

# TECHNOLOGICAL DEVELOPMENTS IN Engineering, Management, Arts and Science

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# 3

## Structural Elucidation of Drug 1-Hydroxyurea (Hydrea) by Using Argus Lab 4.0.1 Software

**K. Laxmi**

Department of Chemistry, Chaitanya Bharathi Institute of Technology (CBIT),  
Gandipet, Hyderabad, India.

\*Corresponding author E-mail: klaxmi\_chm@cbit.ac.in

### ABSTRACT

1-Hydroxyurea (Hydrea) is an antineoplastic (anti-cancer) agent. With the help of ArgusLab 4.0.1 software according to the Hartree-Fock (HF) calculation method Conformational analysis and geometry optimization of 1-Hydroxyurea (Hydrea) was performed. Calculation of minimum heat of formation of 1-Hydroxyurea (Hydrea) is done by geometry convergence function applying Argus Lab software. In order to obtain geometries, geometric parameters and thermodynamic parameters PM3 semi empirical quantum mechanical calculations were performed on the most stable structure of 1-Hydroxyurea (Hydrea). Applying the optimized molecule HOMO and LUMO frontier orbital energies were also determined. Electron density surface of 1-Hydroxyurea (Hydrea) is estimated by employing PM3 geometry with PM3 wave function.

**Keywords:** 1-Hydroxyurea, ArgusLab 4.0.1, PM3 semi empirical quantum mechanical calculations, conformational analysis, geometry optimization, HOMO and LUMO, Electron density surface.

### Introduction

Hydroxyurea belongs to a class of drugs called antimetabolites.<sup>1,2</sup> In order to treat chronic myeloid leukemia, ovarian cancer, and certain types of skin cancer (squamous cell cancer of the head and neck) Hydroxyurea is used.<sup>3,4</sup> When hydroxyurea is administered in people suffering with Cancer it acts as a substitute for some parts that the cancer cells need to grow. As a result when Cancer cells take in hydroxyurea, it prevents the cancer cell from growing.<sup>5-7</sup> Because Cancer cells grow more rapidly than normal cells, the drug hydroxyurea is more effective.

## Biomass-Derived Carbon Materials: Production and Applications

### Chapter 13

# Recent Advances of Biomass-Derived Porous Carbon Materials in Catalytic Conversion of Organic Compounds

N. Mahendar Reddy, D. Saritha, Naveen K. Dandu, Ch.G. Chandaluri, Gubbala V. Ramesh

Book Editor(s): Alagarsamy Pandikumar, Perumal Rameshkumar, Pitchaimani Veerakumar

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## Summary

The inevitable rise of the world population has been producing huge amount of biomass, which has now one of the major hazards to human existence on the planet. On the other hand, the shift to the bio-based economy from the fossil-based economy is a major challenge that is being thoroughly vetted. Biomass valorization is one of the key approaches to address the earlier-mentioned problems. Porous carbon (PC) materials as a catalyst and/or catalytic supports are used in numerous applications such as fuel cells, supercapacitors, and organic synthesis. This chapter aims to provide an overview of production of PC from biomass, and its various catalytic applications such as hydrogenation would be discussed.

## References



Weedmark, D. (2018). Human activities that affect the ecosystem. <https://sciencing.com/human-activities-affect-ecosystem-9189.html> (accessed 20 August 2020).



Nanotechnology-Based Additive Manufacturing: Product Design, Properties and Applications, Volume 2

Chapter 3

## Nanomaterials and Nanostructures in Additive Manufacturing: Properties, Applications, and Technological Challenges

Sathish K. Kurapati, N. Mahendar Reddy, R. Sujithra, Ramesh Kola, Gubbala V. Ramesh, D. Saritha

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### Summary

Additive manufacturing (AM) has considered as one of the progressive manufacturing procedures for the manufacturing of extremely supportable functional prototypes. AM technology has permitted the construction of unique profitable, industrial-scale manufacture with superior reproducibility, which is inspiring to realize with conventional engineering methods. Nanoscale materials have diverse physical and chemical qualities as well as size-reliant assets, quantum confinement, huge surface/volume ratio, and decent catalytic action. Nanomaterials are the class of engineering constituents that can offer functionality in the products constructed by AM. Nanomaterial integration into 3D printing approaches can contribute an extensive variety of assemblies with adaptable mechanical, chemical, and electrical performance. The AM of nanocomposites has fascinated extreme consideration and is developing as it can make expansively adapted portions with significantly changed and upgraded properties compared to the unreinforced constituents. Nanomaterials are mixed into a polymer structure to progress material properties. This chapter deals with the classification of nanomaterials, followed by improvement in properties and applications of materials and technical challenges established by the collaborative incorporation of nanomaterials with AM technologies.

### References



This book covers the history of the fuel cell. The origins of fuel cell technology, as well as its evolution over time, are discussed. a basic summary of fuel cell types based on temperature and fuel type. The literature on advanced metal oxide support materials is addressed, mainly on titanium dioxide, tin dioxide, and spinel oxides. This book provides an overview of fuel cells as well as potential catalysts.



G. Venkata Ramesh  
N. Mahender Reddy

Dr. G. V. Ramesh has an extensive history in academic and industry research. He has five years of postdoctoral experience in Japan (National Institute of Materials Science, NIMS) and has published 34 academic articles and 5 patents internationally. The group has produced a variety of metal, intermetallic, and metal oxide nanoparticles/nanostructure.

# Metal Oxides as Support Materials for Electrocatalysts in Fuel Cells

History to Advanced Catalyst Supports



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"From Chemistry to Power: A Journey into Fuel Cell Technology" is a concise and engaging book that explores the world of fuel cells, from fundamental chemistry to practical applications. It provides a comprehensive overview of fuel cell technology, covering principles, catalysts, components, and performance considerations. The book delves into electrochemical processes, different types of fuel cells, and the role of catalysts in fuel cell reactions. It also examines key components, system design, and integration strategies for optimal performance. Real-world case studies and examples highlight applications in transportation, electronics, and power generation. The book addresses challenges, technological advancements, market trends, and future prospects. With accessible language and clear explanations, this book is a valuable resource for researchers, engineers, students, and professionals interested in sustainable and clean energy solutions through fuel cell technology.



Gubbala V. Ramesh

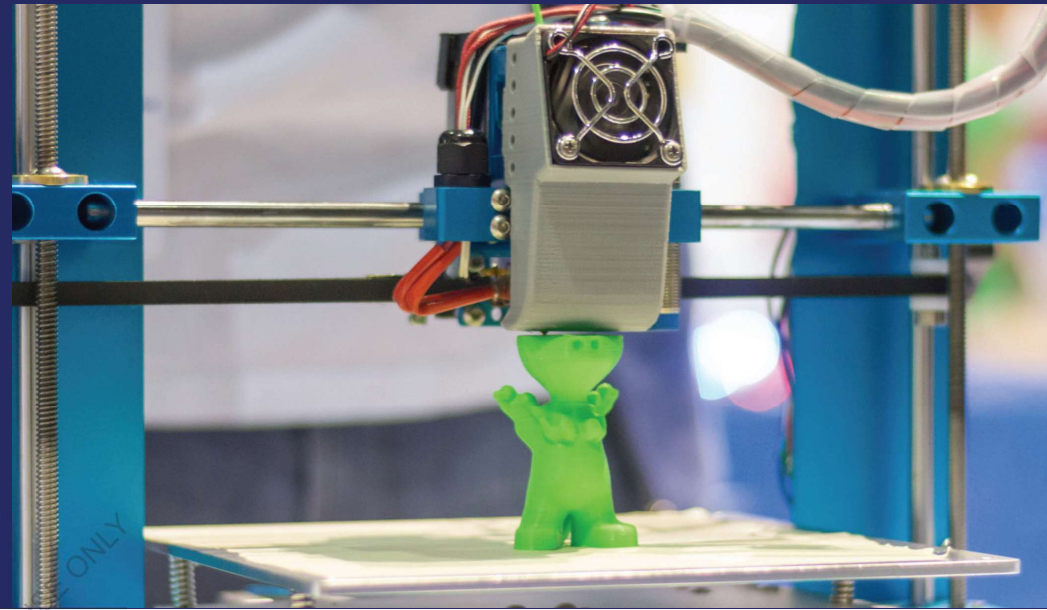
## From Chemistry to Power: A Journey into Fuel Cell Technology

Dr. Gubbala. V. Ramesh is a renowned academic researcher specializing in nanomaterials and their applications. With extensive experience in academia and industry, he has published 40 journal papers, secured 5 patents, and focuses on synthesizing nanoparticles for fuel cells, sensing, and more. Currently an Associate Professor at CBIT, Hyderabad.



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**"4D Printing: Exploring the Next Revolution in Additive Manufacturing"** offers an engaging and in-depth look into the future of 3D printing's more advanced sibling - 4D printing. Starting from its inception, the book maps the evolution of 4D printing, highlighting the game-changing technologies that have helped it break new ground. It decodes the science behind 4D printing, and with a nuanced examination of the materials and techniques pivotal to this domain, brings the reader face-to-face with the heart of this burgeoning field. The role of cutting-edge technologies like AI and machine learning in shaping the future of 4D printing is explored, illuminating the dynamic intersection of additive manufacturing and digital design. A detailed rundown of the versatile applications of 4D printing, from healthcare to aerospace, sets the stage for understanding its real-world impact. The book addresses the challenges 4D printing faces, and the ethical considerations it entails, and gazes into the future, opening a window to the exciting prospects that lie ahead. Immerse yourself in this comprehensive guide and journey into the next revolution in additive manufacturing.



Dr. Gubbala V. Ramesh  
Dr. N. Mahender Reddy



Dr. Gubbala V. Ramesh is a renowned academic researcher specializing in nanomaterials and their applications. He has published 40 journal papers, and 5 international patents, focusing on synthesizing various nanostructures for fuel cells, sensing, and more—currently an Associate Professor at CBIT, Hyderabad.

## 4D Printing: Exploring the Next Revolution in Additive Manufacturing



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### About Authors



Dr. Gubbala V. Ramesh is a renowned academic researcher with expertise in nanomaterials and their applications. With a strong background in academia and industry, including five years of postdoctoral experience at Japan's National Institute for Materials Science (NIMS), he has published 40 international journal papers and secured five international patents. Dr. G. V. Ramesh's research focuses on synthesizing metal, intermetallic, and metal oxide nanoparticles/nanostructures and exploring their potential applications in fields such as fuel cells, exhaust gas purification, sensing, and photocatalysis. Currently an Associate Professor at the Department of Chemistry, Chaitanya Bharathi Institute of Technology (A) in Hyderabad, India. He actively collaborates with industry partners, aiming to bridge the gap between academia and industry and develop practical solutions for various sectors.



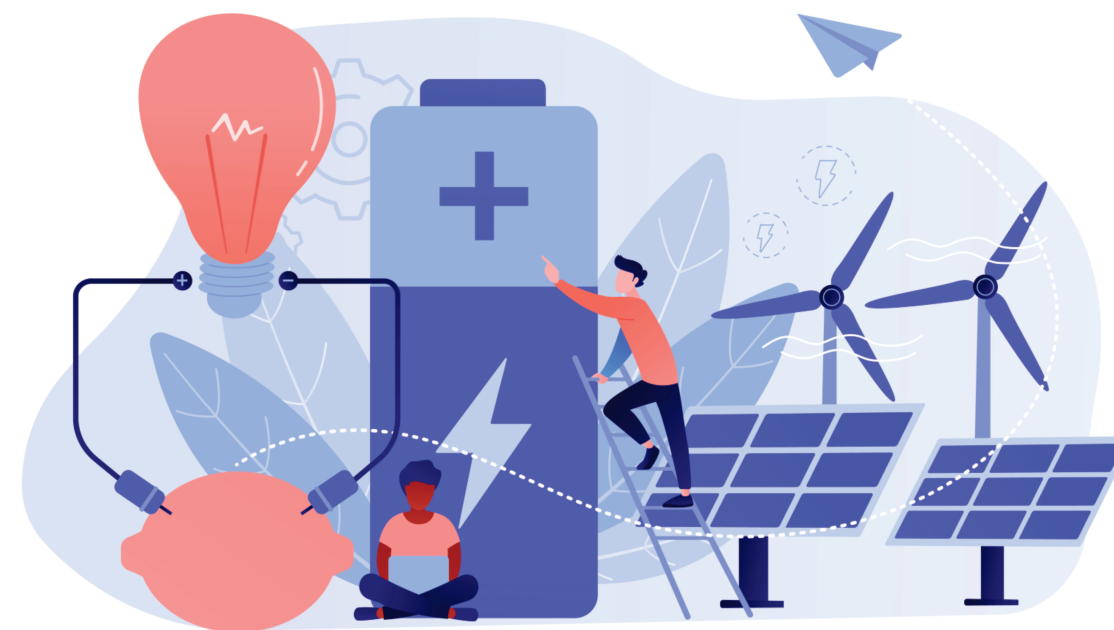
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# POWERING THE FUTURE : A COMPREHENSIVE GUIDE TO BATTERY TECHNOLOGY AND ITS POTENTIAL



- Dr. Gubbala V. Ramesh



### Author's Profile



Dr. RAMESH KOLA, M.Sc., Ph.D., working as Sr. Assistant Professor in the Department of Chemistry, Chaitanya Bharathi Institute of Technology (A), Gandipet, Hyderabad, Telangana. He published 30 research papers in international and national journals of repute. He presented 10 research papers at various national and international conferences. He is a life member of Indian Science Congress Association, Community Member of American Chemical Society and Royal Society of Chemistry Affiliate member. He obtained his Ph.D. degree in Chemistry from Osmania University, Hyderabad. He has a total of 18 years of teaching and research experience. His areas of research interest include Physical Organic Chemistry, Catalysis, Materials Science and Green Chemistry.



Mrs. Jenifer Robinson, M.Sc.(Chemistry), M.Sc.(Applied Psychology), M.Phil. (Chemistry), (Ph.D.) - Research Scholar in Chemistry, is the Head of the Department of Science and French in Indian School Al Wadi Al Kabir, Sultanate of Oman. She has 26 years of experience in the Teaching profession and in Research. She is currently pursuing her Ph.D. in Chemistry, SBAS, KR Mangalam, Gurugram, Haryana, India. She has successfully completed many Chemistry related seminars and workshops and has a rich knowledge in investigatory projects, research paper presentations, authoring book chapters and Chemistry smart draw of chemical structures. She has presented her research ideas in national and international conferences and received various awards - Aavishkar National Global Teacher Award, International Oman Chapter Vidya Jyothi Award, CBSE Best Teacher Award and Women Ioon Innovative Teacher Award. She has published books, manuals and research papers during her service.



Dr. Sujit Tewari, is presently serving as an Assistant Professor in the Dept. of Physics Karimganj College, Assam. Earlier he had served in National Institute of Technology Silchar. Dr. Tewari obtained M.Sc. in Physics in 2000 and M.Phil. in Resonance Raman Spectroscopy in 2001 from Assam University Silchar. He completed his Ph.D. in Physics in 2010 from National Institute of Technology Silchar. He has been recipient of a number of fellowships including the senior research fellowship of Council of Scientific and Industrial Research (CSIR) Govt. of India. He has published many research papers in reputed international journals and 3 Books. Also he is working as Editor, Reviewer for some international journals. He has completed a number of major & minor research projects with sponsorship from UGC & D BT Govt. of India. Dr. Tewari is member of various academic and scientific bodies nominated by Govt. of India. His area of research includes synthesis and characterization of Compound Semiconductor nanomaterials for device application.



Dr. Vivekanand B. Jadhav, has 13 years of teaching and 15 Years of research experience in the field of Synthetic carbohydrate Chemistry, Heterocyclic Chemistry and Green chemistry. Currently he is working as an assistant Professor in Department of Chemistry of Shri Muktanand College, Gangapur, Dist.-Aurangabad, Maharashtra. He has completed his Ph.D. from prestigious Indian Institute of Chemical Technology, Hyderabad & also worked as a postdoctoral Research Associate in Seoul National University, Seoul, South Korea, for two years. He has also worked as a Visiting Fellow in Jawaharlal Nehru Centre for Advanced Scientific Research, Jakkur, Bangalore-560064, India, under the guidance of Dr. T. Govindaraju, faculty fellow, New Chemistry Unit, JNCASR, Bangalore under Visiting Fellowship Programme 2012-13.

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**Dr. Shanthi**, Working as an Associate Professor and HOD of Chemistry in the Department of Basic Science & Humanities, Muffakham Jah College of Engineering & Technology (MJCET), Banjara Hills, Hyderabad. She has 18 years of experience in teaching. She received her M.Phil in the year 2008 and Ph.D in the year 2013 in the area of research in **Chemoinformatics and Bioassay Studies** from **Osmania University, Hyderabad**. She is a **Member of ISTE**. She has **published 21** research and technical papers in National/International journals as well as conferences.



**Dr. A.Kishore Kumar**, Working as an Assistant Professor of Chemistry in the Department of Humanities and Sciences (H&S), Vardhaman College of Engineering, Shamshabad, Hyderabad. He has 7 years of experience in teaching. He qualified CSIR UGC - NET (JRF & SRF) and awarded Ph.D. in Chemistry from **Osmania University, Hyderabad**. His research focus is **Synthesis of Biologically Active Hetero Cyclic Compounds**. He has

**published 25** research papers in peer reviewed national/International journals as well as conferences.



**Dr. K.Ramesh**, working as Sr. Assistant Professor in the Department of Chemistry, Chaitanya Bharathi Institute of Technology(A) (CBIT) Gandipet, Hyderabad, Telangana. He has 17 years of experience in teaching. He received his Ph.D in the area of research in **Physical Chemistry** from **Osmania University, Hyderabad**. He has **published 25** research and technical papers in National/International journals as well as conferences.



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## 3

## Nanomaterials and Nanostructures in Additive Manufacturing: Properties, Applications, and Technological Challenges

Sathish K. Kurapati<sup>1</sup>, N. Mahendar Reddy<sup>1</sup>, R. Sujithra<sup>2</sup>, Ramesh Kola<sup>1</sup>, Gubbala V. Ramesh<sup>1</sup> and D. Saritha<sup>1</sup>

<sup>1</sup> Chaitanya Bharathi Institute of Technology, (A), Department of Chemistry, Hyderabad, TS-500075, India

<sup>2</sup> Motilal Nehru National Institute of Technology, Department of Applied Mechanics, Allahabad, Prayagraj, UP-211004, India

### 3.1 Introduction

Additive manufacturing (AM) is a progressive fabrication expertise that can produce a extensive variety of materials/devices which are very useful across many fields. The AM, formerly recognized as rapid prototyping or 3D printing, is a unique construction technique described by the Testing and Materials for American Society as “a procedure of linking constituents to generate things from 3D model statistics, typically layer upon layer, as divergent to subtractive engineering procedures” [1]. Unlike the conventional techniques, the AM is endeavored to produce a range of complex structures with great precision and also tender great economic and environmental benefits by curtailing raw material wastage [2]. Numerous AM methods were established in the recent past that were reliant on the choice of input materials, power source, and working principle, such as two-photon polymerization, binder jet printing, bioprinting, rapid tooling, stereolithography (SL), fused deposition modeling, selective laser melting, electron beam melting, and laser-engineered net-shaping [3–5]. The major advantages of these techniques stem from the freedom in design, fabrication with minimal tooling, technical competence, and hazardous chemicals [6, 7]. Hence, the AM is winning greater importance across many disciplines, such as energy materials, micro-electronics, and medical applications.

The nanomaterials created a revolution in material science due to their outstanding properties and stretched their applications into many fields. Nanomaterials with particle size at least in one dimension below 100 nm display unique electrical, optical, and magnetic properties unlike their bulk counterparts, and these assets largely depend on the size. Apart from this at this nanoscale, many nanoparticles (NPs) display special characteristics such as paramagnetism, ferromagnetism,





# ENGINEERING CHEMISTRY

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# ENGINEERING CHEMISTRY

## AUTHORS

**Dr. Neerja Shukla**

**Dr. Sharad Tajane**

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**Dr. Jayati Chatterjee Mitra**, Professor of Chemistry in the faculty of Science of Dr. C.V. Raman University, Bilaspur, Chhattisgarh, India

**K Gopinath**, M. Sc., M. Phil., B. Ed., Assistant Professor, Department of Chemistry, Dhirajlal Gandhi College Of Technology, Salem, Tamilnadu, India

**Sachin S Shende**, Assistant professor chemistry, Netaji Subhash Chandra Science College, Mulchera Dist. Gadchiroli, Maharashtra, India

**Dr. M Mamatha**, Assistant professor, Chaitanya Bharthi Institute of Technology, Telangana, India



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**K Gopinath**, M. Sc., M. Phil., B. Ed., Assistant Professor, Department of Chemistry, Dhirajlal Gandhi College Of Technology, Salem, Tamilnadu, India

**Sachin S Shende**, Assistant professor chemistry, Netaji Subhash Chandra Science College, Mulchera Dist. Gadchiroli, Maharashtra, India

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Nanotechnology-Based Additive Manufacturing: Product Design, Properties and Applications, Volume 2

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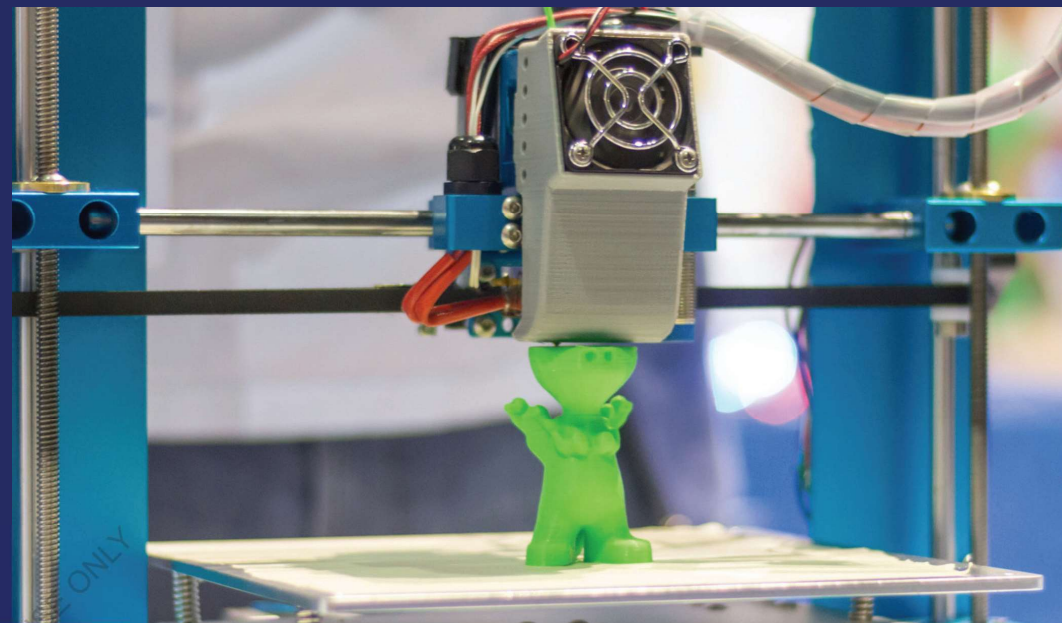
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**Metal Oxides as Support Materials for Electrocatalysts in Fuel Cells**

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Dr. Gubbala V. Ramesh  
Dr. N. Mahender Reddy



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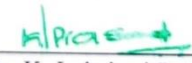
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Chemical Engineering, B V Raju Institute of Technology, Narsapur in collaboration with Dr  
B R Ambedkar National Institute of Technology, Jalandhar on 4<sup>th</sup> -5<sup>th</sup> November 2022.

  
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Dr. K. Lakshmi Prasad  
Principal BVRIT, Narsapur



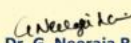


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Compound: Nini - Revers in 3rd International Conference on

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## CERTIFICATE

Prof./Dr./Mr./Ms./Mrs. M. Priyanka Shanthi, CBIT has  
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from floral waste in 3<sup>rd</sup> International Conference on  
Chemical, Bio & Environmental Engineering (CHEMBIOEN 2022) held at Department of  
Chemical Engineering, B V Raju Institute of Technology, Narsapur in collaboration with Dr  
B R Ambedkar National Institute of Technology, Jalandhar on 4<sup>th</sup> -5<sup>th</sup> November 2022.

Dr. G.B. Radhika  
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### About the Authors



**Dr. Keshetti Sreekala** working as an Assistant Professor in the Department of Computer Science and Engineering at Mahatma Gandhi Institute of Technology, has about 18 years of teaching experience. She received her M.Tech., degree in Computer Science from Jawaharlal Nehru Technological University, Hyderabad. She received Ph.D., degree in Computer Science Engineering from Jawaharlal Nehru Technological University, Hyderabad, Telangana state. She has published 15 research papers in refereed international journals and 10 research papers in the proceedings of various international conferences. She also published a book titled Data Structures and Algorithms using C. She has received best paper award for her research paper at one of the international conferences. Her areas of research include Machine Learning, Artificial Intelligence and Grid Computing.



**Dr. Vanitha Guda** working as an Assistant professor in the Department of Computer Science and Engineering at Chaitanya Bharathi Institute of Technology (A) Gandipet, Hyderabad, has about 16 years of teaching experience. She received her M.Tech., degree in Computer Science and Engineering from Jawaharlal Nehru Technological University, Hyderabad. She received Ph.D., degree in Computer Science Engineering in the field of Natural Language Processing from Jawaharlal Nehru Technological University, Hyderabad, Telangana. She has 03-National patents, 01-International patent and presented 18 papers in National and International Journals, Conference and Symposiums. Her main area of interest includes Artificial Intelligence, Machine Learning, Natural Language processing and Language processors.



**Dr. B. Indira** working as an Assistant Professor in the Department of MCA, Chaitanya Bharathi Institute of Technology (A), Hyderabad has about 20 years of teaching experience. She received her MCA degree from Kakatiya University, Warangal in 1996. She received Ph.D., degree in Computer Science from Sri padawanthi Mahila Vidyapeetham, Tirupati in 2010. She has published 44 research papers in refereed international journals and 33 research papers in the proceedings of various international and national conferences and 4 book chapters and also published a book entitled "Fundamentals of C". She is guiding 8 Ph.D., scholars from various Universities and two scholars were awarded their doctoral degree. Her areas of research include Data Structures and Algorithms, Artificial Neural Networks, Machine Learning and Internet of Things.



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# Graphitic Carbon Nitrides based Dye Sensitized Solar Cells and Perovskite Solar Cells for Energy harvesting

Bhanu Chandra Marepally<sup>1</sup>, Maneesh Reddy Venumbaka<sup>1,2,\*</sup>, Selvakumar Duraisamy<sup>2,\*</sup>, Saravanan Sigamani<sup>3</sup>, Hima Bindu D<sup>2,4</sup> and Vigneswaran Dhasarathan<sup>5</sup>

<sup>1</sup>Chaitanya Bharathi Institute of Technology, Hyderabad, T.S. India – 500075

<sup>2</sup>KPR Institute of Engg. and Technology, Coimbatore, T.N. India – 641407

<sup>3</sup>Swarnandhra College of Engineering and Technology, Narsapur, A.P. India – 534280

<sup>4</sup>YSR Engg. College of Yogi Vemana University, Proddatur, A.P. India – 516360

<sup>5</sup>University of Hradec Králové, Czech Republic

## Abstract

A material capability to serve a particular application or purpose is best determined by their properties like electrical, chemical, physical, mechanical, thermal stability, etc. For that, graphitic carbon nitride ( $g\text{-C}_3\text{N}_4$ ) is well suited due to metal free and exhibiting most of the afore-mentioned characteristics makes it one of the most fascinating materials for photo energy harvesting. The variations in these properties are governed by the structural and morphological characteristics of the material. It can synthesize by using various synthesis methods and obtained results in different structures and shape which have profound the effects on the efficiency of dye sensitized solar cells (DSSCs) and Perovskite solar cell (PSCs). So, it is beneficial to study the different methods that are used to synthesize various forms of  $g\text{-C}_3\text{N}_4$ . In this chapter, along with the various synthesis techniques, different roles and properties of  $g\text{-C}_3\text{N}_4$  in DSSCs and PSCs applications were reviewed. Significantly, the cell efficiency of  $g\text{-C}_3\text{N}_4$  integrated  $\text{TiO}_2$  photoanodes highly achieved the maximum cell efficiency of 8.07% with  $\text{Co}_3\text{S}_8$  nanoarrays as counter electrodes. In PSC device,  $\text{CH}_3\text{NH}_3\text{PbI}_3$ :  $g\text{-C}_3\text{N}_4$  (DMF) cell structure yielded maximum and remarkable cell efficiency of 19.49% with short-circuit current of 24.31 mA/cm<sup>2</sup>.

**Keywords:** Graphitic Carbon Nitride,  $g\text{-C}_3\text{N}_4$ , Dye Sensitized Solar Cells, DSSC, Perovskite, Synthesis, Solar, Harvesting, Photoenergy

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## 1. Introduction

Due to rapid industrialization and urbanization, the day-to-day energy demand increased substantially, leading to the fast depletion of the conventional fuel sources (Coal, Natural gas, Oil, etc.). Moreover, the carbon emissions released from the combustion of these fuels results in environmental pollution and climatic imbalances. This, created the need for immediate action towards identifying the alternate sources, which are abundant, renewable, and eco-friendly to meet the world energy demand. Among the various sources, solar energy becomes a promising alternative because of its high capacity and potential to meet current and future energy demands [1]. It is estimated that the efficient usage of solar irradiance for 1

hour across the world is enough to generate one year's global energy consumption [2].

Various technologies are being researched and developed to generate energy using sunlight. Among them, solar cells are of key research interest due to their high efficiencies in comparison to other solar technologies. These are categorized into three generations, in which silicon cells belonging to the first generation occupies the major market share, followed by second-generation CIGS solar cells. The remaining types of solar cells are in the lab-scale research and development only. Recently, Dye Sensitized Solar Cells (DSSCs) are in the category of the third-generation solar cells based on thin films, gained much traction and attention from the researchers due to their advantages like - simple fabrication process, cost-effectiveness [3-4], environmental friendliness [5], low-weight, easy-



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# Nanoscale Semiconductors

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## Materials, Devices and Circuits

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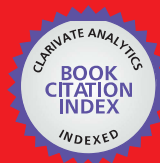
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# Investigation of SAC Channel Effects on MIMO System Capacity and Optimal Coherence Distance Estimation under Different Angular Dispersions for Next-Gen Networks

*Vinodh Kumar Minchula and Gottapu Sasibhushana Rao*

## Abstract

In practical 4G/5G MIMO systems, it is difficult to have independent fading among sub channels between different antenna pairs. There will be sub channel correlation between the transmit and receive antenna pairs. Spatial Antenna Correlation (SAC) is an important constraint in the performance of MIMO system capacity. It is observed that, if there is correlation then it effects the random distribution of eigenvalues and more correlation means it is probable that a few eigenvalues are large and rest are small. Therefore, correlation effects the loss in capacity and is bound by its eigenvalue distribution. In this chapter, the different SAC channel effects on Ergodic and outage MIMO capacities are analyzed and the correlation between signals received among antenna pairs are investigated to determine the optimal coherence distance between the spatial antennas under different angular dispersion conditions (rich and poor scattering phenomena).

**Keywords:** MIMO, SNR, BER, SAC, ergodic capacity, outage capacity

## 1. Introduction

The growing demand for the high capacity wireless mobile communication systems (e.g. 5G cellular systems) under severe multipath fading conditions has drawn a great attention towards the MIMO compared to conventional SISO, SIMO or MISO communication systems. However, the Spatial Antenna Correlation (SAC) is one of the predominant factors that limit the MIMO systems performance substantially in terms of capacity which is a function of covariance of correlation coefficients obtained due to coherence distance between the antennas and angular spread of the multipath

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Chapter

## Food Colours Toxicology and Food Safety

By *Vanga Sri Varsha, Tanmayi Boreda, Adithi Reddi Kamana, Sanjana Reddy Pailla, Yashasvi Kambhampati, T Gourav, Ashoutosh Panday, Sanjeeb Kumar Mandal, Bishwambhar Mishra*

Book [Microbial Pigments](#)

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**ABSTRACT**

Food colours or colourants are used in a variety of edible goods to enhance their looks because consumers value appearance. A variety of additive colorants have traditionally been permitted in safe and healthy amounts to enhance the appearance of food for commercial value. However, people have long been aware of the hazardous consequences of food colours, which has resulted in the enactment of basic laws by

[Back to Top](#)

# Green carbon nanomaterials and their application in food, agriculture, and biomedicine

# 3

Ch S.H. Sudheshna<sup>1</sup>, Jyothika Meenakshi Kambhampati<sup>1</sup>,  
Chinthakindhi Samanth<sup>1</sup>, Gali Chaitra<sup>1</sup>, Harika Reddy Pulipelli<sup>2</sup>,  
Bhushan Vishal<sup>3</sup>, C. Nagendranatha Reddy<sup>1</sup>, Sanjeeb Kumar Mandal<sup>1</sup>,  
Divya Prema Suroju<sup>1</sup>, Dinesh Chand Agrawal<sup>4</sup>, Bishwambhar Mishra<sup>1,\*</sup>

<sup>1</sup>Department of Biotechnology, Chaitanya Bharathi Institute of Technology, Hyderabad, Telangana, India; <sup>2</sup>Department of Microbiology and Molecular Genetics, School of Medicine, University of California, Irvine, CA, United States; <sup>3</sup>School of Biological Sciences, Nanyang Technological University, Singapore; <sup>4</sup>School of Life & Basic Sciences, Jaipur National University, Jaipur, India;

\*Phone: 040-24193276; Email Id: bishwambhar\_biotech@cbit.ac.in

## 3.1 Introduction

Nanomaterials are substances having at least one exterior dimension that range within 1 and 100 nm. A "nanomaterial" is any substance that contains internal or exterior structures that are on the nanoscale. A nanoparticle is a tiny, three-dimensional object at the nanoscale. The term "nanotechnology" refers to the synthesis and use of materials having structural qualities intermediate with at least one dimension falling between 1 and 100 nm, between those of atoms and bulk materials [1,2]. Nanometric materials have unique features that set them apart from bulk materials or atoms. American physicist Feynman, who was a 1959 Nobel Prize winner, was the first to propose the concept of nanotechnology. Due in large part to the creation of novel approaches for their characterization and adaptation as well as the assembly of nanomaterials, nanoscience and technology have seen significant growth over the past 10 years [3].

There are several cutting-edge methods available right now for producing nanoparticles, nanotubes, and their assemblages. Certain semiconductor, metal, and other material nanostructures' size-dependent electrical, optical, and magnetic properties are now better known. In addition to the well-established methods of spec-



# Role of different types of carbon nanotubes in food sciences and food sensing applications

# 7

Balaji Doolam<sup>1</sup>, Divyamshu Surabhi<sup>1</sup>, Chandan Kumar Gautam<sup>2</sup>,  
Rajasri Yadavalli<sup>1</sup>, Naru Rakesh Reddy<sup>1</sup>, Aishwarya Kulkarni<sup>1</sup>,  
Karthikeya S.V. Gottimukkala<sup>3</sup>, Sanjeeb Kumar Mandal<sup>1</sup>,  
Bishwambhar Mishra<sup>1,\*</sup>

<sup>1</sup>Department of Biotechnology, Chaitanya Bharathi Institute of Technology, Hyderabad, Telangana, India; <sup>2</sup>Department of Biology, University of Miami, Coral Gables, FL, United States; <sup>3</sup>Department of Laboratory Medicine and Pathology, University of Washington, Seattle, WA, United States;

\*Phone: 040-24193276; Email Id: bishwambhar\_biotech@cbit.ac.in

## 7.1 Introduction

“Nutrition isn’t just about eating, it’s about learning to live.” beautifully written by Patricia Compton, illustrates the prime necessity to fully understand the food product we consume. To understand the properties associated with the complex food molecules, food science is applied; whose scope grays the line between agricultural and nutritional science(s) and focuses on the development of food safety, food processing, food packaging, how molecules such as carbohydrates, lipids, proteins, and water interact with each other under storage conditions. Additionally, the birth of food technology has given numerous opportunities to improve the fields explored by food science and to understand the concentrations of various components present in various foods. This is where the exponential advancement of nanotechnology provides limitless potential toward the improvement of food sciences, food sensing biosensors, and food properties such as texture, taste, and nutritional value [1, 2].

c0005 Implications of caged  
molecular structure of  
buckminster fullerenes in  
food sciences and industry  
applications

Mohammad Zaki Shamim<sup>1</sup>, Pampi Deka<sup>1</sup>, Yugal Kishore Mohanta<sup>2</sup>,  
Bishwambhar Mishra<sup>3</sup>, Kunal Biswas<sup>4</sup> and Awdhesh Kumar Mishra<sup>5</sup> AU:2

<sup>1</sup>Department of Food Nutrition and Dietetics, Faculty of Sciences, The Assam Down Town  
University, Guwahati, Assam, India

<sup>2</sup>Nano-Biotechnology and Translational Knowledge Laboratory, Department of Applied Biology,  
School of Biological Sciences, University of Science and Technology Meghalaya, Baridua,  
Meghalaya, India

<sup>3</sup>Department of Biotechnology, Chaitanya Bharathi Institute of Technology (CBIT), Gandipet,  
Hyderabad, Telangana, India

<sup>4</sup>Centre for Nanoscience & Nanotechnology International Research Centre, Sathyabama  
Institute of Science and Technology, Chennai, Tamil Nadu, India

<sup>5</sup>Department of Biotechnology, Yeungnam University, Gyeongsan, South Korea

s0010 **5.1 Introduction**

p0015 Graphite and diamond are two examples of the many different forms that carbon  
may take in the natural world. Carbon is the most abundant element on Earth.  
Fullerenes are the fourth type of allotrope that carbon can take. Fullerenes  
are spherical molecules that are soluble in a wide variety of organic solvents.  
This is in contrast to the extended solid-state structures of graphite and diamond.  
This characteristic enables a wide variety of chemical manipulations to be  
carried out [1].

p0020 A fullerene is a structure made of carbon that has a fused ring system and is



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## Plant-Derived Drugs for Alzheimer’s Disease and Other Neurological Disorders

[B. Sumithra](#)  [Sanjeeb Kumar Mandal](#), [Bishwambhar Mishra](#), [K. V. S. S. N. Mounika](#), [J. Caleb Joel Raj](#) & [C. V. S. Aishwarya](#)

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### Abstract

Alzheimer’s disease (AD) is a progressive, debilitating neurological disorder associated with chronic damage to neuronal cells that result in the disruption of the function and structure of the nervous system. AD is irreversible and frequently associated with an elderly population with long pre-symptomatic conditions and late onset. Common symptoms include dementia,

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## Dietary Natural Polyphenols Against Bacterial and Fungal Infections: An Emerging Gravity in Health Care and Food Industry

[Biswajit Patra](#), [Nibedita Das](#), [Mohammad Zaki Shamim](#), [Tapan Kumar Mohanta](#), [Bishwambhar Mishra](#) & [Yugal Kishore Mohanta](#)

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### Abstract

Polyphenols are the great metabolites of plants and are associated with protection against UV radiation and hostility by microorganisms. There has been lot of significance in the medical advantages of dietary plant polyphenols as cancer prevention agent. Awareness has expanded

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## Microbial Synthesis of Gold Nanoparticles

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### Abstract

Due to their nanoscopic size and notable structural variations from many of their counterparts, nanoparticles exhibit qualities that make them sustainable building materials. Owing to this fact, they have become a key focus of research and possess numerous applications in biology and as well as in agriculture. One such notable example of nanoparticles is gold nanoparticles.

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4.2. Factors influencing the general productivity i...

4.3. Factors influencing the process scale-up

4.4. Conclusions and perspectives


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**Figures (1)**



**Current Developments in Biotechnology and Bioengineering**

Photobioreactors : Design and Applications

2023, Pages 59-88

## Chapter 4 - Factors affecting the microalgal biomass productivity in photobioreactors

S. Deepak Mohan Reddy, N. Deepika, Meghana Reddy Dropathi, S. Vishwanatha, J. Dhanish Daaman, C. Nagendranatha Reddy, Rajasri Yadavalli

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### Abstract

The potential of microalgae for biofuel and value-added products generation has been recognized for years because they contain oils and produce biomass rapidly, as well as fact that they can grow in non-arable soils and wastewater. Microalgae contributing to the food, pharmaceutical, aquaculture, and cosmetic sectors are also important for

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### Abstract

In global public health, clinical treatment of pathogenic infection has become a grave issue. Antibiotics are now the only therapy option; however antibiotic overuse has resulted in resistance to multiple drugs and thereby a surge in fatality rates during antiinfection therapies. The advent of nano systems for various biological and drug delivery applications has piqued the interest of scientists all over the world. Microbes

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## Deciphering the Nexus Between Oxidative Stress and Spermatogenesis: A Compendious Overview

[Caleb Joel Raj](#), [C. V. S. Aishwarya](#), [K. V. S. S. N. Mounika](#), [Bishwambhar Mishra](#), [B. Sumithra](#), [Bhushan Vishal](#) & [Sanjeeb Kumar Mandal](#)

Chapter | [First Online: 07 December 2022](#)

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### Abstract

Oxidative stress (OS) and reactive oxygen species (ROS) are one of the main reasons for the multifactorial concern – male infertility. ROS are active components of cellular metabolism that are intrinsic to cellular functioning and are present at minimal and unreactive levels in normal cells. They are an integral component of the sperm developmental physiology, capacitation,

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## Recovery of Valuable Products from Vegetable Wastes

Pooja Aich, Balraj Sudha, Kanagaraj Suganya, Bishwambhar Mishra, Bapatla Sumithra, Sanjeeb Kumar Mandal ✉, Sundaravadivelu Sumathi ✉

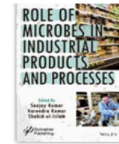
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First published: 10 October 2022 | <https://doi.org/10.1002/9781119901198.ch10>

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### Summary

Vegetables are essential for human health because they provide a significant quantity of vitamins, minerals, and fiber in our balanced meals. Vegetable production produces a large amount of liquid and solid waste, containing many valuable high-value components with significant economic benefits. If not used or disposed of properly, it may cause pollution. On the other hand, this waste material is high in valuable compounds and is thrown into the environment. These are unique, fresh, and cost-effective bases of flavoring, additives, dietary fiber, protein, antioxidants, and antimicrobials, which could be used in the beverage and food industries to produce beneficial products. As a result, new concepts concerning the practice of these by-products for more utilization in the manufacture of high-nutritive edible products or supplements have piqued interest as these are high-value products with the potential for economic recovery. This review aims to encourage vegetable production and processing by emphasizing the possibility of extracting active molecules from vegetable waste and their application in industries. These advantages would pave the way for the potential use of vegetable waste for therapeutic and nutraceutical applications. The retrieval of these bioactive substances from industrial by-products is currently generating much interest, owing to their positive effects on people. This review concentrates on the vegetable by-products with bioactive properties and their potential applications in health sectors (nutraceuticals) and food



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## Actinobacteria in Natural Product Research: Avenues and Challenges

Santhoshini Hazari, Uzma Tabassum, Anum Jehan Siddiqui, Shivani Hazari, Addagatla Ravindar, Sanjeeb Kumar Mandal, Sanjay Kumar, Bishwambhar Mishra ✉

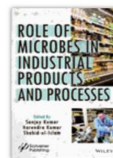
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### Summary

Actinobacteria are well-known biosynthetic factories that generate a wide range of secondary metabolites. In numerous ways, recent genetic discoveries appear to impact the exploitation of these metabolically diverse microorganisms. Specifically, different methodologies progress continuously, from the isolation of new species through the findings of new chemicals. Over the past decades, researchers have developed industrially competitive strains of actinomycetes with excellent performances. This chapter summarizes the occurrence, habitat, and diversity of actinobacteria in the natural environment. Novel bioactive compounds and major enzymes synthesized by the groups of actinomycetes have been summarized. Furthermore, the current challenges and future perspectives for industrial strains more systematically through metabolic engineering strategies are also discussed.



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Chapter 5

## Marine Microbes as a Resource for Novel Enzymes

Kanagaraj Suganya, Balraj Sudha, Bishwambhar Mishra, Bapatla Sumithra, Sanjeeb Kumar Mandal✉, Sundaravadivelu Sumathi✉

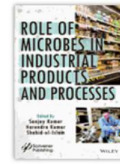
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### Summary

Microbial enzymes have many benefits over the enzymes obtained from plant and animal sources because of their chemical action activities, cheaper, abundant supplies, and relatively a lot of stability. A marine setting, which includes seventy-one of the surfaces, is not only wealthy with variety but also an enormous resource for potential microorganisms for helpful applications. Microorganisms and fungi in marine ecosystems secrete various enzymes that support their environment and ecological roles. Marine microbic enzymes became the main target of attention, and various enzymes had drawn the eye of microbic explorers. Many enzymes are extracted from water or marine sediments, refined and characterized for their properties and potential applications. Primary targets of recent protein technology still working on the maintenance of foods and food parts, economical use of raw resources, the development of food quality like flavor and style, manufacture of dietic foods, eliminating opposing



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## Food Preservatives From Microbial Origin: Industrial Perspectives

N.S.V. Lakshmayya, Y. Swarna Lekhya, Yugal Kishore Mohanta, Sanjeeb Kumar Mandal, Dinesh Chand Agrawal, Bishwambhar Mishra ✉

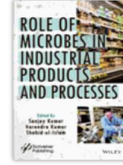
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### Summary

Biological preservatives derived from plants, animals, and bacteria have gained favor because they are more dependable, ethical, and safe. The food industry is looking for natural antimicrobials due to consumer preferences for the additives derived from nature and worries about the assurance of manufactured preservatives. Such preservatives are more stable, but they are also cheaper and more widely available in nature. Bacteriocins, enzymes, plant extracts, peptides, and fermented substances are examples of natural antimicrobials. Numerous *LAB* bacteriocins have promising implementations in the food market preservation, and their application in the food market can aid in alleviating the use of additives and preservatives along with the severity of thermal processing, culminating in food products that are effectively



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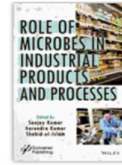
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### Summary

Microorganisms are widespread, living pioneer species of the earth. They are indispensable for the ceaseless existence of various other organisms, including humans. Their interaction ranges from cycling nutrients in the environment to manufactured applications that include food production, medicinal, energy development, wastewater treatment, and warfare. Although various microbes are employed in different fields, they are proven to be promising in the medicinal field with their discoveries and applications for the well-being of people globally. The feasibility in culturing, selecting, and manipulating microbes makes them comparatively more advantageous in large-scale bioprocess industries. Mostly, the application of microbes in this industry is for antibiotics. Amoxicillin and penicillin are commonly known antibiotics produced from the fungus *Penicillium*. This chapter is an effort to highlight the tremendous potential of



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## Plant Synthesized Nanoparticles for Dye Degradation

[Varimadugu Aruna](#), [Nainika Chada](#), [Medagam Tejaswini Reddy](#), [Vadakavila Geethikalal](#), [Kiranmai Dornala](#) & [C. Nagendranatha Reddy](#)

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### Abstract

Dyes are mostly used in many industries such as textile, food, leather, cosmetics, pharmaceuticals, paper industry, etc. Industrial dyes when released spoil the ecosystem, they are hazardous to aquatic life, animals, and mankind. So there is a need to degrade the dyes to reduce the toxicity present in them. Among various methods available for the degradation of dyes the best method is to use nanoparticles synthesized from plants because it is promising.

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## Smart Health Care by Harnessing the Internet of Things (IoT): Applications, Challenges, and Future Aspects

[C. V. S. Aishwarya](#), [J. Caleb Joel Raj](#), [Sanjeeb Kumar Mandal](#), [C. Nagendranatha Reddy](#) & [Bishwambhar Mishra](#)

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### Abstract

Internet of things (IoT), the modern paradigm of networking is constantly evolving and has become a common area of research with numerous opportunities. IoT-enabled devices have helped solve many problems in the health-care sector, and the improved potential to keep patients safe and healthy has empowered physicians to provide curative care. These devices

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# Effect of Emergent Rigid Vegetation on Flow Properties in an Open Channel



J. R. Khuntia, K. Devi, B. S. Das, K. K. Khatua, and S. Jena

**Abstract** The flow characteristics in open channels with emerging rigid vegetation are discussed in this paper. By strengthening ecosystem sustainability and restoration, vegetation can be actively exploited as a tool for flood management. Vegetation growing in channels irregularly raises the hydraulic resistance, which can result in energy loss and reduced conveyance capacity. The results of the earlier experiments have been thoroughly investigated regarding the flow resistance produced by uniformly distributed vegetation stems. The vegetation consists of emergent rigid rods replicating stem of a tree. Velocities were measured using 3D acoustic Doppler velocimeters (ADV), with both downward facing and upward facing probes. The magnitude of the longitudinal velocities was found to decrease significantly behind the vegetative stem. Due to the presence of turbulence, the transverse and vertical velocities were high. According to the findings, vegetation density, stem diameter, vegetation length and flow depth all affect flow resistance. Additionally, it has been seen that as vegetation density increased, the flow rate reduced. The relationships between friction factor ( $f$ ) and Manning's coefficient ( $n$ ) with the independent non-dimensional geometric and roughness parameters have been demonstrated. Experimental data sets of NITR and past researchers have been taken for developing a new mathematical relationship for roughness in terms of non-dimensional parameters.

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J. R. Khuntia (✉) · K. Devi  
Department of Civil Engineering, Chaitanya Bharathi Institute of Technology (A),  
Hyderabad 500075, India  
e-mail: [jnanaranjan444@gmail.com](mailto:jnanaranjan444@gmail.com); [jnanaranjan\\_civil@cbit.ac.in](mailto:jnanaranjan_civil@cbit.ac.in)

K. Devi  
e-mail: [kamalinidevi1@gmail.com](mailto:kamalinidevi1@gmail.com); [kamalinidevi\\_civil@cbit.ac.in](mailto:kamalinidevi_civil@cbit.ac.in)

B. S. Das  
Department of Civil Engineering, National Institute of Technology Patna, Patna 800005, India  
e-mail: [bsd.nitrkl@gmail.com](mailto:bsd.nitrkl@gmail.com); [bsd.ce@nitp.ac.in](mailto:bsd.ce@nitp.ac.in)

K. K. Khatua · S. Jena  
Department of Civil Engineering, National Institute of Technology Rourkela, Rourkela 769008,  
India  
e-mail: [kkkhatua@nitrkl.ac.in](mailto:kkkhatua@nitrkl.ac.in)

S. Jena  
e-mail: [sjena@nitrkl.ac.in](mailto:sjena@nitrkl.ac.in)

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1

# Numerical Investigation of Secondary Flow Structures in a Gravel Bed Asymmetric Compound Channel



S. Sahoo, K. Devi, J. R. Khuntia, and K. K. Khatua

**Abstract** The efficiency of a water management system is determined largely based on its water conveyance capacity through canals. Any reduction in this capacity may result in consumers not getting sufficient water resources. Amongst many factors affecting the conveyance capacity of an open channel, one of the most significant impacts is the generation of secondary currents. The secondary flow cells are generated due to the lateral and vertical component of flow velocities. There have been many experimental and analytical investigations performed to understand the effect of secondary flow cells. However, to overcome such rigorous and time-consuming experimental procedures, numerical simulations can be applied using computational fluid dynamics (CFD). In this present study, numerical simulations have been performed to understand the impact of secondary current cells in an asymmetric compound channel. Amongst many turbulence models available in ANSYS Fluent software package,  $k-\omega$  turbulence model has been selected because of its capability to provide good results with less computing resources. The numerically simulated results are validated with theoretical models. It has been observed that the numerical results confirmed well with the theoretical models. Three types of vortices, namely longitudinal vortex, free surface vortex, and bottom vortex are observed in the channel cross-section. As the flow depth increases, the vortices are shifted towards the interface of main channel and flood plain and also, they are decreased with increase of relative depth, which clearly agrees with theoretical studies. This study will be helpful

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S. Sahoo (✉) · K. K. Khatua  
Department of Civil Engineering, National Institute of Technology, Rourkela 769008, India  
e-mail: [sarjatisahoo1991@gmail.com](mailto:sarjatisahoo1991@gmail.com)

K. K. Khatua  
e-mail: [kkkhatua@nitrkl.ac.in](mailto:kkkhatua@nitrkl.ac.in)

K. Devi · J. R. Khuntia  
Department of Civil Engineering, Chaitanya Bharathi Institute of Technology (A), Hyderabad,  
Telangana 500075, India  
e-mail: [kamalinidevi1@gmail.com](mailto:kamalinidevi1@gmail.com); [kamalinidevi\\_civil@cbit.ac.in](mailto:kamalinidevi_civil@cbit.ac.in)

J. R. Khuntia  
e-mail: [jnanaranjan444@gmail.com](mailto:jnanaranjan444@gmail.com); [jnanaranjan\\_civil@cbit.ac.in](mailto:jnanaranjan_civil@cbit.ac.in)

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101



# IoT-Integrated Deep Learning Model and SmartBin System for Real-Time Solid Waste Management

Dr. K. Saravanan<sup>1</sup>, Dr Kapil Aggarwal<sup>2</sup>, Karthick Raja M<sup>3</sup>, N R Dakshina Murthy<sup>4</sup>, Sireesha koneru<sup>5</sup>, Archee Verma<sup>6</sup>

<sup>1</sup>Professor, Department of Information Scene and Engineering,  
New Horizon College of Engineering, Bangalore, Karnataka,  
India. dr.saravanank@newhorizonindia.edu

<sup>2</sup>Associate Professor, Department of Computer Science and  
Engineering, Koneru Lakshmaiah Education Foundation,  
Vaddeswaram, Guntur, Andhra Pradesh, India.  
kapil594@gmail.com

<sup>3</sup>Assistant Professor, Department of Computer Science and  
Engineering, Sri Eshwar College of Engineering, Kinathukadavu,  
Coimbatore, Tamilnadu, India. krajamuthiah@gmail.com

<sup>4</sup>Associate Professor Civil Engineering Department CBIT,  
Hyderabad, Telangana, India. m.geetha@sru.edu.in

<sup>5</sup>Assistant professor, Department of Mechanical Engineering,  
Koneru Lakshmaiah Education Foundation, Green fields,  
Vaddeswaram, Guntur, Andhra Pradesh, India.  
sireekonerus@kluniversity.in

<sup>6</sup>D Y Patil college of Architecture, Pune, Maharashtra, India.  
ar.archeeverma@gmail.com

**Abstract**— The increasing number of people living in metropolitan areas increases the risk that garbage will be disposed of in an unsustainable manner. Because of the high volume of people frequenting city halls and other government facilities, many urban areas now incur astronomical costs for garbage disposal. Waste collection and sorting is the most important part of any waste management system. Smart trash management is recommended in this research by the use of electronic smart sorting through the Internet of Things. The system's two primary functions—trash collection and waste classification—are controlled by a Raspberry Pi 4b microprocessor and three modules. In the past, these two primary features have been implemented independently; however, in this study, features are merged to provide a more complete smart bin waste disposal system. Overflow alarms using ultrasonic and tracker sensors initiate garbage pickup. To effectively separate biodegradable from non-biodegradable solid wastes, two methods have been used. The first method incorporates a Convolutional Neural Network (CNN) and Long Short Term Memory (LSTM) with the IoT, whereas the second method takes the first method's model and adds more sensors. Three different approaches of data collection are used with CNN+LSTM-based IoT. Images from Kaggle is the first approach, while using search engines like Google and Bing is the second, and direct capture in a studio is the third. It has been shown that the second method is superior, with an accuracy of 99%.

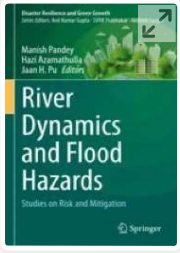
**Keywords**—Deep Learning, Internet of Things, Smart Waste Management, Sensors, CNN.

## I. INTRODUCTION

Objects of daily use will soon be embedded with microcontrollers and communication protocols as envisioned

by the Internet of Things (IoT) [1]. The "smart city," characterized by "smart" infrastructure, "smart" persons, and "smart" cooperation, is a popular example of an IoT product [2]. By making available open access to specific subsets of data, IoT paves the way for the creation of a wide variety of digital services while transparently incorporating a large number of diverse end systems [3]. Smart waste management is a crucial concept in the concept of the "smart city." Among the many factors that determine a waste management system's efficiency is the distance between the central sorting facility and the collection sites. As a result of the time and energy required, waste management is an expensive endeavor. The authorities have instituted the recycling bin and launched the 3Rs campaign in an effort to enhance trash management procedures (recycle, reuse and reduce) [9]. This demonstrates the ineffectiveness of prior programs and the pressing necessity for the creation of a smart waste management system to replace the current ones. Improvements to the current waste management system have been made feasible thanks to developments in the field of IoT. Because of the lack of real-time monitoring in the current waste management system, implementing sensors in the trash can in conjunction with Internet of Things connectivity is essential. The sensors may gather information like fill level, temperature, humidity, and more. All of this information may then be uploaded to the cloud and stored there until it is needed. As a result of data processing, current waste management system's limitations are understood and able to address those issues, ultimately leading to greater system efficiency. One step towards creating a smart city is to implement Internet of Things technology in garbage cans.

Garbage categorization research using deep neural networks is presented in [6]. The author of [7] suggests a smart bin system that employs ML/AI/II/IoT to make use of existing bins and analyze images. This method makes use of convolutional neural networks (CNNs) to identify and categories different sorts of trash, such as metal, glass, paper, and plastic. In [8], the concept



**River Dynamics and Flood Hazards** pp 203–221

## Estimation of Shear Force Distribution in Two-Stage Open Channel Using SVM and ANFIS

[B. S. Das](#), [J. R. Khuntia](#) & [K. Devi](#)

Chapter | [First Online: 29 November 2022](#)

**88** Accesses

Part of the [Disaster Resilience and Green Growth](#) book series (DRGG)

### Abstract

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The prediction of discharge is a challenging task for compound channel due to exchange of momentum at the junction of main channel and floodplain. From the literature, it has been found that, using apparent shear force (ASF) concept at the interface of floodplain and main channel, the accurate discharge can be predicted. ASF is a function of various non-dimensional parameters such as channel width ratio ( $\alpha$ ), relative flow depth ( $\beta$ ), main channel aspect ratio ( $\delta$ ), relative roughness ( $\gamma$ ), bed slope ( $S_0$ ), Froude number ( $Fr$ ), and side slope ( $m$ ). In this paper, an attempt has been made to model ASF by considering the aforementioned non-dimensional parameters. A total of 152 datasets have been collected from various literatures related to ASF. In the recent days, artificial intelligence (AI) and machine learning (ML)

# Evaluation of the Shear Strength Design Equations for Slender and Non-Slender RC Beams Admixed with Recycled Concrete Aggregate without Web Reinforcement

M.V.S.S. Sastri<sup>1,a)</sup>, K. Jagannadha Rao<sup>2,b)</sup> and V.Bhikshma<sup>3</sup>

<sup>1</sup>Dept. of Civil Engineering, Vasavi College of Engineering (A), Ibrahimbagh, Hyderabad-500 031-Telangana-India. <https://orcid.org/0000-0002-9198-1638>

<sup>2</sup> Dept. of Civil Engineering, Chaitanya Bharathi Institute of Technology (A), Hyderabad-500 075-Telangana-India. <https://orcid.org/0000-0002-9528-627X>

<sup>3</sup>Dept. of Civil Engineering, OU College of Engineering (A), Osmania University, Hyderabad-500 007-Telangana-India. <https://orcid.org/0000-0003-1917-509X>

<sup>a)</sup> Corresponding Author: [mvss.sastri@staff.vce.ac.in](mailto:mvss.sastri@staff.vce.ac.in), [sastrimvss@gmail.com](mailto:sastrimvss@gmail.com)

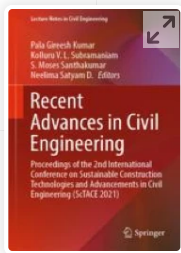
<sup>b)</sup> [kjagannadharao@yahoo.com](mailto:kjagannadharao@yahoo.com)

**Abstract.** In this investigation, studies were done to know the effect of the presence of recycled coarse aggregates (RCA) and Pozzolans in shear deficient rectangular beams in evaluating the shear strength of concrete. The selected slender and moderate deep beams without shear reinforcement were tested under two-point loading and the obtained results are compared with the renowned research work and design codes on natural coarse aggregates. An important observation is the replacement ratio of RCA is an important parameter to be introduced in the equations proposed by the various researchers on shear strength prediction while the current design codes are conservative in the prediction of ultimate shear strength of beams. The proposed method is then verified using the available experimental data of 330 RCA and NCA data of rectangular beams without stirrups.

**Keywords.** RCA, Recycled Concrete Aggregates: Shear stress: HSC, High Strength Concrete: C&DW, Construction & Demolition Waste.

## INTRODUCTION

The compressive strength of concrete is an important property of this ubiquitous material used in the construction industry. HSC is a popular because of its utilization in high rise structures and utilization at the local level is also increasing due to the dearness of land cost. The sustainability of concrete is obtained when the coarse aggregates replace Recycled Coarse Aggregates (RCA) despite this the society has not accepted it, particularly in structural applications (1, 2). The reviews of the research have reported that RCA is an inferior material compared to natural aggregates because of its mechanical properties, especially in compression (3, 4). In case, if the HSC is admixed with RCA the strength of aggregates is less compared to NCA hence failure happens before the maximum strength attained through the aggregates and also due to the adhered mortar which already had some cracks due to the difference in the paste nature. An extensive study was done on flexural behaviour of reinforced concrete (RC) members and conclusions are included in the codes of various countries. But the progress towards the formulations and understanding of the flexural and shear stress is under progress in the past half-century, and a lot of work is undertaken to understand the behaviour of RC members. The progress towards the understanding of shear is less, and that is why several publications are appearing in the journals indicating the complexity of the problem (5). Most of the researchers and International building codes evaluated the HSC using empirical equations which can't provide a uniform factor of safety against the failure, and the quantum of work done on the HSC using RCA is less due to the variability of its strength.



**Recent Advances in Civil Engineering** pp 467–480

## Workers Safety at Indian Construction Sites—A Survey

[M. V. Krishna Rao](#) , [G. Tarun](#) & [V. Hari Leela](#)

Conference paper | [First Online: 14 May 2022](#)

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### Abstract

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The construction industry is known as one of the unpredictable and hazardous sectors in which the workers are more susceptible to construction accidents. Despite many efforts put in to enhance construction site safety, construction accounts for quite disproportionate number of occupational injuries and fatalities. Urbanized nations attempt to guarantee stringent lawful enforcement of construction site safety in the industry by implementing various safety management systems. Conversely, occupational safety in the industry is

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Sustainable Approach for Resilient  
Infrastructure  
**26-27 June 2021**



Dr. K. Jagannadha Rao  
Dr. U. Johnson Alengaram  
Dr. M.V Krishna Rao  
Dr. N.R Dakshina Murthy





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**Editors:**

**Dr. K. Jagannadha Rao**, Professor, Department of Civil Engineering, Chaitanya Bharathi Institute of Technology (A), Gandipet, Hyderabad, Telangana, 500075

**Dr. M.V. Krishna Rao**, Professor, Department of Civil Engineering, Chaitanya Bharathi Institute of Technology (A), Gandipet, Hyderabad, Telangana, 500075

**Dr. N.R. Dakshina Murthy**, Associate Professor Department of Civil Engineering, Chaitanya Bharathi Institute of Technology (A), Gandipet, Hyderabad, Telangana, 500075

**Dr. Johnson Alengaram U**, Associate Professor Department of Civil Engineering, Office of the Faculty Engineering, University of Malaya, Kuala Lumpur, 50603, W. Persekutuan Kuala Lumpur, Malaysia

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**EVALUATION OF WATER QUALITY INDEX IN GANDIPET LAKE  
SURROUNDINGS**

**Ramanarayan Sankriti**

Assistant Professor  
Chaitanya Bharathi Institute of Technology  
Gandipet, Hyderabad  
Telangana-500075, India.

**Saravanan Subbarayan**

Assistant Professor  
Department of Civil Engineering  
National Institute of Technology  
Tiruchirappalli, Tamil Nadu-620015  
India.

**Aswari Sultana Begum**

Assistant Professor  
Chaitanya Bharathi Institute of  
Technology, Gandipet, Hyderabad  
Telangana-500075, India.

**Allu Venkatakrishna Reddy**

UG student  
Chaitanya Bharathi Institute of  
Technology, Gandipet, Hyderabad  
Telangana-500075, India.

**Banoth Naveen**

UG student  
Chaitanya Bharathi Institute of Technology  
Gandipet, Hyderabad  
Telangana-500075, India.

**ABSTRACT**

To assess water quality of Gandipet Lake (Osmansagar reservoir) and its surroundings whether it is fit for consumption, Water Quality Index (WQI) technique proposed by Ramakrishnaiah (2009) was adopted. A water quality index provides a single numeral that signifies water quality holistically at a certain location and time based on several water quality parameters. The purpose of an index is to convert complex water quality data into information that is well understood by the community. Eight most important parameters related to water quality such as pH, total dissolved solids (TDS), total hardness, total alkalinity, dissolved oxygen (DO) and electrical conductivity (EC) were taken for the calculation of WQI. The WQI values for the Gandipet Lake ranged from 77-91. The values of WQI showed that the water was free of any impurities at the sampling site. Owing to anthropogenic activities such as dam operations, water may get polluted to some extent, resulting in the decrease of water quality index. Also, WQI can be used as a tool in comparing the water quality of different sources. It gives the community a general idea of the possible problems with water in a particular region. Water Quality Index is one of the most effective ways to communicate the information on water quality trends to the public or to the policy makers and water quality management.

**Keywords:** Drinking, WQI, Gandipet lake, Osmansagar, Ramakrishnaiah (2009).

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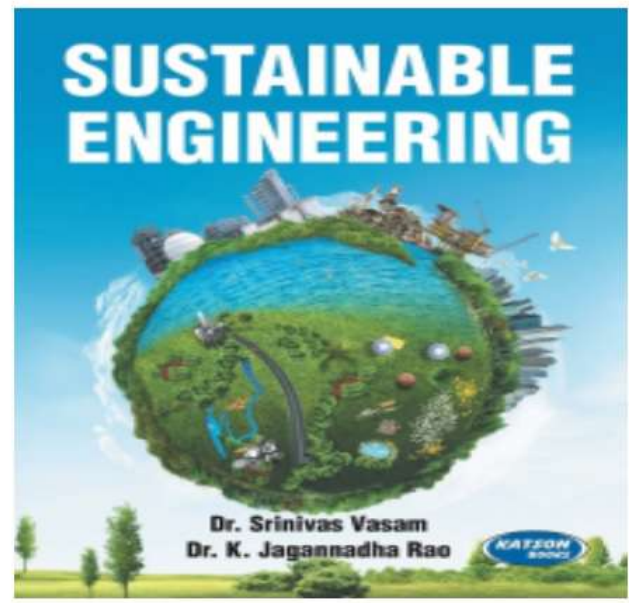
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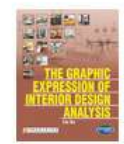
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## **Macroscopic Analysis of Traffic Flow Behavior on Multi-Lane Highways under Heterogeneous Traffic Conditions**

Kanchumurthy Anusha<sup>1</sup>, Poojari Yugendar<sup>2\*</sup>, S.MOSES SANTHAKUMAR<sup>3</sup>

<sup>1</sup>M.Tech Student, *Transportation Division, Department of Civil Engineering, National Institute of Technology Tiruchirappalli -620015, Tamilnadu, India, Ph.:+91-9884934170*

<sup>2</sup>Assistant Professor, *Department of Civil Engineering, Chaitanya Bharathi Institute of Technology, Gandipet, Hyderabad-500075, Telangana State, India, Ph.:+91-9441305396*

<sup>3</sup>Professor, *Transportation Division, Department of Civil Engineering, National Institute of Technology Tiruchirappalli -620015, Tamilnadu, India*

<sup>a</sup>[anusha.navodhaya@gmail.com](mailto:anusha.navodhaya@gmail.com), <sup>b</sup>[pyugendar\\_civil@cbit.ac.in](mailto:pyugendar_civil@cbit.ac.in), <sup>c</sup>[moses@nitt.edu](mailto:moses@nitt.edu)

**Abstract.** Traffic flow behaviour is a complex phenomenon and need better understanding and concepts for its analysis. The highways in India normally operate under mixed traffic conditions and the driving behaviour varies from one place to another. Macroscopic models which are quite suitable for describing the behaviour of entire stream and further accepted worldwide for estimation of capacity. The present study demonstrates the dynamic nature of PCU factors on two-way two-lane highways under highly heterogeneous traffic composition. Dynamic PCU's were estimated based on speed and size of vehicle type in the traffic stream with respect to a standard passenger car. The PCU values obtained in this study were compared with the existing static PCU's to get an overview of how the PCU varies when dynamics is involved. The present study also analyses the macroscopic traffic flow behaviour such as capacity and speed flow modeling on multilane highways. The VISSIM model parameters those were sensitive to capacity are calibrated based on the traffic composition observed in field by taking measure of effectiveness as traffic volume, speed and capacity. Validation of model was also performed by the same methodology with the help of VISSIM model on four-lane divided highways.

Keywords: *Capacity; Traffic flow; microscopic simulation; VISSIM.*

### **1. Introduction**

Traffic flow behavior on multilane highways is a complex phenomenon and need better conceptual and logical way of understanding and analysis. There are three main approaches to analyze the traffic flow behavior. First is microscopic approach that considers the response of each individual vehicle in a disaggregate manner. The individual driver – vehicle combination was examined. Second is the mesoscopic approach which provides the medium detail and description of traffic flow. Third is the macroscopic approach which provides the medium detail and description of traffic flow. Third is the macroscopic approach that at the traffic flow behavior in aggregate sense and also provides details of overall operational efficiency of the system. Number of parameters are also associated with traffic flow analysis approaches and those are interrelated with one another to develop traffic flow models. Traffic flow models describe the motion of a traffic stream with the mathematical formulation.

# Stress–Strain Behaviour of Self-consolidated Processed Recycled Aggregate Concrete



Nune Srikanth, N. R. Dakshina Murthy, and M. V. Seshagiri Rao

**Abstract** Self-consolidating concrete (SCC) is considered as a special concrete that streams and strengthens by its self-weight and passes through the congested reinforcement without any segregation and mechanical vibration. In the recent era, a bombastic amount of construction and demolition (C&D) scrap produced from deteriorated structures and ready mix concrete plants is creating a severe environmental pollution. This has encouraged the reuse of C&D scrap as aggregates in concrete. Utmost investigation was carried out on the consumption of recycled coarse aggregate (RCA) in self-consolidating concrete. In the present study an experimental investigation has been carried to develop SCC mixes of standard grades M35 and M45 using unprocessed and processed RCA at different percentage replacements of natural coarse aggregate (NCA) (0, 25, 50, 75 and 100% by weight) as per Nan-Su method. The processing of RCA is done using Deval's abrasion testing machine for different number of revolutions. Fresh properties of SCC were determined by means of slump-flow, L-box and V-funnel. The perfunctory properties such as compressive strength and stress–strain behaviour were determined. It has been observed that the usage of processed recycled coarse aggregate obtained higher compressive strength compared with unprocessed recycled coarse aggregate in SCC. The portion of recycled aggregate content increase has shown that the peak stresses are lower and their corresponding strains are higher. From the experimental findings it has been noticed that the processing of recycled aggregate up to 500 revolutions and 50% replacement of natural aggregate showed the optimum results.

**Keywords** Self-consolidating concrete · Unprocessed recycled coarse aggregate · Reprocessed coarse aggregate · Stress–strain behaviour

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N. Srikanth  
JNTUH, Hyderabad, India  
e-mail: [srikanth.6090@gmail.com](mailto:srikanth.6090@gmail.com)

N. R. Dakshina Murthy (✉)  
Hyderabad, India  
e-mail: [nrdmurthy@yahoo.com](mailto:nrdmurthy@yahoo.com)

M. V. Seshagiri Rao  
Hyderabad, India  
e-mail: [rao\\_vs\\_meduri@yahoo.com](mailto:rao_vs_meduri@yahoo.com)



# Studies on Infiltration Rate of Pervious Concrete



Nune Srikanth and N. R. Dakshina Murthy

**Abstract** Concrete is the only material in the construction engineering for which the usage has been multifold over the last decade. Owing to rapid urbanization, there has been an increase in the consumption of construction materials by which the natural resources are depleting day by day. Porous concrete or no fines concrete or permeable concrete is known as special type of concrete which allows the water to penetrate through the concrete, thereby reducing the external runoff and boosting the ground water table. As pervious concrete has little to no fine aggregate, the voids of coarse aggregate particles will be filled by the cementitious paste to preserve the interconnectivity. The perviousness is the only parameter which indicates the penetrability of no fines concrete. Since the rate of infiltration depends upon pore sizes, geometry and interconnectivity of coarse aggregate, it exactly indicates the effectiveness of pervious concrete. To preserve the water quality for future generations, the pervious concrete can be used as sustainable construction practice. In the current study, the experiments were carried out with a constant water/cement, varying cement/aggregate and also varying size of aggregate in the total aggregate content. The compressive strength was determined for standard cubes of  $150 \times 150$  mm. The falling head permeability apparatus was designed to determine the coefficient of permeability for various samples. The cylinder-shaped casts of 11 cm in diameter and 18 cm in depth were used to determine the rate of infiltration by conducting permeability test on pervious concrete. The mix proportion satisfying infiltration rate and strength properties is recommended as the sustainable pervious concrete.

**Keywords** Pervious concrete · Rate of infiltration · Compressive strength · Permeability

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N. Srikanth  
JNTUH, Hyderabad, India  
e-mail: [srikanth.6090@gmail.com](mailto:srikanth.6090@gmail.com)

N. R. Dakshina Murthy (✉)  
CBIT, Hyderabad, India  
e-mail: [nrdmurthy@yahoo.com](mailto:nrdmurthy@yahoo.com)



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