Environment Health and Society

Environment Health and Society

Barun Kumar Mishra
(Editor in Chief)
Chander Shekhar Singh
(Co Editor)
Varsha Gupta
(Co Editor)

ACADEMIC PUBLICATION
Delhi-110090

Published by

Academic Publication
B-578,Street No-8,
Near Shanti Palace,1st Pusta,
Sonia Vihar, Delhi- 110090
Tel.: 9811966475,9811966603
E-mali : academicpublicationsdelhi@gmail.com
E-mali : academic2014@gmail.com
www : academicpublication.in

Ghaziabad office
C-21 Nishant Colony Pavi Loni
Sadak Pur Ghaziabad-201002

First Edition Published, 2021

ISBN : 978-93-83931-24-8

Laser Typesetting by : Tamalika Computers

Printed at : Nagri Printers, Delhi

PUBLISHED IN INDIA

Published by Academic Publication, Delhi-110090

PRINCIPAL'S DESK

The motto of our college is "tejaswinavdhitamastu". The larger essence of any learning system is to spread the ray of knowledge and wisdom to eradicate all darkness among the individuals. We impart knowledge to the students and along with it attempt to inculcate among them - wisdom, compassion and a humanitarian spirit to reach out to the social world. Hence we by engaging our students to be what and how ought to be a citizen of a civil society strive our best to follow the message taught to us by our great literature and our lived experience of the environment and ecology. The importance of Discipline, values and integrity are the very foundation of this College. Besides rigorous scholastic programmes, we seek to develop and nurture the different facets of a Student. For attaining this goal, the college encourage the students to be self aware about various environmental problems that are exponentially increasing in the world. Extensive deforestation is among one of the many reasons that has been converting green Delhi into a concrete jungle. We aim to find our strengths in order to reach the true potential to nurture oneself by nurturing and taking care of one's own environment.

Environmental Studies is an interdisciplinary academic field which systematically studies human interaction with the environment in the interests

of solving complex problems of our ecology. It is a broad field of study that includes the natural environment, built environment, and the sets of relationships between them. The field encompasses study in basic principles of ecology and environmental science, as well as associated subjects such as ethics, policy, politics, law, economics, philosophy, environmental sociology and environmental justice, planning, pollution control and natural resource management. The environment studies enlighten us about the importance of environment and protection and conservation of the same vis-a-vis our indiscriminate release of pollution into the environment. At present a great number of environmental issues have grown in size and complexity day by day, threatening the survival of mankind on earth. We study about these issues besides and effective suggestions in the Environment Studies.

Environmental Science's Conferences provides unique platform for eminent Professionals, Scientists, Researchers, Academicians, and Entrepreneurs across the globe to participate and share their research advancements and new technologies. It provides an integrated, quantitative and interdisciplinary approach to study the environmental systems and find solutions to resolve the problems associated with it for sustainability. To explore the issues, innovations and integrated approaches towards environmental sustainability, Rajdhani College initiated the Environmental Science Conference in the 2019 handling issues such as Climate Change, Biodiversity loss, Health and Environment, Social Perspectives of Environment etc. the aim of this conference was to enlighten the scholars and students of diverse discipline about the problematic agendas of our own environment that we overlook. The issues of gravity relating to our environment and ecology are discussed and addressed here comprehensively to sensitise ourselves regarding them.

WELCOME MESSAGE

It was a great pleasure to welcome scientists, academicians, delegates and students to the "National Conference on Emerging Challenges of Environmental Health, Society and Policies" on February 15th - 16th, 2019. The topics of this conference viz. Environmental Health, Social Issues pertaining to Environment, and Environmental Policies, are indeed diverse; covering almost every aspect related to environmental problems and related solutions. The conference is all set to declare every human being that freedom from environmental problems is ensured only by managing them articulately.

The permanent subject of life is "Development". But in the fast pace of life, Human Beings regarded "development" as speed-increasing, scope-expanding and per-capita GNP-raising. While enjoying the gains, this "development" offers, people have forgotten that the environment is being damaged. The rapid urban developments have created multiple risk scenarios and imbalances in the environment, because of which the civilization is most vulnerable to varied natural and health catastrophic disasters. All these concerns require continuous scrutiny and analysis. Sustainable development is the need of the hour to establish a new idea of development and realize its revolution, which stays in the environment and all resources. In order to

reduce poverty, there has to be continuous pursue of economic growth, but growth cannot continue without the awareness of the environment. This contemporary world is facing unprecedented ecological crisis that can only be resolved by adopting scientific innovations and practices, which are environmental friendly and which will be able to provide social and economic benefits at large.

Thethematic impetus of this conference seeks to provide a transformative approach to environment and development that will ensure social, economic and environmental benefits to the society. A balance between economic growth and care of the environment is needed to prevent environmental degradation, which outcomes as less economic productivity and imperil health.Therefore, promoting and reinforcing the use of renewable resources, replacing conventional fuels by other renewable energies, etc. will contribute to the preservation of ecosystem. I am sure that the outcome of the conference will bring viable information to the academicians and scientific communities and will provide the best exposure to the students, researchers and teaching faculties of the college.

The two-day conference is lined up with 5 plenary lectures, more than 35 oral & poster presentations. I hope that the participants of the conference found it interesting and beneficial through interactions and exchange of knowledge with eminent speakers and researchers.

I, along with the organizing committee and editors, would like to thank all the authors for their contribution of excellent papers, and sponsors for their sturdy support. My heartfelt thanks to the Advisory Committee and many student volunteers whose munificent support have the made the conference possible.

Dr. Pankaj Garg

Convenor,

National Conference on Emerging Challenges of Environmental Health, Society and Policies - 2019

MESSAGE

A better understanding of environmental issues relevant to social equity and ecological security forms the basis of prioritizing interdisciplinary research and developing scientifically sound policies. Examining economic and social aspects of environmental challenges help in providing sustainable solutions acceptable to the society as well as the industry. In this context, the present book entitled "**Environment Health and Society**"will not only serve as a valuable compendium based on the proceeding of a national seminar held at the Rajdhani College, University of Delhi but will also act as valuable resource for the young under-graduate students to the scholars of sustainability. In spite of vast literature on the fundamental concepts of ecology and environment, scholars and teachers face challenges to relate those concepts with the emerging environmental issues affecting society and in evolving legal and technological solutions to address those issues. Authors, young scholars to experts, from diverse disciplines like environment and ecology, chemistry and physics, sociology and history, philosophy, psychology, and sociology, participated and debated different contemporary environmental issues of national and global importance. Close interaction and discourse among scholars and experts from different discipline provide an edge to the present book in developing a holistic view of important issues,

such as biodiversity, pollution, ecosystem, and human health, emerging technologiesfor environmental remediation, climate change and sustainable development, and environmental philosophy and ethics. In total, twentychapters covering more than 247 pages are presented in One sections which includes thematic areas, such as Mechanisms and evidence of linking air pollutants with non-communicable diseases, Environmental fate of chemicals and emerging risks due to change in land use, Case studies on groundwater pollution in urban ecosystems, Emerging technologies for remediating contaminants and managing wastes, Impact of change in climate on biodiversity, Use of models to assess biodiversity and predict impact of pollutants on health, Impact of changing climate on biodiversity and sustainable development, Increasing risks to environmental pollution due to changing lifestyle, and Ancient wisdom, philosophy and environmental ethics. Such an organization of the book citing current and important citations of the primary source makes the book extremely useful for the young students to budding scientists, to experts. An environmental account of toxicity from presumably safe environmental chemicals, emerging technologies to treat the waste, case studies revealing the importance of models in biodiversity and health studies are fascinating readings. The book is not only rich in primary data presented in lucid tables and self-explanatory figures but also with novel ideas in both understandings and solving our complex environmental challenges.

To sum up, the Book will provide a panoramic view of today's linkages among environmental health, biodiversity, and quality of life. The case studies presented in the book are contextualized in the broader debate on global environmental issues. The readers will admire the organizers of the Seminar, editorial and reviewer teams, and the authorswho have endeavored hard to bring inter-disciplinary voices to present a harmonious picture of complex environmental issues in the book.

Based on my experience, in post-graduate teaching and research on ecological restoration and human well-being, of more than 20 years, I am confident that this book will serve as an essentialstudy material for under-graduate and post-graduate students, and a reference book for research scholars and teachers engaged in training on the linkages between environment, and sustainable development. Enjoy deep learning!

09January 2020

Dr Radhey Shyam Sharma

Professor

CONFERENCE PROGRAM

The conference was inaugurated by Sh. Chandi Prasad Bhatt,the eminent environmentalist and he delivered the keynote address. The editors feel indebted to the teachers of the Environment Science Department, Rajdhani College, Ms Sana Rahman, Dr. Tapasya Tomar, for their invaluable support during the organization of the conference and in preparation of this book. Special thanks is extended to Ms Mansi, Department of Chemistry, Dr Jyoti Kasana and Dr Sooraj Department of Commerce, and all other members of the Committee on the Environment.

This book contains a compilation of selected papers presented at the National Conference on Emerging Challenges of Environmental Health, Society and Policies organized by the committee on Environment and Related Issues [ERI], Rajdhani College in collaboration with the Department of Environmental Studies, University of Delhi held on 15-16 Feb, 2019 at Rajdhani College. After organizing the conference, the college presents this edited volume of Proceedings to our readership containing Fourteen Peer reviewed articles/research papers. In this volume, the authors address a variety of Emerging Challenges of Environmental Health, Society and Policies.

Mr. Rahat Zehra and Dr. Madhulika Singh mentioned the capability of remote sensing and geographic information system to study the impact of land use activities in the basin of river Yamuna. Their study gives an overview of the possible reasons of pollution in brisk manner which helps initiate the replenishment work of the water quality.

Ms. Ritu Payal and Ms. Arti Jain examined the production of Activated Carbon from corn cob (an Industrial waste) and its utilization in the treatment of laboratory waste water using batch process for the remediation of Eriochrome Black T (EBT).

Atul Goswami and Vandana Mishra identified a relationship between the increasing levels of air pollution and the increasing incidences of diabetes mellitus type 2.

Shafali Garg et al emphasized the research on environmental routes of the drug & chemistry of degradation products and its interactions with different environmental phases.

Geetanjali Sageena observed that Drosophila mealanogaster might offer a significant contribution in the field of medicine. She states that Drosophila responds specifically to pathogens, discriminating between classes of surface molecules on different intruders.

The work of Arti Jain and Priti Malhotra emphasized on the environment friendly methodology for the treatment of waste water. According to their approach, the application of rice husk for waste treatment can evolve as economically sustainable and environmentally friendly approach to remove toxic metals from water and soil.

Kavita Singh reviewed the impact of climate change in terms of atmospheric carbon dioxide concentration (parts per million by volume) from 2000 to 2018 by taking under consideration the major taxonomic groups-Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi & Protists and plants.

Shipra Tyagi and Kiranmay Sarma monitoredtThe toxic metals such as Cd, Cr, Ni,and Pb and results obtained show that majority of the samples were found exceeding as per the suggested limits of the drinking water. The dominance of the toxic metals is observed in the order of Ni > Cr > Pb > Cd.

Pankaj Poria, Harveen Kaur, Deepak Rawat and Vandana Mishra provided evidences on laboratory-based cell lines and animal models confirmed dyes and dye metabolites as genotoxic, carcinogenic and teratogenic.

P.C. Thapliyal, Vibhrant and A. Dixit discussed the various uses of nanotechnology as well as the health and environmental effects of exposure to nano-particles.

Paromita Mukherjee, Radhey Shyam Sharma and Vandana Mishra hypothesized that crystal violet dye might undergo phase-transfer in environment, therefore, escape from degradation and mineralization during traditional wastewater treatment.

Dr. Divya Sharma pointed out that the demands for a safe pollution free and healthy environment, shall come within the scope of human rights. The human rights would be strengthened by the amalgamation of environmental concerns providing victims of environmental dilapidation the opportunity of access to free and fast justice and enabling the expansion of the scope of human rights protection and generation of concrete solutions for cases of environment degradation.

According to Saiyami Bhardwaj, Pankaj Kumar, Vandana Mishra, Air pollution consisting of PM is a complex mixture of neurotoxic metals and compounds which induce inflammatory responses; amyloid beta accumulation, oxidative stress, and microglia-mediated inflammation, thereby, causing neurotoxicity. Neurodegenerative disorders are, therefore, a result of collaborative interaction of various physiological and metabolic mechanisms wherein the children and people of the least developed countries are at a higher risk.

According to Sana Rehman, Nawin Kumar Tiwary, Abdul Jamil Urfi, birds are important indicator of the habitat quality. The poor water, vegetation condition, landscape characteristic, human presence can affect the birds adversely. It is therefore, important to know the water quality status for the health of the birds.

Contents

1

'पर्यावरण हमारे समाज की सामूहिक जिम्मेदारी है।' राजधानी कालेज में पर्यावरण पर आयोजित राष्ट्रीय संगोष्ठी मे श्री चन्दी प्रसाद भट्ट जी का बीज व्याख्यान। संकलन एवं सम्पादन – बरुण कुमार मिश्रा

श्री चन्दी प्रसाद भट्ट

इसमें विद्यार्थियों कों सम्मिलित कर उनकी सेवा व शिक्षा को एकीकृत करके यमुना नदी के पर्यावरण को सुधारने का प्रयास करना चाहिए। भले ही इसका लाभ विद्याथियों को परिक्षा में क्रेडिट के तौर पर पारितोषिक दिया जाए। इसमें उनका मनोबल उचच और दृढ़ होगा। मैंने जैसा निवेदन किया आज यह संकट दिनो दिन गहरातार जा रहा हैं, और यह पर्यावरण संकट जिस रूप में विकसित होता जा रहा हैं उसका हमें ध्यान नहीं हैं। मेरा आप सभी युवाओं से निवेदन हैं कि यदि आप अभी से जागेंगे नहीं तो आप सबका भविष्य संकट में हैं। मेंरा आशय आपको डराना नहीं हैं बल्कि सच्चाई बताना हैं। अगर हम आज से ही सक्रिय हो जायें तो जो संकट आने वाला है उससे शायद बच जायें। मैं फिर से आपके महाविद्यालय के प्राचार्य डॉ. राजेश गिरि जी का ह्रदय से आभारी हूँ और आप सब विद्वत जनों से इस अवसर पर बात करने का मुझे जो मौका उसके लिए सबकका ह्रदय से आभार।

जैसे आपने यहाँ सी एन जी चलाई उसी प्रकार हिमालय मैं भी एसी परिवहन और ऊर्जा के स्रोत के उसका असर निम्नतम हो। हमें मुख्यतया यह सोचना है कि जो

बारिश की मारक क्षमता हैं, इसके बारे में केदारनाथ की त्रासदी के बाद गाँव की बहनों ने कहा, जाड़ो की बारिश तो बर्फ के ऊपर जम जाती हैं गर्मी में वहीं पानी तापमान के बढ़ने की वजह से गर्म होकर नीचे तेजी से उतरता हैं, और इस समस्या के मूल में वहाँ के पर्यावरण में तापमान वृद्धि एक सबसे बड़ी वजह हैं। आज हिमालय के हिमनदियों और ग्लेशीयर लेकस की हालत ज्यादा अच्छी नहीं हैं। हमें चाहे सड़क बनानी हो या कुछ और भी विकास का काम करना हो तो कोई त्रासदी होने के पहले ही वैज्ञानिकों से सलाह ले लेनी चाहिए। वैसे भी प्रदूषण से सम्बन्धित कई कानून बने पर उनका ठीक से अनुपालन नहीं हो पा रहा हैं।

मेरा आहवाहन है कि वृक्षों और वनस्पतियों को बनाने के कार्य में आप लोग सहयोग करें। मेरा निवेदन है प्राचार्य जी से और प्रोफेसर सिंह से कि यमुना को कुछ–कुछ दूरी तक एडाप्ट करें और एन. एस. एस. के कार्यक्रम की तर्ज पर सेवा कर वहाँ सफाई और जैव विविधता को समृद्ध बनायें।

उनका भी काफी योगदान है और उसका लाभ स्थानिय लोगों को भी मिलता रहता है। महिलाओं ने भी गाँव–गाँव में संगठन बनाकर पर्यावरण संवर्धन का काम अपने हाथ में लिया। उसके परिणाम भी काफी उत्तम निकले। आज हरियाली लाने की विशेष आवश्यकता हैं, और हरियाली का तात्पर्य केवल बड़े पेड़ ही नहीं हैं। बल्कि छोटी वनस्पतियाँ जो कि वर्षा के प्रभाव से उपजती और पनपती हैं वो भी हरियाली का हिस्सा हैं।

जैसा कि आपने सुना होगा 2015–16 में जून के महिने में उत्तराखण्ड में अति वृष्टि हुई और 18 हजार से अधिक सैलानी फस गए और सकड़ों लोग बहकर था भूस्खलन की वजह से जान गवाँ बैठे। अब सवाल यह उठता है कि ऐसी बारिश क्यों हूई ? वैसे तो इसकी वजह वैश्विक तापमान बताया जा रहा हैं पर उसके बावजूद वहाँ की परिस्थिकि पर यात्रियों के आवागमन से होने वाले दबाव को भी हमें ध्यान में रखना होगा। कभी पुरे साल में बद्रीनाथ पहुँचने वाले यात्रियों की संख्या 10,000 होती थी आज एक दिन में वहाँ इतने लोग पहुँचते हैं। ऐसे बदलते पारिदृष्य का दुष्प्रभाव हमें एक बिगड़ती पारिस्थिति के रूप में मिलता हैं जबकि यदि नियोजन अपनाया जाये तो हम ऐसी आपदा कारी परिस्थिति से बच सकते हैं।

जैसा कि प्रोफेसर अमरजीत सिंह जी ने श्रषिकेश से चम्बा के बीच के पर्यावरण के बारे में अपनी चिन्ता व्यक्त की और वह काफी संकट कारी भी हैं। परन्तु ठेकेदारों को इससे कोई मतलब नहीं हैं। हमारा यह मानना है कि जो दोहन करने लायक सम्पदा हैं उसका दोहन अवश्य हो पर उसका दुष्प्रभाव हमारे लोगों पर जो वहाँ रह रहें हैं उन पर न पड़े। इस प्रकार से ऐसे जो दबाव हैं हमारे पर्यावरण पर इनको कैसे कम किया जाय? यह तो तभी सम्भव हैं जब नीचे से आवाज उठेगी। आज इस विषय

पर बहुत सारा विज्ञान सम्मत शोध चल रहा है पर उस शोध का लाभ वहाँ के भुक्त–भोगी लोगों तक पहुँचाये जाते की आवश्यकता हैं। कई बार ऐसे शोध डी. एस. टी. की आलमारी में बन्द हो जाते हैं, जबकि ये चीजें जन सामान्य तक पहुँच कर उन्हें लाभ दें।

हमारे इस आन्दोलन में पेड़ को बचाने के लिए गढ़वाल और कुमाऊँ विश्वविद्यालय के युवाओं की विशेष भूमिका रही। उन्होंने पुरे उत्तराखण्ड़ में जन जागरण किया, दूसरा हरियाली लाने के काम में उनका अभूतपूर्व योगदान रहा और यह ईको–डेवलपमेण्ट के नाम से प्रसिद्ध हैं। चिपकी के साथ–साथ शुरू वन और पर्यावरण संवधर्न शिविर आज भी चल रहे हैं। आपके विश्वविद्यालय के विभिन्न कालेजों के छात्र भी उन शिविरों में कई बार आते हैं।

यदि आप इस पर जरा भी लापरवाही दिखाएंगे तो वो आप हो की निगल लेगी। हम इस बात पर भी जोर देते हैं कि परिवेश और परिस्थिति पर हर विश्वविद्यालय में कार्यक्रम होते रहने चाहिए। अगर दिल्ली का उदाहरण ले तो यहाँ 80 से अधिक कालेज हैं और अगर लोग रूचि ले तो यहाँ की यमुना नदी के बारे में ठोस विज्ञान सम्मत जानकारी उपलब्ध हो सकती हैं। यमुना के किनारे जो रहने वाले लोग हैं उन तक भी पहुँचा जाये।

पर्यावरण के केन्द्र में हैं हिमालय हिमालय के बारे में सदियों से लिया जा रहा हैं। गीता में लिखा गया हैं कि हिमालय रीढ की हड्डी हैं, आज आप देख रहे हैं मानसून हैं, मौसम का नियन्त्रक हैं। हिमालय निरन्तर बढ़ रहा है और अगर हम उसमें थोड़ी भी छेड़–छाड़ करते हैं तो भूस्खलन आदि जैसी समस्या आरम्भ हो जाती हैं। उसका प्रभाव हमारी नदियों पर पड़ता हैं। आज हम एक तरफ हम उसकी पारिस्थिकिय पर दबाव डाल रहे हैं और उस दबाव का दुष्परिणाम पुरा देश भूगत रहा हैं। हिमालय पर विकास प्रभाव हैं, बजार का प्रभाव हैं, हिमालय पर विकास का प्रभाव हैं, बाजार का प्रभाव हैं। बाजार का प्रभाव हैं, वहाँ की जँगलो, पर का वहाँ की जड़ी–बुटियों पर खनिज सम्पदा पर बाजार की दृष्टि हैं। बाजार को ये मतलब नहीं हैं कि उसका क्या दुष्प्रभाव हिमालय पर और वहाँ रह रहे लोगों पर पडेगा।

जैसा कि आपने कोशी के बारे में सुना हैं 2008 में इसने 35 किलोमिटर अपना मार्ग बदला। हिमालय में कहीं भी यदि कोई गडबडी हेाती हैं तो हमारी जो तीन नदियाँ हैं गंगा, ब्रहमपुत्र और सिन्धु उन तीनों नदियों पर दुष्प्रभाव पड़ेगा। जबकि इन तीन नदियों का सम्बन्ध पुरे देश के साथ हैं, देश की 41ः आबादी इन नदियों के बेसीन में बसती हैं जिसका क्षेत्रफल 43ः से भी अधिक हैं। इन तीनों नदियों का जो वाटर बजट हैं वो 63ः हैं। आज यह समझने की आवश्यकता है कि इन तीनों नदियों पर यदि ज्यादा दुष्प्रभाव पड़ता हैं तो वह देश की अर्थव्यवस्था, व पर्यावरण को सीधे प्रभावित करेगा।

अभी हमारे बीच विद्वत जल, शिक्षक और शोधकर्ता भी मौजूद हैं तथा सबसे अच्छी बात है कि जो युवा हमारे समक्ष बैठे हैं वे कल को प्रशासन का अधिकार ग्रहण करेंगे।

2

Removal of heavy metal toxin Chromium from water effluent using silica nanoparticles obtained from rice husk : An agricultural waste

Arti Jain* and Priti Malhotra
Daulat Ram College, Department of Chemistry, University of Delhi, North Campus, New Delhi 110007, India
Email id: jainarti21@gmail.com

Abstract: Heavy metals like chromium (VI) present in water effluents from various industries have recently posed a serious threat to the environment and human health. Rapid industrialization especially in tanneries, metal plating facilities, batteries, paper and textile industries majorly release chromium in large amounts and need urgent attention as it is a potential toxin for humans and aquatic life. Silica nanoparticles (Nps) were prepared from agricultural waste rice husk following a green route of synthesis and chromium was adsorbed on the surface of SiO_2 Nps. Absorption of Cr (VI) on the surface of SiO_2 Nps by a batch absorption procedure was found to be pH dependent and altered the nanoparticle surface chemically. The pH

dependent absorption isotherm exhibited nonlinear Langmuir absorption model. It was observed that silica nanoparticles were a promising adsorbent for the removal of chromium from waste water

Keywords: Rice husk, Nano silica, Toxic metals, Adsorption, Green process

Introduction: One of the consequences of industrial food production activities is the generation of high volumes of waste, whose disposal can be problematic, since it occupies large spaces, and when poorly managed can pose environmental and health risks for the population. The rice industry is an important activity and generates large quantities of waste. The main solid wastes generated in the rice production cycle include straw, husk, ash, bran and broken rice. As an important staple food, rice is one of the majority grown agricultural products of the world. Therefore rice husk becomes the most widely available agricultural waste. An insight into its composition and morphology, clearly indicate towards its various applications. Rice husk consist of 75-90% organic matter such as cellulose, lignin etc [1] and the remaining components are silica, alkalis and other trace elements. High amount of silica is present in biomass of ash from rice husk and so its applications have a fairly wide range. Both industrial and domestic application of rice husk (RH) and rice husk ash (RHA) are attributed to their potential adsorption capacities and surface morphology leading to catalysis applications [2-3].

Rice plants cumulate silica through polymerization of the water soluble silicic acid (H_4SiO_4) absorbed from soil into insoluble polysilicic acids, followed by precipitation as amorphous silica and deposition in exterior plant cell walls. In this process, rice acts as a bio-refinery factory for high quality amorphous silica[4-5]. World's annual rice residue output is estimated to be around 600 million tons. From the reported 10–20% hydrated silica by mass of the dry rice residue, straw and husk represent 60–120 million tons annual potential. Deriving silica from rice husk has been extensively reported in the last two decades. With more than two thirds of the rice residues being rice straw, silica derived from rice straw has twice of the potential of rice husk. The objective of present work was to develop an efficient route to extract amorphous silica from rice straw in high purity and then conversion into nanosilica for further applications [6-7].

Chromium is a toxic heavy metal being released in the environment by applications like tanning, wood preservation and pigments, dyes for plastic,

paints, and textiles. Chromium occurs in a number of oxidation states, but chromium (VI) and chromium (III) are of main environmental concern [8-10]. Extensive work has been reported for the removal of chromium employing waste agricultural materials.

By using the rice husk, remediation of waste water can be done by removing toxic heavy metals from it. The application of rice husk for waste treatment can evolve as economically sustainable and environmentally friendly approach to remove toxic metals from water and soil. One waste becoming scavenger for another waste material can be well emphasized by this paper.

Experimental Work

Methodology Techniques/Sampling /Tools/Materials:

a) Washing and acid treatment

RH was washed thoroughly with water to remove the soluble particles, dust, and other contaminants present, whereby the heavy impurities such as sand are also removed. It was then dried in an air oven at about 110°C for 24 h. The dried RH was ultrasonicated with an acidic solution (HCl, HNO_3, and CH_3COOH in different concentrations) for nearly 30 min by stirring frequently. It was cooled and kept intact for about 20 h. It was then decanted and thoroughly washed with warm distilled water until the rinse became free from acid, and this was designated as RH'. The wet RH' was subsequently dried in an oven at 110°C for 24 h.

b) Thermal treatment

A weighed RH' as well as RH were subjected to heat treatment to obtain the ash. Samples were burned inside a programmable furnace (Metrex programmable furnace), and different methods were applied. Different temperatures (500°C, 700°C, and 1,000°C) and rates (2°C/min, 5°C/min, and 10°C/min) were checked. We designated these as ashes (RHAs).

c) Extraction of silica

A sample of 20.0 g RHA was stirred in a 160-mL, 2.5-M sodium hydroxide solution. The solution was heated in a covered beaker for 3 h by stirring constantly and filtered; the residue was then washed with 40 mL of boiling

distilled water. The obtained viscous, transparent, and colorless solution was allowed to cool down to room temperature, and 10 M H_2SO_4 was then added under constant stirring at controlled conditions until it reached pH 2; NH_4OH was added up to pH 8.5 and was allowed to stand at room temperature for 3 h.

d) Preparation of nanosilica

Nanosilica was prepared by reflux technique of the above extracted silica with 6.0 M HCl for 4 h and then washed repeatedly using distilled water to make it acid free. It was then dissolved in 2.5 M sodium hydroxide by stirring. H_2SO_4 was added until it reached pH 8. The precipitate silica was washed repeatedly with warm, distilled water to make it alkali free and then dried at 50°C for 48 h in the oven.

Results and Discussion

Nanosilica was obtained from sodium silicate solution using precipitation method. The reaction is as follows:

$$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$$

The silica particles were generated from the solution by adding sulfuric acid as catalyst. The acidic condition of pH 2 indicates approximately the complete precipitation

of silica from sodium silicate by the following reaction:

$$Na_2SiO_3 + H_2SO_4 \rightarrow SiO_2 + Na_2SO_4 + H_2O$$

At a low silicate concentration and with the pH less than 8, $Si(OH)_4$ is the dominant species in its aqueous solution. At higher concentrations, the silanols, the Si(OH) groups,

spontaneously polymerize to yield higher oligomers linked by a disiloxy bond. Such a reaction is most favorable when one of the silanols is deprotonated to a Si-O- group.These oligomers grow into colloid-sized silica particles in which larger particles grow at the expense of smaller ones. At a higher pH (greater than 8), however, the much more concentrated silicate solution is stable. This is because disiloxy bonds undergo nucleophilic attacks by OH- via a five coordinated intermediate.

Fig 1a: Rice husk ash **Fig 1b:** Nanosilica

The FTIR spectra of almost all RHA samples gave typical bands of O-Si-O stretching (at 1,096 and 798 cm -1) and bending vibrations (at 466 cm^{-1}). The bands at 3,437 and 1,633 cm^{-1} corresponded to the O-H stretching and bending vibrations (Figure 2). Figure 3 shows the results of the FTIR analyses of extracted silica and nanosilica. The peaks at 1,101 and 804 cm^{-1} are due to the Si-O-Si asymmetric and symmetric stretching modes, respectively. The band centered at 469 cm^{-1} is due to the bending frequency of Si-O-Si. A large broad band around 3,429 cm^{-1} is attributed to the presence of the O-H stretching frequency for the silanol group and the remaining adsorbed water. A band around 1,630 cm^{-1} is assigned to the bending vibration of water molecules bound to the silica matrix. No peak was found between 2,800 and 3,000 cm^{-1}. It means that there were no original organic compounds in the silica after controlled combustion and extraction. The FTIR spectra showed no significant changes in the peak position for extracted silica and nanosilica. Silica with a high surface area is a good compound to be used as adsorbent or support for catalysts. Also, the reactivity of silica is directly related to its surface area.

Removal of heavy metal ions (Cr(VI)) from waste water:

Batch sorption studies: Accurately weighed mass of nanosilica (1g) is separately placed in 20 ml RB flask. 10 millilitres of the adsorbate solution (tannery wastewater) was added to flask. The flask was ultrasonicated in ultrasonicator at room temperature. sample was filtered prior to analysis in

order to minimize interference of the silica fines with the analysis. All the experiments other than effect of pH were conducted in the pH range of 6.6–6.8. The supernatant sample was analyzed for its using atomic absorption spectrophotometer (Motras).

Effect of concentration of adsorbent:

The effect of concentration of adsorbent on adsorption, while keeping the adsorbate concentration and contact time constant was studied and found that with increase in concentration of adsorbent, adsorption also increases although increase is not linear. Results are shown in figure 2a and Fig 2b

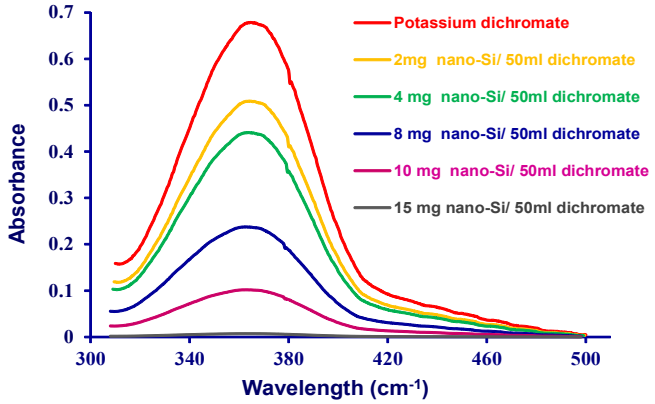


Fig 2a: Absorbance values at different time

Fig 2b: Adsorbance of Cr(VI) on nanosilica in different time

g) Comparision between various adsorbents:

Purification of waste water using batch process with different adsorbents: In order to show the excellence of this protocol, commercial activated carbon, ordinary silica, and nanosilica, respectively were taken in 100 cc beaker

and then 20 mL stock solution of heavy metal was taken in it. Metal ions bound with the different adsorbents; as a result, pure water was obtained. From the data (Fig. 3), it was found that the absorbance of all the contaminated solutions was decreased upon addition of adsorption materials. This implies that the concentration of the impurities in the solution was reduced upon biosorption as heavy metals got trapped on their surfaces. Best result is found with nanosilica.

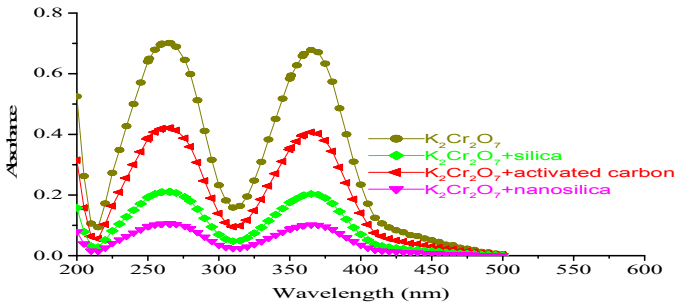


Fig 3: Absorbance of potassium dichromate solution before and after sorption on different adsorbents

Conclusion: This environmental friendly methodology promises several attracting features for the treatment of waste water. The application of rice husk for waste treatment can evolve as economically sustainable and environmentally friendly approach to remove toxic metals from water and soil. Waste to wealth becoming can be well emphasized by this paper.

Acknowledgment: The authors (A. Jain and P. Malhotra) are thankful to University of Delhi, New Delhi for their financial assistance.

References:

Siqueira, EJ, Yoshida, IVP, Pardini, LC, Schiavon, MA Ceram. Int. 35, 213 (2009)

Sun, L, Gong, K: Ind. Eng. Chem. Res. 40, 5861 (2001)

Ghosh, TB, Nandi, KC, Acharya, HN, Mukherjee, D Mater. Lett. 12, 175 (1991)

Conradt, R, Pimkhaokham, P, Leela-Adisorn, U: J. Non-Cryst. Solids 145, 75 (1992)

Real, C, Alcala, MD, Criado, JM:. J. Am. Ceram. Soc. 79, 2012 (1996)

Rafiee, E, Shahebrahimi, SM, Shaterzadeh,M, Int. Nano Lett. 29, 2, (2012)

Zhou J, et al. Effective removal of hexavalent chromium from aqueous solutions by adsorption on mesoporous carbon microspheres. J. Colloid Interf. Sci. 2016;462:200

Siqueira, EJ, Yoshida, IVP, Pardini, LC, Schiavon, MA Ceram. Int. 35, 213 (2009)
Sun, L, Gong, K: Ind. Eng. Chem. Res. 40, 5861 (2001)
Ghosh, TB, Nandi, KC, Acharya, HN, Mukherjee, D Mater. Lett. 12, 175 (1991)

2

Particulate matter as a new causal factor for increasing incidences of diabetes in rapidly urbanizing countries

Atul Goswami and Vandana Mishra*
(*corresponding author)
Department of Environmental Studies
(Bioresources and Environmental Biotechnology Laboratory)
University of Delhi, Delhi-110007

Abstract

Though diabetes mellitus (DM) represents a genetic disorder, changing lifestyle governs the prevalence of diabetes in global population. However, as per the International Diabetes Federation, besides lifestyle and genetic factors, air pollutants have emerged as new causal factors for increasing incidences of diabetes, which will result in 566 million incidences of diabetes by the year 2030. Recent studies have shown a strong link between long-term exposure to air pollution and the development of diabetes mellitus. As per one of the estimates, in 2018 3.2 million people developed diabetes exclusively due to exposure to even low levels of air pollution in countries undergoing rapid urbanizations and modernization. Particulate matters (PMs)

enter the bloodstream during breathing and alter the body function, such as insulin sensitivity and production. However, the underlying metabolic pathway(s) linking the pollution exposure and onset of diabetes are still unknown. We evaluated the studies on air pollutants and incidences of diabetes and hypothesized the putative mechanism. We propose to undertake cohort studies involving pollution-exposed subject and assessing the risk for onset of diabetes.

Keywords: Air pollution, Particulate matter, Urban Areas, Developing Countries, Diabetes.

Email IDs of Authors:

Vandana Mishra: mistletoe_h@hotmail.com (corres-ponding)

Atul Goswami: lucky92giri@gmail.com

Introduction:

Diabetes mellitus or diabetes represents a group of metabolic disorders and an abnormal condition that results in high level of blood sugarover a prolonged period. In diabetes either pancreas fails to produce enough insulin or cells remain insensitive to the insulin produced by the pancreas (Wu et al., 2014). Based on the metabolic responses, three main types of diabetes mellitus include: (i) Type 1 DM- pancreas fails to produce enough insulin, primarily due to the loss of beta cells but the primary cause for this ailment is unknown, (ii) Type 2 DM - cells fail to respond to the insulin produced by the body properly and the most common reasons for such an ailment include lack of exercise, and increase in body weight imbalanced body-mass index, and (iii) Gestational diabetes - a temporary condition of abnormally high blood sugar levels in pregnant women with a family history of diabetes develop, which goes away with the childbirth. Of these, type 2 DM prevails in 90% cases of DM across the world population, which often shows imbalanced metabolic rate as well. Diabetes mellitus and air pollution have been responsible for increasing number of deaths annually worldwide. As per the air quality database 2016, the urban population is at a greater risk of pollution exposure than in a rural setting because of high levels of automobile exhaust, vehicular emissions and developmental activities.

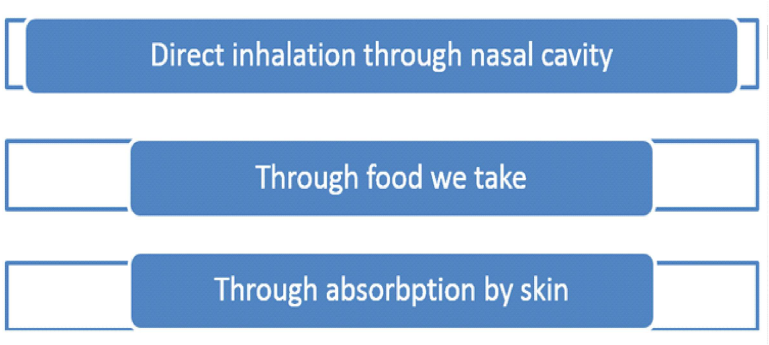
Particulate Matter: The Tiny Devil

Fine particulate matter represents collection of particles such as dust, aerosols, condensing vapors, fly ash, fumes, mist, smoke, and soot that remain suspended in the air for a long period of time. Such particles originate directly from a variety of stationary and mobile sources (primary emissions) or formed in the by transformation of gaseous emissions in the atmosphere (secondary emissions) (Xu et al., 2011). Based on the variations in the diameter, the particulate matter and hair strand can be arranged as $PM_{2.5}$<PM_{10}<hair strand.

How Particulate Matter Enters The Body?

Particulate matter enters the body mainly via nasal channel and eventually in the blood stream through alveolar exchange (Dubowsky et al., 2006). Mainly particulate matter enters the body by inhalation but intake from the food and direction absorption through skin can't be neglected.

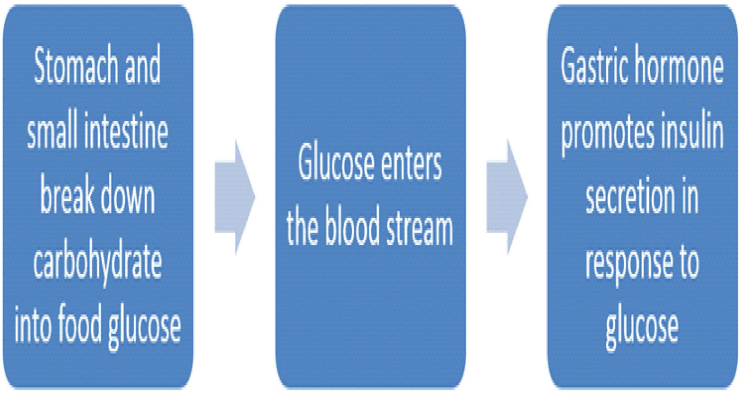
Fig. 1: Entry of particulate matter in the body



Insulin Production and its Action

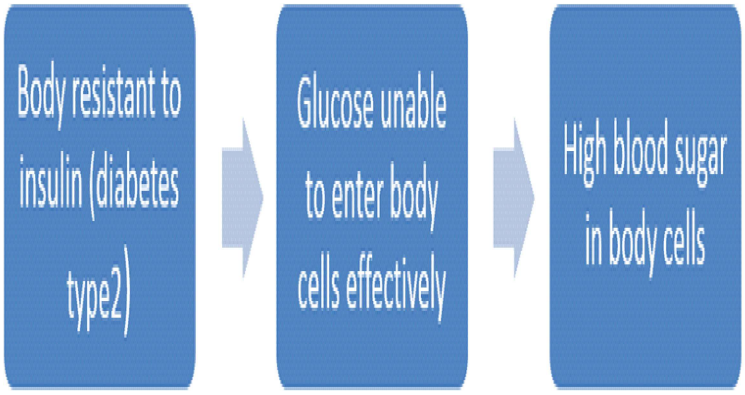
As we are aware that insulin in produced by specialized cells of pancreas called beta cells present at the islets of langerhans. The small intestine and stomach secretions breakdown the carbohydrates present in the food we intake and convert it into glucose, the glucose enters the blood stream and the gastric hormone promotes the insulin secretion in response to the glucose (Dubowsky et al., 2006; Esposito et al., 2016; Haberzettl et al., 2016).

Fig. 2: Insulin action in normal individual



In case of diabetes, the insulin either is not produced by the pancreas properly or the cells of the body are not able to utilize the insulin produced by the pancreas. In either of the case, the glucose level rise sharply in the blood stream and this prolonged rise in the blood sugar level lead to diabetes. As discussed earlier in the more common case of diabetes mellitus type2, the body is resistant to the effects of insulin produced by the pancreas due to which the glucose is not able to enter the body cells effectively which leads to building of glucose in the blood stream (Park, 2017).

Fig. 3: Insulin resistance in diabetes mellitus type2



PM Levels in Urban Areas Worldwide

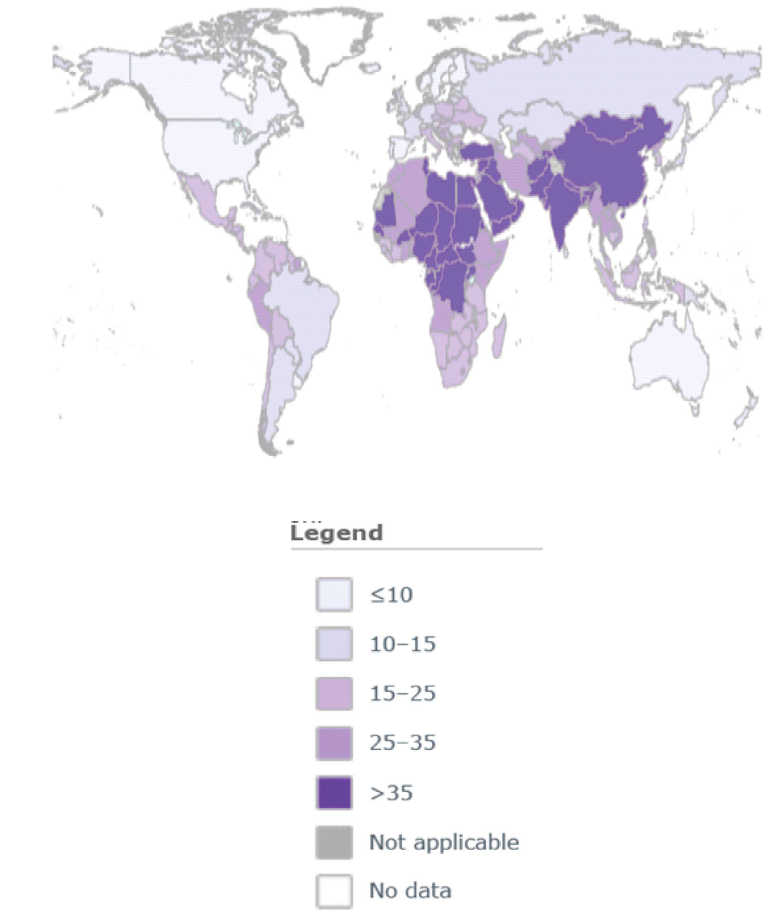
As per WHO 2018 report more than 80% of people living in urban areas where air pollution are being monitored are exposed to air quality levels that exceed the world health organization limits. Although all regions of the world have shown a significant impact but effects have been more severe for the populations of rapidly urbanizing developing nations and low income cities where the rate of development is high. These areas include mainly cities from developing nation with most cities from Asia (India and China in particular). Recent urban air quality database also suggests 98 out of 100 cities in developing and underdeveloped countries with more than 100,000 inhabitants do not meet air quality guidelines of world health organization. On the other hand in developed counties that percentage decreased to 56% (Djankov & Saliola, 2019).

Relation between Rapid Urbanization and Diabetes

Environmental health studies across the countries show a relationship between rapid urbanization and increasing incidence of diabetes in developing nations (Sun et al., 2009). In fact, most cities with very high particulate matter levels lie in the rapidly urbanising and developing nations of the world. For example, India with maximum number of cities in top 50 most polluted cities of the world followed by China. The United Nations report on 'Trends of Urbanization Worldwide' shows clearly that the rate of growth of rapid urbanizing population increase is twofold in Asian and African nations as compared to that of North American and European nation. This growth rate is marginally high in Latin American nations compared to that of European and North American nation. The growth rate was low in Oceania, North American and European nations. WHO report on 'Trends of prevalence of diabetes region wise', derives parallelism between the increasing occurrence of incidences of diabetes in Eastern Mediterranean region, South-East Asian region in the recent decades and the increasing levels of pollution as compared with the remaining developed world. Similarly report on changing status of environmental health in India also showed a significant relationship between increasing incidences of diabetes in polluted cities of urban areas of India, whereas the rural areas still show a significantly low incidences of diabetes (Rajagopalan & Brook, 2012). Both global research on correlation studies and clinical research established significant connection between occurrence of diabetes and increased particulate matter

emission in developing world, though deciphering the exact mechanism needs further scientific research.

Fig. 4: Annual mean levles of fine particulate matter ($PM_{2.5}$) in urban areas (µg/m^3): 2016



Possible Mechanisms of Insulin Resistance due to Particulate Matter

There have been various possible mechanisms established by various clinical analysis around the globe for insulin resistance and occurrence of diabetes, some studies suggest that PM deregulate glucose metabolism in body (Liu et al., 2017), whereas other indicate towards insulin resistance induced by particulate matter inhalation (O'Neill et al., 2007). Various mechanism established by clinical studies considered are discussed as follows-:

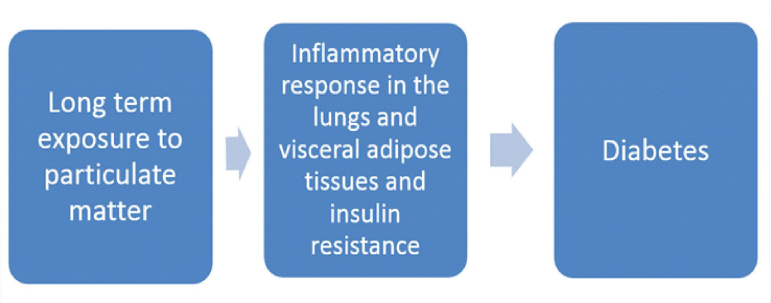
Endothelial Dysfunction

As per one of the recent studies, particulate matter is an emerging driver of increasing risk of type 2 diabetes in a global population (Esposito et al, 2016). Endothelial dysfunction, which precedes insulin resistance has been proposed as a possible mechanism of particulate matter-induced diabetes (Meo et al., 2015). PM acts as a mediator of endothelial dysfunction implicated in reduced peripheral glucose uptake. Also, early life represents a vulnerable period $PM_{2.5}$ induced genetic and lifestyle disorders, like diabetes.

Inflammation Dysgregulates Visceral Adipose Tissue

Recent evidence suggests that exposure to ambient PM can be associated with elevated systemic pro inflammatory biomarkers (Wolf et al., 2016). Indeed, one study reported that the association of inflammation (as assessed by blood levels of complement fragment C3c) with propensity to diabetes was enhanced by exposure to particulate matters (Esposito et al., 2016). A recent meta-analysis of prospective studies identified two inflammatory markers, that is, interleukin-6 and C-reactive protein, significantly associated with diabetes with an increased risk of 26 % for elevated C-reactive protein and 31 % for elevated interleukin-6 levels (Dubowsky et al., 2006).

Fig 5: Putative mechanism of particulate matter and diabetes via endothelial tissue



Hepatic Insulin Resistance

$PM_{2.5}$ exposure decreases tyrosine phosphorylation in the liver but does not affect insulin receptor substrate 1 (IRS-1) levels (Esposito et al., 2016). Similarly, short-term (5-day) exposure to low dose $PM_{2.5}$ was shown to reduce metabolic insulin sensitivity in healthy individuals (Liu et al., 2014).

Oxidative Stress and Diabetes

Epidemiological studies have shown that inhalation of $PM_{2.5}$ causes insulin resistance which can be either in the form of metabolic dysfunction or oxidative stress (Xu et al., 2011). Insulin stimulates extracellular secretion of amyloid beta (Aâ) protein and inhibits its intracellular accumulation. Therefore insulin resistance leads to upregulation of BACE expression and Aâ precursor protein, which further leads to build-up of Aâ protein (Elbaz et al., 2007; Schikowski et al., 2015) .

Conclusion

Emergence of air pollution specifically particulate matter as a new causal factor for diabetes is major concern for sustainable health in fast-developing nations. Based on the current evidence, we identified a relationship between the increasing levels of air pollution and the increasing incidences of diabetes mellitus type 2. Though exact mechanisms explaining the correlation between increasing pollution and triggering diabetes are still unknown, we pointed plausible mechanisms affecting tissue and organ. Inflammation of the adipose tissue affecting the uptake of insulin, oxidative stress leading to insulin

resistance and reduction of metabolic insulin sensitivity in hepatic tissue might be the missing links of the story of particulate matter triggered diabetes. Identifying the exact mechanism of such relationship would help in suggesting the remedial measure for ensuring sustainable health in developing nations.

References

Djankov, S., & Saliola, F. (2019). *CHANGING NATURE OF WORK A World Bank Group Flagship Report WORLD DEVELOPMENT REPORT*. Retrieved from http://documents.worldbank.org/curated/en/816281518818814423/pdf/2019-WDR-Report.pdf

Dubowsky, S. D., Suh, H., Schwartz, J., Coull, B. A., & Gold, D. R. (2006). Diabetes, obesity, and hypertension may enhance associations between air pollution and markers of systemic inflammation. *Environmental Health Perspectives*. https://doi.org/10.1289/ehp.8469

Elbaz, A., Dufouil, C., & Alpérovitch, A. (2007). Interaction between genes and environment in neurodegenerative diseases. *Comptes Rendus - Biologies*, *330*(4), 318–328. https://doi.org/10.1016/j.crvi.2007.02.018

Esposito, K., Petrizzo, M., Maiorino, M. I., Bellastella, G., & Giugliano, D. (2016). Particulate matter pollutants and risk of type 2 diabetes: a time for concern? *Endocrine*. https://doi.org/10.1007/s12020-015-0638-2

Haberzettl, P., O'Toole, T. E., Bhatnagar, A., & Conklin, D. J. (2016). Exposure to fine particulate air pollution causes vascular insulin resistance by inducing pulmonary oxidative stress. *Environmental Health Perspectives*. https://doi.org/10.1289/EHP 212

Liu, C., Bai, Y., Xu, X., Sun, L., Wang, A., Wang, T. Y., … Rajagopalan, S. (2014). Exaggerated effects of particulate matter air pollution in genetic type II diabetes mellitus. *Particle and Fibre Toxicology*. https://doi.org/10.1186/1743-8977-11-27

Liu, C., Xu, X., Bai, Y., Zhong, J., Wang, A., Sun, L., … Rajagopalan, S. (2017). Particulate Air pollution mediated effects on insulin resistance in mice are independent of CCR2. *Particle and Fibre Toxicology*. https://doi.org/10.1186/s12989-017-0187-3

Meo, S. A., Memon, A. N., Sheikh, S. A., Rouq, F. A., Usmani, A. M., Hassan, A., & Arian, S. A. (2015). Effect of environmental air pollution on type 2 diabetes mellitus. *European Review for Medical and Pharmacological Sciences*.

O'Neill, M. S., Veves, A., Sarnat, J. A., Zanobetti, A., Gold, D. R., Economides, P. A., … Schwartz, J. (2007). Air pollution and inflammation in type 2 diabetes: A mecnanism for susceptibility. *Occupational and Environmental Medicine*. https://doi.org/10.1136/oem.2006.030023

Park, S. K. (2017). Ambient Air Pollution and Type 2 Diabetes: Do the Metabolic Effects of Air Pollution Start Early in Life? *Diabetes*. https://doi.org/10.2337/

dbi17-0012

Rajagopalan, S., & Brook, R. D. (2012). Air pollution and type 2 diabetes: Mechanistic insights. *Diabetes*. https://doi.org/10.2337/db12-0190

Schikowski, T., Vossoughi, M., Vierkötter, A., Schulte, T., Teichert, T., Sugiri, D., … Luckhaus, C. (2015). Association of air pollution with cognitive functions and its modification by APOE gene variants in elderly women. *Environmental Research*, *142*, 10–16. https://doi.org/10.1016/j.envres.2015.06.009

Sun, Q., Yue, P., Deiuliis, J. A., Lumeng, C. N., Kampfrath, T., Mikolaj, M. B., … Rajagopalan, S. (2009). Ambient air pollution exaggerates adipose inflammation and insulin resistance in a mouse model of diet-induced obesity. *Circulation*. https://doi.org/10.1161/CIRCULATIONAHA.108.799015

Wolf, K., Popp, A., Schneider, A., Breitner, S., Hampel, R., Rathmann, W., … Peters, A. (2016). Association between long-term exposure to air pollution and biomarkers related to insulin resistance, subclinical inflammation, and adipokines. *Diabetes*. https://doi.org/10.2337/db15-1567

Wu, Y., Ding, Y., Tanaka, Y., & Zhang, W. (2014). Risk factors contributing to type 2 diabetes and recent advances in the treatment and prevention. *International Journal of Medical Sciences*, *11*(11), 1185–1200. https://doi.org/10.7150/ijms.10001

Xu, X., Liu, C., Xu, Z., Tzan, K., Zhong, M., Wang, A., … Sun, Q. (2011). Long-term exposure to ambient fine particulate pollution induces insulin resistance and mitochondrial alteration in adipose tissue. *Toxicological Sciences*. https://doi.org/10.1093/toxsci/kfr211

4

Right to have Clean Environment

Dr. Divya Sharma
Assistant Professors, Department of Commerce
Bharati College, University of Delhi, Janak Puri, Delhi
Contact No. 9999158955

Human Rights are "the basic rights and freedom to which all humans are entitled". Human rights are based on dignity, equality and mutual respect – regardless of nationality, religion, cast, sex, social status or beliefs. In India, the fundamental rights were included in the constitution because they were considered essential for the development of the personality of every individual and to preserve human dignity.

As recently in silver jubilee lecture of The National Human Rights Commission (NHRC), India, held on 10th September 2018 in New Delhi. Dr Mathur, Director General, TREI, spoke about 'Clean environment as a Human Right: Exploring synergies between the environment, SDGs, and human rights' and urged the NHRC to initiate a dialogue on the issue of the right to a clean environment as a human right. He also said, "I would suggest that a clean environment is now emerging as a human right in India. It was not an issue 100 years ago because at that time, we produced very little waste, and that waste was easily absorbed by the environment around us.

However, as we have developed, as we produce and consume more, and as our population density has increased, pollution now lives cheek to jowl with us: these include landfills that are falling onto neighbouring buildings; particles and NOx that choke us; and wastewater which sloshes over our shoes every time we cross roads in front of our homes or offices or factories. I would like to briefly outline the contours of this transition"

Human Rights

Human rights demand recognition and respect for the inherent dignity to ensure that everyone is protected against abuses which undermine their dignity, and give the opportunities they need to realize their full potential, free from discrimination. Hence rights are all about being treated fairly and treating others fairly, and having the ability to make choices about your own life. These basic properties of our Human Rights are as follows:

- **Having a quality of being Universal** means belong to all of us – everybody in world
- **Cannot be alienate** Means that they cannot be taken away from any human being.
- **Are neither divisible nor interdependent** means Governments should not be able to pick and choose which are respected
- **May be violated** Although they are inalienable, they are not invulnerable. Violations can stop people from enjoying their rights, but they do not stop the rights from existing.
- **Essential to follow.** They are essential for freedom, justice, and peace.

Human rights are the basic rights that all the human being can enjoy, no matter where they live. There rights are universal in nature. The idea of human rights is originated from the ideas of civilized nations and enforced by the United Nation Organisation. The enjoyment of human rights is guarantee internationally. Hence Human Rights are universal, absolute and fundamental moral claims, in the sense that they belong to all human beings, they are inalienable and are basic to a real living. Few common rights are listed below:

- **Human rights include civil and political rights,**

such as:

- The right to freedom of thought and expression
- The right to freedom of religion or conscience
- The right to property
- The right to freedom of assembly
- The right to privacy
- The right to vote.
- **Human rights includes economic and social rights,such as:**
- The right to an adequate standard of living
- The right to adequate food, housing, water and sanitation
- The rights you have at work
- The right to education

Fundamental Rights

In India fundamental rights help not only in protection but also the prevention of gross violations of human rights. They emphasise on the fundamental unity of India by guaranteeing to all citizens the access and use of the same facilities, irrespective of background.

1. Right to equality :

- Article 14: All people shall be equally protected by the laws of the country.
- Article 15: No person shall be discriminated on the basis of religion, race, caste, sex or place of birth.
- Article 16: State cannot discriminate in the matters of employment.
- Article 17: Abolishes the practice of untouchability.
- Article 18: Prohibits the State from conferring any titles, citizens of India cannot accept titles from a foreign State.
- 2. **Cultural and Educational Right :** to have access to education

and to conserve their culture

- Article 29: Protection of interests of minorities
- Article 30: Right of minorities to establish and administer educational institutions

3. Right to freedom:

- Article 19:
- Freedom of speech and expression
- Freedom to assemble peacefully without arms
- Freedom to form associations or unions or co-operative societies
- Freedom to move freely throughout the territory of India
- Freedom to reside and settle in any part of the territory of India
- Freedom to practice any profession or to carry on any occupation, trade or business
- Article 20: protection of conviction for offences.
- Article 21: Right to life, personal liberty and Right to die with dignity.
- Article 21A: Education to all children of the age of six to fourteen years
- Article 22: Protection against arrest and detention in certain cases.

4. Right against exploitation:

- Articles 23: Abolition of trafficking in human beings
- Article 24 : Abolition of employment of children below the age of 14 years in dangerous jobs

5. Right to freedom of religion:

- Articles 25: Freedom of conscience and free profession, practice and propagation of religion
- Article 26: Freedom to manage religious affairs
- Article 27: Freedom to payment of taxes for promotion of any particular religion

- Article 28: Freedom to attendance at religious instruction or religious worship in certain educational institutions

6. **Right to constitutional remedies:** enforcement of Fundamental Rights.

Constitutional Framework towards Clean Environment

Environment is the wellspring of life on earth like water, air, soil, etc., and determines the presence, development and improvement of adequate standard of living. The concept of ecological protection and preservation is not new. It has been intrinsic to many ancient civilizations. But unfortunately the right to a healthy environment was never a priority. Constant environment deterioration could eventually endanger life of present and future generation of human beings and also for other animals on the planet. It will not be true to say that healthy environment is neglected area legislation. Protection of life and protection and conservation of environment and sustainable use of natural resources and its need is reflected in the constitutional framework of India. Article 21 of the Indian constitution states that no person shall be deprived of life and personal liberty except according to procedures established by law. Under Part IVA of the Constitution (Article 51A- Fundamental Duties), the Constitution casts a duty on every citizen to improve and protect the nature and have compassion for all living beings. Furthermore, the Constitution under Part IV (Article 48A- Directive Principles of State Policies) stipulates that the State shall try to improve and protect the environment and safeguard forests and wildlife of the country.

Meaning of Environment

The word "environment" relates to the surroundings or conditions in which a person, animal, or plant lives or operates. It includes virtually everything. It can include anything which may belongs to physical surroundings that are common to all of us, including air, space, land, water, plants and wildlife.

According to the Webster Dictionary, Environment is defined as the "Aggregate of all the external condition and influences affecting the life and development of an organism.

The Environment (Protection) Act, 1986

Section 2(a) environment "includes water, air and land and the inter-

relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property."

Thus, the crux of above definitions is that environment means the surroundings in which we live and is essential for our life.

Environment protection related laws

According to pattern of Indian legislature, we have number of legislations. Some of the important legislations for environment protection are as follows:

- The Air (Prevention and Control of Pollution) Act, 1981
- The Water (Prevention and Control of Pollution) Act, 1974
- The Environment Protection Act, 1986
- The Hazardous Waste Management Regulations
- The Wild Life (Protection) Act, 1972
- The Forest Conservation Act, 1980
- The Public Liability Insurance Act, 1991
- The National Green Tribunal Act, 2010.

These important environment legislations have been briefly explained:

- **The Air (Prevention and Control of Pollution) Act, 1981 (the "Air Act")**: The objective of this act is to provide for the prevention, control and abatement of air pollution and for the establishment of Boards at the Central and State levels with a view to carrying out the aforesaid purposes.

- **The Water Prevention and Control of Pollution Act, 1974 (the "Water Act")**: This act has been enacted to provide for the prevention and control of water pollution and to maintain or restore wholesomeness of water in the country. It further provides for the establishment of Boards for the prevention and control of water pollution with a view to carrying out the aforesaid purposes. The Water Act prohibits the discharge of pollutants into water bodies beyond a given standard and lays down penalties for non-compliance. At the Centre, the Water Act has set up the CPCB which lays down standards for the prevention and control of water pollution. At the State level, SPCBs function under the direction of the CPCB and the State Government.

- Further, the Water (Prevention and Control of Pollution) Cess Act was enacted in 1977 to provide for the levy and collection of a cess on water consumed by persons operating and carrying on certain types of industrial activities.

- **The Environment Protection Act, 1986 (the "Environment Act")**: Act provides for the protection and improvement of the environment. This act establishes the framework for studying, planning and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations threatening the environment. It is an umbrella legislation designed to provide a framework for the coordination of central and state authorities established under the Water Act, 1974 and the Air Act. The term "environment" is understood in a very wide term under sec 2(a) of the Environment Act. It includes water, air and land as well as the interrelationship which exists between water, air and land, and human beings, other living creatures, plants, micro-organisms and property.

Under the Environment Act, the Central Government is empowered to take measures necessary to protect and improve the quality of environment by setting standards for

- emissions and discharges of pollution in the atmosphere by any person carrying on an industry or activity;
- regulating the location of industries;
- management of hazardous wastes, and
- protection of public health and welfare.

From time to time, the Central Government issues notifications under the Environment Act for the protection of ecologically-sensitive areas or issues guidelines for matters under the Environment Act.

- **Hazardous waste management regulations**: Hazardous waste means any waste which, by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics, causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances.

Few rules dealing with hazardous waste management are listed below:

- **Hazardous Wastes (Management, Handling and**

Transboundary) Rules, 2008, a guide for manufacture, storage and import of hazardous chemicals and for management of hazardous wastes.

- **Biomedical Waste (Management and Handling) Rules, 1998**, were formulated for proper disposal, segregation, transport, etc, of infectious wastes.

- **Municipal Solid Wastes (Management and Handling) Rules, 2000**, enabling municipalities to dispose municipal solid waste in a scientific manner.

- **E - Waste (Management and Handling) Rules, 2011:** the primary objective of this act is to reduce the use of hazardous substances in electrical and electronic equipment by specifying threshold for use of hazardous material and to channelize the e-waste generated in the country for environmentally sound recycling.

- **Batteries (Management & Handling) Rules, 2001** deal with the proper and effective management and handling of lead acid batteries waste

- **The Wild Life (Protection) Act, 1972**: the main objective of of this act is to effectively protecting the wild life of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives. The Act was amended in January 2003 and punishment and the penalty for offences under the Act have been made more stringent.

- **The Forest Conservation Act, 1980**: the objective to enact this act is to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end, the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.

- **The Public Liability Insurance Act, 1991**: this act was enacted with the objectives to provide for damages to victims of an accident which occurs as a result of handling any hazardous substance. The Act applies to all owners associated with the production or handling of any hazardous chemicals.

- **The National Green Tribunal Act, 2010 (NGT Act)**: The main objective of this act is to provide establishment of a National Green Tribunal (NGT) for the effective and expeditious disposal of cases relating to

environment protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto.

Judicial Interpretations: Clean Environment Is Our Human Right

In India there arises a requirement for a comprehensive analysis of the protection of the environment in view of protection of Human Right. In recent years, higher judiciary is paying sustainable focus in devising and monitoring the implementation of measures for pollution control, conservation of forests and wildlife protection. Many of these judicial interventions have been triggered by the persistent incoherence in policy-making.

Almitra H. Patel & Ors. vs. Union of India and Ors.

In this case NGT was dealing with the issue of solid waste management in India. In this case, Mrs. Almitra Patel and another had filed a PIL under Article 32 of the Constitution of India before the Apex Court whereby the Petitioner sought the immediate and urgent improvement in the practices that are presently adopted for the way Municipal Solid Waste or garbage is treated in India. The Tribunal found that the magnitude of the problem was gigantic because over a lakh tonnes of raw garbage is dumped every day and there is no proper treatment of this raw garbage which is dumped just outside the city limits on land, along highway, lakes, nalas etc.

The Tribunal noted the requirement of conversion of this waste into a source of power and fuel therefore direction was issued to every state and union territory to immediately implement Solid Waste Management Rules, 2016. The most important direction of the Tribunal was a complete prohibition on open burning of waste on lands, including at landfills to give safe and clean environment to live.

Srinagar Bandh Aapda Sangharsh Samiti & Anr. v. Alaknanda hydro Power Co. Ltd. & Ors.

Tribunal has to decide whether the 2013 Uttarakhand floods which caused mass destruction of life and property is the to compensate by defendant as they had dumped a huge quantity of 'muck' generated during construction of the Srinagar Hydro Electric Project without taking the prescribed measure

to secure such much from the floods. The Tribunal reached the conclusion that although the 2013 Uttarakhand floods were the result of a cloud burst but the damage caused to the residential area was not the result of Act of God, the damage to the property as alleged by the applicants was incurred as a result of flood water, which brought along soil and muck, entering residential premises.

This is one of those judgments, whereby the NGT followed the principle of 'polluter pays' and made a private entity liable to pay a compensation by making them subject to a code of environmental jurisprudence.

Rural litigation and Entitlement Kendra vs. State of Uttar Prades

The Supreme Court ordered the closure of certain limestone quarries followed by land reclamation, afforestation and soil conservation in those areas, pointing out that while the closure of these mines would cause losses to owners and employees, this was a necessity for "protecting and safeguarding the right of the people to live in healthy environment with minimal disturbance of ecological balance and without avoidable hazard to them and to their cattle, homes and agricultural land and undue affectation of air, water and environment."

M.C. Mehta v. Union of India

Issue originated in the aftermath of oleum gas leak from Shriram Food and Fertilisers Ltd. complex at Delhi. This gas leak occurred soon after the infamous Bhopal gas leak and created a lot of panic in Delhi. One person died in the incident and few were hospitalized.

The Supreme Court made the following observation:

Factories were closed down immediately as Inspector of Factories and Commissioner (Factories) issued separate orders dated December 8 and 24, 1985. This incident took place only a few months before Environment (Protection) Act came into force, thus became a guiding force for having an effective law

he High Court was directed to nominate one or more Judges as may be necessary for the purpose of trying such actions so that they may be expeditiously disposed of. The court adjudicating on the issue of Shriram's closure produced several new stances that are hailed even today.

Apex Court directed certain tanneries to stop functioning reason being discharging foul effluents without setting a primary treatment plant. Held

that "we are conscious that closure of industries may bring unemployment, loss of revenue but life, health and ecology have a greater importance to people"

Subhash Kumar vs. State of Bihar

In this case Supreme Court directly linked environmental protection with the right to life guaranteed under Article 21. While delivering a judgment in response to a public interest litigation (PIL) filed against industries, which the petitioner alleged were polluting the Bokaro river, the Court held that the right to life, guaranteed under Article 21, also includes the right to pollution-free air and water.

Conclusion

From the above discussion it is evident that environmental and human rights are closely related. The demands for a safe pollution free and healthy environment, shall come within the scope of human rights. The human rights would be strengthened by the amalgamation of environmental concerns providing victims of environmental dilapidation the opportunity of access to free and fast justice and enabling the expansion of the scope of human rights protection and generation of concrete solutions for cases of environment degradation.

Bibliography

The Air (Prevention and Control of Pollution) Act, 1981

The Water (Prevention and Control of Pollution) Act, 1974

The Environment Protection Act, 1986

The Hazardous Waste Management Regulations

The Wild Life (Protection) Act, 1972

The Forest Conservation Act, 1980

The Public Liability Insurance Act, 1991

The National Green Tribunal Act, 2010.

Almitra H. Patel & Ors. vs. Union of India and Ors. Writ petition case no 888, 1996

Srinagar Bandh Aapda Sangharsh Samiti & Anr. v. Alaknanda hydro Power Co. Ltd. & Ors. (2014) 1 SCC 769

Rural Litigation and entitlement Kendra vs. State of Uttar Pradesh A.I.R. 1985 S.C. 625.

M.C. Mehta v. Union of India AIR 1992 S.C. 382

M.C. Mehta v. Union of India AIR 1997 S.C. 734
Subhash Kumar vs. State of Bihar and Ors., A.I.R. 1991 S.C. 420.
www.teriin.org
https://en.wikipedia.org/wiki/Human_rights_in_India
www. nhrc.nic.in
https://amnesty.org.in/about-us/what-are-human-rights/

5

Drosophila melanogaster- a model organism to assess the impact of pollution on Human health

Geetanjali Sageena , Assistant Professor, Keshav Mahavdiyalaya University of Delhi

geetanjalisageena@gmail.com

Abstract

Beginning with industrial revolution, anthropogenic activities have continued to affect the ecosystems. The quality of air and water that are essential for survival of all life have deteriorated extensively. The need of the hour is to identify a cost-effective model of living organism that can be used to assess the quality of environment on a continuous time scale so as to take timely corrective measures. Due to ethical issues many organisms that were being used earlier can no longer be used and hence there is a need to develop alternative model systems. *Drosophila* shares 60% of its genome with the human with many organ systems paralleling those of humans and hence they can safely be used to assess the quality of environment and its impact on the health .

Introduction

Drosophila melanogaster has been extensively used as a model system to study various biological response (Zhang et al.,2007). In 1900, for the first time an American entomologist, Charles Woodsworth proposed to use Drosophila as powerful genetic model organism (Sturtevant 1959). The strengthening features which makes fly research unique ranges from its short generation time, ease in handling and amenable to manipulations in genetic system with no ethical constraints. From more than a century, the Drosophila research has underpinned modern genetics and is regarded as most sought model organism in modern biological science. Despite certain biochemical and physiological limitations associated with Drosophila invertebrate model use to study human biology (Hao et al.,2008), D. melanogaster has been extensively used to unravel the underpinnings of many human diseases such as Alzheimers (Lez et al.,2013), Huntington (Krench et al.,2013) and others by way of what is popularly referred to as humanizing the fly. Further, certain modifications in Drosophila model system have helped to overcome limitations particularly to study pathogenic human viruses (Chaudhuri et al.,2007). Approximately 75% of the genes responsible for human disease are known to be substantially evolutionarily conserved making it central to use for understanding molecular mechanisms of human diseases. The organism enabled milestone discoveries on completion of its genome sequenced and continues to be on forefront (Adams et al.,2000). The compact genome of 180 Mb consists of 130 Mb of euchromatin (with roughly 13,500 genes) comparable with the size of single human chromosome (Chien et al.,2002).The Drosophila database, Flybase (http://flybase.org) 1992 provides an extensive source of information reflecting the strength of the model organism in genetic research (dos Santos et al.,2015).

Life Cycle

Drosophila mealanogaster is a cosmopolitan holometabolous organism belonging to order Diptera under the family Drosophilidae. Its exhibits complete metamorphosis, wherein lifecycle includes 3 pre adult stages i.e. egg, larvae and pupae. Under optimum laboratory conditions,

Drosophila adults become sexually receptive after 8-10 hours from the time of emergence (Ashburner et al.,2005). Eggs laid on suitable substratum begins to hatch approximately after 18 hours of laying, which is sensitive to

abiotic conditions like temperature and humidity (Alpatov, 1932; David and Clavel,1969; Sissiqui and Barlow, 1972). Once the eggs hatch, three larval moults namely L1, L2 and L3 are observed which lasts for 24, 24 and 48 hours respectively. L1 are said to be surface feeders which later on molting to L2 enters a burrowing stage (Sokal et al.,1960). In order to acquire resources larvae actively feeds for approximately 110 hours before it ceases feeding during late L3 stage and wander off in search of a suitable pupation site. Pupation takes place about after 4 days of oviposition (Sameoto and Miller, 1968). Adult eclosion from pupal cases begins after 4-5 days. On completion of metamorphosis, adult flies eclose with wings unfolding in 1 hour and body pigmentation occurring in 2-3 hours (Ashburner et al.,2005). The versatile model organism can be considered as combinational powerful research tool due to distinct phases in its lifecycle. The embryo and larva are considered to be an important tool to study fundamental development and physiological processes respectively. The study on pupal imaginal discs has provided significant insight to human biology (Beira et al., 2016). The research using adult Drosophila has made key advances in therapeutics due to rich repertoire of genetic tools (Hales et al., 2015).

Many internal adult structures are functionally analogous to vertebrates-including humans thereby unravelling molecular mechanisms of various disorders ranging from cancer, diabetes, Parkinsons Disease, viral infections, neuronal dysfunction and gut disorders (Reiter et al.,2001; Read et al.,2005; Musselman et al.,2011; Feany and Bender, 2000; Sabin et al.,2010; Inagaki et al.,2010; Charng et al.,2014; Apidianakis and Rahme, 2011).

Strategies to study Human Diseases

Most of our understanding of the biology underlying the human disease comes from the study of *Drosophila* research *(*Pandey and Nichols, 2011) . The study mainly implies three strategies namely Forward genetics, Reverse genetics and Diagnostic strategy. An unbiased mutagenic approach of Forward genomics aims to identify the sequential variation of a given phenotype through transposons, chemical mutagenesis and transgenes (Hummel and Klambt, 2008; Bokel, 2008; Markstein *et al.,*2008; Szabad *et al.,*2012). In reverse genetics, to study their phenotypes in vivo mutations are created in fly homologs of human genes. To facilitate this Transposable Elements (TE), Targeted gene disruption (using short palindromic repeats) and gene silencing through RNAi (RNA interference) is employed. (Beumer

and Carroll, 2014; Mohr, 2014). In Diagnostic strategy, the pathogenic properties of the variants linked to human diseases can be assessed using powerful model D. *melanogaster* to close the knowledge gap.

Cancer

The Drosophila has emerged as valuable model recapitulating various aspects of cellular metabolism that is a known hallmark of malignancy in humans. The Drosophila imaginal discs are similar to mammalian cells susceptible to cancer thereby making it an excellent model organism to study proliferation during tumorigenesis. The epithelial structures of imaginal disc extensively proliferate during development of larva and differentiates to adult structures after metamorphosis. The cell cycle proliferation consists of G1, S, G2 and M phase similar to mammalian cells (Edgae et al.,1996). The cell cycle machinery is highly conserved Cyclins (A, B, D and E) and Cyclin dependant Kinases (Cdk1, Cdk2, Cdk4 and Cdk6) between mammals and flies. The cell cycle regulators i.e. mammalian retinoblastoma protein (pRb), E2F are known to have Drosophila homologs RBF and dE2F respectively (Du et al.,1996, Dynlacht et al.,1994). Additionally, the embryogenesis provides an excellent system for the study of cell proliferation (Foe et al.,1993). The biochemical and molecular pathways governing cell fate specification are also seen to be conserved from flies to humans (Davidson et al.,1990). The proliferation response is observed in response to altered Notch activity in Drosophila, similar mutations in human Notch homologs resulted in lymphomas suggesting that cell fate determination processes remain conserved as well (Artavanis et al.,1995). The ectopic gene expression by introduction of the GAL4/ yeast UAS system in fly can be used to study tumour suppression and mammalian oncogenes expression (Brand et al.,1993). The wide range of tissue specific promoters (eyes specific or neuronal) or ubiquitous promoters (actin or heat shock promoters) are present for controlling the expressions.

The universal Insulin-like growth factor signalling also plays a pivotal role in development and regulation of metabolism. The IGF receptor binds to tyrosine kinase leading to the activation of Ras or TOR pathways. The *Drosophila* IGF components namely Rheb, Tsc1, and Tsc2 have served to determine its contribution in components of the insulin/IGF system, including Rheb, Tsc1, and Tsc2, are organized in the insulin/Akt pathway, thereby suggesting the role of various key elements during cascade including tumor

supressors and oncogenes (PTEN and PI-3K, Akt, TOR) (Cully *et al.,*2006). Tumor growth in *Drosophila* induces hike in levels of *ImpL2,* a homolog of the secreted insulin growth factor-binding protein alleviates degeneration of muscles (cachexia), observed in patients with advanced cancerous stage (Figueroa *et al.,*2015; Kwon *et al.,*2015). Thus, *Drosophila* play a key role to explore mechanistic link between cancer and metabolism.

Cardiac Diseases

Cardiac disorders are among leading cause of mortality worldwide. Few aspects of heart development and cardiac dysfunction are known to be conserved between *D. melanogaster* and vertebrates (Ocorr *et al.,*2007). The heart precursor in *Drosophila* originate in late mesoderm. The linear tubular structure converges on dorsal midline extending from 1-6 abdominal segments. The dorsal vessels consist of distinct contractile cardiomyocytes flanked by non-contractile pericardial cells. The four cardiac chambers consist of 6 myocardial cells sharing similarities with mammalian sarcomere structure (Lehmacher *et al.,*2012), pacemaker is located in first and fourth chamber i.e. comparable to 4 distinct chambers in vertebrate embryo heart (Medioni *et al.,*2009; Dulcis *et al.,*2005). Cardiac rhythms are regulated by pumping of haemolymph by narrow anterior portion Aorta (Bier *et al.,*2004) in open vascular cavity allowing the flow of immune cells and other essential nutrients required for homeostasis. There is remarkable conservation of signalling pathways (Choma *et al.,*2011; Ahmad *et al.,*2017), similar genes known to code excitation-contraction coupling (inducing increase in cytosolic intracellular calcium) in humans and *Drosophila* (Lin *et al.,*2011). Cardiogenic genes required for morphogenesis and development in *Drosophila* embryonic heart are conserved in humans (Neely *et al.,*2010). The conserved physiology of cardiac function is well evident by the *Drosophila* homeobox transcription factor *Tinman*, often regarded as cardiac development- master gene (Olson *et al.,*2006). To discern the mechanisms underlying cardiac myopathies Insulin-IGF and TOR receptor play a crucial role (Wessells *et al.,*2009). Further for the quantification of cardiac impairments, heart functional imaging of *Drosophila* observed similar *in vivo* contractions to EEG clinical echocardiography (Choma *et al.,*2011).

Renal Diseases

The basic tasks performed by *Drosophila* and human renal system share

homology and is fundamentally similar via transportation, excretion and osmoregulation (Weavers *et al.,*2009; Denholm *et al.,*2003). The nephrocytes and Malpighian tubule in *Drosophila* are functionally analogous to tubular part of vertebrate nephrons. The Drosophila tubule (assessed by microarray) has shown enriched expression to many of the classic human renal loci and sequential similarity (assessed by BLASTP). Several orthologous genes are known to play a pivotal role in renal function and development both in humans and *Drosophila* (Dow *et al.,*2010). The fly counterparts are present for the genes encoding for electrolyte transporting proteins (Hatton *et al.,*2007). The renal development genes *Kruppel and Cut, Sns* and *Dwnt* involved in cell specification, proliferation and differentiation have mammalian counterparts. The *Drosophila* model is one of the best models to study kidney impairments and nephrolithiasis (stone formation by calcium oxalate and phosphate) (Miller *et al.,*2013).

Neurodegenerative Diseases

The central nervous system in *Drosophila* comprises of neuronal and glial cells in bilaterally symmetrical brain. The motor neuron output similar to humans is seen for sensing information related to olfaction, vision, touch and taste (McGuire *et al.,*2005). In the visual system, approximately there are 115 different types of neurons in Drosophila, which is similar to vertebrates (Venken *et al.,*2011). Though the fly brain is comparatively simpler than vertebrates but yet it shares numerous chemicals, cellular, genetic properties and Notch signalling pathway is evolutionary conserved allowing parallels with humans (Kopan *et al.,*2009). The mammalian homolog *Wnt* plays an important role in neuronal development as seen from *wingless* in *Drosophila* (Bejsovec *et al.,*2005). *Drosophila* has been used to study proteinopathies such as ataxia, amyotropic sclerosis and Huntington's, Parkinsons and Alzheimers disease (Casci *et al.,*2015; Watson *et al.,*2008; Jackson *et al.,*1998; Dauer *et al.,*2003; Mershin *et al.,*2004). Thus, *Drosophila* provide a powerful platform to perform functional annotations of human genes to study the molecular mechanisms that underlie diseases of the nervous system.

Immunological Diseases

The mechanism of innate immunity is fairly conserved for elucidation of defense from pathogens in *Drosophila* (Hoffmann *et al.,*1999). Humans

and *Drosophila* share general defense strategies like epithelial barriers, antimicrobial peptides and phagocytosis. *Drosophila* has been used to study a widespread form of leukemia, acute myeloid leukaemia. The transcription factors AML1 activate myeloid differentiation and is having a counterpart in the fly (Sinenko *et al.,*2010). *Drosophila* respond specifically to pathogens, discriminating between classes of surface molecules on different intruders. *Toll* and *Imd* are the two master genes of *Drosophila* immunity, but FoxO, JAK/STAT, and JNK transduction also have a key role to play (Varma *et al.,*2007). *Toll* signalling in *Drosophila* aids in inflammatory responses via toll-like receptors (Tauszig *et al.,*2000). The restriction factors of flies also help in examining the defense against viral infection. *Pastrel* restriction factors in *Drosophila*, are induced in host cells by virus infection and they can recognize specific viral elements (Cogni *et al.,*2016). Another similarity between organisms, includes circadian rhythms known to participate in immune regulation both in *Drosophila* and in humans (Lee *et al.,*2008).

Plethora of research has been done on *D. melanogaster* species to assess the human health (Spradling et al., 2006; Arias 2008; Bellen et al., 2010). For genotoxicity the SMART somatic mutation and recombination test) is one of the rapid yet inexpensive assay (*Rizki et al.,* 2006). The *Drosophila* has laid ground for numerous discoveries in the field of neurobiology (Bellen *et al.,* 2010). Recently, Drosophila offer new ideas to fight vector borne diseases (Serbus *et al.,* 2008). The introduction of specific *Wolbachia* strain from Drosophila into mosquito Aedes aegypti which is known to transmit dengue fever, yellow fever, and chikungunya (McMeniman et al., 2009; Moreira et al., 2009; Walker et al., 2011). wMel Wolbachia strain, is known to block the transmission of dengue virus by rapidly spreading in mosquito population. Thus, Drosophila proves to be an exemplary model to improve health. Wide array of literature for understanding the impact of metal induced toxicity gainfully employed the use of Drosophila (Sageena *et al.,* 2014). It has also been considered as a model for effective oxidative stress management due to production of free radicals/ reactive oxygen species (ROS) known to have implications in various diseases (Finkel *et al.,* 2000; Lushchak 2011; Sageena *et al.,* 2018). The impact of genotype X environment interaction can also be seen as a plasticity response in Drosophila (Heisenberg *et al.,*1995; Sageena *et al.,* 2014). Thus it can rightly be called as a hallmark to medical sciences.

Conclusion

Drosophila provides a powerful standalone platform for unlocking mechanisms contributing to the pathogenesis of many diseases. This will lead to future breakthrough in biomedical research.*Drosophila* is offering a significant contribution in the field of medicine.

1. Pandey U.B. and Nichols C.D. (2011). Human disease models in *Drosophila melanogaster* and the role of the fly in therapeutic drug discovery. Pharmacol.Rev. 63:411–436.

2. Adams M.D., Celniker S.E., Holt R.A., Evans C.A., Gocayne J.D., Amanatides P.G., Scherer S.E., Li P.W., Hoskins R.A., Galle R.F. et al., (2000). The genome sequence of Drosophila melanogaster. Science 287:2185–2195.

3. Sturtevant A. H. (1959). Thomas Hunt Morgan. *Biogr. Mem. Natl. Acad. Sci.* 33:283-325.

4. Ashburner M, Golic K.G. and Hawley R.S. (2005). *Drosophila:* A Laboratory Handbook. Cold Spring Harbor NY: Cold Spring Harbor Laboratory Press.

5. Alpatov W.W. (1932). Egg production in *Drosophila melanogaster* and some factors which influence it. J. Exp. Zool. 63:85-111.

6. Siddiqui W. and Barlow C. (1972). Population growth of *Drosophila melanogaster* (Diptera: Drosophilidae) at constant and alternating temperatures. Ann. Entomol. Soc. Am. 65:993-1001.

7. Sokal R.R., Ehrlich P.R., Hunter P.E. and Schlager G. (1960). Some factors affecting pupation site of *Drosophila.* Ann. Entomol. Soc.Am.53:174-182.

8. Sameoto D.D. and Miller R.S. (1968). Selection of pupation site by *Drosophila melanogaster* and *D. simulans*. Ecology 49:177-180.

9. Bokel C. (2008). EMS screens: from mutagenesis to screening and mapping Methods Mol. Biol. 420:119–138.

10. Hummel T. and Klambt C. (2008). P-element mutagenesis. Methods Mol. Biol. 420:97–117.

11. Markstein M., Pitsouli C., Villalta C., Celniker S.E. and Perrimon N. (2008). Exploiting position effects and the gypsy retrovirus insulator to engineer precisely expressed transgenes. Nat. Genet. 40:476–483.

12. Szabad J., Bellen H.J. and Venken K.J. (2012). An assay to detect in vivo Y chromosome loss in *Drosophila* wing disc cells. G3 Bethesda Md. 1095–1102.

13. Mohr S.E. and Perrimon N. (2012). RNAi screening: new approaches, understandings, and organisms. Wiley. Interdiscip. Rev. RNA.3:145–158.

14. Beumer K. J. and Carroll D. (2014). Targeted genome engineering techniques in *Drosophila.* Methods **68**: 29-37.

15. Read R.D., Goodfellow P.J., Mardis E.R., Novak N., Armstrong J.R. and Cagan R.L., (2005). A *Drosophila* model of multiple endocrine neoplasia type 2. Genetics 171:1057-1081.

16. Musselman L.P., Fink J.L., Narzinski K., Ramachandran P.V., Hathiramani S.S., Cagan R.L. and Baranski T.J. (2011). A high-sugar diet produces obesity and insulin resistance in wild-type *Drosophila.* Dis. Model. Mech. 4:842–849.

17. Feany M.B. and Bender W.W. (2000). A *Drosophila* model of Parkinson's disease. Nature 404:394–398

18. Sabin L.R., Zhou R., Gruber J.J., Lukinova N., Bambina S., Berman A., Lau C.K., Thompson C.B. and Cherry S (2009). Ars2 regulates both miRNA- and siRNA-dependent silencing and suppresses RNA virus infection in *Drosophila.* Cell 138:340–351.

19. Reiter L.T., Potocki L., Chien S., Gribskov M. and Bier E. (2001). A systematic analysis of human disease-associated gene sequences in *Drosophila melanogaster*. Genome Res. 11:1114-1125.

20. Zhang J., Schulze K.L., Hiesinger P.R., Suyama K., Wang S., Fish M., Acar M., Hoskins R.A., Bellen H.J. and Scott M.P. (2007). Thirty-one flavors of *Drosophila* rab proteins. Genetics 176:1307-1322.

21. Chaudhuri R., Lindwasser O.W., Smith W.J., Hurley J.H. and Bonifacino, J.S. (2007). Downregulation of CD4 by human immunodeficiency virus type 1 Nef is dependent on clathrin and involves direct interaction of Nef with the AP2 clathrin adaptor. J. Virol. 81: 3877-3890.

22. Hao L., Sakurai A., Watanabe T., Sorensen E., Nidom, C.A., Newton, M.A., Ahlquist, P and Kawaoka, Y. (2008). *Drosophila* RNAi screen identifies host genes important for influenza virus replication. Nature 454:890-893.

23. Apidianakis Y. and Rahme L. G. (2011). *Drosophila melanogaster* as a model for human intestinal infection and pathology. Dis. Model. Mech. 4:21-30.

24. Charng W.L., Yamamoto S. and Bellen H. J. (2014). Shared mechanisms between *Drosophila* peripheral nervous system development and human neurodegenerative diseases. Curr. Opin. Neurobiol.27:158-164.

25. Inagaki H. K., Kamikouchi A. and Ito K. (2010). Protocol for quantifying sound-sensing ability of *Drosophila melanogaster*. Nat. Protoc.5:26-30.

26. dos Santos G., Schroeder A. J., Goodman J. L., Strelets V. B., Crosby M. A., Thurmond J., Emmert D. B. and Gelbart W. M. the FlyBase Consortium. (2015). FlyBase: introduction of the *Drosophila melanogaster* Release 6 reference genome assembly and large-scale migration of genome annotations. Nucleic Acids Res. 4: D690-D697.

27. Edgar B.A. and Lehner C.F. (1996). Developmental control of cell cycle regulators: a fly's perspective. Science 274:1646-1252.

28. Du W., Vidal M., Xie J.E. and Dyson N. (1996). RBF, a novel RB-related gene that regulates E2F activity and interacts with cyclin E in *Drosophila.* Genes Dev. 10:1206-1218.

29. Dynlacht B.D. Brook A., Dembski M., Yenush L. and Dyson N. (1994). DNA-binding and trans-activation properties of *Drosophila* E2F and DP proteins. Proc. Natl. Acad. Sci. U. S. A. 91:6359-6363.

30. Davidson E.H. (1990). How embryos work: a comparative view of diverse modes of cell fate specification. Development 108:365-389.

31. Artavanis-Tsakonas S., Matsuno K. and Fortini M. E. (1995). Notch signaling. Science 268:225-232.

32. Foe V.E. Odell G. and Edgar B. (1993). Mitosis and Morphogenesis in the *Drosophila* embryo. In the Development of *Drosophila melanogaster* (Vol. I) (Arias, M.B.a.A.M., ed.), pp. 149-300, Cold Spring Harbor Laboratory Press.

33. Brand A.H. and Perrimon N. (1993). Targeted gene expression as a means of altering cell fates and generating dominant phenotypes. Development 118:401-415.

34. Cully M., You H., Levine A.J. and Mak T.W. (2006). Beyond pten mutations: The pi3k pathway as an integrator of multiple inputs during tumorigenesis. Nat. Rev. Cancer. 6:184-192.

35. Figueroa-Clarevega A and Bilder D. (2015) Malignant *Drosophila* tumors interrupt insulin signaling to induce cachexia-like wasting. Dev. Cell. 33:47-55.

36. Kwon Y., Song W., Droujinine I.A., Hu Y., Asara J.M. and Perrimon N. (2015). Systemic organ wasting induced by localized expression of the secreted insulin/IGF antagonist impl2. Dev. Cell.33:36-46.

37. Chien S., Reiter L.T., Bier E. and Gribskov M. (2002). Homophila: human disease gene cognates in *Drosophila.* **Nucleic Acids Res 30**:149-151.

38. Medioni C., Sénatore S., Salmand P.A., Lalevée N., Perrin L. and Sémériva M. (2009). The fabulous destiny of the *Drosophila* heart. Curr. Opin. Genet. Dev.19:518-25.

39. Dulcis D. and Levine R.B. (2005). Glutamatergic innervation of the heart initiates retrograde contractions in adult *Drosophila melanogaster.* J Neurosci 25:271-80.

40. Lin N., Badie N., Yu L., Abraham D., Cheng H., Bursac N., Rockman H.A. and Wolf M.J. (2011) Method to measure myocardial calcium handling in adult *Drosophila*. Circ Res 108:1306-15.

41. Bier E. and Bodmer R. (2004). *Drosophila,* an emerging model for cardiac disease. Gene. 342(1):1-11.

42. Lehmacher C., Abeln B. and Paululat A. (2012). The ultrastructure of *Drosophila* heart cells. Arthropod Structure & Development.41(5):459-474.

43. Ahmad S.M. (2017). Conserved signaling mechanisms in *Drosophila* heart development. Developmental Dynamics: An Official Publication of the American Association of Anatomists. 246(9):641-656.

44. Choma M.A., Suter M.J., Vakoc B.J., Bouma B.E. and Tearney G.J. (2011). Physiological homology between *Drosophila melanogaster* and vertebrate cardiovascular systems. Disease Models & Mechanisms. 4(3):411-420.

45. Neely G.G., Kuba K., Cammarato A., Isobe K., Amann S., Zhang L., Murata M., Elmen L., Gupta V., Arora S., Sarangi R., Dan D., Fujisawa S., Usami T., Xia C.P., Keene A.C., Alayari N.N., Yamakawa H., Elling U., Berger C., Novatchkova M., Koglgruber R., Fukuda K., Nishina H., Isobe M., Pospisilik J.A., Imai Y., Pfeufer A., Hicks A.A., Pramstaller

P.P., Subramaniam S., Kimura A., Ocorr K., Bodmer R. and Penninger J.M.(2010). A global in vivo *Drosophila* RNAi screen identifies NOT3 as a conserved regulator of heart function. Cell. 141(1):142-153.

46. Olson E.N. (2006). Gene regulatory networks in the evolution and development of the heart. Science. 313(5795):1922-1927

47. Ocorr K.A., Crawley T., Gibson G. and Bodmer R. (2007). Genetic variation for cardiac dysfunction in *Drosophila*. PLoS One. 2(7): e601.

48. Wessells R., Fitzgerald E., Piazza N.., Ocorr K., Morley S., Davies C., Lim H.Y., Mitchell L., Hayes M., Oldham S. and Bodmer R. (2009) d4eBP acts downstream of both dTOR and dFoxo to modulate cardiac functional aging in *Drosophila*. Aging Cell. (5):542-552.

49. Denholm B., Sudarsan V., Pasalodos-Sanchez S., Artero R., Lawrence P., Maddrell S., Baylies M. and Skaer H. (2003). Dual origin of the renal tubules in *Drosophila*: mesodermal cells integrate and polarize to establish secretory function. **Curr Biol 13**: 1052–1057.

50. Weavers H., Prieto-Sanchez S., Grawe F., Garcia-Lopez A, Artero R., Wilsch-Brauninger M., Ruiz-Gomez M., Skaer H. and Denholm B. (2009). The insect nephrocyte is a podocyte-like cell with a filtration slit diaphragm. **Nature 457**:322-326.

51. Dow J.A. and Romero M.F. (2010). *Drosophila* provides rapid modeling of renal development, function, and disease. American Journal of Physiology Renal Physiology. 299(6):F1237-F1244.

52. Hatton-Ellis E., Ainsworth C., Sushama Y., Wan S., VijayRaghavan K. and Skaer H. (2007). Genetic regulation of patterned tubular branching in *Drosophila*. Proceedings of the National Academy of Sciences of the United States of America.104(1):169-174.

53. Miller J., Chi T., Kapahi P., Kahn A.J., Kim M.S., Hirata T., Romero M.F., Dow J.A. and Stoller M.L. (2013). *Drosophila melanogaster* as an emerging translational model of human nephrolithiasis. The Journal of Urology.190(5):1648-1656.

54. Bejsovec A. (2005). Wnt pathway activation: New relations and locations. Cell. 120(1):11-14.

55. Kopan R. and Ilagan M.X. (2009). The canonical notch signaling pathway: Unfolding the activation mechanism. Cell. 137(2):216-233

56. Mershin A., Pavlopoulos E., Fitch O., Braden B.C., Nanopoulos D.V. and Skoulakis E.M. (2004). Learning and memory deficits upon TAU accumulation in Drosophila mushroom body neurons. Learning & Memory.11(3):277-287.

57. Dauer W. and Przedborski S. (2003). Parkinson's disease: Mechanisms and models. Neuron. 39(6):889-909.

58. Jackson G.R., Salecker I., Dong X., Yao X., Arnheim N., Faber P.W., MacDonald M.E. and Zipursky S.L (1998). Polyglutamine-expanded human huntingtin transgenes induce degeneration of *Drosophila* photoreceptor neurons. Neuron.21(3):633-642.

59. Casci I. and Pandey U.B. (2015) A fruitful endeavor: Modeling ALS in the fruit fly. Brain Research.1607:47-74.

60. Watson M.R., Lagow R.D., Xu K., Zhang B. and Bonini N.M. (2008). A *Drosophila* model for amyotrophic lateral sclerosis reveals motor neuron damage by human SOD1. The Journal of Biological Chemistry. 283(36):24972-24981.

61. Venken K. J. T., Simpson J. H. and Bellen H. J. (2011). Genetic manipulation of genes and cells in the nervous system of the fruit fly. *Neuron* 72, 202-230.

62. McGuire S.E., Deshazer M. and Davis R.L. (2005) Prog. Neurbiol. 7(5):328-47.

63. Hoffmann J.A., Kafatos F.C., Janeway C.A. and Ezekowitz R.A. (1999). Phylogenetic perspectives in innate immunity. Science.284(5418):1313-1318.

64. Sinenko S.A., Hung T., Moroz T., Tran Q.M., Sidhu S., Cheney M.D., Speck N.A. and Banerjee U. (2010). Genetic manipulation of AML1-ETO-induced expansion of hematopoietic precursors in a *Drosophila* model. Blood. 116(22):4612-4620.

65. Varma H., Cheng R., Voisine C., Hart A.C. and Stockwell B.R. (2007). Inhibitors of metabolism rescue cell death in Huntington's disease models. Proceedings of the National Academy of Sciences of the United States of America.104(36):14525-14530.

66. Tauszig S., Jouanguy E., Hoffmann J.A. and Imler J.L. (2000). Toll-related receptors and the control of antimicrobial peptide expression

in *Drosophila.* Proceedings of the National Academy of Sciences of the United States of America. 97(19):10520-10525.

67. Cogni R., Cao C., Day J.P., Bridson C. and Jiggins F.M. (2016). The genetic architecture of resistance to virus infection in *Drosophila*. Molecular Ecology. 25(20):5228-5241.

68. Lee J.E. and Edery I. (2008). Circadian regulation in the ability of *Drosophila* to combat pathogenic infections. Current Biology: CB.18(3):195-199.

69. Spradling A., Ganetsky B., Hieter P., Johnston M., Olson M., Orr-Weaver T., Rossant J., Sanchez A. and Waterston R. (2006). New roles for model genetic organisms in understanding and treating human disease: report from the 2006 Genetics Society of America meeting. Genetics. 172(4):2025-32.

70. Arias A.M. (2008). *Drosophila melanogaster* and the development of biology in the 20th century. Methods Mol Biol. 420:1-25.

72. Bellen H.J., Tong C. and Tsuda H. (2010).100 years of *Drosophila* research and its impact on vertebrate neuroscience: a history lesson for the future. Nat Rev Neurosci. 11(7):514-22.

73. Rizki M., Kossatz E., Velázquez A., Creus A., Farina M., Fortaner S., Sabbioni E. and Marcos R. (2006). Metabolism of arsenic in *Drosophila melanogaster* and the genotoxicity of dimethylarsinic acid in the *Drosophila* wing spot test. Environ Mol Mutagen. 47(3):162-8.

74. Bellen H.J., Tong C. and Tsuda H. (2010). 100 years of *Drosophila* research and its impact on vertebrate neuroscience: a history lesson for the future. Nat Rev Neurosci. 11(7):514-22.

75. Serbus L.R., Casper-Lindley C., Landmann F. and Sullivan W (2008). The genetics and cell biology of *Wolbachia*-host interactions. Annu. Rev. Genet.42:683-707.

76. McMeniman C.J., Lane R.V., Cass B.N., Fong A.W., Sidhu M., Wang Y.F. and O'Neill S.L. (2009). Stable introduction of a life-shortening Wolbachia infection into the mosquito *Aedes aegypti.*Science. 323(5910):141-4.

77. Moreira L.A., Iturbe-Ormaetxe I., Jeffery J.A., Lu G., Pyke A.T., Hedges L.M., Rocha B.C., Hall-Mendelin S., Day A., Riegler M., Hugo

L.E., Johnson K.N., Kay B.H., McGraw E.A., van den Hurk A.F., Ryan P.A. and O'Neill S.L.(2009). A *Wolbachia* symbiont in Aedes aegypti limits infection with dengue, Chikungunya, and Plasmodium. Cell. 139(7):1268-78.

78. Walker. T, Johnson P.H., Moreira L.A., Iturbe-Ormaetxe I., Frentiu F.D., McMeniman C.J., Leong Y.S., Dong Y., Axford J., Kriesner P., Lloyd A.L., Ritchie S.A., O'Neill S.L.and Hoffmann A.A. (2011). The wMel Wolbachia strain blocks dengue and invades caged *Aedes aegypti* populations. Nature. 476(7361):450-3.

79. Sageena G1., Choudhary S., Mishra N., Roshan R. and Shakarad M. (2014). Role of Juvenile Environment in pre-adult development and Adult metabolites in *Drosophila melanogaster*. IJERD.4:361-370.

80. Finkel T. and Holbrook N.J. (2000). Oxidants, oxidative stress and the biology of ageing. Nature. 408:239-247.

81. Lushchak V.I. (2011) Environmentally induced oxidative stress in aquatic animals. Aquatic Toxicology 101:13-30.

82. Sageena G.2, Mishra N., Choudhary S., Roshan R. and Shakarad M. (2018). Effect of Heavy Metal Tolerance Induced Oxidative Stress on Energy Metabolism in *Drosophila melanogaster*. Expert Opin Environ Biol 7(2):1-3.

83. Heisenberg M., Heusipp M. and Wanke, C. (1995) Structural plasticity in the *Drosophila* brain. J Neurosci.15:1951-1960.

84. Sageena G.3, Choudhary S., Mishra N., Roshan R. and Shakarad M (2014). Role of Environment on larval growth in *Drosophila melanogaster,* IJAER 9:1029-1032.

85. Lenz S., Karsten P., Schulz J.B. and Voigt A.J. (2013). *Drosophila* as a screening tool to study human neurodegenerative diseases. Neurochem.127(4):453-60.

86. Krench M. and Littleton J.T. (2013). Modeling Huntington disease in *Drosophila*: Insights into axonal transport defects and modifiers of toxicity. Fly (Austin). 7(4):229- 236.

87. Beira J.V. and Paro R. (2016). The legacy of *Drosophila* imaginal discs. Chromosoma. 125(4):573-592.

88. Hales K.G., Korey C.A., Larracuente A.M. and Roberts D.M. (2015). Genetics on the Fly: A Primer on the *Drosophila* Model System. Genetics. 201(3):815-842.

6

Impact of Anthropocene era on Global biodiversity

Kavita Singh
Assistant Prof. of Environmental Studies
M. S. College for Women, University of Delhi, Delhi

Abstract

The distinctive feature of Earth is the existence of life, and the most amazing feature of life is its diversity. Approximately 9 million types of plants, animals, protists and fungi inhabit the Earth. The term 'Anthropocene' not yet formally recognized is increasingly used to label Earth's current epoch. A major feature of this period is the rapid biodiversity loss for meeting the ever-increasing needs of the Earth's human population. Human activities in the anthropocene are impacting biodiversity in a cyclical consequence, unprecedented in the human history and in turn squeezing the sustainability of resources for human survival.

The Industrial Revolution has lead to energy-driven consumption of fossil fuels, leading to a rapid increase in CO_2 emissions, disrupting the global carbon cycle and leading to environmental warming impact. Global warming and a changing climate have a range of impending ecological, physical and

health impacts, including extreme weather events (such as floods, droughts, storms, and heat waves); sea-level rise; altered crop growth; and disrupted water systems etc.

In this paper, the impact of climate change in terms of atmospheric carbon dioxide concentration (parts per million by volume) from 2000 to 2018 been reviewed. The major taxonomic groups under consideration are Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi & Protists and plants. The data consists of ten years starting from 2000 to 2018 at an interval of two years. Drift in statistics of species in the threatened categories is evaluated. A significant drop can be seen in many fragile taxonomic groups. Meeting the challenge of understanding and maintaining the value of biodiversity in the Anthropocene demands a genuinely interdisciplinary approach.

Key words: Anthropocene, Biodiversity loss, Carbon dioxide, Threatened categories, Interdisciplinary approach

Perspective of Anthropocene

The term 'Anthropocene' emerged in 2000 to encapsulate the concept of a time period during which anthropogenic activity has come to have a major effect on the natural functioning of the planet (Malhi, 2017). Although not formally recognized, it is increasingly used to label Earth's current epoch (Corlett, 2015). A major hallmark of this period is the transformation of ecosystems for human use (McGill et al, 2015), to the rapid erosion of species richness in the most highly transformed areas of Earth (Newbold et al, 2015). At global scales, evidence is mounting that humans are precipitating Earth's sixth mass extinction (Payne et al., 2016) and the collapse of its life support systems (Steffen et al, 2015).

The concept acts as an umbrella term, incorporating a range of human influences on the planet including climate change, biodiversity loss and mixing, resource limitation, and waste production etc. The prevailing narrative is converging on a start date for the Anthropocene in the mid twentieth century, concurrent with the Great acceleration of human alteration of the planet. Irrespective of the process of formalization, the Anthropocene has spilled out of its natural sciences origins to become a catalyst for numerous cultural, philosophical, and political debates about how to understand and respond to human domination of the Earth (Malhi, 2017).

Evidence of Anthropocene era

Evidences for 'Anthropocene' can be summarized (Vaughan, (2016). as :

1. Extinction rates of flora and fauna far above the long-term average. The Earth is now moving towards sixth mass extinction which would see almost 75% of species extinct in the next few centuries if current trends persist.

2. Increased the concentrations of CO_2 in the atmosphere by about 120 parts per million since the industrial revolution because of fossil fuel-burning, leaving concentrations today at around ~412 ppm and rising.

3. Nuclear weapon tests in the 1950s and 60s left traces of an isotope common in nature, 14C, and a naturally rare isotope, 293Pu, through the Earth's mid-latitudes.

4. Put so much plastic in our waterways and oceans that microplastic particles are now virtually ubiquitous, and plastics will likely leave identifiable fossil records for future generations to discover

5. Doubled the nitrogen and phosphorous in our soils in the past century with our fertiliser use. According to some research, we've had the largest impact on the nitrogen cycle in 2.5bn years

6. Left a permanent marker in sediment and glacial ice with airborne particulates such as black carbon from fossil fuel-burning

Proposals for recognizing the start of the Anthropocene include an 'early Anthropocene' reflecting spread of agriculture and deforestation; Columbian Exchange of Old World and New World species; the Industrial Revolution at ~1800; and the mid-twentieth century 'Great Acceleration' of population growth and industrialization (Waters et al, 2016).

Recent anthropogenic deposits contain new minerals and rock types, with rapid global dissemination of novel materials including elemental aluminum, concrete and plastics, shaped into abundant rapidly-evolving 'techno fossils'. Fossil-fuel combustion has disseminated black carbon, inorganic ash spheres and spherical carbonaceous particles worldwide, showing near-synchronous global increase around 1950. Anthropogenic sedimentary flux changes have intensified, including enhanced erosion through deforestation and road construction. Widespread sediment retention behind dams has amplified substantive delta subsidence.

Geochemical signatures include elevated levels of polyaromatic hydrocarbons, polychlorinated biphenyls and pesticide residues, and increased 207/206Pb ratios from leaded gasoline, largely from ~1945–50. Soil nitrogen and phosphorus inventories have doubled in the past century through increased fertilizer use, generating widespread signatures in lake strata and nitrate levels in Greenland ice higher than any time during the previous 100,000 years.

Atmospheric CO_2 and CH_4 concentrations depart from Holocene and indeed Quaternary patterns from ~1850, markedly from ~1950, with associated steep fall in temperature permanently captured by tree-rings and calcareous fossils. An average global temperature increase of 0.6- 0.9° C from 1900, mostly in the last 50 years, is now rising beyond the Holocene variation of the last 1400 years, along with modest enrichment of oxygen in Greenland ice from ~1900. Global sea-levels increased at 3.2 ± 0.4 mm/ year from 1993-2010, and are now rising above Late Holocene rates. Depending on the trajectory of future anthropogenic forcing, these trends may reach or exceed the envelope of Quaternary interglacial conditions.

CO_2 concentration as indicator of the Anthropocene

The emission of large quantities of a colourless, odourless gas such as carbon dioxide (CO_2) can affect the energy balance at the Earth's surface has reinforced the concern that human activity can adversely affect the broad range of ecosystem services that support human (and other) life (IPCC, 2007; MEA, 2005) and could eventually lead to a 'crisis in the biosphere', cited in (Grinevald, 2007). Taken together, these trends are strong evidence that humankind, our own species, has become so large and active that it now rivals some of the great forces of Nature in its impact on the functioning of the Earth system. The imprint on the environment was also evident in the atmosphere, in the rise of the greenhouse gases CO_2, CH_4 and nitrous oxide (N_2O). Carbon dioxide, in particular, is directly linked to the rise of energy use in the industrial era as it is an inevitable outcome of the combustion of fossil fuels. Between 1800 and 2000, the human population grew from about one billion to six billion, (McNeill, 2000). The fraction of the land surface devoted to intensive human activity rose from about 10 to about 25–30% (Lambin, & Geist, 2006).

Although the atmospheric CO_2 concentration provides a very useful indicator to track the evolution of the Anthropocene (Steffen et al 2007), it

is not particularly useful for identifying a beginning date for the Anthropocene because natural sinks of carbon in the oceans and on land dampened and delayed the imprint of the early industrial period on the atmosphere. For example, atmospheric CO_2 concentration was 283 ppm in 1800 and 284 ppm in 1825 (Etheridge et al, 1998), all of which lie within the range of Holocene variability of 260–285 ppm (Indermuhle et al, 1999). Only by 1850 did the CO_2 concentration (285 ppm) reach the upper limit of natural Holocene variability and by 1900 it had climbed to 296 ppm (Etheridge et al, 1998), just high enough to show a discernible human influence beyond natural variability. Since the mid-twentieth century, the rising concentration and isotopic composition of CO_2 in the atmosphere have been measured directly with great accuracy (Keeling, 1960), and has shown an unmistakable human imprint. Figure 1 shows atmospheric carbon dioxide concentration (parts per million by volume) from 2000 to 2018.

Methane emissions are those stemming from human activities such as agriculture and from industrial methane production. The addition of man-made greenhouse gases to the atmosphere disturbs the earth's radiative balance. This is leading to an increase in the earth's surface temperature and to related effects on climate, sea level rise and world agriculture. Emissions of CO_2 are from burning oil, coal and gas for energy use, burning wood and waste materials, and from industrial processes such as cement production.

Carbon dioxide (CO_2) makes up the largest share of the greenhouse gases contributing to global warming and climate change. Converting all other greenhouse gases (methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6)) to carbon dioxide (or CO_2) equivalents makes it possible to compare them and to determine their individual and total contributions to global warming. The Kyoto Protocol, an environmental agreement adopted in 1997 by many of the parties to the United Nations Framework Convention on Climate Change (UNFCCC), is working towards curbing CO_2 emissions globally.

Types of anthropogenic impact on biodiversity

Human impacts on biodiversity are not single dimensional. Following the Millennium Ecosystem Assessment (MEA, 2005), we identify five broad categories of human impact with the potential for resulting biodiversity trends

to differ by category. Current ecological theory is relatively weak in enabling us to predict how anthropogenic impacts will change biodiversity, so most of our knowledge to date is empirical. The current knowledge of how five different human impacts affect biodiversity are summarized as below:

1. Land-cover change – human-caused land-cover change typically decreases species richness in the changed area. However, by creating more heterogeneous habitat structure, meta-community to biogeo-graphical-scale species richness can increase by, for example, bringing in edge or open habitat species (Laurance et al, 2002). Also, during restoration or recovery from disturbance, species richness often peaks at intermediate successional stages rather than either immediately after change or at the original 'climax' state (Odum, 1969).

2. Chemical release – detrimental pollution often, but not always, decreases richness (e.g., mine tailings (Herna´ndez & Pastor, 2008), insecticides (Brittain et al, 2010), acid rain (Schindler et al, 1989). The effects of fertilizer pollution (i.e., eutrophication) are more complex, with richness both increasing and decreasing depending on various factors (Olde Venterink et al, (2003); Dodson et al, 2000), although the biomass of producer and detrivore levels usually increases.

3. Overharvesting – nonselective harvesting has drastically decreased biomass as well as species richness (Koch & Barnosky, 2006), but selective harvesting of top predators can sometimes lead to predator release with increased biomass or species richness (Paine, 1966). Grazing can increase or decrease plant species richness, depending on interactions with available nutrients (Proulx & Mazumder, 1998).

4. Climate change – although dire predictions of species loss due to climate change have been made (Thomas et al, 2004), it is difficult to prove that any modern species has gone extinct due to current climate change. The paleontological record provides a mixed record of examples, with North American trees losing only a single species (Jackson & Weng, 1999) and North American small mammals gaining species richness due to invasions through the glacial–interglacial cycles of the Quaternary. Tree diversity in Asia shows similar patterns, whereas Europe lost a significant number of tree species during the same period Latham and Ricklefs (1993).

5. Species transport/invasions – with the exception of invasive predators on islands that had not previously experienced predation (Blackburn

et al, 2004) it is difficult to document extinctions of species due to invasions at large spatial scales. Evidence for invasion-caused local-scale extinctions is not unheard of, but also not common (Gurevitch & Padilla. 2004). However, both modern (Gurevitch & Padilla. 2004), Sax & Gaines, 2003) and paleo records (Vermeij 1991) show that large bursts of interchange increase richness at the larger scales.

Thus the effects of anthropogenic impacts on biodiversity are complex and varied. In particular, anthropogenic impacts can both increase and decrease species richness. Until we have a very good understanding of the magnitude of each of these effects in different situations, it would be difficult to tell from averaging across human impacts what the overall trend would be.

The Anthropocene and trends in biodiversity

'How terrible is the biodiversity catastrophe?' is a question many professional ecologists have been asked in some form by lay acquaintances. Rephrased in scientific terms, this is a question about trends in biodiversity: is biodiversity improving (going up) or worsening (going down)? Not coincidentally, governments have posed the same question and identified policy goals for trends in biodiversity. The 2002 United Nations Convention on Biological Diversity (CBD) (Secretariat of the Convention on Biological Diversity, 2010) set out 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level'. Most people assume that biodiversity trends must be strongly negative for a simple reason: we live in the Anthropocene. The movement to name a new geological era 'the Anthropocene' (Steffen et al, 2011) is a recognition of the degree to which humans are now the dominant driver of patterns in global biogeochemistry and biodiversity. Humans have (MEA, 2005):

(i) modified as much as 50% of terrestrial land cover;

(ii) consumed roughly 40% of the Earth's primary productivity every year;

(iii) doubled the annual conversion of nitrogen from inert atmospheric sources into biologically reactive forms and mined so much phosphorous that the drainage of synthetic fertilizers into the oceans has created giant anoxic dead zones;

(iv) emitted enough CO_2 through the burning of fossil fuels that a doubling of the atmospheric concentration is likely in the lifetime of some people alive today;

(v) increased the concentrations of CO_2 and other greenhouse gases with the result that short-term increases in global temperature will overshadow normal annual- to millennial-scale variation; and

(vi) Hunted and fished to such a degree that dominant top predators are absent or endangered on land and sea. The cumulative impact of a population of over 7 billion humans clearly warrants the geological label of Anthropocene.

For ecologists, it is both an interesting intellectual challenge and a pressing question of sustainability, ethics, and policy to understand and predict the effects of these changes on biodiversity. Given the enormous impacts humans are having, it is conventional wisdom that the changes in biodiversity must be large and negative.

Drift in statistics of species in the threatened categories

All of the statistics presented for species only (i.e., they do not include subspecies, varieties or geographically isolated subpopulations or stocks). The major taxonomic groups under consideration are Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi & Protists and plants. The data consists of ten years starting from 2000 to 2018 at an interval of two years.

Species assessed as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU) are referred to as "threatened" species. Reporting the proportion of threatened species on The IUCN Red List is complicated because: not all species groups have been fully evaluated, and some species have so little information available that they can only be assessed as Data Deficient (DD).

Changes in numbers of species in the threatened Critically Endangered (CR) category from 2000 to 2018 (IUCN Red List version 2018-2) for the major taxonomic groups (Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi and Protists and plants) are summarized in figure 2. According to the International Union for Conservation of Nature (IUCN) Red List of threatened and endangered species, one-

quarter of mammal species, one-eighth of bird species, and over 40% of amphibian species are threatened; although much less is known about invertebrates and plants, thousands of these species are also at risk (Steffen et al, 2011). Figure 3 and figure 4 indicates changes in numbers of species in the threatened Endangered (EN) and threatened Vulnerable (VU) categories from 2000 to 2018 for the major taxonomic groups (Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi and Protists and plants). A significant drop can be seen in many fragile taxonomic groups.

The Living Planet Index suggests that vertebrate populations now have 52% fewer individuals than 40 years ago (McClellan et al, 2014). There are discussions of an impending sixth major mass extinction analogous to the previous five documented mass extinctions (Pimm et al, 2014). The great negative impact of humans is so well accepted that many ecologists have largely moved on to exploring questions of the implications for humans of this impending decline of biodiversity (Hooper et al, 2012). However, if we examine the literature on empirically documented trends in biodiversity, a complex picture emerges with many contradictory results. For example, total biodiversity on many oceanic islands, often perceived as among Earth's most fragile ecosystems, has stayed steady or even increased, despite repeated waves of extinction that have accompanied the arrival of humans on islands (Sax et al, 2002). There is considerable empirical evidence that continental biodiversity at regional or local scales is also holding steady or increasing (Sax & Gaines 2003). Three recent analyses (Dornelas et al, 2014; Supp & Ernest 2014) that collectively assembled published data from hundreds of biodiversity inventory studies found that local diversity is, on average, constant. Indeed, almost all human impacts can have positive as well as negative effects on biodiversity. Over much longer timescales, paleontological data show that life is surprisingly resilient (McGill et al, 2005). Many of the direct projections of biodiversity studies versus other sources of information are largely due to comparisons of apples with oranges. Specifically, we argue that achieving an accurate and general assessment of trends in biodiversity depends on the recognition of two key dimensions: the type of biodiversity measured and the spatial scale of the observations. We propose that progress in understanding biodiversity trends depends on explicitly addressing these two aspects.

Conserving Biodiversity at Global Level

Conserving biodiversity spans multiple sectors, from governments and academia to environmental and development non-government organizations (NGOs), to businesses and community groups. Repeated efforts over several decades have included courageous international commitments, including the 2020 Aichi targets enshrined in the United Nations Convention of Biological Diversity (CBD, 2014), and the Sustainable Development Goals for 2030 settled in 2015 (Waage et al, 2015). However, progress to slow biodiversity loss has hindered (Butchart et al, 2010), and it is becoming increasingly clear that neither of these commitments for global biodiversity conservation are likely to be met given estimated increases in human population (Gerland et al, 2014) and consequent hassle for natural resources (Sulston et al, 2013). The severity of environmental challenges facing humanity has led many to suggest that a new approach to biodiversity conservation is needed (Mace, 2014). Perhaps the most down-to-earth option is to incorporate the value of biodiversity into decision-making using economic methods (Atkinson et al, 2012), and yet this idea remains highly controversial (Silvertown, 2015; Neuteleers & Engelen, 2015).

Predicting effects of anthropogenic activities on values of biodiversity

Improving scientific understanding of the links between biodiversity and value should result in improved prospects for biodiversity. However, recent analyses show that while indicators of effective responses are improving (e.g. awareness of the value of biodiversity and establishment of protected areas) the state of biodiversity is deteriorating, according to standard metrics. This suggests that a key challenge moving forward is to identify and overcome the innumerable social, cultural and political obstacles to effective translation of policy into actions and financial resources that benefit biodiversity. To do this, ecologists and conservation biologists need to engage much more strongly with and draw on the social sciences (e.g. political science, psychology and anthropology) as well as the humanities (e.g. history, philosophy and aesthetics).

This in itself will require focused effort by members of all these disciplines to share knowledge and develop common languages and frameworks (Bohan, 2016) . Ultimately, meeting the challenge of

understanding and maintaining the value of biodiversity in the Anthropocene demands a genuinely interdisciplinary approach, one that rigorously unites the social sciences, natural sciences and humanities on the one hand, and researchers and practitioners on the other. At a time of planetary collapse, and political divide, such collaboration and cooperation within and between disciplines and sectors has never been more important.

Conclusion

In summary, further research is required in many areas before we can reliably quantify the impacts of anthropogenic activities on the values of biodiversity and develop robust metrics to guide environmental policy. Similarly, more evidence is needed to support the idea that functional traits extracted from present-day snapshots of ecological networks or assemblages can help us predict the resilience of ecosystems in the face of environmental change.It is the need of hour to effectively translate policies into actions and financial resources that benefit biodiversity.

Anthropocene demands a authentically interdisciplinary approach, researchers and practitioners to combact biodiversity loss. Collaboration and cooperation along with data sharing within Governments, NGOs, and between disciplines and sectors have to be integrated.

References:

Assessment, M. E. (2005). Ecosystems and human well-being: wetlands and water.

Atkinson, G., Bateman, I., & Mourato, S. (2012). Recent advances in the valuation of ecosystem services and biodiversity. *Oxford Review of Economic Policy, 28(1*), 22-47.

Blackburn, T. M., Cassey, P., Duncan, R. P., Evans, K. L., & Gaston, K. J. (2004). Avian extinction and mammalian introductions on oceanic islands. *Science*, *305*(5692), 1955-1958.

Brittain, C. A., Vighi, M., Bommarco, R., Settele, J., & Potts, S. G. (2010). Impacts of a pesticide on pollinator species richness at different spatial scales. *Basic and Applied Ecology*, *11*(2), 106-115.

Butchart, S. H., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J. P., Almond, R. E., ... & Carpenter, K. E. (2010). Global biodiversity: indicators of recent declines. *Science,* 1187512.

CBD. 2014 Resourcing the Aichi Biodiversity Targets. Report of the High-Level Panel on Global Assessment of Resources for Implementing the Strategic Plan for Biodiversity 2011–2020. *Montreal*, Canada.

Corlett, R. T. (2015). The Anthropocene concept in ecology and conservation. *Trends in ecology & evolution*, *30*(1), 36-41.

Dodson, S. I., Arnott, S. E., & Cottingham, K. L. (2000). The relationship in lake communities between primary productivity and species richness. *Ecology*, *81*(10), 2662-2679.

Dornelas, M., Gotelli, N. J., McGill, B., Shimadzu, H., Moyes, F., Sievers, C., & Magurran, A. E. (2014). Assemblage time series reveal biodiversity change but not systematic loss. *Science, 344*(6181), 296-299.

Etheridge, D. M., Steele, L. P., Langenfelds, R. L., Francey, R. J., Barnola, J. M., & Morgan, V. I. (1998). Historical CO_2 records from the Law Dome DE08, DE08-2, and DSS ice cores. *Trends: a compendium of data on global change*, 351-364.

Gerland, P., Raftery, A. E., Ševèíková, H., Li, N., Gu, D., Spoorenberg, T., ... & Bay, G. (2014). World population stabilization unlikely this century. *Science, 346(6206)*, 234-237.

Grinevald, J. (2007). La biosphère de l'anthropocène: climat et pétrole, la double menace: repères transdisciplinaires (1824-2007). *Georg éditeur.*

Gurevitch, J., & Padilla, D. K. (2004). Are invasive species a major cause of extinctions?. *Trends in ecology & evolution*, *19*(9), 470-474.

Hernández, A. J., & Pastor, J. (2008). Relationship between plant biodiversity and heavy metal bioavailability in grasslands overlying an abandoned mine. *Environmental geochemistry and health*, *30*(2), 127-133.

.Hooper, D. U., Adair, E. C., Cardinale, B. J., Byrnes, J. E., Hungate, B. A., Matulich, K. L., ... & O'Connor, M. I. (2012). A global synthesis reveals biodiversity loss as a major driver of ecosystem change. *Nature, 486(7401),* 105.

Indermühle, A., Stocker, T. F., Joos, F., Fischer, H., Smith, H. J., Wahlen, M., ... & Meyer, R. (1999). Holocene carbon-cycle dynamics based on CO_2 trapped in ice at Taylor Dome, Antarctica. *Nature, 398(6723),* 121.

Intergovernmental Panel on Climate Change, (IPCC). 2007 Climate change 2007: the physical science basis. Summary for policymakers. Geneva, Switzerland: IPCC Secretariat, World Meteorological Organization.

Jackson, S. T., & Weng, C. (1999). Late Quaternary extinction of a tree species in eastern North America. *Proceedings of the National Academy of Sciences*, *96*(24), 13847-13852.

Keeling, C. D. (1960). The concentration and isotopic abundances of carbon dioxide in the atmosphere. *Tellus, 12(2)*, 200-203.

Koch, P. L., & Barnosky, A. D. (2006). Late Quaternary extinctions: state of the debate. *Annual Review of Ecology, Evolution, and Systematics*, *37*.

Lambin, E. F., & Geist, H. J. (Eds.). (2006). Land-use and land-cover change: local processes and global impacts. *Springer Science & Business Media*.

Latham, R. E., & Ricklefs, R. E. (1993). Global patterns of tree species richness in moist forests: energy-diversity theory does not account for variation in species richness. *Oikos*, 325-333.

Laurance, W. F., Lovejoy, T. E., Vasconcelos, H. L., Bruna, E. M., Didham, R. K., Stouffer, P. C., ... & Sampaio, E. (2002). Ecosystem decay of Amazonian forest fragments: a 22 year investigat-ion. *Conservation Biology*, *16*(3), 605-618.

Mace, G. M. (2014). Whose conservation?. *Science, 345(6204)*, 1558-1560.

Malhi, Y. (2017). The concept of the Anthro-pocene. *Annual Review of Environment and Resources*, *42*, 77-104.

McClellan, R. et al. (2014) WWF Living Planet Report 2014: Species and Spaces, People and Places, *World Wide Fund for Nature*

McGill, B. J., Dornelas, M., Gotelli, N. J., & Magurran, A. E. (2015). Fifteen forms of biodiversity trend in the Anthropocene. *Trends in ecology & evolution*, *30*(2), 104-113.

McGill, B. J., Hadly, E. A., & Maurer, B. A. (2005). Community inertia of Quaternary small mammal assemblages in North America. *Proceedings of the National Academy of Sciences*, *102*(46), 16701-16706.

McNeill, J. R. (2001). Something new under the sun: An environmental history of the twentieth-century world (the global century series). *WW Norton & Company*.

MEA (Millennium Ecosystem Assessment). 2005 Ecosystems and human well-being: synthesis. Washington, DC: Island Press.

Neuteleers, S., & Engelen, B. (2015). Talking money: How market-based valuation can undermine environmental protection. *Ecological Economics*, 117, 253-260.

Newbold, T., Hudson, L. N., Hill, S. L., Contu, S., Lysenko, I., Senior, R. A., ... & Day, J. (2015). Global effects of land use on local terrestrial biodiversity. *Nature, 520*(7545), 45.

Odum, E. P. (1969). The strategy of ecosystem development. *Boletín CF+ S*, (26).

Olde Venterink, H., Wassen, M. J., Verkroost, A. W. M., & De Ruiter, P. C. (2003). Species richness–productivity patterns differ between N , P , and K limited wetlands. *Ecology*, *84*(8), 2191-2199.

Outlook, G. B., CHM, C. H. M., Cooperation, S. S., Fund, J. B., Protocol, C., Plan, S., ... & Decisions, C. O. P. M. O. P. (2010). Global biodiversity outlook 3. In Montréal, Canada: Secretariat of the Convention on Biological Diversity.(http://gbo3. cbd. int/) Phil. Trans. R. Soc. B (Vol. 9).

Paine, R. T. (1966). Food web complexity and species diversity. *The American Naturalist*, *100*(910), 65-75.

Payne, J. L., Bush, A. M., Heim, N. A., Knope, M. L., & McCauley, D. J. (2016).

Ecological selectivity of the emerging mass extinction in the oceans. *Science, 353(6305)*, 1284-1286.

Pimm, S. L., Jenkins, C. N., Abell, R., Brooks, T. M., Gittleman, J. L., Joppa, L. N., ... & Sexton, J. O. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science, 344(6187),* 1246752.

Proulx, M., & Mazumder, A. (1998). Reversal of grazing impact on plant species richness in nutrient poor vs. nutrient rich ecosystems. *Ecology*, *79*(8), 2581-2592.

Quintessence Consortium. (2016). Networking our way to better ecosystem service provision. *Trends in ecology & evolution*, *31*(2), 105-115.

Sax, D. F., & Gaines, S. D. (2003). Species diversity: from global decreases to local increases. *Trends in Ecology & Evolution, 18(11)*, 561-566.

Sax, D. F., Gaines, S. D., & Brown, J. H. (2002). Species invasions exceed extinctions on islands worldwide: a comparative study of plants and birds. *The American Naturalist, 160(6)*, 766-783.

Schindler, D. W., Kasian, S. E. M., & Hesslein, R. H. (1989). Losses of biota from American aquatic communities due to acid rain. *Environmental monitoring and assessment*, *12*(3), 269-285.

Secretariat of the Convention on Biological Diversity (2010) Global BIodiversity Outlook 3, Secretariat of the Convention on Biological Diversity

Silvertown, J. (2015). Have ecosystem services been oversold?. *Trends in ecology & evolution, 30(11)*, 641-648.

Steffen, W., Crutzen, P. J., & McNeill, J. R. (2007). The Anthropocene: are humans now overwhelming the great forces of nature. AMBIO: *A Journal of the Human Environment, 36(8)*, 614-621.

Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011). The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 369(1938)*, 842-867.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., ... & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science, 347(6223)*, 1259855.

Sulston, J., Rumsby, M., & Green, N. (2013). People and the Planet. *Environmental and Resource Economics, 55(4)*, 469-474.

Supp, S. R., & Ernest, S. M. (2014). Species level and community level responses to disturbance: a cross community analysis. *Ecology, 95*(7), 1717-1723.

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., ... & Hughes, L. (2004). Extinction risk from climate change. *Nature*, *427*(6970), 145.

Vaughan, A. (2016). Human impact has pushed Earth into the Anthropocene, scientists say. *The Guardian*, *7*.

Vermeij, G. J. (1991). When biotas meet: understanding biotic interchange. *Science*, *253*(5024), 1099-1104.

Waage, J., Yap, C., Bell, S., Levy, C., Mace, G., Pegram, T., ... & Mayhew, S. (2015). Governing the UN Sustainable Development Goals: interactions, infrastructures, and institutions. *The Lancet Global Health, 3(5)*, e251-e252.

Waters, C. N., Zalasiewicz, J., Summerhayes, C., Barnosky, A. D., Poirier, C., Ga³uszka, A., ... & Jeandel, C. (2016). The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science*, *351*(6269), aad 2622.

Wilcove, D. S., & Master, L. L. (2005). How many endangered species are there in the United States?. *Frontiers in Ecology and the Environment, 3(8),* 414-420.

World Open data bank (https://data.worldbank.org/indicator/EN.ATM.METH.KT.CE ? contextual = default &end=2012&start=1970&view=chart)

Figures

Figure 1: Atmospheric carbon dioxide concentration (parts per million by volume) from 2000 to 2018.

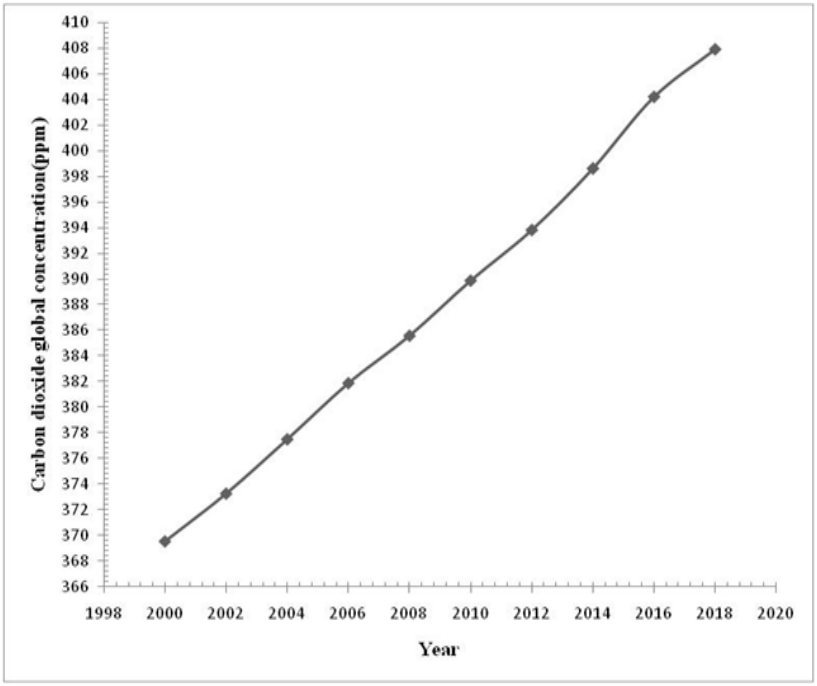


Figure 2: Changes in numbers of species in the threatened Critically Endangered (CR) category from 2000 to 2018 (IUCN Red List version 2018-2) for the major taxonomic groups (Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi and Protists and plants)

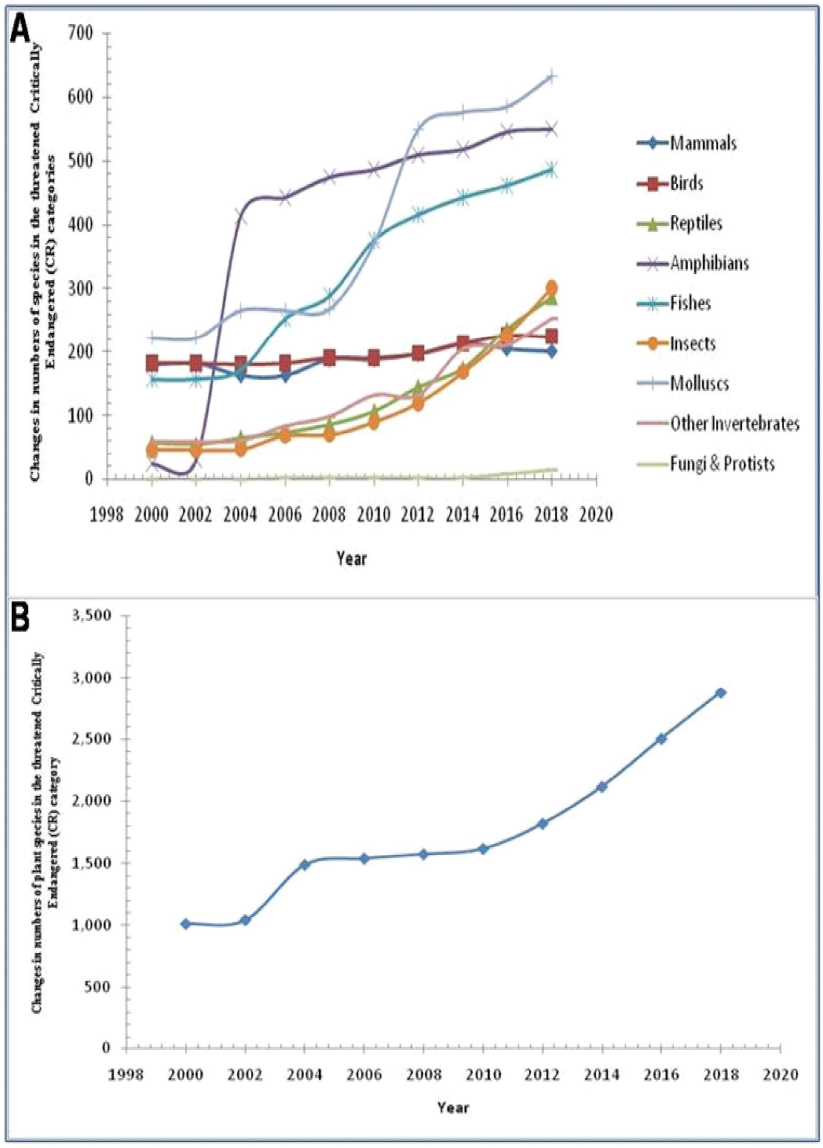


Figure 3: Changes in numbers of species in the threatened Endangered (EN) category from 2000 to 2018 (IUCN Red List version 2018-2) for the major taxonomic groups (Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi and Protists and plants).

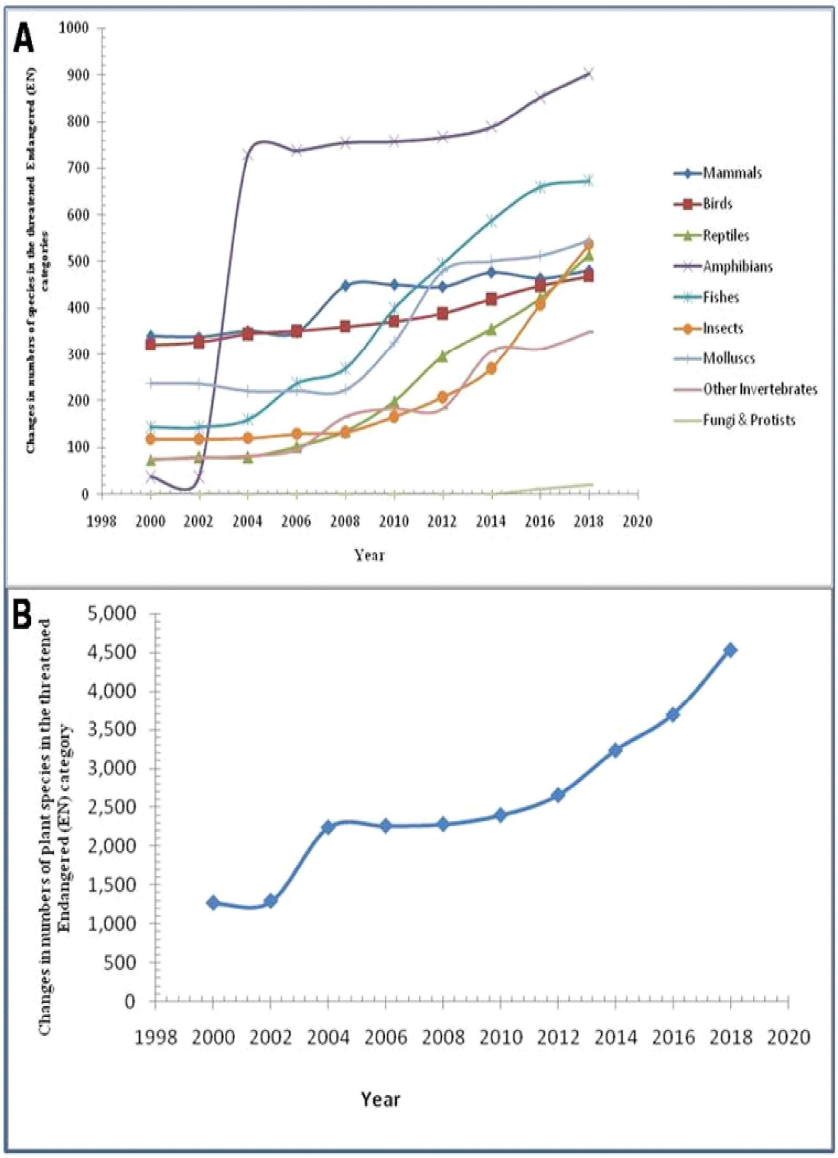
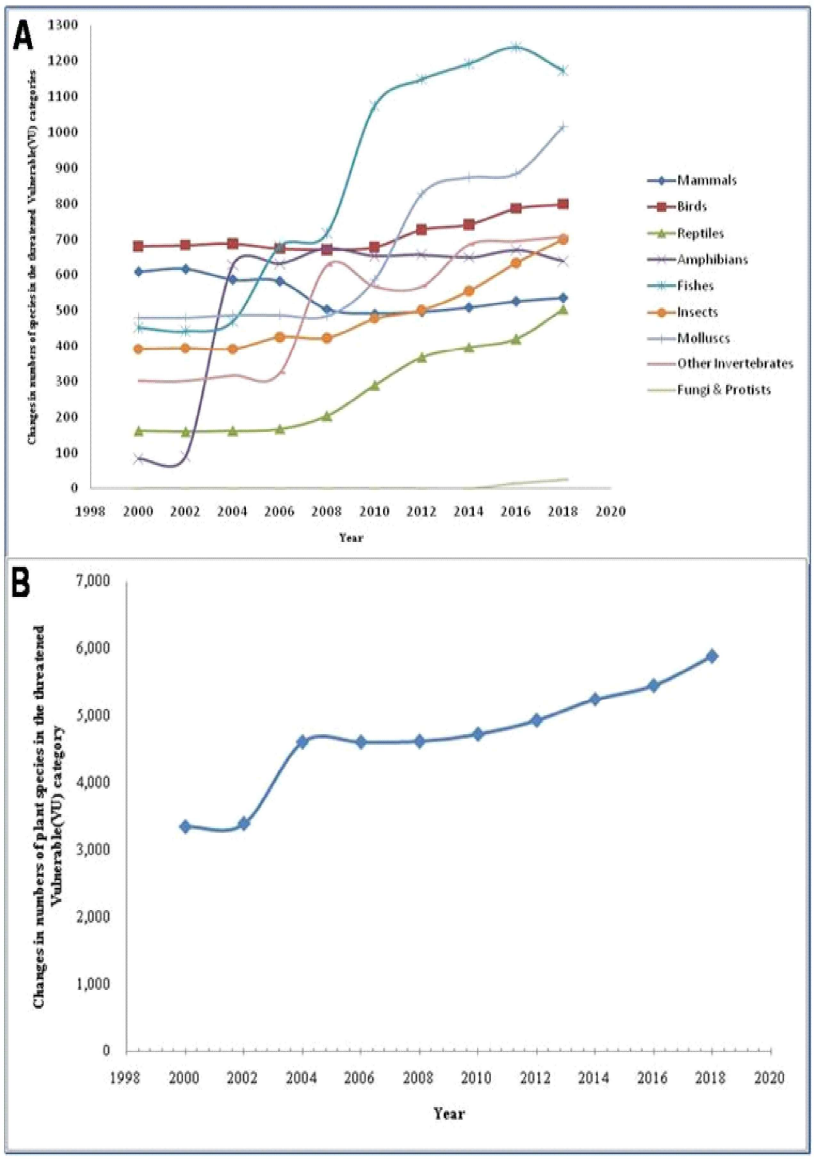


Figure 4: Changes in numbers of species in the threatened Vulnerable (VU) category from 2000 to 2018 (IUCN Red List version 2018-2) for the major taxonomic groups (Mammals, Birds, Reptiles, Amphibians, Fishes, Insects, Molluscs, Other Invertebrates, Fungi and Protists and plants)



7

Plasma technologies for municipal solid waste treatment

Krishna Gopal[a], Akshta Rajan and Akhileshwar Prasad Singh

Department of Physics & Electronics, Rajdhani College, University of Delhi, Delhi-15

[a]Email:kgopal874u@gmail.com

Abstract: Plasma is a quiasunuetral gas of charged particle which exhibit collective behavior. Plasma based technologies treat the municipal solid waste and remove impurities and contaminants from air and water by the use of an energetic plasma created from gaseous species. Gases such as argon and oxygen, as well as mixtures such as air and hydrogen/nitrogen are being used to produce plasmas. Conventional methods of municipal solid waste treatment certainly do not solve problems upto a significant level because of the harmful residues such as ash, dust, gases left behind cannot be filtered off even with the usage of innovative technologies. Present review describes the plasma arc technology for solid waste treatment and compares it with conventional methods of the treatment. The plasma is not applied to the waste directly, but used as a source of very high temperature for the waste nearby which is therefore heated rapidly and substantially by radiation. By increasing the temperature of the solid waste, organic

components are broken down into simpler atoms/molecules and inorganic components are melted into a glassy slag. Plasma methods of the solid waste treatment are more flexible than incineration because it can be modular. Air pollution control technologies for acid gases (NOx and SOx, etc.), volatile organic compounds, greenhouse gases, ozone layer depleting substances, etc. have been commercialized based on the hybrid technologies catalysis, incineration and adsorption methods.

1. Introduction

In Physics and chemistry, plasma is an ionized gas containing electron, ions and neutral atom characterized by the collective behavior. In general, plasma can be classified as thermal and non-thermal plasmas [1]. In thermal plasmas, all plasma species are in local thermal equilibrium, i.e. all species have same temperature. In other types of plasmas, most of the coupled energy is primarily releases to the free electrons which exceed the temperatures of the heavy component (ions and neutral) by orders of magnitude. Hence, the collections of energetic electrons in relatively cold ions and neutrals are called non-thermal plasmas. In general, plasmas can be generated by applying an electric field to a neutral gas when applied field exceeds certain threshold (breakdown strength) a gas discharge and thus plasma is formed. Plasmas can be generated with different characteristics according to type of the pollutants. Thermal and Non-thermal plasma based pollution control technology can assist in reducing the health and economic impacts in future. Environmental pollution not only affects the human health but also the economy, where approximately 0.06–0.09% of the population experiences premature death caused by air pollution [2] and 2.5 to 3 times these numbers are admitted to hospitals. Economic development, globalization and rising living standards have increased the quantity and complexity of generated waste, while industrial diversification and the provision of expanded health-care facilities have added substantial quantities of industrial hazardous waste and biomedical waste into the waste stream that have severe environmental and human health consequences.

Air pollution can be controlled by using non-thermal plasmas, solid and liquid wastes treatment by thermal plasmas and drinking and waste water treatments by thermal and non-thermal plasma methods [3-8]. The majority of plasmas operate under atmospheric gas pressure and higher electron

temperature. Normally, the gas temperature above combustion temperature (2300K) is deûned as thermal plasma since the discharge plasma is mainly sustained by thermal ionizations [9]. Plasmas, which have temperature below 2300K, can be termed as non-thermal plasma and discharge is mainly sustained by electron impact ionizations. Present review describes the plasma arc technology for solid waste treatment and compares it with conventional methods of the treatment.

Plasma-arc technology was developed during the late 1800s to provide extremely high temperatures and it employed in the metallurgy industry. In early 1900s, plasma heaters were used in the chemical industries to manufacture acetylene from natural gas. Plasma-arc heaters have also been used in NASA Space program in early 1960s for simulating and recreating the extreme high heat of re-entry into the earth's dense atmosphere encountered by spacecraft from orbit. Large-scale industrial plants were built and commissioned for the development of plasma arc technology during 1980s by various companies like Pyrolysis Systems Inc (Canada), Siemens (Germany), Plasma Energy Applied Technology Inc (USA), Plasmapole (France) etc.

2. Basic Principle for plasma gasification

In general, an electrical arc produces, when relatively high voltage or high current electricity is passed between two electrodes which are spaced apart. Inert gas under pressure is passed through the arc into a sealed container of waste material that creates very high temperatures around 14,000 °C in the arc column. Temperature at few feet from the plasma torch is quite high as 2,800-4,500 °C. Most of the wastes dissociate into basic elemental components in a gaseous form, and complex molecules are separated into individual atoms at very high temperature. Plasma arc (from electrical input) has been in used for many years as the part of waste disposal/destruction. When solid waste exposes to very high temperatures around 3000-4000 ^{o}C , the organic components are broken down into simpler atoms/molecules and inorganics are melted into a glassy slag. When this operates in oxygen containing atmosphere or in air, the organic components burn to produce CO_2 and water. In the absence of oxygen, the process is termed as 'plasma gasification' and it produces a combustible gas, made up mainly of carbon

monoxide (CO) and hydrogen which can be cooled and treated for use in other equipment. Some of the metals include mercury most of the time and others such as cadmium, lead etc. these metals evaporate at the high temperatures and leave the exit gas stream from which they will need to be condensed/removed. Precursors to dioxins/furans will be destroyed at the high operating temperatures; though care is necessary to avoid them reforming as the gas stream is cooled. In present plasma gasification plants, the temperature level has been reduced to optimize power use that gives favorable conditions for volume reduction of ash (as an inert glassy slag for beneficial use) and destruction of toxic components in flue gases.

3. Plasma Gasification System

The design of plasma gasification plant is not standardized and various companies engaged in their manufacture custom build the facility as per customers' specifications. However, following are some of the essential parts of gasification system for waste treatment.

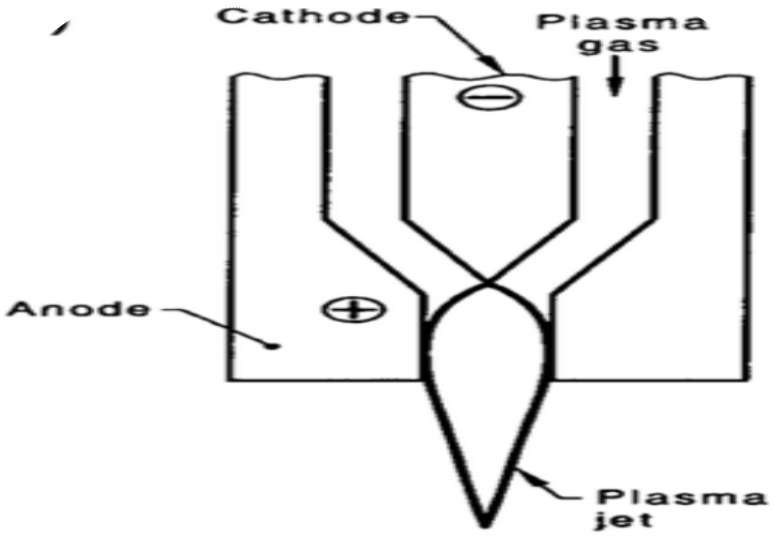
3.1 Trituration and Conveyor Section

This section of the gasification consist a grinder or crusher for breaking the trash into manageable size for handling by conveyor, which through it to the plasma furnace.

3.2 Plasma Torch

In gasification system, Plasma is being produced by a device called plasma torch or plasmatrons. It can produce extremely high temperatures that cannot be otherwise created except through nuclear fusion/fission. By passing a DC current between the cathode and the anode of the plasma arc torch and simultaneously passing of air in the annular space of the torch, an extremely high-temperature environment is created ranging in temperature from 5,000 ^{o}C to 10,000 ^{o}C. Manufactured plasma torch can be classified as DC, AC or RF torches depending on the primary source that can be a direct current, alternating current at mains frequency, or at radio frequency. Generally, a conventional DC plasma torch comprises a tungsten cathode and a water-cooled copper anode that shaped in the form of a nozzle.

Fig.1. Plasma torch mentioned in the form of its component (a) cathode (b) plasma gas (c) Anode (d) plasma jet



Cathode and anode separates by an insulator that also consist an inlet for working gas to produce plasmas. When a gas is injected in the electrode gap and a dc arc is established between the electrodes, the arc is pushed through the nozzle resulting in a high temperature, high velocity flame. The body of the torch consists of cooling chambers for cathode and anode. The torch is supplied with water and power through water-cooled cables which are in turn coupled to the main power supply and water heaters. Fig. 1 shows the different parts of a plasma torch.

3.3 Pyrolysis Chamber

It is an air-locked chamber having one or more plasma torches. It allows the garbage in but ceases hot gases from escaping in to the atmosphere. The chamber is lined with heat-resistant refractory material. Drainage system for slag is present at bottom side of the chamber. It also incorporates a water-cooling system. The exit vent for the gases is placed at the top of the chamber.

3.4 Gas Reformer and Heat Exchanger

The gas reformer convert hydrocarbon fuel into a reformate gas such as hydrogen-rich gas known as synthesis gas (syngas) or producer gas. In the heat exchanger, the hot gases heat water to produce steam turbine coupled to a generator to produce electricity.

3.5 Gas Clean-up Filter

The produced gases by the pyrolysis mainly comprise carbon monoxide (25 %), hydrogen and hydrocarbons (15 %) and carbon dioxide and nitrogen (60 %). Later, it requires to 'clean' the syngas or producer gas. It is done using gas clean-up filter. Thereafter, the gas is burned in internal combustion (IC) engine generator sets or turbines to produce electricity.

4. Basic process of Plasma gasification

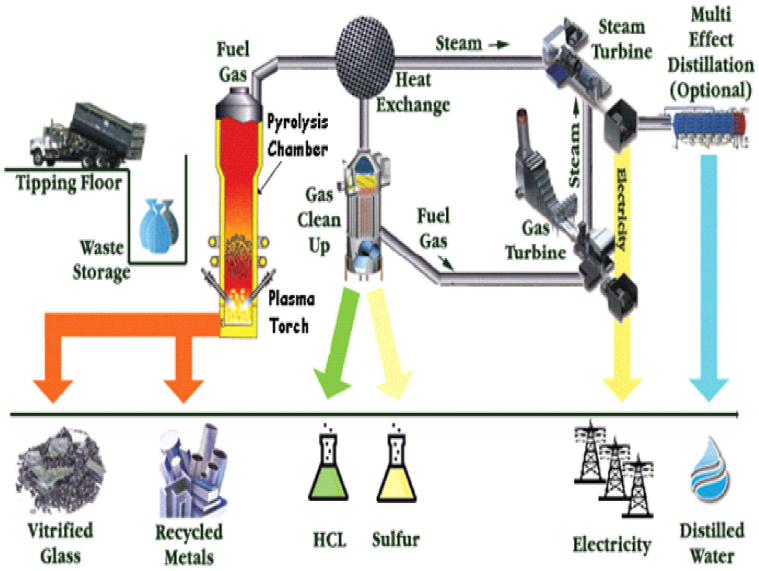
Initially, the waste is passed through crusher and grinder that reduce the waste size accordingly. The crushed waste is fed in to the pyrolysis chamber from the top. One or more plasma torches are installed in the chamber. Since plasma reactor operates in an oxygen starved environment, combustion process does not take place. With core temperature running up to 10,000 ^{o}C, plasma is able to breakdown toxic compounds within milliseconds, avoiding the formation of secondary combustion products including the polluting flue gas. The molecular dissociation starts above 2700 ^{o}C and temperature below this will produce incomplete dissociation. Thus, with the temperatures achieved in a system (above 2700 ^{o}C), all the molecules are totally dissociated.

For waste processing, the plasma arc is not applied to the waste itself, but used as a heat source of very high temperature for the nearby waste which is therefore heated rapidly and substantially by radiation, though not to the full temperatures of the plasma. Both organic and inorganic wastes including industrial, biomedical, and nuclear and e wastes can be processed at atmospheric pressure using this technology. The extreme temperatures generated using a plasma torch system, transform the organic matter into basic gases such as synthetic gas (syngas – a mix of hydrogen and carbon monoxide gas. This synthetic gas is almost a green fuel, which is used by advanced gas turbines for the generation of electrical power.

The inorganic materials are simultaneously melted into molten slag, which upon cooling becomes a vitrified, inert glass-like material (through

magmavication process) that can be used by the construction industry. The homogenous and sulphuric products contained in the feed are transformed to hydrochloric acid (HCl), hydrofluoric acid (HF) and hydrogen sulphide (H_2S). Suitable neutralization techniques for these three products are employed. No ashes are produced in the process. Syngas is made up of carbon monoxide, hydrogen, water and nitrogen. Small amounts of chlorine, hydrogen sulfide, particulate, carbon dioxide and metals with boiling points less than 2280º F are contained in the gas. Because of the low oxygen atmosphere and high temperature, the base elements of the gas cannot form toxic compounds such as furans, dioxins, NOx, or sulfur dioxide in the reactor. As the gas exits the reactor, it first goes to a gas reformer and then it is cooled in a series of high temperature heat exchangers. The sensible heat is reduced to about 270º F and is used to generate high-pressure steam that is fed to a steam turbine to produce electricity. All essential components of a plasma gasification plant are show in Fig. 2.

Fig 2. Complete Set up of plasma gasification plant [10].



1. Products from Plasma Gasification System

The three major by-products of the plasma gasification process are syngas, vitrified glass and electricity. The by products are explained below:

5.1 Syngas

Syngas (from *synthesis gas*) is basically referred as the mixture of gases. It consists of primarily the hydrogen, carbon monoxide, and very often some carbon dioxide. It has less than half the energy density of natural gas. Since syngas is combustible, it can be used as a fuel source or as an intermediate for the production of other chemicals.

1.2 Vitrified Glass

The inorganic fraction in the waste melt and forms an inert vitrified glass that has excellent applications in the construction industry, including concrete aggregate, road bed/fill and sandblasting.

5.3 Electricity

High-pressure steam from the heat exchanger goes to a steam turbine where it is converted to electricity. Generated electricity from the steam source provides most of the power needed for the functioning of the internal power plant requirements. Therefore, by-products from the gasification process are quite capable to fulfil all internal requirements for the functioning of the plant.

2. Comparison of Conventional technology With Plasma Arc Technology

Incineration is the conventional method to burn the waste material in the presence of oxygen. Incinerators have significant air emission control problems. It has been reported that the incinerator works at low temperatures (400–500°C) in Delhi waste treatment plant. There remains a possibility of the pathogens survival if the incineration is incomplete or done at low temperature. An ample Airflow is the key requirement to enhance the combustion process in the incinrators . The demand for excess airflow limits the temperature that is achievable. Due to insufficient temperature generated in the process chamber, incinerators produce extremely toxic

products like furanes and dioxins. This can cause air pollution or the toxic pollutants can remain in the bottom ash, eventually finding their way into landfills. Whereas, in case of plasma waste treatment, very high temperatures are obtained and complete dissociation of waste takes place. Thus, no residue is formed which is to be again treated as waste.

3. Economic price estimation for the waste treatment

Here, it requires averages 670 electrical power units (kWh) for conversion of one ton of municipal solid waste into vitrified solids, metals, hydrogen and carbon monoxide gas. At Rs 4 per unit, the cost of conversion works out to be Rs 2600 per ton. Although one may be able to reduce the running cost by, say, 75 per cent, after selling the byproducts, the net cost of the plant would still be Rs 1000 per ton. Here, we consider Delhi for cost estimation with its current population of over 17 million. The average garbage generation may be around 0.7 kg per person each day in Delhi while Americans' average of about 2 kg per person per day). Accordingly, Delhi would be generating around 12,500 metric tons of garbage per day. The net operational cost would thus be Rs 8.875 million per day (at Rs 800 per ton) or Rs 2950 million per annum. This is in addition to garbage collection and transportation and other infrastructure costs. A Startech plasma converter that could handle 1900 tons of waste daily costs roughly $240 million. Delhi would require ten such huge plants at a whopping cost of $100 million (roughly Rs 44 billion) .

4. Impact on Environment

Plasma gasification process uses very high temperature plasma to disrupt the waste. Carbon based waste is almost converted to the fuel gas, therefore, plasma gasification is considered as closest technology available that produces no hazardous waste. All the tars, char and dioxins are broken down because of the temperatures and drastic conditions involved in the waste treatment process. The gaseous output from the reactor is cleaner and there is no ash at the bottom of the reactor, while there are no by-products that end up to landfills provided that there are available markets for the produced slag. The use of plasma gasification processes reduce methane emissions produced from the disposal to landfill sites.

5. Advantages and disadvantages of plasma gasification

system

Plasma technologies have major advantages in comparison to the conventional technologies: It creates less atmospheric pollution compared to combustion/incineration technology. Since the system works in absence of oxygen, oxides of nitrogen and sulphur are not emitted during normal operations. Toxic materials become encapsulated and are therefore much safer to handle than the toxic ash left by combustion process. Since the plasma arc would instantly convert organic materials into synthetic gas, often called 'Syngas', and melt inorganic materials, which when cooled become rock-like and can be sold as construction materials. It disposes waste materials very quickly. Present technology can be utilized to run large scale waste treatment plant with less running cost.

The major disadvantages of plasma gasification technique can be described as: The installation cost of the solid waste treatment plant is quite high as its average cost of for setting a plasma gasification plant is about Rs. 1-1.2 million. Volatile metals that obtained as byproduct after treatment can leads to the vaporization and it might mixes in the main air stream. The materials of construction of the unit and the air management system will have to be designed to handle these materials if they are introduced into the unit. The electrodes used for plasma arc are consumed gradually during the waste melting cycle. They should be replaced regularly.

6. CONCLUSION

Plasma-based arc technologies are being used widely for solid waste treatment that emits non-hazardous by-products in the form of syngas and rock type material. Since, installed plant has high net energy input (i.e. high operating cost) and high capital costs, it seems uneconomic for more general wastes. Recently, modified designs of the plasma based plant have been developed with optimized parameters to take advantage of the perceived environmental credentials, compact footprint and potential for high conversion efficiency when the 'syngas' is used with downstream power generation equipment. Now, the by-products from the solid waste treatment plant are being offered in the form of electrical output and claimed low capital and operating costs of the plant.

References

F. F. Chen, "Introduction to Plasma Physics and Controlled Fusion," Plenum Press, New York (1984).

J. S. Chang, J. Electrostat. **57 273**–19(2003).

K. Urashima and J. S. Chang, IEEE Trans. Dielectr. Electr. Insul. **7** 602–14(2001).

M. B. Chang and J. S. Chang Ind. Chem. Eng. Res. **46** (2006).

H. H. Kim, Plasma Process. Polym, **1** 91–110 (2004).

J. S. Chang, Sci. Technol. Adv. Mater, **2** 571–6 (2001).

B. R. Locke, M. Sato, P. Sunka, M. R. Hoffmann and J. S. Chang, Ind. Chem. Res, **45** 882–905(2006).

J. S. Chang, Plasma Sources Sci. Technol, **17,** 045004 (2008).

T. G. Beuthe and J S Chang , Japan. J. Appl. Phys, **38,** 980605(1999).

https://www.bioenergyconsult.com/msw-to-energy/

S. K. Neema and K.S. Ganeshprasad, Current Science, **83(3)** 271-278(2002).

K. C. Bhasin, Electronics for You **41(1)** 115-122 (2009).

8

Solid Waste Management and Environmental Sustainability in Surat City, Gujarat

Latambika Sapawat,
Department of Geography, University of Delhi, Delhi

Abstract

The present study reflects solid waste management and environmental sustainability in the Surat city of Gujarat state. Study was conducted to know why the Surat city is performing well in solid waste management and how other cities of India can learn from the Surat. Paper shows the municipal status of solid waste in city. Paper talks about how people dispose these wastes. In result, it was found that people of Surat city are matured enough as maximum of them opts garbage truck for disposing wastes. Door to Door system is doing good in maintaining the cleanliness of city. Paper talks about environmental challenges in city. In result, it was found that not major environmental problems are there in city except in some isolated areas like slums and newly merged areas. People are much aware of harmful effect of throwing garbage, health risk related to wastes and presence of rodents and insects due to illegal disposal of garbage. As a result, they refrain from throwing wastes openly. Surat Municipal Corporation (SMC) is also playing vital role in maintaining healthy environment of city. SMC has achieved distinction in converting wastes into fuel and compost. Proper utilization of

public private partnership has helped municipality in maintaining efficiency in collecting and disposal of garbage and conversion into fuel and compost effectively. The study reveals that people are less aware about their garbage disposal by authority. If awareness is spread among people it could promote in segregation of waste into dry and wet waste at source easily. This will make work for municipality easier in terms of recycling and disposing the waste. This paper has shown that how combination of people participation with good governance can help in maintaining good environment of city.

Keywords: Solid Waste Management, garbage disposal, door to door initiative, environmental sustainability, garbage segregation.

1. INTRODUCTION

The population of the urban centres is continuously increasing due to industrialization and migration from the surrounding rural areas. The increase of urban population is a scenario of the whole world. As a whole, the world urban population increased by 100 times during the last 200 years, while total population increased only by 6 times in the same period (Simone et. al., 2001). As the human population increases in urban areas many social and environmental problems emerge. One of the major problems associated with urbanization is the problem of waste. The term "Waste" was defined for the first time by European Council in their guidelines EU Directive 75/442/EEC which is amended as per new guideline published in 2008. According to this guideline, "Any substance or object the holder discards or intends to discard or is required to discard" is waste under the Waste Framework Directive (European Directive: 2008/98/EC). Around the world, waste generation rates are rising. In 2016, the world's cities generated 2.01 billion of solid waste, amounting to a footprint of 0.74 Kg per person per day. With rapid population growth and urbanization, annual waste generation is expected to increase by 70 percent from 2016 levels to 3.40 billion tonnes in 2050. United Nation through Sustainable development goals (SDG) has emphasized on the proper solid waste management in many sub-goals, like SDG 3: good health and well-being has goal to reduce illness from hazardous chemicals and air, water and soil pollution and contamination; SDG 6: Clean water and sanitation also weights on proper SWM as target on eliminating dumping and minimizing release of hazardous materials so that water quality could improve; SDG 7: Affordable and clean energy emphasize on SWM technologies which can drive renewable energy from organic waste; SDG

11: Sustainable cities has goal to ensure access for all to adequate, safe, and affordable solid waste collection services; SDG 12: Responsible consumption and production emphasize on proper environmentally management of all wastes generated by human in order to minimize their adverse impact on human health and the environment; SDG 13: Climate action talks about adapting adequate SWM practices that can prevent emission of large amount of greenhouse gas and lastly SDG 14: Life below water emphasize on eliminating of uncontrolled dumping of SWM in oceans to prevent marine pollution (Sustainable Development Goals, 2015).

Waste can de differentiated in the form of gaseous, liquid and solid waste. Concern of this paper is on solid waste. Solid waste is defined as the organic and inorganic waste materials produced by households, commercial, institutional and industrial activities that have lost their value in the eyes of the first owner.' (Marijik, 1994). It is also defined as "material that no longer has any value to a human being who is responsible for it, and is not intended to be discharged through a pipe line." (Cointreau, 1982). The solid waste includes the material of organic and inorganic in composition. It could be classified as residential wastes, commercial wastes, municipal wastes, industrial wastes and agricultural wastes. In India as the cities are advancing, materialistic life is generating solid waste on huge amount. Surat is also facing same problem of uncontrolled solid waste generation. This paper will look into the types of waste generated in Surat city.

Solid Waste Management (SWM) defined as the application of techniques to ensure an orderly execution of the various functions of collections, transport, processing, treatment and disposal of municipal solid waste. (Zia and Devadas, 2008). Solid Waste Management is a complex task which depends as much upon organisation and cooperation between households, communities, private enterprises and municipal authorities as it does upon the selection and application of appropriate technical solutions for waste collection, transfer, recycling and disposal (Peter et al, 1996). This paper will look into how solid waste in managed in Surat city and what are its implication on cities environmental sustainability.

2. STUDY AREA

Surat is a city in the Indian state of Gujarat. The city is located in the south of Gujarat (Figure 1) and its Latitude and Longitude points are 21.1700° N, 72.8300° E. The city is located 306 km south of the state capital, Gandhinagar;

265 kilometres south of Ahmedabad; and 289 kilometres north of Mumbai. The Surat municipal corporation has many roles in maintaining the administration in the city. In Surat city, Surat Municipal Corporation provides various public services by decentralising way, hence zonal system has been implemented so that people of Surat can utilise public services with ease and convenience. City is divided in 7 zones (Figure 2), named as west zone, centre zone, north zone, east zone, southwest zone, and south east zone (District Census Handbook, Surat, 2011).

Figure 1: Location of Surat city in Gujarat

Source: Census of India, 2011

Figure 2: Zone Map of Surat City

Source: Census of India, 2011

Surat is a port city situated on the banks of the Tapti river. It has an average elevation of 13 meters. The Surat district is surrounded by the Bharuch, Narmada (North), Navsari and Dang (South) districts. To the west is the Gulf of Cambay. The River Tapti flows from the East to the West and is second largest inter-state rivers, spread across the areas of Maharashtra, Madhya Pradesh and Gujarat.

Surat has a tropical Savanna climate (Köppen: Aw), moderated strongly by the Sea to the Gulf of Cambay. The summer begins in early March and lasts till June. April and May are the hottest months, the average maximum temperature being 40 °C (104 °F). Winter starts in December and ends in late February, with average temperatures of around 23 °C (73 °F). Sufficient amount of rain falls here. Monsoon begins in late June and the city receives about 1,000 millimetres (39 in) of rain by the end of September. Dominantly, the soils are very deep, well drained and fine and medium textured. They are slightly alkaline, slight to strong saline. Soil depth in Surat is well distributed in two parts. The Soils in western side are dominantly very deep followed by moderately deep and in eastern part soils are dominantly shallow followed by moderately shallow. Soil structure of Surat varies from clayey to loamy clay. Soil salinity in Tapi region is little bit strong in nature. Surat is one of the districts in southern districts of the state have a sizable area under forest. Moist deciduous forests occur in Surat division. These forests

are not evergreen and shed their leaves during March and April, through the under-wood and shrub cover are fairly green. Teak is an important species which drops its leaves only in the cold weather in localities which are relatively dry or cold, but is almost evergreen in the moistest parts of its distribution. Teak needs a moderately good rainfall and a well-drained terrain. The associates of teak in the moist deciduous forests are Terminalia tomentosa and Anogeissus latifolia.

According to the 2011 India census, the population of Surat is 60,81,322. Surat will be the most populous city in Gujarat by 2023 and Surat city's population is likely to grow at a rate of more than 60 percent, and Since Surat's growth rate is above 60 percent, it will continue growing faster than Ahmedabad's below 30 percent population growth. The initial provisional data released by census India, 2011, shows that density of Surat district for 2011 is 1,337 people per sq. km (District Census Handbook, Surat, 2011). In 2001, Surat district density was at 968 people per sq km. Surat district administers 4,549 sq km of areas. As the population is increasing problem of solid waste management is rising and its implication on environmental sustainability is matter of concern. Thus, the Surat city is selected for the study.

3. DATA SOURCE AND METHODOLOGY

The study is based on both primary and secondary sources of data. The secondary data has been collected from Surat municipal corporation (solid waste department), thesis and reports of Central Pollution Control Board (CPCB). Besides, books, journals, articles, internet websites were also consulted. For primary data a set of questionnaires has been prepared and according to that people responses have been gathered. For this simple random sampling technique has been chosen, total 100 households have been selected randomly.

Status of solid waste has been acquired on the basis of secondary data collected from Surat municipal corporation. Problem related to solid waste management has been figured out through collection of primary data. Information on types of waste collected, their disposal methods, waste management practices have been collected through gathered respondent's answers and solid waste department, Surat. These collected data and feedback of the respondents gathered from questionnaire have been presented through tables and simple diagram like bar diagram and pie diagram.

4. RESULT AND DISCUSSION 4.1 MUNICIPAL STATUS OF SOLID WASTE

Population of more than 6 million living in Surat city has many aspirations and desires. With the passage of time desires are changing, so the consumerism is also increasing, changing of lifestyle and increase in production and consumption has changed the nature of wastage quantitatively and qualitatively. According to report of Central Pollution Control Board (CPCB), per capita was generation in Surat city is 400 gram/day. Wastes are disposed through door to door garbage collection system and container lifting system.

Table 1: Existing Status of Solid Waste Management (SWM) in Surat, 2013 Head 2013

Total quantum of solid waste generated (MT)	1434
Total quantum of solid waste collected and transported (MT)	1350.28
% of garbage handled by SMC	75
% of garbage handled by Contractor	25
Generation per person (gm/day)	400
Efficiency in % (Collection/Generation)	94.16
Density of Waste (kg/m3)	533

9

Textile Dye-Environment-Human Interactions : Emerging Risks to Environmental Health

Pankaj Poria, Harveen Kaur, Deepak Rawat, Vandana Mishra*
Department of Environmental Studies
Bioresources & Environmental Biotechnology Laboratory
University of Delhi, Delhi-110007
(* Corresponding author: Dr Vandana Mishra, mistletoe_h@hotmail.com)

Abstract

Chemical dyes drive the growth of different industries, especially of the developing countries including India and China. Among various industries, the textile industry uses >50% of the dyestuff of global market, which include >1,00,000 commercially available dyes belonging to different structural classes, such as, acidic, basic, disperse, azo, anthraquinone and metal complex dyes. Due to complex structural class, the dyes are resistant to degradation by light, water, and biotic factors. Intermediate degraded products of dyes in the industrial effluent act as genotoxicants, mutagens, and carcinogens, therefore, cause occupational and environmental hazards to human and other living organisms. In human, dyes cause respiratory

sensitization, allergic contact dermatitis, and other maladies. Health safety of the industrial workers and environmental security of water bodies have become a matter of great concern for ecologists, industrialists and policy makers. The dyes severely affect the water bodies as they deteriorate the aesthetic value, reduce light compensation points, lower the biological productivity, and cause ecotoxicity at different levels of biological organization. Also, the dyes and associated heavy metals contaminate groundwater and thus reduce the cost of prime land. Though the dye color has been considered as a major environmental threat, we critically evaluated the scientific literature and demonstrated the dye metabolites as more potent environmental and health hazards which need immediate attention.

Keywords: textile dyes; human health impacts; environmental impacts.

Email IDs of Authors:

Pankaj Poria: poria.pankaj10a@gmail.com

Harveen Kaur: harveenk6@gmail.com

Deepak Rawat: deepak.rawat.2509@gmail.com

Vandana Mishra: mistletoe_h@hotmail.com

Contents

1. Prevalence of dyes in the environment: An emerging challenge

The production and consumption of dyes have increased exponentially during the past decades. Developing nations like India, China, and other Asian economies have become a major hub of textile industries, especially in the dyeing sector (IHS Markit, 2018). Different classes of dyes are being produced with the maximum production of reactive and disperse dyes. Almost 320 thousand metric tons of dyes and pigments were produced in the fiscal year 2017, up from 240 thousand metric tons in 2014 (Statista, 2017). This ever increasing usage of dyes has grave repercussions for the environment.

Textile dye effluents have severely impacted the biosphere, hydrosphere and lithosphere of earth system (Gupta et al., 2017; Rawat et. al., 2016). Starting from the water body in which the effluents are disposed off to the surrounding land and soil, all have been severely affected. Moreover, even living organisms have shown drastic changes due to exposure to dyes, both direct and indirect, causing severe health implications (Hassaan et al., 2017; Lowry et al., 1980; Rajaguru et al., 2002). Despite >3 decades of extensive research on the effects of dyes, these efforts fail to bring about noticeable changes due to poor documentation, therefore the need for this review arises for a comprehensive study of the environment and human health challenges of textile dyes.

2. Methodology

We searched online databases viz. Scopus, Pubmed, and Web of Science and further retrieved research papers on the effect of usage of dyes on humans and the environment. To examine the effect of dyes on human health, we analyzed research papers on case studies of occupational exposure to textile dyes and extrapolated studies on cell lines, rat/mice and other animal models.

3. Results and Discussion

3.1 Impact of dyes on the environment

3.1.1 Impact of dyes on the aquatic ecosystem

The textile industry is a highly water-intensive industry with a significant portion of the water being used in the dyeing sector. This indiscriminately high usage leads to equally high pollution of water bodies (Rawat et al., 2018; Singh et al., 2017). Up to 200 tons of water is polluted in the production of 1 ton of fabric during traditional dyeing and finishing processes (Moore et al., 2004). The effluent released by the industry is characterized by its high BOD, COD, TDS, and presence of heavy metals like chromium and is often colored due to the presence of raw dyes (Carneiro et al., 2010). Colorants in dyes reduce the aesthetic quality of the water body, whereas high TDS of effluent increases the turbidity of water body resulting in reduced penetration of sunlight in water and thereby in low photosynthetic activities in submerged plants. High levels of nitrates and sulphates in textile effluent accelerate eutrophication of water body (Lunau et al., 2012). Sharma et al. (2005) monitored the response of aquatic macrophytes towards textile industry wastewater and observed that plant growth was adversely affected. The shoots of submerged macrophytes became highly brittle with one of them losing almost all its leaves. Also, the dry weight of the plants got reduced markedly (Fig. 1). In fact, the dye wastewater showed similar toxic effects on free floating and emergent macrophytes, except *Phragmites*. A similar effect was seen on the growth of nitrogen-fixing cyanobacteria *Anabena* sp. by Hu et al. (2001). On addition of water containing azo dye RP2B, the growth of cyanobacterium was inhibited along with inhibition of chlorophyll A and protein synthesis in a dose-dependent manner.

The dye wastewater has far-reaching effects even on the aquatic animals. The dyes in the effluent are highly resistant and therefore can bioaccumulate in the aquatic animals causing ecotoxicity at higher levels of food chain creating challenges for human consumption. Belpaire et al. (2015) showed the accumulation of textile dyes in the muscle tissue of wild European eel-*Anguilla anguilla.* The eels sampled from the area around the textile industries showed the maximum level of dye accumulation (Fig. 1). In another study, Marlasca et al. (1998) showed the induction of micronuclei accompanied by hepatic alterations in rainbow trout which was exposed to textile industry effluent (Fig. 1). Therefore, the consumption of these aquatic

plants and animals is a major cause of concern as it may lead to several health risks as discussed in section 3.3.

3.1.2 Impact of dyes on the terrestrial ecosystem

Textile industry effluent severely alters the properties of lithosphere, specifically resulting in steep decline in soil productivity due to alteration of many factors that govern the biotic components and drive physiochemical cycles of the soil. Addition of the effluent also causes the introduction of several undesirable chemicals and associated ions which ultimately change the dynamics of the soil system. The results of all this can be seen on the plant growth which gets severely halted, sometimes even leading to plant death.

Krishna et al. (2004) monitored the soil health around the industrial region and observed that effluent also increased the levels of toxic heavy metals in soils. Topac et al. (2009) showed that the nitrogen transformation processes in the soil get severely altered on the addition of dye water containing sulphonated azo dye and sulfanilic acid. They found that the urease activity, arginine ammonification rate, nitrification potential, and ammonium oxidizing bacteria showed a significant decrease in numbers along with restriction in the nitrogen use efficiency of the plants resulting in lower productivity. In a similar study by Batool et al. (2012), it was shown that the ammonium oxidation process got suppressed when water released by textile and dyestuff industries was added. Parallel findings were obtained by Imran et al. (2015) when they studied the soil microbial community composition on the addition of dyes. A marked shift in both fungal and bacterial communities was observed on analysis of the phospholipid profiles (Fig. 2). Moreover, different dye had different severity of impact on different microbiota. While Reactive Black 5 had a significant negative impact on fungal PLFA, the opposite was the effect of Direct Red 81.

The reuse of the effluent for irrigation purposes has become nearly impossible due to its high salinity and sodicity which impairs the growth of plants (Rathore, 2011). Oguntade et al. (2014) studied the impact of dye wastewater on irrigation of *Amaranthus cruentus*. They observed that 100% of the plant root hairs got damaged and in severe cases even resulted in the plant death (Fig. 2). Moreover, there was a reduction in the number of leaves and their dry and wet weights. Also, the stem girth increased due to the accumulation of heavy metals. Zhou et al. (2003) studied the effect

of reactive X-3B red dye on iron uptake of three food crops: soybean, rice, and watermelon. It was shown that iron uptake was inhibited with a severe effect on the activity of iron reductase which led to a deficiency of iron in the crops (Fig. 2). Also, the anthraquinone and azo dyes altered the foliage volatiles, carotenoids, and physiology of wheat (Copaciu et al., 2013). Several studies on *Allium cepa* showed the generation of oxidative stress and inhibition of photosynthetic activity (Jadhav et al., 2011). Therefore, contamination of an area with dyes has grave consequences on the plant health. Besides bioaccumulation of the dyes, the alteration in plant physiological processes poses severe threat on food security of the country. Moreover, consumption of such crops may lead to health complications in humans as well.

3.2 Dyes and human health concern

As already discussed, both plants and animals get contaminated with dyes which are present in the surrounding environment due to bioaccumulation and therefore consumption of such food poses several health risks (Fig. 3). Moreover, cases of occupational exposure causing several problems and maladies have become increasingly common. Reports of cancer being caused due to the same have been on the rise since the past decade. Several studies have been carried out to see the impact of dyes on mammals, especially on humans by taking rat/mice as model organisms. Also, the effect of dye exposure is not confined to a single system of the human body. The dyes spread through the circulatory system in the whole body causing several complications ranging from mere allergy and irritation to severe and fatal cases of cancer. The effects on different organ systems have been discussed briefly as under.

3.2.1 Impact of dyes on sensory system

The workers involved in dyeing and handling of dyes in the industries have been impacted profoundly. The exposure, even when acute has been a cause of major health problems ranging from the irritation of skin and eyes to severe cases of chemosis and even permanent blindness (Fig. 3). The dyes are also known to cause skin allergies, contact dermatitis and epidermal edema (Hassaan et al., 2017).

Some dyes can migrate through the skin. This gets further enhanced due to low precipitation fastness of the dyes and poor dyeing techniques accompanied by inadequate safety conditions. Moreover, various microbes present on the skin epidermis can absorb dyes from skin tight cloths eventually causing skin irritation. Dyes combine with HSA (human serum albumin) forming dye-HSA conjugate which acts as antigen and a potential allergen (Sun et al., 2016).

3.2.2 Impact of dyes on digestive system

Accidental inhalation of dyes or consumption of water and food contaminated with dyes results in major complications in organs of the digestive system. Parent dyes, as well as their toxic metabolites serve as hepatocarcinogen and have also been proven to cause colon tumor and colon cancer (de Lima et al., 2007). These dyes are also shown to have genotoxic and clastogenic (chromosome break) properties (Tsuboy et al., 2007).

Gut microflora, especially that of the liver degrade the parent azo dyes into mutagenic and carcinogenic metabolites which are responsible for showing such drastic effects in organs of the digestive system. Various radicals present in dyes are sites for metabolic activities by hepatic enzymes and form genotoxic intermediates (Umbuzeiro et al., 2005). The amino, alkylamino or acetylamino groups containing azo dyes can undergo oxidative metabolism forming carcinogenic compounds (Guaratini et al., 2000). Increased apoptotic index of HepG2 cells and increased numbers of micronuclei on the exposure of dyes to these cell lines are also result of the toxicity of such dyes (Fig. 3) (Tsuboy et al., 2007).

3.2.3 Impact of dyes on reproductive system

The toxic effect of dyes can even be seen on the reproductive system. The dyes are known to cause alteration of spermatogenesis and abnormalities in sperm morphology leading to reduced sperm motility. The exposure also leads to a loss in the ability to produce young ones i.e. infertility. Some dyes also show cytotoxic and genotoxic effects on the reproductive system (Fernandes et al., 2015).

Dye exposure reduces the size of the reproductive organs including testes, epididymis and seminal vesicles (Fernandes et al., 2015; Suryavathi et al., 2004). In fact, the arrangement and number of cells in reproductive

organs also changed drastically. For example, there was an observable expansion of the interstitial space and decrease in both the number and size of Leydig cells. Accompanied with this, there was a significant reduction in total protein, cholesterol and lipid content of the reproductive organs and decrease in fructose content of the seminal vesicles along with considerable decrease in the sperm count (Fig. 3) (Suryavathi et al., 2004).

3.2.4 Impact of dyes on lymphatic system

The dye wastewater leads to genotoxicity in the lymphatic system mainly in the human peripheral blood lymphocytes. Moreover, in cases of chronic exposure; sarcoma of spleen also takes place. The dye water when taken up by the human system leads to DNA damage in the lymphocytes (Rajaguru et al., 2002). Furthermore, an increase in micronucleus of human lymphocytes (an important precursor to carcinogenesis) on exposure to dyes is also reported (Chequer et al., 2013).

3.2.5 Impact of dyes on urinary system

The urinary system is also impacted immensely, the most prominent effect being the development of bladder cancer and bladder tumor (Fig. 3). Development of kidney cancer has also been reported (Morikawa et al., 1997).

Dyes based on benzidine and /or containing aromatic amines or their derivatives are known to be carcinogenic. Even the metabolites of aromatic dyes have tumorigenic properties. The analysis of urine samples of exposed workers showed the presence of benzidine which is known to be a potential human bladder carcinogen. Even other metabolites of benzidine were also present and are known to produce harmful effects (Lowry et al., 1980).

3.2.6 Impact of dyes on respiratory system

Inhalation of dyes in cases of occupational exposure causes several allergies. In some cases, it is also shown to cause edema of pharynx and larynx which causes defects of speech and may also cause problems while eating. Development of hypersensitivity along with symptoms of allergic rhinitis and asthma on exposure to reactive dyes has also been shown (Alanko et al., 1978)

4. Conclusions and future perspectives

Textile industry drives the economic growth but poses a hidden threat to environment and human health. Industrial dye effluent deteriorates the quality of waterbodies and soils, interferes with biogeochemical cycles, alters the biotic community (plants and microbes) and their interactions, and challenges the plant and animal health directly by damaging the DNA or interfering with metabolic processes and indirectly by affecting the nutrient uptake and assimilation. The evidence from cohort studies on occupational hazard, toxicity assays on laboratory-based cell lines and animal models confirmed dyes and dye metabolites as genotoxic, carcinogenic and teratogenic.

Several European countries have banned some classes of dyes that contain carcinogenic chemical moiety. Such stringent regulatory provision in developing nations like India and China would also prevent damage to environmental and human health in future. Also, the regulations and legal framework must integrate environmentally relevant research as mandatory. Besides framing environmentally relevant regulations, the cases of health complications due to occupational exposure can be minimized by improving the working conditions and regulating the working hours to minimize the exposure.

Guidelines for functioning of industries and industrial workers would play a significant role in addressing environmental challenges from textile dyeing industries. A green tag on the clothes declaring the use of green technologies at different stages of manufacturing of the clothes would attract the global community to pay for environmental services and encourage the industrialist in adopting the green practices. Through technological shift from wet to air drying dyeing, we can not only increase the efficiency of dyeing but can also decrease water pollution. However, such a shift in technology may happen slowly over a period of time with the help of additional financial resources. Moreover, to improve the quality of environment, we need to use ecological framework for remediation of the industrial wastewater and affected waterbodies and soils.

References

Alanko, K., Keskinen, H., Björkstén, F., & Ojanen, S. (1978). Immediate type hypersensitivity to reactive dyes. *Clinical & Experimental Allergy*, *8*, 25-31.

Batool, S., Khalid, A., Jalal, K. C. A., Sarfraz, M., Balkhair, K. S., & Ashraf, M. A.

(2015). Effect of azo dye on ammonium oxidation process and ammonia-oxidizing bacteria (AOB) in soil. *RSC Advances*, *5*, 34812-34820.

Belpaire, C., Reyns, T., Geeraerts, C., & Van Loco, J. (2015). Toxic textile dyes accumulate in wild European eel *Anguilla anguilla*. *Chemosphere*, *138*, 784-791.

Carneiro, P. A., Umbuzeiro, G. A., Oliveira, D. P., & Zanoni, M. V. B. (2010). Assessment of water contamination caused by a mutagenic textile effluent/dye house effluent bearing disperse dyes. *Journal of Hazardous Materials*, *174*, 694-699.

Chequer, F. M. D., Dorta, D. J., & de Oliveira, D. P. (2011). Azo dyes and their metabolites: does the discharge of the azo dye into water bodies represent human and ecological risks?. In: *Advances in Treating Textile Effluent*. IntechOpen, New Delhi, India.

Chequer, F. M. D., Lizier, T. M., de Felício, R., Zanoni, M. V. B., Debonsi, H. M., Lopes, N. P., & de Oliveira, D. P. (2015). The azo dye Disperse Red 13 and its oxidation and reduction products showed mutagenic potential. *Toxicology in Vitro*, *29*, 1906-1915.

Copaciu, F., Opriº, O., Coman, V., Ristoiu, D., Niinemets, Ü., & Copolovici, L. (2013). Diffuse water pollution by anthraquinone and azo dyes in environment importantly alters foliage volatiles, carotenoids and physiology in wheat (*Triticum aestivum*). *Water, Air, & Soil Pollution*, *224*, 1478.

de Aragao Umbuzeiro, G., Freeman, H. S., Warren, S. H., De Oliveira, D. P., Terao, Y., Watanabe, T., & Claxton, L. D. (2005). The contribution of azo dyes to the mutagenic activity of the Cristais River. *Chemosphere*, *60*, 55-64.

de Lima, R. O. A., Bazo, A. P., Salvadori, D. M. F., Rech, C. M., de Palma Oliveira, D., & de Aragão Umbuzeiro, G. (2007). Mutagenic and carcinogenic potential of a textile azo dye processing plant effluent that impacts a drinking water source. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis*, *626*, 53-60.

Fernandes, F. H., Bustos-Obregon, E., & Salvadori, D. M. F. (2015). Disperse Red 1 (textile dye) induces cytotoxic and genotoxic effects in mouse germ cells. *Reproductive Toxicology*, *53*, 75-81.

Guaratini, C. C., & Zanoni, M. V. B. (2000). Textile dyes. *Química Nova*, *23*, 71-78.

Hassaan, M. A., & El Nemr, A. (2017). Health and environmental impacts of dyes: Mini Review. *American Journal of Environmental Science and Engineering*, *1*, 64-67.

Hu, T. L., & Wu, S. C. (2001). Assessment of the effect of azo dye RP2B on the growth of a nitrogen fixing cyanobacterium–*Anabaena* sp. *Bioresource Technology*, *77*, 93-95.

IHS Markit (2018). *Dyes - Chemical Economics Handbook (CEH)*. Retrieved from https://ihsmarkit.com/products/dyes-chemical-economics-handbook.html

Imran, M., Shaharoona, B., Crowley, D. E., Khalid, A., Hussain, S., & Arshad, M. (2015). The stability of textile azo dyes in soil and their impact on microbial

phospholipid fatty acid profiles. *Ecotoxicology and Environmental Safety*, *120*, 163-168.

Jadhav, S. B., Phugare, S. S., Patil, P. S., & Jadhav, J. P. (2011). Biochemical degradation pathway of textile dye Remazol red and subsequent toxicological evaluation by cytotoxicity, genotoxicity and oxidative stress studies. *International Biodeterioration & Biodegradation*, *65*, 733-743.

Krishna, A. K., & Govil, P. K. (2004). Heavy metal contamination of soil around Pali industrial area, Rajasthan, India. *Environmental Geology*, *47*, 38-44.

Lowry, L. K., Tolos, W. P., Boeniger, M. F., Nony, C. R., & Bowman, M. C. (1980). Chemical monitoring of urine from workers potentially exposed to benzidine-derived azo dyes. *Toxicology Letters*, *7*, 29-36.

Lunau, M., Voss, M., Erickson, M., Dziallas, C., Casciotti, K., & Ducklow, H. (2013). Excess nitrate loads to coastal waters reduces nitrate removal efficiency: mechanism and implications for coastal eutrophication. *Environmental Microbiology*, *15*, 1492-1504.

Marlasca, M. J., Sanpera, C., Riva, M. C., Sala, R., & Crespo, S. (1998). Hepatic alterations and induction of micronuclei in rainbow trout (*Oncorhynchus mykiss*) exposed to a textile industry effluent. *Histology and Histopathology*, *13*, 703-712.

Moore, S. B., & Ausley, L. W. (2004). Systems thinking and green chemistry in the textile industry: concepts, technologies and benefits. *Journal of Cleaner Production*, *12*, 585-601.

Morikawa, Y., Shiomi, K., Ishihara, Y., & Matsuura, N. (1997). Triple primary cancers involving kidney, urinary bladder, and liver in a dye worker. *American Journal of Industrial Medicine*, *31*, 44-49.

Oguntade, A. O., Adetunji, M. T., Arowolo, T. A., Salako, F. K., & Azeez, J. O. (2015). Use of dye industry effluent for irrigation in *Amaranthus cruentus* L. production: effect on growth, root morphology, heavy metal accumulation, and the safety concerns. *Archives of Agronomy and Soil Science*, *61*, 865-876.

Puvaneswari, N., Muthukrishnan, J., & Gunasekaran, P. (2006). Toxicity assessment and microbial degradation of azo dyes. *Indian Journal of Experimental Biology*, *44*, 618-626.

Rajaguru, P., Vidya L., Baskarasethupathi, B., Kumar, P. A., Palanivel, M., & Kalaiselvi, K. (2002). Genotoxicity evaluation of polluted ground water in human peripheral blood lymphocytes using the comet assay. *Mutation Research/ Genetic Toxicology and Environmental Mutagenesis*, *517*, 29-37.

Rathore, J. (2011). Assessment of water quality of River Bandi affected by textile dyeing and printing effluents, Pali, Western Rajasthan, India. *International Journal of Environmental Sciences*, *2*, 560.

Rawat, D., Mishra, V., & Sharma, R. S. (2016). Detoxification of azo dyes in the context of environmental processes. *Chemosphere*, *155*, 591-605.

Rawat, D., Sharma, R. S., Karmakar, S., Arora, L. S., & Mishra, V. (2018). Ecotoxic

potential of a presumably non-toxic azo dye. *Ecotoxicology and Environmental Safety*, *148*, 528-537.

Sharma, K. P., Sharma, K., Kumar, S., Sharma, S., Grover, R., Soni, P., Bhardwaj, S. M., Chaturvedi, R. K.,& Sharma, S. (2005). Response of selected aquatic macrophytes towards textile dye wastewaters. *Indian Journal of Biotechnology*, *4*, 538-545.

Singh, S., Mishra, R., Sharma, R. S., & Mishra, V. (2017). Phenol remediation by peroxidase from an invasive mesquite: Turning an environmental wound into wisdom. *Journal of Hazardous Materials*, *334*, 201-211.

Statista (2017). *India - dyes and pigments production volume 2017*. Retrieved from https://www.statista.com/statistics/726947/india-dyes-and-pigments-production-volume/

Sun, H., Liu, Y., Li, M., Han, S., Yang, X., & Liu, R. (2016). Toxic effects of chrysoidine on human serum albumin: isothermal titration calorimetry and spectroscopic investigations *Luminescence, 31*, 335–340

Suryavathi, V., Sharma, S., Sharma, S., Saxena, P., Pandey, S., Grover, R., & Sharma, K. P. (2005). Acute toxicity of textile dye wastewaters (untreated and treated) of Sanganer on male reproductive systems of albino rats and mice. *Reproductive Toxicology*, *19*, 547-556.

Topaç, F. O., Dindar, E., Uçaroðlu, S., & Baþkaya, H. S. (2009). Effect of a sulfonated azo dye and sulfanilic acid on nitrogen transformation processes in soil. *Journal of Hazardous Materials*, *170*, 1006-1013.

Tsuboy, M. S., Angeli, J. P. F., Mantovani, M. S., Knasmüller, S., Umbuzeiro, G. A., & Ribeiro, L. R. (2007). Genotoxic, mutagenic and cytotoxic effects of the commercial dye CI Disperse Blue 291 in the human hepatic cell line HepG2. *Toxicology in Vitro*, *21*, 1650-1655.

Zhou, Q., Xu, J., & Cheng, Y. (2004). Inhibitory effects of reactive X-3B red dye (RRD) on iron uptake by three crops. *Plant and Soil*, *261*, 155-162.

Fig. 1: Ecological impact of dye wastewater on aquatic ecosystems

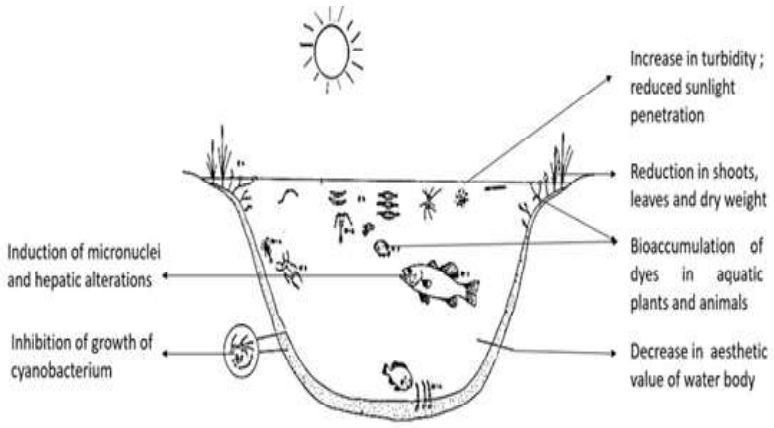


Fig. 2: Potential harms of dye wastewater on plant health

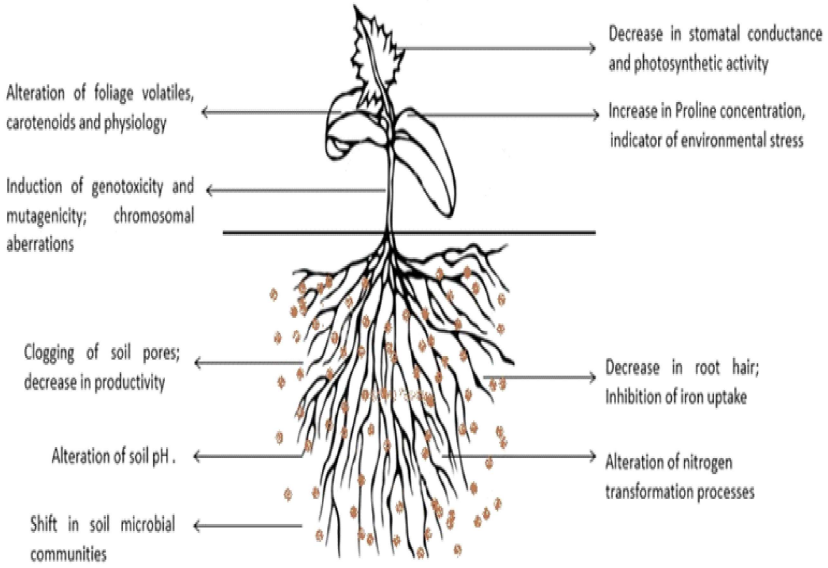
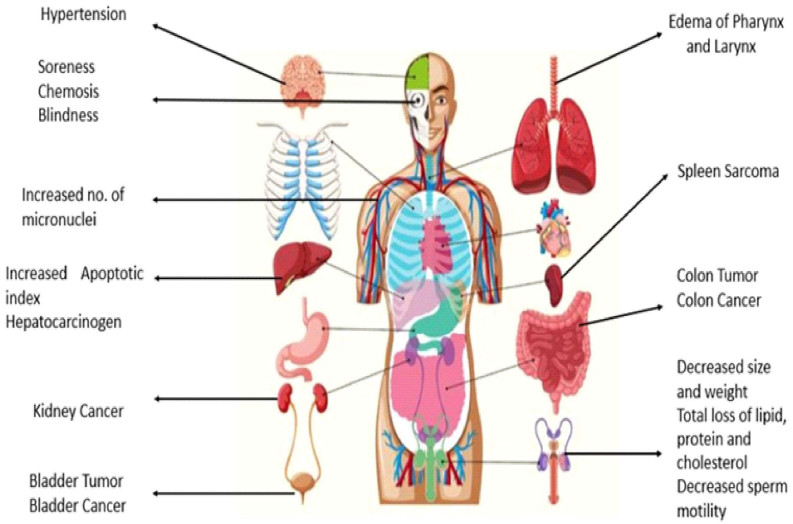


Fig. 3: Effects on human health due to acute and chronic exposure of dyes



10

Tracking Environmental Pathway of Crystal Violet, a Multi-purpose Industrial Dye

Paromita Mukherjee, Radhey Shyam Sharma and VandanaMishra*

(*corresponding author: Vandana Mishra: mistletoe_h@hotmail.com)

Department of Environmental Studies

(Bioresources and Environmental Biotechnology Laboratory)

University of Delhi, Delhi-110007

Abstract

Dye industries drive economic growth in developing countries but also pose challenges to society, particularly to the socio-economically deprived communities. Laboratory-safe dyes produce toxic metabolites after physicochemical and biological interactions in the environment. Therefore, the unpredictable fate of dyes remains a hidden case of environmental justice. We used triphenylmethane dyes (crystal violet) as a model dye to track the environmental pathway of the dyes and to predict the socio-ecological challenges associated with the environmental route of the dyes. Triphenylmethane dyes (crystal violet), the synthetic dye used widely used in wood, silk, and paper industries and laboratories, cause toxicity to aquatic

fauna and human health. We hypothesized that crystal violet dye might undergo phase-transfer in environment, therefore, escape from degradation and mineralization during traditional wastewater treatment. We tested movement of crystal violet in the water-sediment system created *in vitro* conditions that mimic the streams receiving the wastewater from dye manufacturing and dyeing industries. Socio-economically deprived communities primarily employed in dyeing industries or occupying nearby areas bear the cost of uncertain fate of dyes in effluents. Environmental fate of dyes therefore, remains uncertain in industrial effluent and thus challenges the health of workers who remain unaware of the health cost of toxic metabolites (occupational hazard). Also, non-specific treatment of industrial effluent adds to environmental burden borne by the deprived communities because they irrigate the agriculture field using effluent contaminated water or they drink the contaminated ground water. We propose that tracking environmental pathway of dyes and their metabolites would help in formulating efficient wastewater management plans to protect environment and ensure social justice.

Email IDs of Authors:

Paromita Mukherjee: paromitam1.8@gmail.com

Radhey Shyam Sharma: radheyss26@gmail.com

Vandana Mishra: mistletoe_h@hotmail.com

1. Introduction

Synthetic dyes serve as primary coloring agents for several industries such as textiles, paper, printing, paints, plastic manufacturing and packaging. Textile dyeing industries rely primarily on synthetic dyes and have been considered as number one polluter of clean water. As per the World Bank estimates, textile dye effluent carry >70 toxicants and nearly half of them persist in environment that include dyes and its metabolites (Kant, 2012). Triphenylmethane dyes are a versatile class of water-soluble synthetic dyes which are used in many industries viz. textiles, paper, ink manufacturing, , leather, etc. (Zablocka-Godlewska et al., 2009). Triphenylmethane dyes have been reported to cause photophytotoxicity due to production of reactive oxygen species (Lewis & Indig, 2002). Some basic triphenylmethane dyes such as crystal violet (CV), methyl green, and malachite green inhibit

glutamine synthesis in *Staphylococcus aureus* (Fry, 2009). If taken in by living organisms, thyroid peroxidase catalyse oxidation of triphenylmethane dyes and produce N-dealkylated aromatic amines (Cho et al., 2003), which are structurally similar to carcinogenic aromatic amines produced by the degradation of azo dyes (Rawat et al., 2018). Some triphenylmethane dyes are also known to be mutagenic and carcinogenic, but are still being used extensively.

Physico-chemical and biological methods have been tested for decolorization of triphenylmethane dye, however, their role in detoxification of dyes is poorly understood. CV is a model triphenylmethane dye which was first prepared in 1883 by Kern (Tewari & Vishnoi, 2017). CV is a known carcinogen and is used to dye wool, silk, cotton. It is largely known for its use as a microbial staining agent and has been used as an antiseptic and antifungal agent. There is limited and conflicting data on whether dyeing wastewater treatment technologies are capable of detoxifying the wastewater after decolorization. *Shewanella*, a ubiquitous bacterium commonly found in diverse aquatic environments , degraded and reduced CV toxicity but failed to detoxify it completely (Chen & Ting, 2015). Physical methods, such as combined adsorption and oxidation process, though decolorized CV significantly (71%) their role in reducing ecotoxicity still uncertain (Chen et al., 2011). Advance oxidation processes (AOP) like Fenton have been receiving attention for treatment of dye wastewater, but little information is available on the dye degradation pathway, making it difficult to predict the fate of the dye in treated effluents (Fan et al., 2009). Electrochemical methods also showed degradation of CV into simpler products, however, the ecotoxic potential of degraded products has not been ascertained (Palma-Goyes et al., 2010). Though combined process of AOP followed by microfiltration removed CV from the effluent, the effect of these processes on ecotoxic potential of dye effluent was not ascertained (Jana et al., 2010). Casas et al., (2009) showed that Polypore mushroom (*Trametes versicolor*) degrades basic triphenylmethane dyes and basic character of the dyes is linked to their toxicity levels.

Therefore, dyes either in untreated or treated dye wastewater might cause ecotoxicity due to their unknown fate into the environment. Insufficient data on the fate of dyes released as untreated or partially treated wastewater into the water bodies coupled with poorly implemented environmental laws increase the complexity of problem in the developing countries. Movement

of dyes across the environmental compartment, though poorly understood, would help in identifying specific ecotoxicological threats and finding solutions to minimise the risk from dye effluent. CV being one of the most widely known and studied model dyes was used for investigating the movement of triarylmethane dyes in water-sediment microcosms. Two phase (water and sediment) microcosm serves as an ideal tool for evaluating degradation and tracking movement of organic pollutants across the environmental compartment (Jing et al., 2016), therefore, we analyzed decolorization of CV and ascertained phase-transfer of CV from water to sediment and vice-versa.

2. Materials and Methods

a. Chemicals

Crystal Violet (C.I. number 42555) and methanol (HPLC grade) were from Fisher Scientific, USA. Double distilled water used during the experiment.

b. Study area and sampling

Water and sediment samples were collected from river Yamuna. The sampling sites were selected that do not receive any industrial effluent. Environmental levels of CV in water and sediment were tested. Water and sediment samples lacking traces of CV were used in the study. Water samples were stored at 4ºC shortly before setting up the microcosm. Sediment was air dried and sieved through a 2 mm sieve before setting up the microcosms.

c. Experimental design

Microcosms were set up at two levels of CV dye (low: 25 ppm; and high: 50 ppm) in 500 ml containers. Four microcosm systems used in the study include: (i) W-microcosm: 200 ml water-only, (ii) S-microcosm: 100 gm of sediment only, (iii) W-C-microcosm: contaminated water (200 ml dye fortified water, 100 gm sediment), and (iv) S-C-microcosm: contaminated sediment (200 ml water, 100 gm dye fortified sediment).

d. Dye fortification

Dye was fortified into different microcosm using procedure provided in

(Jing et al., 2016). Working solutions of CV (90mM,150mM) were appropriately used to setup lower concentration (25ppm) and higher concentration (50ppm) microcosms. Working solution of CV was injected drop-wise into the W-microcosm; S-microcosm, in the water compartment of W–C-microcosm, and in the sediment compartment of S–C-microcosm, using micro syringe.

e. Sample collection, storage and dye extraction

Sediment and water were collected from different microcosm set up on 1d till and continued till 15d at an interval of 2d. To track the movement of dye into different environmental phase (sediment or water), dye in water samples was directly measured at OD_{590nm}, and that from the sediment was extracted into methanol, which was the suitable solvent for AO7 and CV according to pilot studies performed in the laboratory.

f. Statistical analysis

Two-way ANOVA was conducted with the type of microcosms (W, W-C, S-C) and the initial concentration of CV (25ppm, 50ppm) as the two factors influencing decolorization and phase-transfer of dye. Post-hoc analysis was conducted for pair-wise comparisons (SPSS ver. 16 was used for statistical analysis.

3. Results and discussion

a. Dye decolourization

More than 96% CV was decolorized in all the microcosms (Figs.1 & 2) except in 50ppm S–C microcosm (82.178±4.06%). However, CV did not show decolorize in S-microcosm. Initial concentration of CV showed a significant effect on decolorization of CV in the different microcosms since the interaction between the two factors was significant ($F_{2, 12}$=15.124, p=0.001, ž=0.716). At high concentration of CV (50ppm), the environmental compartment (water or sediment); to which the dye was added showed a significant effect on CV decolorization ($F_{2, 12}$ = 45.532, p<0.001, ž=0.884); however, influence of environmental compartment on dye decolorization was not significant at lower concentration of CV (25ppm). In fact, the

initial concentration of CV showed a significant effect ($F_{2, 12}$= 51.012, p<0.001, ž=0.810) when CV was added to the sediment (S–C microcosm) but not when it was added to water (W- and W–C-microcosm) (Fig. 3). In contrast with lower concentration of CV (25ppm), CV decolorization in S–C microcosm (82.1%±4.06) differed significantly from water-only system (96%±1.19, p<0.001) and W–C-microcosm (99.7%±0.39, p<0.001) at higher concentration of CV (50ppm) (Figs. 2 & 3). Such a contrasting results S–C-microcosm and W–C-microcosm suggest a affinity of CV to the sediment compartment (Fig 4). The decolorization of CV in W–C-microcosm may be a result of the phase-transfer of CV from the water to the sediment. Aside from phase-transfer, various abiotic processes, such as photolysis, hydrolysis and sorption, and biotic interactions, such as microbial degradation and transformation would also be responsible for the decolorization of CV in the microcosms. However, further studies are required to understand the dynamics, mechanisms and the rate of transfer of CV across the phases. Mechanisms of decolorization govern the chemical nature of products formed after decolorization of CV. Studies under visible and UV irradiation have shown that photo degradation of CV might lead to the formation of N-demethylated products that structurally resemble carcinogenic amines (Li & Zhao, 1999; Liao et al., 2011). Enzymatic decolorization of CV yielded small intermediates with high oxidative activity (Liu et al., 2014). Biodegradation by *Agrobacterium* followed by phytotoxicity and microbial toxicity studies showed a decrease in initial concentration of CV without elimination in the toxicity of the metabolites as compared to CV (Parshetti et al., 2011). These studies indicate that even though CV was decolorized in different microcosms, it is difficult to say that the products lack any toxicity. Also, environmental partitioning of CV will influence the site of accumulation of these presumably toxic products.

b. Environmental partitioning of CV at higher and lower concentration

Fig. 4 showed the phase-transfer of CV between water and sediment compartment in the W–C and S–C microcosms. Irrespective of whether the dye was fortified in water or in the sediment, CV showed an affinity to the sediment as >60% of the residual dye was found in the sediment

compartment of all microcosms. At 50ppm, phase transfer of CV from sediment to water was lesser as compared to when the initial CV concentration was 25ppm (Fig. 4b & 4d). Fluctuation of dye concentration in the sediment compartment may be attributed to the decolorization of the dye due to photolysis, hydrolysis, biodegradation and sorption along with the phase-transfer of the dye. In W–C microcosm, the dye moved from water compartment to sediment compartment almost immediately after dye fortification in the water (Fig. 4a & 4c). In a sorption study using biochar and CV, toxicological analysis demonstrated no toxicity in CV dye residues (Vyavahare et al., 2019), although whether any toxicity was demonstrated in the biochar due to CV sorption was not studied. Since over 60% of the residual dye in all microcosms was found in the sediment, the impact of decolorization and sorption of CV in the sediment needs to be studied. Any toxicity caused by CV and its degradation products may target organisms found in the sediment and affect crop health if it is used for agriculture.

4. Conclusion

Studies on transfer of dyes provide useful information to reveal environmental pathways of the dyes and possible implications on environment and ecosystem. More than 80% of the CV decolorized in the natural water and sediment (except in S-microcosm) within 15 days. When the initial concentration of CV was high, its phase-transfer from sediment to water was less as compared to when initial CV concentration was low. CV demonstrated a tendency to remain in the sediment compartment irrespective of whether it was added to the water or the sediment. Dyes such as CV which have an affinity to the sediment will tend to adhere to the particles present in its vicinity, instead of getting diluted due to run off. The communities residing next to the rivers and streams which act as recipient of the dyeing effluents face the threat of being exposed to the toxic metabolites. The wide practice of using river sediments for growing vegetables will further increase the risk of exposure to the toxicants which are adsorbed to the contaminated sediment. The impact of phase-transfer of CV from water into natural soil and sediments on their toxicity is yet not known and further studies are required.

Fig. 1: Percent decolorization (Mean ± SD) of CV at 25ppm (Grey) and CV at 50ppm (Black) over 15 days in all the microcosms viz. (a) Water only (W) microcosm; (b) Water contaminated with CV (W-C) microcosm; and (c) Sediment contaminated with CV (S–C) microcosm

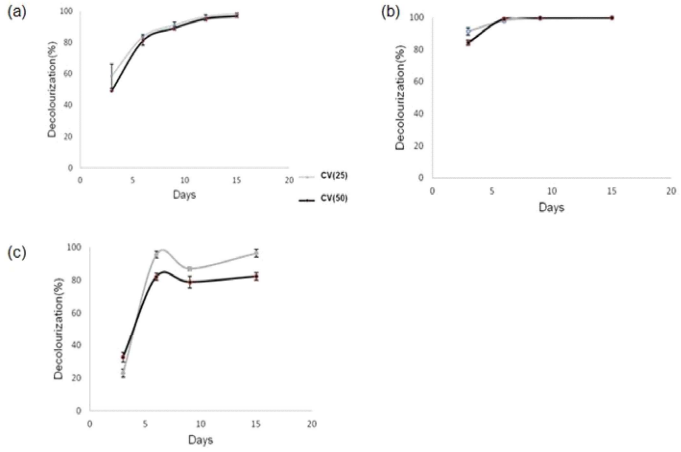


Fig. 2: Percent decolorization (Mean ± SD) of CV at 15th day in different microcosms ('*' indicates the significant difference ($p<0.001$) between S–C-microcosm contaminated with 25ppm CV and 50ppm CV).

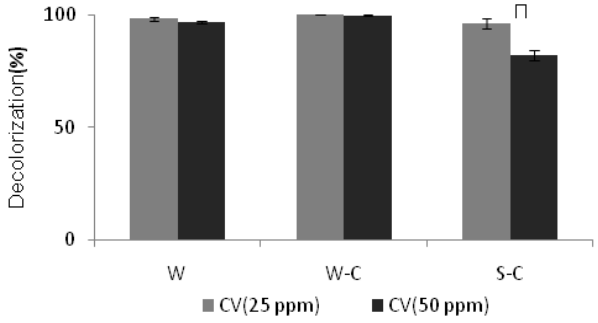


Fig. 3: Two way ANOVA plot of percent decolorization of CV. The two factors affecting decolorization of CV are (1) Concentration (CV: 25ppm and 50ppm) and (2) Type of microcosm (W: water only, W–C: water contaminated with CV, S–C: sediment contaminated with CV)

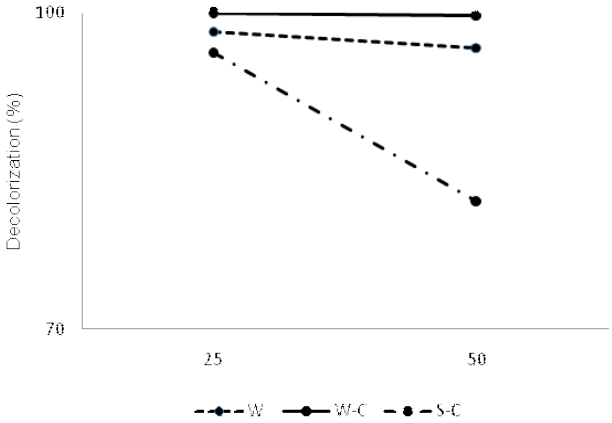
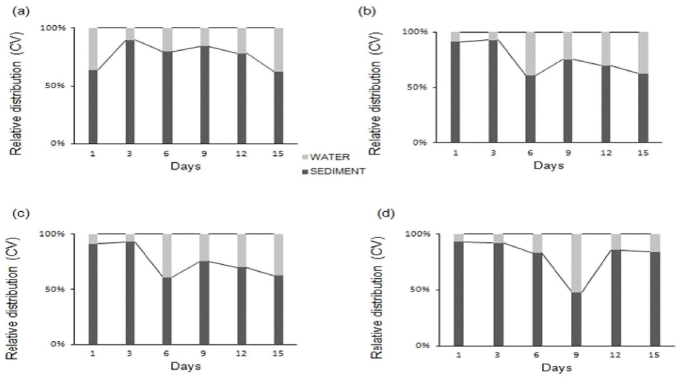


Fig. 4: Relative distribution of CV (%) in water and sediment from (a) W–C (25ppm), (b) S-C (25ppm). (c) W-C (50ppm) and (d) S-C (50ppm) microcosms sampled periodically till 15th day.



References

Casas, N., Parella, T., Vicent, T., Caminal, G., & Sarrà, M. (2009). Metabolites from the biodegradation of triphenylmethane dyes by Trametes versicolor or laccase. *Chemosphere*, *75*(10), 1344–1349. https://doi.org/10.1016/j.chemosphere.2009.02.029

Chen, C. C., Chen, W. C., Chiou, M. R., Chen, S. W., Chen, Y. Y., & Fan, H. J. (2011). Degradation of crystal violet by an FeGAC/H 2O 2 process. *Journal of Hazardous Materials*, *196*, 420–425. https://doi.org/10.1016/j.jhazmat.2011.09.042

Chen, S. H., & Yien Ting, A. S. (2015). Biodecolorization and biodegradation potential of recalcitrant triphenylmethane dyes by Coriolopsis sp. isolated from compost. *Journal of Environmental Management*, *150*, 274–280. https://doi.org/10.1016/j.jenvman.2014.09.014

Cho, B. P., Yang, T., Blankenship, L. R., Moody, J. D., Churchwell, M., Beland, F. A., & Culp, S. J. (2003). Synthesis and characterization of N-demethylated metabolites of malachite green and leucomalachite green. *Chemical Research in Toxicology*, *16*(3), 285–294. https://doi.org/10.1021/tx0256679

Fan, H., Huang, S., Chung, W., Jan, J., Lin, W., & Chen, C. (2009). Degradation pathways of crystal violet by Fenton and Fenton-like systems/ : Condition optimization and intermediate separation and identification, *171*, 1032–1044. https://doi.org/10.1016/j.jhazmat.2009.06.117

Fry, B. A. (2009). Basic Triphenylmethane Dyes and the Inhibition of Glutamine Synthesis by Staphylococcus aureus. *Journal of General Microbiology*, *16*(2), 341–349. https://doi.org/10.1099/00221287-16-2-341

Jana, S., Purkait, M. K., & Mohanty, K. (2010). Applied Clay Science Removal of crystal violet by advanced oxidation and micro fi ltration. *Applied Clay Science*, *50*(3), 337–341. https://doi.org/10.1016/j.clay.2010.08.023

Jing, X., Yao, G., Liu, D., Liu, M., Wang, P., & Zhou, Z. (2016). Environmental Fate of Chiral Herbicide Fenoxaprop-ethyl in Water-Sediment Microcosms. *Scientific Reports*, *6*(February), 1–7. https://doi.org/10.1038/srep26797

Kant, R. (2012). Textile dyeing industry an environmental hazard. *Natural Science*, *04*(01), 22–26. https://doi.org/10.4236/ns.2012.41004

Lewis, L. M., & Indig, G. L. (2002). Effect of dye aggregation on triarylmethane-mediated photoinduced damage of hexokinase and DNA. *Journal of Photochemistry and Photobiology B: Biology*, *67*(3), 139–148. https://doi.org/10.1016/S1011-1344(02)00308-1

Li, X., Liu, G., & Zhao, J. (1999). Two competitive primary processes in the photodegradation of cationic triarylmethane dyes under visible irradiation in TiO, 1193–1196.

Liao, Y. H. Ben, Wang, J. X., Lin, J. S., Chung, W. H., Lin, W. Y., & Chen, C. C. (2011). Synthesis, photocatalytic activities and degradation mechanism of Bi 2 WO 6

toward crystal violet dye. In *Catalysis Today* (Vol. 174, pp. 148–159). Elsevier B.V. https://doi.org/10.1016/j.cattod.2011.03.048

Liu, L., Zhang, J., Tan, Y., Jiang, Y., Hu, M., Li, S., & Zhai, Q. (2014). Rapid decolorization of anthraquinone and triphenylmethane dye using chloroperoxidase: Catalytic mechanism, analysis of products and degradation route. *Chemical Engineering Journal*, *244*, 9–18. https://doi.org/10.1016/j.cej.2014.01.063

Palma-goyes, R. E., Guzmán-duque, F. L., Peñuela, G., González, I., Nava, J. L., & Torres-palma, R. A. (2010). Chemosphere Electrochemical degradation of crystal violet with BDD electrodes/ : Effect of electrochemical parameters and identification of organic by-products. *Chemosphere*, *81*(1), 26–32. https://doi.org/10.1016/j.chemosphere.2010.07.020

Parshetti, G. K., Parshetti, S. G., Telke, A. A., Kalyani, D. C., Doong, R. A., & Govindwar, S. P. (2011). Biodegradation of Crystal Violet by Agrobacterium radiobacter. *Journal of Environmental Sciences*, *23*(8), 1384–1393. https://doi.org/10.1016/S1001-0742(10)60547-5

Rawat, D., Sharma, R. S., Karmakar, S., Arora, L. S., & Mishra, V. (2018). Ecotoxic potential of a presumably non-toxic azo dye. *Ecotoxicology and Environmental Safety*, *148*(June 2017), 528–537. https://doi.org/10.1016/j.ecoenv.2017.10.049

Vyavahare, G., Jadhav, P., Jadhav, J., Patil, R., Aware, C., Patil, D., … Gurav, R. (2019). Strategies for crystal violet dye sorption on biochar derived from mango leaves and evaluation of residual dye toxicity. *Journal of Cleaner Production*, *207*, 296–305. https://doi.org/10.1016/j.jclepro.2018.09.193

Zablocka-Godlewska, Ewa/ ; Przystas, Wioletta; Grabinska-Sota, E. (2009). Decolourization of Triphenylmethane Dyes. *Environment Protection Engineering*, *35*(1), 161–169.

11

Environmental Issues Associated With Nanomaterials

P.C. Thapliyal, Vibhrant and A. Dixit

Organic Building Materials Group, CSIR-Central Building Research Institute

Roorkee- 247667, Uttarakhand, INDIA.

Abstract

Currently nanomaterials are one of the most talked about industries. This sector is delivering major sustainability, health and well-being benefits to society. But exciting as this may sound; we must ensure that human health and environmental impacts are considered. Although standard hazard assessments are available for a wide range of things such as chemical compounds but nanomaterials have unique properties so cannot be evaluated in exactly the same way. Nanomaterials are already entering our environment, albeit at low levels. They are being found in waste water from products like toothpaste, sun lotion etc. Short-term environmental safety studies have also found that many nanomaterials adsorb (form a thin film) on the surface of organisms' epidermis. It is vitally important we get to grips with the potential adverse impacts of nanomaterials before widespread environmental dispersion occurs. At present, the long-term effects of nanomaterial exposure on ecosystems are poorly understood. Nor do we

know the impact of nanomaterial exposure. We also don't know enough about how nanomaterials can affect humans when exposed in small doses and over long periods. Tests have shown that once nanomaterials enter the body they become trapped in the liver, but we don't know what risk they can cause for long term. The current standard non-animal safety tests cannot accurately predict the potential harm associated with nanomaterial exposure. In this paper, we review the possible ethical and environmental implications of engineering and handling nanomaterials along with the environment where these materials are often found dispersed. We will discuss the various uses of nanotechnology as well as the health and environmental effects of exposure to nanoparticles.

Keywords: Nanomaterials, Environmental effects, Safety, Hazards, Buildings.

Introduction

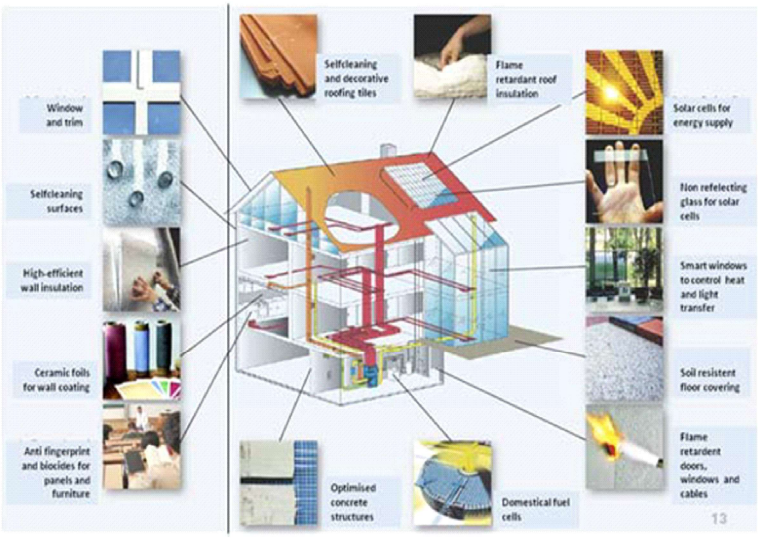
The many extraordinary properties of nanomaterials, such as mechanical stiffness, strength, and elasticity as well as the high electrical and thermal conductivity, have generated considerable excitement since the initial discovery. Nanotechnology will be one of the key technological drivers in building an innovation towards the smart, sustainable and inclusive growth. Nanotechnology has rapidly promoted the development a new generation of smart and innovative products and processes that are nanoenabled, and have created a tremendous growth potential for a large number of industry sectors. It is important that this development continues so that all the useful properties of engineered nanomaterials can be fully utilized in a number of nanotechnology applications. Simultaneously nanotechnology applications have also created some concerns of their possible effects on human health and safety and environmental burden. A few observations on some potentially harmful effects have in some cases overshadowed the dramatic benefits of these materials and their nanotechnology applications. However, the real concern, rather than observations on some hazards of exposure to engineered nanomaterials, is the lack of systematic studies on hazards of or exposure. Safe and sustainable development of nanomaterial-enabled technologies and products requires close attention to the potential impact of these materials on human health and the environment.

Emerging nanotechnology applications in biomedical and electronic industries are way ahead. Construction industry has recently started seeking

out a way to advance conventional construction materials using a variety of manufactured nanomaterials and applications in the construction industry should be considered not only for enhancing material properties but also in the context of energy conservation. This is a particularly important prospect since a high percentage of all energy used is consumed by commercial buildings and residential houses in heating, lighting, and air conditioning.

Nanomaterials in construction

Only a limited amount of nano products make it to the construction site of today due to lack of awareness and the fact that nano sized ingredients are often too expensive to offer competitive products at economical price. Main products in the market are nanoparticle improved concrete, nano coatings and insulation materials. Although intensive research, development and engineering is going on and in future the market share of nano products and their diversity will grow.



In this context, the nano particles found to be most mentioned are carbon fluoro (CF) polymers, carbon nanotubes (CNT), titanium dioxide (TiO_2), zinc oxide (ZnO), silica (or silica fume; SiO_2), silver (AgO), and aluminium oxide (Al_2O_3). Among all nano products used in the construction industry, coatings and paints have up to now been probably most successful in conquering a noticeable place at the market. Nanotechnology finds its way to paints and coatings due to the following reasons:

1. Nanoparticles do better interact by deeper penetration with the underlying substrate surface, improved coverage and/or an increased coating surface interaction, resulting in a more durability.

2. Nanoparticles are transparent to visible light which gives new characteristics to otherwise opaque coatings like high scratch, UV resistance, IR absorption or reflection, fire resistance, anti bacterial and self cleaning properties.

Effect of nanomaterials on human beings

Small dimensions of nanoparticles results in different electronic properties reflected in their chemical activity towards human bodies. For example, a number of the nano materials studied induce more pronounced inflammatory effects due to agglomeration or binding more efficiently to specific parts in the human body and thus preventing them to function properly.

The reduction in size and change in electronic properties influences their physical behaviour also. To name a few examples:

- Nanoparticles are so small that they do behave similar to gases.
- Nanoparticles are so small that they can penetrate deeper inside the lungs and are more easily absorbed in the blood.
- Unlike most other chemical substances they can be absorbed by the nasal nerve system and hence transported to the human brain easily.
- Some of the nanoparticles can cross the placenta and reach the fetus dangerously.

Hence it can be concluded that because of their size and surface properties nanoparticles can reach cells, organs etc. in the human body and can penetrate through the human skin as well. In addition to size, the specific shapes of nanoparticles play a key role in the toxic behaviour of these materials.

There are many scenarios during the life-cycle of nanomaterials used in construction sector, for example nano product manufacturing, construction sites or during disposal in the field. The riskiest tasks in construction sites involve handling these dusty or liquid materials and when during their application dust or aerosols is generated, for example when spraying a nano-coating. Risks of exposure to nanoparticles during handling of solid prefabs involving nanoproducts are small as the nanomaterials are embedded in a

matrix and exposure will take place after the wear and tear of materials. Exposure through inhalation leads to inflammation of the airways, bronchitis, asthma and other associated cardiovascular effects.

Conclusions

If we acknowledge that new materials have new and useful properties, then we must also accept that such new materials could pose new or unanticipated risks. This is not to say that the biological or toxicological effects of a novel material are necessarily "novel". Indeed, the final common pathways of cellular or organ damage may be conserved for different nanomaterials, but it is nevertheless of considerable importance to understand how those pathways are triggered to understand the structure-activity relationship of a chemical or a material. We need to understand the properties of the materials and how these are connected to the biological effects in order to make them both useful and safe.

Fadeel, B Bussy, C. Merino, S. et al. {2018}, "Safety assessment of graphene-based materials: Focus on human health and the environment", *ACS Nano*, 12, 10582"10620.

Lee, J. Mahendra, S. Alvarez, P. J. J. {2010}, "Nanomaterials in the Construction Industry: A Review of Their Applications and Environmental Health and Safety Considerations", *ACS Nano*, 4 (7), 3580–3590.

Oberdorster G et al. {2004}, "Translocation of inhaled ultrafine particles to the brain Inhalation Toxicology" 16 (6 7): 437 445

Poland CA, et al. {2008}, "*Nature Nanotechnology*", 3, 2008, 223

Pacurari M et al {2008}, "*Environmental Health Perspectives*", 116, 9, 1211

Kostaleros K {2008}, "*Nature Biotechnology*", 26, 7, 774 776

Pulskamp K et al {2006}, "*Toxicology Letters*", 168, 58 74

Wick P et al. {2007} "*Toxicology Letters*", 168, 121 131

Sayes C M et al {2006}, "*Toxicol. Sciences*" 92(1), 174 185

Díaz-Soler B. M., Martínez-Aires M. D. & López-Alonso M., {2016} "Emerging risk in the construction industry: Recommendations for managing exposure to nanomaterials" *DYNA*, 83 (196), 48-54

12

Analysis of Spatio-Temporal variability of pollutants in river Yamuna and its correlation with Land Use activities of the basin

RAHAT ZEHRA

Ph.D Scholar, Amity Institute of Geo Informatics and Remote Sensing, AUUP, NOIDA, India

Email:- rahatrsgis@gmail.com

Dr. MADHULIKA SINGH,

Director, Amity Institute Of Geo Informatics and Remote Sensing, AUUP, NOIDA, India

Abstract

This study exploits the capability of remote sensing and geographic information system to study the impact of land use activities in the basin of river Yamuna .The Water quality of the area was monitored in 2018 using multi parameter probe at 14 sampling sites .The secondary data for 2005, 2010 and 2016 was collected from Central Pollution Control Board; Landsat satellite data from series 5, 7 and 8; Carto Sat Digital Elevation Model and Google Earth for the defined variables. Space borne sensors data in addition to GIS technique provided platform to analyze land use and its impact on

the river. The Physio- Chemical parameters were measured with Horiba multi parameter probe which resulted into values of hydrogen potential, dissolved oxygen(mg/L) , electric conductivity (mS/cm), turbidity (NTU), temperature (°C), oxidation reduction potential(mV) and total dissolved solids(g/L). The Heavy Metal detection was performed using Atomic Absorption Spectrophotometer for Copper, Iron, Manganese and Zinc. Further, the land use characterization was performed with Supervised classification technique of ERDAS Imagine along with a visual classification performed using Google Earth and Ground Truth Verification via Garmin eTrex GPS to obtain detailed thematic map of the categories. The Water Quality Index calculation for individual site on basis of guideline laid by National Sanitation Foundation and Central Pollution Control Board. The Water Quality Variability was depicted by thematic maps produced using ArcGIS software.

Keywords— Remote sensing, Geographic Information System, Heavy Metal Pollution, Water Quality Index.

I. Introduction

Yamuna river originates from Bandar punch Glacier (31.026648° N, 78.571880 °E); located in Sankari Range (Uttarakhand) at a height of 6387 meters. Being a major tributary of river Ganga with a catchment area of 366,223 km^2; covers a distance of 1376 kilometers before confluence with Ganga at Allahabad. It traverses through parts of Uttarakhand, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and the entire region of Delhi. The major tributaries namely Betwa, Chambal, Ken, Sindh and Tons contributes to 70.9% of the entire catchment area. . [1].

Precisely the causes of pollution are categorized as anthropogenic, ecological and geographical factors namely an ever increasing population base with poor practices of sanitation, untreated industrial and domestic waste, large areas of waste dump, diffusion through agriculture practices, animal husbandry practices, religious rituals etc. result in to deteriorated quality of water. Moreover the magnitude of various parameters viz runoff, flow direction, underground seepage have varying impact throughout the

course of river. Various Heavy metals found in rivers are Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Nickel and Zinc. Sources from mining, metallurgical processing industry, paints, plating, batteries, pesticides, fertilizer, refineries, tannery, thermal power plants, beneficiation of ores etc. add to the pollution. Subtle addition could be from decay of organic matter from plants and animals.

Remote sensing technology with ability of synoptic and repetitive coverage, sensors to detect changes, observations at various resolutions provides access to the remotest segments of earth was employed. With resolution of 10 meters accessibility the researchers are equipped to accurately reach the most inaccessible points. With competences to capture, process, store, manipulate, analyze and manage the voluminous data and generate meaningful representations of spatial data; Geographic Information System bridges the gap between science technocrats and layman.

II. Materials and Methods

Study Area

The study area derived from the Landsat 8 OLI imagery (Table 1) dated 26 November 2018 having path no. 146-147 and row no. 39-41 extends between Dak Patthar (30.504937°N, 77.791141°E) and Rambagh, Agra (27.200283°N, 78.033355°E) covering approx. 450 kms of the river length.

Methodology

Landsat satellite data from series 5, 7 and 8; Carto Sat Digital Elevation Model was corrected for geometric errors etc. The vector shape file of river Yamuna was prepared by onscreen digitization technique from the Landsat 8 composite using ArcGIS 10.6. Carto Sat – 1 (Carto DEM Version-3 R1-(Table 2).was used for generating terrain elevation values and the slope map of the study area. Further, the land use characterization was performed with Supervised classification technique of ERDAS Imagine. A visual classification performed using Google Earth and Ground Truth Verification via Garmin eTrex GPS to obtain detailed thematic map of the land use categories. For land use classification the United States Geological Survey (USGS) and National Remote Sensing Center (NRSC) definitions were used.

Table.1. Landsat 8 OLI specifications.

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1- Ultra blue (Coastal/ Aerosol)	0.435-0.451	30
Band 2 Blue	0.452-0.512	30
Band 3 Green	0.533-0.590	30
Band 4 Red	0.636-0.673	30
Band 5 Near Infra Red (NIR)	0.851-0.879	30
Band 6 Short Wave Infra Red (SWIR) 1	1.566-1.651	30
Band 7 Short Wave InfraRed (SWIR) 2	2.107-2.294	30
Band 8 Panchromatic	0.503-0.676	15
Band 9 Cirrus	1.363-1.384	30
Band 10 Thermal Infra Red (TIRS) 1	10.60-11.19	100*30
Band 11 Thermal Infra Red (TIRS) 2	11.50-12.51	100*30

Table 2. The specifications of CartoSat-1

S.No	Property	Values
1	Spatial Resolution	2.5m
2	Radiometric Resolution	10 bits
3	Swath	30 kms
4	Product Dimensions	30 km * 30 km
5	Planimetric Accuracy	15m (CEP90)
6	Vertical Accuracy	8m(LE 90)
7	Processing Tools	SAPHIRE 1.0

The sampling sites were selected considering the major point sources and the fact of high demographic density in alluvial soil belt. The region has an elevation from 72 to 1582 meters above mean sea level. The river velocity, flow direction, accumulation, seepage etc. are dependent on the slope and elevation of the region.

Fig.1.Sampling Sites from Dak Patthar to Agra.

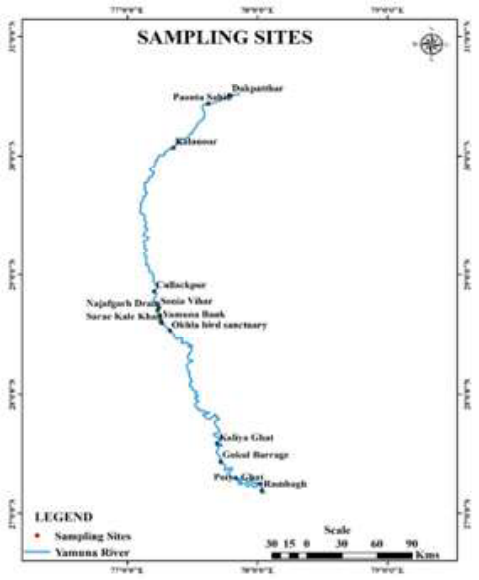


Fig:2. Map showing the extracted Digital Elevation Values

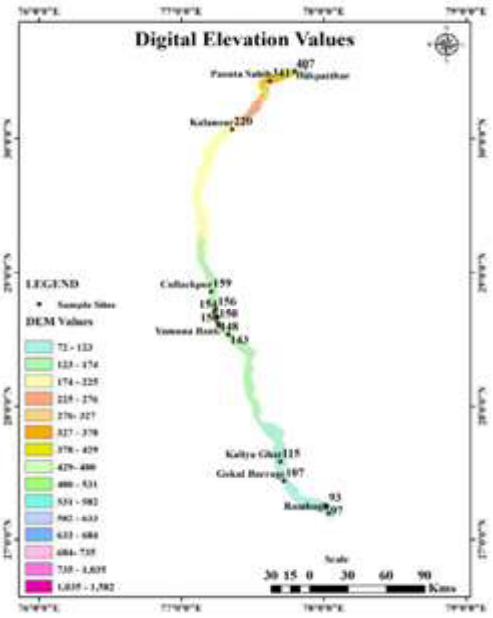


Fig. 3. Indraprastha Power Station Site.

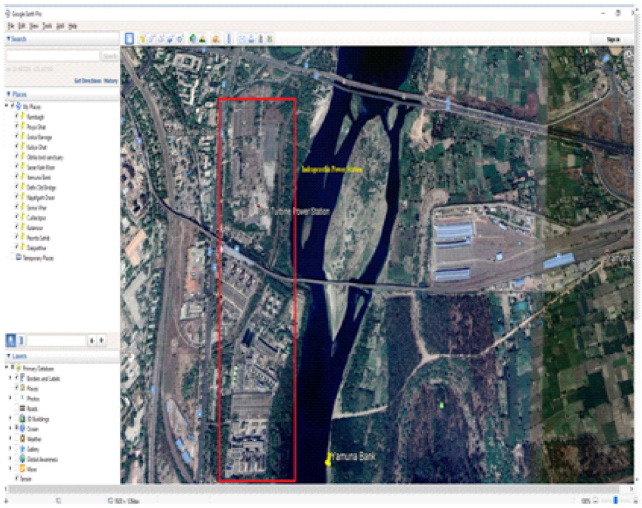
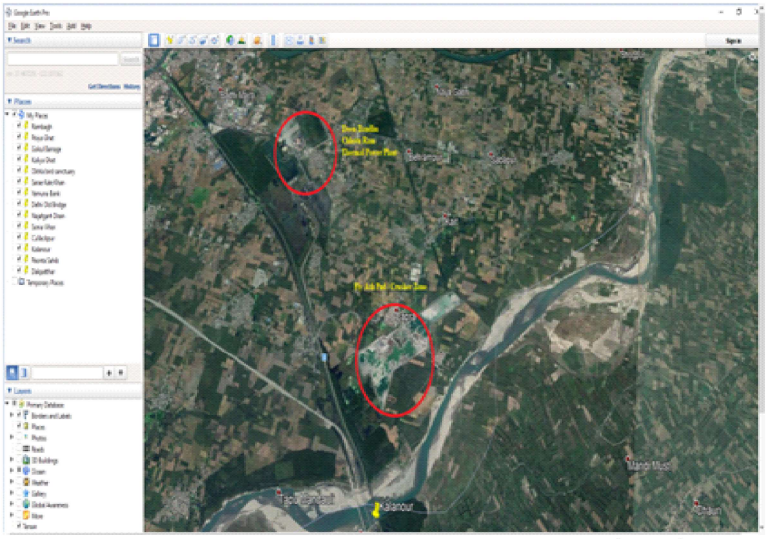


Fig.4. Kalanour, Yamuna Nagar Site.



The samples were taken from 14 locations between 13th -19th Nov 2018 and studied for values of hydrogen potential, dissolved oxygen (mg/L), electric conductivity (mS/cm), turbidity (NTU), temperature (°C), oxidation reduction potential (mV) and total dissolved solids (g/L). Chloride, Phosphate, Nitrate, Nitrite, Sulphate, Silica, Biological Oxygen Demand, Chemical Oxygen

Demand and Fecal Coliform were derived in the laboratory with APHA guidelines. (Table 3and 4)

The Heavy Metal detection was performed using Analytikjena Atomic Absorption Spectrophotometer for Copper, Iron, Manganese and Zinc (Table 5).

The site specific Water Quality Index was calculated using 9 parameters viz. Dissolved Oxygen, Fecal Coliform, pH, BOD, Temperature, Total Phosphate, Nitrates, Turbidity and Total Solids. The calculations were performed using the formula :

$$WQI = \sum_{k=1}^{n} Qi\, Wi$$

Where Qi= Sub index for ith water quality parameter;

Wi= Weight associated with ith water quality parameter;

N= Number of water quality parameter.

The weights assigned by NSF and CPCB were considered.(Table 6 and 7).

Table.3. In-situ Physical Parameter

Site_Name	pH	Temp (°C)	TDS (ppm)	EC (mS/cm)	DO (mg/L)	Turbidity (NTU)
Dak Patthar	7.86	19.8	79	158	7.18	1.9
Paonta Sahib	7.3	19.7	175	351	7	26.8
Kalanour	7.44	21	184	368	8.1	18.7
Cullackpur	7.53	21	247	505	7.5	13.4
Sonia Vihar	7.21	20.5	312	624	6.4	8.1
Najafgarh Drain	6.91	19.8	885	1781	7.1	22.8
Delhi Old Bridge	7.2	19.8	559	1106	1.5	17.6
Yamuna Bank	6.98	21.7	614	1228	2.9	16.2
Sarae Kale Khan	7.49	19.8	633	1265	3.6	18.7
Okhla Bird Sanctuary	7.45	19.2	586	1288	6.4	21.1
Kaliya Ghat	7.51	21.1	526	1052	5.7	23
Gokul Barrage	7.38	24	528	1087	8.5	26
Poiya ghat	7.55	21	679	1358	5.3	18
Rambagh	7.16	21.7	548	1175	5.2	22

Table.4.Chemical analysis

Site_Name	Cl- (ppm)	PO3-(ppm)	NO3- (ppm)	NO2- (ppm)	SO4-2(ppm)	SiO2 (ppm)	BOD (mg/L)	F.Coliform (CFU/100ml)
Dak Patthar	196	0.04	0.63	Bdl	35.1	6.81	1.9	14
Paonta Sahib	206	0.06	4.26	0.01	121.36	7.21	2.2	18
Kalanour	230	0.37	10.7	0.04	195.26	14.27	9	22
Cullackpur	1281.16	0.92	19.23	0.92	294.5	16.11	12.3	14532
Sonia Vihar	1012.8	1.06	11.2	0.97	345.7	12.41	18.1	16279
Najafgarh Drain	1376.61	3.19	1.1	0.75	491.21	10.6	22.4	32154
Delhi Old Bridge	1198.3	2.13	0.92	0.5	341.9	11.7	22.9	46521
Yamuna Bank	1541.28	1.84	0.88	0.49	312.02	18.59	33	76430
Sarae Kale Khan	1931.9	1.44	2.81	0.04	528.14	20.34	37	88346
Okhla bird sanctuary	2086.3	2.67	17.6	0.81	582.46	19.2	28	114758
Kaliya Ghat	1780.9	2.04	14.32	0.12	575.88	18.46	24	119437
Gokul Barrage	1874.4	1.95	5.75	0.09	684.25	18.12	29	120274
Poiya ghat	2115.8	2.26	4.11	0.05	764.12	16.24	21.6	121036
Rambagh	1679.2	2.11	3.18	0.05	672.37	16.02	21.1	122094

Table:5.Heavy Metal Concentrations in 2018.

Site _Name	Copper (ppm)	Iron (ppm)	Manganese (ppm)	Zinc(ppm)
Dak Patthar	0.0255	0.0677	0.217	1.0143
Paonta Sahib	0.0031	0.2191	0.262	1.1014
Kalanour	0.3247	0.3884	0.1192	1.6482
Cullack Pur	0.0849	0.7547	0.1235	1.6241
Sonia Vihar	0.472	0.2891	0.2618	3.137
Najafgarh	0.1959	0.2671	0.3215	3.1789
Delhi Old Bridge	0.8203	0.3938	0.7757	3.1685
Yamuna Bank	0.2537	0.3135	0.7781	7.1897
Sarae Kale Khan	0.1208	0.2195	0.8167	8.1469
Okhla Bird Sanctuary	0.1467	0.1834	0.9822	2.9774
Kaliya Ghat	0.1116	0.1971	0.9495	6.2574
Gokul Barrage	0.8922	0.3642	0.9205	1.5977
Poiya Ghat	0.7839	0.2831	0.0489	6.0387
Ram Bagh	0.2873	0.3886	0.0756	3.9344

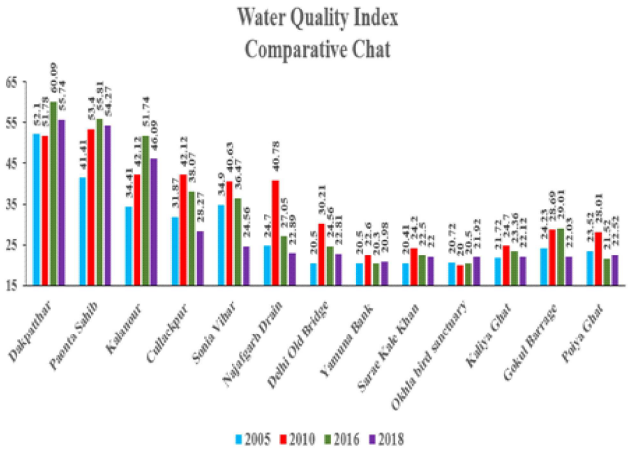
Table 6. Weight associated with different parameters as per NSF WQI

Factor	Weight
Dissolved oxygen	0.17
Fecal coliform	0.16
pH	0.11
Biochemical oxygen demand	0.11
Temperature change	0.10
Total phosphate	0.10
Nitrates	0.10
Turbidity	0.08
Total solids	0.07

Table 7: Original and Modified Weights for the computation of NSF WQI.

Water Quality parameters	Original Weights from NSF WQI	Modified Weights by CPCB
DO	0.17	0.31
FC	0.16	0.28
pH	0.11	0.22
BOD	0.11	0.19

Fig.3. Comparative Site Specific Water Quality Index.



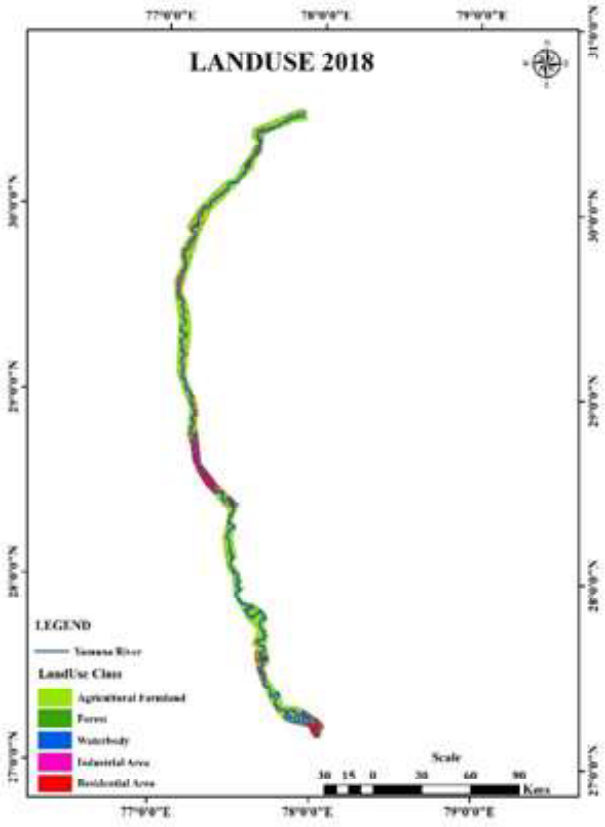
Utilizing the expertise of image interpretation elements on Landsat 8 OLI imageries and Google Earth the classification system of Land use of the study area was performed. The width of 2.5 kms on both the sides of the river bank were classified using ERDAS Imagine Supervised Classification technique. To authenticate the interpretation overlay technique was used for manually digitized vector shape file of land use classes on to the classified image of ERDAS Imagine. The various classes resulted into values listed below (Table.8).

Table:8.LandUse Classification

Land Use Category	2005 (%)	2010 (%)	2016 (%)	2018 (%)
Agricultural Farm	42	37.11	31.21	33
Built Up/ Settlements	32	40.12	42.49	47
Forest	5	3.15	3.3	2
Industrial	15	14.62	21	14
Barren	6	5	2	4
Total	100	100	100	100

Source:- USGS Classification Scheme and NRSC Guidelines.

Fig:4: Land Use Map



III. Results and Discussions

The abuse of river via the industrial effluents, untreated waste and poor agricultural practices created an imbalance between natural sectors of the environment. As noted from Table 5.maximum value of Copper was registered to be 0.8922 ppm at Gokul Barrage, Iron was 0.7547 ppm at Cullackpur, Manganese was found to be 0.9822 ppm at Okhla Bird Sanctuary; while Zinc was 8.1469 ppm at Sarae Kale Khan. Fig: 3. Illustrates water quality over the years has deteriorated at a faster rate than it was presumed. Though, Dak Patthar has upheld it to be more than 50 throughout; various sites of Delhi observed values approx. 20.

Interestingly from table 8 it was derived that the Agriculture Farms increased in 2019 due to afforestation activity in parts of Dak Patthar and the Industrial area declined in 2010 due to official sealing in Delhi NCR which caused dye industries of Seelampur, Mathura, Sonipat region to be shut. However there was an increase in small scale industries viz. conveyor belt manufacturing, leather bag processing, naphthalene ball manufacturing, wooden and aluminum door blocks, detergent industry, diagnostic rubber consumables, ice block manufacturing, garment dying, agarbatti manufacturing, screws and bolts etc.Further there was a decrease due to non-functioning of 3 out of 5 units of NTPC Badarpur plant, parts of steel and alloy factories in Kalanour, decrease in cold storage factories in between Agra and Mathura.

IV. Conclusion

The study provides a platform to understand the dynamics of water pollution; the trends and structure. New techniques of geospatial modeling of the pollution are fortified. The use of remote sensing and GIS provides access to information which is not available through the field survey. Since the database is a compilation from 2005-2018 it gives an overview of the possible reasons of pollution in brisk manner which helps initiate the replenishment work of the water quality.

V. Acknowledgement

We would like to specially thank and acknowledge Dr Kuldeep Singh, Director Amity Center for Soil Sciences for his personal guidance and the valuable help given by his team. The efforts of National Testing Laboratory Private Ltd, Delhi were commendable.

References:

Malik, D. et al (2014), Heavy Metal Pollution of the Yamuna River: An Introspection. *International Journal of Current Microbiology and Applied Science* (2014) 3(10) 856-863. URLhttp://www.ijcmas.com.

Vrebos, D. et al (2017),The impact of land use and spatial mediated processes on the water quality in a river system. Science of the Total Environment (2017) ;601-602:365-373 DOI: 10.1016/j.scitotenv.2017.05.217

Wrublack, S.C et al (2018) Variation Of Water Quality along a river in Agricultural Watershed With Support Of Geographic Informatiob Systems And Multivariate

Analysis. Engenharia Agrícola., Jan 2018, vol.38, no.1, p.74-81.doi.org/10.1590/1809-4430-eng .agric. v38n1p74-81/2018.

Vizcaíno I. P. et al (2016) Spatio-Temporal Analysis ofWater Quality Parameters in Machángara River with Nonuniform Interpolation Methods. Water 2016, 8, 507; doi:10.3390/w8110507.

Kar S. et al (2016) Classification of river water pollution using Hyperion data. Journal of Hydrology 537 (2016) 221–233..doi.org/10.1016/j.jhydrol.2016.03.047.

Isioye, O. A et al (2012) Terrain Analysis in GIS and Its Significance to Surface Runoff Analysis (A Study of Basawa Community in Sabon Gari L.G.A. of Kaduna State, Nigeria), International Journal of Engineering Research and Technology. Volume – 1, Issue – 1 Article #06.

Rawat K.S. et al (20118) Water Quality Indices and GIS based evaluation of a decadal groundwater quality, Geology, Ecology, and Landscapes, 2:4,240-255, DOI: 10.1080/24749508.2018.1452462.

Huixuan Li (2018), Spatial Assessment of Water Quality with Urbanization in 2007–2015, Shanghai, China. Remote Sensing. Remote Sens. 2018, 10, 1024; doi:10.3390/rs10071024.

Gholizadeh MH et al (2017) Study on Spatiotemporal Variability of Water Quality Parameters in Florida Bay Using Remote Sensing.Journal Remote Sensing & GIS 6: 207. doi: 10.4172/2469-4134.1000207

13

Consumption of polyunsaturated fats in India: Balancing Omega-3 and Omega- 6 in Edible Oils

Rajni*, Suman Meena, Mansi Y.Chaudhary
Rajdhani College, Department of Chemistry, Delhi University
E-mail: rajnigrover777@gmail.com

ABSTRACT

The consumption of vegetable oils has increased drastically in the last century. While some vegetable oils have been linked to health benefits, there are concerns about the excessive intake of omega-6. Both omega-6 and omega-3 fatty acids are essential fatty acids in terms that human beings need some of them in diet because their body can't produce them. Throughout evolution, humans got omega-3 and omega-6 in a certain ratio. While this ratio differed between populations, it is estimated to have been about 1:1. However, in the past century or so, this ratio has shifted dramatically and may be as high as 20:1. Scientists have hypothesized that too much omega-6, relative to omega-3, may contribute to chronic inflammation. Chronic inflammation is an underlying factor in some of the most common diseases, such as cardiovascular disease, cancer, diabetes, arthritis and auto immune disorders.

Introduction:

Lipids are considered as macro nutrients for humans. They are essential in body for absorption or mobilization of some fat soluble vitamins like vitamin A, E and fat soluble antioxidants those who cannot absorb without lipids. Many bioactive lipid molecules generated by the metabolism of lipids act as fundamental mediator of multiple signaling pathways as they are indispensable compounds of cell membranes. Any sort of change in composition of cell membrane due to change in metabolism of lipid may lead to interruption of signaling network and could be associated with many inflammatory complications (1-6). Depending on the presence and absence of double bond, lipids are majorly classified as saturated (SFAs—without double bonds), monounsaturated (MUFAs—with one double bond) and polyunsaturated fatty acids (PUFAs—with two or up to six double bonds). The PUFAs further classified as omega 3 and omega 6 fatty acids depending on the position of the first double bond from the methyl end of the fatty acid. Omega-6 fatty acid also known as linoleic acid (LA) (18:2ù-6) and omega-3 fatty acids as alpha-linoleic acid (ALA) (18:3ù-3). Due to absence of the endogenous enzyme, human body and other mammals cannot synthesize PUFAs, that must be derived from diet only and therefore they are essential for our body and hence known as essential fatty acids (7, 8). However these fats are different from others as they are not used for energy and have an important role in inflammation and blood clotting process. Obviously inflammation is essential for our survival, which helps to protect our body from infection and injury.

The evolutionary studies of human diet from the Paleolithic age has shown that our body evolved by consuming a diet that is much lower in saturated fatty acids, which is much lower than what we consume in today's diet (9). Moreover, the omega-6 fatty acids lower the serum cholesterol concentration(10) so that indiscriminate recommendation has been taken to substitute the omega-6 fatty acid for saturated fat and all the traditional saturated fats like butter, ghee etc. have been replaced by edible vegetable oils that quoted "Rich in omega-6". As some of branded vegetable oils have been linked to health benefits of omega-6, the consumption of vegetable oils in the Indian diet increased drastically in two decades. As a result, the intake of total fat and saturated fats as percentage of total calories consumed has continuously decrease and replaced by the edible vegetable oils in Indian diet. Even though, after China and Canada being the third largest producer

(11.3%) of oilseed in the world, India ranked 7th largest importer of edible oils in the world and meets 57% of the domestic edible oil requirements through imports (11).

Vegetable oils are rich source of essential fatty acids (LA and ALA), unsaturated fatty acids, vitamin E and vitamin A and contain no dietary cholesterol, so, these must be a part of a normal balanced and healthy diet. Apart from that most of the vegetable oils consumed in India such as sunflower, rice bran, soybean, palm oil and hydrogenated vegetable oils, refined vegetable oils are rich in omega 6 fatty acid that leads the current diet become very rich in alpha-linolenic acid (ALA) and deficit in linoleic acid (LA) fatty acids and the balance of omega-6/omega-3 has been highly disturbed in Indian population fat ratios and leading to an unhealthy omega-6/omega-3 ratio of 38:1 to 50:1 in urban area on India, instead of 1:1 which is actually required ratio for human body (12) table1. LA is found in high amounts in grains while fish oil, flaxseed, chia, rapeseed, walnuts and perilla are rich in ALA. The amount of ALA is also higher in green leafy vegetables, particularly wild plant than LA. This unbalanced ratio is in favor of omega-6 which is actually pro-inflammatory and pro-thrombotic in nature. Moreover, it enhances obesity, causes diabetes and atherosclerosis (13-15) whereas the omega-3 fatty acid is anti-inflammatory in nature. Consumption of diet rich in omega-3 fatty acid reduce the risk of coronary heart disease (16, 17), hypertension (18, 19), type2 diabetes (20, 21), renal disease, chronic obstructive pulmonary disease (22).

Moreover in the present scenario the edible oils used in India don't have any specifications for fatty acid composition. The Food Safety and Standard Authority of India (FSSAI) (2010) proposed the permissible limit of TFA (<10%) in hydrogenated vegetable oils but no limit of omega-6 fatty acids in edible oils. This unawareness about the higher intake of omega-6 through diet may increase the risk of the most serious modern diseases including cardiovascular disease, metabolic syndrome, Alzheimer's, obesity, diabetes and many type of cancers in Indian population.

This review focuses on the potential value of omega-6/omega-3 fatty acids ratio in the diet (vegetable oils) as a target for reducing risk of different disease.

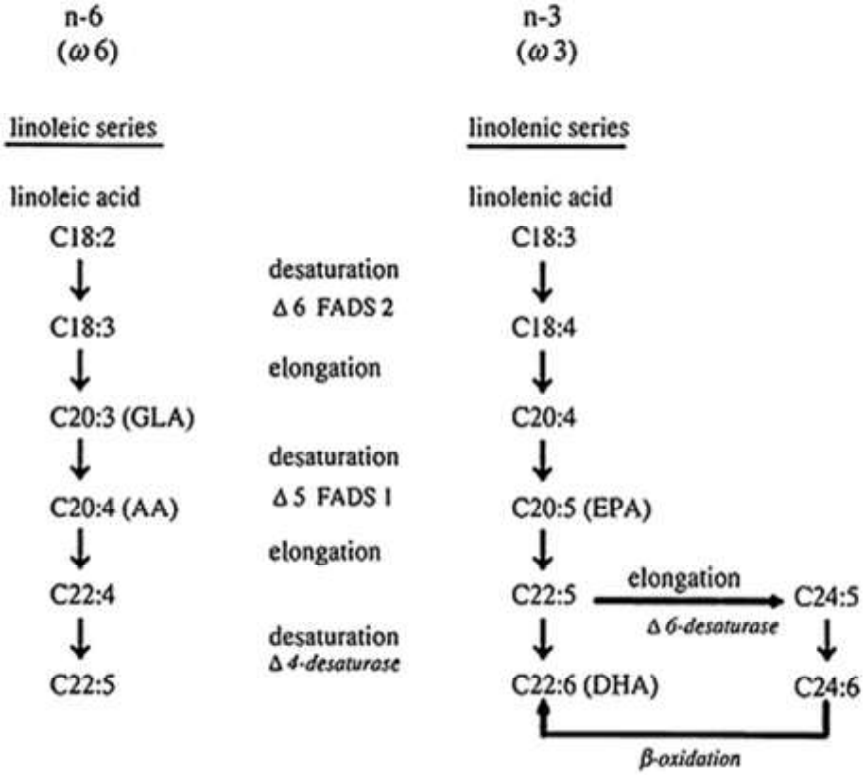
Table 1: Ratio of Omega-6/Omega-3 in Different Populations. Data from Eaton et al. (23)

Population	**ω-6/ω-3**
Paleolithic	0.79
Current Japan	4.00
Current UK and Northern Europe	15.00
Current India, rural	5-6.1
Current India, urban	38-50

The metabolic and physiological aspects of essential fatty acids

Linoleic acid (LA; 18:2 n-6) and á-linolenic acid (ALA; 18:3 n-3) are the fundamental PUFAs of body that metabolized to longer chain fatty acids of 20 to 22 of carbon atoms. Arachidonic acid (AA; 20:4 n-6) is obtained from the metabolism of linoleic acid (LA) and EPA (20:5 n-3) and DHA (22:6 n-3) are from alpha-linolenic acid(ALA). in this process due to adding extra double bonds to the carboxyl end of the fatty acid molecule the chain length and degree of unsaturation increases(24) **[Fig 1].**

Fig 1: Desaturation and elongation of ω-3 and ω-6 fatty acids by the enzymes fatty acid de-saturases FADS2(D6) and FADS1(D5), which are encode rate-limiting enzyme for fatty acid metabolism.



There is a competition between both omega-3 and omega-6 fatty acids for the desaturation enzyme during the metabolism. However omega-3 acid is the preference of D-4 and D-6 desaturases than omega-6 acid. But the trans fatty acid as well as high intake of omega-6 interfere with the desaturation and elongation of omega-3 fatty acid (25-27). EPA and DHA, the byproduct of ALA PUFAs metabolism can be derived only from direct ingestion or by synthesis from dietary ALA. All mammals, except for certain carnivores can convert LA to AA and ALA to EPA and DHA with a slow process. EPA and DHA are essential in pregnancy period for proper fetal development and healthy aging (Table 2) .They are precursors of several metabolites like potent lipid mediators and considered beneficial in the prevention of several diseases (28).

Table 2: Roll of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in body

• Both DHA and EPA are the key component of all cell membranes composition and play an important role in anti- inflammatory process and in viscosity or permeability of the cell membrane (29).
• **Brain**: DHA is the most abundance component of brain and supporting the brain health of children and adults throughout the life. The maternal intake of DHA leads to the normal development of brain in fetus and breastfed infants.
• **Eyes**: DHA plays an important role in both infant visual development and visual function throughout as the major structural fat in the retina of the eye.
• **Heart**: DHA is found in abundant level in heart tissue, as a result DHA is important for hearth health throughout life. It also contributes to maintenance of normal blood triglyceride levels, blood pressure and heart rate. Both the EPA and DHA recover the plaque stability thereby decrease endothelial activation and improve vascular permeability and good vascular permeability of heart tissue decreasing the chance of cardiovascular event (30).

The importance of omega-6/omega-3 ratio in human body: The omega-6 and omega-3 fatty acid distinct by the location of double bond from the methyl end of fatty acid molecule. In omega-3 fatty acid, first double bond is located between 3rd and 4th carbon atom while the first double bond of omega-6 is between 6th and 7th carbon atoms. Both the LA and ALA and their long-chain derivatives are important component of cell membrane of animal as well as plants. Because omega-3 desaturase enzyme (converting enzyme) in human body cells cannot convert omega-6 to omega-3 that means these two classes inter convertible and often have opposing physiological functions. AA is the parent compound of eicosanoid production so that high intake of omega-6 fatty acid with the modern diet increase the production of eicosanoid metabolic product from omega-6 acid, specially thromboxanes, leuko- trienes, prostaglandins, hydroxy fatty acids and lipoxins (31). The adequate production of eicosanoid is biologically active but their large amount is contributed to the formation of thrombus and atheromas; to

allergic and inflammatory disorders. Thus a omega-6 rich diet increase the risk of physiological state that is pro-aggregatory and prothrombotic for body.

a) Omega-6/Omega-3 fatty acids ratio and Obesity

As earlier discussed, DHA and EPA are the key components of all cell membranes composition and any sort of change in composition of cell membrane due to change in metabolism of lipid, may lead to interruption permeability of the cells. Through Adipogenesis and lipid homeostasis mechanism, omega-6 plays the main role in fat accumulation in body while omega-3 can inhibit the same at multiple steps (32-36). Omega-6 increases the cellular membrane permeability through which it increases the cellular triglyceride content. In addition, omega-6 also modulate the brain-gut-adipose axis and inflammatory properties of eicosanoids, which ultimately affect the fat mass growth in body (37-39). High intake of omega-6 leads to increase in the AA level in adipose tissue which is associated with BMI and obesity. While omega-3 fatty acid play opposite role and reduce fat deposition in adipose tissue by increasing â-oxidation and suppressing lipogenic enzyme (36)**.** Various studies have shown that EPA and DHA supplementation may reduce the excessive weight of already obese body.

b) Omega-6/Omega-3 fatty acids ratio and cardiovascular disease

An increase in the amount of linoleic acid in the adipose tissue and in platelets is positively associated with cardiovascular diseases as linoleic acid increases low-density Lipoprotein oxidation and serverity of coronary Athero-sclerosis (40-42). In the form of serum cholesterol esters and phospholipids fatty acids, the concentrations linoleic acid are found higher in the patients with cardiovascular disease (CVD) with those without CVD (43). Whereas long chain PUFAs like DHA (docosahexaenoic acid) and EPA (eicosapetaenoic acid) have the inverse effect in platelets and related to CVD. Increasing the ratio of omega-6/omega-3 can reduce the amount of omega-3 in body as it compete with ALA metabolism to long PUFAs which act the positive effect against cardio vascular disease (44). Overall the high omega-6 can increase the blood pressure that leads to blood clots, heart attack and stroke.

Table 3: Effect of omega-6 rich vegetable oils as a causative factor of cardio vascular disease

Greater amount of linoleic acid oxidation products are found in LDL and plasma of patients with atherosclerosis (45)
A diet that is high in oleic acid or lower in linoleic acid decrease the LDL susceptibility to oxidation (46).
A meta-analysis of randomized controlled trial found in human body that when saturated fat and trans fat is replaced by omega-6 fat, there is an increase in all-cause mortality, ischemic heart disease mortality and cardiovascular mortality.
Linoleic acid is the most copious PUFAs in LDL and is extremely vulnerable to oxidation being one of the very first fatty acids to oxidize. Greater the linoleic acid products found within atherosclerotic plaques and Degree of oxidation determines the severity of atherosclerosis.(45)

c) Omega-6/Omega-3 fatty acids ratio and Diabetes

Both the PUFAs are good fat for human nutrition therapy and are beneficial for a good lipid profiles in healthy persons and for the type 2 diabetic patients, but should be consumed in a moderate amount. on increasing the ratio of omega-6/omega-3 increased the amount of omega-6 fatty acids which leads to decrease the insulin sensitivity in muscles and promote the fat accumulation in adipose tissue. whereas the omega-3 PUFAs improve several metabolic abnormalities which are responsible for diabetes mellitus. it increase the production and secretion of adipocytokines such as adiponectin and leptin enzymes and improve the insulin sensitivity via anti-inflammatory effect mediated directly(47-49).

The increase in the ratio of omega-6/omega-3 causes an increase in the endocannabinoid signaling and related meadiators. Endocannabinoids are lipids, the concentration of which are regulated by dietary intake of PUFAs and by biosynthetic and catabolic enzyme's activity . Endocannabinoid is regulating the appetite and metabolism and on increasing the concentration of omega-6 will increase the endocannabinoid signaling

which is actually responsible for inflammation and weight gain.

Edible vegetable oil as a source of PUFAs (ALA and LA):

Vegetable oils are rich source of unsaturated fatty acids, PUFAs, vitamin E, without any dietary cholesterol so they must be a part of healthy diet in moderated amount. They contain both good fats like omega-3 and omega-6 fatty acid, in different composition. India is having a wide range of vegetable oil crops grown in different climate zone. Some of the traditional cultivated oilseed's crops are mustard, groundnut, sesame, rapeseed, castor, sunflower and coconut. Still India is a big importer of edible oil as larger amount of palm oil, sunflower oil, soybean oil, rice bran oil, olive and cottonseed oils are being consumed these days.

The growing population, economic growth, urbanization, changing food habits and deeper penetration for the fried food is driving India's vegetable oil consumption, which is actually have the higher ratio of omega-6/omega-3 than required ratio for human body. Table 4 shows the percentage of saturated, MUFAs and PUFAs in the different edible vegetable oils (50-55)

Type of oil	**Saturated fatty acid**	**Monosaturated fatty acid (ω-9)**	**alpha-linolenic acid (ALA) (18:3ω-3)**	**Linoleic acid (LA; 18:2 n-6)**	**Total PUFAs**	**Omega-6/omega-3 ratio**
Mustard oil	8	70	12	10		5:6
Sunflower oil	10.3	19.5	0.2	65.7	65.7	1:120
soybean	15.6	22.6	7	51	57.7	1:10.6
Ground nut oil	20.3	46.5	-	31.4	31.5	1:50
Canola oil/rapeseed	7.4	61.8	9.1	18.6	28.1	2:1
Coconut	82.5	6	-	-	1.7	-
Palm oil	49	40	0.2	9.1	9.3	1:20
Flaxseed	9.0	18.4	53	13	67.8	1:4.3
Olive oil	13.8	71.3	o.7	9.8	10.5	12.8:1

From Table 4, it can be deduced that flaxseeds contain the highest percentage of omega-3. Out of all oils consumed in India, Canola oil, Mustard oil and olive oil are the healthiest options as they has low amount of saturated fatty acid as well as an adequate ratio of omega-6/omega-3. Moreover omega-3 rich foods are flax, rape, chia, perilla, walnuts and also found in the chloroplasts of green leafy vegetables. To maintain the balance of omega-6/omega-3 ratio we should cut down omega-6 and boost omega-3 in our diet.

Conclusion

- Human beings evolved on diet that provide equal amount of omega-3 and omega-6 fatty acids and human body have a certain omega-6/omega-3 ratio, that should be balanced through diet.
- Due to the replacement of saturated fat by edible vegetable oils which are rich in omega-6 PUFAs, increasing intake of omega-6 is disturbing the balance of PUFAs ratio, that is associated with weight gain, cardiovascular disease, type 2 Diabetes, and other inflammatory diseases.
- To maintain the PUFAs ratio balance, it is essential that every effort is made to decrease the omega-6 and to increase the omega-3 in diet. This can be done by changing the edible vegetable oils high in omega-6 like sunflower oil, rice bran, soybean, cottonseed and palm oil to other oils high in omega -3 such as flax seed, chia seed, rapeseed, walnut and high in mono-saturated like olive oil.
- Vegetable oils contain both good fats but not in ratio that is actually required for our body. So it should be consumed in moderate amounts. For Indian population, mustard oil, canola oil, and olive oils are good options for consumption as they have an adequate amount of saturated fat as well as have good ratios of PUFAs. Meanwhile for a healthy amount of omega-3 PUFAs, one may increase fish intake 2-3 times per week and decrease the meat intake.

Reference

Mišurcová, L.; Vávra Ambrožová, J.; Samek, D. Seaweed lipids as nutraceuticals. Adv. Food Nutr. Res. 2011, 64, 339–355.

Burdge, G.C.; Wootton, S.A. Conversion of eicoapentaenoic, docosapentaenoic and docosahexaenoic acids in young women. Br. J. Nutr. 2002, 88, 411–420.

Brenna, J.T.; Salem, J.N.; Sinclair, A.J.; Cunnane, S.C. á-Linolenic acid supplementation and conversion to n-3 long-chain polyunsaturated fatty acids in humans. Prostaglandins Leukot. Essent. Fat. Acids 2009, 80, 85–91.

Brenna, J.T. Efficiency of conversion of á-linolenic acid to long chain n-3 fatty acids in man. Curr. Opin. Clin. Nutr. 2002, 5, 127–132.

Huang, Ch.; Freter, C. Lipid metabolism, apoptosis and cancer therapy. Int. J. Mol. Sci. 2015, 16, 924–949

Simmons, G.E.; Pruitt, W.M.; Pruitt, K. Diverse roles of SIRT1 in cancer biology and lipid metabolism. Int. J. Mol. Sci. 2015, 16, 950–965

Simopoulos A.P. Evolutionary aspects of diet and essential fatty acids. In: Hamazaki

T., Okuyama H., editors. Fatty Acids and Lipids—New Findings. Volume 88. Karger; Basel, Switzerland: 2001. pp. 18–27.

Kang J.X. The importance of omega-6/omega-3 fatty acid ratio in cell function. The gene transfer of omega-3 fatty acid desaturase. In: Simopoulos A.P., Cleland L.G., editors. Omega-6/Omega-3 Essential Fatty Acid Ratio: The Scientific Evidence. Volume 92. Karger; Basel, Switzerland: 2003. pp. 23–36. [PubMed]

EATON SB, KONNER M (1985) Paleolithic nutrition. A consideration of its nature and current implications. N Engl J Med 312: 283-289.

Report of the National Cholesterol Education Program Expert Panel on detection, evaluation and treatment of high blood cholesterol in adults (1988) Arch Intern Med 148: 36-69

R.S. Jat, V.V. Singh, Pankaj Sharma* and P.K. Rai (2019) Oilseed brassica in India: Demand, supply, policy perspective and future potential. OCL 2019, 26, 8

Simopoulos A.P. The importance of the omega-6/omega-3 Fatty Acid ratio in cardiovascular disease and other chronic diseases. Exp. Biol. Med. 2008;233:674–688. doi: 10.3181/0711-MR-311. [PubMed] [CrossRef]

Simopoulos A.P. Dietary Omega-3 Fatty Acid Deficiency and High Fructose Intake in the Development of Metabolic Syndrome, Brain Metabolic Abnormalities, and Non-Alcoholic Fatty Liver Disease. Nutrients. 2013;5:2901–2923. doi: 10.3390/nu5082901. [PMC free article] [PubMed] [CrossRef]

Donahue S.M., Rifas-Shiman S.L., Gold D.R., Jouni Z.E., Gillman M.W., Oken E. Prenatal fatty acid status and child adiposity at age 3 years: Results from a US pregnancy cohort. Am. J. Clin. Nutr. 2011;93:780–788. doi: 10.3945/ajcn.110.005801. [PMC free article] [PubMed] [CrossRef]

Kromhout D., de Goede J. Update on cardiometabolic health effects of ù-3 fatty acids. Curr. Opin. Lipidol. 2014;25:85–90. doi: 10.1097/MOL.0000000000000041 [PubMed] [CrossRef]

DE LORGERIL M, RENAUD S, MAMELLE N, SALEN P, MARTIN JL, MONJAUD I, GUIDOLLET J, TOUBOUL P, DELAYE J (1994) Mediterranean a- linolenic acid-rich diet in secondary prevention of coronary heart disease. Lancet 343: 1454-1459

SINGH RB, NIAZ MA, SHARMA JP, KUMAR R, RASTOGI V, MOSHIRI M (1997) Randomized, double-blind, placebo-controlled trial of fish oil and mustard oil in patients with suspected acture myocardial infarction. The Indian experiment of infarct survival-4. Cardiovasc Drugs Ther 11: 485-491

APPEL LJ, MILLER ER, SEIDLER AJ, WHELTON PK (1994) Diet supplementation with fish oils and blood pressure reduction: a meta-analysis. Ann Intern Med 120(suppl): 10

APPEL LJ, MILLER ER 3rd, SEIDLER AJ, WHELTON PK (1993) Does supplementation of diet with "fish oil" reduce blood pressure? A meta-analysis of controlled clinical trials. Arch Intern Med 153: 1429-1438

CONNOR WE, PRINCE MJ, ULLMANN D, et al. (1993) The hypotriglyceridemic

effect of fish oil in adult-onset diabetes without adverse glucose control. Ann N Y Acad Sci 683: 337-340

RAHEJA BS, SADIKOT SM, PHATAK RB, RAO MB (1993) Significance of the n-6/n-3 ratio for insulin action in diabetes. Ann N Y Acad Sci 683: 258-271

SHAHAR E, FOLSOM AR, MELNICK SL, TOCKMAN MS, COMSTOCK GW, GENNARO V,HIGGINS MW , SORLIE PD, KO WJ, SZKLO M (1994) Dietary n-3 polyunsaturated fatty acids and smoking-related chronic obstructive pulmonary disease. Atherosclerosis Risk in Communities Study Investigators. New Engl J Med 331: 228-233

Eaton S.B., Eaton S.B., III, Sinclair A.J., Cordain L., Mann N.J. Dietary intake of long-chain polyunsaturated fatty acids during the Paleolithic. In: Simopoulos A.P., editor. The Return of w-3 Fatty Acids into the Food Supply. I. Land-Based Animal Food Products and Their Health Effects. Volume 83. Karger; Basel, Switzerland: 1998. pp. 12–23.

Simopoulos A.P. ù-3 fatty acids in health and disease and in growth and development. Am. J. Clin. Nutr. 1991;54:438–463. [PubMed]

Emken E.A., Adlof R.O., Rakoff H., Rohwedder W.K. Metabolism of deuterium-labeled linolenic, linoleic, oleic, stearic and palmitic acid in human subjects. In: Baillie T.A., Jones J.R., editors. Synthesis and Application of Isotopically Labeled Compounds 1988. Elsevier Science Publishers; Amsterdam, The Netherlands: 1989. pp. 713–716.

Hague T.A., Christoffersen B.O. Effect of dietary fats on arachidonic acid and eicosapentaenoic acid biosynthesis and conversion to C22 fatty acids in isolated liver cells. Biochim. Biophys. Acta. 1984;796:205–217. [PubMed]

Indu M., Ghafoorunissa P. N-3 fatty acids in Indian diets—Comparison of the effects of precursor (alpha-linolenic acid) vs. product (long chain n-3 polyunsaturated fatty acids) Nutr. Res. 1992;12:569–582.

Serhan CN, Chiang N, Van Dyke TE. Resolving inflammation: dual anti-inflammatory and pro-resolution lipid mediators. Nat Rev Immu- nol. 2008;8:349–61. Nutr. 2011;93:402–12

Smith GI, Atherton P, Reeds DN, Mohammed BS, Rankin D, Rennie MJ, Mittendorfer B. Dietary omega-3 fatty acid supplementation increases the rate of muscle protein synthesis in older adults: a random- ized controlled trial. Am J Clin 30. Dawczynski C, Martin L, Wagner A, Jahreis G. n-3 LC-PUFA-enriched dairy products are able to reduce cardiovascular risk factors: a double- blind, cross-over study. Clin Nutr. 2010;29:592–9

Simopoulos AP. Omega-3 fatty acids in health and disease and in growth and development. Am J Clin Nutr 54:438–463, 1991

Amri E.Z., Ailhaud G., Grimaldi P.A. Fatty acids as signal transducing molecules: Involvement in the differentiation of preadipose to adipose cells. J. Lipid Res. 1994;35:930–937. [PubMed]

Jump D.B., Clarke S.D., Thelen A., Liimatta M. Coordinate regulation of glycolytic

and lipogenic gene expression by polyunsaturated fatty acids. J. Lipid Res. 1994;35:1076–1084. [PubMed]

Ringbom T., Huss U., Stenholm A., Flock S., Skattebol L., Perera P., Bohlin L. Cox-2 inhibitory effects of naturally occurring and modified fatty acids. J. Nat. Prod. 2001;64:745–749. doi: 10.1021/np000620d.[PubMed] [CrossRef]

Mirnikjoo B., Brown S.E., Kim H.F., Marangell L.B., Sweatt J.D., Weeber E.J. Protein kinase inhibition by omega-3 fatty acids. J. Biol. Chem. 2001;276:10888–10896. doi: 10.1074/jbc.M008150200.[PubMed] [CrossRef]

Corey E.J., Shih C., Cashman J.R. Docosahexaenoic acid is a strong inhibitor of prostaglandin but not leukotriene biosynthesis. Proc. Natl. Acad. Sci. USA. 1983;80:3581–3584. doi: 10.1073/pnas.80.12.3581

Schwinkendorf D.R., Tsatsos N.G., Gosnell B.A., Mashek D.G. Effects of central administration of distinct fatty acids on hypothalamic neuropeptide expression and energy metabolism. Int. J. Obes. 2011;35:336–344. doi: 10.1038/ijo.2010.159

Hennig B., Watkins B.A. Linoleic acid and linolenic acid: Effect on permeability properties of cultured endothelial cell monolayers. Am. J. Clin. Nutr. 1989;49:301–305

Lepperdinger G. Inflammation and mesenchymal stem cell aging. Curr. Opin. Immunol. 2011;23:518–524. doi: 10.1016/j.coi.2011.05.007

Guyenet SJ , Carlson SE . Increase in adipose tissue linoleic acid of US adults in the last half century. Adv Nutr 2015;**6**:660–4.

Parthasarathy S, Khoo JC, Miller E, Barnett J, Witztum JL, Steinberg D. Low density lipoprotein rich in oleic acid is protected against oxidative modiûcation: implications for dietary prevention of athero- sclerosis. Proc Natl Acad Sci USA 87:3894–3898, 1990.

Reaven P, Parthasarathy S, Grasse BJ, Miller E, Almazan F, Mattson FH, Khoo JC, Steinberg D, Witztum JL. Feasibility of using an oleate- rich diet to reduce the susceptibility of low density lipoprotein to oxidative modiûcation in humans. Am J Clin Nutr 54:701–706, 1991

Schwertner HA , Mosser EL Comparison of lipid fatty acids on a concentration basis vs weight percentage basis in patients with and without coronary artery disease or diabetes. Clin Chem1993;**39**:659–63.

Hodgson JM , Wahlqvist ML , Boxall JA , et al .Can linoleic acid contribute to coronary artery disease? Am J Clin Nutr 1993;**58**:228–34

Jira W , Spiteller G , Carson W , et al . Strong increase in hydroxy fatty acids derived from linoleic acid in human low density lipoproteins of atherosclerotic patients. Chem Phys Lipids 1998;**91**:1–11

Brooks CJ ,Harland WA , Steel G , et al . Lipids of human atheroma: isolation of hydroxyoctade cadienoic acids from advanced aortal lesions. Biochim Biophys Acta 1970; **202**:563–6

Banga A, Unal R, Tripathi P, et al. Adiponectin translation is increased by the

PPARgamma agonists pioglitazone and omega-3 fatty acids. Am J Physiol Endocrinol Metab. 2009;296:E480–489. [PMC free article] [PubMed]

Vemuri M, Kelley DS, Mackey BE, et al. Docosahexaenoic Acid (DHA) But Not Eicosapentaenoic Acid (EPA) Prevents Trans-10, Cis-12 Conjugated Linoleic Acid (CLA)-Induced Insulin Resistance in Mice. Metab Syndr Relat Disord. 2007;5:315–322

Oh DY, Talukdar S, Bae EJ, et al. GPR120 is an omega-3 fatty acid receptor mediating potent anti-inflammatory and insulin-sensitizing effects. Cell. 2010;142:687–698. [PMC free article][PubMed]

Katragadda, H. R.; Fullana, A. S.; Sidhu, S.; Carbonell-Barrachina, Á. A. (2010). "Emissions of volatile aldehydes from heated cooking oils". Food Chemistry. **120**: 59. doi:10.1016/j.foodchem.2009.09.070.

Fats and fatty acids contents per 100 g (click for "more details") example: avocado oil; user can search for other oils". Nutritiondata.com, Conde Nast for the USDA National Nutrient Database, Standard Release 21. 2014. Retrieved 7 September 2017. Values from Nutritiondata.com (SR 21) may need to be reconciled with most recent release from the USDA SR 28 as of Sept 2017

"Canola oil, fat composition, 100 g". US National Nutrient Database, Release 28, United States Department of Agriculture. May 2016. Retrieved 6 September 2017

"Linseed/Flaxseed oil, cold pressed, fat composition, 100 g". US National Nutrient Database, Release 28, United States Department of Agriculture. May 2016. Retrieved 6 September 2017

"Olive oil, salad or cooking, fat composition, 100 g". US National Nutrient Database, Release 28, United States Department of Agriculture. May 2016. Retrieved 6 September2017.

"Soybean oil, salad or cooking, fat composition, 100 g". US National Nutrient Database, Release 28, United States Department of Agriculture. May 2016. Retrieved 6 September2017

14

Removal of EBT from Waste Water Using Activated Carbon Derived From Agricultural Waste Corncob

Ritu Payal[1*], Arti Jain[2]

ritupayal.10@gmail.com

[1]Rajdhani College, Department of Chemistry, University of Delhi, New Delhi 110007.

[2]Daulat Ram College, Department of Chemistry, University of Delhi, New Delhi 110007.

Abstract

Scientific exploration is both beneficial and problematic for the environment and to human population. One of the consequences of industrial activities is the generation of high volumes of waste, whose disposal can be problematic, since it occupies large spaces, and when poorly managed can pose environmental and health risks for the population. As an environment remediation, the preparation of low-cost adsorbents from waste materials has several advantages, mainly of economic and sustainable nature. The production of activated carbon (AC) from agricultural by-products is a research field that has gained increased interest in recent years because of its potential for the disposal of agro-residues. ACs are carbons of highly

microporous form with both high internal surface area and porosity, and commercially the most common adsorbents used for the removal of organic compounds from air and water streams. This paper deals with the production of AC's from corn cob (an industrial waste) and its utilization in the treatment of laboratory waste water using batch process for the remediation of Eriochrome Black T (EBT).

Keywords: Activated carbon, agricultural waste, macroporous, biochar, industrial waste, EBT, spectrophotometer.

1. Introduction

Various industrial activities involved during the production of organic molecules and dyes, pesticides, fertilizers, storage batteries, metal plating, mining, research laboratories, smelting, tanneries, *etc*. can be considered as major culprit for water pollution besides a potent threat to the environment. United Nations organization (UNO) surveys validate the scarcity of pure water and potential health hazards associated with it [1,2]. Here, we are focusing mainly on the experiments performed in undergraduate research laboratories as a large amount of organic dyes are disposing off in the water sewage and is hazardous for the marine lives [3]. The small size, stability and non-biodegradable characteristics of the pollutants render them invulnerable to be removed from polluted water [4]. Numerous water purification industrials are inclining towards cost effective exploitation of agricultural waste for the water purification. They are encashing the lignocellulosic and carbonaceous characteristics of these materials [5].

In quest of our study for the treatment of EBT contaminated laboratory waste water an agricultural waste - corn cob was chosen which is obtained as an agricultural byproduct from a popular cultivated cereal crop Maize. The Corncobs have various potential uses such as thickening agent in cooking, precursor in synthesis of biodegradable plastics, cosmetics, soaps, medicines, less expensive adhesives, production of biodiesel, bioethanol and biogas to accomplish the increasing demand for biofuels. CC is a lignocellulosic material composed of cellulose, hemicellulose and lignin that are embedded in a multilayered matrix which makes it prone to enzymatic degradation [6]. Corncobs on burning produces activated carbon (AC) which has been exploited as bioadsorbant for EBT in the polluted water.

2. MATERIALS AND METHODS

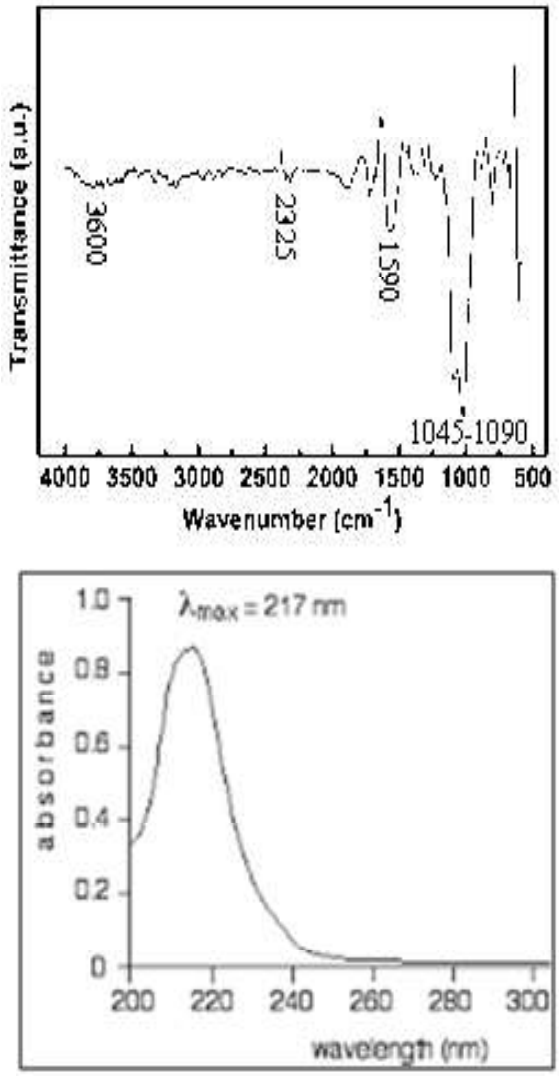
The corncobs residues were obtained from the fields of Uttar Pradesh (India). All reagents used in the present study were of analytical grade and the stock solutions (100 ppm) were prepared in de-ionized water. The corn cobs residue were washed thoroughly and repeatedly to remove sand, dusty particles and small stones followed by drying at 110°C in an oven overnight. Washed and dried corn cobs were carbonized in a Metrex programmable furnace at 900 C followed by activation. Subsequently, the product was chemically activated using KOH 850 °C for ~3 h. The second step involved physical activation of the char samples at 900°C using steam as the activation agent [7,8] (Fig. 1). The chemical stability, high mechanical strength, and macroporous structure of activated carbon make them effective adsorption material for removing organic dye (EBT) from waste water [9].

Fig. 1: Corn cobs: (a) before carbonization (b) carbonization, (c) activated Carbon

1. RESULTS AND DISCUSSION

The characterization of AC was done using FTIR spectra (Fig. 2a) and UV-Vis Spectra (Fig. 2b). Fig. 2a show bands at 3600 cm^{-1}, 2325 cm^{-1}, 1590 cm^{-1}, 1045–1090 cm^{-1} which depicts the presence of –OH group, aliphatic –CH stretching mode, C=C stretching vibration mode and C–O stretching vibration mode of various functionalities, respectively. The labelling of bands finds support from literature. Moreover, no impurities peaks were observed and justify the formation of pure activated carbon. UV-Vis absorption spectrum shows strong absorption band maxima at 217 nm. This may be attributed to photo excitation of electrons from the valence band to the conduction band [10].

Fig. 2: a) FTIR spectra (b) UV-Vis Spectra of activated carbon

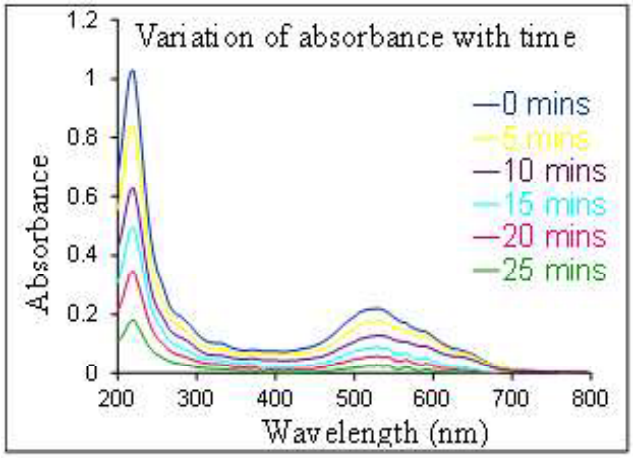


Treatment of waste water using batch process with AC: With the aim of proving the merit of this protocol, activated carbon was taken in 100 mL beaker and then 20 mL stock solution of EBT was poured over it. EBT gets adsorbed on the adsorbate *i.e.* AC (Fig. 3); as a result, pure water was obtained.

Fig. 3: Adsorption of EBT on activated carbon w.r.t. time

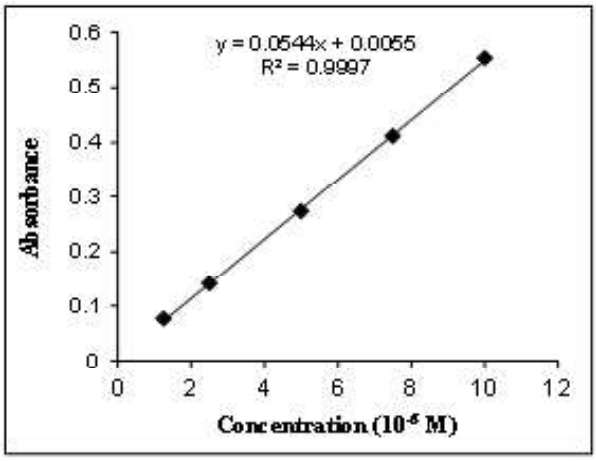
UV-Vis Spectrophotometric analysis: In order to validate this method absorbance data of polluted water containing EBT (Fig. 4) was recorded on Motras Scientific spectrophotometer. Fig. 4 showed that the absorbance of contaminated solution was decreased upon addition of AC as a result of decrease in the concentration of the EBT in the solution upon adsorption as it entrapped on the mesoporous surfaces of AC.

Fig. 4: UV-Vis spectra showing adsorption of EBT upon AC



The decrease in concentration of EBT upon binding with AC was also verified by the calibration curve (Fig. 5) which showed a linear relationship between absorbance and concentration *i.e.* Absorbance ∝ Concentration (Lambert-Beer Law).

Fig. 5: Calibration curve showing variation of absorbance and concentration



CONCLUSIONS

Corn cobs yields activated carbons having macroporous structure and larger surface area. The activated carbon was efficiently used for the removal of EBT from laboratory wastewater. Adsorption of the EBT with AC was fastest within the first 15 min of adsorption and removed ~80% of dye from the water samples. Moreover, agricultural waste corn cobs are readily available, the investigations provides a cost effective resource of removing metal ions from polluted water. Thus, scavenger on scavenger approach is aptly justified from this work.

ACKNOWLEDGEMENT"

The authors are thankful to University of Delhi, New Delhi for their financial assistance.

References

O. Ioannidou, A. Zabaniotou, Agricultural residues as precursors for activated carbon production – A review. Renew. Sust. Energ. Rev. 2007, 11(9), 1966-2005.

P. Malhotra, R. Payal, A. Jain, Whether to worry with waste: a review on activated carbon precursors from various waste materials. Int. J. Adv. Research 2016, 4(1), 14- 20.

N. Gaur, G. Flora, M. Yadav, A. Tiwari, A review with recent advancements on bioremediation-based abolition of heavy metals. Environ. Sci.: Processes Impacts, 2014, 16(2), 180-193.

S.T. Akar, S. Arslan, T. Alp, D. Arslan, T. Akar, Biosorption potential of the waste biomaterial obtained from cucumis melo for the removal of Pb^{2+} ions from aqueous media: Equilibrium, kinetic, thermodynamic and mechanism analysis. Chem. Eng. J. 2012 (185-186). 82-90.

P. Malhotra, R. Payal, A. Jain, Drinking water and health: A unique solution for remediation of contaminated water for sustainable health. J. Basic and Appld. Engg. Res. 2016, 3(1), 44-47.

M. Pointner, P. Kuttner, T. Obrlik, A. Jäger, H. Kahr, Composition of corncobs as a substrate for fermentation of biofuels. Agronomy Research 2014, 12(2), 391–396.

W. Buah, J. MacCarthy, S. Ndur, Conversion of corn cobs waste into activated carbons for adsorption of heavy metals from minerals processing wastewater. Int. J. Env. Prot. Policy. 2016; 4(4): 98-103.

X.F. Zhang, B. Wang, J. Yu, X.N. Wu, Y.H. Zang, H.C. Gao, P.C. Su, S.Q. Hao, Three-dimensional honeycomb-like porous carbon derived from corncob for the removal of heavy metals from water by capacitive deionization. RSC Adv. 2018, 8, 1159-1167

R. Payal, A. Jain, P. Malhotra, Waste to wealth approach: Removing toxic heavy metals and organic dyes from waste water using agricultural waste. Int. J. Chem. Env. Biol. Sci., 2017, 5(1), 46-49.

R.S. Raveendra, P.A. Prashanth, B.R. Malini, B.M. Nagabhushana, Adsorption of Eriochrome Black-T azo dye from aqueous solution on low cost activated carbon prepared from tridax procumbens. Res. J. Chem. Sci. 2015, 5(3), 9-13.

15

Mechanistic Pathways of Neurodegenerative Diseases due to Metal Loaded Particulate Matter

Saiyami Bhardwaj, Pankaj Kumar, Vandana Mishra*
Department of Environmental Studies
Bioresources & Environmental Biotechnology Laboratory
University of Delhi, Delhi-110007
(* Corresponding author: Dr Vandana Mishra, mistletoe_h@hotmail.com)

Abstract

Increasing levels of air pollution in developing countries challenges the sustainability of their economies. Particulate matters (PMs), specifically ultrafine particulate matters loaded with neurotoxic metals have become major drivers of neurocognitive disorders among citizens of developing nations, but the exact mechanisms through which they drive such health effects are still poorly understood. Unravelling PM-triggered metabolic pathways causing neurological disorders would not only be important in understanding the epidemiology of diseases but also assist in identifying key metabolic checkpoints for early diagnosis and drug targets for the disorders. This chapter analyses the link between air pollutants and the possible

metabolic and physiologic pathways triggering the impairment of neurocognitive function. Besides revealing the putative cellular pathways of neurocognitive disorders in air pollutant-exposed individuals, we also identified the priority areas of research that will bridge the significant gap in the current knowledge of pollution and neurocognitive health. Research and policies on the priority areas of research would help the environmental scientists and clinicians to develop better insights into underlying mechanisms linking the pollutants and neurocognitive functions for better health management.

Keywords: Air quality, Particulate matter, Neurocognitive health, Metals, Microglial activation

Email IDs of Authors:

Saiyami Bhardwaj: saiyami539@gmail.com

Pankaj Kumar: thakurpankaj.910@gmail.com

Vandana Mishra: mistletoe_h@hotmail.com

Introduction

Air pollution is considered as one of the biggest risk factors in terms of years of potential and productive life lost due to premature mortality and disability represented by disability-adjusted life years (DALYs) (Mannucci & Franchini, 2017). According to the State of Global Air Report 2018, air pollution has been ranked as the 5th highest factor contributing to early deaths. Air pollution is a complex mixture of harmful gases and particles including particulate matter (PM), nitrogen oxide species (NOx), sulphur oxide species (SOx), carbon monoxide, ozone, hydrocarbons, volatile organic compounds (VOCs), metals and other inorganic chemicals (Goldberg et al., 2006; Kilian & Kitazawa, 2018). PM has been further divided into an ultrafine fraction having a diameter less than 100 nm ($PM_{0.1}$), fine fraction including PM of diameter 2.5 microns or less ($PM_{2.5}$) and a coarse fraction of PM between 10 and 2.5 microns (PM_{10}) (Jeon & Lee, 2016). The size of pollutants is correlated with their potential for causing health problems (Kilian & Kitazawa, 2018). The particle size of lesser than 10 microns in diameter cause most serious health effects as they can get into the lungs and blood stream. Therefore, widely used as an indicator to quantify ambient air pollution (Lilian, 2002).

Increasing pace of economic development is resulting in higher levels of ambient air pollution and deteriorating public health (Mannucci & Franchini, 2017). Studies on the health impact of $PM_{2.5}$ in the developing countries of Asia showed that the smaller size and greater solubility of PM cause higher toxicity through mechanisms of oxidative stress and inflammation (Goldberg et al., 2006). Metals loaded PM have also been found to be associated with oxidative stress and neuro-inflammation (Cicero et al., 2017). Toxic metals are majorly reported to accumulate in the smallest particles ($PM_{2.5}$ or less), and such fraction can easily penetrate the epithelial barriers (Block & Calderõn-Garcidueñas, 2009). These metals on contact with tissue/cells inside the body undergo complex reactions and form compounds which are lipophilic and thus can cross the blood-brain barrier easily (Banks, 2009). Moreover, many metal ions are key cofactors in brain cell functions and mechanisms; thus a slight change in their concentration leads to various neurodegenerative disorders (Cicero et al., 2017).

Neurodegenerative disorder is a broad term for all the conditions including dementia, Parkinson's disease (PD), Alzheimer's disease (AD), Huntington's disease (HD), and Amyotrophic lateral sclerosis (ALS) that affect neurons in the human brain and are one of the major socioeconomic burdens of the society (Elbaz, Dufouil, & Alpérovitch, 2007; Kilian & Kitazawa, 2018). Many studies have shown the association between particle pollution with serious health effects such as respiratory problems and cardiovascular diseases. However, epidemiological studies linking air pollution with central nervous system-related (CNS) and neurodegenerative disorders are lacking in comparison with cardiovascular and respiratory diseases (Nash & Fillit, 2006). Incidences of neurodegenerative disorders are increasing within the population, and at times, their association with PM has been reported (Bozyczko-Coyne & Williams, 2007). Therefore, it is noteworthy to examine the neurotoxicity of airborne particles, the possible molecular and cellular pathways through which they act as risk factors for various neurodegenerative disorders. Besides this, the vulnerable groups are identified and current research gaps and the future scope of this study has been discussed.

Metal load on particulate and neurodegeneration

Air contaminants include particular airborne matter: suspended particulate matter (SPM), ultrafine particular matter (UFPM), chemicals, metals, and

many organic compounds. These toxic components differ in their characteristics based on the compounds they form when they get inside the body (Banks, 2009). Toxic pollutants associated with PM could be mixtures of solids and liquids located on the surface or embedded inside the matter (Karagulian et al., 2015). Toxic metals are mainly found embedded or located in the ultrafine particulate matters ($PM_{2.5}$) (Chen & Schwartz, 2009). Metals generated by industrial emissions like Iron (Fe), Nickel (Ni), Vanadium (V), Chromium (Cr), Copper (Cu), and Zinc (Zn) are well known to be associated with particulate matter and play a significant role in generation of reactive oxygen species (ROS) (Table 1) (Caito & Aschner, 2015; Cicero et al., 2017; Geiger, Cooper, & Cooper, 2010). Epidemiological studies have shown that particulate matter released from the industries or vehicular exhaust cause oxidative stress and can easily penetrate the nasal or olfactory epithelium thereby reaching the CNS and inducing neurodegenerative disorders (Karagulian et al., 2015; Rossignol & Frye, 2012). The vulnerability of CNS to oxidative stress can be attributed to the high metabolic demands of the brain and high energy usage. Particulate matter loaded with various toxic metals cause neurodegenerative disorders like Parkinson's disease, Alzheimer disease, Huntington's disease, Amyotrophic lateral sclerosis, and transmissible spongiform encephalopathy (Table 1) (Caito & Aschner, 2015). Thus, PM carrying metals and other toxic compounds are potent factors affecting public health (Sharp et al. 2004).

Many neurotoxic metals such as Cd, Cr (VI), Pb, Mn, Hg, and V are reported to be loaded in PM (Table 1). Arsenic (As) is released through volcanic activity, erosion of rocks, forest fires, and human activities. Central and peripheral nervous system disorders are common due to arsenic inhalation and ingestion. Moreover, Alzheimer's and Parkinson's disease, and Guillain-Barré syndrome are also associated with As-induced neurotoxicity (Geiger et al., 2010). Cd used in metal-plating, and the plastics industry causes irritability, cognitive deficit, Alzheimer's and Parkinson's disease (Chen & Schwartz, 2009; Geiger et al., 2010). Inhalation of airborne chromium from ferrochrome production, ore refining, chemical processing, cement-producing plants, automobile brake lining, and catalytic converters cause cognitive deficits (Geiger et al., 2010). Pb is commonly inhaled as a result of the combustion of solid waste, coal, and oils, emissions from iron and steel production and lead smelters. Children are more exposed to Pb toxicity because of its direct transfer from hand to mouth upon contact with

paint products, toys, etc. Pb is also associated with slow nerve conduction in adults, decline in intelligence quotient (IQ) level and neurodevelopmental effects in children (D'Angiulli, 2018; Geiger et al., 2010; Lilian et al., 2014). Another neurotoxic metal Mn is released from gasoline additive (Methyl cyclopentadienyl manganese tricarbonyl), coke ovens and is a well-known cause for manganism, which is an extra pyramidal neurological disorder characterized by rigidity in action tremor. Bradykinesia and inhibition or blockage of synaptic transmission are also associated with Mn neurotoxicity (Block & Calderõn-Garcidueñas, 2009; Geiger et al., 2010). Hg commonly used in thermometers, industrial processes, lubrication oils, and dental amalgams causes negative effects on CNS such as tremors, slowed sensory and motor nerve function, erethism (increased excitability), irritability, excessive shyness, paraesthesia (a sensation of pricking on the skin), mental retardation, and cerebral palsy (Geiger et al., 2010; Schikowski et al., 2015). Other wide ranges of neurologic problems due to Hg exposure include ataxic gait, clumsiness, muscle weakness, dysarthria, , and loss of neurons in the granular layer of the cerebellum as well as the loss of granular cells in the somatosensory, visual and auditory cortical areas (Caito & Aschner, 2015). V, which is commonly released from rubber, ceramic, and plastic industries, is widely associated with oxidative stress, cognitive decline, and reduced IQ level.

Metals-induced neurodegeneration: Biochemical, molecular and cellular pathways

The possible pathways triggering impairment at the molecular and cellular level include insulin resistance, oxidative stress, tonic up-regulation of the inflammatory markers, microglial activation which in turn leads to white matter and grey matter damage, reduced apical dendritic spine density, and branching in hippocampus (Fig. 1) (Block & Calderõn-Garcidueñas, 2009; Schikowski et al., 2015). Experimental studies have shown that ambient air pollution leads to tissue damage and oxidative stress. Metals like Ni and V get accumulated at target brain regions showing maximum accumulation at the olfactory mucosa followed by olfactory bulb and frontal cortex thereby justifying that nasal olfactory pathway is a key portal of entry for air pollutants especially $PM_{2.5}$ (L. Block and Calderõn-Garcidueñas, 2009).

Biochemical pathway

Epidemiological studies have shown that inhalation of $PM_{2.5}$ causes insulin resistance as a result of CNS injury, which can be either in the form of metabolic dysfunction or oxidative stress (Fig. 2). Insulin stimulates extracellular secretion of amyloid beta (Aâ) protein and inhibits its intracellular accumulation. Therefore, impaired insulin signaling leads to the accumulation of Aâ protein leading to the formation of plaques and negatively impacting memory and learning (Monte, 2012; Wei, Chen, Li, & Sang, 2019). PM exposure leads to upregulation of BACE expression and Aâ precursor protein, thereby leading to a build-up of Aâ protein, which leads to neurocognitive impairment (Monte, 2012). Also, predisposition of apolipoprotein epsilon-4 leads to accelerated amyloid â42 accumulation in neurons and blood vessels thereby increasing the chances of neurophysiological damage (Elbaz et al., 2007; Laskowitz, Horsburgh, & Roses, 1998; Schikowski et al., 2015).

Molecular pathway

Air pollutants particularly PM affect the brain either by directly reaching the brain and getting adsorbed or with the help of circulating cytokines (a type of inflammatory marker) like TNFá and IL-1â which are generated as a result of systemic inflammation in the peripheral immune system (Figure 2) (Block & Calderõn-Garcidueñas, 2009; Rückerl et al., 2007). These circulating cytokines are translocated either via epithelium or blood-brain barrier to reach brain parenchyma (Rückerl et al., 2007; Sharp et al., 2004). Another key portal for the entry of PM is nasal olfactory pathway wherein the inhaled particles cause neurodegenerative disorders by reaching and affecting trigeminal nerves, hippocampus and other parts of the brain which are disproportionately laden with abundant receptors for inflammatory markers (Block & Calderõn-Garcidueñas, 2009; Kilian & Kitazawa, 2018).

Cellular pathway

At the cellular level, various cell types are the mediators of air pollution caused neurotoxicity (Fig. 2). One such noteworthy example of cells mediating neurotoxicity is microglia (Rezaie, 2003). These are the innate immune cells residing in the brain which become responsive to all types of CNS injuries caused either by the components of air pollution directly or through the inflammatory cytokines generated in response to systemic inflammation (Rock et al., 2004; Rückerl et al., 2007). These microglia are sensitive to oxidative stress to the extent that free radicals can easily escape

microglia and reach the CNS where they damage the neurons (Rezaie, 2003; Rock et al., 2004). Another such cells are astroglia, which provides microglia-neuron contact, acts as a cushion to excess neurotransmitters, and gets activated in response to CNS damage secreting excess inflammatory cytokines (Sama et al., 2007). However, the exact mechanism responsible for the activation of astroglia remains undiscovered (Block & Calderõn-Garcidueñas, 2009; Campbell, 2004).

Above mentioned mechanisms synergistically lead to neuronal death and damage to CNS. Since CNS is not known to regenerate as efficiently as other systems, the neurocognitive impairment and decline become gradually progressive with age. (Chen & Schwartz, 2009).

Vulnerable groups

Ambient air pollution affects people of all age groups but in a different way when exposed over prolonged periods. Children and old age group are found to be more susceptible than the others (State of Global Air, 2019). Since children tend to play closer to the ground and spend more time outdoors, they are more exposed to airborne contaminants (C.-G. Lilian et al., 2014). As compared to adults, children have higher chances of experiencing early brain disturbances with reported cases of oxidative stress and inhibitory response when exposed to PM (D'Angiulli, 2018; C.-G. Lilian et al., 2014). Moreover, children are comparatively more vulnerable to air pollution caused stress as their immune system, and lungs are still in the developing phase (Mannucci & Franchini, 2017).The dosage of airborne pollutants required to damage the developing brain in the early stages of life is very low as compared to the dosage, which is required to damage the adult brain. (C.-G. Lilian et al., 2014)

Furthermore, the epithelial barriers of the children are not so well developed, and exposure of PM leads to the breakdown of epithelial barriers, particularly nasal and alveolar capillaries. This results in easy entry of PM to the CNS through these two key portals (Geiger et al., 2010; C.-G. Lilian et al., 2014). Thus, neurocognitive impairment at early stages could have long-lasting implications including low IQ level, low academic performance, and hampered economic progress mainly due to persistent exposure to pollution (Chen & Schwartz, 2009; D'Angiulli, 2018; Guxens et al., 2018).

Conclusions and future scope

Air pollution consisting of PM is a complex mixture of neurotoxic metals and compounds which induce inflammatory responses; amyloid beta accumulation, oxidative stress, and microglia-mediated inflammation, thereby, causing neurotoxicity. Neurodegenerative disorders are, therefore, a result of collaborative interaction of various physiological and metabolic mechanisms wherein the children and people of the least developed countries are at a higher risk. Correlating air pollution and neurocognitive health as a causal factor for each other is well justified. The gaps in the knowledge still exist in determining the exact risk of metals associated with neurodegenerative disorders in the ambient air, characterization of the mechanism of their entry into the human body and elimination of the same from the brain. Also, questions like whether neurological effects are synergistic or independent of respiratory and cardiovascular effects needed to be answered. A better insight into the underlying mechanisms of neurocognitive impairment caused by air pollution and precautionary strategies to minimize the extent of pollution is required for better health management among the emerging economies.

References:

Banks, W. A. (2009). Characteristics of compounds that cross the blood-brain barrier. *BMC Neurology*, *5*, 5–9.

Block, M. L., & Calderõn-Garcidueñas, L. (2009). Air pollution: mechanisms of neuroinflammation and CNS disease. *Trends in Neurosciences*, *32*, 506–516.

Bozyczko-Coyne, D., & Williams, M. (2007). Neurodegeneration. *Comprehensive Medicinal Chemistry II*, 6, 193–228.

Caito, S., & Aschner, M. (2015). Neurotoxicity of metals. In *Handbook of Clinical Neurology*, 131, 169-189.

Campbell, A. (2004). Inflammation, neurodegenerative diseases, and environmental exposures. *Annals of the New York Academy of Sciences*, *1035*, 117–132.

Chen, J. C., & Schwartz, J. (2009). Neurobehavioral effects of ambient air pollution on cognitive performance in US adults. *NeuroToxicology*, *30*, 231–239.

Cicero, C. E., Mostile, G., Vasta, R., Rapisarda, V., Signorelli, S. S., Ferrante, M., … Nicoletti, A. (2017). Metals and neurodegenerative diseases. A systematic review. *Environmental Research*, *159*, 82–94.

D'Angiulli, A. (2018). Severe Urban Outdoor Air Pollution and Children's Structural and Functional Brain Development, From Evidence to Precautionary Strategic Action. *Frontiers in Public Health*, *6*, 1–7.

Elbaz, A., Dufouil, C., & Alpérovitch, A. (2007). *Interaction between genes and environment in neurodegenerative diseases*, *330*, 318–328.

Fortoul, T. I. (2015). Health Effects of Metals in Particulate Matter, *Current air quality issues*, IntechOpen.

Geiger, A., Cooper, J., & Cooper, A. G. and J. (2010). Overview of Airborne Metals Regulations, Exposure Limits, Health Effects, and Contemporary Research. *Cooper Environmental Services*, 1–50.

Goldberg, M. S., Burnett, R. T., Yale, J. F., Valois, M. F., & Brook, J. R. (2006). Associations between ambient air pollution and daily mortality among persons with diabetes and cardiovascular disease. *Environmental Research*, *100*, 255–267.

Guxens, M., Lubczyñska, M. J., Muetzel, R. L., Dalmau-Bueno, A., Jaddoe, V. W. V., Hoek, G., … El Marroun, H. (2018). Air Pollution Exposure During Fetal Life, Brain Morphology, and Cognitive Function in School-Age Children. *Biological Psychiatry*, *84*, 295–303.

Jeon, Y.-M., & Lee, M.-Y. (2016). Airborne nanoparticles (PM 0.1) induce autophagic cell death of human neuronal cells. *Journal of Applied Toxicology*, *36*, 1332–1342.

Karagulian, F., Belis, C. A., Dora, C. F. C., Prüss-Ustün, A. M., Bonjour, S., Adair-Rohani, H., & Amann, M. (2015). Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level. *Atmospheric Environment*, *120*, 475–483.

Kilian, J., & Kitazawa, M. (2018). The emerging risk of exposure to air pollution on cognitive decline and Alzheimer's disease – Evidence from epidemiological and animal studies. *Biomedical Journal*, *41*, 141–162.

Laskowitz, D. T., Horsburgh, K., & Roses, A. D. (1998). Apolipoprotein E and the CNS response to injury. *Journal of Cerebral Blood Flow and Metabolism*, *18*, 465–471.

Lilian, C.-G., Torres-Jardón, R., RandyJ. Kulesza, S.-B. P., & D'Angiulli, A. (2014). Air pollution and detrimental effects on children's brain. The need for a multidisciplinary approach to the issue complexity and challenges. *Frontiers in Human Neuroscience*, *8*, 1–7.

Lilian, C. (2002). Safety Evaluation — Environmental Air Pollution and Brain Damage. *Toxicology Pathalogy*, *30*, 373–389.

Mannucci, P. M., & Franchini, M. (2017). Health effects of ambient air pollution in developing countries. *International Journal of Environmental Research and Public Health*, *14*, 1–8.

Monte, S. de la. (2012). Contributions of Brain Insulin Resistance and Deficiency in Amyloid-Related Neurodegeneration in Alzheimers Disease. *Drugs*, *72*, 49–66.

Nash, D. T., & Fillit, H. (2006). Cardiovascular Disease Risk Factors and Cognitive Impairment. *The American Journal of Cardiology*, *97*, 1262–1265.

Rezaie, P. (2003). Microglia in the human nervous system during development. *Neuroembryology*, *2*, 18–31.

Rock, R. B., Gekker, G., Hu, S., Sheng, W. S., Cheeran, M., Lokensgard, J. R., & Peterson, P. K. (2004). Role of microglia in central nervous system infections. *Clinical Microbiology Reviews*, *17*, 942–964.

Rossignol, D. A., & Frye, R. E. (2012). A review of research trends in physiological abnormalities in autism spectrum disorders: Immune dysregulation, inflammation, oxidative stress, mitochondrial dysfunction and environmental toxicant exposures. *Molecular Psychiatry*, *17*, 389–401.

Rückerl, R., Greven, S., Ljungman, P., Aalto, P., Antoniades, C., Bellander, T., … Peters, A. (2007). Air pollution and inflammation (Interleukin-6, C-reactive protein, fibrinogen) in myocardial infarction survivors. *Environmental Health Perspectives*, *115*, 1072–1080.

Sama, P., Long, T. C., Hester, S., Tajuba, J., Parker, J., Chen, L. C., & Veronesi, B. (2007). The cellular and genomic response of an immortalized microglia cell line (BV2) to concentrated ambient particulate matter. *Inhalation Toxicology*, *19*, 1079–1087.

Schikowski, T., Vossoughi, M., Vierkötter, A., Schulte, T., Teichert, T., Sugiri, D., …Luckhaus, C. (2015). Association of air pollution with cognitive functions and its modification by APOE gene variants in elderly women. *Environmental Research*, *142*, 10–16.

Sharp, Z., Atudorei, V., Elder, A., Gelein, R., & Kreyling, W. (2004). *Translocation of Inhaled Ultrafine Particles to the Brain*. *16*, 437–445.

Wei, W., Chen, M., Li, G., & Sang, N. (2019). Atmospheric PM2.5 aspiration causes tauopathy by disturbing the insulin signaling pathway. *Ecotoxicology and Environmental Safety*, *169*, 301–305.

Table 1: PM loaded neurotoxic metals, their source, concentrations of concern, and neurological effects caused by them.

Metal	Source of contamination	Minimum concentration (µg/m^3) showing neural toxicity As per U.S. national ambient air concentrations	Neurological defect	Reference
As	Metal smelters	0.02	Learning deficits, Guillain-Barre similar syndrome with confusion, irritability, cognitive loss associated with Alzheimer's disease, Amyotrophic lateral sclerosis	(Fortoul, 2015; Geiger et al., 2010)
Cd	Fossil fuel burning, incineration of municipal waste	0.008	Irritability, depression, cognitive deficit, associated with Alzheimer's disease, Parkinson's disease	(Caito & Aschner, 2015; Fortoul, 2015; Geiger et al., 2010)
Cr	Refining, chemical, refractory processes, leather tanneries	0.0016	Cognitive deficit	(Caito & Aschner, 2015; Cicero et al., 2017; Geiger et al., 2010)
Fe	Metallurgy, leather tanning, mining of iron ores	1.6	Cognitive decline, degeneration of nervous system, ataxia, accumulation of α-synuclein (found in patients with Parkinson's disease)	(Geiger et al., 2010)
Pb	Paints, leaded gasoline combustion	0.04	Cognitive decline, decline in IQ level, oxidative Stress	(Geiger et al., 2010; C. Lilian, 2002)
Mn	Coke ovens, gasoline additive Methylcyclopentadienyl manganese tricarbonyl (MCMT)	0.02	Parkinson's disease, manganism (extrapyramidal neurological disorder characterized by rigidity action tremor, bradykinesia, induces glial activation, block synaptic transmission)	Block & Calderõn-ırcidueñas, 2009; ;iger et al., 2010)
Hg	Dental amalgam, old pints, laxatives	0.014	Atrophy of large myelinated motor axon	(Caito & Aschner, 2015; Geiger et al., 2010)
V	Rubber, plastic, ceramic industry	0.065	Parkinson's disease, morphological and functional alterations in central nervous system (CNS), decrease in dendritic spine density	(Geiger et al., 2010)
Cu	Copper ore smelting, metallurgical processes	0.29	Alzeihmer's disease, amyotrophic lateral sclerosis, Huntington's disease, Parkinson's disease, oxidative	(Geiger et al., 2010)

Figure 1: Synergistic pathways triggered by metal-loaded particulate matter leading to neurodegeneration. This includes impaired insulin signaling leading to insulin resistance, oxidative stress, tonic upregulation of the inflammatory markers like cytokines and activation of microglia which are the resident innate immune cells of the brain. These interrelated mechanisms, in turn, lead to white matter and grey matter damage reduced apical spine density, and dendritic branching in the hippocampus.

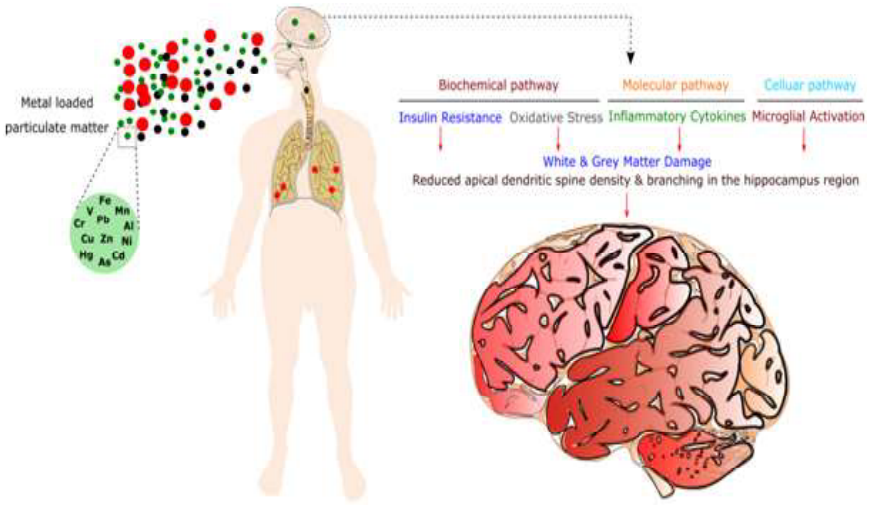
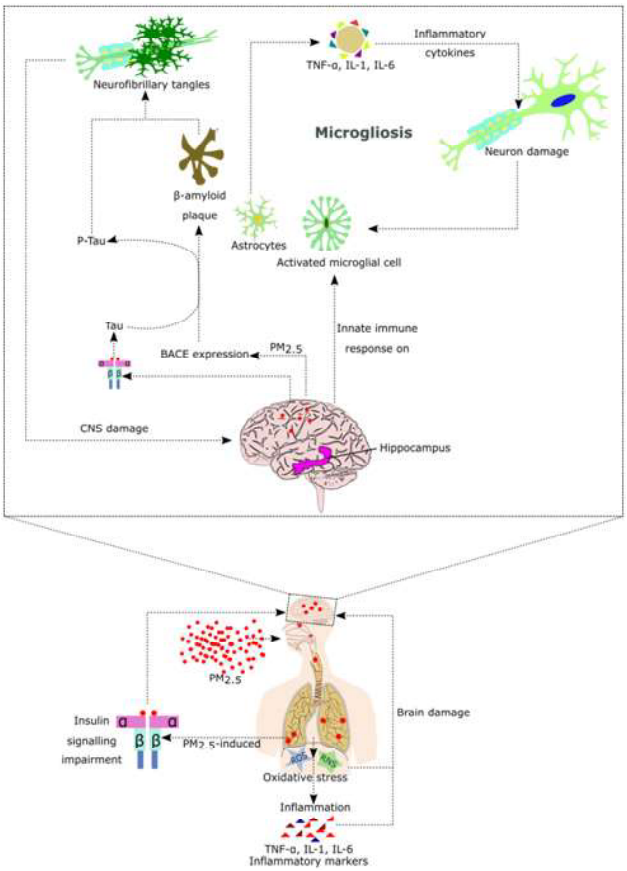


Figure 2: Overview of pathways leading to neurocognitive impairment: Inhalation of $PM_{2.5}$ leads to pulmonary inflammation, which results in tonic upregulation of inflammatory markers, leading systemic inflammation in heart, liver, and brain. These inflammatory markers translocate via BBB to the brain where inhaled nanoparticles reach the hippocampus and cause neuroinflammation by activating the microglia and then follow a toxic reactive cycle of microglial activation and neuronal death known as microgliosis. Components of air pollution may directly lead to the formation of ROS and RNS, which leads to CNS damage. $PM_{2.5}$ causes impaired insulin signaling which results in phosphorylation of tau and formation of plaques. This effect is enhanced by upregulation of BACE expression, which leads to formation of beta-amyloid plaques, finally leading to the formation of neurofibrillary tangles.



Abbreviations: RNS, reactive nitrogen species; ROS, reactive oxygen species; IL-6, interleukin 6; IL-1β, interleukin 1 beta; TN F-α, tumor necrosis factor alpha; BBB, the blood-brain barrier.

16

Distribution of wetland birds in River Yamuna: An occupancy modeling study

Sana Rehman*, Nawin Kumar Tiwary, Abdul Jamil Urfi

Department of Environmental Studies, University of Delhi, Delhi 110007, India

E- mail: sanarehman12@gmail.com*Presenting Author

Abstract

Previous studies have demonstrated an association between various biotic and abiotic habitat variables to richness and abundance of water birds. Many of these studies fails understand that the species might be present even if it is not detected in a habitat. Occupancy modelling is now emerging as an important tool for addressing such questions. This study focuses on estimation of occupancy status of several wetland bird species over a stretch of the river Yamuna in the year 2013 & 2018. Due to rapid urbanization we have been losing our aesthetic wealth, and the major cause is pollution, discharge of untreated water and encroachment along its stretch. Several policies and strategies should be made on grass root level to decrease the level of pollution in this river.

Keywords: Water birds, Occupancy, Delhi, River Yamuna

Introduction:

According to the Central Pollution Control Board (CPCB) the water of river Yamuna falls under category "E" which makes it suitable for using it either for industrial activities i.e. for cooling or for recreations completely ruling out the possibility of underwater life which supports other terrestrial lifeforms. Pollution in this river has been well documented (Paliwal et al 2007) especially through its stretch from Delhi. In this study we tried to document the dependence of birds on the river and Najafgarh Drain and sampled the variety of wetland birds found in this region. The river Yamuna, the largest tributary of the Holy River Ganga, has a length of 1,376 km and cross over major cities of India including Delhi, Agra, Faridabad, and Haryana. It originates from the Yamunotri Glacier of Uttar Kashi in Uttaranchal) and has a catchment area of 3,66,223 km^2. Although the river is polluted almost throughout its journey in plains but maximum of pollution occurs during its journey through Delhi region which contributes about 79% of total pollution load (Upadhyay *et. al* 2011). The main sources of pollution in NCT are:

1. Rapid migration in Delhi leading to increase in population and poor sanitation practices;
2. Untreated wastewater from drains;
3. Untreated wastewater from industries;
4. Agricultural runoffs (undetected and untreated pesticide residues leave a toxic mark all across the river)
5. Dead body dumping, solid waste dumping and animal washing.
6. Religious activity and immersion of idols.

Wetland ecosystems are part of our natural wealth. A recent assessment of the monetary value of our natural ecosystems estimated them at US$ 33 trillion*. This reflects the many crucial functions of wetlands such as flood Control, groundwater recharge, shoreline stabilization and protection from storm, sediment and nutrient retention and export, climate change mitigation, water purification, reservoirs of biodiversity, wetland products, recreation and tourism, cultural value and many more. It is no accident that river valleys and their floodplains have been the focus of human civilizations for over

6,000 years – and that many other wetland systems have been equally critical to the development and survival of human communities. Occupancy modelling is a new approach that we have used to assess the Occupancy status of different bird species in River Yamuna. We specifically aimed to assess the importance of habitat quality with respect to birds for two years 2013 and 2018 specifically in Delhi NCR.

Methods: Delhi - Capital city of India lies in the Semi-arid zone and thus receives scanty rainfall. The present study was conducted along the river Yamuna passing through Delhi in two widely separated sampling years 2013 and 2018. The surveys were conducted from January to April 2013 and January to March 2018.The field study protocol was designed using software Google Pro to access the sites at least a kilometre apart. This survey was done over using randomly placed point transect of 10 min on the banks of the River and the bird species found within 30m radius from a point of observation was noted down. Presence and absence data in the form of 0 and 1 were collected respectively.

Program Presence ver. 5.0 is used to estimate the proportion of area occupied (PAO) or estimate of occupancy probability (Ψ), by a particular species according to the model presented by (Mackenzie *et al* 2002, 2003).

There are considerable chances that a species might go undetected, even when present at the site. As a result, the naïve occupancy estimate of PAO given by the formula,

$$PAO = \frac{\text{Sites where species are detected}}{\text{Total sites surveyed}}$$

will underestimate the true PAO. Mackenzie et al. model enables the estimation of probability of detecting the species by the means of multiple surveying of site.

2.3.1 Mackenzie *et al* Model (2002):

Mackenzie et al proposes a model and likelihood-based method for estimating the proportion of area occupied (PAO) or Occupancy estimate probability (Ψ) when detection probability are less than 1. The model is based on his

argument that, non-detection of a species at a site does not imply that the species is absent unless the detection probability is 1. (Mackenzie *et al* 2002). This model is an extension of closed population Mark recapture model, with an additional parameter (Ψ) which represents the probability of species present in the area. It can be used to estimate the presence of those individuals which are never encountered at the site using the information gathered from those individuals encountered at least once.

A model of likelihood can be delineated using a series of probabilistic arguments similar to those used in Mark recapture modeling (Leberton *et al* 1992). A species will be present at the site where it is detected even once; and was either detected or not detected at each sampling occasions. e.g, the likelihood for a site with history 1001, Where '1' represents detection and '0' represents non-detection would be –

$$1001- \qquad \Psi_i \times p1.(1\text{-}p2).(1\text{-}p3).p4$$

Where, Ψ_i is Probability that a species is present at site i, p is the probability that the species will be detected at site i, given presence.

However, if a species is not detected at a site, does not entail that it is absent. For site A with detection history '0000', the likelihood is given by

$$0000- \quad \Psi_i \times (1\text{-}p1).(1\text{-}p2).(1\text{-}p3).(1\text{-}p4) + (1\text{-}\psi)$$

Where, $(1\text{-}\psi)$ = probability that the species was genuinely absent the site

When presence and detection probabilities are constant across the sampling sites, the combined mode of likelihood is given by

$$L(\psi, \mathbf{p}) = \left[\psi^{n} \cdot \prod_{t=1}^{T} p_t^{n_t} (1 - p_t)^{n - n_t}\right] \times \left[\psi \prod_{t=1}^{T} (1 - p_t) + (1 - \psi)\right]^{N-n}.$$

Where, N is total number of surveyed sites, n is the number of distinct

sampling occassions and n_t is the number of sites where species was detected at time t.

Assuming independence of the sites (Mackenzie *et al* 2002), the product of all terms constructed in this manner creates the model likelihood. Till now, the presence and detection probabilities have been defined as site specific.

Results: In both studies > 73 species of resident and migratory water birds, were sighted in over 82 km stretch of riverine habitat. Banks of Yamuna and its adjoining wetlands are one of the most important bird sites in Delhi. Several waders such as Painted Stork, Wooly-necked Stork, Asian Open bill, Grey Heron and Purple Heron can be seen in the vicinity of Yamuna, which comes here for foraging. Flocks of Ducks and Goose which includes Bar-headed Goose, Grey lag Goose, Ruddy Shelduck, Common Shelduck, Spot-billed Duck are common sightings. Winter visitors like Black-winged Stilt, Common Teal, Yellow wagtail, White wagtail, Citrine Wagtail, Northern Shoveler, Wood Sandpiper, Spotted Sandpiper, Spotted Redshank and Black-tailed Godwits are seen near the bank of Yamuna and nearby wetlands in large numbers. Most of these winter visitors come from icy northern and central Asia to the Indian subcontinent, to protect themselves from the cold in their country of origin. Okhla Bird Sanctuary: Okhla Barrage, located at the point where river Yamuna leaves the territory of Delhi and enters the neighboring state of Uttar Pradesh, is one of the most 'Important Bird Area' on the river Yamuna (Urfi, 2003). Species occupancy related strongly to the extent of preferred habitat. Occupancy of birds such as Black winged Stilt (*Himantopus himantopus*), Little Grebe (*Tachybaptus ruficollis*) , Red Wattled Lapwing (*Vanellus indicus*) , Common Moorhen (*Gallinula chloropus*) has significantly decreased. However, there has been significant increase in the occupancy of Ruff (*Philomachus pugnax)*, Yellow Wagtail (*Motacilla flava*), Grey Heron (*Ardea cinerea*). According to our observation birds have become opportunistic in nature feeding on the solid waste and debris on the banks.

Table 1 : The list of the birds sighted during the survey

Common Name	Scientific Name	IUCN Status
Anatidae		
Knob-billed Duck	*Sarkidiornis melanotos*	LC
Gadwall	*Anas strepera*	LC
Eurasian Wigeon	*Anas penelope*	LC
Indian Spot-billed Duck	*Anas poecilorhyncha*	LC
Northern Shoveler	*Anas clypeata*	LC
Ferruginous Duck	*Aythya nyroca*	N. TH
Tufted Duck	*Aythya fuligula*	LC
Podicipedidae		
Little Grebe	*Tachybaptus ruficollis*	LC
Phoenicopteridae		
Greater Flamingo	*Phoenicopterus roseus*	LC
Ciconiidae		
Painted Stork	*Mycteria leucocephala*	N. TH.
Woolly-necked Stork	*Ciconia episcopus*	LC
Threskiornithidae		
Glossy Ibis	*Plegadis falcinellus*	LC
Red-naped Ibis	*Pseudibis papillosa*	LC
Ardeidae		
Indian Pond Heron	*Ardeola grayii*	LC
Eastern Cattle Egret	*Bubulcus coromandu*	LC
Grey Heron	*Ardea cinerea*	LC
Purple Heron	*Ardea purpurea*	LC
Great Egret	*Ardea alba*	LC
Intermediate Egret	*Egretta intermedia*	LC
Little Egret	*Egretta garzetta*	LC
Phalacrocoracidae		
LittleCormorant	*Microcarbo niger*	LC
Indian Cormorant	*Phalacrocorax fuscicollis*	LC
Great Cormorant	*Phalacrocorax carbo*	LC
Anhingidae		
Oriental Darter	*Anhinga melanogaster*	N. TH.
Rallidae		
White-breasted Waterhen	*Amaurornis phoenicurus*	LC
Purple Swamphen	*Porphyrio porphyrio*	LC
Common Moorhen	*Gallinula chloropus*	LC
Eurasian Coot	*Fulica atra*	LC
Recurvirostridae		
Black-winged Stilt	*Himantopus himantopus*	LC
Charadriidae		
River Lapwing	*Vanellus duvaucelii*	LC
Yellow-wattled Lapwing	*Vanellus malabaricus*	LC
Red-wattled Lapwing	*Vanellus indicus*	LC
Jacanidae		
Bronze-winged Jacana	*Metopidius indicus*	LC
Scolopacidae		
Common Redshank	*Tringa totanus*	LC
Common Sandpiper	*Tringa glareola*	LC
Wood Sandpiper		LC
Ruff	*Philomachus pugnax*	LC
Laridae		
Black-headedGull	*Chroicocephalus ridibundus*	LC
Brown-headed Gull	*Chroicocephalus brunnicephalus*	LC
Alcedinidae		
White-throated Kingfisher	*Halcyon smyrnensis*	LC
Hirundinidae		
Barn Swallow	*Hirundo rustica*	LC
Motacillidae		
Western Yellow Wagtail	*Motacilla flava*	LC
Citrine Wagtail	*Motacilla citreola*	LC
Grey Wagtail	*Motacilla cinerea*	LC
White Wagtail	*Motacilla alba*	LC
White-browed Wagtail	*Motacilla maderaspatensis*	LC

Species	Occupancy Estimate (Ψ) 2013	Occupancy Estimate (Ψ) 2018
BLACK WINGED STILT (*Himantopus himantopus*)	0.755 ± 0.131	0.728 ± 0.119
COMMON MOORHEN (*Gallinula chloropus*)	0.834 ±0.133	0.261 ± 0.157
GLOSSY IBIS (*Plegadis falcinellus*)	0.382 ± 0.362	*
GREAT EGRET (*Ardea alba*)	0.598 ± 0.419	0.558 ±0.040
GREY HERON (*Ardea cinerea*)	0.323 ±0.233	0.551 ±0.126
LITTLE GREBE (*Tachybaptus ruficollis*)	0.517 ±0. 124	0.245 ± 0.103
INDIAN POND HERON (Ardeola grayii)	0.667 ± 0.188	0.587 ± 0.208
RED WATTLED LAPWING (*Vanellus indicus*)	0.745 ±0.102	0.700 ±0.117
SPOT BILLED DUCK (*Anas poecilorhyncha*)	0.475 ± 0.180	*
WHITETHROATED KINGFISHER (*Halcyon smyrnensis*)	0.525 ± 0.192	*
WHITE BROWED WAGTAIL (*Motacilla maderaspatensis*)	0.724 ± 0.470	*
COMMON SANDPIPER (*Actitis hypoleucos*)	0.701 ± 0.183	0.710 ± 0.097
YELLOW WAGTAIL(*Motacilla flava*)	0.594 ±0.369	0.721 ± 0.134
RUFF (*Philomachus pugnax*)	0.382 ± 0.362	0.605 ±0.365
PURPLE SWAMPHEN (*Porphyrio porphyrio*)	0.618 ± 0.129	0.447 ± 0.205
WIRE TAILED SWALLOW (*Hirundo smithii*)	*	0.220 ±0.104
LITTLE EGRET (*Egretta garzetta*)	*	0.381 ± 0.150
RIVER LAPWING (*Vanellus duvaucelii*)	*	0.521 ± 0.124

Conclusions & Recommendations:

Birds are important indicator of the habitat quality. The poor water, vegetation condition, landscape characterstic, human presence can affects the birds adversely. It is therefore, important to know the water quality status for the health of the birds. Aquatic birds are largely dependent on the aquatic fauna and flora for foraging and rearing their nest. Phytoplanktons, macro-invertebrates, amphibians and fishes are important constituents of their food. Benthic flora and fauna are largely dependent on water quality.

Water quality is continuously going down in metropolitan cities, like Delhi, due to inorganic and organic pollution. Inorganic pollution involves metal contamination from industries while organic load is composed of solid wastes. Metal contamination can lead to serious problems in birds, fishes, amphibians, macro invertebrates and phyto-benthoes.

Water acidification adversely affects freshwater ecosystems without much acid neutralizing capacity. Cultural eutrophication and toxicity of ammonia nitrate and nitrite can however affect many aquatic ecosystems. In general, freshwater animals seem to be more sensitive to the toxicity of inorganic nitrogenous compounds then seawater animals, with nitrate begin less toxic than ammonia and nitrate in any case. Extensive kills of invertebrates and fishes, particularly sensitive benthic species, are probably the most dramatic manifestation of hypoxia (or anoxia) in eutrophic and hypereutrophic aquatic ecosystems with low water turnover rates. The decline in dissolved oxygen concentration can also promote the formation of reduced c, such as hydrogen sulphide, resulting in higher adverse (toxic) effects on aquatic animals.

Moreover occurrence of toxic algae can significantly contribute to the extensive kills of aquatic animals (Camargo 2006). Aquatic eutrophication also promotes pathogenic infection of *ribeiroia* in amphibians, birds, snails etc. (Johnson *et al.* 2007).

References:

Bibby, C., N. D. Burgess, and D. A. Hill. (1992). *Bird Census Techniques*. Academic Press, Oxford, U.K.

Central Pollution Control Board, Status Of Water Quality in India—2006, CPCB, New Delhi, India, 2006.

Johnson, P.T.J., Chasa, J.M., Dosch, K.L., Harson, R.B. Gross, J.A., Larson, D.J., Sutherland, D.R., Carpenter, S.R. (2007), Aquatic eutrophication promotes pathogenic infection in amphibians, *PNAS* 104(40), PP 15781-15786

Leberton, J. D., K. P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals. A unified approach with case studies. *Ecological Monographs* 62:67-118.

MacKenzie, D.I., Nichols J.D., Hines, J.E., Knutson ,M.G., Franklin, A.B. (2003), Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. *Ecology* 84:2200–2207.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. *Ecology* 83 (8)

Upadhyay, R., Dasgupta, N., Hasan, A. and Upadhyay, S. K. (2011) Managing water quality of River Yamuna in NCR Delhi. Physics and Chemistry of the Earth, Parts A/B/C, 36(9), 372-378.

Urfi, A.J. (2003). The birds of Okhla Barrage Sanctuary, Delhi, India. *Forktail* 19: 39-50

17

Environmental menace of pharmaceutical drug diclofenac and its redressal

Shafali Garg[1,2], Pankaj Kumar[1], Vandana Mishra[1], Ludovic Dumee[2], Radhey Shyam Sharma[1,#]

1: Department of Environmental Studies, University of Delhi; 2: Deakin University, Geelong,Institute of Frontier Materials,Waurn Ponds, 3216, Victoria, Australia; #: Corresponding author

Abstract

Indian pharmaceutical industriesrank among the top 5 pharmaceutical markets of the world with an estimated worth of over US $36.7 billion, act as a major driver of Indian economy but environmental impacts of persistent pharmaceuticals pose a challenge to sustainability. Diclofenac has been one of the most prescribed non-steroidal anti-inflammatory drugs (NSAIDs) with a market share of 27.8 % globally, which has emerged as a major threat to biodiversity and human health. European Union has included diclofenac in its watch list to test and monitor the harmful effects in environmental compartments.Diclofenac has been reported in wastewater treatment plants (WWTPs), aquatic organisms, cattle, soil, and groundwater, however, its impact on local ecology and overall biodiversity is not yet fully

understood.In WWTPs, diclofenac hydrolyzes or conjugates with sludge. Pharmaceutically active compounds (PhACs) bioaccumulate in living organisms and cause toxicity across the trophic levels. 4'-hydroxydiclofenac, a major metabolite of diclofenac, inhibits prostaglandin synthesis, impair foetus development (teratogenic) and shows acute toxicity. Diclofenac damages kidney and liver in human, influence expression of multiple genes, causes inflammation, and malformation of gills in fish. In fact, diclofenac showed fatal effects on Asian vulture population.Many countrieslack specific guidelines on the target-specific wastewater treatment of pharmaceutical industry or environmental monitoring of pharmaceutical compounds or its metabolites.There is a need for formulation of guidelines and strict implementation of regulations in order to manage pharmaceutical waste.

Keywords: Diclofenac, Pharmaceutical pollution, Environmental health and drugs, Vulture population decline, Pharmaceutically active compounds

Email IDs of Authors:

Radhey Shyam Sharma: radheyss26@gmail.com

Ludovic Dumee: ludovic.dumee@deakin.edu.au

Shafali Garg: shafaligarg@hotmail.com

Pankaj Kumar: thakurpankaj.910@gmail.com

1. Introduction

Globally, Pharmaceutical industry values at US $1.14 trillion. India constitutes 3.1-3.6% of the global market with an estimated worth of over US $36.7 billion, thus acts as a major driver of the Indian economy. India has 546 US-FDA approved company sites, highest outside USA (IBEF, 2019). Worldwide consumption of active compounds amounts to 100,000 tons or more per annum. Fifteen grams of pharmaceuticals are consumed by a person every year, and this value is as high as 50g for developed countries (Alder et al., 2006). A high amount of drugs remain unabsorbed during treatment and excreted out by the body in the original form or transformed forms through faeces and urine. Drug or its metabolic products released from human body form pharmacologically active compounds (PhACs), which cause toxicity in living organisms of aquatic and terrestrial organisms, even at low

concentrations (Mohapatra et al., 2016). After entering into the aquatic ecosystems, the PhACs move across the environmental compartments. Pharmaceutical products are often called pseudo-persistent in nature. Unsafe disposal of medicines at home or in hospitals, animal waste and leachate from biomedical waste treatment, noncompliance of pharmaceuticals producing industries with the standards prescribed by the government further complicating the problem of increasing pharmaceutical waste in the environment (Santos et al., 2013). Due to the burgeoning population, and access to better healthcare across the countries, the total production and consumption of pharmaceutical drugs and products are also increasing. Medical advances and drug discovery have also contributed to the leaching of drugs in the environment. Taken together, socio-economic and regulatory factors governing the production, consumption and management of pharmaceutical run-off have been driving the deteriorating environmental health in developing nations (He, Wang, Liu, & Hu, 2017).

Majorly worrisome classes of drugs present in the wastewater treatment plants and water bodies are antibiotics, analgesics/anti-inflammatories, β-blockers/diuretics, antiepileptics, contraceptives, psycho-stimulants, steroids and other related hormones. Antibiotics run-off results into the evolution of multi-drug resistant bacteria, whereas steroids and oestrogen-based products act as endocrine disruptors for living organisms in marine and terrestrial ecosystems (Hernando, Mezcua, Fernández-Alba, & Barceló, 2006). Endocrine disruptors serve as a major threat to biodiversity as they cause feminization of male fish, alteration of DNA integrity, and affect immune cell number and ability to breakdown pollutants (Li, 2014). Carbamazepine, an antiepileptic drug, has teratogenic effects. Carbamazepine is degraded into biologically active products and incomplete intermediates that have a high risk of transport across a water-sediment compartment (Li et al., 2013). Antibiotics and endocrine disrupting steroidal hormones are widely studied. Non-steroidal anti-inflammatory drugs (NSAIDs) had silently spread into the environment over the years, coming into light only between 2002-2006 when vulture populations from south-east Asia reached the verge of extinction.

Due to increasing population (3.92 billion in 1973 to 7.63 billion in 2018) and better medical healthcare, the market for NSAIDs has increased

enormously (Global Burden of Disease Health Financing Collaborator Network et al., 2019). With an annual increase of 4% between 1950 to 2016, NSAIDs comprises a major share of the pharmaceutical market. Most popular NSAIDs are ibuprofen, diclofenac, aspirin, acetaminophen, ketoprofen and naproxen (He et al., 2017). Till 2012, according to their daily defined doses (DDDs), Diclofenac and mefenamic acid were the most prescribed NSAIDs (Dhabali, Awang, Hamdan, & Zyoud, 2012). Currently, Meloxicam is the most prescribed NSAID (Drug Stats) by medical practitioners. However, due to the high cost of the other drugs, Diclofenac remains the most widely used NSAID worldwide, especially for treating veterinary cases, in the third world countries (Table 2). Its market share (27.80 %) is more than the combined share of the next three sold drugs-ibuprofen, mefenamic acid, and naproxen (McGettigan & Henry, 2013). Diclofenac is used for treating pain in case of arthritis or acute injury to reduce inflammation, as an analgesic, antipyretic as well as anti-uricosuric (Lonappan, Brar, et al., 2016). It was discovered in 1973 by Ciba-Geigy, a Switzerland-based pharmaceutical company, later taken over by Novartis.

Table 1: Global consumption of diclfenac

Location	Annual consumption (in tonnes)	Population (in millions)	References
Australia	4	20.2	(Khan & Ongerth, 2004)
Germany	75	81.3	(Ferrari, Paxéus, Giudice, Pollio, & Garric, 2003)
England	26.13	49.2	(Acuña et al., 2015)
France	16	61.0	(Ferrari et al., 2003)
Austria	6.14	8.0	(Acuña et al., 2015)
EU	179.8	72.7	(Ternes, 1998)
Europe and Middle East	660	107.6	(Acuña et al., 2015)
Asia and Oceania	970	376.1	(Acuña et al., 2015)
World (86 countries)	1443 ± 58	>80% of world population	(Acuña et al., 2015)
World	2400	612	(Acuña et al., 2015)

This review highlights the need for monitoring pharmaceuticals by taking the case study of NSAID Diclofenac as it triggers undesirable physiological and reproductive alterations among the targeted and non-targeted group of living organisms. The review deals with the occurrence, ecotoxicity and health impacts of Diclofenac in the first section and gives an account of

analytical detection and treatment of diclofenac in the second section. This review also highlights the need of formulating guidelines for the release and treatment of pharmaceutical drugs in countries like India as the exact fate and pathways of many drugs in the environment are still unknown, there is an urgency to study these, practice cautious use and disposal practices.

1. Pharmacokinetics

Diclofenac binds to human serum proteins, primarily to albumin. It fuses with synovial fluid to reach joints. Chemically, diclofenac is 2-(2,6-dichloranilino)phenylacetic acid. Five diclofenac metabolites- 4'-hydroxy-, 5'-hydroxy-, 3'-hydroxy-, 4',5-dihydroxy- and 3'-hydroxy-4'-methoxy-diclofenac are known to occur in human plasma and urine (Figure 1). Diclofenac is eliminated after metabolism through urinary and biliary excretion. Approximately 65% of the dose is excreted through urine and 35% in the bile as conjugates of unchanged diclofenac plus metabolites and15% parent compound is released outside the body (FDA, 2016). The major metabolite of diclofenac- 4'-hydroxydiclofenac shows acute toxicity same as the parent compound and 3'-hydroxydiclofenac inhibits prostaglandin synthesis in the body, rest of the metabolites show nearly no effects (EMEA, 2003). The active compounds present in the degraded drugs are hydrolysed or conjugated with other compounds, which result in the formation of transformation products, the action of which is even lesser studied (Daughton, 2003). Pharmaceutical products often have polar and non-volatile nature. Some drugs have acidic properties and high log K_{ow} due to which they do not enter the atmospheric column, but rather dissolve readily in water and other active compounds present in sludge (Table 2) (Hernando et al., 2006). Inactive ingredients of diclofenac- hydroxypropyl methylcellulose, iron oxide, lactose, magnesium stearate, methacrylic acid copolymer, microcrystalline cellulose, polyethylene glycol, povidone, propylene glycol, sodium hydroxide, sodium starch glycolate, talc, titanium dioxide which enter environment upon usage or unsafe disposal also form part of the problem (FDA, 2016).

Fig 1: Diclofenac and its major metabolites prevalent in environment

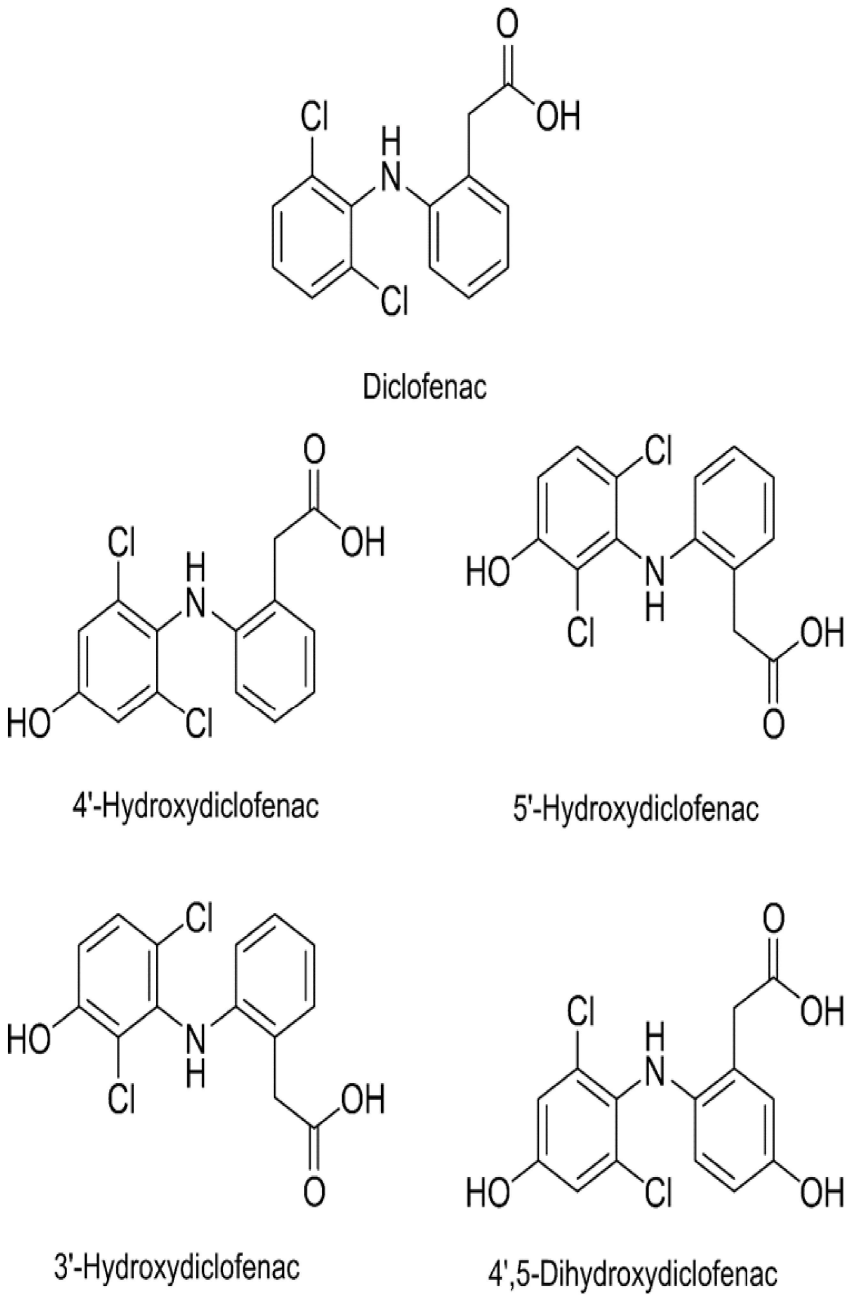


Table 2: Physcial, chemical and ecotoxicological properties of diclofenac

Physical Property	Value for diclofenac	References
Molecular weight (g/mol)	296.16	(European Union, 2013; Lonappan, Brar, et al., 2016; Ternes, 1998)
Water solubility at 25°C (mg/L)	2.37	
Melting point (°C)	283-285	
Boiling point (°C)	412	
pKa	4.15	
Log K_{ow}	4.51	
Henry's law constant (atm-m^3/mol)	4.7×10^{-7}	
Pharmacokineticalhuman excretion rate	15% unchanged (parent), <1% as conjugates	(Alder et al., 2006)
Half-life (h)	3.3 (under sun)	(Fatta-Kassinos, Vasquez, & Kümmerer, 2011)
Human LOEC (mg/kg)	0.1	(EMEA, 2003)
Environmentally safe value (µg/L)	0.1	(European Union, 2013)
LD_{50} value for vultures (mg/kg)	0.1-0.2	(G. Swan et al., 2006)
Toxic range for vultures (ng/g)	70-908	(Nambirajan et al., 2018)

1. Ecotoxicity and occurrence in environment

Diclofenacis used widely for veterinary patients for pain, osteoarthritis and while neutering. When cattle die, vultures feed on their dead body. This exposure causes severe visceral gout, increase in uric acid, kidney damage and finally death in vultures (Becker, 2016; He et al., 2017; McGettigan & Henry, 2013; Oaks et al., 2004; V. Prakash et al., 2003; Vibhu Prakash, 1999; Vibhu Prakash et al., 2012; Sukkar, 2015; G. E. Swan et al., 2 006; Taggart et al., 2007). The LD_{50} value for *Gyps bengalensis* is just 0.1-0.2 mg/kg (Table 2) (G. Swan et al., 2006). In aquatic organisms, diclofenac causes histological changes in the liver, kidney, and gills of fish, effects expression of multiple genes which are involved in the inflammatory response (Cuklev et al., 2011). Diclofenac is potentially teratogenic which induces edema, stunted growth and malformations of tail and notochord (Cardoso-Vera et al., 2017). It also results in a decrease in the number of spawned eggs (Yokota et al., 2016). It was added to EU watchlist in 2013 to test and monitor the harmful effects caused by diclofenac in environmental compartments (Barbosa, Moreira, Ribeiro, Pereira, & Silva, 2016). In Table

4, a list of toxicity studies has been provided with various doses and exposure effects of diclofenac on aquatic organisms and on terrestrial. Diclofenac has been reported in many wastewater treatment plants, agricultural soil and rivers at concentrations as high as 2 to 54 times higher than the EU standards (Table 3) (Al-Rajab, Sabourin, Lapen, & Topp, 2010). EU has suggested d"100 ng/L environmentally quality standard (EQS) for diclofenac in inland water and 10 ng/L in coastal (European Union, 2013). India currently has no guidelines on pharmaceutical compounds in wastewater. Though in 2006, manufacture and import of diclofenac was banned for veterinary purposes after wide outcry over its effect on the vulture population (Nambirajan et al., 2018). However, on prescription, the usage of the drug continues.

Table 3: Different levels of diclofenac reported from different aquatic bodies across the countries

Occurrence	Concentration (ng/L)	Reference
Ground water (Mediterranean)	2	(Rabiet et al., 2006)
River (Pakistan)	4900	(Scheurell et al., 2009)
River (Spain)	260	(Lopez-Serna et al., 2012)
Sea water (Brazil)	19.4	(Pereira et al., 2016)
STPs (France+Greece+Italy)	5450	(Ferrari et al., 2003)
Tap water (Spain)	18	(Carmona, Andreu, & Picó, 2014)
Well (Germany)	590	(Sacher et al., 2001)

Abbreviation- STPs- Sewage Treatment Plants

Table 4: Ecotoxic potential of diclofenac demonstrated in model organisms in laboratory and reported in living organism from environment

Organism	Type of risk involved/Exposure level	Reference
African catfish (*Clarias gariepinus*)	Alters enzymatic and hematological profile in serum and gills at 1.57-6.28 mg/L concentration for 42 days	(Ajima, Ogo, Audu, & Ugwoegbu, 2015)
Carp (Cirrhinus gariepinus)	Increased concentrations of TSH, decreased conc. of T3 and T4	(Saravanan et al., 2014)
Common carp (*Cyprinus carpio*)	Oxidative stress and alters physicochemical and textural properties of muscle at 0.31 ± 0.01 µg/L	(Morachis-Valdez et al., 2015)
	Increased mortality, increased activity of glutathione S-transferase, and decreased activity of glutathione reductase at 3 mg/L, Decreased levels of thiobarbituric-acid-reactive substances at concentrations ≥0.03 mg/L	(Stepanova et al., 2013)
Fathead minnow (*Pimephales promelas*)	Accumulation in Plasma, Meddles withnephron development, modulated genes for kidney repair and regeneration at 0.2-25.0 µg/L for 21 days	(Bickley et al., 2017)
Hopliasmalabaricus, Juveniles Rhamdia, Rainbowtrouts	Hematological changes, immunosuppressive changes	(Ribas et al., 2016; Ghelfi et al., 2016, Cuklev et al., 2011)
Nile tilapia (*Oreochromis niloticus*), Medaka (*Oryziaslatipes*)	Affects sexual differentiation and gametogenesis (Potential Endocrine disruptor)	(Groner et al., 2017, Yokota et al., 2015)
Oriental white-backed vulture (*Gyps bengalensis)* Long-billed vulture (*Gyps indicus*) Slender billed vulture (*Gyps tenuirostris*) Eurasian Griffon vultures (*Gyps fulvus*) African white-backed vulture (*G.africanus*) Cape Griffon vulture (*Gyps coprotheres*)	Visceral Gout, Increase in uric acid production, kidney damage and death	(Naidoo & Swan, 2009; Vibhu Prakash et al., 2012; G. Swan et al., 2006)
Rainbow trout (*Oncorhynchus mykiss*)	Kidney tubular necrosis and hyperplasia, fusion of intestinal villi at 1µg/L	(Mehinto et al., 2010)
	Renal lesions and alterations in gills at 5 µg/L	(Schwaiger et al., 2004)
	Effects on hepatic gene expression at 1-500 µg/L	(Cuklev et al., 2011)
Three-spined stickleback (Gasterosteus aculeatus)	causes renal hematopoietic hyperplasia at 4.6 µg/L.	(Näslund et al., 2017)
Wild-caught three-spined sticklebacks (*Gasterosteus aculeatus*)	LDH activity and transcription disturbed at 1µg/L for 14 days	(Prokkola et al.,

Abbreviations- TSH- Thyroid stimulating hormone, T3- Tri-iodothyronine, T4- Thyroxine, LDH- Lactate dehydrogenase

4. Environmental fate and degradation routes

About 65% of diclofenac occurs as diclofenac metabolites in water (Wiesenberg-Boettcher, Pfeilschifter, Schweizer, Sallmann, & Wenk, 1991). There could be four possible routes of degradation for a drug in the environment- Removal by sorption into the sediments, biotic degradation, abiotic degradation by chemical or photochemical pathways and volatilization. Diclofenac cannot undergo volatilization as it is polar and anionic at environmentally-relevant pH of 7.6. Photo-transformation is the primary transformation process for diclofenac in waterbodies (Tixier, Singer, Oellers, & Müller, 2003). According to a study conducted by Buser et al., 1998, 90% of diclofenac was degraded by photolysis in its course from a river (370 ng/L) to a lake (12 ng/L) in Switzerland. The photo-degradation products of diclofenac are formed by cyclisation of diclofenac into carbazole derivatives and decarboxylation-oxidation of the carbon backbone. 8-Chloro-9H-carbazole-1yl-acetic acid, a primary photo-transformation products of diclofenac, exerts at least six times more toxicity than the parent compound (Agüera et al., 2005; Schmitt-Jansen, Bartels, Adler, & Altenburger, 2007; Schulze et al., 2010). No sorption to sediments and minimal degradation by biotic or chemical agents has been observed for diclofenac. Diclofenac is known to form complexes with metals like Hg(II), Cu(II), Pb(II), and Sn(II) due to the π-π interactions (Refat, Mohamed, Ibrahim, Killa, & Fetooh, 2014; Theodorou et al., 1999). The presence of active groups like amino, hydroxyl, carbonyl, and carboxyl might also result in increased metabolites generation (Lonappan, Brar, et al., 2016). Figure 2 shows a simplified view of the flow of diclofenac into the environment.

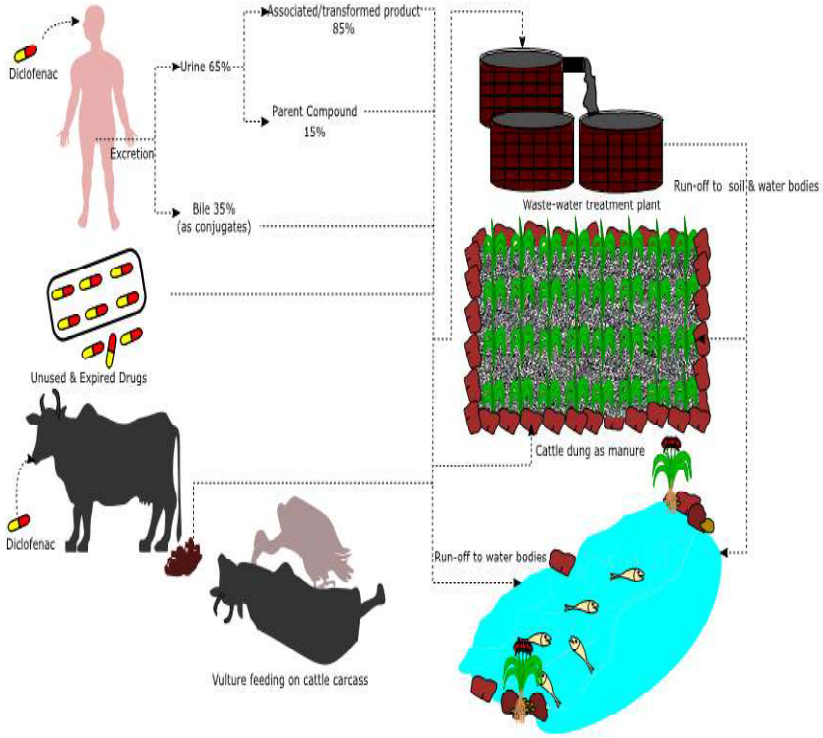
5. Detection, monitoring and treatment

Pharmaceutical by-products form micro-pollutants which are usually present at such low concentrations in the environment that these are below the detection limit of the instrument. Usually Enzyme-linked immune sorbent assay (ELISA) (Deng et al., 2003), High-performance liquid chromatography (HPLC) (Dorado, Berecz, Cáceres, & LLerena, 2003),

Fig. 2: Environmental pathway and ecotoxic potential of diclfenacLiquid chromatography-mass spectroscopy (LC-MS) (Lonappan, Pulicharla, et al., 2016), Gas chromatography/mass spectroscopy (GC/MS) (Deng et al., 2003), and spectrophotometric (Sastry, Mohana Rao, & Prasad, 1987) techniques

are used for detection. Biosensing is also a viable solution to the problem of detection at limits lower than the method quantification limit (MQL) of various instruments. Smith *et al.*, 2007 and Takakusagi et al., 2010mention the possibility and potential of biosensors for detecting pharmaceuticals. Nanotechnology has paved the way of increasing selectivity and sensitivity of the device tremendously.

Fig. 2 : Environmental pathway and ecotoxic potential of diclfenac



PhACs can be effectively managed at the wastewater treatment step of urban water recycling. By use of simple tertiary treatment processes, more than 93% of diclofenac removal has been observed. Conventional activated sludge gives satisfactory removal but once coupled with advanced removal techniques like adsorption on activated carbon followed by ozonation, UV treatment or chlorination, even better removal rates have been achieved. Microbial batch reactors are still not able to show much removal potential, bringing to attention the limited microbial degradation of diclofenac. Table 5 provides the removal efficiency of each technique for diclofenac.

Table 5: Efficacy of diclofenac removal by sewage treatment plants of different designs

Treatment Method	Removal %	References
Activated carbon adsorption followed by ozonation	≥ 93	(Beltrán, Pocostales, Alvarez, & Oropesa, 2009)
Activated sludge	45.6	(A. M. P. T. Pereira, Silva, Meisel, Lino, & Pena, 2015)
Activated sludge process MBR	25	(Martín, Camacho-Muñoz, Santos, Aparicio, & Alonso, 2012)
Conventional activated sludge	75	(Kimura, Hara, & Watanabe, 2005)
Conventional activated sludge with chemical phosphorus removal	22	(Bendz, Paxéus, Ginn, & Loge, 2005)
Conventional activated sludge with chlorination	70	(Anumol, Vijayanandan, Park, Philip, & Snyder, 2016)
Conventional activated sludge with UV	81.4	(Behera, Kim, Oh, & Park, 2011)
Conventional biological treatment	75	(Lonappan, Pulicharla, et al., 2016; Samaras, Stasinakis, Mamais, Thomaidis, & Lekkas, 2013)
Primary treatment (coagulation and floatation)	40-70	(Carballa, Omil, & Lema, 2005)
Submerged MBR	40	(Kimura et al., 2005)

Abbreviations- MBR- Membrane bioreactor

6. Conclusions and scope for future research

Increased purchasing power, coupled with improving health care facilities drives the use of pharmaceuticals, especially NSAIDs like diclofenac by human and animals. Increased demand has been well-supplemented by increased production by the industries and globalisation. Though the exact environmental pathway of NSAIDs drugs is poorly understood, the NSAIDs cause severe health damages to non-targeted living organisms. On the other hand, bioaccumulation, biodegradation, and biomagnification pose long-term adverse effects across the trophic levels in ecosystems. Increasing consumption of NSAIDs, the release of parent NSAIDs and its metabolites from human body or wastewater treatment plants, and discard of unused products from pharmaceutical industries serve as the primary sources for NSAIDs in the environment. Local extinction of vultures demonstrates the severe ecological impact of NSAIDs on non-targeted species. To formulate guidelines on using NSAIDs, designing WWTPs for treating NSAIDs or its metabolites rich wastewater or unused products, monitoring NSAIDs in WWTPs and in the environment, we emphasize undertaking in-depth research on environmental routes of the drug, and chemistry of degradation products and its interactions with different environmental phases. Such studies would also help in developing ecological-based bioremediation of NSAIDs

for reducing the environmental load of NSAIDs and improving human and animal health.

References

Acuña, V., Ginebreda, A., Mor, J. R. R., Petrovic, M., Sabater, S., Sumpter, J., & Barceló, D. (2015). Balancing the health benefits and environmental risks of pharmaceuticals: Diclofenac as an example. *Environment International*, *85*, 327–333. https://doi.org/https://doi.org/10.1016/j.envint.2015.09.023

Agüera, A., Pérez Estrada, L. A., Ferrer, I., Thurman, E. M., Malato, S., & Fernández-Alba, A. R. (2005). Application of time-of-flight mass spectrometry to the analysis of phototransformation products of diclofenac in water under natural sunlight. *Journal of Mass Spectrometry*, *40*(7), 908–915. https://doi.org/10.1002/jms.867

Ajima, M. N. O., Ogo, O. A., Audu, B. S., & Ugwoegbu, K. C. (2015). Chronic diclofenac (DCF) exposure alters both enzymatic and haematological profile of African catfish, Clarias gariepinus. *Drug and Chemical Toxicology*, *38*(4), 383–390. https://doi.org/10.3109/01480545.2014.974108

Al-Rajab, A. J., Sabourin, L., Lapen, D. R., & Topp, E. (2010). The non-steroidal anti-inflammatory drug diclofenac is readily biodegradable in agricultural soils. *Science of The Total Environment*, *409*(1), 78–82. https://doi.org/10.1016/j.scitotenv.2010.09.020

Alder, A. C., Bruchet, A., Carballa, M., Clara, M., Joss, A., Löffler, D., … Ternes, T. A. (2006). *Consumption and occurrence*. (T.A. Ternes & A. Joss, Eds.). London, UK: IWA Publishing. Retrieved from https://www.dora.lib4ri.ch/eawag/islandora/object/eawag%3A11481

Anumol, T., Vijayanandan, A., Park, M., Philip, L., & Snyder, S. A. (2016). Occurrence and fate of emerging trace organic chemicals in wastewater plants in Chennai, India. *Environment International*, *92–93*, 33–42. https://doi.org/https://doi.org/10.1016/j.envint.2016.03.022

Barbosa, M. O., Moreira, N. F. F., Ribeiro, A. R., Pereira, M. F. R., & Silva, A. M. T. (2016). Occurrence and removal of organic micropollutants: An overview of the watch list of EU Decision 2015/495. *Water Research*, *94*, 257–279. https://doi.org/https://doi.org/10.1016/j.watres.2016.02.047

Becker, R. (2016, April 29). Cattle drug threatens thousands of vultures. *Nature*. https://doi.org/10.1038/nature.2016.19839

Behera, S. K., Kim, H. W., Oh, J.-E., & Park, H.-S. (2011). Occurrence and removal of antibiotics, hormones and several other pharmaceuticals in wastewater treatment plants of the largest industrial city of Korea. *Science of The Total Environment*, *409*(20), 4351–4360. https://doi.org/https://doi.org/10.1016/j.scitotenv.2011.07.015

Beltrán, F. J., Pocostales, P., Alvarez, P., & Oropesa, A. (2009). Diclofenac removal from water with ozone and activated carbon. *Journal of Hazardous Materials*,

163(2), 768–776. https://doi.org/https://doi.org/10.1016/j.jhazmat.2008.07.033

Bendz, D., Paxéus, N. A., Ginn, T. R., & Loge, F. J. (2005). Occurrence and fate of pharmaceutically active compounds in the environment, a case study: Höje River in Sweden. *Journal of Hazardous Materials*, *122*(3), 195–204. https://doi.org/https://doi.org/10.1016/j.jhazmat.2005.03.012

Carballa, M., Omil, F., & Lema, J. M. (2005). Removal of cosmetic ingredients and pharmaceuticals in sewage primary treatment. *Water Research*, *39*(19), 4790–4796. https://doi.org/https://doi.org/10.1016/j.watres.2005.09.018

Cardoso-Vera, J. D., Islas-Flores, H., SanJuan-Reyes, N., Montero-Castro, E. I., Galar-Martínez, M., García-Medina, S., … Gómez-Oliván, L. M. (2017). Comparative study of diclofenac-induced embryotoxicity and teratogenesis in Xenopus laevis and Lithobates catesbeianus, using the frog embryo teratogenesis assay: Xenopus (FETAX). *Science of The Total Environment*, *574*, 467–475. https://doi.org/10.1016/J.SCITOTENV.2016.09.095

Carmona, E., Andreu, V., & Picó, Y. (2014). Occurrence of acidic pharmaceuticals and personal care products in Turia River Basin: From waste to drinking water. *Science of The Total Environment*, *484*, 53–63. https://doi.org/https://doi.org/10.1016/j.scitotenv.2014.02.085

Cuklev, F., Kristiansson, E., Fick, J., Asker, N., Förlin, L., & Larsson, D. G. J. (2011). Diclofenac in fish: blood plasma levels similar to human therapeutic levels affect global hepatic gene expression. *Environmental Toxicology and Chemistry*, *30*(9), 2126–2134. https://doi.org/10.1002/etc.599

Daughton, C. G. (2003). Cradle-to-cradle stewardship of drugs for minimizing their environmental disposition while promoting human health. I. Rational for and avenues toward a green pharmacy. *Environmental Health Perspectives*, *111*(5), 757–774.

Deng, A., Himmelsbach, M., Zhu, Q.-Z., Frey, S., Sengl, M., Buchberger, W., … Knopp, D. (2003). Residue Analysis of the Pharmaceutical Diclofenac in Different Water Types Using ELISA and GC"MS. *Environmental Science & Technology*, *37*(15), 3422–3429. https://doi.org/10.1021/es0341945

Dhabali, A. A. H., Awang, R., Hamdan, Z., & Zyoud, S. H. (2012). Associations between prescribing nonsteroidal anti-inflammatory drugs and their potential prescription-related problems in a primary care setting. *Int. Journal of Clinical Pharmacology and Therapeutics*, *50*(12), 851–861. https://doi.org/10.5414/CP201689

Dorado, P., Berecz, R., Cáceres, M. C., & LLerena, A. (2003). Analysis of diclofenac and its metabolites by high-performance liquid chromatography: relevance of CYP2C9 genotypes in diclofenac urinary metabolic ratios. *Journal of Chromatography B*, *789*(2), 437–442. https://doi.org/https://doi.org/10.1016/S1570-0232(03)00137-5

EMEA. (2003). *Commitee for veterinary medical products diclofenac summary report*. Retrieved from http://www.emea.eu.int

European Union. (2013). *Directives 2000/60/EC and 2008/105/EC*. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:226:0001:0017:EN:PDF

Fatta-Kassinos, D., Vasquez, M. I., & Kümmerer, K. (2011). Transformation products of pharmaceuticals in surface waters and wastewater formed during photolysis and advanced oxidation processes – Degradation, elucidation of byproducts and assessment of their biological potency. *Chemosphere*, *85*(5), 693–709. https://doi.org/https://doi.org/10.1016/j.chemosphere.2011.06.082

FDA. (2016). Voltaren ® (diclofenac sodium enteric-coated tablets). Retrieved from https://www.accessdata.fda.gov/drugsatfda_docs/label/2011/019201s039s040lbl.pdf

Ferrari, B., Paxéus, N., Giudice, R. Lo, Pollio, A., & Garric, J. (2003). Ecotoxicological impact of pharmaceuticals found in treated wastewaters: study of carbamazepine, clofibric acid, and diclofenac. *Ecotoxicology and Environmental Safety*, *55*(3), 359–370. https://doi.org/10.1016/S0147-6513(02)00082-9

Global Burden of Disease Health Financing Collaborator Network, A. Y., Cowling, K., Micah, A. E., Chapin, A., Chen, C. S., Ikilezi, G., … Dieleman, J. L. (2019). Past, present, and future of global health financing: a review of development assistance, government, out-of-pocket, and other private spending on health for 195 countries, 1995-2050. *Lancet (London, England)*, *0*(0). https://doi.org/10.1016/S0140-6736(19)30841-4

Hans-Rudolf Buser, *, Thomas Poiger, and, & Müller, M. D. (1998). Occurrence and Fate of the Pharmaceutical Drug Diclofenac in Surface Waters: Rapid Photodegradation in a Lake. https://doi.org/10.1021/ES980301X

He, B. shu, Wang, J., Liu, J., & Hu, X. min. (2017). Eco-pharmacovigilance of non-steroidal anti-inflammatory drugs: Necessity and opportunities. *Chemosphere*, *181*, 178–189. https://doi.org/https://doi.org/10.1016/j.chemosphere.2017.04.084

Hernando, M. D., Mezcua, M., Fernández-Alba, A. R., & Barceló, D. (2006). Environmental risk assessment of pharmaceutical residues in wastewater effluents, surface waters and sediments. *Talanta*, *69*(2 SPEC. ISS.), 334–342. https://doi.org/10.1016/j.talanta.2005.09.037

IBEF. (2019). Pharma Industry in India: Pharma Sector Overview, Market Size, Analysis. Retrieved May 25, 2018, from https://www.ibef.org/industry/pharmaceutical-india.aspx

Khan, S. J., & Ongerth, J. E. (2004). Modelling of pharmaceutical residues in Australian sewage by quantities of use and fugacity calculations. *Chemosphere*, *54*(3), 355–367. https://doi.org/https://doi.org/10.1016/j.chemosphere.2003.07.001

Kimura, K., Hara, H., & Watanabe, Y. (2005). Removal of pharmaceutical compounds by submerged membrane bioreactors (MBRs). *Desalination*, *178*(1), 135–140. https://doi.org/https://doi.org/10.1016/j.desal.2004.11.033

Li, J., Dodgen, L., Ye, Q., & Gan, J. (2013). Degradation Kinetics and Metabolites of

Carbamazepine in Soil. *Environmental Science & Technology*, *47*(8), 3678–3684. https://doi.org/10.1021/es304944c

Li, W. C. (2014). Occurrence, sources, and fate of pharmaceuticals in aquatic environment and soil. *Environmental Pollution*, *187*, 193–201. https://doi.org/https://doi.org/10.1016/j.envpol.2014.01.015

Lonappan, L., Brar, S. K., Das, R. K., Verma, M., Surampalli, R. Y., Kaur, S., … Surampalli, R. Y. (2016). Diclofenac and its transformation products: Environmental occurrence and toxicity-A review. *Environment International*, *96*(October 2017), 127–138. https://doi.org/10.1016/j.envint.2016.09.014

Lonappan, L., Pulicharla, R., Rouissi, T., Brar, S. K., Verma, M., Surampalli, R. Y., & Valero, J. R. (2016). Diclofenac in municipal wastewater treatment plant: quantification using laser diode thermal desorption—atmospheric pressure chemical ionization—tandem mass spectrometry approach in comparison with an established liquid chromatography-electrospray ionizat. *Journal of Chromatography A*, *1433*, 106–113. https://doi.org/https://doi.org/10.1016/j.chroma.2016.01.030

Martín, J., Camacho-Muñoz, D., Santos, J. L., Aparicio, I., & Alonso, E. (2012). Occurrence of pharmaceutical compounds in wastewater and sludge from wastewater treatment plants: Removal and ecotoxicological impact of wastewater discharges and sludge disposal. *Journal of Hazardous Materials*, *239–240*, 40–47. https://doi.org/https://doi.org/10.1016/j.jhazmat.2012.04.068

McGettigan, P., & Henry, D. (2013). Use of Non-Steroidal Anti-Inflammatory Drugs That Elevate Cardiovascular Risk: An Examination of Sales and Essential Medicines Lists in Low-, Middle-, and High-Income Countries. *PLoS Medicine*, *10*(2), e1001388. https://doi.org/10.1371/journal.pmed.1001388

Mohapatra, S., Huang, C.-H., Mukherji, S., & Padhye, L. P. (2016). Occurrence and fate of pharmaceuticals in WWTPs in India and comparison with a similar study in the United States. *Chemosphere*, *159*, 526–535. https://doi.org/https://doi.org/10.1016/j.chemosphere.2016.06.047

Naidoo, V., & Swan, G. E. (2009). Diclofenac toxicity in Gyps vulture is associated with decreased uric acid excretion and not renal portal vasoconstriction. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *149*(3), 269–274. https://doi.org/10.1016/j.cbpc.2008.07.014

Nambirajan, K., Muralidharan, S., Roy, A. A., & Manonmani, S. (2018). Residues of Diclofenac in Tissues of Vultures in India: A Post-ban Scenario. *Archives of Environmental Contamination and Toxicology*, *74*(2), 292–297. https://doi.org/10.1007/s00244-017-0480-z

Näslund, J., Fick, J., Asker, N., Ekman, E., Larsson, D. G. J., & Norrgren, L. (2017). Diclofenac affects kidney histology in the three-spined stickleback (Gasterosteus aculeatus) at low ìg/L concentrations. *Aquatic Toxicology*, *189*, 87–96. https://doi.org/https://doi.org/10.1016/j.aquatox.2017.05.017

Oaks, J. L., Gilbert, M., Virani, M. Z., Watson, R. T., Meteyer, C. U., Rideout, B. A.,

… Ahmed Khan, A. (2004). Diclofenac residues as the cause of vulture population decline in Pakistan. *Nature*, *427*, 630. Retrieved from https://doi.org/10.1038/nature02317

Pereira, A. M. P. T., Silva, L. J. G., Meisel, L. M., Lino, C. M., & Pena, A. (2015). Environmental impact of pharmaceuticals from Portuguese wastewaters: geographical and seasonal occurrence, removal and risk assessment. *Environmental Research*, *136*, 108–119. https://doi.org/https://doi.org/10.1016/j.envres.2014.09.041

Pereira, C. D. S., Maranho, L. A., Cortez, F. S., Pusceddu, F. H., Santos, A. R., Ribeiro, D. A., … Guimarães, L. L. (2016). Occurrence of pharmaceuticals and cocaine in a Brazilian coastal zone. *Science of The Total Environment*, *548–549*, 148–154. https://doi.org/https://doi.org/10.1016/j.scitotenv.2016.01.051

Prakash, V., Pain, D. J., Cunningham, A. A., Donald, P. F., Prakash, N., Verma, A., … Rahmani, A. R. (2003). Catastrophic collapse of Indian white-backed Gyps bengalensis and long-billed Gyps indicus vulture populations. *Biological Conservation*, *109*(3), 381–390. https://doi.org/10.1016/S0006-3207(02)00164-7

Prakash, Vibhu. (1999). Status of Vultures in Keoladeo National Park, Bharatpur, Rajasthan, with Special Reference To Population Crash in Gyps Species. *The Journal of the Bombay Natural History Society.*, *96*, 365–378. Retrieved from https://www.biodiversitylibrary.org/part/155585

Prakash, Vibhu, Bishwakarma, M. C., Chaudhary, A., Cuthbert, R., Dave, R., Kulkarni, M., … Green, R. E. (2012). The Population Decline of Gyps Vultures in India and Nepal Has Slowed since Veterinary Use of Diclofenac was Banned. *PLoS ONE*, *7*(11), e49118. https://doi.org/10.1371/journal.pone.0049118

Prokkola, J. M., Nikinmaa, M., Lubiana, P., Kanerva, M., McCairns, R. J. S., & Götting, M. (2015). Hypoxia and the pharmaceutical diclofenac influence the circadian responses of three-spined stickleback. *Aquatic Toxicology*, *158*, 116–124. https://doi.org/https://doi.org/10.1016/j.aquatox.2014.11.006

Rabiet, M., Togola, A., Brissaud, F., Seidel, J.-L., Budzinski, H., & Elbaz-Poulichet, F. (2006). Consequences of treated water recycling as regards pharmaceuticals and drugs in surface and ground waters of a medium-sized Mediterranean catchment. *Environmental Science & Technology*, *40*(17), 5282–5288. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16999100

Refat, M. S., Mohamed, G. G., Ibrahim, M. Y. S., Killa, H. M. A., & Fetooh, H. (2014). Synthesis and characterization of coordination behavior of diclofenac sodium drug toward hg(ii), pb(ii), and sn(ii) metal ions: Chelation effect on their thermal stability and biological activity. *Synthesis and Reactivity in Inorganic, Metal-Organic and Nano-Metal Chemistry*, *44*(2), 161–170. https://doi.org/10.1080/15533174.2012.752009

Samaras, V. G., Stasinakis, A. S., Mamais, D., Thomaidis, N. S., & Lekkas, T. D. (2013). Fate of selected pharmaceuticals and synthetic endocrine disrupting

compounds during wastewater treatment and sludge anaerobic digestion. *Journal of Hazardous Materials*, *244–245*, 259–267. https://doi.org/https://doi.org/10.1016/j.jhazmat.2012.11.039

Santos, L. H., Gros, M., Rodriguez-Mozaz, S., Delerue-Matos, C., Pena, A., Barceló, D., & Montenegro, M. C. B. S. M. (2013). Contribution of hospital effluents to the load of pharmaceuticals in urban wastewaters: identification of ecologically relevant pharmaceuticals. *Science of the Total Environment*, *461*, 302–316.

Sastry, S., Mohana Rao, A. R., & Prasad, T. N. V. (1987). Spectrophotometric Analysis of Diclofenac Sodium and Piroxicam and Their Pharmaceutical Preparations. *Analytical Letters*, *20*(2), 349–359. https://doi.org/10.1080/00032718708064571

Scheurell, M., Franke, S., Shah, R. M., & Hühnerfuss, H. (2009). Occurrence of diclofenac and its metabolites in surface water and effluent samples from Karachi, Pakistan. *Chemosphere*, *77*(6), 870–876. https://doi.org/10.1016/j.chemosphere.2009.07.066

Schmitt-Jansen, M., Bartels, P., Adler, N., & Altenburger, R. (2007). Phytotoxicity assessment of diclofenac and its phototransformation products. *Analytical and Bioanalytical Chemistry*, *387*(4), 1389–1396. https://doi.org/10.1007/s00216-006-0825-3

Schulze, T., Weiss, S., Schymanski, E., von der Ohe, P. C., Schmitt-Jansen, M., Altenburger, R., … Brack, W. (2010). Identification of a phytotoxic phototransformation product of diclofenac using effect-directed analysis. *Environmental Pollution*, *158*(5), 1461–1466. https://doi.org/10.1016/j.envpol.2009.12.032

Smith, M. W., Smith, J. W., Harris, C., Brancale, A., Allender, C. J., & Gumbleton, M. (2007). Phage display identification of functional binding peptides against 4-acetamidophenol (Paracetamol): An exemplified approach to target low molecular weight organic molecules. *Biochemical and Biophysical Research Communications*, *358*(1), 285–291. https://doi.org/https://doi.org/10.1016/j.bbrc.2007.04.122

Stepanova, S., Praskova, E., Chromcova, L., Plhalova, L., Prokes, M., Blahova, J., & Svobodova, Z. (2013). The effects of diclofenac on early life stages of common carp (Cyprinus carpio). *Environmental Toxicology and Pharmacology*, *35*(3), 454–460. https://doi.org/https://doi.org/10.1016/j.etap.2012.09.011

Sukkar, E. (2015). Risk of heart problems prompts removal of OTC diclofenac from UK pharmacy shelves. *The Pharmaceutical Journal*. https://doi.org/10.1211/PJ.2015.20067579

Swan, G. E., Cuthbert, R., Quevedo, M., Green, R. E., Pain, D. J., Bartels, P., … Wolter, K. (2006). Toxicity of diclofenac to Gyps vultures. *Biology Letters*, *2*(2), 279–282. https://doi.org/10.1098/rsbl.2005.0425

Swan, G., Naidoo, V., Cuthbert, R., Green, R. E., Pain, D. J., Swarup, D., … Wolter, K. (2006). Removing the Threat of Diclofenac to Critically Endangered Asian Vultures. *PLoS Biology*, *4*(3), e66. https://doi.org/10.1371/journal.pbio.0040066

Taggart, M. A., Senacha, K. R., Green, R. E., Jhala, Y. V., Raghavan, B., Rahmani, A. R., … Meharg, A. A. (2007). Diclofenac residues in carcasses of domestic ungulates available to vultures in India. *Environment International*, *33*(6), 759–765. https://doi.org/10.1016/J.ENVINT.2007.02.010

Takakusagi, Y., Takakusagi, K., Sugawara, F., & Sakaguchi, K. (2010). Use of phage display technology for the determination of the targets for small-molecule therapeutics. *Expert Opinion on Drug Discovery*, *5*(4), 361–389.

Ternes, Thomas A. (1998). Occurrence of drugs in German sewage treatment plants and rivers. *Water Research*, *32*(11), 3245–3260. https://doi.org/10.1016/S0043-1354(98)00099-2

Theodorou, A., Demertzis, M. A., Kovala-Demertzi, D., Lioliou, E. E., Pantazaki, A. A., & Kyriakidis, D. A. (1999). Copper(II) complexes of diclofenac: Spectroscopic studies and DNA strand breakage. *BioMetals*, *12*(2), 167–172. https://doi.org/10.1023/A:1009246122577

Tixier, C., Singer, H. P., Oellers, S., & Müller, S. R. (2003). Occurrence and Fate of Carbamazepine, Clofibric Acid, Diclofenac, Ibuprofen, Ketoprofen, and Naproxen in Surface Waters. *Environmental Science & Technology*, *37*(6), 1061–1068. https://doi.org/10.1021/es025834r

Wiesenberg-Boettcher, I., Pfeilschifter, J., Schweizer, A., Sallmann, A., & Wenk, P. (1991). Pharmacological properties of five diclofenac metabolites identified in human plasma. *Agents and Actions*, *34*(1–2), 135–137. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1793018

Yokota, H., Eguchi, S., Hasegawa, S., Okada, K., Yamamoto, F., Sunagawa, A., … Nakano, E. (2016). Assessment of *in vitro* antiovulatory activities of nonsteroidal anti-inflammatory drugs and comparison with *in vivo* reproductive toxicities of medaka (*Oryzias latipes*). *Environmental Toxicology*, *31*(12), 1710–1719. https://doi.org/10.1002/tox.22173

18

Appraisal of groundwater quality based on toxic metal pollution in Loni block of Ghaziabad district, Uttar Pradesh, India

[*]Shipra Tyagi[1] and Kiranmay Sarma[1]

[1]University School of Environment Management, Guru Gobind Singh Indraprastha University, Sector 16-C, Dwarka, New Delhi-110078, India

Email: [*]shipra.usem.900680@ipu.ac.in kiranmay@ipu.ac.in

Abstract

Groundwater scarcity and quality deterioration are one of the severe problems in India. Apart from geo-genic processes, anthropogenic sources also play a crucial role in influencing the natural composition of the groundwater. The presence of toxic metals in subsurface acts as potential pollutants that further cause unfavorable contamination levels are promoting future ecological and health implications. The present study focused on estimating the quality of groundwater about toxic metals pollution in Loni block of Ghaziabad district (Uttar Pradesh). The groundwater samples, fetched from shallow aquifers, were analyzed for the presence of toxic metals such as cadmium (Cd), chromium (Cr), nickel (Ni), and lead (Pb). The levels of the concerned metals were crossing the permissible limits of

drinking water standards (BIS) and found that water was unfit for drinking purposes. For evaluation of pollution loads, the extent of toxic metals was investigated by the application of relative weightage method called Heavy metal Pollution Index (HPI). The results obtained to have mean HPI value of 324.95 which was observed beyond the HPI critical value of 100. The presence of highly toxic metals is a matter of great apprehension for government authorities to take actions with immediate effects and through regular monitoring in order to preserve the quality of groundwater resources from further degradation.

Keywords: Groundwater contamination, Toxic metals, Heavy metal Pollution Index, Loni block, Ghaziabad district

1. Introduction

Groundwater is a hidden freshwater resource which has been predominantly utilized in domestic, industrial and irrigation practices. The excessive consumption and over-exploitation due to increased water demands had significantly degraded the groundwater quality. Groundwater contamination can be categorized into natural or anthropogenic sources. The former includes natural dissolutions primarily from weathering of rock-minerals and later consists of non-point (diffuse) sources such as chemical fertilizers and pesticides runoff from irrigation activities and point sources pollution associated with urban and industrial sectors. Consequently, the land use pattern of overlying surfaces majorly influences the groundwater quality by releasing nutrients and toxic chemicals (Ouyang 2011). Moreover, the gradual release of toxic compounds through untreated effluents from industrial units and wastewater discharges from domestic sewage subsequently induces pollution at the sub-surface levels.

Toxic elements are generally characterized by their ability to cause a high level of toxicity even at trace concentrations (Marcovecchio et al. 2007; Zakhem et al. 2015). The poisonous effects of the toxic metals are governed by their non-degrading and bio-accumulating properties that chiefly target the functioning of human central nervous system and internal organs (Lee et al. 2007; Lohani et al. 2008). Therefore, the effluence from toxic metals generates possible ecological as well as human health implications that are imperative to monitor. Metals like cadmium (Cd), chromium (Cr), lead (Pb) and nickel (Ni) are some of the extremely toxic elements even at trace amounts (Jain et al. 2010). These metals are commonly used as raw

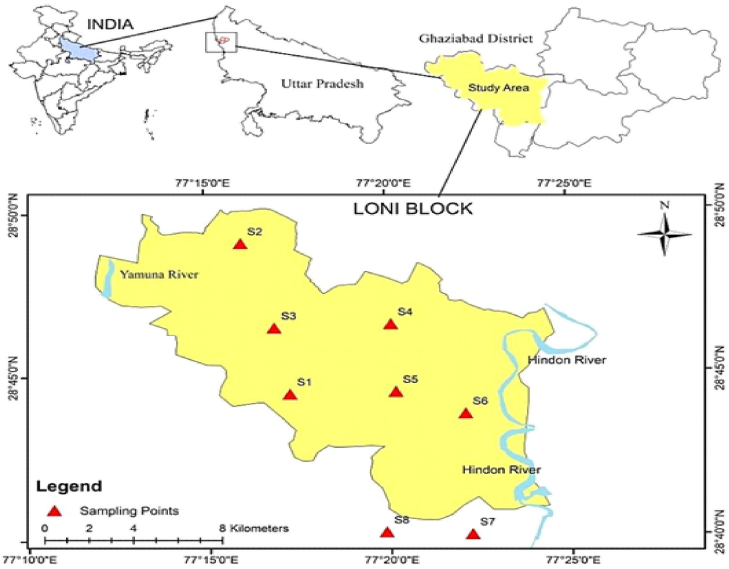
material in various manufacturing and processing industrial units (Kar et al. 2008). Similarly, generation of households' wastes also discharges metals to the environment. Therefore, the contamination studies of toxic metals become essential to examine the pollution extent of the groundwater.

Heavy metal Pollution Index (HPI) is a useful mathematical technique that investigates the general water quality status based on the concentrations of heavy metal. The indexing of water quality assures a convenient way of summarizing multifaceted water quality data and assesses water quality ranking relative to the desirable limits of existing contaminants. This method has been widely applied for estimating the levels of heavy metal pollution of the groundwater resources (Mohan et al. 1996; Reza et al. 2011; Prasad et al. 2014; Zakhem et al. 2015; Balakrishnan et al. 2016; Chaturvedi et al. 2018) as it transforms large water quality data into a single category representing the overall suitability of drinking water quality. It also provides insight into the extent to which water quality is affected by anthropogenic activities. Therefore, it is a valuable tool that can be applied in environmental monitoring programs to report the water quality scenario and to facilitate its communication to both area managers and the general public.

2. Study area description

The present study was carried out in Loni block, one of the administrative divisions of Ghaziabad district of Uttar Pradesh, India (Figure 1). Geographically, the extent of the Loni city lies in the longitudes 77º5¹E to 77º42¹E and latitudes 28º50¹N and 28º55¹N, adjoining the National Capital Territory (NCT) of Delhi. It is located on the old floodplain of river Yamuna and Hindon basin. The river Yamuna with its tributary Hindon flows through the Loni in southwards direction. The physiographical area consists of three major regions; older alluvial plain, older floodplain, and an active floodplain. Rainfall is due to south-west monsoon (CGWB 2009). The prime studied locations for monitoring is surrounded by upcoming residential complexes, numerous small & large scale industrial clusters within the block. Former studies within the region have also highlighted that groundwater quality deterioration is related to its dynamic land use pattern and industrial units that have majorly added to the groundwater pollution (Singh et al. 2012; Kumari et al. 2013).

Fig 1 Location map of the study area with sampling locations



1. Methodology

3.1 Sampling collection

A total number of eight sampling locations in western parts of Ghaziabad district in Loni block were identified (Fig 1). The groundwater sampling was done in the vicinity of industrial (S1&S8), residential (S3, S5, S6, S7) and agricultural (S2 & S4) types of land use. Samples were drawn from India Mark II, and local hand pumps at depth ~40-60 ft. After flushing out water for 10-15 minutes, samples were collected in pre-washed and acidified (10% HNO_3 of Analytical reagent grade) polyethylene bottle. pH below 2 was maintained of the samples with conc. HNO_3 in order to avoid degradation and further preservation of the toxic metals. All the samples were stored at 4ºC until analysis was performed.

3.2 Detection of toxic metals and analysis

The acid digestion of the samples was carried out with 10 ml. conc. HNO_3 (A. R. Grade) and filtered with Whatman no. 42 filter paper as outlined in the standard method (APHA 2005). The determination of Cd, Cr, Ni, and

Pb was performed by using atomic absorption spectrophotometer (Agilent 280 FS AA). The procedure followed was kept consistent with standard curves and blank readings for the respective metals and readings were recorded in replicates to retain the accuracy of the results.

3.3 Heavy metal Pollution Index (HPI)

HPI is an effective rating method that was established to assess the inclusive water quality and for appraisal of the pollution levels based on heavy metal. HPI was developed as the mathematical expression formulated (Mohan et al., 1996) as equation (1);

$$HPI = \frac{\sum_{i=1}^{n}(W_i \times Q_i)}{\sum_{i=1}^{n} W_i} \quad \text{(Eq. 1)}$$

Where; Q_i is the sub-index of the i^{th} element; W_i is the unit weightage of the i^{th} element ($W_i = 1/S_i$); n is the number of elements measured. The sub-index (Q_i) of the elements is calculated by equation (2):

$$Q = \sum_{i=1}^{n} \frac{|M_i - I_i|}{S_i - I_i} \times 100 \quad \text{(Eq. 2)}$$

Where; M_i is the monitored value of heavy metal of the i^{th} element; S_i is the permissible limit of the i^{th} element; and I_i is the desirable limit of the i^{th} element, in ppm units. The critical HPI index value is considered 100.

2. Results and Discussion

4.1 Toxic metal pollution in compliance with drinking water standards

The descriptive statistics of the toxic metals concentration in the groundwater samples is given in Table 1. Metals concentrations were compared with Indian drinking water standards (BIS 2012).

Cd is naturally found in the earth's crust. It is one of the commonly used metals for steel as corrosion resistant plating, as a plastic stabilizing component and widely used in batteries. Cd is released to the environment

in wastewater. Moreover, non-point or diffused sources includes fertilizers based contamination and local air pollution. On exposure, Cd simply gets accumulated in the liver and kidneys (Kumari et al. 2013). The drinking water pollution of Cd may also be caused by the impurities introduced by the galvanized pipes and metal fittings. The value of Cd in the studied region ranged from BDL-0.018 ppm with mean concentrations of 0.011ppm (Table 1). The groundwater samples of location S1, S2, S3, S4, S5, S6 were exceeding the standard limit of 0.003 ppm (BIS 2012). The maximum concentration of Cd was recorded at site S3 which is a densely populated residential area and discharges from domestic sewage and wastewater from the nearby households could be the reason for its extreme levels.

Cr is widely distributed in Earth's crust and found in valence states. Cr^{3+} element is an essential nutrient however; Cr^{6+} dosage leads to higher toxicity as it is considered as a human carcinogen. The prominent anthropogenic sources of Cr includes discharges from dyes and paints pigments, wood preservatives and also used in the metal alloys (Zakhem et al. 2015). The Cr levels varied from BDL-0.055ppm with an average value of 0.021 ppm. In the studied region, only two samples S1 and S8 were crossing the limit of 0.05 ppm (BIS 2012) and the levels of Cr were recorded highest for these sites which are located in the proximity of the prominent industrial clusters of Loni and Sahibabad areas.

Ni naturally arises as oxides or sulfides forms in the Earth's crust. It is majorly used in the manufacture of stainless steel and nickel alloys (Kumari et al. 2013). The pollution sources also include nickel-based waste disposal and its byproducts. The Ni levels ranged from 0.027-0.112 ppm, and all the samples were found to exceed the limit of 0.02 ppm (BIS 2012). Apart from the natural dissolution of Ni-bearing rocks, the gradual release of the Ni from stainless steel hand pumps that are made up of non-resistant materials and release from industrial nickel deposits in the ground might be the reason for its increased concentration found in the groundwater. Similar results were observed by one of the conducted studies in the industrial region of Ghaziabad district (Kumari et al. 2013; Chabukdhara et al. 2017). Therefore, groundwater is hazardous to consume for drinking purpose as the presence of Ni also causes allergic contact dermatitis in human population and it is a potential carcinogen (Chabukdhara et al. 2017).

Pb is one of the most toxic and carcinogenic elements found in nature and principally used in the production of lead-acid storage batteries, solder and alloys. Moreover, it is also released from smelting; exhaust fumes from

automobiles and leaching of Pb from corrosive action lead-based pipes (Samantara et al. 2017). Prolonged exposure of Pb causes severe effects like headache, abdominal ailments, nerve and kidney damage and promote mental retardation in children (Chabukdhara et al. 2017). Pb ranged from BDL-0.050 ppm with an average level of 0.017 ppm. The highest value was 0.050 ppm found at site S1 which is nearest to the small iron-based industrial and small stone crushing units. Groundwater sampling sites S1, S2, S5, S7, and S8 crossed the permissible limit of 0.01 ppm (BIS 2012). Majority of the sites in the residential areas and various Pb based connection fittings from houses could be the reason for its occurrence.

Table 1 Descriptive statistics of toxic metals and HPI value of the respective sites

Sampling Location	Toxic Metals (ppm)				HPI Value
	Cd	Cr	Ni	Pb	
S1	0.015	0.054	0.112	0.050	490.38
S2	0.016	0.002	0.097	0.015	431.33
S3	0.018	0.016	0.101	BDL	448.78
S4	0.014	BDL	0.086	BDL	351.76
S5	0.014	BDL	0.084	0.020	390.50
S6	0.014	BDL	0.082	BDL	349.78
S7	BDL	0.044	0.027	0.020	56.64
S8	BDL	0.055	0.033	0.030	80.36
Min.-Max.	*BDL-0.018	BDL-0.055	0.027-0.112	BDL-0.050	56.64-490.38
Mean ± S.D.	0.011±0.01	0.021±0.03	0.078±0.03	0.017±0.02	324.95±165.4
BIS (2012)	*0.003*	*0.050*	*0.020*	*0.010*	#*100*
Samples above BIS (2012) limit (%)	75%	25%	100%	62.5%	75%

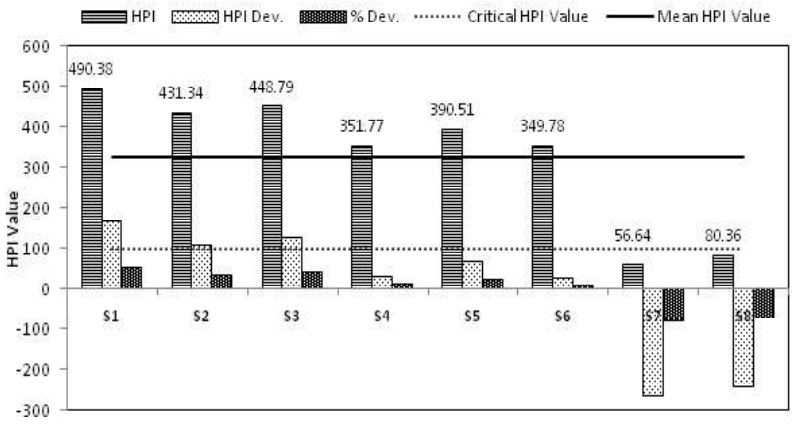
*BDL: Below Detectable Limit; #HPI Critical value

4.2 Heavy metal pollution indexing approach

HPI value was calculated for the respective sites (Table 1) and deviation from HPI mean value and percentage deviation (%) for each groundwater samples is presented in Fig 2. It was used for estimating the overall

groundwater quality based on the toxicity of the samples. From the concentrations of toxic metals, the mean HPI value was 324.95 and observed far above the HPI critical index value of 100 (Table 1). The computed HPI value for the respective groundwater samples showed that sites S1, S2, S3, S4, S5, S6 of the Loni block were beyond the HPI critical value of 100 (Table 1). Mostly, the corresponding sites were located in the proximity to populated residential and industrial clusters. The presence of higher values of all toxic metals found within the region might be associated with the higher HPI values at the corresponding sites of the block. The positive HPI deviation shows that there is increase within the value in comparison to the mean HPI value.

Fig 2 HPI value with HPI deviation and HPI percentage deviation of the respective sites



5. Conclusion and recommendation

The toxic metals such as Cd, Cr, Ni, and Pb were monitored and results obtained show that majority of the samples were found exceeding as per the suggested limits of the drinking water. The dominance of the toxic metals is observed in the order of Ni > Cr > Pb > Cd. For inclusive groundwater quality based upon toxic metals, the application of HPI method was estimated. The mean HPI value was 324.95 calculated from the monitored concentration of the toxic metals considered in the groundwater and relatively found beyond the critical HPI index value of 100. This situation explains that groundwater pollution concerning measured toxic metals is predominantly higher for the

selected sites in Loni block of Ghaziabad district. Proper conservation and remediation plans need to be implemented for groundwater pollution. Subsequent tracking of the areas must be of prior concern where high levels of toxicity are persistent within the district. Proper legislation and strict guidelines should be regulated in order to access safe drinking water and to prevent further deterioration of the groundwater quality with respect to toxicity.

Acknowledgment

The authors would like to gratefully acknowledge University School of Environment Management, Guru Gobind Singh Indraprastha University (GGSIPU), New Delhi, for providing necessary research facility and financial assistance.

References

APHA, AWWA and WEF (2005) Standard Methods for the Examination of Water and Wastewater, 21st Edition *American Public Health Association* Washington, D.C, USA

Balakrishnan, A., Ramu, A. (2016) Evaluation of Heavy metal pollution index (HPI) of groundwater in and around the coastal area of gulf of Mannar biosphere and Palk Strait *Journal of Advanced Chemical Sciences* 2(3):331-333

BIS (2012) Bureau of Indian Standard Specification for Drinking Water IS: 10500:2012 (Second Revision) BIS, New Delhi

CGWB (2009) Central Groundwater Board, Groundwater Brochure of Ghaziabad District, U.P. Online at: http://cgwb.gov.in/District_Profile/UP/Ghaziabad.pdf. Accessed at: 11 September 2018

Chabukdhara, M., Gupta, S.K., Kotecha, Y., Nema, A.K. (2017) Groundwater quality in Ghaziabad district, Uttar Pradesh, India: Multivariate and health risk assessment *Chemosphere* 179:167-178

Chaturvedi, A., Bhattachrjee, S., Singh, A.K., Kumar, A. (2018) A new approach for indexing groundwater heavy metal pollution *Ecological Indicators* 87:323-331

Jain, C.K., Bandyopadhyay, A., Bhadra, A. (2010). Assessment of groundwater quality for drinking purpose, District Nanital, Uttarakhand, India *Environmental Monitoring and Assessment* 166:663-676.

Kar, D., Sur, P., Mandal, S.K., Saha, T., Kole, R.K. (2008) Assessment of heavy metal pollution in surface water *International Journal of Environmental Science and Technology* 5(1): 119–124

Kumari, S., Singh, A.K., Verma, A.K., Yaduvanshi, N.P.S. (2013) Assessment and spatial distribution of groundwater quality in industrial areas of Ghaziabad,

India *Environmental Monitoring and Assessment* 186:501–514

Lee, C.L., Li, X.D., Zhang, G., Li, J., Ding, A.J., Wang, T. (2007) Heavy metals and Pb isotopic composition of aerosols in urban and sub-urban areas of Hong Kong and Guangzhou, South China evidence of the long-range transport of air contaminants. *Environment Pollution* 41(2):432–447

Lohani, M.B., Singh, S., Rupainwar, D.C., Dhar, D.N. (2008) Seasonal variations of heavy metal contamination in river Gomti of Lucknow city region *Environmental Monitoring and Assessment* 147(1–3):253–263

Marcovecchio, J.E., Botte, S.E., Freije, R.H. (2007) Heavy metals, major metals, trace elements. Handbook of water analysis CRC Press London

Mohan, S.V., Nithila, P., Reddy, S.J. (1996) Estimation of heavy metal in drinking water and development of heavy metal pollution index *Journal of Environmental Science Health A*, 31(2):283-289

Ouyang, Y., (2011) Estimation of shallow groundwater discharge and nutrient load into a river. *Ecological Engineering*, 38(1):101–104.

Prasad, B., Kumari, P., Bano, S., Kumari S. (2014) Ground water quality evaluation near mining area and development of heavy metal pollution index *Applied Water Science* 4:11-17

Reza, R., Singh, G., Jain, M.K. (2011) Application of heavy metal pollution index for groundwater quality assessment in Angul district of Orissa, India *International Journal of Research Chemistry and Environment* 1(2):118-122

Samantara, M.K., Padhi, R.K., Sowmya, P., Kumaran, P., Satpathy, K.K. (2017) Heavy metal contamination, major ion chemistry and appraisal of the groundwater status in coastal aquifer, Kalpakkam, Tamil Nadu, India *Groundwater for Sustainable Development* 5: 49-58

Singh, V.K., Bikundia, D.S., Sarswat, A., Mohan, D. (2012) Groundwater quality assessment in the village of Lutfullapur Nawada, Loni, District Ghaziabad, Uttar Pradesh, India *Environmental Monitoring and Assessment* 184(7):4473–4488

Zakhem, A.Z., Hafez, R. (2015) Heavy metal pollution index for groundwater quality assessment in Damascus Oasis, Syria *Environmental Earth Sciences* 73:6591-6600

19

Assessment of groundwater quality status by using Water Quality Index (WQI) method in National Capital Territory, Delhi, India

Tapasya Tomer[1], Deeksha Katyal [2] ,Varun Joshi[2]

Affiliations

[1]Rajdhani College, University of Delhi, Raja Garden, New Delhi-110015, India.

[2] University School of Environment Management, GGSIP University, Sector-16C, Dwarka, New Delhi-110078, India.

Abstract

Water quality index (WQI) is a technique that reduces a significant amount of water quality data into a single numerical value. Further, integration of geographical information system (GIS) with WQI can be used for effective interpretation of spatial variation in groundwater quality status. The present study was designed with a total of 22 sampling sites selected district-wise with the purpose of obtaining representative samples from each district. Samples were collected during post-monsoon seasons for the year 2013-2015. To generate hydrochemical data for WQI, groundwater quality of selected sites were analyzed using standard methods for 12 physico-chemical parameters. The overall result indicated that all the districts of NCT of

Delhi exhibited "Poor" to "Unfit for drinking" groundwater quality. The deteriorated quality could be attributed to the effect of precipitation in the dissolution and downward movement of domestic, industrial and agricultural contaminants into the groundwater. Finding of this investigation revealed that the groundwater at various locations required some degree of treatment before consumption and it also needs to be protected from the risk of the prevailing contamination.

Keywords: Groundwater, Water quality index, GIS, Delhi.

Introduction

Groundwater is one of the essential elements of the environment which is vital for sustaining life. The versatile use of this precious asset has its importance but with its continuous withdrawal for ages, its availability may reach the threshold level and its quality might get affected (Ghosh, 2014). Further, unprecedented population growth, urbanization and industrialization have resulted in its contamination (Singh et al. 2013). Therefore, it is significant to control water pollution and monitor water quality (Simeonova et al. 2003).

Water quality index is one of the most effective tools to monitor the surface as well as sub-surface waterpollution and can be used proficiently in the implementation of water quality management programmes (Alobaidy, 2010). The objective of a water quality index is to turn complicated water quality data into simple information that is comprehensible and usable by the public (Dhok et al., 2011). The first ever water quality index was devised by Horton in 1960s as a tool to evaluate the water quality. Later on used by several workers for the quality assessment of different water resources. In this study Tiwaria and Mishra (Tiwari and Mishra, 1985). Water Quality index was used. This index provide information on a rating scale from zero to hundred. Higher value of index indicates excellent quality of water and lower value shows poor water quality (Sasane and Patil, 2013). The objective of the present work is to assess the suitability of ground water for human consumption based on computed water quality index values for the capital city Delhi.

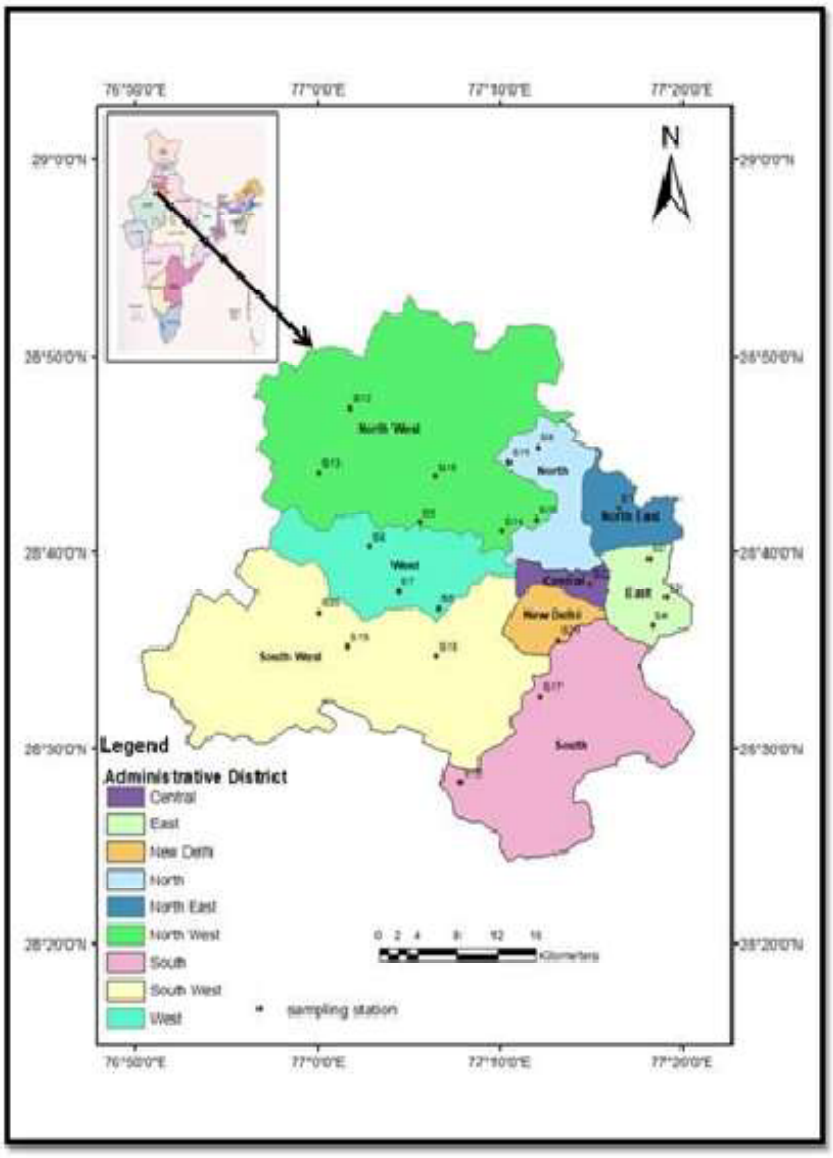
Study Area

National Capital Territory (NCT) of Delhi occupies an area of 1483 km^2

which lies between 28º24'15" and 28º53'00" N latitudes and 76º50'24" and 77º20'30" E longitudes (Fig 1). Administratively, it is divided into nine districts. This region is the part of Gangetic alluvial plain, and has an elevation ranging from 198 to 220 m above mean sea level. The climate of the study area is characterized by extreme summer season from March till June, the warm monsoon period between July to September and cold winters from October to February.

The average annual rainfall of territory is 612 mm. About three fourth of the total annual rainfall is received during the monsoon months (July - September) and the rest in the form of winter rain (CGWB, 2012; Kumar et al. 2009). Geologically, the area is transected by a rocky quartzite ridge which is a prolongation of the Aravalli Hills extending along the southern border of Delhi and ending to the north on the west bank of the Yamuna River (Srivastava and Ramnathan, 2008). The groundwater availability in the territory is controlled by the hydrogeological situation attributed to the different geological formation. Physiographically, the study area shows four major distinct physiographic units that influence the groundwater occurrence : (a) the Delhi ridge, (b) isolated and nearly closed Chattarpur alluvial basin, (c) alluvial plains on the eastern and western sides of the ridge; and (d) Yamuna floodplain deposits (Katyal, 2011; Tomer et al. 2016).

Figure 1: The study area and location of groundwater samples



A total of 22 sites were selected district wise for the collection of ground water samples across the study area. Study sites with their names and station code are listed in Table 1.

Site code	Site name
S1	Gokulpuri
S2	CBD shahadra
S3	Ghazipur crossing
S4	Mayur vihar
S5	Mangolpuri
S6	Mayapuri
S7	Vikaspuri
S8	Nangloi
S9	Burari
S10	Kingsway camp
S11	Bhalsawa lake
S12	Bawana
S13	Kanjhawala
S14	Ashok vihar
S15	Rohini
S16	Ayanagar
S17	Hauz khas
S18	Shekhawati line
S19	Dwarka
S20	Najafgarh
S21	Lodhi garden
S22	Rajghat

Material and Methods

Sample collection and analysis: District wise a total of 22 groundwater samples were collected during post-monsoon seasons for the year 2013-2015. The samples were analyzed for 12 physicochemical parameters. These parameters includes pH, total dissolved solids (TDS), Total hardness (TH), calcium, magnesium, total alkalinity (TA), chloride, fluoride, nitrate, sulphate, sodium and iron by adopting standard methods of American Public Health Association (APHA, 2012).

Water quality index: Water quality index is an effective tool which aims at providing solitary numerical value for the large and comprehensive water quality data to illustrate the water quality. It is calculated from the point of view of human consumption. Water quality and its suitability for drinking purpose can be examined by determining its quality index. Bureau of Indian Standards (BIS, 2012) for drinking have been considered for calculation of WQI. In this study, index developed by Tiwari and Mishra (1985) was used.

WQI was calculated by considering 12 physicochemical parameters through the following steps:

$$WQI = anti\log\left[\sum_{n=1}^{n} w Log_{10} q_n\right] \quad (1)$$

Where *W* is weighting factor computed using the equation 2

$$w_n = \frac{k}{S_n} \quad (2)$$

k is proportionality constant derived from

$$k = \left[\frac{1}{\sum_{n=1}^{n} \frac{1}{S_n}}\right] \quad (3)$$

S_n is Indian drinking water Standard (BIS, 2012) value of the water quality parameter. *q* is quality rating parameter, calculated using the formula.

$q_n = (Vactual - Videal)/(Vstandard - Videal) \times 100$

where *n* is the number of water quality parameters, Vactual is the value of the water quality parameter obtained from laboratory analysis, Videal is a value obtained from the standard tables, Vstandard is standard given by the BIS for the water quality (Table 2).

Table 2: Unit weights of chemical parameters for calculating WQI

Chemical parameter	BIS permissible limit, 2012 (S_n)	Unit weight (W_n)
pH	8.5	0.026
TDS	500	0.000
TH	200	0.001
Calcium	75	0.003
Magnesium	30	0.007
Total alkalinity	200	0.001
Chloride	250	0.001
Fluoride	1	0.220
Nitrate	45	0.005
Sulphate	200	0.001
Sodium	100	0.002
Iron	0.3	0.732
		Σwi=1.00

Based on the WQI values, the water quality was rated as excellent, good, poor, very poor and unfit for human consumption (Table 3). ArcGIS 10.2.3 software was used to generate spatial distribution map of water quality index (WQI) of the study area.

Table 3. Water quality index rating and their categories for drinking water

Water quality index	**Water quality**
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unfit for drinking

Results and Discussion

The WQI values (Table 4) of different stations were compared with water quality index rating chart (Table 3). WQI values in study area were found to vary from 28.17 to 112.34 and therefore can be categorized into five classes "excellent water" to "water, unfit for drinking" (UFD).

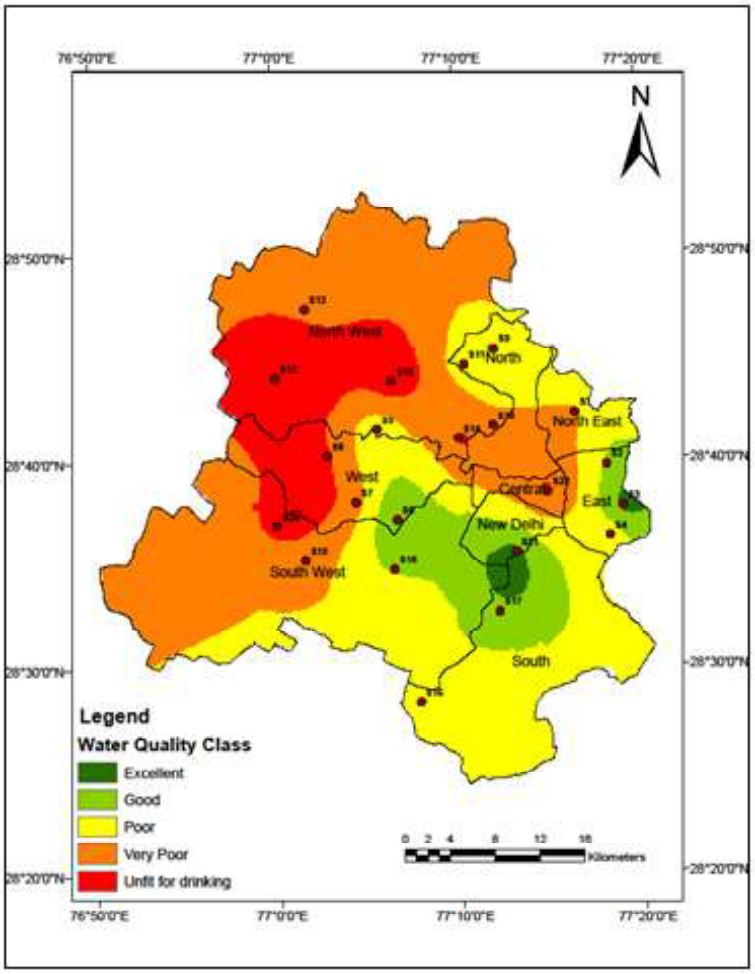
Table 4 : Location wise WQI values and water quality status

Site code	WQI	Water Quality
S1	67.49	Poor
S2	42.03	Good
S3	33.44	Good
S4	51.46	Good
S5	51.73	Good
S6	28.17	Excellent
S7	80.33	Very Poor
S8	96.21	Very Poor
S9	40.03	Good
S10	89.07	Very Poor
S11	53.25	Poor
S12	89.64	Very Poor
S13	112.34	UFD
S14	94.21	Very Poor
S15	97.67	Very Poor
S16	55.32	Poor
S17	32.81	Good
S18	45.91	Good
S19	81.21	Very Poor
S20	95.11	Very Poor
S21	29.12	Good
S22	101.68	UFD

According to WQI result 4.54% groundwater samples showed ‘‘excellent quality’’, about 36.36% samples covered under ‘‘good water’’ 13.64% of the water samples were of the ‘‘poor’’ quality and 36.36 were of ‘‘very poor’’ quality. About 9.09% of the water samples covered in the category of ‘‘water, unfit for drinking’’. Integration of WQI values with spatial interpolation technique can represent spatial distribution of water quality as well as categorized the study area into different vulnerable zones. The spatial

distribution map of water quality class was generated by using GIS and spatial interpolation method (Figure 2).

Figure 4: Spatial distribution of water quality Index (WQI)



Worst i.e unfit for drinking water quality groundwater was reported in some part of North-West particularly around Kanjhawala, Ashok Vihar and Rohini, areas in vicinity of Nangloi in West, Najafgarh in South-West, Rajghat in Central Delhi. "Very poor" quality was observed in major part of North-West, South-West, North, Central and some part of West and North-East

Delhi. "Poor" quality groundwater was found around Bhalaswa in North, Mayur Vihar in East, major part of South Delhi particularly around Aya Nagar. Whereas, the extent of "Excellent" to "Good" was restricted to Mayur vihar in East, Lodhi Garden in New Delhi, Hauz Khas in South, Shekhawati lines in South-West and Mayapuri region of West district of Delhi.

The "Poor" to "Worst" groundwater quality in post- monsoon season could be attributed to the role of precipitation in the dissolution and downward movement of domestic, industrial and more importantly agricultural contaminants (Singh, 2012). Deteriorated groundwater quality, especially in North, North-East, New Delhi and Central Delhi particularly at Rajghat, could also be reasoned to pollutant transfer from the River Yamuna, Principal surface water body of NCT of Delhi (Datta *et al.,* 1997).

Conclusion

In the present investigation, an attempt was made to assess and to map the groundwater quality of Delhi region using WQI. WQI was found to be a very useful and an efficient tool to summarize and to report on the monitoring data to the decision makers in order to understand the status of the groundwater quality; and to have the opportunity for better use in future as well. The overall result of the WQI revealed a higher WQI, indicating the deteriorated water quality. Only nine locations had a satisfactory result with a WQI below 50. The groundwater at thirteen locations required some degree of treatment before consumption and it also required to be protected from the risk of the prevailing contamination. This study also demonstrated that the use of GIS and WQI methods could provide useful information for water quality assessment.

References

Alobaidy, A. H. M. J., Abid, H. S., & Maulood, B. K. (2010). Application of water quality index for assessment of Dokan lake ecosystem, Kurdistan region, Iraq. *Journal of water resource and protection*, *2*(09), 792.

American Public Health Association (APHA, 2012). *Standard methods for the examination of water and wastewater,* 22nd edition, American Public Health Association Washington, DC, USA. pp1360.

Bureau of Indian Standards (BIS, 2012). *Indian Standard Drinking Water-*

Specification. Bureau of Indian Standards (BIS) Second revision, IS 10500:2012.

Central Ground Water Board (CGWB, 2012). *Groundwater year book of national capital of territory, Delhi*. New Delhi: Ministry of Water Resources, Government of India.

Datta, P.S., Deb, D.L. & Tyagi, S.K. (1997). Assessment of groundwater contamination from fertilizers in the Delhi area based on ^{18}O, NO_3 and K+ composition. *Journal of Contaminant Hydrology*, *27*, 249-262.

Dhok, R. P., Patil, A.S. & Ghole, V.S. (2011). Quality of ground water and its suitability for drinking purpose, *Water Research & Development* , 1(1), 27-35.

Ghosh, T. (2014). *Identification and Spatial Analysis of Groundwater Vulnerability Zones of Murshidabad District (West Bengal).* Unpublished PhD Thesis. Department of Geography, Faculty of Science. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat.

Katyal, D. (2011). Water quality indices used for surface water vulnerability assessment, *International Journal of Environmental Sciences,* 2(1), 1-20.

Kumar, M., Sharma, B., Ramanathan, A.L., Rao, M.S. & Kumar, B. (2009). Nutrient chemistry and salinity mapping of the Delhi aquifer, India: source identification perspective. *Environmental Geology, 56*, 1171-1181.

Reza, R., & Singh, G. (2010). Assessment of ground water quality status by using water quality index method in Orissa, India. *World Applied Sciences Journal*, *9*(12), 1392-1397.

Singh, S. K., Srivastava, P. K., & Pandey, A. C. (2013). Fluoride contamination mapping of groundwater in Northern India integrated with geochemical indicators and GIS. *Water Science and Technology: Water Supply*, *13*(6), 1513-1523.

Simeonov, V., Stratis, J. A., Samara, C., Zachariadis, G., Voutsa, D., Anthemidis, A., et al. (2003). Assessment of the surface water quality in Northern Greece. *Water Research, 37*, 4119–4124.

Srivastava, S.K. & Ramanathan, A.L. (2008). Geochemical assessment of groundwater quality in vicinity of Bhalswa landfill, Delhi, India, using graphical and multivariate statistical methods. *Environment Geology*, *53*, 1509-1528.

Tiwari, T.N. & Mishra, M. (1985). A preliminary assessment of water quality index of major Indian rivers. *Indian Journal of Environmental Protection, 5*(4)*,* 276-279.

Tomer, T., Katyal, D. & Joshi, V. (2016). Hydrochemical characterization and evaluation of groundwater quality of Delhi region, Journal of water resources engineering and management. 3(2), 32-41.

Sasane, V.V. & Patil, V.M. (2013). Assessment Of Ground Water Quality Status Using NSFWQI Method In Selected Rural Area Of Kopargaon, Ahmednagar, Maharashtra, *International Journal of Advanced Tech. in Civil Engg.* 2(1), 5-10.

Singh, G. (2012). *Surface and sub-surface water quality in the NCT of Delhi and its implications on the urban environments*. Unpublished PhD Thesis, University of Delhi, Delhi, India.

20

पर्यावरण की ज्ञानमीमांसा रू वेदान्त दर्शन के संदर्भ में

[Epistemology of Environment: with reference to Vedanta philosophy]

डॉ रविंद्र कुमार

भूमिका

भारतीय दर्शन की समझ है, यथा पिण्डे तथा ब्रह्माण्डे, अर्थात् जैसी संरचना व्यष्टि की है वही संरचना समष्टि की है. यहाँ व्यष्टि अथवा जीव अथवा मानव व्यक्ति को एक ब्रह्माण्डीय संरचना (बवेउपब मदजपजल) के रूप में ही समझा गया है. वेदांत दर्शन के अनुसार आत्मा और ब्रह्म में तादात्म्य है. आत्मा से ही आत्मा यह रचती है. यहाँ चेतन और अचेतन तत्त्वों की सामानांतर सत्ता नहीं स्वीकार की गई है. ब्रह्म या आत्मा या चेतना की उपस्थिति को सार्वत्रिक स्वीकार की गई है यदि मुझे या आपको किसी भी स्थिति या स्थान पर चेतना का अनुभव नहीं होता है तो हमारी समझ की त्रुटि है न कि चेतना का अभाव. तो यह जो ब्रह्माण्डीय सृष्टि की संरचना है वह चेतन है अथवा चेतनानिर्मित है. अतएव पारिस्थितिक परिवर्तन से मनुष्य की चेतना में और फिर उसके व्यवहार में परिवर्तन परिलक्षित होता है उसी तरह सबके केन्द्र चेतना ही है. प्रकृति के दोहन के पीछे की सबसे बड़ी समझ यह है कि चेतना और ज्ञानवान मनुष्य उसे अचेतन तथा अन्य समझता है और उससे अनात्मीय व्यवहार करता है. उसे जब

यह बोध होगा कि प्रकृति उसकी आत्मा का, उसके स्व का ही विस्तार है तो वह उससे आत्मीय व्यवहार करेगा उसके दोहन में क्रूरता और परायापन का व्यवहार नहीं करेगा प्रत्युत उसकी व्यथा का अनुभव करेगा. और वास्तविकता भी यही है कि जैसे हम अपने अंग–प्रत्यंग की रक्षा करते हुए स्वयं की रक्षा करते हैं वैसे ही आत्मा से ही उत्पन्न हुई प्रकृति की रक्षा करते हुए हम अपने विस्तार की रक्षा करते हैं.

मुख्य खण्ड

पर्यावरण शब्द जिस अर्थ में प्रयुक्त हो रहा है, वह एक नया शब्द है. पुराने कोशों में और यहां तक कि संस्कृत हिंदी कोशों में भी यह शब्द उपलब्ध नहीं है। पर्यावरण शब्द की उत्पत्ति, परि–उपसर्ग के साथ आवरण शब्द की संधि से होती है। इसके साथ ही आङ्पूर्वक वरण शब्द का प्रयोग भी संस्कृत शब्दार्थ–कौस्तुभ ग्रंथ में हमें प्राप्त होता है, जिसका अर्थ है, 'ढकना, छिपाना, घेरना, ढक्कन, पर्दा, घेरा, चारदीवारी, वस्त्र, कपड़ा और ढाल (वही, पृ. 200)। इसी ग्रंथ में संस्कृत के उपसर्ग 'परि' का अर्थ–सर्वतोभाव, अच्छी तरह, चारों ओर तथा आच्छादन आदि के रूप में मिलता है और 'आङ्' भी संस्कृत का एक उपसर्ग है, जिसका अर्थ, 'समीप, सम्मुख और चारों ओर से होता है (वही, वृ. 170)। वरण शब्द संस्कृत के 'वृ' धातु से बना है, जिसका अर्थ, 'छिपना, चुनना, ढकना, लपेटना, घेरना, बचाना आदि है (वही, पृ. 1056)। इसी प्रकार पर्यावरण दृ परि़आवरण से बने शब्द का अर्थ, 'चारों ओर से ढंकना, चारों ओर से घेरना या चारों ओर का घेरा' होगा। अतएव वैज्ञानिक कोशकारों ने इसका अर्थ, 'पास पड़ोस की परिस्थितियां और उनका प्रभाव' के रूप में माना है। डॉ. रघुवीर ने तकनीकी शब्द कोष निर्माण के समय 'इन्वायरमेंट' (फ्रेंच शब्द) के लिए सर्वप्रथम 'पर्यावरण' शब्द का प्रयोग किया है। वे ही इसके प्रथम 'शब्द प्रयोक्ता है (कंप्रिहेंसिव इंग्लिश–हिंदी डिक्शनरी, डॉ. रघुवीर, पृ. 589)। इन्वायरमेंट शब्द भी बहुत प्राचीन नहीं है। जर्मन जीव वैज्ञानिक अर्नेस्ट हीकल द्वारा 'इकॉलाजी' शब्द का प्रयोग सन् 1869 में किया गया, जो ग्रीक भाषा के ओइकोस (गृह या वासस्थान) शब्द से उद्धृत है। यही शब्द पारिस्थितिकी के अंग्रेजी पर्याय के रूप में इन्वायरमेंट शब्द से प्रचलित हुआ है। (पर्यावरण तथा प्रदूषण, अरुण रघुवंशी, पृष्ठ 41)। इन्वायरमेंट शब्द का प्रयोग, ऐसी क्रिया जो घेरने के भाव को सूचित करे, के संदर्भ में किया जाता है। विभिन्न कोशों में इसके विभिन्न अर्थ दिए गए हैं। जैसे–वातावरण, उपाधि, परिसर, परिस्थिति, प्रभाव, प्रतिवेश, परिवर्त, तथा वायुमंडल, वातावरण और परिवेश, अड़ोस–पड़ोस, इर्द–गिर्द, आस–पास की वस्तुएं एवं पर्यावरण आदि।

भारत में दार्शनिक चिंतन ब्रह्माण्डीय चिन्ता के रूप में विकसित हुआ है. पर्यावरण का निर्माण करने वाले समस्त तत्वों की सृष्टि किस क्रम में और किस प्रकार हुई और उसके कारक तत्व कौन से हैं, तभी पर्यावरण के समस्त रहस्यों से आवरण दूर किया

जा सकता है। ऋग्वेद ख10.129, के ऋषि इसी सृष्टि संबंधी प्रश्नों से टकराता हुआ कहते हैं,

नासदासीन्नो सदासात्तदानीं नासीद्रजो नोव्योमा परोयत्।
किमावरीवः कुहकस्य शर्मन्नंभः किमासीद् गहनंगभीरम् १

अर्थात उस समय असत् नहीं था। सत् भी नहीं था, रज नहीं था, अन्तरिक्ष नहीं था और उससे परे जो कुछ है वह भी नहीं था, वह आवरण करने वाला तत्त्व कहाँ था और किसके संरक्षण में था। उस समय गहन और गंभीर क्या था ..... ?

यह चिंतन यहाँ ठहर नहीं गया, प्रत्युत इसका ज्ञानात्मक विकास निरन्तर जारी रहा. इसी प्रकार ब्राह्मण ग्रंथों एवं उपनिषदों में दृतैत्तिरीय ब्राह्मण (2, 8, 9, 6 तथा 1, 1, 3, 1), गोपथ ब्राह्मण (1, 1, 1, 2), सामविधान ब्राह्मण 1ध1), जैमिनीयोपनिषद् ब्राह्मण (7, 1, 1), शतपथ ब्राह्मण (6, 1, 1, 13, 19, 2, 2, 3, 28), जैमिनीय ब्राह्मण (1, 68 तथा 2, 146, ऐतरेय ब्राह्मण (5, 5, 7), ताङ्य ब्राह्मण (4,1, 1), तैत्तिरीय संहिता (4, 1, 8, 3), ऐतरेये उपनिषद् (1, 1), तैत्तिरीय उपनिषद् (2, 7, 10) आदि में भी सृष्टि प्रक्रिया का वर्णन है, जो वेदों की विषद् व्याख्या रूप हैं और उन अर्थों का पूरक भी है। इसी क्रम में दार्शनिकों एवं वेदांत ने भी उसी प्रकार चिंतन किया है। पौराणिक दृष्टि तथा मनु का सृष्टि सिद्धांत व आयुर्वेद का चिंतन भी वैदिक विज्ञान का समर्थन करता हुआ ही प्रतीत होता है। देखा जाए तो सृष्टि की उत्पत्ति और जगत् का विकास ही पर्यावरण प्रादुर्भाव है। सृष्टि का जो प्रयोजन है वही पर्यावरण का भी है। जीवन और पर्यावरण का अन्योन्य संबंध है। इसीलिए आदिकाल से मानव पर्यावरण के प्रति जागरूक रहा है, ताकि मानव दीर्घायुष्य, सुस्वास्थ्य, जीवन–शक्ति, पशु, कीर्ति, धन एवं विज्ञान को उपलब्ध हो सके। यही कामना अथर्ववेद का ऋषि, 'आयुः प्राणं प्रजां पशुं' (अथर्ववेद, 19, 71, 1) व 'शत जीव शरदो' ...अथर्ववेद, 3, 11, 4) करता है और ऋग्वेद में ऋषि, 'शतां जीवंतु शरदः...' (ऋग्वेद 10ध18ध4) तथा यजुर्वेद में ऋषि, 'शतिमिन्नु शरदो अंति...' (यजुर्वेद, 25ध22) तथा वह ऋषि का आशीर्वाद पाता है कि हे मनुष्य! बढ़ता हुआ तू सौ शरद ऋतु और सौ बसंत तक जीवित रहे। इंद्र (विद्युत), अग्नि, सविता (सूर्य), बृहस्पति (संकल्पशक्ति) और हवन (यज्ञ) तुझे सौ वर्ष तक आयुष्य प्रदान करें (अथर्ववेद)।

वैदिक चिन्तक इस बात से पूरी तरह अभिज्ञ रहे कि पर्यावरणीय तत्वों में समन्वय होना ही सुख शांति का आधार है। पदार्थों का पारस्परिक समन्वय ही शांति है। प्राकृतिक पदार्थों में शांति की भावनाएं अनेक स्थलों पर हमें उपलब्ध होती हैं। जैसे–पृथ्वी हमारे लिए कंटकरहित और उत्तम बसने योग्य हो (ऋग्वेद, 7ध35ध3 तथा यजुर्वेद 36ध 13)। हमारे दर्शन के लिए अंतरिक्ष शांतिप्रद हो (ऋग्वेद, 10ध35ध5)। वह आकाश जिसमें बहुत पदार्थ रखे जाते हैं, हमारे लिए सुख करने वाला हो (ऋग्वेद, 7ध35ध2)।

सूर्य, अपने विस्तीर्ण तेज के साथ हमारे लिए सुख करने वाला हो (ऋग्वेद, 10ध्35ध्8)। सूर्य, हमारे लिए सुखकारी तपे (यजुर्वेद, 36ध्10), चंद्रमा हम लोगों के लिए सुखरूप हो (ऋग्वेद, 7ध्35ध्7)। नदी, समुद्र और जल हमारे लिए सुखप्रद हो (ऋग्वेद, 7ध्35ध्8)। पीने का जल और वर्षा का जल हमारे लिए कल्याणकारी हो (यजुर्वेद, 36ध्12)। जलधाराएं तुम्हारे लिए अमृत वस्तुएं बरसाएं (अथर्ववेद, 8/6/5)। ज्योतिर्मय अग्नि हम लोगों के लिए सुखरूप हो (ऋग्वेद, 7ध्35ध्4)। अग्नि दुःखदायक रोगादि को और अनावृष्टि आदि दुःखों का हनन करती है (सामवेद मंत्र–4)।

इसी प्रकार अन्य पर्यावरणीय घटकों के लिए भी शुभेच्छाएँ व्यक्त की गई हैं। जैसे– शीघ्र चलने वाली वायु हम लोगों के लिए सब ओर से सुखरूप होकर बहे (ऋग्वेद, 7ध्35ध्4)। पवन हमारे लिए सुखकारी चले (यजुर्वेद, 36ध्10)। पूर्व आदि चारों दिशाएं व विदिशाएं हमारे लिए सुखरूप हों (ऋग्वेद, 7ध्35ध्8)। समस्त दिशाएं हमें मित्रवत सुख दें (अथर्ववेद, 19ध्15ध्16)। विशेष दीप्ति वाली उष्माएं हमारा कल्याण करें (ऋग्वेद 7ध्35ध्10)। दिन और रात्रि हमारे लिए सुखकारी हो (यजुर्वेद 36ध्11)। हम दिन और रात में अभय रहें (अथर्ववेद, 19ध्15ध्16)। मेघ हम प्रजाजनों के लिए शांतिप्रद हों (ऋग्वेद, 7ध्35ध्10)। बिजली और गरज के साथ शब्द करते हुए पर्जन्य (मेघ) देव की वर्षा कल्याणकारी हो (यजुर्वेद, 36ध्10) आदि.

उन प्राचीन ऋषियों की ज्ञानात्मक संवेदना चिंतन के क्रम में यहाँ तक पहुंची कि पृथ्वी पर्यावरण का आधारभूत अंग है। प्राणी जिस पर बसते हैं और जिसके आधार पर जीवन पाते हैं, वह भूमि निश्चय ही वंदनीय एवं अतिशय उपयोगी है। इसीलिए पृथ्वी को माता कहकर नमन करने का संकेत वेदमंत्रों में है (अथर्ववेद, 12ध्1ध्23ध्2ध्5, ऋग्वेद, 10ध्18, 10ध्11यजुर्वेद 9ध्22, 13ध्18, 36ध्13 व अथर्ववेद, 12ध्1ध्1–3, 12ध्1ध्6, 10ध्12, 6ध्21ध्1)। पृथ्वी के अत्यधिक महत्व का प्रतिपादन आधुनिक पर्यावरणविदों ने भी किया है। भूमि या मिट्टी सर्वाधिक मूल्यवान संसाधन हैं, क्योंकि विश्व के 71 प्रतिशत खाद्य पदार्थ मिट्टी से ही पैदा होते हैं। 2 प्रतिशत भाग में ही कृषि योग्य भूमि है, जो निम्न प्रकार है–

1. कृषि भूमि दृ भूमंडल का 2 प्रतिशत– 71 प्रतिशत खाद्य पदार्थ।
2. वन भूमि– भूमंडल का 8.8 प्रतिशत– 10.4 प्रतिशत खाद्य पदार्थ।
3. घास मैदान– भूमंडल का 7.2 प्रतिशत– 12 प्रतिशत खाद्य पदार्थ।
4. दलदल व मरुस्थल–भूमंडल का 10.4 प्रतिशत– 3.3 प्रतिशत खाद्य पदार्थ।
5. समुद्र– 71.8 प्रतिशत– 3.3 प्रतिशत खाद्य पदार्थ।

इस प्रकार हम देखते हैं कि भूमि या मिट्टी एक अतिसीमित किंतु मूल्यवान संसाधन है। खाद्य पदार्थों की समुचित उपलब्धि के लिए इस सीमित संसाधन को प्रदूषण से बचाना आज की अनिवार्य आवश्यकता है।

ऋग्वेद में भूमि संरक्षण संबंधी विभिन्न विचार उपलब्ध हैं। उनमें ऋषि द्वारा विद्वानों को सत्य लक्षणों से युक्त ज्ञान से प्रकाशित मंत्रों से भूमि को धारण करने का निर्देश दिया गया है (ऋग्वेद, 1ध्67ध्3)। उनमें राजा को आदेश दिया गया है कि वह धन, औषधि, जल आदि को धारण करने वाली पृथ्वी की सुरक्षा करें (ऋग्वेद, 3ध्51ध्5 तथा 3ध्55ध्22)। यजुर्वेद में यह कामना करते हुए संदेश दिया गया है कि भूमि को अपने दुष्कर्मों से न बिगाड़ें, उसको प्रदूषित करना उसके प्रति हिंसा है। भूमि की हिंसा हम और हिंसा हमारी भूमि न करे (यजुर्वेद, 10ध्23)। अथर्ववेद में ऋषि कहते हैं कि सबका पालन करने वाली भूमि की उपजाऊ शक्ति को नष्ट न होने दें। हे भूमि, हम तेरी खुदाई करें, वह शीघ्र भर जाए, हम तेरी हिंसा न करें (अथर्ववेद, 12ध्1ध्34–35)। भूमिसूक्त के ऋषि प्रार्थना करते हुए कहते हैं कि यज्ञ भूमि में देवताओं के लिए हम अंलकृत हव्य प्रदान करें। उसी भूमि में मरणशील मनुष्य स्वधा और अन्न से जीवन धारण करते हैं। वह भूमि हमें वृद्धावस्था तक प्राणप्रद वायु प्रदान करे। पृथ्वी की गोद हमारे लिए निरोग और सब रोग से रहित हो। दीर्घकाल तक जागते हुए हम अपने जीवन को इसकी सेवा में लगाएं (अथर्ववेद, 12ध्1ध्22 तथा 12ध्1ध्62)।

इस संदर्भ में अथर्ववेद का भूमिसूक्त द्रष्टव्य है जिसका ऋषि हमें बताता है कि निवास योग्य तथा विभिन्न कार्यों में प्रयोग होने वाली भूमि का संरक्षण करने से वह सुखद होती है। हे भूमि, तुम्हारी पहाड़ियां, हिमाच्छादित पर्वत, वन, पुष्टि देने वाली भूरे रंग की मिट्टी, कृषि–योग्य काली मिट्टी, उपजाऊ लाल रंग की मिट्टी अनेक रूपों वाली, सबका आश्रय स्थान, स्थिर भूमि पर अजेय, अवध्य और अक्षत रहकर हम निवास करें (अथर्ववेद, 12ध्1ध्11)। वेदों में मनुष्य को समृद्ध बनाने वाली उर्वरा भूमि के लिए कृषकों एवं वैज्ञानिकों की प्रेरणा दी गई है कि वे उसकी उर्वरा–शक्ति बनाए रखने के लिए पर्यावरण–प्रदूषित करने वाले खाद के स्थान पर, गोबर–खाद प्रयुक्त खेती को ही उत्तम फलवती मानकर, मधुर अन्न उत्पन्न करने वाले खाद के स्थान पर उन्नत करें। बार–बार बुआई से भूमि की उर्वरा शक्ति नष्ट होने की ओर संकेत किया गया है कि सब कुछ देने वाली जिस विस्तृत पृथ्वी की जागरूक, विविध व्यवहारों में कुशल विद्वान प्रजाजन प्रमादरहित होकर रक्षा करते हैं, उस भूमि को हम प्रिय मधु दिया करें तथा हम उसके तेज को बढ़ाएं (अथर्ववेद, 19ध्31ध्2 तथा 12ध्17)।

सृष्टि के क्रमिक विकास की तत्त्वमीमांसा में हम जाते है तो पाते हैं कि आत्मा से ही भौतिक पदार्थों की सृष्टि हुई है. तैत्तिरीय उपनिषद् में स्पष्ट कहा गया है, तस्माद्वा एतस्मादात्मन आकाशः संभूतः। आकाशाद्वायुः।

वायोरग्निः। अग्नेरापः। अद्भ्यः पृथिवी। पृथिव्या ओषधयः। ओषधीभ्योऽन्नम्। अन्नात्पुरुषः। स वा एष पुरुषोऽन्नरसमयः। ख्तैत्तिरीय उपनिषद् ,

अर्थात उस इस आत्मा से ही आकाश उत्पन्न हुआ, आकाश से वायु, वायु से अग्नि, अग्नि से जल, जल से पृथ्वी, पृथ्वी से ओषधियाँ, ओषधियों से अन्न और अन्न से पुरुष उत्पन्न हुआ. इस लिए यह पुरुष अन्न–रस–मय है. यही अद्वैत वेदान्त के पंचीकरण सिद्धांत आधार स्रोत है. पंचीकरण सिद्धांत के अनुसार पाँचों भूत दृ पृथ्वी, जल, तेज, वायु और आकाश दृ पंचीकृत होते हैं अर्थात किसी भी एक तत्त्व में अन्य चारों तत्त्वों का भी समावेश अनिवार्य रूप से होता है और ये सभी चेतन आत्मा से ही संभव हुए होते हैं अतएव इनमें चेतनांश भी होता है. यहाँ भौतिक तत्त्व यानी पञ्चभूत की चेतन आत्मा या ब्रह्म से निरपेक्षता को स्वीकार नहीं किया गया है. क्योंकि यदि चेतन और अचेतन को स्वतन्त्र और सामानांतर मान लेते हैं तो दोनों के बीच के संबंधों समझना असंभव हो जाएगा. जैसा कि यहाँ बताया गया है भौतिक तत्त्व चेतन तत्त्व का विस्तार है. इन भौतिक तत्त्वों की उपस्थिति और यहाँ तक कि उसकी क्रियाशीलता अथवा गतिशीलता चेतना पर आधारित है.

अन्नाद्वै प्रजाः प्रजायन्ते। याः काश्च पृथिवीं श्रिताः। अथो अन्नेनैव जीवन्ति। अथैनदपि यन्त्यन्ततः। अन्नँ हि भूतानां ज्येष्ठम्। तस्मात् सर्वौषधमुच्यते। सर्वं वै तेऽन्नमाप्नुवन्ति। येऽन्नं ब्रह्मोपासते। अन्नँ हि भूतानां ज्येष्ठम्। तस्मात् सर्वौषधमुच्यते। अन्नाद् भूतानि जायन्ते। जातान्यन्नेन वर्धन्ते। अद्यतेऽत्ति च भूतानि। तस्मादन्नं तदुच्यत इति। तस्माद्वा एतस्मादन्नरसमयात्। अन्योऽन्तर आत्मा प्राणमयः। .... अन्योऽन्तर आत्मा मनोमयः। ..... अन्योऽन्तर आत्मा विज्ञानमयः। ..... अन्योऽन्तर आत्माऽऽनन्दमयः। (तैत्तिरीय उपनिषद् २.२–५)

यहाँ चेतना के पांच स्तरों का प्रसंग है, अन्नमय, प्राणमय, मनोमय, विज्ञानमय और आनन्दमय. अन्न से जीवों की उत्पत्ति होती है, अन्न जो पृथ्वी के आश्रय से उत्पन्न होती है और जीव अन्न से ही जीवित रहता है. यह अन्न प्राणियों से भी बड़ा है. इस अन्नब्रह्म की उपासना होनी चाहिए. अन्न ही सबसे बड़ी औषधि है. इसलिए अन्न ब्रह्म की उपासना करें. फिर प्राणमय ब्रह्म, मनोमय ब्रह्म, विज्ञानमय ब्रह्म और आनन्दमय ब्रह्म की भी बात की गई है. तथापि जीवों के जीवन से सन्दर्भ में आधारभूत अन्न ही है जो साक्षात् रूप से भौतिक तत्त्व से जुड़ा है.

21

Impact of Change in Climate and Environment on Biodiversity: Global Quest for Sustainable Consumption

Dr. Sheetal Kapoor*
Sukriti Kapoor**

Abstract

Rapid industrialization and globalization has a major environmental impact, unfortunately degrading in most cases. Development today means material prosperity and conspicuous consumption and measuring a country's performance on GDP even at the cost of environment degradation. High standard of living implies more goods and services unmindful of their implications for environment, climate and impact on biodiversity. Want based conspicuous consumption does not produce happiness whereas the need based consumption leads to development of all. The nature is being robbed of its inherent capacity to regenerate and if we continue to tread on the path set by modern civilization, we are sure to face calamities such as global warming inducing climate change, pollution, cyclones, floods.; destruction of the ecosystem, and undermining sustainable lifestyles There has been increasing global recognition that unsustainable patterns of consumption have extreme serious social and environmental impacts worldwide.

Promoting sustainable consumption and production have thus become important aspects of sustainable development. Every single purchase decision affects the environment, business, consumers and the workers who manufacture the products. Therefore, what is required is a responsible behaviour from all stakeholders in preserving the environment.

* Associate Professor and Convenor Consumer Club, Department of Commerce, Kamala Nehru College, University of Delhi.

**Research Scholar

Introduction

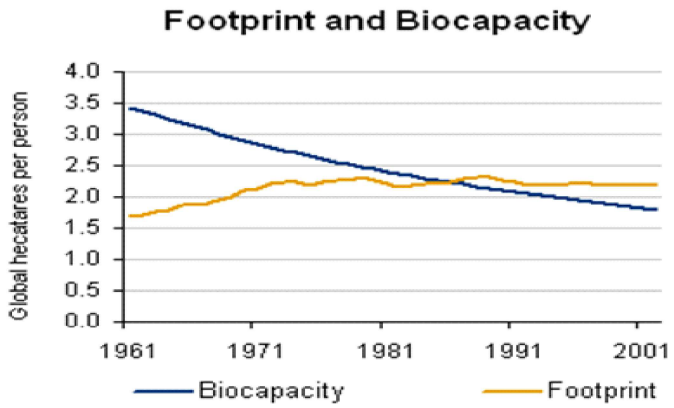
In the Indian society lifestyles have largely been regulated by long-standing practices. Since ancient times Indians have believed in *Aparigraha* (non possession), conservation of resources, and in need-based consumption, not want-based. Economic reforms carried on since1991 have produced remarkable results, making India one of the most exciting prospects among the emerging markets. The Indian middle class has become wealthy and there is a major shift in consumer behaviour. An Indian consumer who at one point of time was saving for the rainy day is not hesitant in taking home loans, car loans and does not shy away from spending on the life's luxury. Whereas the West which is already facing a consumerist society and the governments and social organizations are educating business and the consumers about ethical consumption, will the Indian consumer with its new found wealth think about sustainable consumption?

In 1987 the United Nations' World Commission on Environment and Development often referred as the Brundtland Report brought the concept of sustainable development to mainstream attention, and made it clear that our pre-existing approach to economic development, our systems of production, and our systems of consumption are unsustainable. Sustainable Development means meeting our needs without jeopardizing the ability of future generations to meet their needs[i]. By 1992 around 70 different definitions of sustainable development had been noted and the proliferation of them continued[ii].

Further the issue of sustainable consumption has been of growing interest after the conclusion of the Earth Summit at Rio de Janeiro in 1992[iii]. This Earth Summit Treaty signed by 143 nations provided international recognition to sustainable consumption and production by adopting the Agenda 21 action

plan. In that Summit sustainable consumption was fully supported and the major causes of continued deterioration of environment were discussed. Environmental disasters in Alaska, Bhopal and Chernobyl in the early 1990s led to the growth of a consumer segment concerned with the preservation of the environment. Green marketing, also known as ecological marketing and environmental marketing is not a recent phenomenon but it became a worldwide phenomenon during the nineties[iv]. Eco- foot printing seeks to calculate the level of resources we consume as an individual, organizations, cities, regions and nations and compares this with the resources nature can provide and sustain in terms of land, water, energy and resources. The first global foot print on humanity was published by WWF in 1998. It clearly showed that human beings are exceeding the physical capacity of the planet to support its numbers, activities and lifestyles[v] .

Fig 1.1 Ecological Footprint vs Global Biocapacity



Source: WWF Our Living Planet, Geneva, 1998, www.footprintnetwork.org

In 2002, humanity's demand on the biosphere, its global Ecological Footprint, was 13.7 billion global hectares, or 2.2 global hectares per person. Thus in 2002, humanity's Ecological Footprint exceeded global biocapacity by 0.4 global hectares per person, or 23 percent. This finding indicates that the human economy is in ecological overshoot: the planet's ecological stocks are being depleted faster than nature can regenerate them. Thus we are eroding the future supply of ecological resources and operating at the risk of environmental collapse.

In 1992 Rio Summit, 2001 Kyoto Summit, and now 2009 Copenhagen summit have continued the dialogue, leading to international agreements, and national laws.

In the past the focus was on Population Control, on Environmental Degradation and Pollution. Today and for the next few decades the sustainable development debate will center on "Climate Change and carbon accumulation" in the earth's atmosphere. Energy use is at the heart of this process. And global corporations are at the center of this debate. They are now a major influence on the global carbon cycle.

United Nations has also framed Global Compact (UNGC) Programme based on the world's largest corporate citizenship initiative aiming for a more sustainable and inclusive world economy. It is supported by over 4000 participants in over 100 countries. It includes many of the world's most influential companies, such as Coca Cola, Levi, Strauss, Nestlé, Microsoft and many more. Companies from all over the world report their progress on implementing the 10 Global Compact principles. United Nations Secretary-General Kofi Annan first proposed the Global Compact in an address to the World Economic Forum on 31 January 1999. The Global Compact's operational phase was launched at UN Headquarters in New York on 26 July 2000. The Secretary- General invited business leaders to join an international initiative — the Global Compact — that would bring companies together with UN agencies, labour and civil society to advance universal social and environmental principles. Since then every year World forums to study the impact on climate change and how to curtail it have been organised by UN where countries have taken pledge to implement sustainability goals in their own countries.

Environmental Impact

The IPAT equation i.e., population, affluence and technology describes how these three factors are having a strong impact on global. Global Climate Change is not just a research question, or a topic, or an area, it is a whole "Science" with 80,000 scientists, journals and conferences, studying it for over 40 years.

The best scientific consensus is in the IPCC Reports, which offer a comprehensive view of scientific findings[vi]. The natural Carbon Cycle of the earth is being changed by ANTHROPOGENIC or human activities.

Carbon is the most fundamental element on earth. And earth's atmosphere and productivity rests on a balanced carbon cycle.

For 650,000 years Carbon has remained between 170 ppm and 280 ppm. Since the mid 1800s it has started rising, and expected to go on rising a Carbon accum is growing at 2.3 ppm per year. Now it has reached 380-400 ppm. IPCC scenarios show them going to 970 ppm. Current wisdom is that we need to bring Carbon accumulation to 350 ppm – which means to 1990 level. We need not just slow the accumulations but actually REVERSE them.

Accumulated carbon traps heat in the earth's atmosphere and causes global temperatures to rise.

At 450 ppm all sorts of catastrophic things start happening – e.g. glaciers melt, permafrost melts, ice shelves melt, sea levels rise, viruses travel across temperature zones to create new diseases, agricultural productivity changes, more severe weather.

If Carbon accumulations reach those levels - Sea Level Rise alone would risk lives of 60 billion people, water shortages will affect 200 million people, disease vectors spread will affect over 500 million people

So it is in our collective interest to address Climate crisis now, because many of the changes are NOT EASILY REVERSIBLE.

For example, one of the implications of Global Climate Change for India is the Ganges. Ganges is a sacred river. Our cultural and religious identity is tied to this river. It is also a source of water and for 200 millions of people. The Himalayan river ecosystems supplies water to over 500 million people in India and China.

There are many causes of glacier melt, deforestation, warming, pollution particles etc, and the whole ecosystem is poorly understood.

Implications of the Study

In the modern context globalisation is a recent phenomenon, but as a concept and philosophy, it is as old as the globe. In non-technical words globalisation means sharing, caring, partnership, and togetherness. It rests on inter-dependence, mutuality and friendliness. Historically speaking globalisation is an Indian concept. A hymn in Vedas defines it as 'Vasudhaiv Kutumbkum' meaning the whole world is one family. Swami Vivekananda's Vedanta is global in its content and core. The New World Order which he visualized

was based on the concept of 'Jiva is Shiva', i.e. all human beings are equal and that a happy amalgem of the best of East and West would make the world a better place to live and contemplate[vii].

In 2008, the WBCSD's[viii] Future Leaders Team spoke with young business professionals about sustainable consumption in India. These young business people also represented young Indian consumers, mainly from the middle and upper socio-economic groups. Following are some of the insights regarding sustainable consumption – and its prospects – in India:

1. Consumption patterns: Indian household incomes are set to almost triple over the next two decades.

2. Consumer awareness: Awareness and understanding of sustainable consumption among consumers was low; the majority of Indian consumers still buy small, unpackaged goods from low-cost, family-run shops. Even to wealthier Indian consumers, sustainable consumption was felt to imply only consuming less; the concept of consuming differently is "a significant but missing factor".

3. The role of brands: Middle and high income Indian consumers are very brand conscious, so brand owners can play a major role, both in changing their practices and in educating their consumers.

4. The role of business. Participants felt that sustainability and CSR should be embedded into corporate strategies, including the responsible investment of company assets

A first step towards Sustainable Consumption is to recognize that consumption patterns will inevitably change in the future, if only by force for environmental protection. Secondly, we must try to modify consumption patterns and establish sustainable consumption as a norm. This will not only bring in far more efficient use of materials and energy it would also seek to improve the quality of life. Thus, it involves attaining a better balance between work and leisure, as between income and consumption. Further, preventing yesterday's luxuries from becoming today's necessities and tomorrow's relicts. In future certain core areas for sustainable consumption as mentioned by European Environmental Impact of Products (EIPRO) Project are[1]:

1. Sustainable food and drink choices: consumers should reduce their consumption of meat products as their impact in climate change, further locally and seasonal products should be preferred, and greater composting of biodegradable food waste.

2. Sustainable housing consumption choices: Emphasis on purchasing homes using sustainable materials and choosing and creating homes with high level of insulation and energy efficiency.

3. Sustainable Travel Behaviour: this may involve reducing the amount of travel undertaken by doing work from home or teleconferencing services. Car pool or finding alternative transport means such as cycling wherever possible.

This would involve a movement by consumers towards ethical consumption, role of business in sustainable marketing and initiatives by the government and society in promoting sustainable consumption.

Role of Consumers in Ethical Consumption[x]

Consumers can play an important role towards sustainable consumption by making purchasing decisions, lifestyle choices and peer-to-peer influencing. Ethical consumption stresses the role of the consumer in preventing labour exploitation, environmental degradation and adherence to basic labour and human rights while buying products. When a consumer goes beyond the brand name and label information and tries to find out about the business which produces and sells the product, s/he walks in to the realm of ethical issues in consumption. By consuming consciously and ethically consumers can realistically create change. Before buying anything s/he should ask: Who makes it? Who needs it? And who profits from it?

The effects of constantly buying things, while discarding older but often functioning things, increasing demands on the world's resources for this consumption, managing more waste, exploiting other people to labour over this, and so on. And all this while many still go hungry and poor because their lands are being used to export food and other resources for producing products to be consumed elsewhere. As a responsible consumer we should consume products consciously.

Ethical consumption is a way to help us feel that we have power as consumers that we can vote with our rupees. By using this consumer power we can have impact on the larger economy and help create a world where the economy benefits all people in more equal ways. Some suggestions regarding ethical consumption are:

1.Consumption should be need based and we should not be swayed by marketing-forces.

2.Using products which are energy efficient and also reducing consumption of fossil fuel.

3.Making a point to ask about the people who make the things we buy.

4.Considering the environment cost of producing the product. One should avoid buying a product whose manufacturer is polluting rivers, land or air.

5.Thinking about how we would dispose of the product once we finish with it.

6.Supporting fair trade by checking that the manufacturer pays a remunerative price to farmers.

7.Reusing things and fixing things that are broken.

8.Not getting swayed by advertisements and sales promotion devices.

9.Investing money ethically into socially responsible corporations.

10. Boycotting companies that exploit workers, deceive or cheat consumers, harm the environment or display any form of socially irresponsible behaviour.

Radically restructuring the usage of the environment can be achieved by discipline and selflessness. Instead of throwing something away, one should take time to fix it or take it to a tradesperson to fix it. The cost may be cheaper than buying a new one and we would be reducing waste.

Role of Business in Sustainable Marketing

Sustainable marketing accepts the limitations of marketing concept and is a macro-marketing concept. It embraces the idea of sustainable development, which requires a change in the behaviour of virtually everyone, including both producers and consumers. Sustainable marketing emphasizes on triple bottom line of ecological, social and economic issues[xi]. Thus sustainable marketing is defined as building and maintaining sustainable relationships with customers,

the social environment and the natural environment. Moreover sustainability marketing is related to Corporate Social Responsibility (CSR). CSR is a concept where by companies integrate social and environmental concerns in their business operations and their interaction with stakeholders on a voluntary basis[xii]. Systematic approaches to integrating environmental responsibilities include environmental systems such as, EMAS and ISO 14000 which are voluntary in nature. Many companies such as, Philips through its energy efficient lighting, Henkel's by introducing phosphate free

detergents, Adidas's green footwear and apparel, Nokia's energy efficient products are some of the approaches adopted by companies towards sustainable marketing. A recent global consumer survey carried out by Nokia showed that 44% of unused phones by people are simply kept at home. Responding to the survey, Nokia established 5,000 collection points for unwanted mobile devices in 85 countries, the largest voluntary scheme in the mobile industry, and is developing a series of campaigns and activities to give people more information on why, how and where to recycle their old and unwanted devices, chargers and mobile accessories. Nokia estimated that if all Nokia users unplugged their chargers when their phones were fully charged, enough energy would be saved to power 100,000 average-sized European homes. Marketing has a vital role to play in decoupling material consumption from consumer value. It has the ability to facilitate both innovation and choice influencing for sustainable consumption, because it allows products and information to flow between producers and consumers.

Role of Government and NGO's in Sustainable Consumption: It is important to promote sustainable consumption through environmental education and public awareness campaigns sponsored by the Centre and State governments and advocacy groups. In several areas, desirable limits and standards for consumption need to be established and applied through appropriate mechanisms including education, incentives and legislation. Development decisions regarding technology and infrastructure are a major determinant of consumption patterns.

It is therefore important to evaluate and make development decisions which structurally lead to a more sustainable society.

Conclusion: Sustainable consumption is a universal challenge. Businesses, governments, civil society and consumers all have the power to affect change, sometimes in ways that are not traditionally perceived to be their role. Consumers may feel a moral responsibility to live sustainably, however they cannot do so without effective support from governments, NGOs and the businesses with which they interact. Businesses, governments and civil society must be aligned with these values since they depend on the spending and votes of individuals. There should be certain value shifts within society to allow a more sustainable society and economy including:

From	To
Egocentric (me first)	Altruistic (Others First)
Conservative	Open to change
Indulgent	Frugal
Materialist	Post-materialist
Techno centric (Technology knows best)	Eco centric (nature knows best)
Anthropocentric (human centred)	Bio centric (all species matter)

In this context, the statement of Mahatma Gandhi becomes quite significant: **"The Earth has enough resources for meeting man's need, but not for its greed"**. Therefore, sustainable consumption is both a challenge and an opportunity.

Excerpts from my Valedictory Speech at Rajdhani College on 16th February 2019

---

1 World Commission on Environment and Development (WCED), 1988, p.8.

2 Kirkby J. O' Keefe and Timberlake, L The Earthscan Reader in Sustainable Development, Earthscan , London 1995.

3 Clapp Jennifer and Peter Dauvergne Path to a Green World: The Political Economy of the Global Environment (Academic Foundation, New Delhi, 2008)

4 Jain, Sanjay K. and Gurmeet Kaur, *Review of Commerce Studies*, Delhi School of Economics, University of Delhi, Vol. 22 (Jan-June 2003).

5 WWF Our Living Planet, Geneva, 1998

6 IPCC 4th Assessment Report 2007, http://www.ipcc.ch/ipccreports/ar4-wg1.htm

7 K. K. Khullar, "Globalisation and India", *Employment News*, January 29 - 4 February, 2005.

8 WBCSD, Future Leaders Team Business Role Workstream – Dialogue on Sustainable Consumption in India, 2008.

9 Tukker A Huppes, G Guinee J, et al (2005) Environmental Impact of Products (EIPRO), European Commission joint Research Centre

10 Kapoor Sheetal, "Ethical Consumption", Consumer Voice, March-April, 2004.

[11] Van Dam, Y. K. and Apeldoorn, P. A. C. "Sustainable Marketing", Journal of Macro Marketing, No. 15 (3) , 1995 pp. 55-56.

[12] Commission of the European Communities (2002) CSR; A Business Contribution to Sustainable Development, Brussels, Commission of the European Communities, p.5.