturing the images or videos. There are multiple methods of face recognition methods are available, but these methods are working by comparing the selected facial feature by capturing the given images. Facial recognition is a type of bio-metric based Artificial Intelligence Technology. AI based facial recognition can be used to identify a person by analyzing the facial features based on the person's facial expression, textures and shape. Facial recognition is a typical system that controls the security system in many real time applications like Classroom attendance register, identifying person inside the rooms and etc.,

A. Literature Survey

According to Chen, Ying-Nong, et.al designed the model with two detectors, one for the face and another for license plates, both are based on a modified Convolution Neural Network (CNN). Pyramid –based localization techniques are applied to identify the regions of faces or license plates. A bootstrapped training procedure is adopted in the Face detector training methodology [1]. Lawrence, Steve, et al proposes the Hybrid Neural-Network solution which compares favorably with other methods and a Self-Organizing Map (SOM) which provides a quantization of the image samples into a topological space where inputs that is nearby in the original space are also nearby in the output space. In this paper, ORL database is used which contains a set of faces. The convolutional neural network is used to extract larger features in a hierarchical set of layers and they replace SOM by KL Transform and CNN by Multilayer Perceptron (MLP) [2]. Li, Haoxiang, et al paper includes CNN cascade for fast face detection with very powerful discriminating capability, while maintaining high performance. The proposed CNN cascade operates at multiple resolutions, quickly rejects the background regions in the fast-low resolution stages and carefully evaluates. A CNN-based calibration stage is included to improve localization effectiveness after each of the detection stages in the cascade [3].

According to Moon, Hae-Min et.al door could by opened by a proper method for long-distance face recognition by resolving the change in recognition rate resulting from distance change in long distance face recognition. The recognition technology that discriminates or recognizes certain individuals is important for the security which provides intelligence services [4]. Lawrence, Steve, C. Lee Giles, and Ah Chung Tsoi proposed that the system consists of local image sampling, a self-organizing map (SOM) neural network and a Convolutional Neural Network (CNN). The SOM is used to provide a quantization of the sampled image into topological space and convolutional neural network is used to extract larger features in a hierarchical set of layers. With five images per person this method results in 3.8% and 10.5% error. They use a database of 400 images of 40 individuals which contains high degree of variability in facial details in "Convolutional neural networks for face recognition" [5]. Ding, Changxing, and Dacheng Tao propose "Robust face recognition via multimodal deep face representation", the deep learning structure is consists of convolutional neural networks (CNN) and a three-layer stacked auto-encoder (SAE). The CNN is used to extract larger features in a hierarchical set of layers. The extract features are concatenated as raw feature vector and its dimension is compressed by three layered SAE [6].

According to Aiman et.al proposes the modified deep learning neural network is used to learn face representation from a smaller database. This system consists of Convolutional neutral networks CNNs, Rectified

Linear Unit (ReLU) and fully connected layers. The synthetically generated samples were augmented by applying Gaussian and Poisson noise to each sample. Thus, the augmented samples improve the generalization power of CNNs. In this network were trained by using the standard AT&T face database [7]. Hjelmås, Erik, and Boon Kee Low made a survey, "Face detection: A survey". In this survey they have used either feature-based or image-based. Because of the lack of standardized tests, they do not provide comprehensive comparative results, if the results were reported on a common database at that time comparisons will be presented. The aim of this survey is to provide the insight into the contemporary research of face detection in a structure manner [8].

*According to Heisele Bernd et.al made a cognitive search for the component-based framework is used for face detection and identification. Hierarchical architecture was shared by both face detection module and identification module. They both consist of two layers. The first layer consists of a set of component classifiers and the second layer consists of the single combination classifier. The component classifiers are independently detected or identify the facial parts given in the image. And their respective outputs were passed to the combined classifier. It is used to perform the final detection or identification of the face. In this paper they compared the detection and identification systems to standard global approaches [9]. Farfade et al proposed Deep Dense Face Detector (DDFD). This method does not require any pose or landmark and it is able to detect our faces in a wide range by using a single model based on deep convolutional neural networks (CNN). They analyzed that the proposed face detector for different face orientations was able to detect the faces from different angles and also handle the occlusion to some extent. The performance of the detector was improved by using sampling strategies [10]. Keller, Daniel N designed the latch assembly for overhead bifold doors is operated by manual or powered winch mechanism. This mechanism is used to open and close the overhead bifold door. Latch assembly was connected either one end or at both the ends overhead bifold door. This can be mounted at the ends of the overhead bifold door. It also consists of a latch arm which is used to move a latching position. At the adjacent of the door jamb the latch member is fixedly positioned. The latch member is positioned between the latch arm and in the overhead bifold door, if the latch arm is drawn down. Which results in the overhead bifold door to be securely latched in its closed position until the winch mechanism is activated for the overhead bifold door opening cycle [11].*so that they are equal. Use automatic hyphenation and check spelling and grammar. Use high resolution (300dpi or above) figures, plots, drawings and photos for best printing result.

B. Creation of the Dataset

In this section the person who are allowed to enter into the place's faces are captured by using the high-resolution camera. For the training of faces there must be required maximum number of photos for the one particular person. It maybe there are 1000 to 2000 images of single person with different angles. So that it produces the maximum accuracy level with minimum number of errors identified. The accuracy level of the program is determined by total number of images and the Epoch value. If the Epoch value is very minimum (i.e., 100) the level of accuracy is also less. Another way the value of Epoch is higher (i.e., 5000) the level of accuracy is higher and that should be required for our process. The capturing images is stored in the new folder. The different views of the face of the person are captured and saved as a complete person dataset. This will be done for different person and the different dataset will be formed. The dataset is packed as a collected package of complete dataset.


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C. Modification of the Dataset

In this section the conversion process takes place. The captured images are converted into the gray scale images as per required. The gray scale images are required the default size of images. The width and Height of the images is must be equal for all the images. These images can modify by itself based on the program entered. During the conversion process the following processes takes place.

1. Holistic Matching Methods
2. Feature-based (structural) Methods
3. Hybrid Methods.

The dataset created will have different properties. The images may have different colors, different sizes etc., the images were converted into gray scale images and they were made as unique color. They were standardized as the standard size.

D. Preparation of the Images

After capturing and conversion of images we prepared the images for the test running. The required program was written by using the python program. That program has been preparing the images for the suitability of face recognition. The following program has been used for preparation of images.

Sample 1

Sample 2

E. Training of Images

The dataset created in the form of images will need training before it is executed. The training is done multiple times on the dataset for the perfect execution of the model. The capturing of images has been trained after the preparation of images. Python program has been written for the training of images. The following program has been used for the training.

F. Recognition of Images

If the face of the known person or provided the person is detected, then the particular person's name is shown and the applications were done according to which we provided. The camera and raspberry pi were used for this particular work. After the finishing of preparation and training the particular faces are ready to capture. The trained faces only identified and allows the persons to get inside the particular region. For the recognition of faces the following program is written by using the python program.

Sample 1

Sample 2

Sample 3

G. Door Opening Mechanism

The mechanism will be made for the automatic opening of doors which receives input signal from the recognized face data. The piston is placed on the wall whose rod is made as the rack and the pinion roller is used to convert the linear actuation into the rotary movement. The parallelogram mechanism is made between the pinion roller and the door. By the use of these mechanisms the automatic opening of the door can be done.

H. Conclusion

The work "Automatic Latching of doors by sensing physiognomic data using Deep Face Recognition Techniques" has been completed successfully. The working of the Automatic Latching of doors is done by sensing images of the different person and the OpenCV Model is also used for this work.

I. Future works

The project is to be developed further by using the Convolution Neural Networks (CNN) model. The project is further developed by making it as an application for the identification of the presence of the different person.

ACKNOWLEDGMENT

We are thankful to RAMCO Institute of Technology provided expertise that greatly assisted the research, although they may not agree with all of the interpretations provided in this article

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Prediction of Temperature Distribution in Three Dimensional Solid Objects using COMSOL and Python

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Abstract

Visualizing the Temperature distribution profile inside a solid is very important for many material industries in order to determine the capacity of material to conduct heat, material is uniform throughout without void and guessing the possibilities of introducing a new alloy for the available temperature. But there are many issues in predicting the three dimensional (3D) temperature plot are overlapping two or more points, discontinuous profile at very high temperatures, visualizing a specific range is not possible. Process of creating an intricate part for a specialized application is prohibitive with respect to cost, time and manufacturing processes. Hence computational models are developed using COMSOL Multi Physics software by selecting the material as stainless steel followed by static thermal analysis with a temperature range of and simulated the temperature flow 1000 ^{o}C to 1500 ^{o}C in a 3D solid body by having three probe node points in the solid. The obtained data is imported to Python as CSV file. The data from the computational models predicts the temperature behavior by using Python Programming language determines a polynomial equation obtained from the trend line. The uniqueness of the prediction is that; we can predict the temperature of the 3D body even if the sensor probe fails to detect the temperature.

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Performance comparison of Closed Loop Heat Pump Dryer with Bed, Tray and Bed-Tray Dryer for Curry Leaves

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Abstract - Heat pump assisted drying provides a regulated drying environment by controlling the temperature and humidity of air through which the product quality can be improved with less energy consumption. It has incredible potential for the future, as well as the opportunity for a revolution in drying techniques. An expansion valve, evaporator, condenser, and compressor make up the heat pump system, in connection with the copper tube of each component. In this project, the heat pump dryer was designed and fabricated where R134a is used as the working fluid to dry the Indian spice Murraya koenigii (curry leaves). Murraya koenigii has many bioactive principles as a result of which it is a medicinally valuable herb. The curry leaves are dried in a closed-loop heat pump dryer under three different methods namely, Bed drying, tray drying, and compound drying which is a combination of both bed and tray drying at three different velocities 1.5 m/s, 2 m/s and 2.5 m/s. The drying characteristics of the closed loop heat pump dryer is analysed with different combination of drying methods and velocities for curry leaves.

Keywords – Drying; Heat pump dryer; Moisture Removal Rate; Bed dryer; Bed-Tray Dryer; Curry leaves.

INTRODUCTION

Heat pump drying method is one in which the drying can be achieved without relying on atmospheric conditions and with minimal energy use. The growth of fungus, yeasts, bacteria and other microorganisms' are prevented in the dried food and medicinal products when it is stored for long duration. The heat pump recovers the latent and sensible heat of evaporated moisture of the drying product and that heat is returned to the dryer by reheating the dehumidified air, resulting in a significant gain in energy efficiency due to heat recovery that would otherwise be lost to the atmosphere in traditional dryers [1]. Three Heat Pump Dryer (HPD) system designs with no air recirculation, two with partial air recirculation, and one with full air recirculation were investigated, As the air recirculation rate is increased, the efficiency of HPD systems with partial air recirculation falls and partial air recirculation systems are more efficient than no air and full air recirculation systems [2]. Heat pump assisted dryer prototype with mechanical opener drying system is fabricated and test was conducted to investigate the performance of heat pump dryer which has done by calculating SMER (Specific Moisture Extraction Rate) and COP (Coefficient of Performance). The homogenous drying is attained in this system with four times higher drying rate compared to natural drying [3]. A proportional–integral–derivative controller (PID) temperature controlled bed heat pump dryer is designed and constructed and thermodynamic analysis was done. The experimental tests were conducted for three different products mint, parsley and basil at 40°C operating temperature with uncertainty of ±0.36°C for the drying air velocity of minimum of 1.01 m/s to 7.4 m/s, the COP of heat pump dryer is obtained as 1.91[4]. The heat pump dryer operating at low temperature is constructed and experiments were conducted for 5 hour duration in sludge with different temperature and mass flow rate conditions. The rise in condensing temperature increases the drying rate whereas the drying rate drops while the evaporation temperature increases and the increase in air mass flow rate will causes for first increase and then decrease in drying rate [5]. The mathematical model was developed by which the drying rate can be calculated for change in parameters during the process to the product of corn in a bed dryer. The model's advantage is that it just uses thermal and physical characteristics, which eliminates the need for preparatory studies to determine kinetic parameters. [6]. To evaluate long-term performance characteristics for the drying

system, mathematical modelling of wheat drying system operating with a ground coupled heat pump and an underground Thermal Energy Storage (TES) tank charged by solar energy was developed. The efficiency of the drying system is greatly influenced by the thermophysical parameters of the geological structure surrounding the subterranean TES tank. [7]. The hybrid drying system, water/air heat pump powered by a concentrated photovoltaic thermal system is designed and developed to dry the softwood and it is reducing the electrical energy consumption 39% and 89% in January and July, respectively than the conventional drying system [8]. The drawback and benefits of different drying technologies, solar dryer, Biomass, Biogas and geothermal which are operating based on the sustainable energy of single heat source and solar hybrid heat sources were discussed quantitatively and qualitatively [9]. The close loop heat pump dryer operating with lower than atmospheric pressure is designed and fabricated and the experiments were conducted for combinations of 0.9 & 0.8 bar pressure and 1.1 & 1.4 m/s velocity operating conditions and the result shows that the drying rate is increased 58.33% by inducing the vacuum pressure and increasing velocity in the close loop heat pump dryer compared to conventional heat pump dryer [10]. The drying behaviour of the grape pomace is investigated in closed loop heat pump dryer at 45 and 50°C temperatures and the better quality of drying is achieved at 45°C [11]. The hot air dryer equipped with heat pump and air recirculated system is constructed to dry Kiwifruit slices and the test was conducted for various ratio of recirculation air and the results conclude at 45°C, 0% recirculation condition consumes maximum specific energy of 21.7 kWh/kg and the minimum specific energy consumption of 7.5 kWh/kg is obtained at 65°C, 100 % air recirculation condition [12]. The drying kinetic of mint leaves is observed in solar assisted bed dryer with different sources of heat energy like electric heater or microwave energy, solar air heater and parabolic trough collector [13]. Exergy analysis of heat pump drying system for drying food products has been completed and the result shows that the exergy efficiency is increased from 65.94 to 91.95% when increasing the operation temperature from 45°C to 55°C [14]. The multifunctional air source heat pump dryer was designed and fabricated for investigating the drying characters of food product and the experiments were conducted for drying garlic chips and results of three different types open, semi-open and closed type of Heat pump dryers performance were compared and the closed type heat pump dryer is less affected by ambient conditions [15]. The drying rate and quality of mature ginger is compared in the types of drying methods, tray drying, heat pump–Dehumidified drying at the temperatures of 40, 50 and 60°C and mixed–mode solar drying at 62.82°C with a radiation intensity of 62.82°C. The better quality is achieved in heat pump–Dehumidified dryer at 40°C and the best drying rate is achieved in the mixed mode of solar dryer [16]. The proposed work compares the performance of closed loop heat pump dryer at three different types of dryer bed, tray and combined bed-tray.

Material and Methods

A. Materials

The experiments were conducted to find the drying rate of Curry leaves (Murraya koenigii) which is having a good medicinal characteristics and that was purchased directly from the formers who are doing cultivating curry leaves in and around the Rajapalayam.

B. Sample preparation

The leaves were thoroughly cleansed with fresh water in order to remove any undesired particles that could impact the product's drying rate. After being cleaned with water, the materials are placed for at least 3 minutes in paper that will absorb the water particles from the leaves' surface. The leaves were purchased on the day and prepared for conducting the experiments on the site in order to avoid the natural drying. The sample preparation for each reading weighs 3 kg.

C. Design and Development of Closed-Loop Heat Pump Dryer

1) Design

The heat pump dryer run by 3 ton capacity compressor is designed dry the different types of herbal leaves with three different types of dryer as bed, tray and bed-tray dryer to evaluate its performance at the transient temperature conditions. The inlet velocity to the drying chamber of the circulated air is maintained as 1.5, 2.0 and 2.5 m/s. The schematic diagram of closed loop heat pump dryer is given in Fig.1 and the specification of

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components and measuring instruments in given in table I and II respectively.

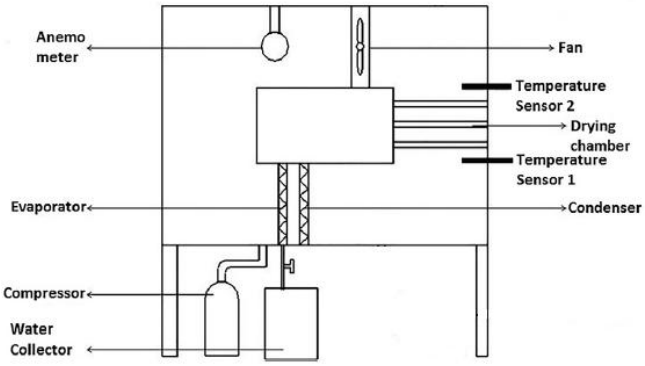

Fig.1 Closed Loop Heat Pump Dryer

TABLE I
SPECIFICATION OF COMPONENTS

Sl. No.	Components	Specifications
1.	Compressor	3-Ton capacity – scroll compressor
2.	Evaporator	3-Ton capacity – Copper coil – vertical finned type
3.	Condenser	3-Ton capacity – Copper coil – vertical finned type
4.	Expansion device	3-Ton capacity expansion valve
5.	Fan	1.5 kW capacity – 2 Nos.
6.	Fabrication plate	G.I Plate with 5 mm thickness
7.	Drying tray	Stainless steel tray with the dimensions of 100 cm x 60 cm

TABLE II
SPECIFICATION OF MEASURING INSTRUMENTS

Sl. No.	Measuring Instrument	Specifications
1.	Anemometer	0 – 45 m/s
2.	Temperature sensor	0 – 99 °C
3.	Humidity sensor	0 – 99 %

2) Operation

The air which is having low Relative humidity can able to absorb the moisture contents in the products. The low relative humidity in air is achieved by the refrigeration system by cooling the air below the dew point temperature and then heated by heat rejected in the condenser. This low-relative-humidity air is directed to the drying chamber, which contains the product to be dried. The high relative humidity air comes out from the drying chamber will be converted to the low relative humidity air by circulating though the evaporator and condenser of the refrigeration system and the process is continuous until the required drying is attained. The drying of products is reached in closed loop heat pump dryer by simultaneous working of two different cycle followed in the heat pump dryer (a) Refrigerant flow circuit and (b) Air flow circuit. The schematic diagram of these two circuit representation is given in Fig.2. [17]

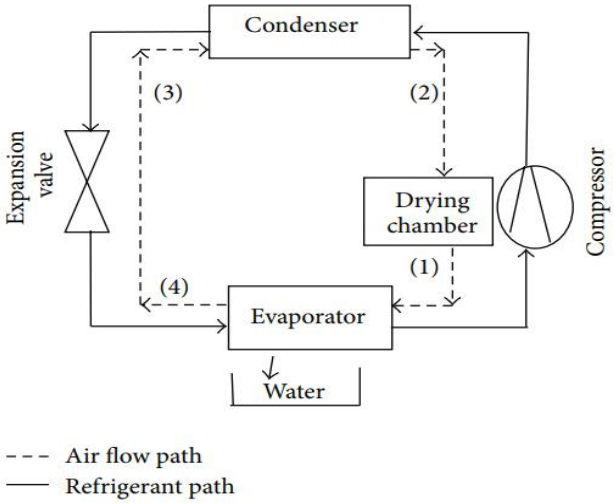

Fig.2 Refrigerant and air flow circuit in Heat pump dryer

Refrigerant flow circuit

The compressor, condenser, expansion device and the evaporator are the main components of the refrigeration flow circuit. The high pressure and high temperature refrigerant comes out from the compressor is entered into the condenser where the condensation of refrigerant is occur and then it is passes through the expansion device and evaporator.

Air flow circuit

In this circuit the air which is not affected by the atmospheric condition is continuously circulated in the closed chamber in which the main components of the refrigeration system like evaporator and condenser is placed.

Working principle

The air of air flow circuit is passed through the evaporator where the air is attained its dew point temperature because of cooling and the moisture present in the air is condensed and the air which is having 100 % relative humidity after condensation of moisture, it passes through the condenser of the refrigeration circuit where the heat rejected from the condenser will be taken by the air and it relative humidity gets reduced. The low

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relative humidity air passes through the drying chamber and the drying is attained and the process continuous because of circulating the air which is comes out from the drying chamber through the evaporator and condenser of the refrigeration circuit. The process flow diagram is given in Fig.3.

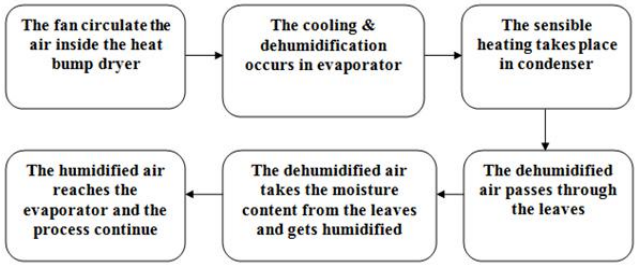

Fig.3 Process flow diagram

D. Methods

1) Evaporation rate

The weight of the dried leaves after 30 minutes of drying in the heat pump dryer is measured immediately taken from the drying chamber to avoid the natural drying. The evaporation rate of the curry leaves can be calculated by the following equation [18].

$$\cdot \downarrow_{\iota} > \frac{\cdot \downarrow_{\cap} \vdots \cdot \downarrow}{\iota \cdot}$$

Where,

m_i is the mass of product before drying in gram

m_f is the mass of product after drying in gram

t is the drying time in second

RESULTS AND DISCUSSION

The drying characteristics of the closed loop heat pump dryer is analysed with bed drying, tray drying, and compound drying for 1.5 m/s, 2 m/s and 2.5 m/s velocities for curry leaves. The performance parameters of Curry leaves for 30 minutes at inlet velocity 1.5 m/s is tabulated in Table III.

TABLE III

COMPARISON TABLE FOR 30 MINUTES AT VELOCITY 1.5 M/S

Drying Methods	Moisture removal rate (g/s)	Average Temperature (˚C)	Average inlet humidity (%)	Average outlet humidity (%)
Bed	0.25	41	30	31
Tray	0.18	43	24	30
Compound	0.28	42	24	33

For various ways of drying Curry leaves, graphs are plotted between inlet and outlet humidity and temperature at 1.5 m/s as shown in Fig 4 a-d.

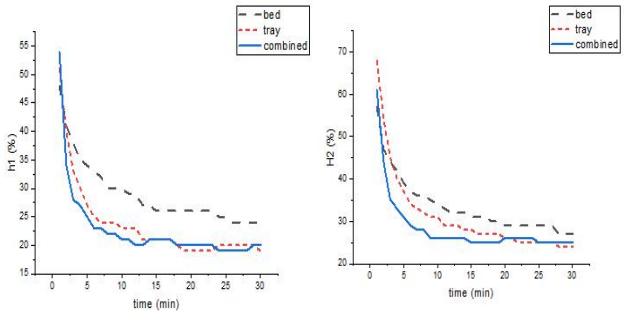

Fig. 4a Time Vs Inlet Humidity Fig. 4b Time Vs Outlet Humidity

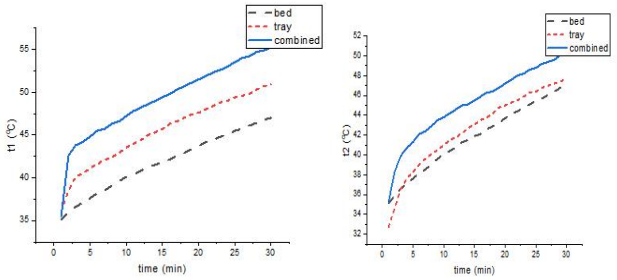

Fig. 4c Time Vs Inlet Temperature Fig. 4d Time Vs Outlet Temperature

In the case of tray drying method the average temperature and outlet humidity for 30 min. is 43ºC and 30% and the drying rate is 0.18g/s respectively, bed method, the average temperature and outlet humidity is 41ºC and 31% and the drying rate is 0.25g/s respectively and in compound method, the average temperature and humidity is 42ºC and 33% and the drying rate is 0.28g/s respectively. The performance parameters of Curry leaves for 30 minutes at inlet velocity 2 m/s is tabulated in Table IV.

TABLE IV

COMPARISON TABLE FOR 30 MINUTES AT VELOCITY 2 M/S

Drying Methods	Moisture removal rate (g/s)	Average Temperature (˚C)	Average inlet humidity (%)	Average outlet humidity (%)
Bed	0.28	44	24	32
Tray	0.21	45	25	28
Compound	0.31	45	25	34

For various ways of drying Curry leaves, graphs are plotted between inlet and outlet humidity and temperature at 2 m/s as shown in Fig 5 a-d.

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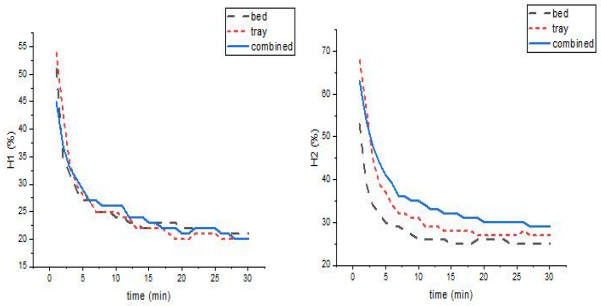

Fig. 5a Time Vs Inlet Humidity Fig. 5b Time Vs Outlet Humidity

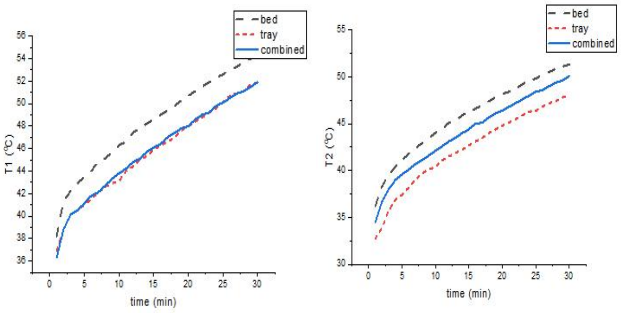

Fig. 5c Time Vs Inlet Temperature Fig. 5d Time Vs Outlet Temperature

The readings were taken for the duration of 30 min. at 2 m/s. In the case of tray drying method the average temperature and outlet humidity for 30 min. is 45ºC and 28% and the drying rate is 0.21g/s respectively, bed method, the average temperature and outlet humidity is 44ºC and 32% and the drying rate is 0.28g/s respectively and in compound method, the average temperature and humidity is 45ºC and 34% and the drying rate is 0.31g/s respectively. At 2 m/s velocity, Compound method removes 18% of moisture, Bed method removes 16% of moisture and Tray method removes 13% moisture from the leaves in 30 minutes. Therefore, the moisture extraction rate in compound method is 11% greater than bed method and moisture extraction rate in bed method is 33% greater than tray method.

The performance parameters of Curry leaves for 30 minutes at inlet velocity 2.5 m/s is tabulated in Table IV.

TABLE V
COMPARISON TABLE FOR 30 MINUTES AT VELOCITY 2.5 M/S

Drying Methods	Moisture removal rate (g/s)	Average Temperature (˚C)	Average inlet humidity (%)	Average outlet humidity (%)
Bed	0.33	44	29	40
Tray	0.23	43	30	35
Compound	0.34	45	27	43

For various ways of drying Curry leaves, graphs are plotted between inlet and outlet humidity and temperature at 2.5 m/s as shown in Fig 6 a-d.

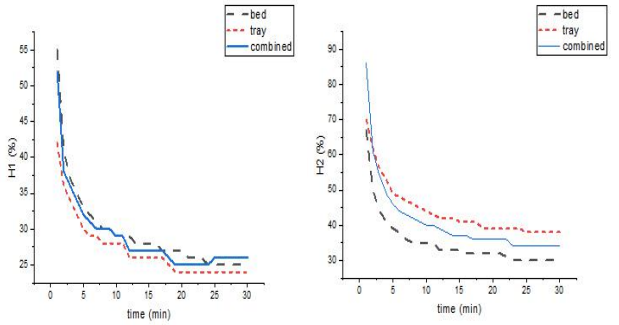

Fig. 6a Time Vs Inlet Humidity Fig. 6b Time Vs Outlet Humidity

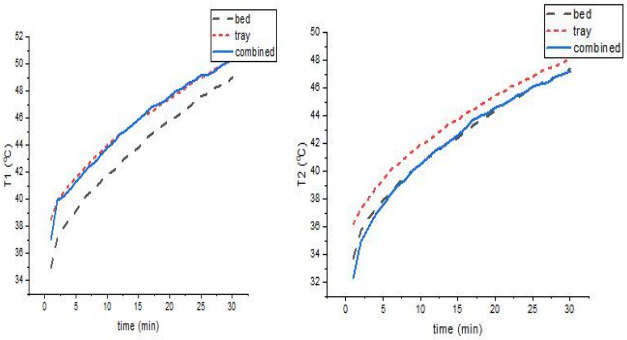

Fig. 6c Time Vs Inlet Temperature Fig. 6d Time Vs Outlet Temperature

The readings were taken for the duration of 30 min. at 2.5 m/s. In the case of tray drying method the average temperature and outlet humidity for 30 min. is 43ºC and 35% and the drying rate is 0.23g/s respectively, bed method, the average temperature and outlet humidity is 44ºC and 40% and the drying rate is 0.33g/s respectively and in compound method, the average temperature and humidity is 45ºC and 43% and the drying rate is 0.34g/s respectively. At 2.5 m/s velocity, Compound method removes 21% of moisture, bed method removes 20% of moisture and Tray method removes 14% moisture from the leaves in 30 minutes. Therefore, the moisture extraction rate in compound method is 3% greater than bed method and moisture extraction rate in bed method is 43% greater than tray method.

The Fig 7 shows the graphical representation of performance comparison of bed, tray and compound method at 1.5, 2.0 and 2.5 m/s velocities. Moisture extraction of Curry leaves is in peak at the velocity 2.5 m/s. Therefore, on comparing the three methods of

drying at 2.5 m/s velocity, the moisture extraction rate in compound method is 36% greater than in bed method.

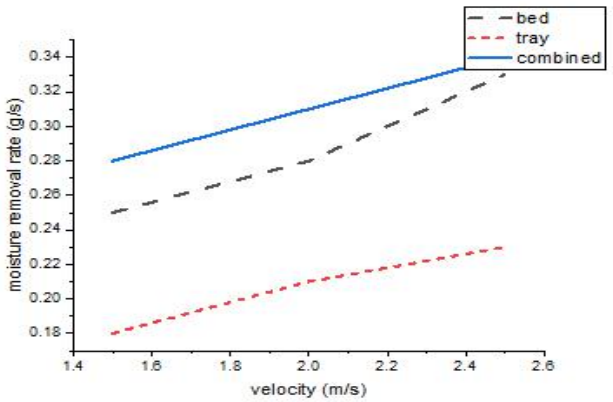

Fig. 7 Inlet Velocity Vs Moisture removal rate

Then moisture extraction rate in bed method is 6% greater than moisture extraction rate in tray method. And moisture extraction rate in compound method is 48% greater than in tray method. Regarding the above discussion, at 2.5m/s drying air velocity, the compound method or combined method has the maximum moisture extraction rate, followed by bed and tray methods.

CONCLUSION

Heat pump dryer is designed and fabricated in this proposed work. This is a promising technology for maintaining the product quality with lower energy consumption and higher drying rate. It is especially applicable for high-value products such as herbs and vegetables. The experiments is conducted to investigate the drying characteristics for Curry leaves at three different velocities and in three different drying chamber in a closed loop heat pump dryer is conducted. Based on the results, the combined drying chamber (bed-tray) produces highest evaporation rates 0.28, 0.31 and 0.34 g/s for the air velocities of 1.5, 2.0 and 2.5 m/s respectively compared to the tray and bed drying chamber. The evaporation rate of bed-tray dryer is 12 % and 55.5 % higher than the bed and tray drying chamber at the velocity of 1.5 m/s. Similarly the evaporation rate is 10.71 % and 47.61 % higher at the velocity of 2.0 m/s and 3.03 % and 47.82 % higher at 2.5 m/s. The evaporation rate is 38.8 % higher in the bed dryer compared to tray at the velocity of 1.5 m/s. Similarly for the evaporation is 33.33 % and 43.47 % higher in the bed dryer than the tray dryer.

Based on the results the following points are concluded.

- The inlet and outlet temperature of air before and after drying chamber is increases continuously while operating at transient temperature conditions.
- The relative humidity of air is continuously decreased at inlet and outlet of the drying chamber with respect to time.
- In the case of drying curry leaves the best evaporation rate is attained in the bed-tray drying chamber.
- The lowest evaporation rate is attained in tray chamber irrespective of inlet velocity of air.

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Paper ID - Title	#6 - AI based studies on smart trash bot using deep learning techniques
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Paper ID – Title: #5 – Augmentation Studies on Manipulators in Solid Waste Management with Deep Learning based Machine Vision System

Authors: Valai Ganesh S and Suresh V

General Chair

Prof. (Dr.) Ajith Abraham
Director, MIR Labs, USA
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MECH-001

DESIGN AND FABRICATION OF FRUIT CUTTING MACHINE

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Automation by innovation reduced man effort and time to a higher level. The review of the previous cutting machine has drawbacks such as high investment cost, manpower, contamination and time consumption. Manual slicing and peeling of fruits has ended up to be a tedious and time-consuming process and is prone to the risk of food contamination leading to high risk of food borne diseases. The peeling process is a very tough and leads to many risks. That is the reason this fruit cutting machine comes in picture, the cost of this machine is nearly a lot of low as the machines which are accessible in market and this can be without any problem limited scale organizations. The main objective of the project is to manufacture an automatic fruit cutting machine with simple design, that saves time and that is of affordable cost. This cutter machine can do both peeling and slicing operations so that the time consumption can be reduced. Moreover the cutting setup consists of stainless steel that eliminate the blackish colour after cutting.

Keywords: *Automation, Low Cost, High Production and Less Man Power.*

MECH-002

PORTABLE DIGESTER FOR BIOGAS PRODUCTION FROM ORGANIC WASTE

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Food wastes occur through via various sources throughout the food system. About one-third of the food produced is wasted globally each year and in low-income countries, most loss occurs during production, while in most of the developed countries more than 100kg of food is wasted by each and every person globally while consuming the food. For example, in a college hostel food and paper waste are in huge amount. Even though these are organic wastes, dumping and disposing of these wastes in bulk amount pollutes the land and even causes contamination to the water resources. Also, disposal in huge amounts is also responsible for the emission of greenhouse gases. The solution to these problems and trying to reuse these wastes in a proper and healthy way is to create a biogas digester which is more efficient and portable than the existing digesters. Addition of zeolite coating which is used to reduce the heat dissipation and helps to store the heat inside the digester. It reduces energy loss and saves more energy and increases the efficiency of the digester. The gas obtained is later used as useful fuel for cooking.

Keywords: *Biogas, Digester, Waste and Zeolite.*

MECH-003

DESIGN AND FABRICATION OF ANIMAL REPELLENT SYSTEM

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The effects of low prey density in the forest due to natural or man created situations, deforestation and human intervention is causing animal migration towards to human habitats especially in the areas which come under the forest territory. The animals are crossing the buffer zones and destroying the agricultural crops of small and marginal farmers. The issue is creating common disinterest on agriculture among small and marginal farmers and directly impacting their livelihoods. Our product is based on the utilization of motion sensing, image capturing and Image processing. Based on the output from the image processing, specific kinds of threatening

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mechanisms are activated for specific types of animals. The process takes place as follows, the components used in the prototype i.e. camera, motion sensor work on the range of 10 metre radius. When any change in the radius or motion is detected in the range of 10m, the camera gets activated and records an image of the subject. The captured image is sent for image processing. Firstly, a tensor flow model is loaded using dnn module of CV2. The photos clicked from the camera of the raspberry pi which possesses the code which is running. In the pre-processing blob image subtracts mean deviation from each channel of the image, i.e. RED, GREEN and BLUE. Then, the result is sent to the tensor flow model (SSD). If it is a human being, threatening mechanisms are not activated. If it is an animal, specific threatening mechanisms are activated based on the respective animal. The various threatening mechanisms involve ultrasounds, infrasound, sound of a tiger growl and fluorescent strobing lights. Meanwhile in the day time the threatening mechanisms are ultrasounds, infrasound and the growl of a tiger and in the nights the strobing lights comes into action. If the animal is still in the vicinity and if the motion is continuously detected, using a GSM module an alert message would be sent to the farmer.

Keywords: *Image Processing, Threatening, Crop Damage, Sounds and Light.*

MECH-004

COMPARATIVE STUDY ANALYSIS OF DAILY LOAD CURVE ON DIFFERENT TARIFFS USING MATLAB

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This paper aims to compare and evaluate the power consumptions in the different tariffs usage. Nowadays electricity costs and consumptions has varies from time to time and season to season and every appliances working with the help of electricity only. Due to this, using the energy rate by the consumer's use factor has also varied by the load and demand factor under electricity measures. In this paper, daily load curve has to be used, based on the energy utilized in the different tariffs like domestic load, commercial load and industry load beneath the cluster of load distribution parameters. It will be useful for collecting the demand of load factor, which is calculated by this curve. It will be reflecting in the power plants that will be varying energy rate helps to producing the electricity from that demand factor value. MATLAB is a multidimensional array function software which using here for analyzing the energy rate taken from the daily curve data and plot the daily load curve for different tariffs with graphical representation data. By this, it will be save and reduce the consumption of fuel costs of power plants, effective cost reductions moreover consumers also be aware of use the electricity carefully based on their needs more economically while lack of electricity supply and power cut during shutdown time and nature calamities.

Keywords: *MATLAB Matrix Laboratory, Load Distribution Parameter, Load Curve, Power Consumptions, Power Plant Engineering and Tariffs.*

MECH-005

IMPLEMENTATION OF STATISTICAL PROCESS CONTROL IN METEOROLOGICAL DEPARTMENT BY USING MATLAB

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This paper focused on implement and monitoring the statistical process control (SPC) in Indian meteorological department center (IMDC) with the broad objective of understanding the

weather forecasting variability and collecting the statistics required for the agriculture, water resource management and warn against the nature calamities. Chennai Meteorological department is one among the six meteorological departmental centers in India. Control chart is data monitoring process used for controlling the variations and finding the root cause problem. In this case, data gather from the IMDC and incorporate in control charts for identifying how tolerance limits of weather measurement value is exceeding in the region of Tamil Nadu. MATLAB is a matrix and mathematical programming software which is used here for plotting the control charts and also draw the graph of weather forecasting for understand the rainfall data.

Keywords: *Control charts, MATLAB, Meteorological, statistical Process Control, Total Quality Management and Weather forecasting.*

MECH-006

FEASIBILITY STUDY ON SMART MICROGRID SYSTEMS IN UNIVERSITY MALAYSIA SABAH, FACULTY OF MEDICINE AND HEALTH SCIENCE

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A microgrid's fundamental concept is to generate electricity through renewable sources such as micro-hydro, photovoltaic, or biomass gasifiers and supply it to meet the load requirements of a particular group of consumers. Since Malaysia has an abundance of renewable sources because of its geographical location, Malaysia has an enormous potential in implementing microgrids which will bring lots of benefits to the nation and its residents. This feasibility study on microgrids was carried out for the Faculty of Medicine and Health Sciences of University Malaysia Sabah. The result will be a benchmark for the implementation of microgrids in other areas in Sabah. Here we identify the renewable energy resources available and faculty load data. We use software simulation to analyse the data. Several simulations were carried out in the HOMER Grid software, and a feasible microgrid system was designed to meet the faculty's load requirements. Technical analysis and financial analysis were carried out for several configurations of optimal systems that could best fit the electrical consumption scenario of the faculty. The net present cost and the Levelized Cost of energy of each system were given much importance during the selection process. Moreover, the CO2 emissions of the systems were also analysed where the feasible solution must have a severe reduction of carbon emission compared to the existing system. Therefore, after considering all the mentioned criteria, the grid integrated PV system proved as the most feasible microgrid system to be implemented in the faculty. It will reduce the dependency of grid base supply, cost-saving, and reduce carbon emission. The result showed the possibility of introducing the microgrid concept to other areas in Sabah.

Keywords: *Microgrid, Renewable Energy, PV System.*

MECH-007

MACHINABILITY INVESTIGATION IN DRILLING BIO HYBRID COMPOSITE AND EXISTING CAR DASHBOARD MATERIAL

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In aerospace, automotive, and civil applications, hybrid composites are widely used. The study of composite drilling has a significant economic impact. In this study, a L9 orthogonal array was used to explore the effect of bio hybrid composite and existing car dashboard material process parameters on hole quality. The thrust force measurement and surface roughness of hybrid composites were investigated experimentally in this research. Thrust force was measured using three different flute drills at spindle speeds up to 1200 rpm. The nonlinear behaviour of this tribo-

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system is investigated, as well as the interdependence of cutting forces in respect to surface damage of parts of the system.

Keywords: *Bio Hybrid Composite, L9 Orthogonal Array, Surface Roughness and Thrust Force.*

MECH-008

A REVIEW ON SMART IRRIGATION SYSTEMS USING ARDUNIO CONTROLLERS

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Smart technology is the need of hour as it increases effectiveness and efficiency. Irrigation systems are also growing smarter as a result of current technologies, which are more efficient than traditional approaches. This paper considers the numerous approaches to irrigate agricultural land utilizing solar electricity and employing modern technology. Since agriculture is such an important part of the economy, a contribution to the improvement of the country's economy should be put into practice in order to boost production and crop quality. This review utilizes a soil moisture sensor-based auto-irrigation system is available that attached to an Arduino Uno, which serves as both a controller and a display. The system hence proposed can act as a global mobile communication as it has the ability to send and receive data between the controller and the user. Also the system incorporates GSM technology for the effective ON/OFF the motor from distant places. The entire system is controlled by arduino unit and solar panels are used to generate the required DC power. Numerous methods to make irrigation effectively. This paper reviews the numerous technology advents taking place in the area of agriculture.

Keywords: *Arduino Uno, GSM, Soil Moisture sensors and Solar Power.*

MECH-009

DESIGN AND ANALYSIS OF CRANE HOOK USING SAE-AISI 1040 AND ASMT GRADE 60

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A crane hook is a device that is used to lift loads using a crane. Crane hooks with circular triangular cross sections, rectangular, and trapezoidal cross sections are frequently utilized. Due to the accumulation of a significant number of forces, the crane hook is prone to failure. The failure of a crane hook is primarily determined by three factors: dimension, material, and overload. To reduce crane hook failure, the tension that occurs in it must be investigated. In this work, the hook is designed using an analytical method for various materials such as SAE-AISI 1040 and ASMT GRADE 60. PTC The crane hook is modelled using Creo software, and the stresses induced in it are calculated using ANSYS software. This outcome aids us in determining stress in the current model. The hook working life is increased and failure stress is reduced by forecasting the stress concentration location.

Keywords: *Analysis, Crane hook, FEA software (ANSYS) and PTC Creo.*

MECH-010

PROGRESS IN IMPROVING THE PRODUCTIVITY OF SOLAR STILL – A REVIEW

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The rise in the global population and industrialization has increased the demand for fresh water production day by day. Desalination is the most common and traditional way of getting

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drinkable water. A solar still is a device used for desalination that uses available solar energy. Solar stills are easy to maintain and inexpensive, but their productivity is restricted. Compared to other conventional desalination systems, solar still produces a low quantity of fresh distillate. Solar still productivity depends on the rate of evaporation and rate of condensation. There are various parameters that influences the rate of evaporation and rate of condensation. Design parameters are controllable by the humans which are altered by the researchers across the World to study the performance of the still. This work reviews the progresses made in a passive solar still for improving the rate of evaporation and rate of condensation which in turn improves the productivity.

Keywords: *Solar Still, Desalination, Rate of Evaporation, Rate of Condensation and Review.*

MECH-011

IMPROVEMENT OF IMPACT PROPERTIES OF WASTE FISHNET FIBER LOADING ON GLASS FIBER REINFORCED PLASTIC COMPOSITES

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In this study, the reuse of multifilament discarded fishnet of mesh size 32 mm and glass fiber composites were incorporated with polyester matrix. The performance of impact resistance and Dynamic Mechanical Analysis (DMA) of these composites were evaluated in accordance with ASTM. The interactions of reinforcement fibers with matrix of various composites were revealed by using Scanning Electron Microscope (SEM). The results of the study suggest that waste multifilament fishnet were added to the glass fiber composites and the impact resistance increases due to the fishnet fiber content. However, the DMA reveals that the composites have better mechanical damping and significant amount of loss modulus. Hence, the reuse of waste fishnet into composites mitigates the problem of waste disposal.

Keywords: *Polymeric composites, DMA, SEM, Fishnet.*

MECH-012

THREE AXIS PNEUMATIC DUMPER

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The vehicles will be unloaded from the trailer in three axes without application of any impact force. By pressing the Direction control valve activated. The compressed gas is goes to the pneumatic cylinder through valve. The pneumatic cylinder acts as a lifting the trailer cabin. the car engine drive is coupled to the compressor engine, so it stores the compressed gas when the vehicle running. This compressed gas is employed to activate the pneumatic cylinder, when the valve is activated. the trendy dumping mechanism trailer/dumper has been fabricated by detecting the issue in unloading the fabric. In today's world there's a spread of products like industrial waste, agricultural products, stones composts, rocks, gravel etc. Conventional trailers can unload in one direction only. just in case of limited space availability, they fail to work. The trailer has mainly targeting this difficulty, and hence an appropriate arrangement has been designed. The dumping mechanism which may operate or unload the products in three directions smoothly with none application of impact forces. it'll be convenient to the driving force to unload the trailer and to beat the space requirement from panel. This mechanism prevents blocking of the road, increases the productivity of the trailer and shortens the time of unloading with small increment in cost. The unloading of materials may be done to the three directions. this is often very useful within the

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shipping industry. We are choosing this project for the decreasing the person power and time. the mix of pneumatics and micro controllers will be seen in our project. we've got chosen this project due to the assorted attractiveness of pneumatics.

Keywords: *Three Axis, Impact Force and Compressed Gas.*

MECH-013

DESIGN AND EVALUATION OF SELF PROPELLED CARROT HARVESTER

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Carrot is one of the major vegetable crops in India. It is a cool season crop and it is cultivated in hilly regions. It needs deep loose loamy soil and it is grown in raised beds of 1 meter breadth and convenient length. Harvesting carrot is a most critical operation and it requires more labour per acre to harvest the carrot. Thus, the study is undertaken to design and fabricate a Self Propelled Carrot Harvester. The carrot harvester consists of a digging unit, conveying unit, de-topping unit, collecting unit and power transmission unit. Digging unit is used to dig the carrot from the soil and the chains used in conveying unit are used to convey the digged carrots. De-topping unit is provided to de-top the leaves from the carrot by using the discs. Bag holding frame is provided to place the gunny bag which collects the de-topped carrot. Transmission unit is used to transmit the engine power to rotate the wheel and to rotate the conveyor chains. Thus the small compact Self Propelled carrot harvester dig, convey, de-top and collect the carrots which is very useful to the farmers by reducing the cost and time. Meanwhile the machine performance can be determined by calculating the digging efficiency, lifting efficiency, de-topping efficiency and fuel efficiency. As the result the time and cost will be more effective in comparison with the manual method of harvesting the carrot.

Keywords: *Carrot Harvester, De-topped Carrot, Efficiency and Transmission Unit.*

MECH-014

DESIGN AND FABRICATION OF GEARLESS POWER TRANSMISSION

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This project represents real time study of gearless transmission mechanism. Today's world requires speed on each and every field. Hence rapidness and quick working is the most important. Now days for achieving rapidness, various machines and equipment are manufactured by man. This transmission system is to be analyses in solid works software to study reaction of elbow rods and hub and then the fabrication of mechanism is carried out. The project GEARLESS TRANSMISSION is being compact and portable equipment, which is skillful and is having something precise in transmitting power at right angle without any gears being manufactured. Introduced gearless power transmission arrangement used for skew shafts. In this transmission system no. of pins or links used must be odd ..., (3, 5, 7, 9, …) & centers of any two pins or links hole must not be on that line which represent the diameter of the shaft. If more pins or links used motion will be smoother, but increase in no. of pins or links not at the cost of strength of the shaft. Power transmission for skew shafts is with the help of either crossed helical gear or worm gear or hypoid gears in a machine, but the manufacturing of these gear is very complex, power loss in gears due to sliding motion and the shaft orientations is very limited means not for every shaft orientation because of standardization of gears, so need arises for a better system. So here I introduced a gearless power transmission system for skew shafts which reduce the losses, cost & save the time and space. This system allows the changing in the orientation of shafts during

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motion which is very interesting and fascinating about this mechanism. Also, during analysis of mechanism and working it is seen that this gearless transmission can be used for both intersecting shafts and skew shafts but here we introduced a solution for skew shafts so main attention is towards the skew shafts.

Keywords: *Transmission, Shaft, Mechanism, Skew Shafts and Gears.*

MECH-015

AUTOMATED CO_2 ENRICHMENT TO PLANTS BY FACTORY EMISSIONS

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Industrial emissions plays a major role in environmental pollution, which contain huge amounts of organic compounds like carbon dioxide(the major reason for the greenhouse effect), carbon monoxide, hydrocarbons, and chemicals into the air. For controlling Pollution the Central Pollution Control Board (CPCB) has given some norms, based on the types of industry. But Factories and manufacturing units find it more difficult to keep up with the norms of the government. An existing model "electro-static precipitator" is used to filter the smoke form the industries, but its cost is high and not very flexible to change its operating conditions. Our project mainly focus on reducing the industrial emission es-specially CO2 in natural way by using Free-Air Carbon dioxide Enrichment (FACE) Technology in enclosed chamber. The CO2 from the factories is treated and enriched to plants which were kept in a transparent enclosed chamber. With the help of LDR sensor, MQ135 sensor and control panels, it automatically open and close the chamber. In day time while during photosynthesis, it kept closed opens during night time for releasing the oxygen. By Enriching the CO2 to the plants will reduce the the usage of fertilizer and water consumption. Initially the conversion rate (CO2→O2) is observed by using different plants. Then the conversion ratio is calculated for the selected plants and further study about plants chemical composition will carried out.

Keywords: *Co_2 enrichment in plants, automated natural air purifier, pollution control, water use efficiency, reduced usage of chemical fertilizer.*

MECH-016

DESIGN AND DEVELOPMENT OF PESTICIDE AND WEEDICIDE SPRAYER

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In modern agriculture, there are many developments from sowing till harvesting. Spraying is a typical operation, which decides the growth and yield of the crop. Up to date, spraying is done with the help of hand pump and electric sprayer but these require more man power. The maximum capacity of this type of sprayer is 15 liters and it can be sprayed for a limited area only. Weeding is also a major problem in the growth of a crop, for which we need more labor. Hence this manual sprayer will help us to overcome these obstacles; it consists of two spraying tanks with a wheel and a handlebar. The tanks will have a battery that gets charged by solar panel to spray fertilizer and also it works under a piston pump pressure method where a rod is connected to the chain cassette and to the piston in the spraying tank. Hence it can be operated manually and with a battery also. There will be multiple nozzles in order to spray over a large area at a faster rate. The height of the nozzles can be adjusted in horizontal and vertical directions. Hence this manual sprayer will cost low and is easy to operate.

Keywords: *Mechanically Operated, Manual Spraying, Piston and Pump, Solar Battery.*

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MECH-017

EXPERIMENTAL ANALYSIS OF RICE HUSK GASIFICATION IN A NEWLY DEVELOPED AIR BLOWN BED GASIFIER

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Currently, fuels costs and usage are increasing day by day, the current share of biofuel and bio solid wastes used for usage in almost all area is low. Air and environment are also polluted by the part of burning of agricultural solid wastes, for changing this scenario, converting the bio solid wastes into syngas by the process called Gasification. It is the process of allowing the bio solids and heating it by high temperature in the bed material and producing syn gas. It is ancient one and this process is used in World War II periods for consuming the fuels in the demand of petroleum and fuels. Air Blown Bed Gasifier (ABBG) is using this same principle, here we deployed high flow rate air blower to make the process efficient. This have interrelated steps and reactions. By the process, first the coal or solid wastes like rice husk, sugarcane bagasse, are feed stock materials. This project work was carried out in four processes they are drying, pyrolysis, reduction, and combustion and base feed stock is rice husk in this gasifier. These four processes involve various temperatures in their respecting zones. It is based on simple concept of incomplete combustion. Drawbacks of air blown bed gasifier process are having the high tar content in produced syngas. A new air blown bed gasifier were modelled using Fusion 360 software. Then it has been fabricated successfully. This product reduces air pollution when compared with unwanted burning of agricultural wastes.

Keywords: *Air Blown Bed Gasifier, Fusion 360, Gasification and Bed Material*

MECH-018

INTENSIVE STUDY ON ADDITIVE MANUFACTURING FOR BIOMEDICAL APPLICATIONS

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The need for adoption of Additive manufacturing technology in biomedical domain is because of its capacity to fabricate geometrically complex objects with no error, flexibility to make changes easily without the need of extra equipment or tools, create tissues and organs with very complex internal structures matching a patient's anatomy and build cost effective devices for daily purposes. Another reason for the advancement and expansion of AM applications in the medical business might be because it is one of the important technologies for saving, extending, or changing people's lives for the better. This work gives an overview about the need of AM technology in biomedical field, the process and materials involved. This is a four-level review that outlines pertinent research and current trends which includes: (i) Bio Printing of tissues and organs (ii) Surgical planning with printed models (iii) 3D printing of surgical instruments and (iv) Personalized Prosthetic implants. In field of medicine and healthcare more cutting edge and ground breaking applications of Additive Manufacturing are exponentially taking place and being researched.

Keywords: *Additive Manufacturing, Bio Printing, Implants and Biomedical.*

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MECH-019

SMART WASTE TRASH BOT MONITORING SYSTEM

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This paper shows the event of a garbage observance system so as to live waste level within the garbage bin in period of time and to alert the municipality, via SMS. The planned system is consisted by the ultrasonic device to live the waste level, the GSM module to send the SMS; associate in an Arduino Uno that controls the system operation. It supposes to come up with and send the warning messages to the municipality via SMS once the waste bin is nearly full, that the trash bin be collected like a shot. Operation of waste management system GPS and GSM technology providing real-time data on landfill status ie. Once they square measure full in order that acceptable action may be allotted. The system notifies the person (Truck Driver) answerable of trash collection by causation a short message (SMS) and telling them wherever the complete bin is exactly set. This development can save a great amount of time especially once the council doesn't have to go and check the level of garbage within the bin. Besides, it'll timely alert the overflow of garbage tanks to the very fact so that garbage is collected on time. That is, the municipal corporation can collect garbage only if it's time and do thus instead of routine wherever even half-full bins square measure collected.

Keywords: *Arduino Uno, GPS and GSM Module and Ultrasonic Sensor.*

MECH-020

BUILDING SMART BOT DESIGN FOR LIBRARY ASSISTANCE

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Developing a Smart intelligence system to navigate the library user's to the required book location with smart inbuilt techniques is the major work behind in this project. Physically Challenged people have the difficulty to reach the book location without any human assistance. The proposed idea has the Android application (equipped with Watson Assistant Chatbot) built in the mobile robot for finding the book location and the bot will navigate the user to the required location. If there are more than 100 of racks and 10000 plus books are available in the library means, this smart bot will assist the user to guide them in a proper direction such that searching time will be reduced. Library management systems are available in the Bot for entry and return of books.

Keywords: *Library Automation, Chatbot, Watson Assistance and Autonomous Robot.*

MECH-021

VITAL ROLE OF RECENT TECHNOLOGIES IN SORTING DIFFERENT SOLID WASTE MATERIALS IN RECYCLING PROCESS

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This paper aims to highlight the importance of recycling in the present situation. The need of recycling is carried out by analyzing the recycling rate in a globally in a statistical manner using Minitab 19.From the analysis the need to maximize the recycling rate with the support of computer vision approaches such as Pre-trained VGG-16 (VGG16), AlexNet, Support Vector

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Machine (SVM), K-Nearest Neighbor (KNN) and, Random Forest (RF) and other modern technologies are studied. From the real time studies it was observed that these trained models has accuracy more than 90% compared to the conventional .The computer vision approach is the most efficient way to sort out the recycled materials from the waste collected yard. These trained models and kits has around 400 images database to classify the waste such as plastic, rubber, metal. This sorting model is useful for the local government officials and in the recycling process. Similarly some of the decisions related to check the significance level from the mean values using Minitab 19 statistical software.

Keywords: *Computer Vision, Models, Database, Sorting Model, Accuracy and Decision.*

MECH-022

DESIGN OF UNDERGROUND HYPER LOOP PIPE SYSTEM USING SIPHON PRINCIPLE TO PREVENT FLOOD IN METRO CITIES

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Due to congested construction of buildings in metro cities, the stagnation of water always occurs due to heavy rainfall. When Rainfall exceeds its limit, the water flow increases and become flood as a natural disaster due to unoccupied space and tight construction. In Smart cities, the massive buildings are made in water stagnant area where there is no way of water to flow or store in a particular area. Due to this water flow becomes flood which creates a major problem for household people in metro cities. To overcome this problem we create a partially vacuumized hyper loop pipes underground in smart cities to suck the rainwater from the ground which carries water from ground surface area or water collector tank through pressure differential to the outer City area. Evacuated water will be stored in a large tank as waste water management and used for future needs. A large tank is used to collect the rain water from the ground surface and then a slight sloping pipe design is made to flow the water by gravitational force to other end of the tank using siphon principle. A slight decrease in pressure from atmospheric pressure creates partial vacuum in pipe which is used to suck the water from high pressure level (stagnant ground water tank) to the other end of low pressure tank by siphon effect. So using this design a large amount of water can be transported through partial vacuum hyper loop pipe for several distances inside the ground by maintaining the pressure level of the pipe which can save people and their households in metro cities from flood and stagnation of water.

Keywords: *Evacuation, Gravitational Force, Hyperloop Pipe, Partial Vaccum and Siphon Principle.*

MECH-023

ENERGY AND EXERGY ANALYSIS OF SINGLE SLOPE PASSIVE SOLAR STILL WITH ATOMIZER

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Only 3% from 97% of the world's water is freshwater; out of which 2/3 are glaciers. As a result, 1.1 billion people worldwide do not have access to safe drinking water. A further 2.7 billion people face freshwater shortages a month. Now a days demand for fresh water increases, as well as technologies to produce freshwater also increasing simultaneously. Humans can not drink salt water which can have many ill effects due to salt water consumption but there are some processes which can turn it into fresh water. One of the promising techniques used for fresh water production is known as desalination. Solar still is working with 100% renewable energy and it is eco-friendly for the environment. The drawback of solar still is lower productivity of fresh water. Many researches are working to improve the performance of the solar still. Evaporation rate is

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directly proportional to the productivity of the solar still. It has been proposed to use atomizer in the modified solar still. Compared to the conventional solar still the modified solar still with atomizer performed well and it produced higher yield.

Keywords: *Desalination, Solar Still, Energy Efficiency, Exergy Efficiency and Atomizer.*

MECH-024

IOT BASED SMART DOOR-TO-DOOR SEGREGATION AND PREDICTION OF SOLID WASTE COLLECTION SYSTEM USING LABVIEW AND GOOGLE FIREBASE

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Segregation and collection of Municipal solid waste in developing countries are one of the major problem faced in developing countries. The areas in which the countries lacking are i) operational inefficiencies of services ii) inadequate service coverage, iii)inadequate landfill disposal, iv)limited utilization of recycling activities. Dumping municipal solid waste in developed countries is one of the major problem faced in developing countries. Here, a novel solution is proposed for collection of solid waste directly from concerned places. An IoT based smart bin is designed and integrated with LabVIEW software and google fire base, which will be identified in private house/common place for an arena. The information regarding overflow of solid waste will be received by the municipal team receiver station/ control room. The team can go to the particular location and collect the solid waste for further processing. Moreover, the prediction of overflow of solid waste can also be found using machine learning algorithm.

Keywords: *LabVIEW, IoT, Municipal Solid Waste and Prediction.*

MECH-025

DESIGN AND OPTIMIZATION OF SUSPENSION SYSTEM USED IN HEAVY LOAD VEHICLE

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A leaf spring is another component of vehicles that is more important in terms of human comfort and safety. It is the most basic and important component of the suspension structure. Because of the importance of suspension design and assembly in the utility and safety of a vehicle, it is important to develop a failure-free suspension design and assembly unit. DFMEA (Design Failure Mode Effective Analysis) techniques were utilised in this research to adopt preventive measures to reduce failure rates. It starts with deciding, categorising, and researching every individual probable failure and grading it using numerical ratings. The four numerical grades are Severity, Occurrence, Detection, and RPN (Risk Priority Number). These numerical ratings are used to identify the most likely failure of leaf springs. To overcome these failures, it is also necessary to analyse and assess the essential features of fatigue failure mode and fatigue life using Finite Element Analysis (FEA) techniques. Finally, methods are presented and advised to improve the performance and longevity of the leaf spring.

Keywords: *DFMEA, Fatigue, Finite Element Analysis, Life Cycle and RPN.*

MECH-026

A REVIEW ON IMPLEMENTATION OF KANBAN SYSTEM IN VARIOUS PROCESS INDUSTRIES

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The goal of this study is to analyze previous Kanban-based manufacturing studies as well as the analytical tools used to determine the number of Kanbans. The study takes into account a number of aspects, including Kanban variations, production methods used by various types of businesses, and analytical tools and methodologies used to model the system. The behavior of modified Kanban and its implications on production systems is one of the most important findings. The findings of numerous investigations could also aid in the development of a unique production system that could outperform existing methods. This analysis serves as a guide for adopting the Kanban method in various production systems, as well as identifying essential criteria.

Keywords: *Kanban, Supply chain, Manufacturing and Optimization.*

MECH-027

MECHANICAL CHARACTERISTICS AND MICROSTRUCTURE EVOLUTION ON SS316L VIA SLM

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Microhardness development of an Selective Laser Melting Stainless Steel 316L component with various dimensions along the construction direction. The complete samples were devoid of holes larger than 60 microns, according to computed tomography (CT) scanning. For samples with diameters of 5 mm, 10 mm, and 15 mm, the mechanical characteristics and microhardness were measured longitudinally. The testing results revealed that the SLM SS316L samples strength diminishes progressively from bottom to top, but their ductility has an inverse connection with the building direction. In comparison to components with 5 mm and 10 mm diameters, the part with a 15 mm diameter has a higher overall strength and lesser ductility. Grain refinement is caused by the increased cooling rate of SS316L closer to the bottom, according to grain size statistics, which is consistent with the Hall-Petch connection. In addition, a quantitative characterisation is used to give extensive evolution on mechanical characteristics.

Keywords: *SLM, Mechanical Characteristics, Relative Density and Micro Hardness.*

MECH-028

MECHANICAL AND TRIBOLOGICAL PERFORMANCE OF 18Ni350 MARAGING STEEL

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Metallic additive manufacturing has been created as a manufacturing technology for complicated functional parts with highly specific mechanical performance requirements that might be used in a variety of technology sectors. As a result, it's critical to describe additive manufacturing materials under a variety of loading circumstances to comprehend probable differences in behavior from their conventional counterparts. The goal of this work is to characterize the mechanical behavior of 18Ni350 maraging steel, which is a common material for additive manufacturing applications. On both conventional and additively manufactured

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maraging steel, a series of physical and mechanical tests were conducted. Finally, the tribological performance of additively fabricated Maraging steel was evaluated. Digital Image Correlation was used to help. Materials-related strategies the maraging steels' complicated behavior was shown in tests, and the additively manufactured material showed promise higher strength than conventional material.

Keywords: *Maraging Steel, 18Ni350, Tribology and Additively Manufactured.*

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Detection of Cracks in Surfaces and Materials Using Convolutional Neural Network

R. Venkatesh, K. Vignesh Saravanan, V. R. Aswin, S. Balaji, K. Amudhan, and S. Rajakarunakaran

Abstract Crack is the separation of an objects or surface in two or more pieces. Identification of these cracks is crucial and plays a vital role in preventing the disaster that will happen due to that crack. The effective identification of these cracks on materials or parts may help the manufacturer to neglect those parts and to find the root cause for the formation of crack. For this, we have developed an image processing model using convolutional neural network. This model will constantly take picture by using the web camera, and these images were processed by the model and that model will predict whether the part or material has a crack on its surface or not. If the crack is detected by the model, those images will be saved, and respective actions will be taken. We have trained our model with 20,000 positive datasets (images with crack) and 20,000 negative datasets (image without any cracks). Then we have tested the model with some random images obtained from the internet. Analysing the results, we found that our model has attained maximum accuracy with an average confidence level of 93–97%. After this stage, we have developed the model to access the device's webcam to capture live video feed and predict the images for cracks. If a crack is present in the image, the model will store the image.

Keywords Computer vision · Crack detection · Deep learning · Convolution · Image filtering

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CHAPTER 7

Tribological Behaviour of Hybrid Natural Fiber Polymer Composites with Novel Fillers

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Abstract: This study has been carried out to demonstrate the tribological behavior of natural fiber-based polyester hybrid composite with novel filler materials. The reinforcement fibers considered in this study are Jute and Coir fiber. The filler materials selected in this work are copper slag (final waste from the copper extraction) and Nanoclay (Montmorillonite K10). The percentage of both reinforcement fibers and fillers has been changed, and the analyses have been carried out. Experiments were conducted on the specimen based on Taguchi's design of experimental technique. L9 Orthogonal array is selected for analysis, and Grey Relational Analysis (G.R.A.) is introduced to determine the better combination of reinforcement and filler to provide better wear resistance and coefficient of friction. Also, a statistical analysis is performed to find the influence of input parameters.

Keywords: ANOVA, Coefficient of Friction, Coir Fiber, Composite Material, Compression Moulding, Copper slag, Grey Relational Analysis, Hybrid Fiber, Hybrid Filler, Jute Fiber, Multi-Objective Optimization, Nanoclay, Natural Fiber, Orthogonal Array, Parameter Optimization, Pin on Disc Wear Test, Polymer Composites, Taguchi Technique, Tribological behavior, Wear.

1. INTRODUCTION

There is a greater demand for materials with unusual combinations of properties in the present situation. It is required that the material must have low density, high strength, abrasion-resistant, impact resistance, and increased hardness [1]. It is difficult to obtain all the properties in the same material. So the research has been carried out, and the engineers have tried to develop a material taking all the properties into consideration. This hunt for various increased properties in a

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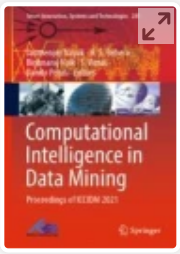

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Computational Intelligence in Data Mining

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About this book

This book addresses different methods and techniques of integration for enhancing the overall goal of data mining. The book is a collection of high-quality peer-reviewed research papers presented in the Sixth International Conference on Computational Intelligence in Data Mining (ICCIDM 2021) held at Aditya Institute of Technology and Management, Tekkali, Andhra Pradesh, India, during December 11–12, 2021. The book addresses the difficulties and challenges for the seamless integration of two core disciplines of computer science, i.e., computational intelligence and data mining. The book helps to disseminate the knowledge about some innovative, active research directions in the field of data mining, machine and computational intelligence, along with some current issues and applications of related topics.

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Keywords

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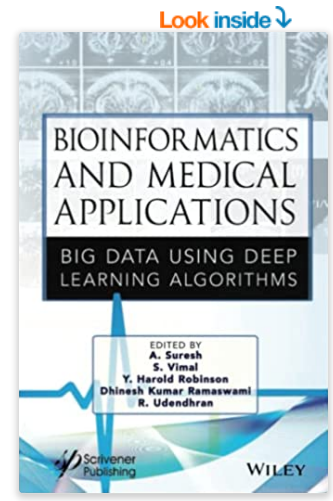

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Solving Fuzzy Quadratic Programming Problems by Fuzzy Neural Network

G. Selvaraj & L. Jarina Banu

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Abstract

A new fuzzy energy function for fuzzy quadratic programming problems is constructed using fuzzy norm. Based on the fuzzy energy function, a new fuzzy neural network is developed for solving fuzzy quadratic programming problems numerically in which all or some parameters are fuzzy. The stability of the proposed fuzzy neural network is established, and numerical examples are demonstrated to substantiate the significance of the proposed fuzzy neural network.

Keywords

Fuzzy quadratic programming problem

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Approximate optimum solution.

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A NOTE ON STRONGLY GORENSTEIN $\mathcal{X}$-FLAT MODULES

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Abstract: Mao and Ding introduced the concept of $\mathcal{X}$ - injective modules. D. Bennis and N. Mahdou introduced and study the concept of Strongly Gorenstein projective and injective modules. In this article, we introduce and study about strongly Gorenstein $\mathcal{X}$ -flat modules, which is the generalization of strongly flat modules. Further we link them with the strongly Gorenstein $\mathcal{X}$-projective modules.

1. INTRODUCTION

Throughout this article, R denotes an associative ring with identity and all R-modules, if not specified otherwise, are left R-modules. R-Mod denotes the category of left R-modules.

Let $\mathcal{X}$ be a class of left R-modules. Mao and Ding in [Mao] introduced the concept of $\mathcal{X}$ - injective modules. A left R-module M is called$\mathcal{X}$-injective if $Ext_R^1(X, M) = 0$for all left R-modules $X \in \mathcal{X}$. We introduced the concept of $\mathcal{X}$ –projective modules. A left R-module M is called $\mathcal{X}$-projective if $Ext_R^1(M, X) = 0$ for all left R-modules $X \in \mathcal{X}$.

D. Bennis and N. Mahdou introduced and study the concept of Strongly Gorenstein projective and injective modules. we introduce and study about strongly Gorenstein $\mathcal{X}$ -flat modules, which is the generalization of strongly flat modules. Further we link them with the strongly Gorenstein $\mathcal{X}$-projective modules.

2. PRELIMINARIES

In this section, we recall some of the known definitions and terminology that will be used in the rest of the work.

Given a class $\mathbb{C}$ of left R -modules, we write

$$\mathbb{C}^{\perp} = \{N \in R - Mod / Ext_R^1(M, N) = 0, \forall M \in \mathbb{C}\}$$

$$^{\perp}\mathbb{C} = \{N \in R - Mod / Ext_R^1(N, M) = 0, \forall M \in \mathbb{C}\}$$

For an R-module M, $fd(M)$ denote the flat dimension of M and $id(M)$ denote the injective dimension of M. The$\mathcal{X}^{\perp}$ coresolution dimension of M, denoted by $cores.dim_{\mathcal{X}^{\perp}}(M)$, is to be the smallest nonnegative integer n such that$Ext_R^{n+1}(A, M) = 0$for all R-modules$A \in \mathcal{X}$ (if no such n exists, set $cores.dim_{\mathcal{X}^{\perp}}(M)=\infty$), and $cores.dim_{\mathcal{X}^{\perp}}(R)$ is defined as $\sup\{cores.dim_{\mathcal{X}^{\perp}}(M) \mid M \in R\text{-}Mod\}$.

Also, we denote by$\mathcal{X}^{\perp}$ the class of all $\mathcal{X}$-injective modules and $^{\perp}(\mathcal{X}^{\perp})$ the class of all $\mathcal{X}^{\perp}$-projective R -modules.

Example 2.1. Let (R, m) be a commutative Noetherian and complete local domain. Assume that the depth R ≥ 2 and $cores.dim_{\mathcal{X}^{\perp}}(R) \leq 1$. Then R/m ⊕ E(R) is an $(\mathcal{X}^{\perp})^{\perp}$-injective module.

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Definition 2.2. An R-module M is said to be Gorenstein projective (G-projective for short), if there exists an exact sequence of projective modules

$$\mathbf{P} = \cdots P_1 \to P_0 \to P^0 \to P^1 \to \cdots$$

such that M ≅ Im($P_0 \to P^0$) and such that $Hom_R(-, Q)$ leaves the sequence **P** exact whenever Q is a projective module.

The exact sequence **P** is called a complete projective resolution.

The Gorenstein injective (G-injective for short) modules are defined dually.

Definition 2.3. An R-module M is said to be Gorenstein flat (G-flat for short),if there exists an exact sequence of flat modules

$$\mathbf{F} = \cdots F_1 \to F_0 \to F^0 \to F^1 \to \cdots$$

such that M ≅ Im($P_0 \to P^0$) and such that $\_ \otimes I$ leaves the sequence F exact whenever I is an injective module.

The exact sequence **F** is called a complete flat resolution.

Definition 2.4. An R-module M is called Gorenstein $\mathcal{X}$-projective, if there exists an exact sequence of $\mathcal{X}$ -projective modules

$$\mathbf{P} = \cdots P_1 \to P_0 \to P^0 \to P^1 \to \cdots$$

such that M ≅ Im ($P_0 \to P^0$) and such that $Hom_R(-, Q)$ leaves the sequence **P** exact whenever Q ∈ $\mathcal{X}$ -projective module.

The Gorenstein $\mathcal{X}$-injective modules are defined dually.

Definition 2.5. An R-module M is said to be Gorenstein $\mathcal{X}$- flat (G-flat for short),if there exists an exact sequence of $\mathcal{X}$- flat modules

$$\mathbf{F} = \cdots F_1 \to F_0 \to F^0 \to F^1 \to \cdots$$

such that M ≅ Im($P_0 \to P^0$) and such that $\_ \otimes I$ leaves the sequence F exact whenever I is an $\mathcal{X}$-injective module.

The exact sequence **F** is called a complete flat resolution.

Definition 2.6. A complete projective resolution of the form

$$\boldsymbol{P} = \cdots \xrightarrow{f} P \xrightarrow{f} P \xrightarrow{f} P \xrightarrow{f} \cdots$$

is called strongly complete projective resolution and denoted by (**P**, f).

An R-module M is called strongly Gorenstein projective (SG-projective for short) if M ≅ Ker f for some strongly

complete projective resolution (**P**, f).

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The strongly Gorenstein injective (SG-injective for short) modules are defined dually.

Definition 2.7. A complete flat resolution of the form

$$\boldsymbol{F} = \cdots \xrightarrow{f} F \xrightarrow{f} F \xrightarrow{f} F \xrightarrow{f} \cdots$$

is called strongly complete flat resolution and denoted by (**F**, f).

An R-module M is called strongly Gorenstein flat (SG-flat for short) if M ≅ Ker f for some strongly complete flat resolution (**F**, f).

3. STRONGLY GORENSTEIN $\mathcal{X}$-PROJECTIVE AND STRONGLY GORENSTEIN $\mathcal{X}$-INJECTIVE MODULES

In this section we introduce and study the strongly Gorenstein $\mathcal{X}$-projective and $\mathcal{X}$-injective modules which are defined as follows:

Definition 3.1. An R-module M is called strongly Gorenstein$\mathcal{X}$-projective (SG$\mathcal{X}$-projective for short), if there exists an exact sequence of $\mathcal{X}$ -projective modules

$$\boldsymbol{P} = \cdots \xrightarrow{f} P \xrightarrow{f} P \xrightarrow{f} P \xrightarrow{f} \cdots$$

such that M ≅ Ker f and such that $Hom_R(-, Q)$ leaves the sequence **P** exact whenever Q ∈$\mathcal{X}$.

The strongly Gorenstein $\mathcal{X}$ -injective (SG$\mathcal{X}$-injective for short) modules are defined dually.

Example 3.2. Let (R,m) be a commutative Noetherian and complete local domain. Assume that the depthR ≥ 2 and $cores.dim_{\mathcal{X}^{\perp}}$(R)≤ 1. Then there exists a SG$\mathcal{X}$-projective and SG$\mathcal{X}$-injective ideal $\overline{R/m}$.

Proof. Since every projective module is $(\mathcal{X}^{\perp})^{\perp}$-projective module, R/m is $(\mathcal{X}^{\perp})^{\perp}$-projective module.

Also by example 2.1, R/m is $(\mathcal{X}^{\perp})^{\perp}$-injective module.

Then there exists an exact complete $(\mathcal{X}^{\perp})^{\perp}$-projective and $(\mathcal{X}^{\perp})^{\perp}$-injective resolution

$$\boldsymbol{P} = \cdots \xrightarrow{f} \mathrm{R/m} \xrightarrow{f} \mathrm{R/m} \xrightarrow{f} \mathrm{R/m} \xrightarrow{f} \cdots$$

such that Ker f R/m (say).

Clearly, $Hom_R(-, Q)$ and $Hom_R(Q, -)$ leaves the sequence **P** exact whenever

Q ∈$\mathcal{X}$⊆$(\mathcal{X}^{\perp})^{\perp}$

This implies that R/m is SG$(\mathcal{X}^{\perp})^{\perp}$-projective and SG$(\mathcal{X}^{\perp})^{\perp}$-injective.

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Proposition 3.3. (1) If $(P_i)_{i\in I}$ is a family of strongly Gorenstein $\mathcal{X}$-projective modules, then $\oplus P_i$ is strongly Gorenstein $\mathcal{X}$-projective.

(2) If $(I_i)_{i\in I}$ is a family of strongly Gorenstein $\mathcal{X}$-injective modules, then ΠI_i is strongly Gorenstein $\mathcal{X}$-injective.

Proof. We know that a sum (resp., product) of strongly complete $\mathcal{X}$–projective (resp., $\mathcal{X}$-injective) resolutions is also a strongly complete $\mathcal{X}$ -projective (resp., $\mathcal{X}$ -injective) resolution [11, theorem 2.4].

Then $\oplus P_i$ is strongly Gorenstein $\mathcal{X}$-projective and ΠI_i is strongly Gorenstein $\mathcal{X}$-injective modules.

Remark 3.4. If we want to construct an example of a non-finitely generated strongly Gorenstein $\mathcal{X}$-projective module, we can see easily, from the previous Proposition and using the ideal (R/m) of example 3.2, that the direct sum (R/m)(I) for any infinite index set I is a non-finitely generated strongly Gorenstein $\mathcal{X}$- projective module.

It is clear that the strongly Gorenstein $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) modules are a particular case of the Gorenstein $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) modules.

Also every $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) module is Gorenstein $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) since there is an exact complex

$$0 \to P \xrightarrow{=} P \to 0$$

with P an $\mathcal{X}$-projective left R-module and such that $Hom_R(-, Q)$ leaves the above sequence exact whenever Q $\in\mathcal{X}$. [6, Observation 4.2.2].

The next result shows that the class of all strongly Gorenstein $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) modules is between the class of all $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) modules and the class of all Gorenstein $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) modules.

Proposition 3.5. Every $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective) module is strongly Gorenstein $\mathcal{X}$-projective (resp., $\mathcal{X}$-injective).

Proof.

Let P be a $\mathcal{X}$-projective R-module, and consider the exact sequence

$$\boldsymbol{P} = \cdots \xrightarrow{f} P \oplus \mathrm{P} \xrightarrow{f} P \oplus \mathrm{P} \xrightarrow{f} P \oplus \mathrm{P} \xrightarrow{f} \cdots$$

$$(x, y) \to (0, x)$$

We have $0 \oplus \mathrm{P} = \mathrm{Ker\ f} = \mathrm{Im\ f} \cong \mathrm{P}$.

Let Q $\in\mathcal{X}$; applying the functor $Hom_R(-, Q)$ to the above sequence **P**, we get

the following commutative diagram:

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$$\cdots \to Hom(P \oplus \mathrm{P}, \mathrm{Q}) \xrightarrow{Hom_R(f,Q)} Hom(P \oplus \mathrm{P}, \mathrm{Q}) \to \cdots$$

$$\cong\downarrow \qquad\qquad \cong\downarrow$$

$$\cdots \to Hom(P, Q) \oplus \mathrm{Hom}(\mathrm{P}, \mathrm{Q}) \xrightarrow{Hom_R(f,Q)} Hom(P, Q) \oplus \mathrm{Hom}(\mathrm{P}, \mathrm{Q}) \to \cdots$$

Since the lower sequence in the diagram above is exact, the upper sequence also exact. Then P strongly Gorenstein $\mathcal{X}$-projective module.

Similarly, we can prove every $\mathcal{X}$-injective module is strongly Gorenstein $\mathcal{X}$-injective.

The next result gives a simple characterization of the strongly Gorenstein $\mathcal{X}_y$-projective modules.

Proposition 3.7. For any module M, the following are equivalent:

(1) M is strongly Gorenstein $\mathcal{X}$-projective;

(2) there exists a short exact sequence $0 \to \mathrm{M} \to \mathrm{P} \to \mathrm{M} \to 0$, where P is a $\mathcal{X}$ -projective module, and $Ext_R^1(M, Q) = 0$

for any $\mathrm{Q} \in \mathcal{X}$;

(3) there exists a short exact sequence $0 \to \mathrm{M} \to \mathrm{P} \to \mathrm{M} \to 0$, where P is a $\mathcal{X}$-projective module, and $Ext_R^1(M, Q') = 0$ for any module Q' with finite $\mathcal{X}$-dimension and $cores.dim_{\mathcal{X}}(M) = 1$;`

(4) there exists a short exact sequence $0 \to \mathrm{M} \to \mathrm{P} \to \mathrm{M} \to 0$, where P is a $\mathcal{X}$ -projective module; such that for any $\mathrm{Q} \in \mathcal{X}$, the short sequence $0 \to \mathrm{Hom(M,Q)} \to \mathrm{Hom(P,Q)} \to \mathrm{Hom(M,Q)} \to 0$ is exact;

(5) there exists a short exact sequence $0 \to \mathrm{M} \to \mathrm{P} \to \mathrm{M} \to 0$, where P is a $\mathcal{X}$ -projective module, such that for any module Q' with finite $\mathcal{X}$-dimension and

$cores.dim_{\mathcal{X}}(M) = 1$, the short sequence $0 \to \mathrm{Hom(M, Q')} \to \mathrm{Hom(M, Q')} \to \mathrm{Hom(M, Q')} \to 0$ is exact.`

Proof. (2) ⇔ (3). Let Q'be any module with finite

$\mathcal{X}$-dimension, say n and let $cores.dim_{\mathcal{X}}(M) = 1$

Then we have an exact sequence

$$0 \to Q_n \cdots \to Q_1 \to Q_0 \to Q' \to 0$$

Applying the functor Hom(M,−) to the above exact sequence, we get, $Ext_R^1(M, Q') = 0$

Conversely, if $\mathrm{Q} \in \mathcal{X}$, then $\mathcal{X}$ -dimension of Q is 0. Then by (3), $Ext_R^1(M, Q) = 0$.

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The other implications follows from the definition of Ext and strongly Gorenstein $\mathcal{X}$-projective module.

4. STRONGLY GORENSTEIN $\mathcal{X}$-FLAT MODULES

In this section we introduce and study the strongly Gorenstein $\mathcal{X}$-flat modules,and further we link them with the strongly Gorenstein $\mathcal{X}$-projective modules.

Definition 4.1. An R-module M is called strongly Gorenstein $\mathcal{X}$-flat (SG $\mathcal{X}$-flat for short), if there exists an exact sequence of $\mathcal{X}$-flat modules

$$\boldsymbol{F} = \cdots \xrightarrow{f} F \xrightarrow{f} F \xrightarrow{f} F \xrightarrow{f} \cdots$$

such that M ≅ Ker f and such that $Hom_R(-, Q)$ leaves the sequence $\boldsymbol{F}$ exact whenever $Q \in \mathcal{X}$.

Definition 4.2. A complete flat resolution of the form is called a strongly complete flat resolution and denoted by (**F**, f). An R-module M is called strongly Gorenstein $\mathcal{X}$ - flat (SG $\mathcal{X}$ -flat for short) if M ≅ Ker f for some strongly complete flat resolution (**F**, f).

Consequently, the strongly Gorenstein $\mathcal{X}$ -flat modules are simple particular cases of Gorenstein $\mathcal{X}$ -flat modules.

Proposition 4.3. Every $\mathcal{X}$-flat module is strongly Gorenstein $\mathcal{X}$-flat.

Proposition 4.4. Every direct sum of strongly Gorenstein $\mathcal{X}$-flat modules is also strongly Gorenstein $\mathcal{X}$-flat.

Proof. Immediate from the proof of Proposition 3.3 using the fact that tensor products commute with sum

Also, similarly to Proposition 3.7, we have the following characterization of the strongly Gorenstein $\mathcal{X}$-flat modules

Proposition 4.5. For any module M, the following are equivalent:

(1) M is strongly Gorenstein $\mathcal{X}$-flat;

(2) there exists a short exact sequence 0 → M → F → M → 0, where F is a $\mathcal{X}$ -flat module, and $Tor(M, I) = 0$ for any $\mathcal{X}$ -injective module I;

(3) there exists a short exact sequence 0 → M → F → M → 0, where F is a $\mathcal{X}$-flat module, and $Tor(M, I') = 0$ for any module I' with finite injective dimension;

(4) there exists a short exact sequence 0 → M → F → M → 0, where F is a $\mathcal{X}$ -flat module; such that for any $\mathcal{X}$ -injective module I, the short sequence 0 → M⊗ I → F⊗ I → M⊗ I → 0, is exact;

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(5) there exists a short exact sequence $0 \to M \to F \to M \to 0$, where F is a $\mathcal{X}$ -flat module, such that for any module I' with finite projective dimension, the short sequence $0 \to M \otimes I' \to F \otimes I' \to M \otimes I' \to 0$, is exact

Proposition 4.6. A strongly Gorenstein $\mathcal{X}$ -flat module is $\mathcal{X}$ -flat if, and only if, it has finite flat dimension.

Proof. Immediate from Proposition 3.7.

Corollary 4.7. If R has finite weak global dimension. Then, an *R*-module is

Gorenstein $\mathcal{X}$-flat if, and only if, it is $\mathcal{X}$ –flat.

Proposition 4.8. A module is finitely generated strongly Gorenstein $\mathcal{X}$ -projective

if, and only if, it is finitely presented strongly Gorenstein $\mathcal{X}$ -flat.

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MATHS-284

ON CONNECTEDNESS OF THE HAUSDORFF FUZZY METRIC SPACE

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Abstract. In recent literature, topological properties of Hausdorff fuzzy metric space has been discussed in detail. In this paper, we made an attempt to answer the open question that eventually completes the necessary and sufficient condition for Hausdorff fuzzy metric space to be connected.

1 Introduction

Fuzzy metric spaces has been introduced and studied by many authors from various point of view. Here, in particular, we consider a topology generated by a fuzzy metric to be Hausdorff [3]. The modified version of fuzzy metric determines the class of spaces that are connected with the class of metrizable topological spaces. Several properties of Hausdorff fuzzy metric spaces has been discussed in [1]. While investigating on the necessary and sufficient conditions on connectedness given in [1]. We made an attempt to answer the open question Q 4.14 [1]. Hence forth we can explore a necessary and sufficient condition for connectedness through Hausdorff fuzzy metric space of non empty compact subsets $\left(Comp(X), H_M, *\right)$.

2 Preliminaries

Given a fuzzy metric space $(X, M, *)$, we shall denote $\wp(X), Comp(X), Fin(X)$, as the set of nonempty subsets, the set of nonempty compact subsets and the set of nonempty finite subsets of (X, τ_M), respectively. The following results from [1,2,3,4,5] are necessary to prove the main result.

Definition 2.1. :

A binary operation $*: [0,1] \times [0,1] \to [0,1]$ *is a* ***continuous triangular norm***

if for all $a, b, c, e \in [0,1]$ *the following conditions hold:*

1. $a * b = b * a$ *(commutativity)*
2. $a * 1 = a$
3. $(a * b) * c = a * (b * c)$ *(associativity)*
4. $a * b \leq c * e$, *whenever* $a \leq c$ *and* $b \leq e$.

In the sequel we shall refer to triangular norm as a t-norm.
Clearly, $a * b = a.b$ & $a * b = min\{a, b\}$ are two common examples of continuoust-norms.

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Definition 2.2. :

*A **fuzzy metric space** is an ordered triple $(X,M,*)$, such that X is a (nonempty) set, $*$ is a continuous t-norm and M is a fuzzy set on $X \times X \times (0,+\infty)$ satisfying the following conditions, for all $x,y,z \in X, s,t > 0$:*

1. *$M(x,y,t) > 0$;*
2. *$M(x,y,t) = 1$ iff $x=y$;*
3. *$M(x,y,t) = M(y,x,t)$;*
4. *$M(x,y,t) * M(y,z,s) \leq M(x,z,t+s)$;*
5. *$M(x,y,\cdot) : (0,+\infty) \to [0,1]$ is continuous.*

If $(X,M,*)$ is a fuzzy metric space, $(M,*)$ will be called a fuzzy metric on X.

Definition 2.3. :

*Let $(X,M,*)$ be a fuzzy metric spaces. We defin the **open ball** $B(x,r,t)$ with the center $x \in X$ and radius r, $0 < r < 1$, $t > 0$; as $B_M(x,r,t) = y \in X : M(x,y,t) < 1-r$.*

Theorem 2.4. :

Every fuzzy metric space is Hausdroff.

Definition 2.5. :

*Let $(X,M,*)$ be a fuzzy metric space. Then we define a **closed ball** with the center $x \in X$ and the radius r, $0 < r < 1$, $t > 0$; as $B[x,r,t] = y \in X : M(x,y,t) \geq 1-r$.*

Lemma 2.6. :

Every closed ball in a fuzzy metric space $(X,M,*)$ is a closed set.

Definition 2.7. :

*Let $(X,M,*)$, be a fuzzy metric space. Let A be a subset of X. Then **closure** of A is denoted by $\bar{A}$ is defined by*

$\bar{A} = \{x \in X : \forall r \in (0,1), t > 0 \; \exists \, y \in A \ni : M(x,y,t) > 1-r\}$.

Definition 2.8. :

Let $(X,M,*)$ be a fuzzy metric space. For every $A,B \in Comp(X)$ and $t > 0$, define

$$H_M : Comp(X) \times Comp(X) \times (0,\infty) \to [0,1] \text{ by}$$
$$H_M(A,B,t) = \min\{\inf(a \in A) M(a,B,t), \inf(b \in B) M(A,b,t)\}.$$

Then $(Comp(X), H_M, *)$ is a *fuzzy metric space.* $(H_M, *)$ *is called Hausdroff Metric on* $Comp(X)$.

Proposition 2.9:

Let $(X,M,*)$ be a fuzzy metric space. Then $Fin_n(X)$ is a closed subset of $Comp(X)$.

Lemma 2.10:

Let Y be a dense subset of a fuzzy metric space $(X,M,*)$. Then $Fin(Y)$ is dense in $(Comp(X),H_M,*)$.

Definition 2.11:

*A fuzzy metric space $(X,M,*)$ is said to be **connected** if (X,τ_M) is connected.*

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Theorem 2.12. :

Let (X,M,∗) be a fuzzy metric space. Then $(Fin_n(X), H_M, *)$ is connected for every n ∈ N if and only if (X,M,∗) is connected.

Lemma 2.13. :

Let A be a connected subspace of a topological space (X, τ_X). Then the closure $\overline{A}$ of A is also connected.

Theorem 2.14. :

Let (X,M,∗) be a fuzzy metric space. If (X,M,∗) is connected, then so is $(Comp(X), H_M, *)$.

3 Main Result

The Converse of the Theorem 2.14 is the question Q 4.14 asked in [1]. The following result shows that the converse is also true.

Theorem 3.1. :

Let $(X, M, *)$ be a fuzzy metric space. If $(Comp(X), H_M, *)$ is connected, then $(X, M, *)$ is connected.

Proof:

Let (X,M,∗) be a fuzzy metric space and Y be a dense subset of a fuzzy metric space (X,M,∗). Assume that $(Comp(X), H_M, *)$ is connected. Our Claim is to show that (X,M,∗) is connected. By Lemma 2.10, we have Fin(Y) is dense in $(Comp(X), H_M, *)$. Hence $\overline{Fin(Y)} = (Comp(X), HM, *)$. Since $(Comp(X), H_M, *)$ is connected, $\overline{Fin(Y)}$ is connected. Also By Proposition 2.9, we get $\overline{Fin(Y)}$ is closed and hence $Fin(Y) = \overline{Fin(Y)}$ Since Fin(Y) is connected, we have Fin(Y) is connected. By Lemma 2.13, $Fin(\overline{Y})$ is connected. Since $\overline{Y} = (X, M, *)$, we have Fin(X,M,∗) is connected.

By Theorem 2.4, $(Fin(X), H_M, *)$ is connected. Now by imposing the necessary and sufficient condition given in Theorem 2.12, we get (X,M,∗) is connected.

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MATHS-328

DOMINATOR NEIGHBORHOOD SUM OF A GRAPH

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Abstract. A Subset S of the vertex set of a graph G is a dominating set if every vertex in V – S is adjacent to at least one vertex in S, the domination number $\gamma(G)$ is the minimum cardinality of a dominating set of G. In this paper among all dominating sets of G, we define dominator neighborhood sum and the relation between minimum and maximum neighborhood sum of dominating sets of G denoted by $n_\gamma(G)$ and $N_\gamma(G)$ respectively.

I. Introduction

By a graph $G=(V,E)$ we mean a finite, undirected and connected graph with neither loops nor multiple edges. The order and size of G are denoted by n and m respectively. For graph theoretic terminology we refer to Chartrand and Lesniak[1].

We start with following definitions.

1. A subset S of vertices of a graph G is called a dominating set of a graph if each vertex not in S is adjacent with some vertex in S. The domination number $\gamma(G)$ is the minimum cardinality of a dominating set of G and $\Gamma(G)$, the upper domination number equals the maximum number of vertices in a minimal dominating set.
2. A set S of vertices in a graph is said to be an independent set if no two vertices in S are adjacent. A maximal independent set is an independent set to which no other vertex can be added to it without destroying its independence property. The number of vertices in the largest independent set is called the independence number and it is denoted by $\beta(G)$.
3. In a Graph G with 'n' vertices, a vertex is said to be a full degree vertex if degree of the vertex is n-1.

II. Dominator neighborhood sum of a graph

Now let us define Dominator neighborhood sum of a Graph:

Let $G=(V,E)$ be a graph. Let $\gamma(G)=k$. Let $S=\{v_1,v_2,...,v_k\}$ be a $\gamma-$set of G. Let $\{V_1,V_2,...,V_k\}$ be the partition of V(G) satisfying the following conditions.

(i) $v_i \in V_i, 1\le i\le k$

(ii) $V_i \subseteq N(v_i), 1\le i\le k$

(iii) If 't_i' denotes the number of full degree vertices in $\langle V_i\rangle, such that \sum t_i$ is maximum.

Let $n_s=\sum_{i=1}^{k} t_i$

Clearly $t_i \ge 1$ since v_i is adjacent to all other vertices in V_i.

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$\therefore n_s \geq \gamma$ and $n_s \leq n$.

$\therefore \gamma \leq n_s \leq n$

Then $n_\gamma(G) = \min_s n_s$ is called minimum dominator neighborhood sum and $N_\gamma(G) = \max_s n_s$ is called the maximum dominator neighborhood sum in which minimum and maximum are taken over all $\gamma-$ sets of G.

Thus $\gamma \leq n_\gamma \leq N_\gamma \leq n$.

Theorem 2.1

Let G be a graph with $\gamma = 1$. Let k denote the number of vertices of degree $n-1$ in G. Then $n_\gamma(G) = N_\gamma(G) = k$

Proof:

Since there are k vertices of degree $n-1$, $\Delta(G) = n-1$. Let v be a vertex of degree $n-1$. Now $\{v\}$ is a dominating set.

$\therefore n_\gamma(G) = k = N_\gamma(G)$

corollary

(i) $n_\gamma(K_n) = n = N_\gamma(K_n)$

(ii) $n_\gamma(K_{1,n}) = 1 = N_\gamma(K_{1,n})$

(iii) $n_\gamma(W_n) = N_\gamma(W_n) = 1, n > 4$

Theorem 2.2

$$n_\gamma(C_n) = N_\gamma(C_n) = \begin{cases} \gamma & n \equiv 0 \pmod 3 \\ \gamma+2 & n \equiv 1 \pmod 3 \\ \gamma+1 & n \equiv 2 \pmod 3 \end{cases}$$

Proof:

Let $C_n = (v_1 v_2 \ldots v_n v_1)$

Case (i): $n \equiv 0 \pmod 3$

Let $n = 3s, s \geq 1$.

Then $\gamma(C_n) = s$ and C_n has exactly three $\gamma-$sets say $\delta_j = \{v_i \mid i \equiv j \pmod 3\}$ $j = 0,1,2$. Further for any $\gamma-$set S of C_n, $P = \{N[v] / v \in S\}$ is the unique partition of V with $n_s = \gamma$.

$\therefore n_\gamma = N_\gamma = \gamma$

Case (ii): $n \equiv 1 \pmod 3$

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Let $n = 3s+1, s \geq 1$.

Then $\gamma(C_n) = s+1$

Then minimal dominating sets of C_n are of two types.

Subcase (i): γ – set is Independent:

Then $S = \{v_1, v_4, v_7 .... v_{3s-2}, v_{3s}\}$ is an independent dominating set. $P = \{N[v_1], N[v_4], ...N[v_{3s-2}], N[v_{3s}]\}$ is the partition of $V(G)$ with $n_s = \gamma + 2$.

This is true for every γ – set.

$\therefore n_\gamma = N_\gamma = \gamma + 2$

Subcase (ii): γ – set is not Independent:

Then $S = \{v_1, v_4, v_7 .... v_{3s-2}, v_{3s-1}\}$ is a dominating set that is not independent.

$P = \{N[v_1], N[v_4], ...N[v_{3s-2}], N[v_{3s-1}]\}$ is the partition of $V(G)$ with $n_s = \gamma + 2$.

This is true for every γ – set.

$\therefore n_\gamma = N_\gamma = \gamma + 2$

Case (iii): $n \equiv 2 (\text{mod} 3)$

Let $n = 3s+2, s \geq 1$.

Then $\gamma(C_n) = \gamma + 1$

Then C_n $S = \{v_1, v_4, v_7 .... v_{3s-2}, v_{3s-1}\}$ has dominating sets of the type $\{v_1, v_4, v_7 ...., v_{3s+1}\}$ or $\{v_1, v_4, v_7 ...., v_{3s}\}$.

$P = \{N[v_1], N[v_4], ..., N[v_{3s+1}]\}$ is the partition of $V(G)$ such that $n_\gamma = \gamma + 1$.

This is true for every γ – set.

$\therefore n_\gamma = N_\gamma = \gamma + 1$

Observations 2.3

(i) For corona of any graph, $n_\gamma = N_\gamma = n$

(ii) For double star, $n_\gamma = N_\gamma = 2$

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Theorem 2.4

If G has a unique $\gamma-$set, $n_\gamma = \gamma$.

Proof

Let $S = \{v_1, v_2, ..., v_r\}$ be a unique $\gamma-$set.

Let $\{V_1, V_2, ..., V_r\}$ be the partition of V(G) satisfying the conditions.

Claim: $n_\gamma = \gamma$.

Suppose $n_\gamma \neq \gamma$.

Then $n_\gamma > \gamma$

(i.e.) the sum of number of vertices of full degree in $\langle V_i \rangle$ is greater than γ.

Then there exists a partition V_i such that it has at least two full degree vertices. Let it be v_i, v_j.

Then $v_i \in S$ or $v_j \in S$.

Suppose $v_i \in S$ and $v_j \notin S$.

Then we can construct a $\gamma-$set containing v_j.

Which is contradiction to uniqueness of $\gamma-$set.

$\therefore n_\gamma = \gamma$

Theorem 2.5

Let a, b, c be three positive integers with $2 \le a \le b \le c$. Then there exists a graph G with $\gamma = a, n_\gamma = b, N_\gamma = c$.

Proof

Consider a path on $a+1$ points $P = (v_1, v_2, ..., v_{a+1})$.

Attach complete graphs on $c-a+1$ and $b-a+1$ points on first and third vertices respectively and attach two pendants on remaining vertices except at v_2.

Let $V(K_{c-a+1}) = \{u_1 (= v_1), u_2 ... u_{c-a+1}\}$.

$V(K_{b-a+1}) = \{w_1 (= v_3), w_2 ... w_{b-a+1}\}$.

Let the pendants attached to $v_i, i \ge 4$ be denoted by $v_{i,j}, j = 1, 2, i \ge 4$.

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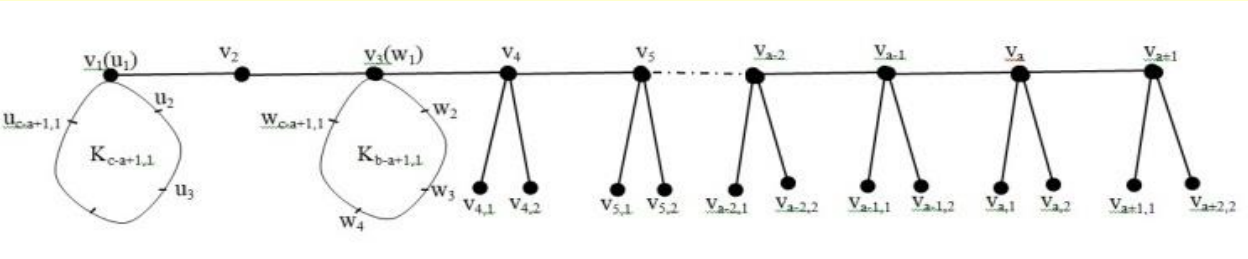

Then minimum dominating set S of the above graph is one of the following types.

(i) $v_1 \in S, v_2 \notin S$ one of $w_2, w_3 \ldots w_{b-a+1} \in S, v_i \in S, i \geq 4$

(ii) one of $u_2, u_3 \ldots w_{c-a+1} \in S, v_2 \notin S, v_i \in S, i \geq 4$

(iii) $v_1 \in S, v_2 \notin S, v_3 \in S, v_i \in S, \forall i \geq 4$

$\therefore \gamma = a$

Case (i): $v_1 \in S, v_2 \notin S$, let $w_2 \in S, v_i \in S$ for $i \geq 4$.

Then $V(G)$ can be uniquely partitioned as

$$V_1 = \{v_1, u_2 \ldots, u_{c-a+1}, v_2\}, t_1 = 1$$

$$V_2 = \{v_2, w_2 \ldots, w_{b-a+1}, v_3\}, t_2 = b-a+1$$

$$V_3 = \{v_4, v_{4,1}, v_{4,2}\}, t_3 = 1$$

…..

$$V_{a-1} = \{v_a, w_{a,1}, v_{a,2}\}, t_{a-1} = 1$$

$$V_a = \{v_{a+1}, v_{a+1,1}, v_{a+1,2}\}, t_{a-1} = 1$$

That gives $n_s = 1+b-a+1+(1+\ldots.1)(a-2) times$

$$= 1+b-a+1+a-2 = b$$

Case (ii): $u_2 \in S, v_3 \in S, v_2 \notin S, v_i \in S, i \geq 4$.

Then $V(G)$ can be uniquely partitioned as

$$V_1 = \{v_1, u_2 \ldots, u_{c-a+1}\}, t_1 = c-a+1$$

$$V_2 = \{v_2, u_3, w_2 \ldots, w_{b-a+1}\}, t_2 = 1$$

$$V_3 = \{v_4, v_{4,1}, v_{4,2}\}, t_3 = 1$$

…..

$$V_{a-1} = \{v_a, w_{a,1}, v_{a,2}\}, t_{a-1} = 1$$

$$V_a = \{v_{a+1}, v_{a+1,1}, v_{a+1,2}\}, t_{a-1} = 1$$

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That gives $n_s = (c-a+1)+(1+....1)(a-1)times$

$= c-a+1+a-1=c$

Case (ii): $v_1 \in S, v_3 \in S, v_2 \notin S, v_i \in S, i \geq 4$.

Then $V(G)$ can be partitioned in two ways

(a) $V_1 = \{v_1, u_2..., u_{c-a+1}\}, t_1 = c-a+1$

$V_2 = \{v_2, w_2..., w_{b-a+1}\}, t_2 = b-a+1$

$V_3 = \{v_4, v_{4,1}, v_{4,2}\}, t_3 = 1$

.....

$V_a = \{v_{a+1}, v_{a+1,1}, v_{a+1,2}\}, t_{a-1} = 1$

$\sum t_i = c-a+1+(1+....1)(a-1)times$

$= c-a+1+a-1=c$

(b) $V_1 = \{v_1, u_2..., u_{c-a+1}, v_2\}, t_1 = 1$

$V_2 = \{v_3, w_2..., w_{b-a+1}\}, t_2 = b-a+1$

$V_3 = \{v_4, v_{4,1}, v_{4,2}\}, t_3 = 1$

.....

$V_a = \{v_{a+1}, v_{a+1,1}, v_{a+1,2}\}, t_{a-1} = 1$

$\sum t_i = 1+b-a+1+(1+....1)(a-2)times$

$= 1+b-a+1+a-2=b$

But we have to consider the partition with maximum $\sum t_i$

$\therefore n_s = c$

$\therefore n_\gamma = \min\{b, c, c\} = b$

$N_\gamma = \max\{b, c, c\} = c$

Thus $\gamma = a, n_\gamma = b, N_\gamma = c$

Hence proved.

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Example 2.6

$4<5<6.a=4,b=5,c=6$.

Proof

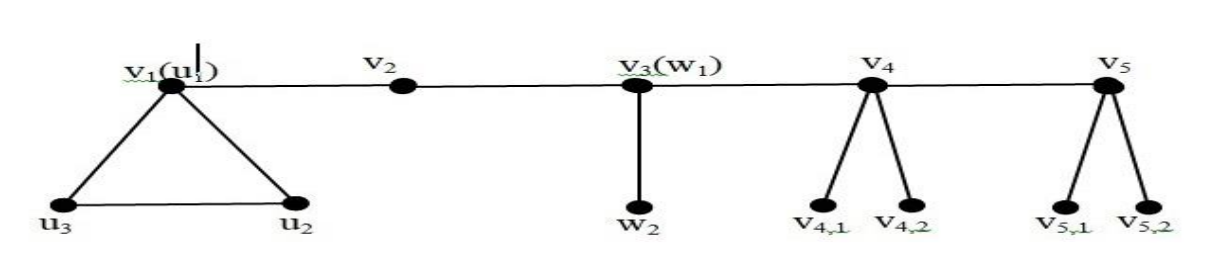
Take a path on $a+1=4+1=5$ points.

$c-a+1=6-4+1=3$

$b-a+1=5-4+1=2$

Attach K_3, K_2 on v_1, v_3.

Attach two pendants on v_4, v_5.



Then $S=\{u_1,w_2,v_4,v_5\}$ or $S=\{u_3,v_3,v_4,v_5\}$ or

$S=\{u_1,v_3,v_4,v_5\}$.

If $S=\{u_1,w_2,v_4,v_5\}$,

$V_1=\{u_1,u_2,u_3,v_2\},t_1=1$

$V_2=\{v_3,w_2\},t_2=2$

$V_3=\{v_4,v_{4,1},v_{4,2}\},t_3=1$

$V_4=\{v_5,v_{5,1},v_{5,2}\},t_4=1$

Thus $n_s=5$.

If $S=\{u_3,v_3,v_4,v_5\}$,

$V_1=\{u_1,u_2,v_3\},t_1=3$

$V_2=\{v_2,v_3,w_2\},t_2=1$

$V_3=\{v_4,v_{4,1},v_{4,2}\},t_3=1$

$V_4=\{v_5,v_{5,1},v_{5,2}\},t_4=1$

Thus $n_s=6$.

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If $S=\{u_1,v_3,v_4,v_5\}$,

then either,

$V_1=\{v_1,u_2,u_3,v_2\},t_1=1$

$V_2=\{v_3,w_3\},t_2=1$

$V_3=\{v_4,v_{4,1},v_{4,2}\},t_3=1$

$V_4=\{v_5,v_{5,1},v_{5,2}\},t_4=1$

Thus $n_s=5$.

Or

$V_1=\{v_1,u_2,u_3\},t_3=3$

$V_2=\{v_2,v_3,w_2\},t_2=1$

$V_3=\{v_4,v_{4,1},v_{4,2}\},t_3=1$

$V_4=\{v_5,v_{5,1},v_{5,2}\},t_4=1$

Thus $n_s=6$.

$\therefore n_\gamma=\min\{5,6,6\}=5$

$N_\gamma=\max\{5,6,6\}=6$

Thus $\gamma=4,n_\gamma=5,N_\gamma=6$

Theorem 2.7

$n_\gamma=n$ if and only if there exists a partition $\{V_1,V_2,....,V_r\}$ of $V(G)$ each induced V_i is complete.

Proof

Suppose each induced V_i is complete.

Then $n_\gamma=n$.

Conversely, suppose $n_\gamma=n$.

Then $\{V_1,V_2,....,V_r\}$ be the partition of $V(G)$ such that $\sum_{i=1}^{r}t_i=n_1+n_2+...+n_r=n$.

To prove that each induced V_i is complete.

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Suppose not, then there exists a partition namely V_j such that $\langle V_j \rangle$ is not complete.

Then there exists a vertex $v_j \in V_j$ such that v_j is not a full degree vertex in $\langle V_j \rangle$.

Then $t_j < n_j$.

$\therefore \sum t_j < n$.

$\therefore n_\gamma < n$

which is a contradiction.

Thus each induced V_i is complete.

Hence proved.

III. We characterize Graphs for which $n_\gamma = n_{\bar{\gamma}}$:

Result 3.1

(1) $n_\gamma(G) = n_\gamma(\overline{G}) = 1$ if and only if $G \cong K_1$.

Theorem 3.2

$n_\gamma(C_n) = n_\gamma(\overline{C_n})$ if and only if $n = 3,4,5$.

Proof

If $n = 3,4,5$, then

$n_\gamma(C_n) = 3 = n_\gamma(\overline{C_n}), n = 3$

$n_\gamma(C_n) = 4 = n_\gamma(\overline{C_n}), n = 4$

$n_\gamma(C_n) = 3 = n_\gamma(\overline{C_n}), n = 5$

Thus $n_\gamma(C_n) = n_\gamma(\overline{C_n})$

Conversely, suppose $n_\gamma(C_n) = n_\gamma(\overline{C_n})$

To prove that $n = 3,4,5$

We have

$$n_\gamma(C_n) = N_\gamma(C_n) = \begin{cases} \gamma & if \quad n \equiv 0(\text{mod}\,3), n > 3 \\ \gamma + 2 & if \quad n \equiv 1(\text{mod}\,3), n > 3 \\ \gamma + 1 & if \quad n \equiv 2(\text{mod}\,3), n > 3 \end{cases}$$

Suppose $n \geq 6$ and $\gamma = 2$.

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Then $n_\gamma\left(\overline{C_n}\right) > \gamma, n \equiv 0(\text{mod}\,3)$

$n_\gamma\left(\overline{C_n}\right) > \gamma + 2, n \equiv 1(\text{mod}\,3)$

$n_\gamma\left(\overline{C_n}\right) > \gamma + 1, n \equiv 2(\text{mod}\,3)$

which is contradiction to $n_\gamma = n_{\overline{\gamma}}$.

Thus $n = 3,4,5$

Hence proved.

Theorem 3.3

$n_\gamma(P_n) = n_\gamma\left(\overline{P_n}\right)$ if and only if $n = 4,5$.

IV. Open Problems

1. Characterize graphs for which $n_\gamma = n_{\overline{\gamma}}$.

2. Obtain upper bounds for n_γ, N_γ and for special types of graphs like Trees, Petersen graph, etc.

3. Is there a relation between $\gamma_c(G)$ and n_γ, N_γ ?

4. Find relation between all domination parameters and n_γ, N_γ

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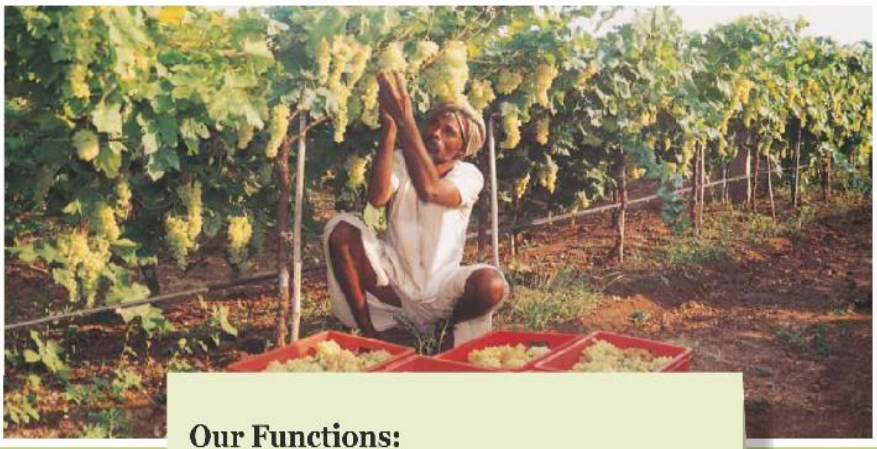

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On Generalized bω-Closed Sets in Ideal Topological Spaces

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Abstract: The aim of this paper is to introduce the notions of generalized bω–closed sets in ideal topological spaces. Characterizations and properties of $I_{gb\omega}$–closed sets and $I_{gb\omega}$–open sets are given.

Keywords:*$I_{gb\omega}$–closed set, $I_{gb\omega}$–open sets,*bω-X_I sets and bω-Y_I sets.

1. Introduction and Preliminaries

An ideal I on a topological space (X,τ) is a nonempty collection of subsets of X which satisfies (i) A ∈ I and B ⊂ A ⇒ B ∈ I and (ii) A ∈ I and B ∈ I ⇒A ∪ B ∈ I. Given a topological space (X,τ) with an ideal I on X and if $\wp(X)$ is the set of all subsets of X, a set operator $(.)^*: \wp(X) \to \wp(X)$, called a local function [9] of A with respect to τ and I is defined as follows: for A ⊆ X, A*(I,τ)={x ∈ X | U ∩ A ∉ I for every U ∈ τ(x) where τ(x)={U ∈ τ | x ∈ U}. We will make use of the basic facts about the local functions [8, Theorem 2.3] without mentioning it explicitly. A Kuratowski closure operator cl*(.) for a topology τ*(I,τ), called the ⋆-topology, finer than τ is defined by $cl^*(A)=A \cup A^*(I,\tau)$ [18].

When there is no chance for confusion, we will simply write A* for A*(I,τ) and τ* for τ*(I,τ). If I is an ideal on X, then (X,τ,I) is called an ideal space. N is the ideal of all nowhere dense subsets in (X,τ).

Definition 1.1: A subset A of an ideal space (X,τ,I) is said to be

(i) ⋆-closed [8] if A* ⊆ A.

(ii) ⋆-dense in itself [6] if A ⊆ A*.

(iii) ⋆-perfect [8] if A = A*.

By a space, we always mean a topological space (X,τ) with no separation properties assumed. If A ⊆ X, cl(A) and int(A) will, respectively, denote the closure and interior of A in (X,τ) and int*(A) will denote the interior of A in (X,τ*).

Definition 1.2: An ideal I is said to be

(i) codense [4] or τ-boundary [14] if τ ∩ I={Φ}.

(ii) completely codense [4] if PO(X) ∩ I={Φ}, where PO(X) is the family of all preopen sets in (X,τ).

Lemma 1.3: Every completely codense ideal is codense but not the converse [4].

Definition 1.4: A subset A of a space (X,τ) is called a

(i) semi-open set[10] if A ⊆ cl[Int (A)]

(ii) α-open set [1] if A⊆Int[cl(Int (A))]

(iii) b-open set [20] if A ⊆ cl[Int (A)] ∪ Int [cl(A)]

The complement of a semi-open (resp. α-open, b-open) set is called semi-closed (resp. α-closed, b-closed) set. The intersection of all semi-closed (resp. α-closed, b-closed) sets of X containing A is called the semi-closure ((resp. α-closure, b-closure) and is denoted by scl(A) (resp. αcl(A), bcl(A)). The family of all semi-open (resp. α-open, b-open) subsets of a space X is denoted by SO(X), (resp. αO(X), bO(X)).

Definition 1.5: A subset A of (X,τ) is called

i) generalized closed (briefly g-closed) set[11] if cl(A)⊆U whenever A⊆U and U is open set in (X,τ).

ii) ĝ-closed or ω–closed set[19] if cl(A) ⊆U whenever A⊆U and U is a semi-open set in (X,τ).

iii) bĝ-closed or bω–closed set[20] if bcl(A) ⊆U, whenever A⊆U and U is a ĝ–open set in (X,τ).

The complement of a g-closed(resp. ω–closed and bω–closed) set is called g-open (resp. ω–open and bω–open) set.

Definition 1.6: A subset A of an ideal space (X,τ,I) is called

i) I_g-closed [3] if A* ⊆ U whenever A ⊆ U and U is open.

ii) I_{g^*}-closed [22] if A* ⊆ U whenever A ⊆ U and U is g-open.

iii) $I_{\hat{g}}$-closed [21] if A* ⊆ U whenever A ⊆ U and U is semi-open.

The following Lemmas will be useful in the sequel.

Lemma 1.7. Let (X,τ,I) be an ideal space and A ⊆ X. If A ⊆A*, then A* =cl(A*) =cl(A)= cl*(A) [17, Theorem 5].

Lemma 1.8. Let (X,τ,I) be an ideal space. Then I iscodense if and only if G ⊆ G* for every semi-open set G in X [17, Theorem 3].

Lemma 1.9. Let (X,τ,I) be an ideal space. If I is completely codense, then $\tau^* \subseteq \tau^{\alpha}$ [17, Theorem 6].

Result 1.10. If (X,τ) is a topological space, then every closed set is bĝ or bω-closed set, but not conversely [20].

Lemma 1.11. Every g-closed set is I_g-closed but not conversely [3,Theorem 2.1].

Remark 1.12. The following statements are true in any ideal spaces:

(i) Every closed set is ⋆-closed set but not conversely [8].

(ii) Every ⋆-closed set is I_g-closed but not conversely [13].

Lemma 1.13. [8] Let (X,τ,I) be an ideal space and A,B are subsets of X. Then the following properties hold:

(i) If $A \subseteq B$, then $A^* \subseteq B^*$,

(ii) $A^* = cl(A^*) \subseteq cl(A)$,

(iii) $(A^*)^* \subseteq A^*$,

(iv) $(A \cup B)^* = A^* \cup B^*$

2. $I_{gb\omega}$-Closed Sets

Definition 2.1. A subset A of an ideal space (X,τ,I) is said to be $I_{gb\omega}$-closed if $A^* \subseteq U$ whenever $A \subseteq U$ and U is $b\omega$-open. **Definition 2.2.** A subset A of an ideal space (X,τ,I) is said to be $I_{gb\omega}$-open if $X-A$ is $I_{gb\omega}$-closed.

Theorem 2.3. If (X,τ,I) is any ideal space, then every $I_{gb\omega}$-closed set is I_g-closed but not conversely.

Example 2.4. Let $X=\{a,b,c\}$, $\tau=\{\Phi,X,\{a\}\}$ and $I=\{\Phi,\{a\}\}$. Then $I_{gb\omega}$-closed sets are $\Phi,X,\{a\},\{b,c\}$ and I_g-closed sets are $\Phi,X,\{a\},\{b\},\{c\},\{a,b\},\{a,c\},\{b,c\}$. It is clear that $\{b\}$ is I_g-closed but it is not $I_{gb\omega}$-closed.

The following theorem gives characterizations of $I_{gb\omega}$-closed sets.

Theorem 2.5. If (X,τ,I) is any ideal space and $A \subseteq X$, then the following are equivalent.

(a) A is $I_{gb\omega}$-closed.

(b) cl*(A) ⊆ U whenever A ⊆ U and U is bω-open in X.

Proof. (a) ⇒ (b) If A is $I_{gb\omega}$-closed, then A*⊆U whenever A ⊆ U and U is bω-open in X and so cl*(A)=A ∪ A* ⊆ U whenever A ⊆ U and U is bω-open in X. This proves (b).

(b) ⇒ (a) Let cl*(A) ⊆ U whenever A ⊆ U and U is bω-open in X. Since A*⊆cl*(A) ⊆U⇒ A* ⊆ U. Hence A is $I_{gb\omega}$-closed.

Theorem 2.6: If a subset A of(X,τ,I) is $I_{gb\omega}$-closed set, then

(1) cl*(A)−A contains no nonempty bω-closed set.

(2) A*−A contains no nonempty bω-closed set.

Proof.

(1) Let A be a $I_{gb\omega}$-closed set in (X,τ,I) and F be a bω-closed subset of cl*(A)−A. Then A ⊆ X − F. Since X − F is bω-open and A is $I_{gb\omega}$-closed, cl*(A) ⊆ X − F. Consequently, F ⊆ X – cl*(A). We have F ⊆ cl*(A). Thus, F ⊆ cl*(A) ∩ (X – cl*(A)) = Φ and so cl*(A)−A contains no nonempty bω-closed set.

(2) The fact is cl*(A)−A = (A∪A*)−A = (A∪A*)∩A^c = (A∩A^c)∪(A*∩A^c) = A*∩A^c = A*−A.

Theorem 2.7. Every ⋆-closed set is $I_{gb\omega}$-closed but not conversely.

Proof. Let A be a ⋆-closed, then A* ⊆ A. Let A ⊆ U where U is bω-open. Hence A* ⊆ U whenever A ⊆ U and U is bω-open. Therefore A is $I_{gb\omega}$-closed.

Example 2.8. Let X={a,b,c}, τ ={Φ,X,{a}} and I={Φ,{a},{c},{a,c}}. Then $I_{gb\omega}$-closed sets are Φ,X,{a},{c},{a,c},{b,c} and ⋆-closed sets are Φ,X,{a},{c},{a,c}. It is clear that {b,c} is $I_{gb\omega}$-closed set but it is not⋆-closed.

Theorem 2.9. Let (X,τ,I) be an ideal space. For every $A \in I$, A is $I_{gb\omega}$-closed.

Proof. Let $A \subseteq U$ where U is $b\omega$-open set. Since $A^* = \Phi$ for every $A \in I$, then $cl^*(A)=A \cup A^*=A \subseteq U$. Therefore, by Theorem 2.5, A is $I_{gb\omega}$-closed.

Theorem 2.10. If (X,τ,I) is an ideal space, then A^* is always $I_{gb\omega}$-closed for every subset A of X.

Proof. Let $A^* \subseteq U$ where U is $b\omega$-open. Since $(A^*)^* \subseteq A^*$ [8], we have $(A^*)^* \subseteq U$ whenever $A^* \subseteq U$ and U is $b\omega$ -open. Hence A^* is $I_{gb\omega}$-closed.

Theorem 2.11. Let (X,τ,I) be an ideal space. Then every $I_{gb\omega}$-closed, $b\omega$-open set is $\star$-closed set.

Proof. Since A is $I_{gb\omega}$-closed and $b\omega$-open. Then $A^* \subseteq A$ whenever $A \subseteq A$ and A is $b\omega$-open. Hence A is $\star$-closed.

Theorem 2.12. Let (X,τ,I) be an ideal space and A be a $I_{gb\omega}$-closed set. Then the following are equivalent.

a) A is a $\star$-closed set.

b) $cl^*(A)-A$ is a $b\omega$-closed set.

c) A^*-A is a $b\omega$-closed set.

Proof.

(a) $\Rightarrow$ (b) If A is $\star$-closed, then $A^* \subseteq A$ and so $cl^*(A)-A=(A \cup A^*)-A= \Phi$. Hence $cl^*(A)-A$ is $b\omega$-closed set.

(b) $\Rightarrow$ (c) Since $cl^*(A)-A=A^*-A$ and so A^*-A is $b\omega$-closed set.

(c) $\Rightarrow$ (a) If A^*-A is a $b\omega$-closed set, since A is $I_{gb\omega}$-closed set, by Theorem 2.6, $A^*-A= \Phi$ and so A is $\star$-closed.

Example 2.13. Let X={a,b,c}, τ={Φ,X,{a},{b},{a,b}} and I={Φ,{b}}. Then g-closed sets are Φ,X,{c},{a,c},{b,c} and $I_{gb\omega}$-closed sets are Φ,X,{b},{c},{a,c},{b,c}. It is clear that {b} is $I_{gb\omega}$-closed set but it is not g-closed.

Example 2.14. Let X={a,b,c}, τ={Φ,X,{a}} and I={Φ}. Then g-closed sets are Φ,X,{b},{c},{a,b},{a,c},{b,c} and $I_{gb\omega}$-closed sets are Φ,X,{b,c}. It is clear that {b},{c},{a,b},{a,c} are g-closed sets but are not $I_{gb\omega}$-closed.

Remark 2.15. By Example 2.13 and Example 2.14, g-closed sets and $I_{gb\omega}$-closed sets are independent.

Remark 2.16. We have the following implications for the subsets stated above.

Theorem 2.17. Let (X,τ,I) be an ideal space and A ⊆ X. If A ⊆ B ⊆ A*, then A*=B* and B is ⋆-dense in itself.

Proof. Since A ⊆ B, then A* ⊆ B* and since B ⊆ A*, then B* ⊆ (A*)*⊆ A*. Therefore A*=B* and B ⊆ A* ⊆ B*. Hence proved.

Theorem 2.18. Let (X,τ,I) be an ideal space. If A and B are subsets of X such that A⊆B⊆A* and A is $I_{gb\omega}$-closed, then B is $I_{gb\omega}$-closed.

Proof. Let U be any bω-open set of (X,τ,I) such that B⊆U. Then A⊆U. Since A is $I_{gb\omega}$-closed, we have A*⊆U. Now B*⊆(A*)*⊆A*⊆U. Therefore B is $I_{gb\omega}$-closed.

The following theorem gives a characterization of $I_{gb\omega}$-open sets.

Theorem 2.19. Let (X,τ,I) be an ideal space and $A\subseteq X$. Then A is $I_{gb\omega}$-open if and only if $F\subseteq int^*(A)$ whenever F is $b\omega$-closed and $F\subseteq A$.

Proof. Suppose A is $I_{gb\omega}$-open. If F is $b\omega$-closed and $F\subseteq A$, then $X-A\subseteq X-F$ and so $cl^*(X-A)\subseteq X-F$ by Theorem 2.5. Therefore $F\subseteq X-cl^*(X-A)=int^*(A)$. Hence $F\subseteq int^*(A)$.

Conversely, suppose the condition holds. Let U be a $b\omega$-open set such that $X-A\subseteq U$. Then $X-U\subseteq A$ and so $X-U\subseteq int^*(A)$. Therefore $cl^*(X-A)\subseteq U$. By Theorem 2.5, $X-A$ is $I_{gb\omega}$-closed. Hence A is $I_{gb\omega}$-open.

The following theorem gives a characterization of $I_{gb\omega}$-closed sets in terms of $I_{gb\omega}$-open sets.

Theorem 2.20. Let (X,τ,I) be an ideal space and $A\subseteq X$. Consider the following statements.

1. A is $I_{gb\omega}$-closed,

2. $A\cup(X-A^*)$ is $I_{gb\omega}$-closed,

3. A^*-A is $I_{gb\omega}$-open.

Then we have (1) $\Rightarrow$ (2) $\Leftrightarrow$ (3).

Proof.

(1)$\Rightarrow$(2) Suppose A is $I_{gb\omega}$-closed. If U is any ω-open set such that $A\cup(X-A^*)\subseteq U$, then $X-U \subseteq X-(A\cup(X-A^*)) = X\cap(A\cup(A^*)^c)^c = A^*\cap A^c = A^*-A$. Since A is $I_{gb\omega}$-closed, by Theorem 2.6, it follows that $X-U = \Phi$ and so $X=U$. Therefore $A\cup(X-A^*)\subseteq U$ which implies that $A\cup(X-A^*)\subseteq X$ and so $(A\cup(X-A^*))^*\subseteq X^*\subseteq X=U$. Hence $A\cup(X-A^*)$ is $I_{gb\omega}$-closed.

(2)$\Leftrightarrow$(3) Since $X-(A^*-A) = X\cap(A^*\cap A^c)^c = X\cap((A^*)^c\cup A)=(X\cap(A^*)^c)\cup(X\cap A)=A\cup (X-A^*)$ is $I_{gb\omega}$-closed. Hence A^*-A is $I_{gb\omega}$-open.

Theorem 2.21. Let (X,τ,I) be an ideal space. Then every subset of X is $I_{gb\omega}$-closed if and only if every $b\omega$-open set is $\star$-closed.

Proof. Suppose every subset of X is $I_{gb\omega}$-closed. If $U\subseteq X$ is $b\omega$-open, then by hypothesis, U is $I_{gb\omega}$-closed and so $U^*\subseteq U$. Hence U is $\star$-closed.

Conversely, suppose that every $b\omega$-open set is $\star$-closed. Let A be a subset of X. If U is $b\omega$-open set such that $A\subseteq U$, then $A^*\subseteq U^*\subseteq U$ and so A is $I_{gb\omega}$-closed.

Theorem 2.22. The union of two $I_{gb\omega}$-closed sets is again $I_{gb\omega}$-closed.

Proof. Suppose that $(A\cup B)\subseteq U$ and U is $b\omega$-open in (X,τ,I), than $A\subseteq U$ and $B\subseteq U$. Since A and B are $I_{gb\omega}$-closed sets, $A^*\subseteq U$ and $B^*\subseteq U$. $(A\cup B)^*=A^*\cup B^*\subseteq U$. Thus, $A\cup B$ is $I_{gb\omega}$-closed.

Theorem 2.23. For each $x\in(X,\tau,I)$, either $\{x\}$ is $b\omega$-closed or $\{x\}^c$ is $I_{gb\omega}$-closed in (X, τ , I).

Proof. Suppose that $\{x\}$ is not $b\omega$-closed, then $\{x\}^c$ is not $b\omega$-open and the only $b\omega$-open set containing $\{x\}^c$ is the space (X,τ,I) itself. Therefore $cl^*(\{x\}^c) \subseteq X$ and so $\{x\}^c$ is $I_{gb\omega}$-closed.

Definition 2.24. A subset A of an ideal topological space (X,τ,I) is said to be

1) a $b\omega$-X_I -set if $A = U\cap V$, where U is a $b\omega$-open set and V is a $\star$-perfect set.

2) a $b\omega$-Y_I -set if $A = U\cap V$, where U is a $b\omega$-open set and V is a $\star$-closed set.

Theorem 2.25. A subset A of an ideal topological space (X, τ , I) is a $b\omega$-X_I -set and a $I_{gb\omega}$-closed set, then A is a $\star$-closed set.

Proof. Let A be a bω-X_I -set and a $I_{gb\omega}$-closed set. Since A is a bω-X_I -set, A = U∩V, where U is a bω-open set and V is a ⋆-perfect set. Now, A = U∩V⊆U and A is a $I_{gb\omega}$-closed set implies that A*⊆U. Also, A = U∩V⊆V and V is ⋆-perfect set implies that A*⊆V. Thus, A*⊆U∩V = A. Hence, A is a ⋆-closed set.

Theorem 2.26. For a subset A of an ideal topological space (X,τ,I), the following are equivalent.

1. A is a ⋆-closed set.

2. A is a bω-Y_I -set and a $I_{gb\omega}$-closed set.

Proof.

(1) ⇒ (2): Let A be a ⋆-closed set and A = X∩A, where X is bω-open set and A is a ⋆-closed set. Hence, A is a bω-Y_I -set. Assume that A be a ⋆-closed set and U be a bω-open set such that A⊆U. Then A*⊆U and hence A is a $I_{gb\omega}$-closed set.

(2) ⇒ (1): Let A be a bω-Y_I -set and a $I_{gb\omega}$-closed set. Since A is a bω-Y_I -set, A = U∩ V, where U is a bω-open set and V is a ⋆-closed set. Now, A⊆U and A is a $I_{gb\omega}$-closed set implies that A*⊆U. Also, A⊆V and V is a ⋆-closed set implies that A*⊆V. Thus, A*⊆U∩V = A. Hence, A is a ⋆-closed set.

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OP-08

GREEN SYNTHESIS AND ANTIBACTERIAL ACTIVITY OF IRON OXIDE NANOPARTICLES USING VITEX NEGUNDO LEAF EXTRACT BY SOL-GEL METHOD

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Abstract :

Sol-gel method was utilized to make Iron Oxide nanoparticles from Vitex negundo leaf extract. The crystal structure, grain size, morphology and magnetic properties are analyzed by using XRD, FTIR, SEM, and VSM. The XRD obviously points out the existence of single phase cubic spinel structure with high purity. The Debye Scherrer formula was used to compute the average crystallite size. EDX has confirmed the existence of Fe and O elemental composition. The presence of different biomolecules in the aqueous Vitex negundo leaf extract, such as flavonoids, terpenoids, glycosides, tannin, phenol and reducing sugar was analyzed and it was confirmed. In FTIR spectra, strong peak observed between 400–600 cm−1, which correlates to magnetite nanoparticle properties. VSM is used to examine their magnetic characteristics at room temperature. At ambient temperature, it shows the super paramagnetic property. Antibacterial activity was found in both Gram positive and Gram negative microorganisms. The nanoparticles are quick and easy to make, eco-friendly, non-toxic, and they can be employed in a magnetic targeting drug delivery system.

Keywords: Iron oxide, Biomolecules, Antibacterial, VSM, Drug delivery

OP-28

SPECTRAL AND MECHANICAL PROPERTIES OF GLYCINE DOPED L-TARTARIC ACID CRYSTAL

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Abstract

Nonlinear optics has become one of the most important areas in recent years. The understanding of polarisation ideas in nonlinear optics has greatly improved. Researchers are developing novel materials with strong NLO features, such as a wide transparency range, high thermal stability, high hardness, and a high damage threshold, that are required for technological applications. Single crystals of glycine doped L-tartaric acid (GLTA) were grown from aqueous solution using a slow evaporation process. The structure of the developing crystal was characterized using the XRD technique. The functional groups were discovered using FTIR characterization. EDS spectroscopy was used to identify the elements in the sample. Using microhardness tester mechanical properties of the sample was analyzed. Nd-YAG laser was used to determine the Laser Damage Threshold values. Spectral and mechanical properties, EDS and LDT studies of glycine doped L-tartaric acid crystal were reviewed in this study.

Key words: NLO; Single crystal; FTIR; Microhardness; LDT

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stability of these compounds and their electronic nature. The three new molecules are showing considerable dipole moment values and hperpolarizability values confirming their NLO active nature and can be used for the preparation of optical materials.

Keywords: 1,2,3-Triazole, Isoovazole, NMR, XRD, DFT, NLO, Antimicrobial Activity.

CHEMISTRY-010

GREEN SYNTHESIS OF CUO NANOPARTICLES WITH HIBISCUS ROSA-SINENSIS AND PHYTOCHEMICAL SCREENING

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The present study is reported with green synthesis of copper oxide nanoparticles from the floweral extract of *Hibiscus rosa-sinensis*. The green synthesis of CuO nano particles can be a modest, alternate synthesis to the conventional physical or chemical method. Synthesized CuO nanoparticles were characterized by the X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX).An XRD result of prepared CuO nanoparticles reveals the monoclinic crystalline structure and crystallite size is36nm. SEM results showed the distribution of CuO nanoparticles are irregular size. In EDX analysis shows that the Cu and O element is present. Further the phytochemical screening was carried out. The presence of phyto-compound in the extracts including glycosides and steroids may be responsible against Gram positive bacteria [Staphylococcus aureus (S. aureus), Streptococcus, Bacillus subtillis (B. subtillis)] and Gram negative bacteria [Escherichia coli (E. coli), Pseudomonas aeruginosa (P. aeruginosa) and Salmonella sp].

Keywords: Nano Particles, Green Synthesis, Phyto-Chemical.

CHEMISTRY-011

GEOMETRICAL AND ELECTRONIC STRUCTURE, STABILITY, BONDING AND SPECTROSCOPIC PROPERTIES OF DIMERS AND TETRAMER OF ICOSAHEDRAL STANNA-CLOSO-DODECABORANES - A COMPUTATIONAL STUDY

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Computational chemistry tools become unavoidable both for experimental and theoretical chemists to address chemical problems. Here we have used DFT (density functional theory) methods to study the geometrical and electronic structure, stability, bonding and spectroscopic properties of dimers and tetramers of icosahedral stanna-*closo*-dodecaboranes (**1-4**). Icosahedral boranes are the unique member of 3D aromatic cluster. It plays main role in clinical applications such as BNCT, anti-HIV, anti-cancer and material applications such as photo optics, hydrogen storage devices, radio nucleide extraction and super acids, etc. Stanna-*closo*-dodeccaborates can forms polymeric clusters like head-head (bonding of two apical Sn vetex 'Sn-Sn') dimer, head-sholder (bonding of apical Sn and shoulder B vertex at upper belt 'Sn-B') dimers and tetramers. These polymeric clusters contribute finest 3D aromaticity than monomeric clusters. The polymeric clusters investigations have been done by DFT at BP86/def2-tzvp level. The computational results show that these dimes and tetramers can be used for the NLO material preparation and other fiields like medicine as drug delivery agents.

Keywords: 3D Aromaticity, BNCT, DFT, Icosahedral Boranes, Photo Optics.

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JANA2006 REFINEMENT ANALYSIS OF NICKEL DOPED COPPER FERRITE NANOPARTICLES FOR PHOTOCATALYTIC APPLICATIONS

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In this study, Nickel doped Copper ferrite ($Ni_xCu_{1-x}Fe_2O_4$ where x = 0, 0.5 and 1.0) nanoparticles were synthesized by the low cost sol-gel combustion method using di-ethanolamine as a surfactant. The X-ray diffraction (XRD) results obviously point out the existence of a single phase cubic spinel structure. The good stoichiometric composition was found from the relative intensity of the most preferential diffraction peaks. Crystallinity of the nanoparticles was found to be good with the help of Jana2006 refinements. The crystallite size estimated from Scherrer's formula fitted well when compared to the W-H analysis. Lattice constant, macrostrain and dislocation density of the nanoparticles were analyzed using reported relations. The value of the lattice constant is found to be increased with the doping of nickel into copper ferrite. Crystallinity also impacts the photocatalytic behavior of the nanoparticles in the field of waste water treatment. Photocatalytic degradation behavior of nanoparticles under the sun light was analyzed. Improved photocatalytic degradation of Congo red under visible light is observed for Nickel doped Copper ferrite when compared to the constituent phases.

Keywords: Nanoparticles, XRD, Jana2006, photocatalytic behavior

Second and Third order NLO properties of L-asparagine L-tartaric acid Crystal doped with Ammonium Sulfate

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Abstract

There are several applications for nonlinear optical materials in laser technology, optical communication, optical computing, and opto electronics. Ammonium sulphate doped L-asparagine L-tartaric acid nonlinear optical single crystal was generated using a slow evaporation approach. The equimolar ratio of L-asparagine and L-tartaric acid to make an aqueous solution and 1% mole of ammonium sulphate was added to the mixture resulted in a high quality single crystal of ammonium sulphate doped L-asparagine and L-tartaric acid. From X-ray diffraction studies, it was revealed that the grown crystal crystallizes in monoclinic structure. Functional groups were identified by FTIR studies. From EDS studies elements present in the crystal were identified. Second order nonlinearity was responsible for producing nonlinear optical phenomena such as Pockel'effect, second harmonic generation, sum frequency generation, difference frequency generation, parametric generation, and nonlinear optical rectification. The second harmonic generation (SHG) conversion efficiency was measured by the Kurtz and Perry powder method using a pulsed Nd:YAG laser. Green laser light is produced when incoming laser light with an energy of 0.70 joule/pulse strikes ammonium sulfate-doped LALTA crystalline material and a KDP sample. The samples' SHG signal is seen as green laser light. Green laser light has been found to have a wavelength of 532 nm, which is half that of incoming laser light. As a result, both the reference sample and the growing sample exhibit the SHG phenomenon at twice the frequency. Green laser energy from the KDP sample is 8.91 joule/pulse, while the energy of green light from the ammonium sulfate-doped LALTA crystal is 9.87 joule/pulse. Therefore, the ammonium sulphate doped LALTA crystalline sample's relative SHG efficiency is 1.1 times that of KDP. In order to investigate third order nonlinear optical features such as nonlinear refractive index, nonlinear absorption coefficient, and nonlinear susceptibility, Z-scan technique was used. The generated crystal of ammonium sulphate doped LALTA was exposed to He-Ne laser of wavelength 632.8 nm. The open aperture Z-scan and closed aperture Z-scan curves for ammonium sulfate doped LALTA crystal were drawn. Prefocus maximum (peak) to postfocus minimum (valley) were visible in the closed aperture Z-scan curve, and this correlates to negative nonlinearity of the sample.

Key words: Single crystal, NLO, XRD, FTIR, EDS, SHG, Z-scan

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GREEN SYNTHESIS OF SILVER NANOPARTICLES USING *AZADIRACHTA INDICA* AND ITS ENHANCED ANTIBACTERIAL ACTIVITY

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Abstract

Silver nanoparticles have admirable medical and non-medical applications when related with other metal nanoparticles. The green synthesis method is used to synthesis silver nanoparticles because of its easy to make, eco-friendly and non-toxic behavior. The crystal structure, grain size and morphology are analyzed by using X-Ray Diffraction (XRD) and Scanning Electron Microscope (SEM). The XRD peaks indicates that the prepared nanoparticles are cubic spinel structure with high purity. The Debye Scherrer formula is used to calculate the particle size. SEM image shows that the particles are in agglomerated form. The prepared silver nanoparticles elements are analyzed by Energy Dispersive X-Ray Analysis (EDX). EDX peak shows that Ag and O elements are only present, it confirms the purity of prepared nanoparticle. The presence of different biomolecules in the aqueous *Azadirachta indica* leaf extract, such as glycosides and terpenoids, Antibacterial activity of the silver nanoparticle was investigated against *bacillus sp.* by well diffusion method. The maximum zone of clearance was observed (2 mm) with 10 mg/mL. From these observed results increasing the concentration of silver nanoparticles, maximum zone of clearance will be observed.

Keywords: AgNPs, Plant extract, XRD, spinel structure, Antibacterial activity.

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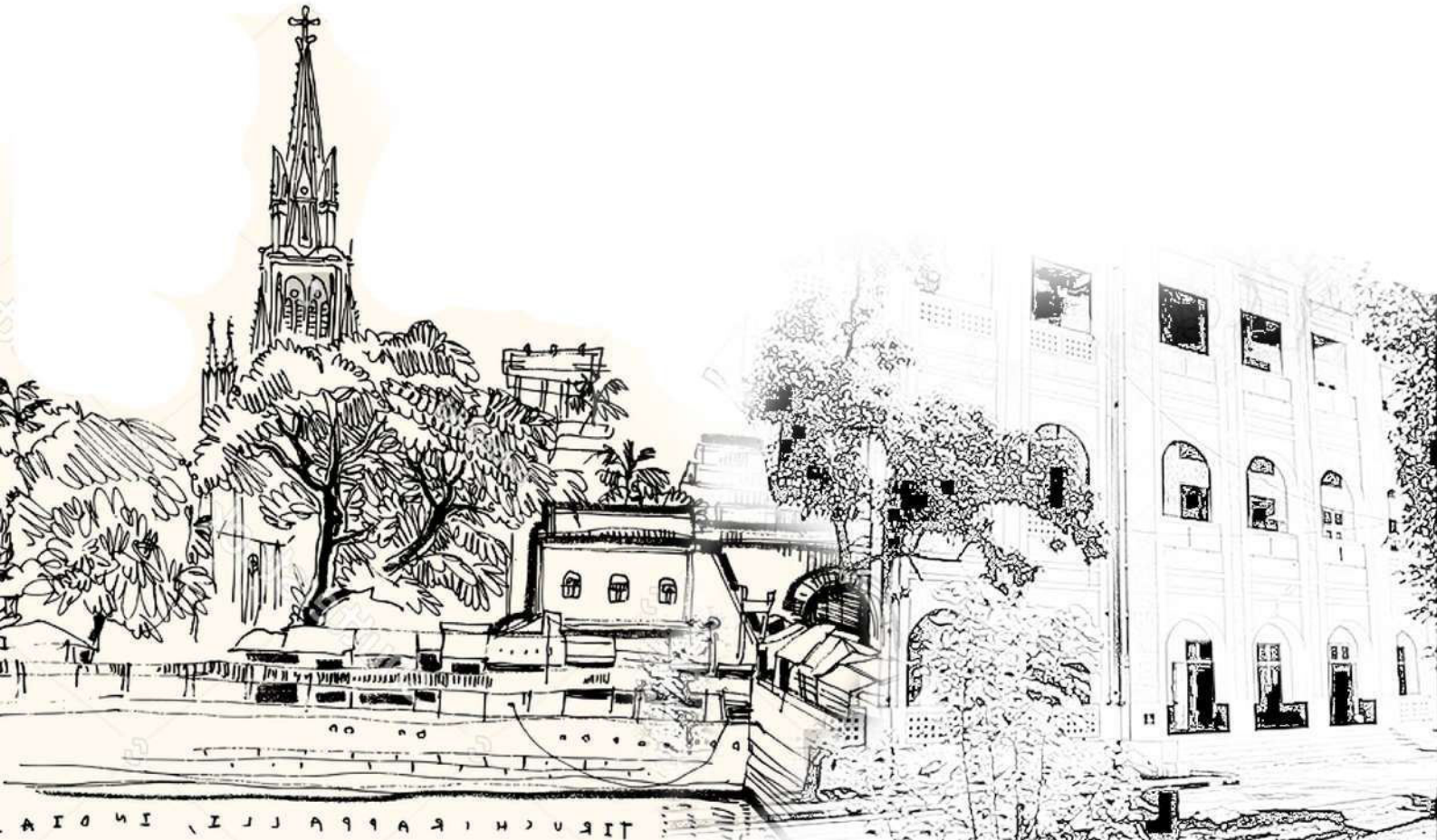

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CHEMSMAT-21 – O6

SODIUM ALGINATE BASED NANOCOMPOSITES AND THEIR APPLICATIONS IN WASTE WATER TREATMENT

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ABSTRACT

Water pollution is one of the major environmental problems in the world today. There are several treatment techniques available to treat the waste water. The mechanisms of waste water treatment include catalytic degradation of wastes, aerobic and anaerobic microbial degradation, use of nanomembrane filters, biomembrane reactors, adsorption based techniques etc., The cost effective and efficient techniques are in demand today as most of the treatment techniques are expensive. Nanomaterial based adsorption techniques are on the rise in the treatment of different types of wastes. Alginate based nanomaterials is an interesting option in the treatment. Alginate is present in sea brown algae. Algae are actually good natural cleaning agents and bio-adsorbers. The functional groups present in the alginate derived from marine algae are found to be acidic or basic or neutral. So, the different elements of waste water can be effectively adsorbed using such derivatives. The composites of alginate were prepared with the combination of carbon nanomaterials, silica, clay, metals, metal oxides etc. They exhibit different adsorption characteristics towards various ingredients such as heavy metals, organic dyes, microbes and other pollutants of waste water.

Keywords: Sodium alginate, adsorption, nanomaterials, and wastewater treatment.

International Conference on
Solution Grown Crystals and Their Useful Applications
(SGCA-2021)

in association with

Indian Association for Crystal Growth (IACG)

13-15 September 2021

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2nd International Web Conference on Advanced Material Science & Nanotechnology (NANOMAT-2021)
Mode of Presentation : Oral Presentation / Poster Presentation

Synthesis and Characterization of Dibromobis(dimethylgloxime)cobalt(II) Complexes

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Abstract

The Dibromobis(dimethylgloxime)cobalte(II) complex $[Co(C_4H_8N_2O_2)_2Br_2]H_2O$ was prepared by precipitation and microwave assisted synthesis technique. The Cobaloxime complex was characterized by using UV-Vis, FTIR, NMR, and single crystal XRD. The peak corresponding to the $\pi \rightarrow \pi^*$ transition of the complex was observed in the UV-Vis spectrum. FTIR spectrum confirmed the presence of vibrational frequencies of N-O, C=N and methyl group. It also confirmed the presence of hydrogen bonded O-H. The peaks in the NMR spectrum confirmed the number and equivance of methyl protons of dimethylglyoxime. The structure of the complex was confirmed by single crystal XRD analysis. The nature of the hydrogen bonding between different moieties of the complexes was observed through Oak Ridge Thermal Ellipsoid Plot (ORTEP). The structural elucidation confirmed that both the glyoxime moieties of the dibromo complex are protonated. The complexes were inter-linked through water molecules by means of hydrogen bonding. The hydrogen bonding was observed between methyl hydrogen of equatorial dimethyl glyoxime and water molecule.

Keywords

Coordination compounds; Cobaloxime; Dibromo Cobalt complexes; Single crystal XRD.

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PP-100

Green synthesis of silver nanoparticles using Vitex negundo and its enhanced antibacterial activity against Bacillus sp

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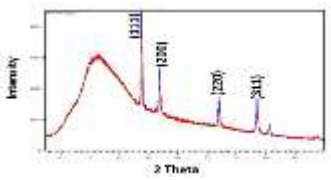
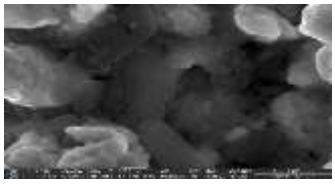
Abstract

Plant-based synthesis of silver nanoparticles (AgNPs) has emerged as a possible alternative to traditional chemical production. In this study, we report low-cost, green synthesis of AgNPs using fresh leaf extract of Vitex negundo collected from Western Ghats (longtitiute and latitiude) The biosynthesized AgNPs was confirmed by different characterization techniques such as UV-Visible Spectroscopy, Fourier transform infrared spectroscopy (FTIR), X-Ray Diffraction (XRD) and Scanning electron microscope (SEM). XRD analysis revealed the prepared silver nanoparticles are crystalline nature. The particle size of the silver oxide with Vitex negundo nanoparticles is estimated by Debye–Scherrer's formula and its value is 20 nm. SEM image shows that the silver nanoparticles are in agglomerated form. Antibacterial activity of the silver nanoparticle was investigated against bacillus sp. by well diffusion method. The maximum zone of clearance was observed (2 mm) with 10 mg/mL. From these observed results increasing the concentration of silver nanoparticles, maximum zone of clearance will be observed.

Keywords: AgNPs, Plant extract, Antibacterial activity, Zone of Clearance.





PP-133

Undoped and Ag doped TiO_2 Nanoparticles by Sol-Gel Method for Dye Effluent Treatment

M. Muralisankar[1,2], G. Kanthimathi[2], T. Vigneswari[3] and O. Senthilkumar*[2]

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Abstract

The present study reported the synthesis of undoped and Ag doped TiO_2 nanoparticles (Ag/ TiO_2 NPs) by sol-gel method using titanium isopropoxide as a precursor material. The structure of the synthesized nanoparticles was confirmed with the help of powder X-ray diffraction. The surface morphology was investigated using scanning electron microscope. The nanoparticles have been found to possess good photo catalytic properties based on the localized surface plasmon resonance (LSPR) effect. The changes in the LSPR with respect to doping were investigated using Raman Spectroscopy. They were applied in the photo catalytic degradation of methyl orange and crystal violet dyes. A series of adsorption and photocatalytic investigations were carried out to find out the degradation efficiency of the nanoparticles. UV-Visible spectroscopy has been used to find the changes in the absorption peaks with respect to degradation at various concentrations of nanoparticles. TiO_2 nanoparticles doped with Ag were found to promote the separation of photo generated charge carriers to improve photo catalytic activity under the visible light compared to pristine nanoparticles.

Keywords: Nanoparticles, Photcatalytic, Surface Plasmon Resonance

ENERGY AND ENVIRONMENT

Management Audits

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Chapter - 20

Solid Waste Management

C. Revathi, O. Senthilkumar and S. Soundeswaran

Abstract

Solid Waste Management (SMW) is one of the critical problems which India is facing currently, With increase in population and consumption power of the people, huge quantities of solid waste are generated every year, It is found to be a challenging task without proper planning and implementation, It is not an organized sector even today, Lack of manpower resources and also financial constraints make the situation still worse, In this scenario, sufficient awareness should be created and the involvement of public-private participation is very essential, This chapter highlights the various aspects of solid waste management in order to create awareness among the public, It also presents the importance of segregation at the source level, collection mechanism and its difficulties, disposal and recycling techniques both at the decentralized and centralized levels,

Introduction

The increasing global population and rapid economic development of the 21st century has changed the lifestyle in agrarian countries, Rapid urbanization has led to the elevation in the amount of waste creation in the metropolitan cities in developed and developing countries, With the rising urbanization and development, industrialization activity intensified and the amount of wastes are increasing with complexity, Human activities make wastes and these wastes are not taken care of, gathered, put away, and discarded, which can be danger to the climate and to general wellbeing, The legitimate removal of metropolitan waste isn't just absolutely vital for the protection and improvement of welfare yet it has an immense potential for asset recuperation, During the course of life cycle of living being, consumption of food is the basic necessity and other products utilized for safety and comfort, This consumption of various things/products cannot be stopped by anyone in our lives, But it has to be better managed in order to maintain the clean environment for all living beings, Everyone has a right to have clean air, water and food, This right can be achieved only by maintaining a clean and healthy

environment, When does material become waste? Any material which is not needed or used by anyone is waste, Waste may also defined as the product which is not functional after its life cycle and dumped in landfills, Industry point of view is that 'unwanted or commercially non-productive will be a waste, In case of common man wastes are products or articles which are not functioning or outdated or not useful, But in reality, parts of solid waste could be useful or can be converted or treated scientifically to make it useful, Hence solid waste can be defined as organic or inorganic waste materials produced out of urban or industrial activities, which has lost their value with respect to one person and may create value to someone else, Creation of waste is unavoidable in each household howsoever large or little, From the beginning of civilization mankind has steadily deviated from nature and today there has been an extraordinary change in the way of life of humans, The quantity of waste produced by the particular area is the reflection of the deviation of the community from nature, Excessive generation of wastes impacts human society, health and environment, In this scenario, it is very important to process the municipal solid wastes (MSW) in a proper manner for environmental sustainability,

India's position in municipal solid waste management

Economic development in India resulted in rapid urbanization and the number of towns and cities have increased from 5161 in 2001 to 7935 in 2011, According to world bank data, out of 1,3 billon, about 35 percent of India's total population lives in urban areas, The amount of waste created in Indian towns and urban communities is expanding day by-day because of its expanding populace and expanded GDP, According to 2016 estimation, India produces 277 million tons of solid waste every year, According to the estimation of the Central Pollution Control Board (CPCB), Mumbai and Delhi cities generate highest waste in India which is 11,000 and 8,700 tons per day of solid waste respectively, The annual amount of solid waste generation in Indian cities was six million tons in 1947 and it is expected to increase to 300 million tons by 2047, Indian economy which is competing with other developed economies has so far not able to effectively manage the massive quantity of waste generation, Rapid increase in the generation of waste takes place in urban as well as rural areas in India due to the better life style of people and population explosion, Inappropriate management of solid waste is taking place in several cities of developing countries, The waste generation from countryside is more biodegradable in nature and metropolitan regions produce more non-biodegradable waste like plastics and bundling, The irresponsible disposal of solid waste and it's management is almost similar in

both urban and countryside, ‘Throwing trash far away from sight' is the generally followed practice, Public welfare and health management activities are the responsibility of an urban local body or municipality in India rather than individual, Nowadays public awareness, the active participation of NGO’s, private companies and technological advances opened up new practices in solid waste management in urban and rural areas, Till now land filling is predominant waste management in developing countries like India and this is not suitable for long term, We can dump the waste or reuse the waste and can make money through appropriate management of wastes, Hence recently waste management industry is adopting economically viable, socially acceptable new practices and it is undertaking radical changes, In general, solid wastes are generated from domestic, commercial, industrial, agricultural, and other miscellaneous activities, Some of the domestic and commercial wastes cannot be differentiated and hence considered together as urban wastes, Municipal solid waste (MSW) is generated from the community and includes degradable, partially degradable and non-degradable materials, There is an urgent need for improvement at the municipal and state level waste management planning and implementation in India,

Solid wastes: Types, Collection, Storage and Transport

Municipal solid waste management (MSW) is the most important service a city provides, MSW is the one and only service which completely falls under government control, About 60 to 80 percentage of municipal solid waste are generated in urban cities by living community, The increased amount of waste generation in recent years may be due to their changing lifestyles, In addition, markets, commercial areas, malls institution and industries are also accumulating MSW, Solid wastes are in general heterogeneous in nature, Thus their physical and chemical characteristics also differs, Its composition may consist of yard waste, food waste, plastics, wood, metals, papers, rubbers, leather, batteries, inert materials, textiles, paint containers, demolishing and construction materials as well as many others that would be difficult to classify, The present level of Solid Waste Management (SWM) service in urban areas is a potential threat to public health and environment, The global nature of MSW includes its contribution to GHG emissions, e,g, the methane from the organic fraction of the waste stream, and the increasingly global linkages of products, urban practices, and the recycling industry, Industrial, commercial, and institutional wastes are often grouped together and usually represent more than 50% of MSW.

Types of wastes

The different types of solid wastes and their quantities are tabulated as follows:

S.No.	Type of Waste	Percentage
1.	Municipal waste	72%
2.	Industrial HW	11%
3.	Biomedical waste	8%
4.	Plastic waste	8%
5.	Electronic waste	1%

The urban MSW waste can further be subdivided into two broad categories such as 1, Organic waste and 2, Inorganic waste, The urban organic solid waste can further be subdivided into three based on their biodegradable speed as

Putrescible waste: These are decomposed by microorganisms so as to cause malodor, gases and acts as feed for rodents, birds or for other vectors

Fermentable waste: These are decomposed rapidly, but without the unpleasant accompaniments of putrefaction.

Non-fermentable waste: They tend to resist decomposition and, therefore, break down very slowly.

Household waste

The unwanted or unusable matters either thrown or collected together for disposal from houses are known as household solid wastes, Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, bulky items, consumer electronics, batteries, oil, tires and household hazardous wastes like paints, aerosols, gas tanks, waste containing mercury, motor oil, cleaning agents, e-wastes like computers, phones, TVs etc, will comes under household solid waste (HSW), This component is very important to include in MSW because the identification and understanding of solid waste generation rate, volume, composition, area specific differences of waste generation and their likely changes over the period of time depend on this part mainly, Approximately 48% of household wastes are not separated properly into category wise before disposal, Also majority of household solid waste (HSW) are putrescible waste, These domestic wastes can be effectively reduced and recycled by composting, Due to lack of knowledge and practice all these HSW which are put under MSW becoming a big setback to the municipality and to the whole nation.

Agricultural solid waste

The increased population geared up the production of agricultural products and altered the conventional practices, The quantity of agricultural production and environmental quality are interdependent and diametrically opposite, Urban sprawl entitled to destruction of country side and recent scientific reports establish that agricultural waste management is not minor, it's a major problem to the society, The excessive use of fertilizers and pesticides lead to leaching and bio accumulation, The farm wastes are generally burned which is considered as one of the major air pollutants.

Industrial solid waste

Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes will come under industrial wastes, Generation and processing of industrial wastes are depicted in the following diagram, (Source: Misra and Pandey, 2005).

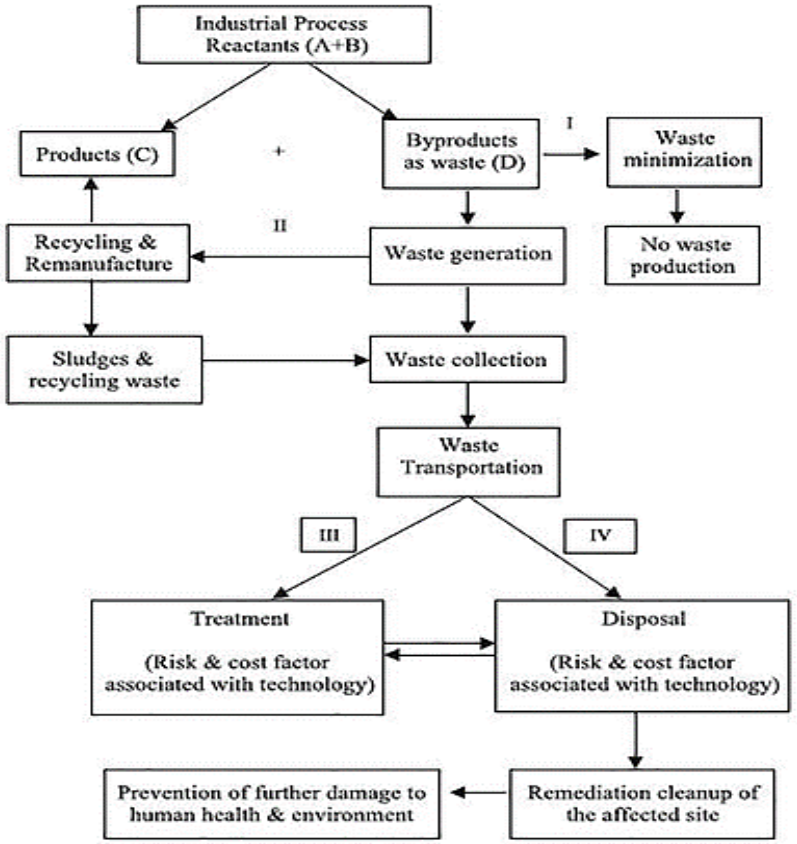

Fig 1: Industrial Solid Waste

Hazardous wastes

These wastes are categorized as hazardous because of their physiochemical, biological, toxic, flammable, explosive and corrosive nature, It causes danger either to living beings or to the environment, Hazardous waste (HW) are the accumulation of industrial outputs for decades together, HW is a not problem of an individual country it is a global problem to deal with, It is our duty to safeguard the environment by regulating HW in an environmentally practicable and rigorous manner, Schedule-I of Hazardous Wastes (Management & Handling) Amendments Rule, 2003 listed 36 processes, These industrial processes generate various categories of hazardous wastes and main rules applicable for such wastes, As per Rule 11 of the Hazardous Wastes Rules, 1989, import of hazardous wastes from any country to India shall not be permitted for dumping, The following table represents different characteristics of hazardous wastes.

Characteristics of hazards	Impact on environment and species
Flammable/Explosive	Emit harmful gases at high temperature and high pressure or cause fire hazards
Pathogenic substances	Contain microorganisms which cause various diseases in both animals and humans
Oxidizing substances	The products which produce oxygen and cause oxidation or combustion
Poisonous substances	They have highly dangerous which cause death and other sickness
Corrosive Substances	They cause much damage to the materials and also flora and fauna
Eco-toxic	The emission of greenhouse gases and other toxic emission and bio accumulation which affects the environment
Organic peroxides	These are organic wastes containing -O-O- in their structure undergo self- accelerating decomposition
Toxic substances	If inhaled or ingested, they may penetrate the skin or cause carcinogenicity

Biomedical waste

Biomedical waste (BMW) is any waste generated during the diagnosis, treatment, or immunization of humans or animals and related research activities, It follows the cradle to grave approach which includes characterization, quantification, segregation, storage, transport, and treatment of BMW, Only about 10%–25% of BMW is hazardous, and the remaining 75%–95% is non-hazardous, It is the duty of manufacturer to produce

environment-friendly medical devices to ensure its safe disposal, WHO reinforced that government should designate a part of the budget for creation, support, and maintenance of efficient health-care waste management system, The pictorial representation of bio-medical waste segregation is shown below, Picture courte https://cpcb,nic,in/,

Elements of solid waste management system

The key elements of MSW are:

- Collection
- Storage
- Transport and
- Disposal

Fig 2: Waste segregation bins

Collection and storage

Collection of garbage from site can be assigned to private contractors either fully or partly, The role assigned to the contractors are a) Collecting

waste from allotted area; b) How frequently the service should be rendered and c) Specific time of collection, For an effective solid waste management, segregation that is called as divided waste processing (DWP) has to take place at the source to meet the challenges, This includes both households and commercial establishments, DWP model differentiates between wet or humid and dry wastes but in India, it is not happening, Segregation of wastes after collection is a challenging task as government lack manpower and financial recourses, In such cases, mostly open dumping is done and the wastes are burnt to empty the space which is highly toxic to the environment and human health, Recycling is not properly organized and it is generally done by informal sectors, More than 75% of the budget spent for collection and transportation which gives little scope for processing and recovery of wastes, Waste collection is the responsibility of the municipal corporations in India, and bins are normally provided for biodegradable and inert wastes, Mixture of biodegradable and inert waste are often dumped as landfills and burnt openly as a common practice, Improvements to waste collection and transport infrastructure in India will create jobs, improve public health and increase tourism, Local bodies spend around Rs, 500–1000 per ton on SWM with 70% of this amount spent on collection and 20% spent on transportation.

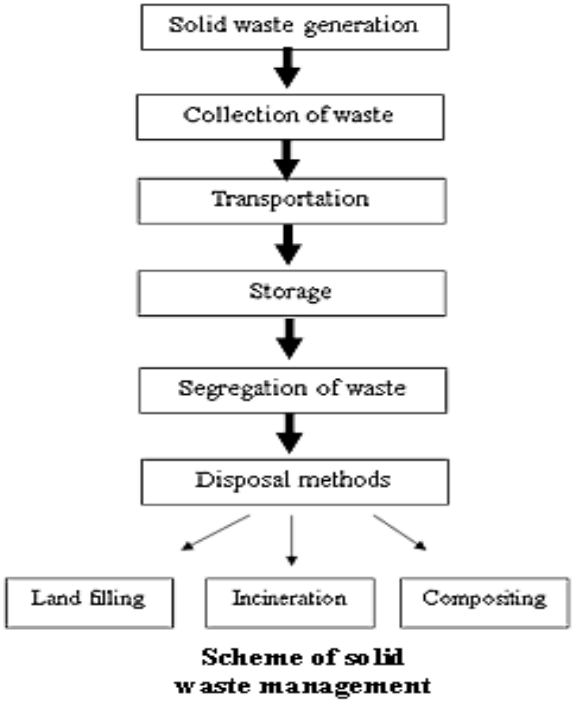

Fig 3: Solid Waste Management

Transport

The transport includes collection from the individual households and industrial establishments, then move to the storage sites and further move to disposal sites or recycling centers after proper segregation, The local municipal authorities have installed large bins at every street ends, The Collecting Vehicles are designed in such a way to reach the points of collection and consists of containers with $7m^3$ to 10 m^3 or larger depending upon area size, They also contain a lifting hook system fitted with heavy duty trucks for carrying all types of waste as well as for handling large quantity, They also contain compaction capability to compress garbage or solid waste should be between 800 and $900kg/m^3$, Compact or small trucks or battery operated vehicles are used for collection from direct disposal sites to transfer stations or to treatment sites, The challenges of this type of collection is that the waste is thrown directly by individual households and institutions having a mix of wet and dry wastes along with household e-waste, non-degradable wastes and biomedical wastes, Additional challenges are due to Vehicle break-down, foul smell and spillage because of improper collection/transportation and inefficient monitoring of routes and operators, These problems are to be addressed for the better solid waste management,

Fig 4: Transport facility

Disposal and Recycling methods

Solid waste management requires proper disposal methods, For an efficient disposal and recycling, segregation of waste at the source (Households and commercial enterprises) is essential, The segregation of wastes at the source is not happening in India generally, So, the position of

India in solid waste management is critical right now, Because disposal directly affects the soil, water resources, air quality, it is a cause of concern for the people and environment at large, India has to develop and implement various technologies for the effective disposal of wastes.

Criteria for waste processing technologies

Criteria for waste processing technologies is defined by Central Pollution Control Board in 2016, Preliminary survey in the cities/towns is recommended where MSW is implemented, Based on their demand, waste treatment technologies are proposed, If the waste quantity is less in a particular town, then more than one town/village can be combined to get required quantity of wastes, If waste quantity is very large, then decentralized treatment mechanism is proposed, The wastes are selected on the basis of quantity, physical and chemical characteristics of the wastes, availability of lands, environmental and climatic conditions, acceptance of the society, market for the products, investment and other environmental norms, Vermi-composting and bio gas plants are selected in small towns where waste generation is up to 30 TPD, Aerobic composting can handle wastes up to 500 TPD, Waste is converted into energy when the quantity exceeds 500 TPD, Waste characteristics such as carbon to nitrogen (C/N) ratio, moisture content, calorific values of the wastes refer to the selection of particular treatment technology, The preferable C/N ratio of 30:1 and moisture content around 60% will be suitable for composting, The calorific value of the wastes should be minimum of 1500 kcal/Kg for incineration (CPCB 2016), Large towns and cities require integrated technologies for processing of the wastes, Some of the key waste treatment techniques are detailed as follows.

Waste processing technologies

Based on the nature of treatment, they are broadly classified into two types, (1) Biological treatment (2) Thermal treatment, Biological treatment process uses micro-organisms to carry out biochemical degradation of wastes under optimum conditions which favor microbial growth, In general, organic contaminants of wastes are decomposed into the components such as CO_2, methane, water etc,, This treatment requires favorable conditions such as optimum pH, moisture, oxygen rich/oxygen deficient environment etc., This can be further divided into aerobic treatment (oxygen rich) and anaerobic treatment (no oxygen), Thermal treatment generally uses burning of the wastes under controlled conditions so that the heat energy can be converted into electrical energy and/or other useful by-products.

Composting: It is a conventional method developed for recycling organic wastes into a nutrient rich supplement called as composts. They are humus like substances which are used to increase soil fertility.

Aerobic Composting: In this type of composting, biodegradable wastes are converted into composts by the activity of bacteria, yeast, fungi, and other organisms in a warm and moist environment. The gases like CO_2, water and other organic gaseous products are released into atmosphere. The end product consists of decomposed products, microorganisms and organic matter that does not degrade during composting process, At the end of the process, the quantity is reduced to 20-60% and moisture content is reduced below 40%, Typically, a 25 m^2 area is required for this type of composting per ton of solid wastes, Machinery, packing and storage occupies some additional space, SWM rules 2016 specifies the standards for compost products, If the particle size of the composting material is small, then more surface is available for effective composting, Porosity of the composting material also enhances degradation process provided the spaces are occupied with air rather than water. The composting pile should also be sufficiently aerated for a better decomposition.

Vermi-composting: In the case of vermi-composting, the degradation of organic matter is done with the help of earth worms. It is more close to the natural process and produces nutrient rich fertilizers. The family of species such as Eudrillus eugineae or Lumbricus rubellus is widely used for composting process. The preferred C/N ratio for vermi composting is 30:1 otherwise nitrogen rich atmosphere and more greens in the waste will generate ammonia gas.

Biogas production: In this technique, the organic matter is decomposed with the help of anaerobic digestion, The process is carried out in the absence of oxygen, Waste water sludge and organic matter are generally treated by this technique, Selective wastes are needed for the efficient production of the mixture of methane and carbon dioxide which is used as fuel, The microorganisms find it difficult to break fibrous matter such as cellulose, lignin etc,, The preferred carbon/nitrogen ratio is 25:30 and the moisture content should be less than 50%,

Landfilling: Landfills are widely used techniques in MSW, It consists of different layers of wastes dumped in a pit over a long period of time, They are designed in such a way that they will not affect the environment appreciably, Landfills are complex systems consisting of different types of wastes which breakdown and decompose over the period of time, The schematic diagram

explains the different layers of land fill, Each layer is supported with soil cover or plastic cover in order to protect it from rodents and flies, Five stages of decomposition are generally observed in a typical landfill, They take place in a sequential order starting from initial adjustment, transition stage, acid phase, fermentation and maturation stage, They are classified into various types depending on the nature of solid wastes used, (1) Sanitary landfills are useful for the dumping of municipal wastes (2) Secure landfills are used for hazardous wastes (3) Monofills usually treat sludge and sewage, The advantages of landfill includes (a) requirement of minimum land area (b) independent of geographical location or climatic conditions (c) environmentally safe (d) the gases can be collected and used as fuel (e) the quantity is reduced into half,

Fig 5: Land filing

Incineration

It is a thermal treatment of wastes, The wastes are combusted around 800-1000°C in a furnace called incinerator and they are oxidized to produce carbon dioxide, water and other non-combustible substances like ash, It also contains small amount of carbon as residue, The flue gas generated from an incinerator is usually filtered with water absorbers or other filtering elements, The generated heat energy is used to produce useful form of energy such as electrical energy, Efficiency of energy conversion depends on calorific value and moisture content of the wastes used in the process, This technique is expensive and combusting only burnable materials. There is a possibility of toxic emissions if segregation is not properly managed.

Pyrolysis

It is a thermal degradation process where the wastes are thermally treated in the absence of oxygen or oxygen starving environment, The required temperature range is 400-1000°C, At moderately high temperature and oxygen less environments, gas is emitted from the waste decomposition often called as syn gas, It consists of hydrogen, carbon monoxide, methane, carbon dioxide and some other hydrocarbons, So it can be used as an effective fuel, Around 75-90% of volatile compounds are produced from organic wastes and 10-25% converted as solid residue, The syn gas is generally purified to remove sulfur, chloride, acid, gases, and trace elements such as mercury,

Open dumping

This is the most commonly used and cost effective technique in India, Generally, the wastes are collected and dumped in the wasteland sites situated at the outskirts of city or town, It is not a recommended method but still most of the towns/villages in India follow because of the cost considerations, lack of planning and ease of disposal, It affects the environment by polluting soil, water and air, It is also a source of pathogenic microbes and insects such as flies and mosquitoes,

Conclusion

Municipal Solid waste management is the management of variety of wastes produced by both household and industries, The rapid urbanization and population explosion in India is responsible for large quantities of MSW, The wastes should be managed individually for the betterment of the environment and society, Segregation of wastes and selection of proper recycling or disposal method is essential in the management of MSW,

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Chapter XXXVIII

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CURRENT TRENDS IN SODIUM ALGINATE BASED NANOCOMPOSITES FOR WASTEWATER TREATMENT

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ABSTRACT

In recent years, wastewater treatment and recycling is essential due to water scarcity and lack of rainfall. Every country is continuously searching for advanced wastewater treatment technologies with good efficiency, eco-friendliness, and low capital cost. Among the various treatment techniques, the one which uses nanomaterials is attracted by the researchers because of their larger surface area per volume. In general, the application of nanomaterials in water treatment is categorized based on the nature of their functionalities such as the catalytic activity of nanomaterials, the use of nano-membranes, bionanotechnolgy based biomembrane reactors and finally the application of adsorption phenomenon. This article addresses the wastewater treatment using a specific nanocomposite called

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sodium alginate-based nanocomposites which functions on the phenomenon of adsorption.

Keywords: Sodium alginate**,** adsorption, nanomaterials, and wastewater treatment.

INTRODUCTION:

Environmental pollution has become a serious problem which is threatening the world today. Large scale industrialization and urbanization have added to the environmental pollution enormously. Even though the impact of environmental pollution has been well understood by the people all around the world, it is almost impossible to make the world completely free from it. This is because the people are very much interested in living in a technologically sophisticated world and they want to enjoy the benefits of science and technology. So, environmental pollution is unavoidable but it is controllable to a great extent by different pollution control techniques offered by the same science and technology. Since the cost of pollution control techniques is very high, the industrialists find it very difficult to adopt them. This problem has stimulated interest in the scientific community to find low-cost pollution control techniques. The present chapter reviews the pollution in waste water and a low cost treatment procedure. Pollution in waste water is in an alarming state especially in developing countries. Generally, large industries generate huge amounts of waste water. It results in the lowering of water table. On the other hand, waste water is also heavily contaminated and become unusable. In this scenario, recycling and reuse of water becomes inevitable. So, waste water treatment is one of the demanding areas of research because of the need for

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recycled water in water-scarce areas. Adsorption is one of basic techniques used for the removal of wastes from the waste water (Cai et. al. 2020). Recently nanomaterials are being used for the treatment (Yang et al 2019). In this chapter, treatment of water using sodium alginate nanocomposites and its future is discussed.

WATER POLLUTION AND ITS SOURCES

Water is the basis of every form of life on earth. Though water is surplus on earth, 97 percent of it is salty and unusable by the humans. Only three percent of the total water is considered as fresh water, out of which two percent exist as glaciers and remaining 1 percent is only available for human's use in the form of rivers, lakes and wetlands. But it is a questionable factor whether humans judiciously use the available quantity of water. The water is getting polluted mainly due to anthropogenic activities. Natural processes such as decomposed animal and vegetable matter, contaminants from volcanic eruptions and other disasters also cause water pollution. Consequently, the physical, chemical and biological characteristics of the water are affected by the pollution which causes harmful effects to the humans and other species on earth (Omer 2019). Some of the anthropogenic contaminations are from inorganic minerals, heavy metals, trace elements, organic matter, dyes and colored pigments (López-Pacheco et.al. 2019). Besides these organic and inorganic chemicals, biological contamination due to animal and vegetable matter and variety of microbes is also responsible for water pollution. The toxic contaminants present in the above mentioned items are listed in table-1.

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These contaminants cause various health related issues to the humankind, animals and plant species. So it is important to treat the waste water and reuse it in order to conserve the water. Treatment of waste water using nanomaterials and nanotechnology is done by the following mechanisms; treatment of waste water by catalytic activity of nanomaterials, use of nano-membranes, purification of waste water by bionanotechnolgy based biomembrane reactors and application of adsorption phenomenon.

Table-I –List of different contaminants

Heavy metals	cadmium, chromium, copper, lead, zinc, nickel, etc.,
Trace Elements	Arsenic, mercury, lanthanides, actinides, etc.,
Organics matter	tri halomethanes, haloacetic acids, amines, etc.,
Chemical matter	Pesticides and fertilizers, etc.,
Coloured pigments	Azo dyes, metallic dyes etc.,
Biological pollution	Bacteria, fungus, decomposed animal, vegetable matter, biomedical wastes etc.,

CATALYTIC NANOMATERIALS

Catalysts are highly active materials in petroleum, pharmaceutical, chemical and polymer industries. Nanosized catalysts are recently attractive because of their high surface area and enhanced activity. The recent studies showed that they play

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an active role in the photochemical degradation of pollutants such as dyes, volatile organic compounds, pesticides etc., (Bratovčić 2019). In general, semiconducting materials and metal oxides are used as photocatalytic nanomaterials for waste decomposition. The mechanism of action is based on the production OH· free radicals in the aqueous medium in the presence of light irradiation. These hydroxyl radicals act as powerful oxidizing agents in decomposing the organic pollutants (Nosaka & Nosaka 2016). Photocatalytic nano materials act as strong antimicrobial agents. For example, TiO_2, ZnO, Ag/TiO_2nanoparticles are some of the highly active photocatalysts. Waste water treatment is also done by the activity of electrocatalysts in a microbial fuel cell set up. Say for example, carbon nano material (eg. multiwalled carbon nanotubes MWCNT) coated electrocatalytic metals such as Pt or Pd in the fuel cell improvised the glucose and ethanol oxidation reactions (Chen and Holt-Hindle 2010). Fenton's reaction based catalysts are used in waste water treatment. For example, nano ferrites or nano iron oxide are used as Fenton catalysts which remain stable during the degradation of pollutant (Kurian and Nair, 2015).

NANOMEMBRANES

Nanomembranes for waste water treatment possess advantages such as catalytic functionality, good permeability and resistance to fouling over the conventional membrane filters (Pendergast and Hoek, 2011). The membranes are usually made up of nanofibres, nano ribbons and CNTs. These fibrous structures are usually synthesized by electrospinning technique. Several polymers such as poly vinyl alcohol (PVA), poly vinyl pyrrolidine

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(PVP), polystyrene, polyethylene terephthalate (PET) are electrospun as fibres for membrane production (Anjum et. al. 2019). The nano membranes are also supported with other hydrophilic polymers such as PVA to make nanocomposite membranes in order to improve the properties of foul resistance. Fouling of membranes is generally due to interaction of organic wastes with hydrophobic membrane structures.

BIONANOTECHNOLGY BASED BIOMEMBRANE REACTORS

Nanotechnology opens up the possibilities of new technologies in the waste water treatment. The combination of nanomaterials along with biological specimens produces an efficient water treatment technology (Yin et al, 2013). Algal growth is generally observed in waste water as it consists of micronutrients, macronutrients and other ambient conditions for the favorable microbial multiplication. This is utilized positively for the waste water treatment and energy production (Abou-Shanab et al, 2013). It has been found that biomembrane reactors are highly useful for the algal growth and biomass recovery (Hu et al, 2015). For example, polyvinylidene fluoride (PVDF) is useful for algal biomass recovery and effective water filtration. However fouling of membrane could not be avoided because of the hydrophobic interaction between membrane structure and microbes. This is prevented by the incorporation of TiO_2 nanoparticles in the membranes (Yin et al, 2013).

ADSORPTION

Adsorption is the process in which adsorbent removes an impurity from the liquid stream being treated. Adsorption refers to the accumulation of molecules or atoms or ions on a surface held there by chemical forces (Chemisorption), electrostatic

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physical forces (physisorption) or both. This process is used in environmental engineering practice for removal of various pollutants. The use of nanomaterials as potential adsorbents is advantageous because of their larger and active surface area. In a typical nanomaterial, more number of atoms is present at the surface which results in efficient adsorption. The factors influencing the adsorption of heavy metal ions are initial concentration of solute (heavy metal ions), dose of adsorbent (activate carbon), agitation / shaking time (contact time), temperature, particle size of adsorbent, initial pH of the medium, presence of foreign substances, ionic strength / salt concentration, nature of adsorbent and adsorbate and adsorption capacity of the adsorbent.

The adsorption process involves the following four steps.

- migration / transport of solute from bulk of the solution to exterior surface of the adsorbent
- diffusion / movement of solute molecule across the solid / liquid interface or adsorption of solute on the external surface of the adsorbent
- migration of the adsorbate by intra-particle diffusion process or
- movement of adsorbed solute from the surface into the interior pores of the adsorbent and
- interaction of solute molecule with surface functional groups of the adsorbent

There are several nanomaterials which are used as adsorbents. Say for example, carbon nanomaterials, activated charcoal, carbon nanotubes, graphene, titanium oxide, zinc oxide etc., Silicon based nano materials are also used as adsorbents. So, in

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general carbon based, oxide based, silicon based nanomaterials are widely used as adsorbents (Anjum et al, 2019). Still, scientists are looking for better alternates which are efficient, cost effective and abundant. Alginate based nanomaterial is one such candidate which is acting as a nano adsorbent. The improvement in adsorption properties is observed when combining alginate with another nanomaterial. Alginate is typically present in sea brown algae. The cell walls usually contain 30-60% of alginic acid. In fact, algae (Sea weeds) are found to be natural cleansers and considered as good bio adsorbers. Heavy metals and other environmental pollutants are effectively adsorbed by the biomass of algae. The alginate which is present in marine algae has functional groups such as weakly acidic, strongly acidic and hydroxyl groups. The derivatives of alginate can also be modified with several active functional groups such as phosphate, amine, imidazole, sulfuric etc., (Khames 2019). They act as potential ion exchangers of heavy metals present in the water and thereby help to cleanse the water. So alginate based nanocomposites are of greater interest for waste water treatment and widely investigated by the researchers.

SODIUM ALGINATE

The salts of alginic acid are called as alginates and the structure of sodium alginate is depicted in figure 1.

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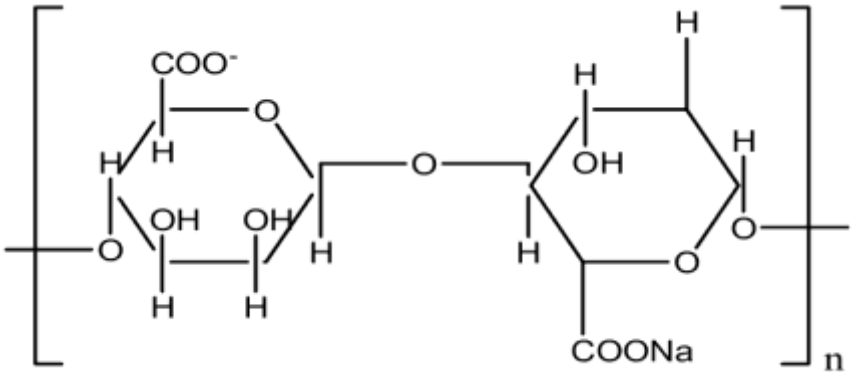

Fig.1. Molecular structure of Sodium Alginate

Alginate unit is an anionic copolymer, a polysaccharide. It generally consists of binary copolymers of β-D-mannuronic acid and α-L-guluronic acid. The empirical formula of sodium salt of alginic acid is $NaC_6H_7O_6$. It is a resin like material. Alginic acid is basically extracted from sea weed and then separated as sodium salt. It is present on the cell walls of sea weeds. Several derivatives of alginate such as potassium, calcium are prepared from the basic sodium alginate. Alginates have three fundamental properties. When it is added in some solution, it increases the viscosity of the resulting solution. It easily forms gels along with calcium alginates. They can be deposited as thin films or fibres on some substrates. These properties of alginates are made use in the waste water treatment procedures. The applications of alginates include water treatment, tissue engineering, drug delivery, antibacterial coatings for food packaging, wound dressing and bio sensors.

SODIUM ALGINATE IN WASTE WATER TREATMENT

Sodium alginate (SA) is a natural adsorbent and prepared as fibres or membranes or gels for adsorbing dyes and other contaminants in the waste water. Thakur et al, (2018) termed sodium alginate based hydrogels as 'sustainable hydrogels' because of its potential in water treatment. Wang et al, (2013)

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used SA as a coagulating agent for synthetic Humic Acid (HA) treatment of water. It was reported that floc size was considerably increased by the use of SA. In another study, marine microalgae are immobilized on the surface of SA bead for treatment of marine water. *Nannochloropsis sp.,* was immobilized and growth rate was found to be high compared to that of free cells. Its uptake capacity for $NH4^{+}$-N was also found to be high (Chen-Lin Soo et al, 2017). Sodium alginate fibres possess to have larger surface area and hence higher adsorption capacity. However it is difficult to prepare SA as fibrous structure because of the improper chain entanglements. It is due to the electrostatic repulsion between anions of the SA network. In order to make stable fibrous structures, cross linking between the networks is proposed (Wang et al, 2019). Cross linking by glutaraldeyhyde, epichlorohydrin and trifluoroacetic acid are tried and reported to possess good adsorption against Methylene Blue (MB) dyes. One of the major advantages of using nanofibres is that they are recyclable. However, low strength of the porous structure under unstable solution environment leads to collapse of the membrane. Hence modification in the structure of SA is required in the form of nanocomposites. In general, clay, carbon nanomaterials, antimicrobial and photocatalytic materials are added to make the nanocomposites of SAs (Wang et al, 2018).

SODIUM ALGINATE BASED NANOCOMPOSITES IN WASTE WATER TREATMENT

(i) Sodium alginate/carbon based nanocomposites

Many researchers showed interest in preparing SA/carbon based nanocomposites. Because SA and its derivatives possess poor

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strength, adding carbon based nanomaterials in the SA network improves its strength. SA nanocomposite consisting of hydroxy apatite was synthesized for the adsorption of radioactive Co(II) pollutant. It was imprinted with Multiwalled Carbon Nanotube (MWCNT) which was functionalized using amide functional group. The optimized nanocomposite bead possessed the surface area of 163.4 $m^2.g^{-1}$ and its adsorption capacity was reported to be 347.8 $mg.g^{-1}$ (Karke-Abadi et al, 2016). The mechanism of adsorption was found to be the possible electrostatic interaction between anionic hydroxyl groups of hydroxyl apatite, negatively charged π electrons of CNT and positively charged Co(II) ions. Adsorption capacity was calculated by the following equation

$$q_t = \frac{C_i - C_e}{W} \times V$$

where q_t - adsorption capacity, C_i – initial concentration in mg L^{-1}, C_e – equilibrium concentration mg L^{-1}, W –mass of the adsorbent, V – volume of the cobalt solution in L.

Natural polymers are also found to be attractive in adsorption experiments. Carboxylated Cellulose nanocrystal (CNC) is one such natural polymer having high crystallinity, large surface area and good specific strength. SA nanocomposite hydrogel beads consisting of CNC were prepared. Carboxylic groups in the nanocomposite network improve the adsorption of heavy metal impurity of Pb (II) in water. The reusability of the composite was also good as confirmed from desorption experiments carried out

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in 0.1 M of hydrochloric acid solution (Hu et al, 2018). Cr(VI) is adsorbed by the use of SA-polyaniline nanofibres. The adsorption was reported to increase with the decrease of pH. It is due to the protonation of amine, hydroxyl and carboxylate groups at lower pH values which increases the electrostatic interaction between SA-polyaniline nanofibre and Cr(VI) (Karthik & Meenakshi 2015). The removal of percentage of Cr(VI) is calculated by the following equation.

$$\%\, removal = \frac{C_i - C_e}{C_i} \times 100$$

As discussed earlier, flocculation capability of sodium alginate was increased by the composite of chitosan. The complex removed the color and turbidity of waste water by 100% and decreased the chemical oxygen demand (COD) by 90% under the optimum temperature of 70°C and pH of 5.5 (Yuan et al, 2013). Fei et al, (2016) reported the nanocomposite hydrogel of Graphene Oxide (GO) encapsulated in the SA network. GO was used to reduce the pore size of SA network. As such GO was found to be nano-toxic and encapsulation by SA reduced its toxicity. On the other hand, GO increases the mechanical stability and dispersability of the composite. This particular nanocomposite was used to selectively adsorb bio accumulated ciprofloxacin. The adsorption capacity was found to be increased by the addition of GO. An Yttrium based-graphene oxide-sodium alginate (Y-GO-SA) hydrogel was used to remove fluoride content from the water. It was prepared by sol-gel technique. 288.96

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mg/g of fluoride was adsorbed at pH 4. The research report also confirmed that the composite can also be used column material for fluoride separation (He et al, 2018).

(ii) Sodium alginate/Silica/Clay based nanocomposites

Sodium alginate was used as template to make composite porous microspheres of calcium silicate and hydroxyapatatite. This particular composite had the advantages of both adsorption and ion exchange properties. An azo dye of Eriochrome blue black R which is commonly used in leather industries was removed from the aqueous solution using the composite microsphere and an adsorption capacity of 76.80mg.g^{-1} was reported. The regeneration capacity of the composite was also reported to be good and recycled five times for the adsorption experiment (You et al, 2019). The adsorption of dye molecules into the porous mircospheres is generally described by Weber's intra-particle diffusion model. In the first step, the dyes molecules are diffused from the solution to the surfaces of the porous microspheres. In the second step, the dye molecules are gradually diffused into the pores because of the rough and porous structure which is defined as intra-particle diffusion. Clays are found to be attractive for adsorption applications because of their layered structure. In order to remove both cationic and anionic dyes from the waste water, sodium alginate was intercalated into the clay layers of activated organo bentonite. Calcium chloride was used as a crosslinker to obtain stable composite beads. The beads were used to remove methylene blue (MB) and methyl orange (MO), the cationic and anionic dyes respectively. The adsorption of cationic MB dye was found to be increased with increase in

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pH, because it gradually deprotonates the functional groups and create negative surfaces. The adsorption of MO was reported to be low in the pH ranges from 2-6 as there is an increase in negative surface which opposes the adsorption of anionic dye (Belhouchat et al, 2016). In an interesting study, zeolite and magnetic nickel ferrites were impregnated into the SA network. Soidum alginate had helped to protect the size of nano nickel ferrites. The magnetic property of nanomaterials allows the settling and separation of adsorbents after completion of the experiments. In addition, the SA template provides both protection and easy desorption of adsorbents after completion of the experiment (Bayat et al, 2018). Porous and stable nanocomposite hydrogels were prepared by mixing SA, chitosan, polyvinyl alcohol and montmorillonite by (Wang et al, 2018). As a general trend of cationic dyes, the adsorption increases with increase in pH. Moreover, MB removal rate was also found to increase with the increase in the weight percentage of montmorillonite possibly due to electrostatic interaction between positively charged dye and negatively charged montmorillonite. The porous structure and high surface area of the montmorillonite was also the reason for efficient adsorption. It was reported that 90% of MB was adsorbed at the pH range of 8-10 for the waiting time of 250 min.

SA based adsorption kinetics is generally explained by pseudo first order and pseudo second order kinetics. The rate equation for the pseudo first order kinetics is shown below

$$\ln(q_e - q_t) = lnq_e - k_1 \times t$$

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where q_e – adsorption capacity at equilibrium ($mg.g^{-1}$), q_t – adsorption capacity at time t, k_1 –first order rate constant (min^{-1}). The rate equation for pseudo second order kinetics is as follows

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e}$$

Most of the research reports concluded that pseudo second order kinetics fit well with the adsorption trend with respect to SA based nanocomposites (Bayat et al, 2018, Belhouchat et al, 2016, Wang et al, 2018, Karthik & Meenakshi 2015). Similarly, adsorption model also follows that of Langmuir model rather than that of Freundlich. Langmuir model assumes that monolayer adsorption takes at the homogeneous surface, whereas Freundlich model assumes that multilayer adsorption takes place.

(iii) Sodium alginate/inorganic nanomaterial based nanocomposites

Photocatalytic effect of the nanomaterials are combined with SA to treat the waste water and used to remove heavy metal and dye contaminants. SA along with ZnO-SiO_2-Eu^{3+} was found to be a potential nanocomposite for decomposing the indigo carmine dye. In fact, nanomaterials were incorporated into the grafted polymer matrix of acrylamide-co-acrylic acid and SA. Photocatalytic degradation was reported to be around 93.4% for nanomaterial composition of 20% after 5h of activity (Agorku et al, 2014). TiO_2 is another important photcatalytic material made as

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nanocomposite with SA-polyacrylic acid hydrogel. A dye, Methyl Violet(MV) was purified using the composite with the uptake capacity of 1156.61mg.g^{-1} (Thakur & Arotiba 2017). Alum is a typical coagulant used in the waste water treatment. So, the sludge usually contains higher concentration of aluminium oxides and other organic contaminants. The alum from the sludge is reused and made as a nanocomposite of SA. Alginate composite produced the beads which help to retain fine particles of alum. So, these beads were used in the adsorption bed for the effective adsorption of contaminants like Arsenic. Moreover the beads were calcined to improve the surface area and porous nature of the composite. Calcined beads were found to have 3-21 times higher adsorption capacity compared to uncalcined beads (Kang et al, 2019). Poormand et al (2016) also did similar investigation and produced low cost adsorbent containing aluminum from the waste water sludge immobilized in SA network. They reported the adsorption capacity of 88.5% at pH 8 for the MB concentration of 50mg/L and SA-alum composite concentration of 0.3g/L. The superparamagnetic property of SA and tetrasodiumthiacalix[4]arenetetrasulfonate (TSTC[4]AS-s-SA) nanocomposite was introduced by the incorporation of Fe_3O_4 nanoparticles. The average size of nanocomposte gels was 50 nm. A series of divalent metallic contaminates such as Pb, Cu, Cd, Ni, Co and Cr(III) were removed by these nanocomposites through adsorption. The adsorption capacity of nanocomposites towards different metals was in the following order: Pb(II) >Cd(II)>Cu(II)>Cr(III)>Co(II)>Ni(II). The desorption experiment was carried out in the presence of 0.2M hydrochloric acid for one

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hour (Lakouraj et al, 2014). The desorption percentage was in the range from 87 to 96.5%. It is calculated by the following formula

$$\%D = \frac{mmoles\ of\ metal\ ions\ desorbed\ into\ HCl\ solution}{mmoles\ of\ metal\ ions\ adsorbed\ by\ the\ nanocomposte} \times 100$$

In a similar study, Fe-Fe_3O_4 nanoparticles were incorporated into the polyvinyl alcohol and SA composite network for the removal of Cr(VI). The adsorption capacity of the composite was reported to be good at lower concentration. It decreased from 100% to 79.5% when the metal concentration increased from 5 to 40mg.L^{-1}. Same trend observed when pH was increased from 3 to 11 (Lv et al, 2013). Makhado et al (2020) investigated sequestration of methylene blue dyes by using the hydrogel nanocomposite of SA-polyacrylicacid-ZnO. Zinc Oxide, in addition to its antimicrobial properties possessed adsorption capabilities towards synthetic dyes. The swelling behavior of SA/Polyacrylicacid hydrogels by the incorporation ZnO nanoparticles was investigated. Higher swelling behavior was observed for the concentration of 50 mg ZnO nanoparticles compared to other higher concentrations. However, 99.32% of adsorption capacity towards Methylene Blue was reported for the concentration of 150 mg of ZnO present in the hydrogel nanocomposite. In another interesting investigation, ZnO encapsulated by SA beads was applied to disinfect bacteria in water. Bacterial disinfection was carried out both in synthetic solution and surface water. 200 cfu/ml of bacteria in the synthetic water were disinfected after 70 min of contact time with nanocomposites whereas bacteria in the surface water were

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disinfected within a min (Motshekga et al, 2018). Biebrich scarlet and crystal violet dyes were removed using SA-Gelatin-ZnS hydrogel nanocomposite. 97.3% of biebrich scarlet and 89.1% of crystal violet were removed from the solution using the composite. Langmuir kinetic model fitted well for biebrich scarlet whereas Freundlich adsorption isotherm fitted for the crysal violet (Priya et al, 2019). The dependence of adsorption on temperature is determined from the thermodynamic functions using Vant Hoff equation as follows

$$ln\frac{q_e}{c_e} = \frac{\Delta H^0}{RT} - \frac{\Delta S^0}{R}$$

where ln q_e/c_e – equilibrium constant, ΔH^0 –enthalpy change, ΔS^0 –Entropy change, R-Universal gas constant (8.314 $JK^{-1}mol^{-1}$), T – Temperature

(iv) Sodium alginate/metal based nanocomposites

The antimicrobial properties of metal nanoparticles such as Ag nanoparticles are well established. This property is being exploited in the waste water treatment using SA based nanocomposites. Silver nanoparticles were incorporated into the SA-polyvinyl alcohol composites by (Abu-Saied et al 2017). It was concluded that Ag/SA/PVA composite effectively inhibit the growth of bacteria and yeast. Green synthesis method was applied for the synthesis of Ag/SA/ carbopol nanocomposite for removing MB dye from the water. The average size of Ag nanoparticles was 19nm. The reported adsorption capacity in this case was 213.7 mg per gram of the composite (Karthiga Devi

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et al, 2016). The antibacterial activity of Ag/SA nanocomposite was also investigated by Yang et al, (2015). Minimal inhibitory concentration (MIC) for S. aureus and E. coli was reported to be 0.25 and 0.13 mg mL^{-1} respectively. Oualid et al (2017) reported the combination of Ag/ZnO/SA for potential application of photocatalytic degradation of organic dyes.

CONCLUSION

The detailed review of existing literature reveals that sodium alginate based nanocomposites and hydrogels are used to remove toxic contaminants such as heavy metals, organic dyes, microbes and other pollutants present in the water samples. Integration of various components such as photocatalytic and catalytic materials, antibacterial agents and adsorbents enhance the activity of SA nanocomposites in treating water. Nanocomposites with porous structure, large surface area, encapsulating network, good mechanical strength, stability under the conditions of pH, temperature and concentrations of the adsorbate and adsorbent and desorption capacity were expected to be favorable for different applications. Although polymeric network characteristics are attractive for making nanocomposites, it is yet to be completely understood the influence of physico-chemical characteristics on the quantitative response. Despite this shortcoming, the number of recent publications proves its capacity as a good adsorbent. Most of the analyses were investigated at the laboratory level. But the reports prove that sodium alginate has the potential to be applied as a good adsorbent in real time waste water treatment. Moreover,

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antibacterial activity of SA and its composites is yet to be explored in detail for applying in waste water treatment.

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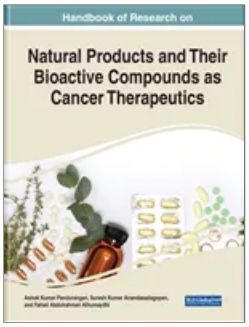

Natural Products and Their Bioactive Compounds as Chemotherapeutics: Natural Products to Prevent Drug Resistance in Cancer Chemotherapy

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Abstract

Cancer is the second world's deadliest disease. Despite substantial advancements in medical technology for cancer therapies, cancer mortality remains greater than projected, and cancer treatment requires additional study. The research carried out in natural products is due to the presence of bioactive compounds, unique structures, and mechanistic actions. Prevention of drug resistance in chemotherapy is predominant in the usage of anticancer drugs. Clinical chemotherapeutic medicines work by causing cancer cells to die, the majority of which is apoptotic. Another way to combat drug resistance in cancer therapy is circumventing apoptosis by targeting non-apoptotic cell death. The authors discussed in this chapter both apoptotic and non-apoptotic cell death.

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Introduction

Cancer is a common fatal disease. The people who are affected by cancer have felt as short life period and not a good quality of life. It affected more than 10 million people in the world per year. World Health Organisation (WHO) reported that it affects one in five men and one in six women in their life and kills one in eight men and one in eleven women. It is a huge burden on society. Cancer is a multifaceted and refractory illness produced by a complex interplay of local tissue microenvironmental and hereditary variables (Klemm and Joyce, 2015). Cancer is a collection of disorders characterized by uncontrolled and aberrant cell division, as well as malignant characteristics such as invasion and metastasis. Cancer is a global issue with significant morbidity and fatality rates.

Surgery, chemotherapy, and radiotherapy are the most common cancer treatments today. While surgery may not always be able to eliminate all cancer cells from the human body, both chemotherapy and radiotherapy kill the normal cells in the body. This is the biggest side effect in cancer treatment. For more than half an epoch, natural products have been broadly scrutinized to prevent drug resistance in cancer chemotherapy due to their astonishing diversity in the chemical field. Mostly natural products derived from plants and animals have been the source for all pharmaceutical companies. Natural products have recently continued to serve as exemplars for biologically active molecules, especially for cancer treatment (Cragg and Pezzuto, 2016).

The purpose of cancer treatments is that:

- It recovers health of the human beings.
- The disease is conveyed under control due to the improvement in the immune system.
- Prevention of reoccurrence of cancer is carried out.
- The symptoms are reduced.

Depending on the type of cancer, there are many types of cancer treatment. Some cancer patients will just require one treatment. Most people, on the other hand, receive a mix of therapies, such as surgery combined with chemotherapy and/or radiation therapy. They are frequently used in tandem. Surgical treatment, chemotherapy, irradiation, and hormone therapy are the most common types of cancer treatment. For clinical treatment, chemotherapy is broadly used. Chemotherapeutic pills destroy swiftly proliferating malignant cells. Cancer chemotherapy is the customary core therapeutic usage. Prevention of drug resistance in cancer chemotherapy is predominant in the usage of anticancer drugs. Because of their distinct chemical structures and bioactive characteristics, natural goods are effective against medication resistance. The discovery of drug-resistant proteins and drug-efflux inhibition activities is the mainstay of cancer chemotherapy (Robey *et al.,* 2018). Drug resistance must be managed carefully for chemotherapy to be effective. Natural goods deserved to dazed medication confrontation, according to the scientific and industrial communities.

Common treatment strategies are including radiotherapy and/or chemotherapy with surgery, resulting in a high treatment failure rate. For example, doxorubicin is used as a chemotherapeutic agent for cancer therapy which persuades the cancer cells as well as normal cells also. There is continuous development in the treatment of cancer for rectifying the side effects in the body. Paclitaxel which is derived from the bark of *Taxus Breifolia* is one of the most successful tales in plant-based natural products (Ashraf, 2020). Trabectedin, anthracycline, and enediynes which are derived from the marine environment and microbiological organisms have also been used as high therapeutic agents. Currently, 10,000 plant species are used in the medicinal field which is available in rain forests and grasslands also. Out of 93 in 174 new compounds which are derived from natural products have been commercialized for cancer treatment in the 1980s (Amaral *et al.,* 2019). From 1981 onwards, new novel drugs which are used for cancer treatment are mostly natural products, because, they contain bioactive compounds. National Cancer Institute (NCI) has identified two anticancer drugs which are derived from natural products during the periods of 19th century are camptothecin and taxol. Figure 1 shows chemotherapeutic agents used for cancer therapy.

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Chapter - 3
Biomedical Waste and Their Disposal Techniques

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Chapter - 3

Biomedical Waste and Their Disposal Techniques

C. Revathi, S. Soundeswaran and O. Senthilkumar

Abstract

Biomedical wastes are infectious and harmful. Management of biomedical waste requires special processing and treatment procedures. Trained professionals are needed in some of the processing steps or medical/health care professional should be trained specifically to manage biomedical waste. The management of biomedical waste in India is defined by the regulations defined by Central Pollution Control Board which is working under Ministry of Environment, Forest and Climate Change. This chapter highlights the current scenario and challenges involved, sources, various stages of processing and handling and degradation steps of biomedical wastes.

Keywords: Bio Medical Waste (BMW), management, sterilization techniques

1. Introduction

Bio medical waste (BMW) is entirely different from other types of waste. It is a challenging task to manage biomedical waste. Hospitals, nursing homes, health care centres, biological testing laboratories, pharmaceuticals, scan centres are the main places where biomedical wastes are generated in large quantities. Furthermore, individuals from all walks of life visit such locations on a regular basis, producing waste, spreading diseases, or getting infected as a result of inadequately handled waste. BMW cannot be handled like municipal waste. The apex body for monitoring BMW in India is Central Pollution Control Board (CPCB). It is directly functioning under Ministry of Environment, Forest and Climate Change. State Pollution Control Boards also function separately and report their findings to CPCB. The country has a strict policy of onsite segregation of created BMW, as well as storing, transporting, and disposing of them in accordance with the guidelines from the Ministry. The first BMW rules were notified by the Government of India in 1998. The rules were periodically

modified as per the requirement and the problems caused due to unprotected handling by the humans, spread of diseases etc., The rules were modified in the years 2000, 2003 and 2011 [1]. However, the rules were amended in 2016 which provides essential steps required for segregation, storage, transportation and disposal methods. In view of sudden surge in Covid-19 spread, the rules were further strictly revised to combat the infection [2].

BMW generated in India was 517 tonnes/day in 2016 which is increased to the level of 557 tonnes per day in 2017 as per CPCB. Centre for Science and Environment (CSE) published a data during COVID-19 pandemic which reported that 139 tonnes of Covid-19-related biomedical waste was generated in April 2021 and it is escalated to a 203 tonnes/day in May 2021. During the period 2017-2019, the number of health care facilities increased from 84,805 to 153,885, however the percentage of properly treated BMW was dropped from 92% to 88% [3-4]. There are a total of 238,170 healthcare facilities in the country, with 87,267 of them being bedded and 151,208 being non-bedded healthcare facilities (HCFs) that generate BMW. There are 198 certified common biomedical waste disposal facilities (CBMWFs), with another 28 under construction [3]. According to a data produced by CPCB in January and May 2021, 22 of the 35 states and union territories generate more biomedical waste than they can handle. The BMW was not properly disposed due to the poor practice of segregation at the source. It causes tremendous threat not only to the environment but also to the workers involved in every step of management process. These poor practices are mainly due to lack of awareness, no proper training and cost involved in the process. The cost for the disposal is almost tripled from Rs. 50 per Kg as per August 2021 data [5]. This cost will generally be divided per bed and usually paid by the patient. It is creating a lot of pressure to both hospitals and patients. This led to improper biomedical waste management. The exploitation posed a major threat to environment and health of its species. The present chapter highlights the importance of BMWM and various techniques involved in the process.

2. Sources of biomedical waste

Biomedical waste includes all the health care related wastes generated by medical facilities. “Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals”. as per Biomedical Waste (Management and Handling) Rules, 1998 of India. The waste generating locations include, Hospitals, Emergency care facilities, Outpatient facilities, dialysis centers, transfusion centers, blood banks,

Clinical laboratories, Research laboratories, Mortuaries, death care facilities, Veterinarians, Nursing homes, Doctor and dentist offices, Oncology Clinics etc., Biomedical wastes are classified into different categories as per World Health Organization (WHO). They are, general wastes, pathological, radioactive, chemical, infectious to potentially infectious wastes, sharps, pharmaceuticals, pressurized containers etc., Out of all the biomedical wastes, the nonhazardous wastes account for 85% [6-7]. The nature of plastic based biomedical wastes generated during Covid 19 include, syringes, surgical/face masks, disposal blades/scalpels, face shields, latex gloves, surgical gowns, shoes cover, sanitizer contaminants, waterproof aprons [8]. The list of hospital wastes as referred by biomedical waste [9] are tabulated as follows. Categories of biomedical waste as per BMWM rules 2016are tabulated in table 1.

Table 1: Types of wastes, segregation and collection identification labels

Category	Type of waste
Yellow	Human Anatomical Waste; Animal Anatomical Wastes; Solid wastes such as items contaminated with blood and other fluids, contamination from dressings, plasters, cotton swabs; discarded drugs which include antibodies and cytotoxic drugs; chemical wastes (both liquids and solids); discarded bedding parts; microbiology and biotechnology laboratory wastes.
Red	Waste generated from disposables such as syringes, needles, intravenous tubes, urine bags, catheters, vaccutainers, gloves etc.
White	Waste sharps including metals, body implants.
Blue	Contaminated glass including vials and ampoules.

3. Steps in management of biomedical waste

It is important to collect, store, transport, treat and dispose the BMW in a proper manner as it involves potential threat to the environment and human health. BMWM rules 2016 suggests to dispose the wastes in Common Biomedical Waste Treatment and Disposal Facility (CBWTF) for complete treatment and disposal.

3.1 Segregation and collection

The first step in waste segregation is to isolate carefully the hazardous wastes from the large quantities of non-hazardous wastes. As per BMW rules 2016, the wastes are segregated very carefully depending on their hazardous level and collected in differently colored containers. The following picture (Fig. 1) depicts the proper segregation methods of bio-medical waste which was adopted from https://cpcb.nic.in/. General category of waste which are not infectious are collected following solid waste management rules 2016.

Efficient segregation will decrease the risks involved in the transportation, management and disposal. The management of BMW is represented in the following steps.

3.2 Handling equipment

A bright yellow colored gloves should be used to segregate the BMW. They have to be washed with carbolic acid soap and a disinfectant every time after the usage. Apron is essential to avoid contamination to skin. It can be made preferably with impermeable and non-inflammable material. The use of mask, goggles and face shield is essential for the segregation and collection. A rubber soled and anti-skid boots are recommended to avoid infections.

Fig 1: Segregation methods (adopted from Pictorial Guide on Biomedical Waste Management Rules 2016 by CPCB)

3.3 Storage and containment

The containers should be properly labeled with biohazard symbol along with type of wastes in the respective colored containers as shown in fig. 1. The containers or baggage should not have any leakage during the storage. Biomedical wastes may be collected in disposable or re-usable pails or

cartons, boxes, drums and portable drums and stored in the respective containers. The storage duration shall not be more than 8-10 hours in big hospitals and 24 hours in in nursing homes. The containers should not be used other than for the prescribed purposes. Storage area or room should also be labeled with a caution sign.

3.4 Transportation of BMW

Manual loading should be avoided during transportation. Trolleys or covered wheel barrow can be used. The containers should always be closed before transportation. The waste should also accompany with signed document by a nurse or a doctor mentioning the name of the date, shift, quantity and destination. Vehicles should also be designed in such a way that they should not spill or cause infections to the drivers and other staff involved in the transport.

4. Waste disposal methods

Mutilation is required to avoid the re-use of plastics and sharps. Mutilation is done with the help of needle cutter. Then the mutilated wastes are stored in leak proof and puncture proof baggages [10-11].

Non-chlorinated yellow bags are used to collect and store discarded cytotoxic drugs and antibiotics. Vitamins, cough syrups, IV solutions and eye drops, salts, amino acids are usually diluted with water and discharged into a sewage if they are present in small quantities as recommended by WHO. However Non-biodegradable antibiotics, antineoplastics and disinfectants should not be mixed with sewage because they may kill the bacteria needed for the decomposition of the wastes in sewage [12]. Heavy metal impurities such as Mercury should be handled separately and submitted to authorized vendors. WHO recommends for safe handling and storage of mercury and replacement of Mercury in the long term [13]. Radioactive wastes are generated from the usage of radio isotopes used for diagnostic and therapeutic applications. The disposal of radioactive waste generated from the hospital or health care centre should be in accordance with the Atomic Energy (Safe disposal of radioactive waste) rules of 1987 [14]. Liquid waste generated by various ways such as body fluids, liquids from the laboratory and operation theatre, cleaning and housekeeping should be treated using effluent treatment plant attached with the hospital or laboratory. Infected glass vials or broken or discarded and infected glass need to be autoclaved to disinfect and packed in cardboard boxes with plastic liner and marked with blue color. They have to be sent to CBMWTF for final recycling [11]. Microbial impurities produced from the microbiology or

biotechnology laboratory have to be disinfected on site using an autoclave as per the WHO guidelines. These hazardous wastes need to be carefully packed in yellow bag and transported to CBMWTF.

4.1 Biomedical waste management after covid-19

These new guidelines are framed on the basis of existing knowledge on covid-19 and also on comparing the waste management practices already being done in the case of contagious diseases such as HIV, H1N1 etc., [2]. The usage of separate colored bins is recommended as per BMW rules 2016. However double layered bags should be used for the collection of wastes from covid-19 isolation wards. A separate bin is recommended for collecting covid-19 related wastes and storing separately in isolated rooms, in addition to normal BMWs before handing over to authorized staff of CBWTF. The baggage should also be labeled with "COVID-19 Waste". Dedicated trolleys and collections bins should be used for covid 19 related BMW. The surface of the containers and baggage should be disinfected with 1% sodium hypochlorite solution everyday. Opening up of a separate covid 19 ward in the hospital has to be reported to SPCBs/PCC and CBWTF in the area. CPCB recommends to install the app COVID19BMW to update the periodic details about BMW. The diaper used by the covid-19 confirmed patient should be treated as biomedical waste and should be collected in yellow bag/container. Personal Protection Equipment (PPE) such as face shield, goggles, aprons, suits, nitrile gloves should be placed in red bag. The masks such as triple layered mask, N95 mask etc., head cover, shoe cover, non-plastic and semiplastic cover-all attire should be thrown in yellow bags. Other solids wastes should be treated separately and handed over to solid waste management system of the corporation or town panchayat. The workers involved in handling and collection of biomedical waste should sanitize themselves periodically. CBWTF should provide PPE to such workers. Dedicated vehicle can be used for the collection of covid-19 BMW. Vehicle should also be sanitized with sodium hypochlorite or any other potential disinfectants. CBWTF may operate their facilities extra hours in case it is essential for treating the covid-19 wastes by informing to SPCB/PCC.

4.2 Methods involved in biomedical waste disposal

Burning the pathogenic waste at high temperature will destroy the material in which the microbes reside. Incineration is considered as quick, easy and simple method of decomposing wastes. However, during this process, an incomplete combustion of waste produces dioxins and furans

which are unintentional by-products. They are very toxic and known as carcinogens. They also damage the immune and endocrine system of human.

Moreover, the ash of incinerator also needs to be checked for their toxin levels before being sent to secured landfill. Keeping these points in mind it is essential to go for the alternative and environment friendly biomedical waste disposal methods.

Plasma pyrolysis is an alternate method to incinerator in which there is an additional chamber where hydrogen and carbon monoxide are kept. The wastes are subjected to combustion in secondary chamber in the plasma pyrolysis process where waste is disposed as secure landfills by converting them into small clinkers.

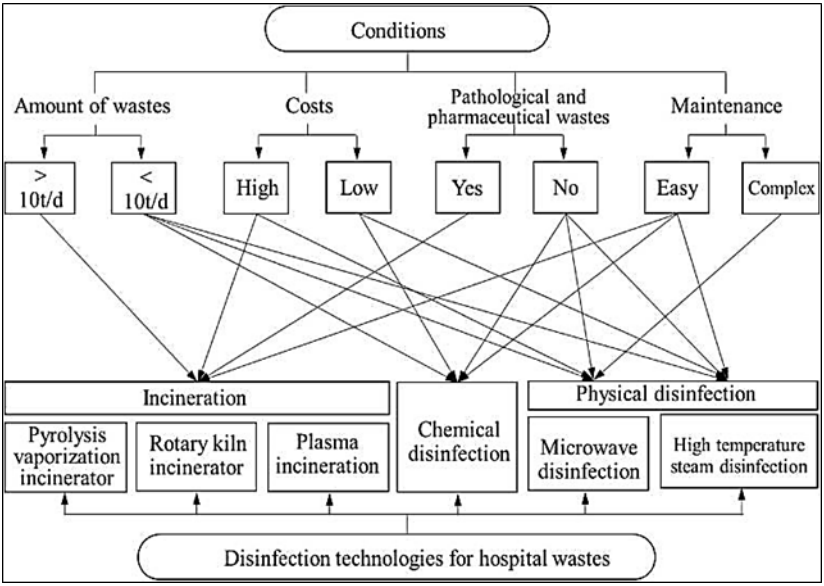

Fig 2: Disinfection technologies (adopted from) [15]

4.3 The alternate waste treatment technologies include

- Thermal
- Chemical processes
- Irradiation technologies
- Biological processes

4.3.1 Thermal

Autoclaves/Hydroclaving (Steam treatment technologies)

The operation of autoclave requires a minimum of recommended temperature-exposure time criterion of 121 °C for 30 min, pressure of 205 kPa or 2.05 bar (15 psig or 30 psia). Autoclaves for medical devices often use trays or stainless-steel baskets, while waste autoclaves use autoclavable carts or bucket-shaped open containers into which the plastic waste bags are stacked.

Hydroclaving is the process which involves steam sterilisation. In autoclaving very hot steam is introduced for a fixed amount of time. Micro-organisms will be completely destroyed at the end of the process. It is highly effective process as it costs much less than other methods and does not present any personal health risks. Though some biomedical waste cannot be disposed via autoclaving they are sanitised by this method and then sent to the landfills.

The various phases involved in auto cleaning process are as follows

i) **Purge phase:** Steam is allowed to flow through the steriliser, which causes the air to be displaced. To achieve a continuous flow purge, the temperature and pressure are gradually increased.

ii) **Exposure (sterilisation) phase:** During this phase, the exhaust valve is closed by programming the control system of the autoclave, allowing the internal temperature and pressure to be raised to the desired set point. The programme maintains the desired temperature till the required time is reached.

iii) **Exhaust phase:** The pressure from the chamber is released through the exhaust valve and the ambient pressure is restored in the interior.

Advantages

- Autoclaves sterilise a range of infectious waste (cultures, stocks, sharps, materials contaminated with blood and fluids), laboratory waste and linen waste, medical instruments and for the treatment of BMW.
- To prevent the discharge of pathogenic aerosols, waste-treatment autoclaves (prevaccum autoclaves) must treat the air that is evacuated at the start of the process with a high-efficiency particle air filter before it is released. It requires less time for action and has greater efficiency.

- Advanced single or multiple-shaft shredders specially made for medical waste can reduce waste volume by about 80%.

4.4 Moist heat sterilization and disinfection

4.4.1 Microwaving

In this process, waste is shredded, mixed with water, and then internally heated. One of the key advantages of this method is that it reduces the amount of biomedical waste produced and it is said to be more energy efficient than incineration.

4.4.2 Promession

Promession is a new technology that combines mechanical vibration and refrigeration to destroy pathological waste. Liquid nitrogen freeze dries the tissue and motion disintegrates the waste.

4.4.3 Pasteurization

Although heat treatment of liquids at high temperatures could be considered pasteurisation, pasteurisation per se finds limited value in medical waste treatment. These temperatures are not sufficient to disable bacterial spores, so the process is not a form of sterilization. Hospitals often pasteurize anesthesia equipment and respiratory devices after their usage.

4.5 Chemical process

Biomedical waste disposal is treating the BMW by various chemicals. The types of waste treated by this technology are cultures, sharps, liquid waste, human waste, laboratory waste and soft waste. Volatile, semi volatile organic compounds, Mercury and radiological waste should not be treated by this method. This technology uses alkaline hydrolysis at higher temperature. Phenolic compounds, hydrogen peroxide, quaternary ammonium compounds, formaldehyde and sodium hypochlorite are commonly used disinfectants to treat biomedical waste. Even ozone also used as disinfectant in this method.

Chemicals kill bacteria and fungi through one or more of the following processes:

- Starving the microorganisms by eliminating access to nutrients.
- Oxidizing the cellular membranes and viral envelopes.
- Creating a toxic environment towards the organisms.

The efficacy of chemical disinfectants depends on operating conditions, including

- The pH of the solution/sample/surface.
- Temperature.
- Presence of other materials such as organic compounds, inorganic salts, other pollutants and nutrients.
- The susceptibility of the pathogens to the specific disinfectant.

4.5.1 Role of quaternary ammonium compounds in chemical process

Also called QACs, Quats, or quaternary ammonium cations, work by disrupting the structures of proteins and lipid membranes. Preparations are typically including 200 ppm to 400 ppm of active ingredients. Benzalkonium chloride is a well-known Quat as are alkyldimethylbenzylammonium chloride (ADBAC) and didecyldimethylammonium chloride (DDAC). Quats have surfactant properties like detergents. Anti-bacterial soaps often contain quaternary ammonium compounds and concerns about the human exposure to QACs is one reason why public health authorities now discourage using of these soaps.

4.6.1 Irradiation technologies

Irradiation is a means of sterilization by exposing waste to gamma rays, as it breaks down bacterial DNA. To generate gamma rays, radioactive isotopes of cobalt are employed. To sterilize equipment or treat waste, pathogens are targeted. In contrast, the ultraviolet (UV) radiation used to treat wastewater is not capable of killing pathogens.

Limitations: The surfaces of waste exposed to the radiation source are more sterile than the surface of waste which is not exposed. Therefore, waste with odd shapes, and the sides of contaminated surfaces facing away from the source, may not be adequately exposed to the radiation.

4.7.1 Biological processes

Biological enzymes are used for treating bio medical waste. The biological reactions will not only decompose the waste but also cause the destruction of all the organic constituents. So plastics, glass and other inert will remain in the residues.

Limitations: Time consuming process and also there is a chance of spreading/multiplying infection before decomposition.

4.8 Hydrogen peroxide sterilization

Sterilization with hydrogen peroxide is a low-temperature sterilisation method that is often used to sanitise heat-sensitive devices. It requires only

minimum amount of time. The steriliser chamber is filled with H_2O_2 vapour, which contacts and sterilises exposed device surfaces.

Radio frequency or microwave energy is used to excite the gas molecules and produce charged particles, in the form of gas plasma, many of which are in the form of free radicals, in an enclosed chamber under deep vacuum. The device's hypothesised method of action is the generation of free radicals inside a plasma field that can interact with critical cell components (e.g., enzymes, nucleic acids) and disrupt microbe metabolism [16].

4.9 Dry heat sterilization

Dry heat sterilisation is performed through conduction. The heat is absorbed by the item's exterior surface, then transferred layer by layer to the item's centre. The entire object will ultimately reach the temperature needed for sterilization. Damage is done by oxidizing the molecules. The organism is killed by destroying the cellular components. Dry heat sterilization is a time-consuming process. It takes more than an hour to kill some of the typical spores [17].

5. Conclusions

Biomedical waste generation is an unavoidable problem in populous countries like India. The management of waste is crucial for maintaining a healthy environment. Central Pollution Control Board constantly monitoring and updating biomedical waste management rules for the betterment of the society. The origin of biomedical wastes is mostly from hospitals and clinical laboratories. They should be equipped with sufficient management and recycling facilities as per the statutory requirements.

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Chapter
19

DRINKING WATER CONTAMINANTS AND HEALTH IMPLICATIONS

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ABSTRACT

Water is an essential component for the survival of all living organisms. We know that, rainwater is one of the purest forms of water. But, when it reaches the earth surface, it get polluted easily due to the discharge of effluents from industries, commercial activities, mining activities and domestic sewages. The addition of wastages makes the water unsuitable for drinking, domestic and industrial purposes due to the adding up of physical, chemical and biological impurities. Each year 1.2 million deaths were reported because of using unsafe water. In low-income countries, 6% of deaths are the results of unsafe water sources. One-in-four people do not have access to safe drinking water for day today life. Unsafe water is responsible for 1.2 million deaths each year. 6% of deaths in low-income countries are the result of unsafe water sources. One-in-four people do not have access to safe drinking water. Whether water is utilized for drinking, home use, food production, or recreation, safe and readily available water is critical for public health. Improved water supply and sanitation, as well as better management of water resources can help countries thrive economically, reduce poverty and supports sustainability.

KEYWORDS: Wastages, Sustainability, Public health.

INTRODUCTION

Water is the most important element that allows life to exist on this planet. The ocean contains nearly all of the accessible water on the planet, and it is too salty to drink or use for irrigation. (Bharucha 2006).only 3 percent is available as fresh water. Of this, 2.997 percent is locked in ice cabs and glaciers. Thus, only 0.003 percent of the earth's total volume of water is easily available as soil moisture, groundwater, water vapor and the water in lakes, streams, rivers and wet lands. Pure form of water present in the earth is a gift from Mother Nature to all living beings. Any alteration of the environment by external forces or contamination by pollutants leads to water pollution. Water pollution is defined as the addition of any

substance to water or changing its physical, chemical and biological characteristics, which may cause harmful effects on human beings and aquatic biota (Sharma and Haur 1994). A number of super-governing systems control the physicochemical properties of water in nature. (Baker 1948, Dara 1975, Kuderia 1985). The main causes of water pollution are natural processes in which decomposed vegetable, animal, and weathered products are introduced into main water resources, as well as anthropogenic processes such as industrial, agricultural, urban, domestic, radioactive, mining sources, use of pesticides and fertilizers by farming communities, and so on. Eventually, potable water is spoiled by the presence of excessive amount of inorganic minerals, heavy metals, trace metals, organic compounds and coloured pigments (Wilber 1969). The categories of pollutants documented as toxic because of their evidenced health hazards are listed below.

- Heavy metals - Cadmium, Chromium, Copper, Lead, Mercury, Zinc, Nickel, etc.,
- Trace Organics - Tri halomethanes, Halo acetic acids, Amines, etc.
- Pesticides and Fertilizers
- Azo dyes and Metallic dyes

Waterborne disorders such as diarrhoea, dysentery, typhoid, jaundice, cholera, and others have been linked to microbial contamination caused by poor sanitation (Tripathi and Pandey 1990).Among the various pollutants present in water, heavy metals are reported to be highly toxic.

HEAVY METALS

The term heavy metal (Trivedy 1998) is generally used whenever there are connotations of toxicity. Nieboer and Richardson 1981suggested that the term heavy metal can be replaced in favours of a classification, which separates metals into class a (oxygen seeking), class B (sulphur or nitrogen seeking) and border line. Non-critical metals, like sodium, potassium, magnesium and calcium, belong to class A, whereas toxic metals, generally, belong to class B or borderline. But essential trace metals, like Fe, Zn, Co, etc. also belong to border line. The classification of elements (Forstner and Wittman 1981) based on the toxicity is presented in Table 1.1. The elemental composition of an adult human being is presented in Table 1.2.

Table 1: Classification of elements based on their toxicity and relative abundance (Forstner and Wittman 1981)

Criteria	Elements
Non-critical	Na, K, Mg, Ca, H, O, N, P, Fe, S, Cl, Br, F, Li, Rb, Sr, Al, Si
Toxic, Insoluble / Rare	Ti, Hf, Zr, W, Nb, Ta, Re, Ga, Lanthanides, Os, Rh, Ir, Ru, actinides
Toxic and relatively abundant	Be, Co, Cu, Zn, Ni, Sn, As, Se, Te, Pd, Ag, Cd, Pt, Au, Hg, Pb, Sb, Bi

Table 1.2: Elemental composition of an adult human being (Bhattacharya and Venkobachar 1984)

Element	Mass (g)	Element	Mass (g)
Aluminium	0.100	Iron	4.20
Arsenic	0.010	Lead	0.08
Antimony	0.070	Magnesium	35.00
Barium	0.020	Manganese	0.02
Boron	0.010	Nickel	0.01
Cadmium	0.030	Potassium	140.00
Calcium	1050	Sodium	105.00
Chromium	0.005	Tin	0.03
Cobalt	0.003	Vanadium	0.02
Copper	0.110	Zinc	2.30

Class A metal ions are essential elements which are required to perform certain key functions like maintaining ionic strength in blood and body fluids(e.g., Na(1), K(1), etc.) and are depositing as salts for the formation of bones and shells (e.g., Ca (II), Mg(II), etc.). Class B metal ions like Mn (II), Cu (II), Zn (II), Ni (II), Fe (III), etc. are also essential to catalysed biochemical (oxidation / reduction) reactions. However, even at low concentrations, certain class B metal ions such as Cd (II), Hg (II), Pb (II), Be (II), Cr (II), and others are highly harmful to living beings. Each element has a permissible concentration range above which it becomes harmful. The danger of toxicity increases when the optimal concentration range for a given element is narrow. Even slight changes in the environment might be dangerous. Although many heavy metals are carcinogenic (Bhattacharya and Venkobachar 1984), industrial development is releasing metal ions into the environment at an unprecedented and ever-increasing rate. Moreover, technological society is exposing the population to some metals in unnaturally high concentration in unusual physical and chemical forms. Since metals are not bio-degradable, (Macchi, Moroni and Tiravarth 1986, Singh and Rawat 1994, Groose 1986) they are highly retained by soils and exposure is likely to persist for a prolonged time. An estimated 359.3 billion gallon of heavy metal ions-bearing waste water is produced annually in countries around the world.

SOURCES OF HEAVY METALS

Geological weathering, mining and industrial processing of ores, metals, and metal components, and leaching of metals from agricultural fields using metallic bio-acids are some of the different sources of heavy metals contamination (Brooks 1997). Electroplating, copper pickling, galvanising, leather tanning, metal finishing, and other essential operations that

discharge effluents containing significant amounts of heavy metals are among the others. Some companies that deal with non-metallic materials produce effluents that contain metals or metal ions (Klein et al 1974).

Fig. 1: Sources of Heavy Metals Pollution

The environmental regulatory bodies have proposed standard limits for effluent discharge. The permissible level of heavy metals in an effluent to be discharged to a natural water source prescribed by WHO (1993) (Huheey et al 1985) and ISI (1991) are given in Table 1.3.

Table 1.3: Permissible levels of heavy metals discharges into natural water source

Metals	WHO (1993) (ppm)	ISI : 10501-91 (1991) (ppm)
Ba	0.700	-
Cd	0.003	0.010
Cr	0.050	0.050
Cu	1.000	0.050 to 1.500
Fe	0.300	0.300 to 1.000
Pb	0.010	0.050
Zn	3.000	5.000
Mn	0.500	0.100 to 0.300
Hg	0.001	0.001
Ni	0.020	-
Al	0.200	0.030 to 0.200

TOXICITY OF HEAVY METALS

The toxicity of heavy metals has increased due to an interaction between the free metal ion and the susceptible target. Cells and tissues involved in the transport of vital metal ions, such as the gastro-intestinal, liver, and renal systems, are particularly susceptible to toxicity. Furthermore, toxicity is caused by their affinity for the sulphydryl (-SH) group of enzymes / proteins, which inhibits enzymatic activity and/or disrupts cellular structures, which varies depending on the metal. The binding or displacement of metal will lead to change in specific activity of biomolecules and may cause interruption to normal metabolism. Ochiai 1997 has framed the following three major categories of general toxicity mechanism for metal ions:

- Blocking the essential biological functional groups of biomolecules especially proteins and enzymes
- Displacing the essential metal ions in biomolecules and
- Modifying the active conformation of biomolecules resulting in the loss of specific activity.

The toxicity of Pb, Cd, Hg, Cu, Cr, Zn and Ni is due to their bioaccumulation through food chain, which produces detrimental effects on human health (Forstner et al 1981). Generally, heavy metals cause irritation, nerve tissue injuries, cardiac strain, heart diseases, disturbed metabolism, kidney malfunction, and hypertension, destruction of central nervous, renal systems, brain damage and cancer. The most common heavy metal pollutants are arsenic, cadmium, chromium, copper, nickel, lead and mercury.

TOXICITY OF ARSENIC

Arsenic is found in significant concentrations in the groundwater of a number of countries. In its inorganic form, arsenic is extremely hazardous. The greatest concern to human health from arsenic is contaminated water used for drinking, food preparation, and irrigation of food crops. Arsenic poisoning from drinking water and eating can lead to cancer and skin sores over time. It has also been linked to diabetes and cardiovascular disease. Exposure during pregnancy and early infancy has been linked to poor cognitive development and a rise in the number of young adults who die. The most critical measure in impacted communities is to provide a safe water source to prevent further arsenic exposure.

TOXICITY OF CADMIUM

Although acute cadmium poisoning is uncommon, gastrointestinal symptoms have been reported after consuming food or drinks contaminated with cadmium from cooking utensils, water pipe solders, or beverage containers.

Cadmium is a metal that can cause acute and chronic health problems in humans. Long-term exposure is the most common cause of cadmium toxicity. Low-level cadmium exposure over time can affect a variety of organs, with the kidneys and bones being particularly vulnerable. Acute cadmium poisoning is quite uncommon. Depending on the route of exposure, acute cadmium poisoning primarily affects the lungs and gastrointestinal tract.

TOXICITY OF CHROMIUM

Chromium is a hazardous heavy metal that can be found in different oxidation states in the environment, ranging from +2 to +6. The most stable forms of chromium are trivalent and hexavalent. In comparison to hexavalent chromium, trivalent chromium has low absorption into the cell. Ingestion, skin contact, and inhalation are the three most prevalent ways for humans to be exposed to chromium. Chromium, which is naturally carcinogenic, is linked to bronchial asthma, lung and nasal ulcers and cancers, skin allergies, reproductive and developmental abnormalities, and more. If you take too much of it, it can kill you.

TOXICITY OF COPPER

Copper is an essential micro-nutrient for all forms of life (Modi and Dave 1995, Lee 1996). An adult's daily copper requirement is approximately 2.0 mg (De 1994). Even though copper is essential for all humans, it can cause issues when it is insufficient or excessive. The Environmental Protection Agency's (EPA) lead and copper rule promulgated, in 1991, that the maximum contaminant level goal (MCLG) for copper (Chen *et al* 1997) is 13 mg/l. Researchers found that copper exerts a much more inhibitory effect on biological processes than zinc and nickel. The presence of excess of copper causes Wilson's disease (Brooks 1997) due to which the bio-synthesis of ceruloplasmin is suppressed. Other toxic effects of copper in humans include congestion of nasal mucous membranes and pharynx, ulceration of nasal septum, metal fume fever, kidney stone formation, etc. The ingestion of acute toxic levels of copper may result in nausea, vomiting, diarrhea, liver damage, hemoglobinuria and hematuria. Copper in water is extremely toxic to aquatic biota.

Fargasova (1990), Salim et al (1993) have proved that the adverse effect caused by copper on plants, i.e., accumulation of copper in plants generates depression of short length. Bioaccumulation of heavy metals including copper affects earthworms also. Aluminium and copper seems to exert deleterious influence on benthic life forms (Carson et al 1986, Marino et al 1992). The Indian Standards Institution (ISI) has prescribed a maximum concentration of 0.1 ppm of copper for drinking water. It has been estimated that the total copper emission to the atmosphere is approximately 74,500 tonnes per year. Natural sources of copper pollution are windblown dusts, vegetation exudates, volcanic emission, etc. Anthropogenic sources include metal production, weed and fossil fuel combustion and waste incineration. Among industrial sources, the main contributors of copper are metal pickling baths, copper plating baths, waste waters from rayon process, pulp and paper mills, petroleum refining, metal work and foundries, mine water, etc (Jha et al 1988, Fosterling et al 1990, Krishnamurti and Viswanathan 1991).

TOXICITY OF LEAD

Lead is a poison that is both lethal and deceptive. Plumbism is the medical term for lead poisoning. It causes haematological damage, as well as gastro-intestinal and haematological problems, as well as an attack on the central nervous system. For adults, WHO recommends

a provisional lead (II) ion tolerance of 7mg kg-1 body weight per day? However, the presence of these contaminants in most industrial and mining effluents, industrial area soil, water, and sewage systems exceeds the tolerance level.

TOXICITY OF NICKEL

Nickel is a costly metal and industrially important one. Nickel compounds are extremely harmful to humans and animals alike. According to Environmental Protection Agency (EPA), USA, the permissible limits of Ni (II) in waste water is 1.0 ppm and according to Bureau of Indian Standards, it is 3.0 ppm in India, acceptable limits of nickel in drinking water (Sharma et al 1992) is 0.01 ppm. Nickel is a potent carcinogen, the contact of nickel with skin results in painful disease, nickel itch, which is followed by sudden death (Mukherjee 1986). Acute poisoning of nickel causes chest pain, tightness of the chest, headache, dizziness, nausea and vomiting, dry cough and shortness of breath, rapid respiration, cyanosis and extreme weakness (Parker 1980) and gastrointestinal irritation and lung cancer, (Lackey and Venugopal 1979, Parker 1980, Clayton and Clayton 1981, Abia and Asuquo 2006). Nickel (II) ions in the effluent when disposed of into lakes and rivers produce ill-effects to living beings and vegetation (Goyal et al 1999). Children are worst affected due to nickel toxicity present in sweets and other food items. Potential sources of nickel bearing waste include ceramics, nuclear power plants, cryogenic containers, electroplating and storage battery industries and silver refineries (Sitting1976).

TOXICITY OF MERCURY

The most prevalent form of mercury poisoning is consuming too much methyl mercury or organic mercury, which is linked to eating seafood. Mercury is present in small amounts in everyday meals and objects and is unlikely to cause harm to your health. The most common cause of this sort of poisoning is eating mercury-containing foods. Children and unborn babies are highly susceptible to mercury poisoning. Hence, poisoning can be avoided by limiting your exposure to this potentially dangerous element. Anxiety, melancholy, irritability, memory issues, numbness, and tumors can all be symptoms of too much mercury. Mercury poisoning can also have a negative impact on the development of a fetus or a young child. High mercury levels in the brain can result in long-term and perhaps irreparable brain damage. For young children who are still developing, the dangers are especially hazardous.

TOXICITY OF BIOLOGICAL IMPURITIES

Micro-organisms present in drinking water are biological contaminants which include bacteria, viruses, protozoans, and parasites, etc., waterborne diseases like typhoid fever, cholera, dysentery, polio, hepatitis, and schistosomiasis are caused by these kind of biological contaminants. They also have a harmful impact on the lives of native species.

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