Journal of Environmental Science & Engineering (JESE)

About the Journal

Started in 1958, Journal of Environmental Science & Engineering (JESE) is a peer reviewed quarterly journal published by the National Environmental Engineering Research Institute (NEERI, CSIR), Nagpur reporting various significant achievements in the field of environmental science and engineering, according to the R&D thrust areas of the Institute. The journal is providing communication links among the members of the scientific community engaged in research in India and abroad covering all the major aspects of environmental science and engineering.

Aims and Scope

The scope of this journal covers Environmental Science and Engineering and the related areas. The journal intends to timely disseminate information related to monitoring of the environmental status across the country and abroad, innovative and effective S&T solutions to environmental and natural resource problems, significant R&D activities in the field of environmental science and technology, environmentally sound technologies and policy analysis. The journal aims at publishing both review and research articles in the field of environmental science and engineering. Case studies and short communications are also published to inform about the hazards and risks likely to occur to the people and environment due to certain materials, and the ways of controlling these hazards and associated risks. Various topics covered in the journal include: air quality monitoring, modeling and management; air pollution control; source management and apportionment studies; carrying capacity based developmental planning; soil and water chemistry, monitoring and management of land degradation; river and lake ecosystem studies; application of fly ash, sewage, sludge and mine tailing on land; ecological approaches to improve ecological and socio-economic values of land-use systems; integrated natural resource management; conservation and sustainable management of under ground biodiversity, remote sensing applications in environmental geo-science; ground water and rain water harvesting; water and waste water treatment; solid and hazardous waste management; eco-friendly technologies; waste land management; biodiversity assessment; biogeochemistry of rivers and estuaries; pollution chemistry, particularly metal speciation and bioavailability in water and soil systems; PAHs and volatile organics in atmosphere; environmental analytical methodologies; monitoring and modeling of urban noise; environmental impact and risk assessment studies; environmental audit studies; chemical process simulation and development; environmental policies; bioremediation and biodegradation studies; environmental biotechnology and genomics studies; research on environmental materials, etc.

The journal publishes high-impact contributions on:

1. Environmental monitoring
2. Environmental biotechnology
3. Environmental systems design modelling and optimisation
4. Environmental impact and risk assessment
5. Solid and hazardous waste management
6. Policy analysis and planning

The Vision

Journal of Environmental Science & Engineering endeavors to become a leading medium for dissemination of scientific and technical information in environmental science and engineering

The Mission

To provide environmental scientific information with description of timely, contemporary advances in environmental science and engineering, and management for use in improving our environment

The *Journal of Environmental Science & Engineering* is published quarterly. The Institute assumes no responsibility for the statements and opinions advanced by contributors. The editorial staff in its work of examining papers received for publication is assisted, in an honorary capacity, by a large number of distinguished scientists. Communications regarding contributions for publication in the journal should be addressed to the Editor-in-chief, *Journal of Environmental Science and Engineering,* Technology Development Centre, CSIR-National Environmental Engineering Research Institute, Nehru Marg, Nagpur – 440 020. All correspondence regarding reprints, journal copies, subscription renewals, claims for missing numbers and advertisements should be sent to the same address.

Annual Subscription (w.e.f. 1 January 2014) : Individual: Rs. 1000/- (Inland) $200 (Foreign) and Institutions & Organizations: Rs. 4000/- (Inland) $600(Foreign). The subscription proforma is placed at our website www.neeri.res.in. You may use the same proforma for placing your orders for subscription & are requested to kindly send the same along with Demand Draft by post to Managining Editor, Journal of Environmental Science and Engineering, Waste Reprocessing Division, CSIR- National Environmental Engineering Research Institute (NEERI), Nehru Marg, Nagpur – 440 020. *The Demand Draft should be drawn in favour of Director, NEERI, Nagpur – 440 020.*

For further details, please write to: Dr. Sunil Kumar, Managing Editor, Journal of Environmental Science & Engineering, Waste Reprocessing Division, CSIR-National Environmental Engineering Research Institute (NEERI) Nehru Marg, Nagpur - 440 020;
Phone : + 91 712 - 2249748; Fax : + 91 712 - 2249900; E. mail : jese@neeri.res.in
Website : www.neeri.res.in / neerijese.org

Printed & Published by : Dr. Rakesh Kumar, Director, CSIR-NEERI on behalf of CSIR-National Environmental Engineering Research Institute, Nehru Marg, Nagpur – 440 020 (India)
Registered with Registration of Newspapers of India (Reg. No. 6465/59)
Printed at : Mudrashilpa Offset Printers, Bajaj Nagar, Nagpur.

Journal of Environmental Science & Engineering

(http://www.neeri.res.in)

ISSN 0367-827 X

Volume 63 | No. 3 | July 2021

CONTENTS

The journal is covered by the following leading abstracting, indexing and current awareness services:

- Chemical Abstracts Service
- Sci-Search – A Cited Reference Science Database
- Engineering Index
- Current Contents
- Research Alert
- Cambridge Scientific Abstracts
- INSPEC
- Biotechnology and Bioengineering Abstracts
- Biological Abstracts
- EMBASE
- Scopus
- IC Journals
- CAB Abstracts
- Elsevier Biobase -Current Awareness in Biological Sciences (CABS)
- Indian Science Abstracts
- BIOBASE
- BAILSTEIN
- IARAS
- Compendex
- ACM
- Ulrich's
- National Library of the Netherlands
- French National Library
- British Council Libraries
- German National Library of Science and Technology
- National Library

J.Environ.Science & Engg. Vol. 3, P. 1230-1245, July, 2021

Soil and Climate Change : An Analysis of Feedback

ANJALI SINGH

Abstract:

All regions of the world are experiencing the effect of climate change in terms of life-threatening heat, droughts, floods and food insecurity. This change is mainly due to the emission of Greenhouse gas (GHG) through anthropogenic activities like urbanization, industrialization and land-use change in agriculture and forest. Soil is a major contributor to GHGs like CO_2, CH_4 and N_2O. Net ecosystem exchange, soil respiration and ecosystem respiration are major pathways of CO_2 emission from soil. Anaerobic condition of submerged soil favours the methanogens which eventually produces methane. The process of nitrification and denitrification in soil participate in the production of NO_2, NO and N_2O in the atmosphere. Methane and nitrous oxide have a global warming potential (GWP) 34 and 298 time higher respectively than that of CO_2. CH_4 emissions were recorded at 600 Giga tonne (Tg) in 2010 and a further increase of 60 % is expected by 2030. An increase of 35 to 60 % in N_2O concentration is expected by 2030. Climate change has also affected the characteristics of soil as such. This review reveals the relationship between soil and climate change with a discussion on various processes of GHG emission from soil and its feedback on soil.

Key Words : *Climate change, carbon pool, methanogens, nitrification and denitrification, soil-deterioration*

1. Introduction

Climate change is revealed by the variability in its properties that continues for an extended period[1]. The changes that have been observed in the present temperature and weather patterns are a result of increased greenhouse gas emissions due to anthropogenic activities. These changes might seem small but even a slight modification in the proportion of greenhouse gases can have a huge impact on a global scale. Unless there is a significant reduction in the emission of greenhouse gas in the coming decades, global warming of 1.5 °C and 2 °C shall exceed during the 21st century[1]. Every decade starting from the 1980s has gotten warmer, the warmest being the last one, 2011-2020. Almost every land area is experiencing hotter days and more heat waves. Heat-related illnesses become more prevalent due to high a temperature. Hot conditions make both the start and the spread of wildfires much easier. The rate of warming in the arctic has been almost twice the global average. With a rise in temperature, more moisture will evaporate which will result in severe rainfall and flooding. Ocean warming also controls the intensity and frequency of tropical storms. Ocean surfaces with warm water provide a conducive environment for cyclones, hurricanes, and typhoons which go on to destroy infrastructure leaving people homeless and resulting in economic losses as well as deaths. Climate change is also taking a toll on the availability of water. This results in agricultural and ecological droughts which affect crops and make ecosystems more vulnerable. Such intense droughts could also lead to sand and dust storms moving huge quantities of sand across continents. With deserts expanding, there is limited land left for growing food. Most of the heat generated from global warming is absorbed by oceans. Water tends to expand with warming and this causes the volume of oceans to increase. This expansion coupled with the ice-sheet melting increases the sea level which directly impacts all the coastal and island communities. Oceans are also major sinks of atmospheric carbon dioxide but excess carbon dioxide results in acidification of ocean water threatening marine life and coral reefs. Forest fires, extreme weather, and invasive pests and diseases induced by climate change have challenged the survival of species on both lands and in the ocean. The rate of loss of species is now 1000 times higher. Hunger and poor

Centre of Advanced study in Botany, Institute of Science, Banaras Hindu University, Varanasi-221005, India
*Corresponding author: aanjalisingh18@gmail.com

J.Environ.Science & Engg. Vol. 3, P. 1246-1251, July, 2021

Copper Nanoparticles Impregnated on Kaolin for Control and Prevention of Biofilms and Microbiologically Induced Corrosion

SHEEBA N.K.[1] , MEERA V[1*] VINOD P.[2]

Abstract:

A biofilm mainly consists of various bacterial cells, extracellular polymeric substrates (EPS) and corrosion products. Biofilm leads to the deterioration of metal pipes which is referred to as microbiologically induced corrosion (MIC). Sulphate reducing bacteria which reduce sulphates into sulphides are mainly responsible for this. This study investigated the efficiencies of two types of filter beds prepared using kaolin and kaolin impregnated with copper nanoparticles (kaolin/Cu-NPs), as pretreatment methods, in removing sulphate and bacteria from synthetic wastewater (sulphate 55 mg/l and HPC 560 CFU/ml), for the control of biofilms and prevention of MIC. The results showed sulphate and bacterial removal capacity for kaolin filter beds ranged from 61.20% to 63.33% and 67.07% to 69.10% for bed depth of 2mm to 8mm respectively. The corresponding efficiencies for kaolin/Cu-NPs filter beds were 62.10% to 63.90% and 78.75% to 81.81% respectively. Though the sulphate removal capacity of the two types of filter beds was almost same, kaolin/Cu-NPs filter beds showed enhanced bacterial removal efficiency and reduction of corrosion potential in GI pipes. Therefore filtration of water through kaolin/Cu-NPs can be employed as an effective pretreatment method for control and prevention of biofilms and MIC in pipes.

Keywords : *Biofilm, Copper nanoparticles, Heterotrophic plate count, Kaolin, Microbiologically induced corrosion, Sulphate*

1. Introduction

A biofilm is usually a coalition of microorganisms that attaches to metal or other surfaces. Biofilms of mixed culture microbes are synergistic and more recalcitrant than formed by single strain microbes. Biofilms consist of many species of bacteria and may include fungi, algae, protozoa, extracellular polymeric substrates (EPS), corrosion debris and by-products. Microbes which are entrenched in the biofilm are called sessile cells and they provide platform for new microbes to attach on it [Jia et al., 2019]. Biofilms often lead to the deterioration of metal pipes transporting water/wastewater which is referred to as microbiologically influenced corrosion (MIC). There are about a dozen of bacteria known to cause MIC of carbon steels, aluminium alloys, and copper alloys in water and soils at pH 4-9 and temperature 10°C to 60°C. The main microorganisms responsible for the MIC are sulphate reducing bacteria (SRB). These bacteria reduce sulphate to sulphide, are anaerobic and can thrive in the temperature ranging from 25°C to 60 °C [Bhola et al., 2010].

Periodic monitoring and control measures should be adopted to prevent biofilm accumulation inside the pipelines. The commonly adopted control measures are physical treatment, chemical treatment and biological treatment. Physical treatment involves pigging, ultraviolet radiation and ultrasonic treatment. In chemical treatment, various chemicals that are harmful to bacteria are used. Biological treatment uses different types of bacteria antagonistic towards the bacteria forming biofilms. Because pipelines are extremely long serving and critical infrastructure, it is paramount to maintain the physical integrity of pipelines [Bhola et al., 2010]. The

[1]Department of Civil Engineering, Government Engineering College, Thrissur, 680009 Kerala, India.
sheebank2015@gmail.com

[1]Department of Civil Engineering, Government Engineering College, Thrissur, 680009 Kerala, India. vmeera@gectcr.ac.in
[2]Department of Civil Engineering, Marian Engineering College, Thiruvananthapuram, 695582, Kerala, India.
dr_pvinod@marian.ac.in

J.Environ.Science & Engg. Vol. 3, P. 1252-1261, July, 2021

Accumulation of Heavy Metals in Different Vegetables: A Random Analysis in India & Insight of Health Risk Concerned

PUSHPA C. TOMAR[1*], KOMAL ARORA[1], ARPITA GHOSH[2*], TANYA KALRA[1], HARISHA KOHLI[1]

Abstract :

Green leafy vegetables are a treasure trove of nutrients, contribute significantly in individual nourishment. However, the rapid increase in the heavy metal pollution resulted in their accumulation in food and ultimately in human liver and kidney, disrupting the biological reactions and pathways undergo inside human body. There are several beneficial and harmful effects of heavy metals in the life of a human. Body needs in low concentrations, however, if this level exceeds, the effect becomes negative, therefore it is vital to study the concentration of heavy metals vegetables whose consumption rate is higher in India. The research trend analysis in this domain was performed using Scopus. Different varieties of mostly consumed vegetables were randomly collected from local markets and farm fields for the analysis of heavy metal concentration. The technique of Energy Dispersive X-Ray Fluorescence has been used to detect various heavy metals. The value of lead and copper is significantly high as being compared to their certified standard value (0.20 mg/kg and 12.2 mg/kg) in Spinach, and similar findings were there for all 17 vegetables. The results revealed the higher potential of accumulation of heavy metals in green leafy vegetables from the soil as compared to others.

Keywords : *Bioaccumulation; Biomagnification; Circular material management; Heavy metals; India; Threat; Vegetables.*

1. Introduction

The world's metropolitan networks are expanding quicker than worldwide populace. This is due to the progression of urbanization even in the countries that are least developed. Anthropogenic activities resulted in the accumulation of waste material causing the significant and unfavourable modification to the surroundings[1]. The expansion in urban development urge the farmers to produce food crops on the contaminated field[2]. The activities related to industrial and municipal contribute highly in making the land polluted with heavy and toxic metals. The predominant source that affected the land of agriculture in urban areas is the utilization of wastewater for the irrigation purposes as the effluents of wastewater are heavily loaded with toxic metals[3,4].

Endowment of metals in soil is the foremost possible way of exposure of toxic metals to the human beings that penetrate inside the body of human via food crops, water, or inhalation of dust[5]. Consumption of contaminated vegetables exposure to heavy metals, resulting to toxicity, is a serious problem and this needs to solved as soon as possible. This study has been designed to detect such heavy metals accumulated in vegetables grown in metal endowed land.

An example of such heavy metal is Cadmium that is known to be a contaminant of food chain and there are studies reported estimating that about 70% of cadmium intake contributed by means of food chain [6]. Growth of vegetables on the contaminated field of land results in the accumulation of toxic metals, and because of the prolonged consumption, that toxic metals get accumulated inside the tissue organs such as kidney and liver, thus altering the biological pathways of kidney, liver, nervous and cardiovascular system, resulting in various disorders [7-15]. The assessment based on the risk of heavy metals imposed on health by the contaminated

[1] Department of Biotechnology, Faculty of Engineering & Technology, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana-121004, INDIA

[2] Indian Institute of Management Sirmaur, Paonta Sahib, Himachal Pradesh-173025, India

Corresponding authors' details: arpita.ghosh@iimsirmaur.ac.in; dr.tomarpushpa@gmail.com

J.Environ.Science & Engg. Vol. 3, P. 1262-1269, July, 2021

Prediction of Possible Fifth Wave of Covid 19 Pandemic in West Bengal Based on Disease Spread Since Inception

ANIRBAN DAS[#1], ARKAJYOTI SANYAL[#1], SOMANGEE CHAKRABARTI[#1], ESHA GUHA ROY[#1], TANMOY DUTTA[#1], SUCHARITA ROY[1,2], ARUP KUMAR MITRA[3*]

Abstract :

The aim of our study was to compare and comprehend the devastation caused due to each subsequent wave of COVID 19 pandemic in West Bengal. We did so by using methods of standard graphical interpretation where we plotted graphs for both positivity rate and deceased proportion against time using GraphPad Prism, and drew basic interpretations from the graphs. Mathematical modelling had been performed using the XGBoost algorithm to predict the possibility of a fifth wave in West Bengal using data from positive cases since disease inception. By the end of our study, we had successfully correlated the decrease in deaths (deceased proportion) with the increase in vaccination efforts, and had also made a futuristic prediction about the trend of the positive COVID cases per day, starting from the end of January 2023, till the month of May 2023, beyond which predictions could not be made due to insufficient data availability.

Keywords : *Graphical interpretation, graph pad prism software, XGBoost Algorithm, mathematical modelling, COVID 19.*

1. Introduction

Due to its quick global spread, the COVID-19 outbreak, which was first discovered in Wuhan, China, has been classified as a pandemic, and was declared as global pandemic by WHO on March 11th, 2020.The first case of COVID 19 in India was documented on 27th January, 2020. Subsequently, COVID19 pandemic started ravaging in West Bengal from the month of March, 2020 (Biswas et al, 2022). The first case in West Bengal was confirmed on 17th March of the same year (Mondal et al, 2020). Data published from virology studies provide evidence of the spread of the virus from infected people to others in direct contact or through respiratory droplets, or by contact with contaminated objects (Cheinnaswamy, 021). Since then, it had its impact on education, healthcare, economy, trade and industries. To study an infectious disease outbreak, formal, quantitative approaches, statistical computing, graphical interpretations, data-based analysis are well established methodologies and are widely used as they are helpful to understand how the disease will spread, the devastation it has caused and the outputs are communicated to policy makers and stakeholders to provide a valuable measure for disease management (Hoseinpour Dehkordi et al, 2020 , Mark Woolhouse, 2011)

Predicting the upcoming or future trends about the spread of the virus and trying to forecast upcoming waves would be of great importance not only economically, but also because the healthcare sector can brace themselves accordingly. Developing appropriate mathematical and statistical models often help greatly in accurately making these predictions. With the passage of time, as data about daily infected cases, deaths and recovery began to be available, researches began to develop various mathematical models or utilize machine learning to predict the transmission of SARS-CoV-2. One of the major tools that was employed to make futuristic predictions about the COVID 19 virus was an algorithm called eXtreme Gradient Boosting (XGBoost), that

1. St. Xavier's College (Autonomous), Kolkata
2. Faculty, Department of Mathematics, St. Xavier's College (Autonomous), Kolkata
3. Faculty, Department of Microbiology, St. Xavier's College (Autonomous), Kolkata
# Contributed equally
*Corresponding author : Address of corresponding author- 30 Park Street, Kolkata-700016, West Bengal

J.Environ.Science & Engg. Vol. 3, P. 1270-1277, July, 2021

Effects of hazardous Sewage and Industrial Effluents on Soil health and agriculture land of Bawal Industrial area (Haryana)

PUSHPA YADAV[1]*, SOMA SHARMA[2]

Abstract :

Escalation in industrialization has led to an exponential rise in soil pollution. Glass, paper and pulp, colour, cement, polymers and automobile industries are producing huge quantities of hazardous sludge, which affects the physico-chemical properties of soil. Here, the effects of the industrial effluents disposal on the characteristics of soil collected from sludge (Site 1) and few meters away from the sludge (site 2) are studied. Available N and K is found to be low but phosphorus (25 to 41 mg/kg) and organic matter (0.12 to 1.315 %) is reported higher in site1. A significant decrease in pH with depth is observed in soil of both the sites. High pH of the site 2 samples can be correlated with lower concentration of iron and organic matter in it. Effluent rich soil pH has showed negative correlation with N, K, Fe, electrical conductivity, P and organic matter. Soil organic matter had reported negative correlation with pH at both the sites. Electric conductivity of site1 is much higher (13.54-20.7 ms/cm) than that of second site, which confirms the large concentration of ions in that soil. As per the guidelines of World Health Organisation, heavy metals are found within the permissible limits except Cd.

Introduction

Soil is the foundation of every ecosystem and can determines the habitat, richness and diversity of an ecosystem. Physical parameters of soil directly affects the yield of crops.[1] Soil properties vary spatially from region to region and affected by its primary composition, soil formation factors and used soil management techniques.[2] Soil analysis has a profound role in improvement of crop production and nutrient management. Interpretation of soil parameters helps to get a real picture of soil and clear the vision of farmers about the deficiencies of micronutrients in it, so that they can treat it according to its suitability and requirements for agronomic and horticulture crop production. Soil test recommendation is required before sowing and addition of fertilizers can be done as per the information of available nutrients present in the soil.[3] Soil analysis also plays crucial role in identifying the level of contamination and types of pollutants present in the soil which is significant in crop production.

Soil of some regions contains high level of toxins from natural sources like weathering of minerals but anthropogenic activities has a major role in soil contamination and out of them industrial effluents play a significant role.[4] Different industries emit various pollutants in the form of gases, liquid or solid wastes, that reaches to soil in many ways. Some industries produce a large amount of corrosive wastes, which can be defined as the liquid with pH higher or equal to 12.5 as per the guidelines issued by Government of India (2016). By-products of chemical reactions, catalysts, solid wastes, spent wash liquids and sludge of waste water management may constitute the corrosive waste.[6] These wastes affects the soil parameters after reaching to the soil due to direct disposal on the nearby land of factories or use of industry effluents in irrigation due to scarcity of water. Various pollutants including heavy metals reach to crops via soil and to our food chain. Soil irrigated with industrial effluents and with water released from solid waste treatment plants was found more polluted than the soil receiving sewage pollutants[7]. Sewage and river water treated soil was found to contain Zinc and Copper as the main pollutant whereas Lead, Cadmium and Zinc were reported in land irrigated with smelter effluents. Seed germination was also found to be affected by the direct use of sugar mill effluents in irrigation in Punjab, Pakistan reported by Yang *et al.*[8] However the use of diluted Sugar mill

[1]KLP College, Rewari, Haryana
[2]RPSDC, Balana, M. Garh, Haryana

J.Environ.Science & Engg. Vol. 3, P. 1278-1296, July, 2021

Plastic Waste Management Techniques Towards Zero Plastic Pollution: Relevant Strategies And Entrepreneurial Way Forward

RADHIKA CHANDHOK, ARPITA GHOSH*

Abstract :

The current study throws light on some remedial actions such as the plastic circular economy, the processes of recycling and plastic-to-fuel conversion that are undertaken to curb plastic pollution. In addition to this, it provides a brief overview of the techniques adopted to date for the removal of microplastics from marine ecosystems. The authors conducted a systematic literature review search, using keywords such as, "Plastic Waste", "Plastic Pollution", "Zero Plastic Pollution", "Recycling of Plastic", "Removal of Microplastic", "Plastic Circular Economy" and "Plastic to Fuel" in databases like Scopus between 2017 and 2022. In addition to a keyword-based literature search, hashtags and sentiment analysis from Twitter were also performed on plastic waste. The predominant emotions exhibited in response to the hashtags are related to positive emotions (with 27% of the tweets associated with positivity), followed by trust, anticipation and joy. The negative emotion comes in fifth place with 10% of the tweets associated with it. This is followed by surprise, fear, anger, sadness and disgust. Further, the study provides strategies for curbing plastic pollution. The present study ought to offer insights into entrepreneurial opportunities for treating plastic waste.

Keywords : *Plastic Waste; Microplastic Removal; Waste Management Techniques; Plastic Circular Economy; Plastic Recycling; Waste Management Behavior; Zero plastic pollution, Twitter sentiment*

Highlights:

- Explored plastic circular economy as a remedial solution to plastic pollution.
- Discussed the processes of recycling and plastic-to-fuel conversion to accomplish zero plastic pollution.
- Demonstrated the strategies and entrepreneurial opportunities for treating plastic waste.

Introduction

Leo Baekeland, in 1907, marked the beginning of a new 'Plastic Age', by coining the term 'Plastic' and defining the same as, synthetic (human-made) material created from polymers, which are long carbon atom chains with sulfur, hydrogen, nitrogen and oxygen filling in the gaps[1]. Plastics are categorized as macro, micro or nano, based on their size. The largest of the three types of plastic is macro-plastic[2]. It is anything that can be seen clearly. Plastic bags, water bottles and fishing nets are examples of macro-plastics. These are often the simplest to spot and collect. Micro-plastic is the next level of plastic categorization[2]. They usually have a diameter of one to five millimeters and are further divided into primary and secondary microplastics[2]. Microbeads in cosmetics and plastic pellets are examples of primary microplastics while secondary microplastics arise due to the breakdown of macro-plastics. The breakdown of micro-plastics produces nano-plastics[2]. They can be less than 0.1 micrometers in length. Nano-plastics are still mostly unknown, yet they are thought to pose a substantial hazard to the environment and humanity [2]. Owing to the versatile, durable, lightweight, moldable, long-lasting and relatively inexpensive nature of plastics, they serve us in many ways, as packaging material, disposable goods, food wrappers and containers, lighter automobiles to save fuel and pollution and in the form of life-saving equipment such as helmets and incubators[3]. Besides the advantages that plastics

Indian Institute of Management Sirmaur, Sirmaur, Paonta Sahib, Himachal Pradesh-173025, India
*Corresponding author: arpita.ghosh@iimsirmaur.ac.in; arpi.335@gmail.com