Handbook of

Environmental crisis and its management

Edited by
Dr. Sumit Nandi

Ideal International E-Publication Pvt. Ltd.

Handbook of Environmental crisis and its management

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1st edition
2021

Ideal International E – PublicationPvt. Ltd.
www.isca.co.in

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Title:	**Handbook of Environmental crisis and its management**
Editor(s):	Dr. Sumit Nandi
Edition:	First
Volume:	I

ISBN: 978-93-89817-51-5

Preface

This book highlights the present environmental tribulation throughout the world and the management process to prevent the degradation. The chapters deal with the various sources of degradation methods of our mother nature. It also encompasses issues related to the methods which can be adopted in a bigger way to resolve the crisis. The book unites the global concepts and illustrates an organized orientation towards a comprehensive understanding of the subject matter. This book would be helpful to the students, engineers, scientists, researchers and professionals who are involved in this area of science.

After several months of exhaustive efforts, this book is the final result of all the researchers who devoted their time for the publication of this handbook. It will definitely be a source for enhancing the latest knowledge in this area.

This book would not have been possible without the continuous effort of the contributors for such eloquent chapters and the publisher. I extend my sincere thanks to them. I also extend my gratitude to the JIS family for being a source of support, encouragement and help.

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Editor

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COVID-19

COVID-19 is the name given by the World Health Organisation (WHO) on February 11, 2020 for the disease caused by the novel corona virus SARS-CoV-2, COVID-19 is a serious global infectious disease outbreak with nearly 3,400,000 cases and around 238,000 deaths worldwide. It is part of a family of viruses called corona viruses that infect both animals and people. This particular one originated in China at the end of 2019, in the city of Wuhan. COVID -19 stands for Corona virus disease 2019. Fig. 1 shows the structural views of Caronavirus.

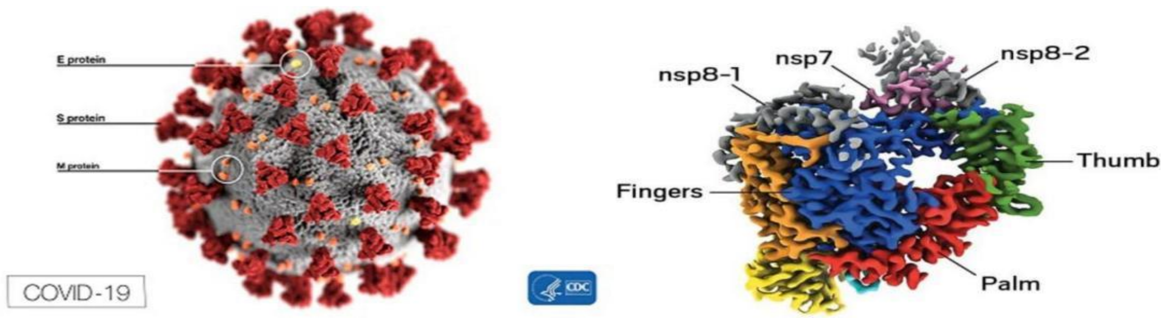


Fig. 1. Structural views of Coronavirus

Why is COVID- 19 so dangerous?

No one is immune: It is a virus that has never been seen in humans, so absolutely no one is immune to it. That added to the fact that it spreads as easily from person to person as influenza through droplets, and infects the upper respiratory system, is what makes it so dangerous. Apart from these, the effectiveness of the vaccines used so far, is not known exactly. As the COVID-19 virus is found in the upper airway — including the mouth and nose — the infection can be spread through coughs, sneezes, huffing and puffing, and likely even loud talking. Moreover, we are learning that infected people are unknowingly spreading the virus days before they begin to experience symptoms. Some may not experience symptoms at all. None of the other diseases caused by corona virus like SARS or MERS spread as easily or widely (1-5). Fig. 2 represents the fatality rate due to Covid-19 compared to normal flue virus.

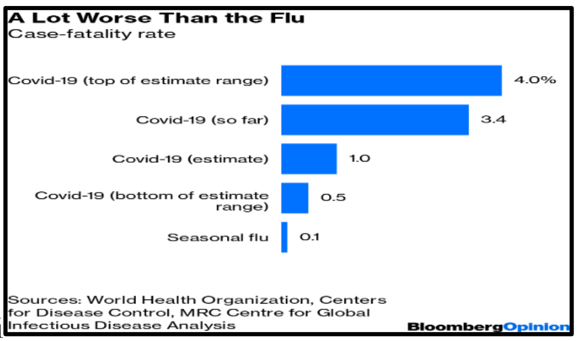


Fig. 2. Fatality rate due to Covid-19

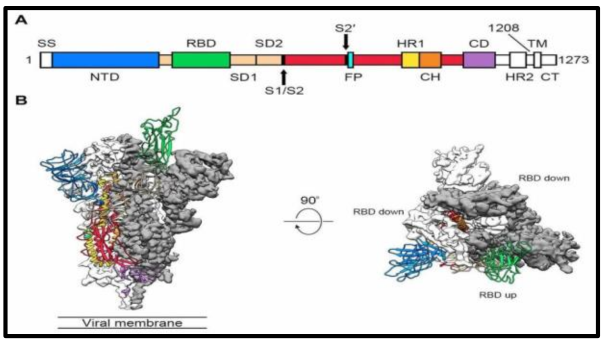


Fig. 3. Structure of 2019-nCoV S in the prefusion conformation

Sticker than SARS-CoV-1: The virus (2019-nCoV S) attaches to the same receptors as SARS-CoV-1, but it is stickier. Fig. 3 represents the structure of 2019-nCoV S in the prefusion conformation. It allows the virus to enter into cells more quickly, get a firmer grasp and begin spreading more quickly throughout the body. This virus also attacks the lower respiratory tract — the bronchial tubes and the lungs — where it can lead to pneumonia. That triggers an inflammatory response as the body attempts to fight the invader. In some people — about 15% — this immune response starts a cyclical overreaction of the body's immune system called a cytokine storm. Cytokine storm also can contribute to coagulopathy [clot formation], kidney damage and heart damage. This is what causing some people to become severely ill or die (6-7).

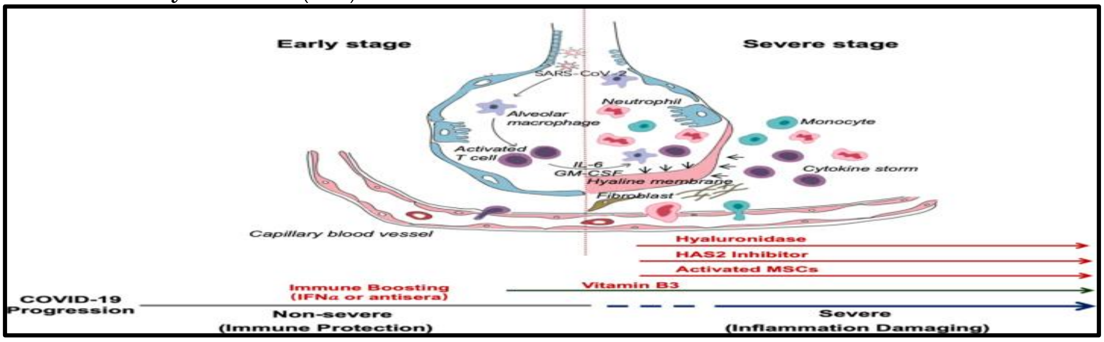


Fig. 4. Schematic representation of the progression of COVID-19 infection and potential adjuvant interventions

Age, Sex and Chronic conditions: Mortality increases with age, with the highest case-fatality rates being observed in people over 70. Obesity and other chronic conditions — such as high blood pressure, diabetes and underlying heart, lung and kidney disease — increase the risk of severe infection. Gender is another risk factor for COVID-19. Men are dying at higher rates than women (8-9).

These are few precautions against COVID-19:

1. Wash hands often with soap and water for at least 20 seconds, especially before eating; and after blowing nose, coughing, or sneezing.
2. If soap and water are not readily available, an alcohol-based hand sanitizer with at least 70% alcohol must be used.
3. We have to avoid touching eyes, nose, and mouth with unwashed hands.
4. We have to avoid close contact with people who are sick.
5. We have to stay home and maintain social distancing.
6. While coughing or sneezing, nose and mouth to be covered with a tissue, then have to throw the tissue in the trash can and wash hands. Clean and disinfect frequently touched objects and surfaces.
7. We have to seek medical attention If we have a fever, a cough, and difficulty breathing in advance.
8. Self-awareness is very important regarding COVID-19.

Fig. 5. Precautions against COVID-19

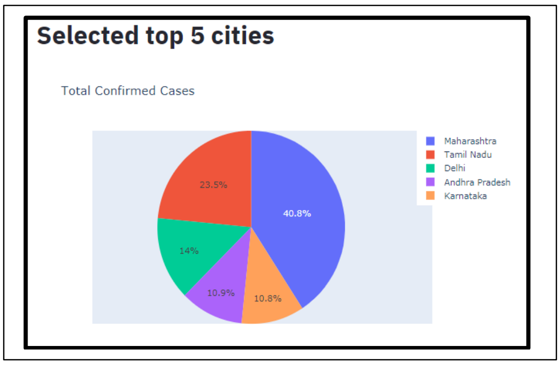
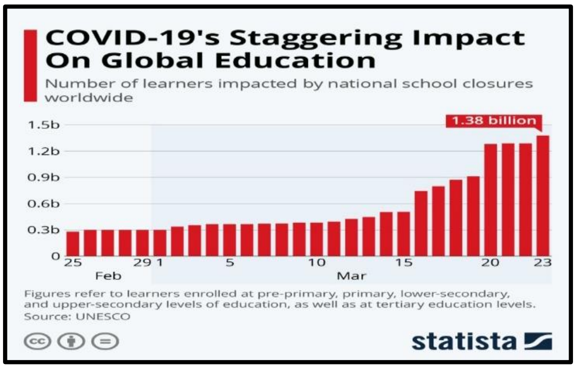


Fig. 6. Scenario in India

Current Global Scenario: COVID-19 is still spreading like wildfire throughout the globe. As of now the total number of confirmed cases of infection is standing at near 153,599,041 and total death count has reached over 3,218,298. The virus has spread over 220 countries /territories affecting every aspect of the socio-economic life of the inhabitants. USA, India, Brazil, France, Italy, New Zealand, Poland and the UK are still implementing the world's largest and most restrictive mass quarantine by putting the country under strict lockdown (10-12). In India, death toll due to the corona virus pandemic rose to 219 K till today while the total number of infections jumped to 19.9 Million including the 16.3 M people who have been treated and discharged so far. Fig. 6 shows the state-wise active cases in India.

Political Scenario: The Ex-US President Donald Trump is criticized for his response to the pandemic. He is accused of making several misleading or false claims, of failing to provide adequate information, and of downplaying the pandemic's significance. Trump is also criticized for having closed down the global health security unit of the United States National Security Council, which was founded to prepare the government for potential pandemics (13). The Government of the Islamic Republic of Iran has been heavily affected by the virus, with at least two dozen members (approximately 10%) of the Iranian legislature being infected, as well as at least 15 other current or former top government officials, including the vice-president. Advisers to Ali Khamenei and Mohammad Javad Zarif have died from the disease (14).



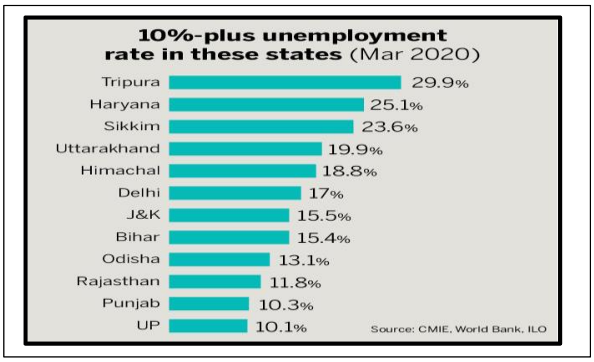


Fig. 7. Effect of COVID-19 on Global education **Fig. 8. Unemployment scenario in India**

A number of provincial-level administrators of the Communist Party of China (CPC) were dismissed over their handling of the quarantine efforts in Central China, a sign of discontent with the political establishment's response to the outbreak in those regions.

Economic Scenario: The International Monetary Fund (IMF) has revised its global GDP growth estimate from 3.3% just 3 months ago to a contraction of 3%, something not seen since the Great Depression of the 1930s. To put this number in perspective, global GDP was estimated at around 86.6 trillion U.S. dollars in 2019 – meaning that just a 0.3 per cent drop in economic growth amounts to almost 3.5 trillion U.S. dollars in lost economic output which is a huge loss.

The Indian economy is expected to lose over 32,000 crore (US$4.5 billion) every day during the first 21-days of complete lockdown which was declared following the corona virus outbreak (15). There is an expectation of rebound of Indian economy in year around 2025.

Global Financial Market Scenario: Economic turmoil associated with the corona virus pandemic has wide-ranging and severe impacts upon financial markets, including stock, bond and commodity (including crude oil and gold) markets. Major events included the Russia–Saudi Arabia oil price war that resulted in a collapse of crude oil prices and a stock market crash in March 2020. Indian market has fared worst among global peers. Indian stock market has lost 26 per cent in dollar terms. China, where the corona virus originated, has been least affected, with just 3 per cent fall in the stock market (16).

Education Scenario: According to data released by UNESCO on 25 March, 2020 school and university closures due to COVID-19 were implemented nationwide in 165 countries (Fig. 7). Including localized closures, this is affecting over 1.5 billion student's worldwide, accounting for 87% of enrolled learners (17).

Entertainment Scenario: The pandemic has impacted the film industry. Across the world and to varying degrees, cinemas have been closed, festivals have been canceled or postponed, and film releases have been moved to future dates. As cinemas closed, the global box office dropped by billions of dollars, while streaming became more popular and the stock of Netflix rose (18).

Science and Technology: The pandemic has impacted productivity of science, space and technology projects, and to the world's leading space agencies - including NASA and the European Space Agency having to halt production of the Space Launch System, James Webb Space Telescope, and put space science probes into hibernation or low power mode.

More than 42.5 million US Dollars have been invested worldwide for research on COVID-19 vaccine. The epidemiology of COVID-19 might differ by geography, and it is likely that effective control of the pandemic will require greater coordination and involvement of the southern hemisphere in vaccine R&D efforts. More than 30 laboratories with over 100 researchers globally are racing towards the generation of a vaccine within a record breaking time of 9 months.India has taken a lead role in this regard (19).

Social Scenario: Recently the World Health Organization issued a report related to mental health and psychosocial issues by addressing instructions and some social considerations during the COVID-19 outbreak. Due to doubts if pets or other livestock may pass on corona virus to humans, many people were reluctant to keep their pets fearing transmission. Recently many countries have reported an increase in domestic violence and intimate partner violence attributed to lockdowns amid the COVID-19 pandemic. Financial insecurity, stress, and uncertainty have led to increased aggression at home. A recent report shows that fear, unemployment and financial factors due to COVID-19 has led to the increase in suicide count worldwide. Fig. 9 shows the social disruption due to COVID-19.

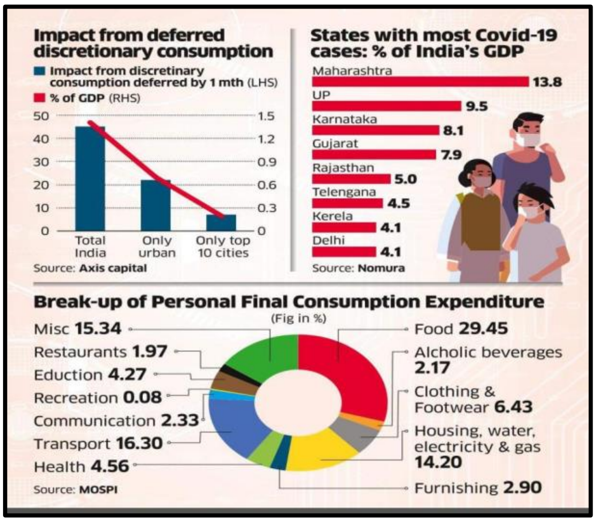


Fig. 9. Social scenario in India

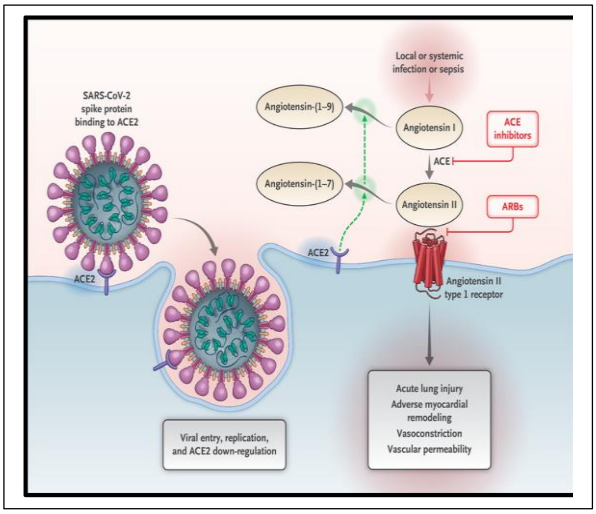


Fig. 10. Interaction between SARS-CoV-2 and Renin–Angiotensin–Aldosterone System

Scientific evidence on COVID-19

Case Study: Renin–Angiotensin–Aldosterone System Inhibitors and Risk of Covid-19 (21).
Background: There is concern about the potential of an increased risk related to medications that act on the renin–angiotensin–aldosterone system in patients exposed to corona virus disease 2019 (Covid-19), because the viral receptor is angiotensin-converting enzyme 2 (ACE2). Fig. 10 describes the interaction between SARS-CoV-2 and the Renin–Angiotensin–Aldosterone System.

Assessments by scientists

It will take years to eradicate Covid-19 virus completely, claim scientists: China's top scientists said the novel corona virus will not be eradicated, joining a growing consensus around the world that the pathogen will likely return in waves likes the flu. It is unlikely for the new virus to disappear the way its close cousin the SARS virus did 17 years ago, as it infects some people without causing obvious symptoms like fever. This group of asymptomatic carriers makes it hard to fully contain transmission as they can spread the virus undetected, a group of Chinese virus and medical researchers told reporters in Beijing at a briefing on Monday.

The virus is unlikely to be eradicated, despite costly lockdowns: A consensus is forming among top researchers and governments worldwide that the virus is unlikely to be eradicated, despite costly lockdowns that have brought much of the global economy to a halt. Some public health experts are calling for the virus to be allowed to spread in a controlled way through younger populations like India's, while countries like Sweden have opted out of strict lockdowns. Fig. 11 shows the different stages of development of vaccines.

Nature of vaccines to be developed against COVID-19: According to the World Health Organization, over 40 different candidate vaccines for COVID-19 are in development. These include an inactivated vaccine being developed in China (Sinovac) using purified COVID-19 virus killed with formaldehyde. A live attenuated vaccine being developed by Codagenix, a U.S.-based company in partnership with the Serum Institute of India (Pune), uses a genetically engineered COVID-19 virus that replicates very poorly. There are multiple other vaccine candidates under development that use DNA, RNA, and viral vector & subunit protein platforms.

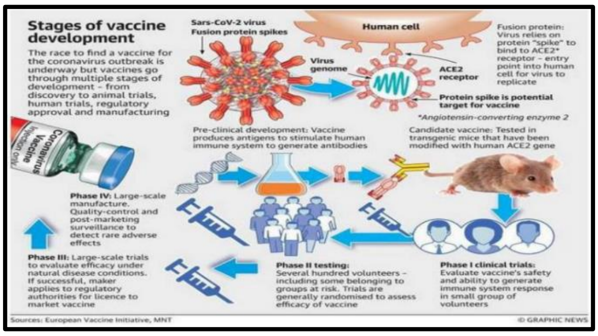
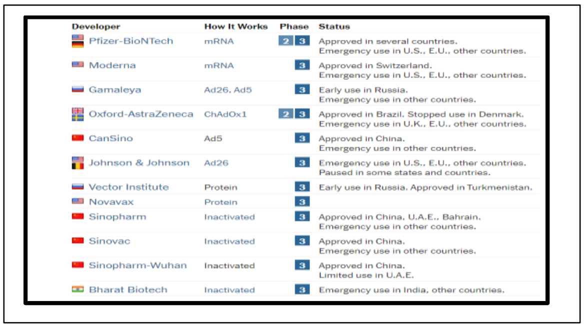


Fig. 11. Stages of development of vaccines



Developer	How It Works	Phase	Status
Pfizer-BioNTech	mRNA	2 3	Approved in several countries. Emergency use in U.S., E.U., other countries.
Moderna	mRNA	3	Approved in Switzerland. Emergency use in U.S., E.U., other countries.
Gamaleya	Ad26, Ad5	3	Early use in Russia. Emergency use in other countries.
Oxford-AstraZeneca	ChAdOx1	2 3	Approved in Brazil. Stopped use in Denmark. Emergency use in U.K., E.U., other countries.
CanSino	Ad5	3	Approved in China. Emergency use in other countries.
Johnson & Johnson	Ad26	3	Emergency use in U.S., E.U., other countries. Paused in some states and countries.
Vector Institute	Protein	3	Early use in Russia. Approved in Turkmenistan.
Novavax	Protein	3	
Sinopharm	Inactivated	3	Approved in China, U.A.E., Bahrain. Emergency use in other countries.
Sinovac	Inactivated	3	Approved in China. Emergency use in other countries.
Sinopharm-Wuhan	Inactivated	3	Approved in China. Limited use in U.A.E.
Bharat Biotech	Inactivated	3	Emergency use in India, other countries.

Fig. 12. List of several approved vaccines

Vaccines against COVID-19: Vaccines typically require years of research and testing before reaching the clinic, but in 2020, scientists embarked on a race to produce safe and effective coronavirus vaccines in record time. Researchers are currently testing 89 vaccines in clinical trials on humans, and 27 have reached the final stages of testing. At least 77 preclinical vaccines are under active investigation in animals. Fig. 12 shows list of few approved vaccines all over the world.

The mRNA-1273 is a piece of RNA that carries the code to make the COVID-19 virus Spike protein when introduced into cells. This protein present on the virus surface is critical for its entry into cells. Immunity (antibodies) to the Spike protein can block virus entry and its multiplication, and thus ameliorate the disease.

Diagnostic test can combat covid-19: One of the achievements of science in the battle against SARS-CoV-2 is the development of the first diagnostic test in less than three weeks from the date of the WHO's announcement of the outbreak in China, back when the virus did not even have a definitive name.

The most widespread tests are based on the detection of the genes of the virus by Polymerase Chain Reaction –PCR. Other tests are also coming on stream with the aim of lowering

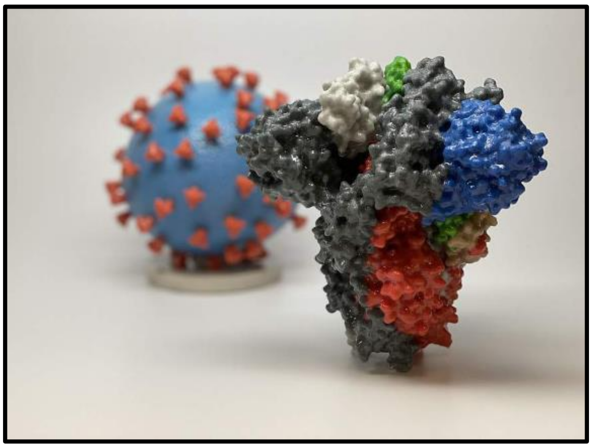


Fig. 13. Action of vaccines on COVID-19 virus

Fig. 14. Robot as helping hand

the cost and speeding up the diagnosis, rapid tests that do not require the samples to be sent to large automated centres, but can be carried out at medical care sites or even at home.

Serological Test: Serological tests, which detect antibodies against the virus in the blood, are particularly important (22). They make it possible not only to diagnose the sick, but also to detect who has recovered from the infection even without symptoms, which experts say will serve to identify people already immune to the virus and to appreciate the true scale of the pandemic. Serological tests have already been used in Singapore and China, and are expected to be available soon for mass use in other countries.

Use of Plasma: Until the new drugs arrive, there are at least two other possible strategies. The first is to use plasma from people who have been infected and have recovered, and whose antibodies can help the ill fight against the virus (23,24). The second is to induce this immunity in animals and extract their serum, a technique invented in the late 19th century. This latter technique is a more rudimentary, though more immediate, version of the use of antibodies explained above, although its effectiveness is not guaranteed.

Scientific tools to fight against covid-19

Drug as a Tool: Drug treatments for COVID-19 are already in the experimental phase, with many clinical trials on going and a number of vaccine candidates under development. Research into blood therapies, including plasma from recovered COVID-19 patients, provides hope for a treatment and possibly a cure. Medical researchers from Rush University Medical Centre in Chicago have discovered that very high levels of a protein known as suPAR (soluble urakinase Plasminogen Activator Receptor) in the blood of individuals with COVID-19 may be a predictor of severe respiratory failure (25). Our research on suPAR and COVID-19 associated lung injury is based on a small sample size, and we will need more data, but the findings support a concept that suPAR is harmful in COVID-19. It may therefore play a prognostic and a causal role in COVID-suPAR (soluble urakinase Plasminogen Activator Receptor)19 associated kidney disease. The FDA said the drugs' risk is manageable when patients are carefully screened and monitored by doctors. A number of studies are testing hydroxychloroquine as a treatment or for prevention of COVID-19. However, the drugs can alter the QT interval, or the time it takes the heart to charge between beats. When that time is too long, it can trigger a rhythm problem that can lead to sudden death.

Robots as a Boon: In the current pandemic situation, robots are being deployed for disinfection, delivering medications and food, measuring vital signs, and assisting border controls. For disease prevention, robot-controlled non-contact ultraviolet (UV) surface disinfection has already been used because COVID-19 spreads not only from person to person via close contact respiratory droplet transfer but also via contaminated surfaces. New generations of large, small, micro-, and swarm robots that are able to continuously work and clean (i.e., not only removing dust but also truly sanitizing/sterilizing all surfaces) could be developed (26).

AI in Medical Field: While several foreign universities are trying to launch a voice-based AI tool for COVID-19 detection, this Indian tool is fully functional and currently in use in Italy to identify COVID-19 patients (Fig. 15). The students have a full-fledged working software with a rich database of patients and healthy samples. This tool is being currently used by the University of Rome to detect COVID-19 patients with 98% accuracy. The tool is being tested by the University of Tor Vergata in Rome and has already been tested on 300 individuals. As someone speaks to the microphone on the app, the tool breaks down the voice in multiple parameters such as frequency and noise distortion. These values are then compared to a normal person's values and the patented technique then determines if the patient is positive or not. A team at the Indian Institute of Science (IISc), Bangalore, is also working on a diagnostic tool based on analysis of cough and respiratory sounds (27).

Fig. 15. AI based virus detection system

Drones Overhead: In some of the severely affected areas, where humans were at a risk of catching the virus, drones came to the rescue (28). Drones were transporting both medical equipment and patient samples, saving time and enhancing the speed of deliveries, while preventing contamination of medical samples. For example, Antwork, a group company of Japanese dronemaker Terra Drone, carried medical samples and other essential materials in Xinchang when the city was grappling with the virus.

Novelty of the chosen tools: It is a saying that "if we can teach a robot to aim a weapon, we can teach it to aim a bottle of disinfectant." It is not likely that specialized masks and respirators, or canned goods and Clorox, will be sufficient to fight a global pandemic. Viral outbreaks like COVID-19 highlight the growing role new medical technology - in particular, ideas from the field of robotics - can play in fighting the spread of novel infectious diseases. health-care experts are focused on more basic automated solutions, like seeing robots perform routine medical work for contagious patients, without replacing or eliminating health-care workers, to free up medical staff so they can spend more time on direct care, as well as reduce risk of their exposure. Hospital beds that can be automated to cycle through a series of positions (e.g., elevate head for X amount of time, then lower and elevate Y) can perform work that is difficult to do for health-care professionals while they are wearing protective gear and focused on higher-priority items. Robots designed for handling bio hazardous waste and decontaminating rooms and ambulances are also ideas born out of an era of increasing experience with pandemic risks.

Autonomous vehicles are a great assert to fight covid-19: Automated warehouses and vehicles can work freely nonstop with no requirement for human-to-human contact, making them ideal solutions for giving delivery services in virus-hit areas. In a climate of social distancing, when on-demand services from Instacart to GrubHub have found a way to limit human contact. Driver-less vehicles don't require a conceivably sick individual in the driver's seat (29). Individuals comprehend in principle that autonomous vehicles will decrease the spread of contamination by taking into account social distancing.

Future Benefits: Extreme cases make us rethink how we do things. The use of technology and the unfathomed research going on in the field of medicines can really bring up a revolution. In future, this know-how will help us in eradicating many diseases. Moreover, it is teaching us that technology is not confined; rather it is limitless and can serve as a boon in the time of distress. This situation is in another perspective, a huge leap of ideas, creativity and utility of resources.

Conclusion

This is indeed a time to think out-of-the-box, in order to find solutions to battle out the pandemic. This is a hard time, a time of grief and confinement. But, it's the hard times that teach us to be happy with whatever we have, to make the best utility of time and resources, to invent something new, to create a better world. Together we can fight this pandemic and lead a normal life once again by following some simple rules and working hand-in hand. Stay at home, and stay safe (30-31). Recently, it is said in a report by Lancet that due to lack of recoverable viral culture samples of SARS-CoV-2 prevents firm conclusions to be drawn about airborne transmission (32). So we have to rethink about the safety measures in a different way. There is a wise saying by Joyce Meyer: Patience is not simply the ability to wait-it is how we behave while we are waiting.

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Use of Nanotechnology for Environmental Sustainability

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Introduction

Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometres, where unique phenomena enable novel applications" [National Nanotechnology Initiative (NNI) 2008]. It deals with manipulating matter at nanoscale. These nanosized particles follow physical and chemical laws which are quite different from the laws applicable for materials in the macroscopic world. Due to enormous surface area to volume ratio, nanoparticles exhibit exclusive properties. It has vast application in industrial sectors like semi conductor technology (e.g., memory, storage, display and optical devices). It has promising application in clean energy production. For example, solar cells, wind, sea, and geothermal energy can produce energy with high efficiency using nanomaterials. In recent times biotechnology and pharmaceutical sectors produce many products like drugs, vaccines and food containing nano materials. In the following sections an effort has been made to discuss how nanotechnology can be used to protect the environment by controlling pollution. This includes treatment, and cleaning up of hazardous waste in order to save human population from extinction. This article also includes an overview of current practice, research findings and probable hazards of nanotechnology.

What do we understand by the term "Pollution"? It has many definitions. One can define pollution as "the presence of a substance in the environment whose chemical composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects" (United States Environmental Protection Agency, 2008). With growing population, pollution has become the biggest environmental challenge. New pollutants are increasing at an alarming rate due to new technological inventions and industrialization. For example, some atmospheric pollutants include toxic gases (nitrogen oxides, sulfur oxides, carbon oxides, ozone, etc.), suspended airborne particles, and volatile organic compounds (VOCs) (1). Soil and water pollutants comprise of pesticides, insecticides, heavy metals (lead, cadmium, arsenic, mercury, etc.), and microbial pathogens. These pollutants enter human body either through inhalation, ingestion, or absorption. Some of these toxicants like heavy metals tend to accumulate in food chains. US National Nanotechnology initiative has identified "Environmental improvement" as one of the eight crosscutting areas of nanotechnology (2,6). Nanotechnology can play an important role in providing new solution for cleaning environment. It can improve conventional technologies by reducing the release of pollutants (3). Pollutants can be automatically degraded by the environment or recycled and converted into another commodity. Nano sensors can help us to detect and to follow the effects of human activities on the environment accurately and quickly (4). If a risk occurs more than its permitted level, nanotechnology solutions can be used to reduce environmental damage (5,6).

Nanotechnology and Solid waste materials

Solid waste materials, produced by human activities are disposed in the environment. Various types of dangerous organic and inorganic pollutants are found in industrial and urban wastes [2]. It is impossible to remove these pollutants by existing technologies. Therefore, modern technologies such as nanotechnology can be used to solve this problem. Some of the nanomaterials used widely in waste management include nano filters, nano sensors, nano photocatalysts, and nanoparticles (7,8,9)

Nano filters in waste management: Toxic and nonbiodegradable materials (arsenic, organic compounds, ammonia, inorganic macro components, heavy metals, etc.) in wastes cannot be eliminated by ordinary chemical processes. Nanofiltration has been applied in waste treatment without any need for chemicals. The produced waste is concentrated and intensive, reducing its transportation and disposal cost (10,11). Applying nano filters can remove 60 to 70% of COD (Chemical Oxygen Demand) and 50% of ammonium in the leachate. Nano filters can be used to remove a wide range of pollutants such as anions and cations, arsenic, uranium, chromium, and pathogens from the wastewater (12). To control the number of deposits on the membrane of filtration, cleaning or replacement of membrane is required and that is expensive. Some compounds such as fullerenes can prevent biological fouling. Bacteria and other microorganisms can also accumulate on the filtering membrane. So, bacteria, other microorganisms and organic materials create an organic film that can block the membranes (13,14,15). Fullerenes can prevent clogging of pipes and filtrating membrane. Coating pipes and membranes with these nanoparticles can be used as a suitable strategy to prevent biological fouling of them (16,17).

Nano photocatalysts and nano porous catalysts: The photocatalyst is a material that causes a chemical reaction in sunlight without being changed. Photocatalysts are not involved directly in oxidation and reduction reactions. Titanium dioxide is an ideal photocatalyst. It produces free radicals in the presence of the three elements - water, oxygen and UV radiation. These radicals can breakdown various harmful compounds into lower toxic carbon compounds (18,19). Having higher surface to volume ratio, titanium dioxide nanoparticles show more photocatalytic properties compared to larger particles. Titanium dioxide is very hydrophilic and can decompose most of the organic contaminants. Therefore, it can absorb heavy metals from wastewater (20,21,22). Porous nano catalysts are used to convert the wastes into ethanol. For this carbon compounds are converted into syngas under high pressure and temperature in a controlled environment. Syngas is converted to ethanol in the presence of porous nano catalysts. Syngas is mainly composed of carbon monoxide, carbon dioxide, hydrogen and methane. Carbon monoxide molecules are producers of ethanol. Nano catalysts improve the absorption of these molecules. Suitable conditions are provided for ethanol formation (23,24,25)

Nanotechnology and air pollution

Due to industrialization harmful air pollutants such as NOx, SOx, CO, etc., are released in environment. The existing procedures for controlling these pollutants have some limitations. Some of them are costly, and some others produce hazardous side materials (26,27). These methods are not able to remove very tiny contaminants from the environment (28,29,30). Nanotechnology can be very useful in this regard. Nano sensors, nano catalysts, nanocomposites, nano filters, and nano biomaterials are used to reduce air pollutants (31,32,33).

Nano structured membrane: Filters are used to control air pollution. A filter has a porous structure where gas is passing, and particles remain in the filter (34,35). The membrane removes particles through three mechanisms, including catching particles in filter structure, applying the inertia force when changing the direction of gas, and electric charge effect of particle and structure of the filter Nano filters have pores between 1 and 10 nm, they can remove different kinds of bacteria, viruses, and organic contaminants effectively (36,37,38).

Membranes using carbon nanotubes have a higher capacity to separate carbon dioxide from the other gases. Carbon nanotubes can trap gases 100 times more effectively than other gas separation technologies (39,40,41). In the case of conventional membranes, the quality of gas separation decreases with the amount of gas passing, while membranes based on carbon nanotubes have no these shortcomings. Nanomembrane technology can be widely used in the separation and purification of gases in industries and preventing their release in the environment.

Catalysts: Nano materials can be used as environmental catalysts in the purification of automobile exhaust gases. Conventional catalysts like ceramic or metal-based catalysts have good efficiency, but they are very expensive (42). So, nanostructured catalysts have been considered as a cheaper alternative for available catalysts (43). Carbon nanotubes are the most appropriate device to adsorb toxic industrial byproducts such as dioxin and other pollutants releasing from chimneys of furnaces (Fig 1). Dioxin contaminates air, soil, water, and living organisms, and is highly stable. Dioxins are carcinogenic and damage the human immune system (44). Though carbon nanotubes very effectively adsorb dioxins, the cost is high. So, research is going on the production of cheap carbon nanotubes. Carbon nanotubes are used in computer displays, reducing the consumption of heavy metals in them.

Nano sensors: These are one of the most important devices to control air pollution. Nano sensors are able to identify and respond to physical stimuli at a nano scale. Nano sensors can be classified into two categories - nanoparticles and nanostructured materials. Nanoparticles can be used as receptors and visual-spatial sensors (Fig. 2) Nano sensors have been constructed from nanomaterials such as porous silicon, which are used to detect chemical and biological reactions (45).

Leakage of toxic gas is one of the biggest risks of the industrial sector. Sensors used in the industry usually detect when the toxic gases are in high concentrations. So faster and more accurate sensors are needed. These sensors are made of a single layer or multilayer nanotubes, to adsorb molecules of toxic gases (46). They can detect very little amounts of molecules of fatal gases. Nano sensors are being designed to identify different types of gaseous compounds, including dioxin, carbon dioxide,

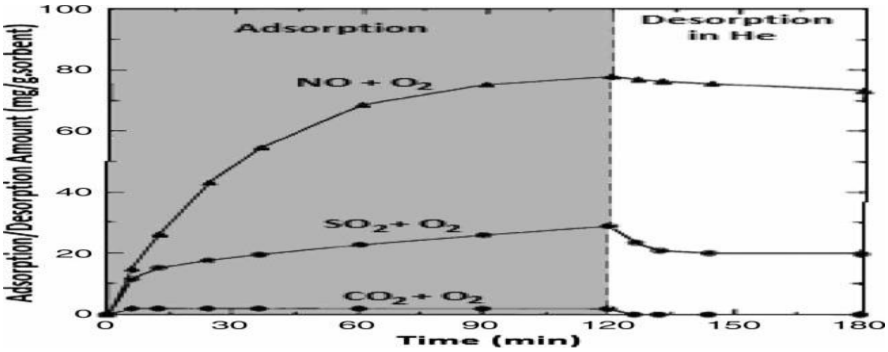

Fig. 1. Adsorption/desorption profile of CO2, NOx, SO2 on carbon nanotubes at 25◦C. (Adapted from R.Q. Long and R.T. Yang, Carbon nanotubes as a superior sorbent for nitrogen oxides, Ind. Eng. Chem. Res. 40 (2001), pp. 4288–4291

sulfur dioxide, nitrogen oxides, and ammonia with higher accuracy and speed than conventional sensors. Examples are nano sensors in the form of smart dust. These ultrafine silicon particles can send the collected data to a central database via wireless in its structure. The data transfer rate is about one Kbps and more in this kind of sensor. These nano sensors can remain suspended in the air easily for hours, and use energy from the sun. Smart dust can transmit data such as temperature, pressure, humidity, the amount of chemicals in the air up to 20 km, and control air pollution continuously in a particular area (47,48).

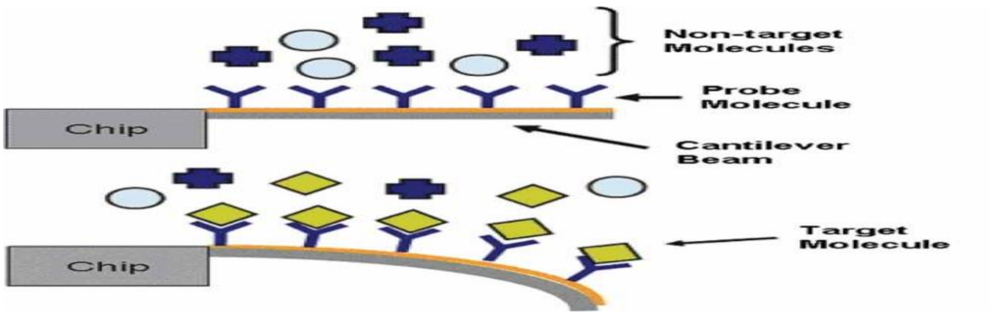

Fig. 2. Schematic diagram of how cantilever-based biosensors work: (a) before and (b) after interaction between target molecule and probe. (Picture courtesy of www.nmji.in)

Nanocoating: Nanostructured coatings with several microns thickness are more efficient than conventional coatings. Nanocoating are used on different surfaces giving them increased chemical, mechanical and thermal resistance, and self-cleaning properties. This reduces consumption energy and detergent. Hence the use of nano coatings reduces the production of pollutants (49).

Nanotechnology for clean water

Only 30% of all water on the Earth is not trapped in the ice or glaciers and only 0.08% of it is clean water. Scarcity of clean water has become an important issue, and it is quite difficult to solve. Nanotechnology methods can be used to improve water quality. These methods use reactive media for separation and filtration, bioremediation and disinfection (50,51). Remediation is the process to remove, minimize or neutralize the pollutants detrimental to human health or environment. There are three categories for remediation process - thermal, physicochemical and biological methods. Methods used in this regard are extraction, adsorption and oxidation. These are less eff ective, expensive and time-consuming. Another method is biological degradation which is inexpensive and environmentally friendly, but very time-consuming. Nanomaterials can be used to enhance affinity, capacity and selectivity for contaminants like heavy metals (52,53). Nanomaterials have properties like higher reactivity, larger surface contact and better disposal capability (54). Some nanomaterials used for remediation of water are zeolites, carbon nanotubes (CNTs), biopolymers, nanoparticles of zero valent iron (ZVI).

Water remediation with iron nanomaterial: One of the systems to remediate water is known as a 'pump and treat' system . The system (Figure 3(a)) first pumps water from the soil to the surface, purifies it and then injects it back into the ground. Until 1998, the pump and treat system was used as a way to remediate water. Another method to remediate water is to use a permeable reactive barrier

(PRB). PRB cleans subsurface groundwater and remediate (Figure 3(b)). This treatment can be used to clean up pollutants such as chlorinated hydrocarbons, aromatic nitro compounds, polychlorinated biphenyls (PCBs), pesticides and chromate compounds The PRB method, has some disadvantages. It is very expensive) and there is no definite time of replacement (55,56,57). Sometimes the reactivity of iron is reduced due to the presence of impurities like metal hydroxide and metal carbonate compounds. Efforts are being made to overcome these weaknesses (58,59). In the 1990s, it was discovered that some zero-valent metals such as iron (ZVI), can be used as a filter material of PBR. This can reduce dangerous contaminants in the water in large quantities (60). 2

ZVI is classified into two types: (1) nanoscale ZVI (nZVI) and (2) reactive nanoscale iron product (RNIP). They are made using the basic techniques of nanotechnology. Nanoscale ZVI (nZVI) particles have a diameter of 100–200 nm composed of zerovalent iron (Fe), whereas RNIP particles consist Fe and Fe_3O_4 of 50/50 in wt%. (61,62) It is found that ZVI is highly reactive to contaminants like Cu^{2+}, chlorinated hydrocarbons, CrO^{2-} and NO^{3-}. Nano-iron can also be used via direct injection into the soil. Once injected, the particles will remain in the form of a suspension and a treatment zone will be formed. Another method is to attach the nanoparticles to a solid matrix like activated carbon. Metals such as zinc and tin have also the ability to reduce contaminants. Two metal alloys such as iron and iron–nickel–copper have been employed to degrade trichloroethene and trichloroethane (63,64). Some commonly used metals are palladium, silver, platinum, cobalt, copper and gold.

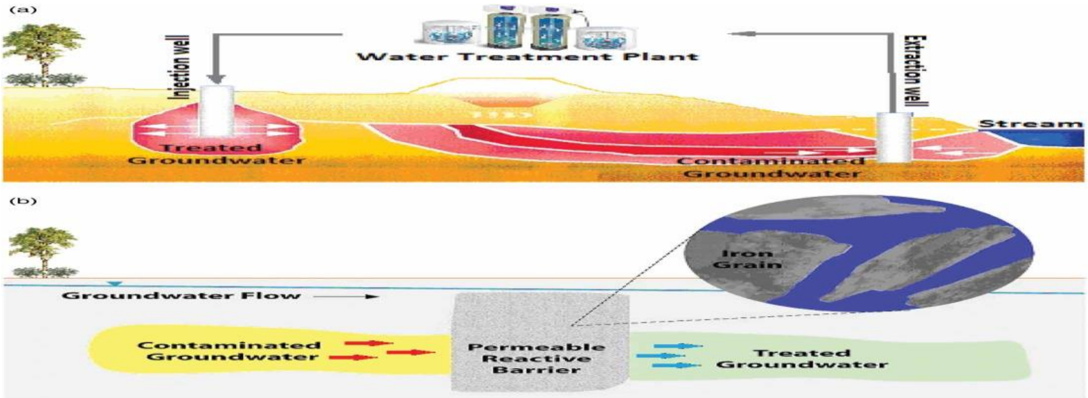

Fig. 3. A schematic diagram of (a) pump and treat system and (b) permeable reactive barrier (PRB) application made with millimeter-sized construction-grade granular iron

Water remediation with ferritin: Ferritin is an iron-containing protein structure found in animals and plants and its function is to store iron. Ferritin is formed when 24 polypeptides form a cage-like protein structure (64,65,66). The iron molecules can enter the cavity through the protein shell. The mineralization process transforms iron molecules into ferrihydrite nanoparticles. Ferritin can remediate toxic metals and chlorocarbon under visible light or solar radiation. The advantages of ferritin over ordinary iron catalyst are: (1) ferritin does not react under photoreduction; and (2) it is also more stable. Another application of ferritin which has been proven in the laboratory is to change chromium Cr (VI) into Cr (III) (67,68). Cr (VI) is a carcinogenic pollutant found in the industrial waste, while Cr (III) is less poisonous and insoluble in water.

Water remediation using polymer nanoparticles: Polymer nanoparticles are used in water treatment. Polymeric nanoparticles have amphiphilic properties like surfactant micelles, where each molecule has hydrophobic and hydrophilic parts. In presence of water, the polymer forms a polymer cell with a diameter of several nanometers inside the hydrophobic part, while the hydrophilic part is outside. Crosslink occurs on polymer nanoparticles before the particles aggregate to maintain their stability. Amphiphilic polyurethane (APU) nanoparticles have good prospects as a remediation agent (69,70).

Bioactive nanoparticles for water disinfection: Nanotechnology can give solutions in cleaning up germs in water. Due to the population explosion, there is growing need for clean water. One of the alter- natives off ered is antimicrobial nanotechnology (71). Several nanomaterials show strong antimicrobial properties through diverse mechanisms, such as (1) photocatalytic production of reactive oxygen species that damage cell components and viruses (e.g. TiO_2, ZnO and fullerol), (2) compromising the bacterial cell envelope (e.g. peptides, chitosan, carboxy fullerene, CNTs, ZnO and silver nanoparticles), (3) interruption of energy transduction (e.g. Ag and aqueous fullerene nanoparticles) and (4) inhibition of enzyme activity and DNA synthesis (e.g. chitosan). Among all materials, TiO_2 has been found to be the best candidate as it is stable in water, nontoxic when ingested and low cost (72).

Nano-fibres and nano-biocides for water purification: Nano-fibres and nano-biocides are used to improve the quality of water filtration membranes (74). Growth of bacteria in water can be inhibited by the surface-modified nano-fibres. Polyvinyl alcohol (PVA) and polyacrylonitrile (PAN) nano-fibres containing silver nanoparticles have excellent antimicrobial activity, PVA nano-fibres can reduce bacteria between 91% and 99% in a contaminated water sample and PAN nano-fibres kill 100%. PVA is a non- toxic and biodegradable synthetic polymer and PVA–silver nanofibres show excellant antimicrobial activity (75).

Nanofiltration: Nanofiltration membranes reject multivalent ions, pesticides and heavy metals more efficiently compared to conventional treatment methods. This technology has become the most cutting-edge technology in water treatment and is now available for practical use at home, business or manufacturing sectors. Depending on the requirement, nanofiltration membranes can be manufactured to target diff erent molecules based on their molecular weight. As an example, Dow Filtec off ers a nanofiltration membrane with the capability to remove molecules higher than 90, 200 or 270 g/mol (73,74,75).

Green manufacturing

All manufacturing processes produce a wide range of wastes harmful to the environment. An environment-friendly manufacturing process should use minimum raw materials. It should also minimize waste production and energy consumption. The method to achieve these goals is called Green manufacturing. Green manufacturing aims at the development of industrial processes (e.g., water-based processes replace organic solvent-based processes). Hazardous substances, i.e., metals, are used in less quantities. Green chemicals are produced which are less harmful to the environment. An example of green nanotechnology is the development of microemulsions (aqueous) as an alternative to VOCs in the cleaning industry. Toxic and carcinogenic compounds, such as chloroform, hexane and perchloroethylene, are used in textile, cleaning and many other industries. Microemulsions containing nano-sized aggregates can be used as receptors for the extraction of specific molecules at the nanoscale level. Scientists have synthesized a microemulsion that becomes the connector between water- attractive and water-repellent substances. The microemulsion is able to clean textiles from oil and is very competitive to the conventional cleaning compounds (76,77,78)

Risk of nanotechnology

Although nanotechnology offers solution to many problems, it may also have adverse eff ects on human health and the environment. Materials that are harmless in bulk forms can become highly toxic at the nanoscale; the inhalation of airborne nanoparticles cause lung disease. CNTs like asbestos particles, if inhaled in sufficient quantities cause lung cancer. The behaviour of nanoparticles in humans and the environment is not still properly understood. Many international organizations, such as the Royal Commission on Environmental Pollution (RCEP) and European Union, are aware about the toxicity and potential health risks of nanomaterials (54).

IITs in India are trying to provide clean water where drinking water is scarce: Some leading Indian Institutes of Technology (IITs) are taking the initiative to provide clean water with the help of science and innovation in places where clean drinking water was not available easily. This effort has been made with the encouragement and vision of the Union Ministry of Science and Technology.

IIT Delhi technologies in water purification (https://fitt-iitd.in/wp-content/uploads/2020/05/IIT-Delhi-Technologies-in-water-purfication.pdf)

IIT Delhi has the following technologies on water purification.

1. MYCO-Capsules for Bio remediation of waste water and Method for preparation of myco-tablets for bioremediation and myco-tablets thereof
2. A polyacrylonitrile ultrafiltration membrane for removal of arsenic and chromium.
3. PVA supported resins for arsenic separation and product thereof
4. An apparatus and a process for removal of arsenic
5. Recyclable Smart Mesh for on Demand Separation of Oily Water
6. A nano-adsorbent for removal of Lanthanide ions from water and associated methods.

7. Polyelectrolyte gels for sorption of crude oil and its emulsions with sea water and deionized water and its process thereof
8. An apparatus and method for mobile-phone based water purification
9. Antimicrobial non-woven fabric for safe water filtration
10. Water purification system

IIT KGP Faculty Makes Purified Drinking Water Available for Rs. 1 (A newspaper report) [https://kgpchronicle.iitkgp.ac.in/iit-kgp-faculty-makes-purified-drinking-water-available-for-rs-1/]

Faculty from IIT KGP has developed a model for purified drinking water supply, costing Rs. 1 per family per day, for a village in Southern Bengal. Dr. Somnath Ghosal from the Rural Development Centre of IIT Kharagpur has involved participatory management offering villagers access to purified drinking water in a sustainable manner, using Water Cards, Water ATM Vending Machine, etc. The unique set-up has been built in the Porapara village in West Midnapore district of Bengal. He has installed a fully automated multi filtered UV treated drinking water facility which can provide close to 1000 litres of purified drinking water to 60 families every day at Rs. 1 per family. While the land was freely provided by the villages, IIT KGP helped built the required infrastructure and water purification technologies and funded the entire project]

Conclusion

Nanotechnology has been developed to save environment and human life. Technologies have been developed to replace the conventional technologies. The water purification process using nanotechnology can use iron nanoparticles, ferritin, polymeric nanoparticles, nano fibres, nano biocides, nano enzymes and nano filtration techniques. Nano technology can also be applied to clean the air from toxic gases such as CO, VOCs and dioxins using CNTs, gold nanoparticles and other adsorbents. Nanoparticles and nanotubes can also be applied as a sensor for toxic substances that are difficult to detect with conventional technology due to their small size and concentration. Nanotechnology can also be useful to prevent the creation of pollutants. Its applications include the synthesis of green materials to prevent the release of hazardous substances into the environment. Although nanotechnology has entered in the field of Green technology, more research is needed to assess its risk. This is in accordance with the principle that the more sophisticated the technologies, the greater the risks they pose.

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Present environmental crisis and its management using nanotechnology

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Introduction

Coronavirus disease 2019 (COVID-19) is a communicable disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It absolutely was first identified in December 2019 in Wuhan, the capital of China's Hubei province, and has since spread globally, resulting in an ongoing pandemic. As of two May 2021, over 152,829,820cases have been reported across 220 countries and territories, resulting in more than 3,206,849 deaths. Approximately, 130,114,682 people have recovered (1).

A pneumonia of unknown cause detected in Wuhan, China was first reported to the WHO Country Office in China on 31 December 2019. WHO is functioning 24/7 to analyse data, provide advice, coordinate with partners, help countries prepare, increase supplies and manage expert networks. The outbreak was declared a Public Health Emergency of International Concern on 30 January 2020. On 11 February 2020, WHO announced a reputation for the new corona virus disease: COVID-19.

The current global crisis of the COVID-19 pandemic has rapidly increased the demand for face masks, with one commonly available mask (N95) filtering out around 95% of fine dust particles. However, these sorts of masks include certain limitations with respect to reusability. Research teams across the planet have developed reusable, nanotechnology-based face masks for increased safety from virus particles.

Nanomaterials are chemical substances or materials that are manufactured and used at a very small scale (2). Nanomaterials usually exhibit novel characteristics compared to the identical material without nanoscale features, like increased strength, chemical reactivity or conductivity. Generally, materials with any external dimension within the nanoscale (1 to 100 nm) or having internal structure or surface structure within the nanoscale. During this scale, the materials' properties change significantly from those at larger scales. This is often called as quantum effects rule the behaviour and properties of particles. Properties of materials are size-dependent during this scale range. Thus, when particle size is made to be in the nanoscale, properties like melting point, fluorescence, electrical conductivity, magnetic permeability, and chemical reactivity change as a function of the size of the particle (3-9). Nano-scale materials have far larger surface areas than similar masses of larger-scale materials. Gold-based nanomaterials have a large amount of potential exciting medical applications as they will be accustomed transport drugs to particular parts of the body or maybe help detect cancer. Hemoglobin, the protein that carries oxygen through the body, is 5.5 nanometers in diameter. A strand of DNA, one among the building blocks of human life, is barely about 2 nanometers in diameter.

Classification of the nanomaterials: Nanomaterials can generally be classified into three categories: 1D nanomaterials (thin wire, tubes, rods), 2D nanomaterials (2D nanostructured films, nanofilms, graphene, nanolayers) and 3D nanomaterials (bulk powers, dispersions, colloids, fibres). When the scale or dimension of a fabric is reduced continuously from an oversized or macroscopic size, like a metre or cm, to a really small size, the properties remain the identical initially, so changes begin to occur, until finally when the scale drops below 100 nm, dramatic changes in properties can occur.

If one dimension is reduced to nanoscale, then we get QUANTUM WELL
If two dimensions are reduced to nanoscale, then we get QUANTUM WIRE
If all the size are reduced to nanoscale, then we get QUANTUM DOT

Quantum confinement effect-an overview: The most popular term within the nano world is quantum confinement effect which is basically because of changes within the atomic structure as a results of direct influence of ultra-small length scale on the energy band structure. The length scale corresponds to the regime of quantum confinement ranges from 1 to 25 nm for typical semiconductor groups of IV, III-V and II-VI. Here the spatial extent of the electronic wave function is comparable the particle size. As a results of those "geometrical" constraints, electrons "feel" the presence of the particle boundaries and reply to changes in particle size by adjusting their energy. This phenomenon is thought because the quantum-size effect. Classification of quantum confined structures is shown in Table 1.

Table 1: Classification of quantum confined structures

Structure	Quantum Confinement	Number of free dimensions
Bulk	0	3
Quantum Well/ Superlattices	1	2
Quantum Wire	2	1
Quantum Dot/ Nanocrystals	3	0

Quantum well may be a thin layer which may confine (quasi-) particles (typically electrons or holes) within the dimension perpendicular to the layer surface, whereas the movement within the other dimensions isn't restricted.

On the other hand, if the diameter of a wire is sufficiently small (in the nano scale), electrons will experience quantum confinement within the transverse direction. As a result, their transverse energy are going to be limited to a series of discrete values.

A quantum dot is a semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons (bound pairs of conduction band electrons and valence band holes) altogether three spatial directions.

Protection from COVID-19 using masks

Problems with normal mask: The current global crisis of the COVID-19 pandemic has rapidly increased the demand for face masks, with one commonly available mask (N95) filtering out around 95% of fine dust particles. However, these types of masks come with certain limitations with regard to reusability. Research teams across the world have developed reusable, nanotechnology-based face masks for increased safety from virus particles.

A mask prepared from a normal piece of cloth cannot really protect people from coming into contact with a virus that may measure only 50 nanometres. The scientist found that a typical cloth mask might only block as little as 50% of the viruses being exhaled. Typical N95 masks use polypropylene microfibers, which are orders of magnitude thicker.

Advantage of using mask prepared from nanofibre membrane: Nanotechnology researchers have given a breakthrough by developing a nanofibre membrane that can be inserted between the material of even homemade masks that reduces the risk of infection. The new design of mask can block 90 to 99% of virus particles, while still allowing the wearer to breathe easily. The membranes are made through a process called 'electrospinning,' which involves dissolving a polymer plastic in a solution then using an electrical current to move a droplet of the **polymer** downward through a needle. As the droplet accelerates, it stretches into a really small fibre that retains a static charge. A liquid polymer being stretched to make nanofibers. These nanofibers randomly landed on a collector create a sort of non-woven mesh. As virus particles also carry their own static charge, they are naturally drawn towards the charge within the fibres. When they come close to a mask, they will be statically attracted to the mask and will not be able to go through it, and so it prevents us from inhaling viruses. the new mask insert allows for a smoother flow of filtered air, while also aiding moisture and heat to escape, making the mask far more comfortable. It is the demand that nanofiber membranes are six times easier to breathe through than existing N95 masks, making them cooler, drier, and more comfortable. Recently, scientists developed a method of embedding nanoparticles of copper, zinc, silver, gold, and cerium into a natural and man-made fibres that develops the anti-viral and anti-bacterial properties in it. The nanotechnology process are often applied to a variety of fibres, both natural and man-made, meaning that even strong durable textiles are often used.

Electrospinning uses strong electric fields to stretch polymer solutions or droplets into extremely thin fibers, typically between 15 and 300 nm in diameter. Most nanofiber masks are also made of polypropylene, but electrospinning allows for additional variety and hence researchers are are looking into greener materials such as cellulose acetate or urethane from renewable carbon. Moreover, masks prepared by nanofiber membranes can effectively filter the most penetrating aerosol particles. Hence, some 4C nanofiber masks have been tested by the US National Institute for Occupational Safety and Health and received the N95 certification—meaning they filter at least 95% of airborne particles. It is also found that nanofibers also make masks more comfortable as they allow more air to pass with the same filtration efficiency. The main reason for this is physics—specifically, the resistance that the air meets when flowing through the mask, commonly referred to as pressure drop.

Usually, the higher the filtration efficiency, the higher the pressure drop, which makes the foremost secure masks, like N95s, less breathable. However, pressure drop is inversely proportional to the surface area of filter fibers, which is a plus point for nanofibers. In cases of normal N95 masks th usual pressure drop is over 100 pascals but for nanofiber membrane masks reduce that resistance (I.e., pressure drop) by up to 60% and so the breathability is incredible. Apart from enhanced breathability, nanofibers dissipate humidity and heat better than traditional fabrics

A mask prepared from a normal piece of cloth cannot really protect people from coming into contact with a virus that may measure only 50 nanometres. The scientist found that a standard cloth mask might only block as little as 50% of the viruses being exhaled. Typical N95 masks use polypropylene microfibers, which are orders of magnitude thicker.

Water droplets created by condensation can dissipate the static charges on the nanofibers and make them less effective filters. Long-lasting charge makes for long-lasting masks, It is said that for regular use, we can probably wear our masks for 2 weeks without losing any efficiency.

How to combat COVID-19 using drugs: The effectiveness of conventional treatments against viral infections progressively fades away because of viral mutations and emergence of new viral strains (10). Recently, the development of broad-spectrum antiviral drugs has caught the attention of researchers, as these drugs could be used against several types of viruses, including new strains (11).To overcome the limitations and to improve antiviral treatments, multidisciplinary research efforts are required toward the development of alternative antiviral therapies, targeting different phases in the viral replication cycle (12, 13). In this regard, nanotechnology has attracted increasing attention and has already established as the potential remedial alternative in prevention and/or treatment of viral infections (14-16). Use of nano--based formulations of drug has indicated a great potential for the control of viral infections, where nanoparticles can both enhance the efficiency of an antiviral drug and also reduce its toxicity (17-20). Nanotechnology has also been used to increase the efficacy of antiviral drugs by overcoming their low bioavailability. Nanomaterials in the form of nanogels can capture the viable virus particles or viral RNA/proteins that can help in the fight against SARS CoV2 (21, 22). The main goal of future research of nanobased antiviral therapies will be the development of nano based formulations that can successfully target precise sites of viral infection (e.g. the respiratory system in the case of COVID 19), reduce drug toxicity in other tissues, and potentially have some intrinsic antiviral activity of its own.

Nanoparticles can act as carrier systems for clustered regularly interspaced short palindromic repeats (CRISPR): CRISPR is a gene editing technique to be used in gene therapy with high precision and potential. Mainly, CRISPR/Cas9 are inserted into the cells in the form of plasmids, mRNA or ribonucleotide proteins, which may be employed by nanocarrier systems to extend the transfection of cells (23, 24).

Conclusion

Nanotechnology applications are to be addressed to facilitate its broader implementation within the wider healthcare system. One of the main challenges is to make sure the safe use of nanomaterials, since most of the studies have only evaluated the biocompatibility using in vitro approaches. The fate and behaviour of nanomaterials in the body can also change when they reach blood circulation due to the formation of protein corona (25, 26). To overcome the above mentioned hurdles, a closer collaboration between regulatory agencies, scientific experts in material science, pharmacology and toxicology is needed. Capacity for largescale manufacturing is another hurdle that needs to be overcome for broader commercialization of nanobased formulations Research and development using innovative methods, such as nanotechnology, is essential to end this pandemic effectively in a short time. Various treatments using nanotechnology are developed and commercialized for common viral infections. The accumulated advancements in these virus fighting nanotechnologies can play an important role in taking SARSCoV2 treatment and vaccine development to the next level. The tedious COVID 19 pandemic, which has not yet been put to finish, is now moving in the direction of overcoming the virus in a step-by-step fashion with the help of Nano medicine. Currently, several companies are moving away from traditional SARSCoV2 treatment and prevention strategies and using nanotechnology to develop various types of masks, vaccines and therapeutics and conduct clinical evaluations. This will make it possible to supply and transform knowledge into products, which, additionally to combating the present pandemic, also will provide means for prevention of future.

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Numerical Weather Prediction

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Introduction

In World War II radar was used as reliable source of military information. Radar Engineers noticed echoes on the screen during the war. These echoes were due to the atmospheric conditions. After the war, radar estimation and prediction of weather was the great point of research. Hydrological modelling and numerical weather prediction have started using radar data. Now a days due to the advancement in the technology, the radar data is used in long-term and short-term weather prediction. The microphysical properties (1-7) of cloud are studied with the help of weather radar. The hydrological modeling and numerical weather prediction (NWP) with the help of weather radar has started in late 20th century. In the beginning of its invention the measurement with the help of radar was thought to be accurate but it is proved that sometimes the error is very large (8-10). Errors are due to the nature of the measurement and meteorological conditions. The radar is referred as a semi-quantitative measurement device (11-12) in spite of that the information of the radar is highly valuable. The real-time coverage and availability of the data is the main cause of its day-to-day increased use in prediction of weather. The accurate measurement and prediction of the spatial and temporal distribution of rainfall is a basic need in hydrology as it is the main source of water. The ground-based weather radar is used for the assessment of storm hazard and flood forecasting, warning, and control. The spatial and temporal variability of rainfall is the topic of research due to the growing attention in the terrestrial hydrological processes in the climate system. Now a days the atmospheric mesoscale models and general circulation models of rainfall parameterizations are verified using ground-based weather radar system. The quantitative precipitation estimation (QPE) (11) issue is not solved till now.

Techniques for atmospheric parameters

The exact estimation depends on scan strategy and data processing. The radar data is used for hydrological applications (13-20). The rainfall estimation quality depends on precipitation type. The classification of precipitation type by radar is done using dual polarization or dual wavelength methods. These methods are limited to research experiments. The precipitation type information is collected from some other sources like surface and/or upper air observations or NWP models by some of the modern forecasting system rather than weather radar.

Measurement of precipitation

The precipitation measurement using radar is based on some basic principles (21-24). Weather radar is used for rainfall estimation (25-27). In radar different information are achieved by rotating an antenna with a variable vertical angle using suitable calibration. The radar antenna sends out a short pulse of e. m. radiation in a particular direction. A small part of this energy is reflected back by precipitating particles to radar antenna (28). The back-scattered average power received by the radar is proportional to the reflectivity factor Z (provided the scattering particles are considerably smaller than the wavelength and are of spherical in shape) and to the factor $|K|^2 = \left|\frac{m^2-1}{m^2+2}\right|^2$, which is a function of complex refractivity index m and thus dielectric constant of the target (29). The received power is also proportional to the radar constant C which includes the emitted power. It is again inversely proportional to the square of the distance of the target r^2 and the square of the one-way atmospheric attenuation i.e; L^2_{Atm} . The radar eq^n. can be given as

$$\overline{P_r} = \frac{C|K|^2 Z}{L^2_{Atm} r^2} \quad (1.1)$$

The radar properties like emitted power, pulse length, 3-dB beam shape, antenna gain and attenuation of the radar hardware are contained in radar constant. The radome distortion of beam is calibrated regularly or in most cases it is neglected. The average value of $|K|^2$ for water is 0.93 and for ice it is 0.18. The radar constant *C* gives all radar properties while all raindrop properties are given by $|K|^2$ and *Z*. The radar reflectivity factor Z (30-32) is obtained from,

$$Z = \sum_{i=1}^{\infty} N_i D_i^6 = \int_0^{\infty} N_v(D) D^6 dD \quad (1.2)$$

where N_i is the number of drops in a unit volume of air with diameter D_i and $N_v(D)$ is the number of drops having diameter between *D* and *(D+dD)*. The radar reflectivity factor (*Z*) is a meteorological quantity and does not depend on radar properties. Due to the variation of radar reflectivity to several orders, it is measured in logarithmic unit as logarithmic radar reflectivity 10log *Z*. The exact measurement with radar requires some specified assumptions like physical properties of the target, beam filling with the randomly scattered precipitation particles, the factor Z through the sample volume (33). In actual these properties are hard to meet. To resolve this issue the concept of effective (or equivalent) radar reflectivity *Ze* is introduced.

Raindrop size distributions and rain rate – reflectivity relations

The radar reflectivity is measured at a height above the ground and the rain rates are measured at the ground. This creates the observer's problem which influences the prediction of rainfall using weather radar systems (34-39). The spatial and temporal distribution of the average power received $\overline{P_r}$ is estimated using equation (1.1). Hence radar reflectivity factor *Z* can be written as

$$Z = \frac{r^2 L^2_{Atm} \overline{P_r}}{|K|^2 C} \quad (1.3)$$

If there is no vertical air motion, then rate of rainfall is expressed as

$$R = 6\pi \times 10^{-4} \int_0^{\infty} {}^3 Dv(D) N_v(D) dD \quad (1.4)$$

Where *D* denotes the equivalent spherical raindrop diameter and $v(D)$ gives the functional relationship between the raindrop terminal velocity (*v*) in still air. The popular form of *v(D)*(40) is

$$v(D) = cD^y \quad (1.5)$$

If we take $c = 3.778$ (*v* and *D* are respectively in *m* s^{-1} and in mm) and $\gamma = 0.6$, then it is in close agreement with data of Gunn and Kinzer (41) in the range of $0.5 \le D \le 5.0$ mm. Numerous relations of *R* [33-37] for *v(D)* are derived by different researchers, but the power law form of the *v (D)* is used as it is consistent with power law relationships between rainfall-related variables, specifically between *Z* and *R*. The reflectivity-rain rate (*Z-R*) relationships (42-53) are specifically used for estimation of rate of rainfall using radar.

A close scrutiny of Eq^n. (1.2) and Eq^n. (1.4) reveals that it is the raindrop size distribution $N_v(D)$ which relates *Z* to *R* [54-62]. Due to that the raindrop size distributions and corresponding $Z-R$ relations have found the attention of hydrologists. The vertical profile of reflectivity gives the value of *Z* aloft and *Z* at the ground surface. The height of the radar beam above the ground is small in the vicinity of radar; hence one can neglect the difference between *Z* aloft and *Z* at the ground. The rainfall cannot be estimated properly using radar because these

Z-R relations are not unique and they depend on types of precipitation, season etc. Moreover, if it is unique, it is hardly known. The $Z-R$ relationships derived by measuring raindrop size distributions at the ground is given by eq^n. (1.5).

Eq^n. (1.5) follows the power law relations as $z = aR^b$ (1.6)

The prefactor *a* and exponent *b* depends on place and season. These coefficients does not depend on rate of rainfall. Coefficients *a* and *b* provides the idea of some of the climatological quantities (52) like the type of rainfall (e.g. stratiform, convective, orographic). Standard treatise on radar meteorology quotes a list of 69 of such empirical power law $Z-R$ relationships derived for different climatic settings in various parts of the world. Based on different climatic conditions Battan quoted a list of 69 empirical $Z-R$ relations. The geometric mean of *a* and the arithmetic mean of the *b* gives the logZ-logR relationships, which is given by

$$Z = 238R^{1.5} \quad (1.7)$$

Comparing this relation with Marshall-Palmer $Z-R$ relations,

$$Z = 200R^{1.6} \quad (1.8)$$

Eq^n. (1.8) gives the best result for rain rates between 1-50 mm h^{-1}. This is the reason for the great success of Marshall-Palmer $Z-R$ relationship for different types of rainfall in many parts of the world, even though the Marshall-Palmer $Z-R$ relationship is derived by measuring the raindrop size distributions in Montreal, Canada, mainly in stratiform precipitation.

Out of 69 $Z-R$ relations proposed by Battan 25 can be used for different types of rainfall estimation whereas 44 relations can't be associated with any type of rainfall (56-57). The physical interpretation of prefactor and exponent in terms of the raindrop size distributions parameters justify their variability.

Scaling law for the raindrop size distribution

It is revealed in numerous studies that the raindrop size distributions are special cases of a general formulation (53-62). This formulation considers the raindrop diameter (*D*) and the reference variable both for the determination of the raindrop size distribution, which in terms give the rain rate (*R*). The beauty of this formulation is - we need not to impose an apriori functional form of the raindrop size distribution.

Using the scaling law formalism (53-62), raindrop size distributions is given as

$$N_v(D,R) = R^{\alpha} g(D/R^{\beta}) \quad (1.9)$$

where $N_v(D,R)$ (m^{-3} mm^{-1}) represents the raindrop size distribution which depends on raindrop diameter D (mm) and the rain rate R (mm h^{-1}), α and β are scaling exponents and $g(x)$ is the general raindrop size distribution as a function of the scaled raindrop diameter $x = D/R^{\beta}$. The quantity R is always taken as reference variable. In this formulation α and β and dimensions of g(x) depends on the choice of the reference variable. The scaling law provides an interpretation of the coefficients of $Z-R$ relationships in terms of the scaling exponents and the shape of the raindrop size distribution. Using Eq^n. (1.9) in Eq^n. (1.2) gives Eq^n. (1.6) provided,

$$a = \int_0^{\infty} x^6 g(x) dx \quad (1.10)$$

and $b = \alpha + 7\beta$ (1.11)

So, it is evident from Eq^n. (1.10) and Eq^n. (1.11) that the coefficient *a* in $Z-R$ relations are given by the shape of the general raindrop size distribution whereas a linear combination of the values of the scaling exponents gives the coefficient *b*. Not only that with the help of scaling law formalism we can derive the relation between other pair of rainfall integral variables. Substitution of Eq^n. (1.9) in Eq^n. (1.4) leads to the constraints (53-62)

$$6\pi \times 10^{-4} \int_0^{\infty} x^{3+\gamma} g(x) dx = 1 \quad (1.12)$$

and $\alpha + (4+\gamma)\beta = 1$ (1.13)

Using Eq^n. (1.13) in Eq^n. (1.11), we get

$$b = 1 + (3 - \gamma)\beta \qquad (1.14)$$

Eq^n. (1.14) contains the scaling exponent β . If we take γ =0.67 in Eq^n. (1.14), then we get,

$$b = 1 + 2.33\,\beta\,. \qquad (1.15)$$

So, we can express b in terms scaling exponents.
Let the general raindrop size distribution as

$$g(x) = \kappa \exp(-\lambda x) \qquad (1.16)$$

On substitution of Eq^n. (1.16) in Eq^n. (1.12), we get,

$$\kappa = [6\pi \times 10^{-4} c\Gamma(4+\gamma]^{-1} \lambda^{4+\gamma} \qquad (1.17)$$

Eq^n. (1.17) an equivalent power law relationship of λ in terms of κ [40]. This is an explicit form of the constraint on g(x) for the special case of an exponential parameterization.

Taking c = 3.778 and γ = 0.67, Eq^n (1.16) yields, $\kappa = 9.50\lambda^{4.67}$. Thus, the self-consistency constraint on g(x) reduces its number of free parameters by one. The two parameters of g(x) in Eq^n. (1.16) reduces to one. A close scrutiny of the Eq^n. (1.13) and Eq^n. (1.17) reveals that

Eq^n. (1.13) is a relation between the scaling exponents α and β and Eq^n. (1.16) is a relation between c and γ . Therefore, we conclude that only two parameters are required to describe the scaling law or any power law relationship (53 – 54) between rainfall-related variables like $Z-R$ relationships for the special case of an exponential parameterization for g(x). Eq^n. (1.17) may be developed for any other functional form for the general raindrop size distribution, viz. the gamma and lognormal parameterizations.

Using Eq^n. (1.16) in Eq^n. (1.10), we get,

$$a = \Gamma(7)\kappa\lambda^{-7} \qquad (1.18)$$

Eq^n. (1.18) is a general expression for a (pre factors) of power law $Z-R$ relationships for the special case of an exponential parameterization for g(x).
Substituting Eq^n. (1.17) in Eq^n. (1.18), we find,

$$a = \Gamma(7)[6\pi \times 10^{-4} c\Gamma(4+\gamma)]^{-1} \lambda^{-(3-\gamma)} \qquad (1.19)$$

Eq^n. (1.19) is a power law relation of a in terms of λ . This equation complements Eq^n. (1.14), they together form a consistent pair of relationships for the estimation of the a and b of power law $Z-R$ relationships in terms of the parameters of the exponential raindrop size distribution. If we take c=3.778 and γ = 0.67 [40], Eq^n. (1.19) reduces to

$$a = 6.84 \times 10^{3} \lambda^{-2.33} \qquad (1.20)$$

Now we want to establish a link between scaling law formalism and the classical exponential parameterization.
Substituting Eq^n.(1.16) into Eq^n. (1.9), we get,

$$N_v(D,R) = \kappa R^{\alpha} \exp(-\lambda R^{-\beta} D) \qquad (1.21)$$

If we put,

$$N_0 = \kappa R^{\alpha} \qquad (1.22) \qquad \text{and } \Lambda = \lambda R^{-\beta} \qquad (1.23)$$

in Eq^n. (1.19), we find that it reduces to the classical exponential parameterization for the raindrop size distribution for the special case.

Among four parameters ($\alpha, \beta, \kappa, \lambda$) two of them can be freely chosen to define $N_v(D,R)$. This implies that the coefficients of the power law N_0 - R and Λ-R relationships given by Eq^n. (1.22) and Eq^n. (1.23) have to follow some restrictions which is imposed by Eq^n. (1.13) and Eq^n. (1.17). From Eq^n. (1.22) we find $N_0 = \kappa$, or equivalently $a = 0$, if $N_0 = 8.0 \times 10^3$ according to Marshall-Palmer assumption

(40) which doesn't depend on the rain rate *R*. In Eq^n. (1.23) if c=3.778 and γ =0.67 as proposed by Atlas and Ulbrich, one can find $\Lambda = 4.23R^{-0.214}$.

For this special substitution of N_0, c, γ, Eq^n. (1.19) and Eq^n. (1.14) respectively gives the value of *a* and *b* and the corresponding $Z - R$ relation can be given as

$$Z = 237R^{1.50}. \quad (1.24)$$

In this relation the value of prefactor and the exponent is same as that of the mean of Battan's 69 $Z-R$ relationships.

Raindrop size distributions from empirical radar reflectivity – rain rate relationships

Many attempts are made to explain the size of the raindrop and to relate it with rate of rainfall [53-63]. Eq^n. (1.14) and Eq^n. (1.19) relates the prefactor and exponent of the of $Z - R$ relations to the parameters of the raindrop size distribution. Using Eq^n. (1.14) and Eq^n. (1.19), β and λ can be evaluated easily. Thus, the dependence of raindrop size distribution on the type of rainfall can be investigated. The value of N_0 is practically restrictive due to different types of rainfall climatologies. As the mean values of prefactor a comes out to be close to zero, so it suggests a constant N_0. The prefactor a is higher than the exponent b for orographic rainfall which is evident from both the relationships (Λ-R, N_0–R) whereas the value of *a* is smaller and the value of *b* is larger for thunderstorm rainfall. The Λ denotes the inverse of the mean diameter of raindrops present in a volume of air whereas N_0 gives the concentration of the smallest raindrops. The observations suggests that, at a specific rain rate, the mean raindrop size is smaller and concentration is larger for orographic type of rainfall whereas the mean drop size is larger and concentration is smaller in thunderstorm rainfall. This is because for different types of rainfall different prefactor and exponent are found.

Conclusion

Weather radars can be conveniently used for rainfall estimation despite of the limitations. Practically, radar sometimes overestimates while at some other times underestimates the rainfall. For long and short ranges each radar is an excellent reliable source for providing spatial information of rainfall. Radar uses reflectivity-rain rate relationships proposed by Marshall-Palmer and Battan for estimation of rainfall which may, again, not be always suitable for a given geographical area. Therefore, to measure the rate of rainfall accurately for an area, corrected reflectivity- rain rate relationship should be used. In the recent days, although, there is appreciable advancement in forecasting and now casting techniques of rainfall, but sometimes the exact location, timing and severity of a particular storm is still questionable. The exact estimation of rainfall depends on scan strategy, processing of data and the type of precipitation (64). So, for exact numerical weather prediction the data obtained from other modern sources like satellite must be considered.

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Utilization of industrial wastes for societal benefits

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Introduction

Present environmental crisis in all aspects of our lives and its management is supposed to be the most challenging job for the benefit of mankind. Our surroundings are degrading day by day which is harmful for us and also for future generations (1-3). Huge amount of wastes are produced day by day from domestic sources, industrial sources and different commercial sources (4-6). Identification of different types of wastes, its categorization and treatment techniques are important for their reuse and recycle. Different industry produces different types of wastes which may be utilized for different purposes for the benefit of the mankind and also helps to clean the environment.

Vegetable oil refinery industry also produces different wastes through refining of oils which may recycled or reused for different aspects. Crude vegetable oil is mainly composed of triacylglycerols (TAGs) along with some diacylglycerols (DAGs) and monoacylglycerols (MAGs). It also contains some non-edible compounds that needs to be removed by a refining process prior to human consumption. During the refining of crude vegetable oils, some byproducts/waste products are formed. These by-products are harmful to the environment if they cannot be used for any beneficial or industrial activity. Treatment of these wastes in proper way may produce different value added products like biofuels (7-11), drug induced products, functional and nutraceutical foods (12-19) etc. Some of the by-products/waste products from vegetable oil refinery industry like fatty acid distillates (FAD), deodorizer distillates (DD), acid oils are studied for making valuable products which are beneficial for human beings. DD/FAD is an excellent source as it contains valuable products like phytosterols, tocopherols, sterols and hydrocarbons (mainly squalene), which can be recovered and isolated as food additives. Different DDs or FADs are used for this purpose like soybean, canola and sunflower, palm, rice bran oil *etc.* Tocopherols, also a good antioxidant, have several beneficial properties such as protective role of vitamin A, β-carotene and essential fatty acids (20). It is also claimed that tocopherols have the ability to prevent diseases like cancer (21), cardiovascular and cataracts (22-24). These are used in different areas like food, cosmetics and pharmaceutical industries (25) and a mixture of α, β, γ and δ isomers containing 60 wt% tocopherols is widely used as additive to many kinds of foods. Squalene, another antioxidant, has several beneficial properties (26) and is utilized in different sectors like cosmetics, medicine, fine chemicals and functional food applications as bactericidal and fungicidal agent, antistatic and emollient or moisturizing agent (27-29). It is also used as an immunologic adjuvant in vaccines. Recently, due to chemo preventive activity, squalene is used as an important part of the Mediterranean diet for the protection of people from cancer (30). Sterols like tocopherols have a number of pharmaceutical, food and cosmetic applications and have been applied for some health benefits. As a supplementary diet used by many people, sterols have shown to reduce cholesterol accumulation, which help to decrease the risk of coronary heart disease (31-32). Cholesterol reduction has also been observed when used in conjunction with steryl esters, phytostanols or stanyl esters as well as sterols (33). Anti-inflammatory and immunomodulatory properties have been observed for plant sterols which can reduce lipid accumulations in arterial walls (34-36). Plant sterols are also thought to have antioxidant and anticarcinogenic properties (37-39). Different chemical as well as biochemical methods have been applied by researchers for the preparation of functional foods using DDs or FADs. So by products of vegetable oil refinery industry has a huge potentiality for its reuse and recycle which can be used for the societal benefit as a whole. Fig. 1 shows vegetable oil refinery plants where these byproducts/wastes are formed.

Fatty acid distillates

Waste like FADs from different vegetable oil refinery industry is produced during the refining process of crude vegetable oils. FADs from coconut oil, palm kernel oil, rice bran oil are mainly utilized for the preparation of low grades soaps but it can be utilized as wealth through the conversion of different functional foods, drug induced commodities as well as biofuels with the help of biocatalyst.

Fig. 1. Vegetable oil refinery plants

Coconut and palm kernel oil FADs: Coconut and palm kernel oil FADs have a good potentiality for the preparation of medium chain glycerides (MCGs) which are mainly utilized as a nutritional supplement for patients suffering as mal absorption caused by intestinal resection and also as an infant feeding formulation (40-42). MCGs have specific applications in the field of food, pharmaceutics and cosmetics. MCGs are useful in treating a number of medicinal disorders like impaired or damaged lipid metabolism, obstructive jaundice, biliary cirrhosis, pancreatitis, cystic fibrosis etc. It can also be utilized for feeding newborn infants, both to assist their initial growth and physiological development (43).

Preparation of MCGs from coconut and palm kernel oil FADs have been carried out by the process of enzymatic hydrolysis, fractional distillation and enzymatic esterification reaction (44-46). For enzymatic hydrolysis, enzyme Amano-30 (*Candida rugosa*) is used at 35±2^{0}C in a controlled temperature bath which contributes nearly 96% conversion. The hydrolyzed fatty acids are fractionally distilled at 120 – 160^{0}C at 4mm Hg for about 30 mins to get the specified fatty acids. Enzymatic esterification was done with fatty acids and glycerol (in a definite ratio) in the presence of lipase NS 40013 (*Candida antarctica*) at 60±2^{0}C for 8 hrs. Two MCGs have been produced from coconut FADs (I and II) and palm kernel FADs (III and IV). It has been observed from Table 1 that both products I and II from coconut FADs contained a significant amount of DAGs (64-67%) followed by MAGs (18-23%) and TAGs (9-10%). Similarly product III and IV from palm kernel FADs contained 63-66% DAGs, 19-23% MAGs and 9.5-10% TAGs. The products can be utilized as MCGs for food and pharmaceutical purposes. Coconut acid oils, a byproduct of coconut oil refinery industry, can also be used for the production MCGs through enzymatic process (47). So microbial lipase technology can be effectively utilized for the production of valuable products from wastes like Coconut and palm kernel oil FADs.

Table 1: Composition of MCGs from coconut and palm kernel oil FAD

Product	FFA (% w/w)	MAG (% w/w)	DAG (% w/w)	TAG (% w/w)
P-I	3.29±0.02	18.28±0.12	67.65±0.31	9.18±0.07
P-II	3.13±0.01	22.39±0.11	64.27±0.43	9.31±0.04
P-III	4.41±0.03	19.21±0.17	66.47±0.29	10.31±0.09
P-IV	3.34±0.02	23.56±0.16	63.05±0.56	9.45±0.03

Rice bran oil fatty acid distillate (RBOFAD): RBOFAD is another major waste of RBO refining industries which is mainly utilized in the soap manufacturing process. RBOFAD contains higher amount of unsaponifiable matters amongst which sterols, tocopherols and hydrocarbons (mainly squalene) are the main components. RBOFAD can be utilized for the production of diglyceride rich products along with these unsaponifiable matters (48). Sterols, tocopherols and squalene can also be extracted from RBOFAD which are recognized as important antioxidant used in different drug induced commodities. Tocopherols and tocotrienols present in RBO can improve the blood circulation and reduce the oxygen demand of human body. α-tocopherol is used in pharmaceutical and cosmetic industries and a mixture of α-, γ- and δ- tocopherols is added to various foods including fats and oils. Squalene has the ability to assist the skin in retaining moisture. It helps to keep our skin soft and healthy and its antioxidant capabilities help to protect from the harsh effect of the environment.

Squalene is being investigated as an adjunctive therapy in some cancers (49-50) effective in inhibiting lung tumors and also demonstrated chemo protective effects against colon cancer in animal models (51). So diglyceride rich oil along with these micronutrients has the immense potential health benefits to human beings.

For the preparation of value added products, initially, RBOFAD was bleached to remove peroxides. After that, bleached RBOFAD and glycerol were treated under vacuum of 4 mm Hg for 8 h using 5% (by weight of substrates) lipase catalyst (NS 40013) by maintaining a temperature of 65±20C. Esterified product was the purified in a molecular distillation unit (Model MS-300, SIBATA Scientific Co. Ltd., Japan). It was a falling film type apparatus and was provided with a rotating wiper that continuously rubbed the falling film on the evaporating surface. The temperature of the reaction product was maintained at 145±2⁰C and 12 pascal pressure to remove the residual fatty acids and volatile impurities. The final product was determined by standard column chromatographic method. Three varieties of products namely P-I, P-II and P-III were produced from RBOFAD by varying the ratio of FAD and glycerol concentration (2:1, 2:1.25 and 2:1.50). The composition of products P-I, P-II and P-III are shown in Table 2 and the characteristics of unsaponifiable matters are shown in Table 3.

Table 2: Composition of value added products

Product	TAG (% w/w)	DAG (% w/w)	MAG (% w/w)	Unsap. Matters (% w/w)
P-I	25.59±0.37	47.54±0.34	13.24±0.13	13.63±0.24
P-II	7.27±0.04	72.86±0.58	6.99±0.05	12.88±0.22
P-III	11.11±0.11	61.16±0.21	15.36±0.09	12.37±0.13

Table 3: Composition of unsaponifiable matters in value added products

Product	Tocopherols (% w/w)	Sterols (% w/w)	Squalene (% w/w)	Others (% w/w)
P-I	30.74± 0.33	13.11±0.16	52.46±0.37	3.69±0.12
P-II	29.31±0.32	13.86±0.17	51.93±0.31	4.9±0.14
P-III	28.78±0.17	14.63± 0.09	52.49±0.29	4.1±0.13

RBOFAD waste can also be used as a source of squalene and it has been extracted through bioprocess technology (52). Squalene is a natural triterpenic hydrocarbon with molecular formula C30H50. It is widely present in animal and vegetable kingdom and is important due to its antioxidant nature. Squalene gets attention of the scientific world due to the beneficial effects of some natural products containing it which is observed in the human health. Squalene is recognized as biochemical intermediate for the synthesis of cholesterol and other steroids. Squalene has several beneficial properties (53) and is utilized in cosmetics, medicine, fine chemicals and functional food applications as bactericidal and fungicidal agent, antistatic and emollient or moisturizing agent (54-56). It is also used as an immunologic adjuvant in vaccines. Recently, squalene has been proposed to be an important part of the Mediterranean diet as it may be a chemo preventive substance that protects people from cancer (57). Squalene is synthesized in our body by the liver and is secreted in large quantities by the sebaceous glands. It is transported in the blood by low density lipoproteins. Squalene represents 12% of the lipids secreted by the sebaceous glands and it is not transformed in cholesterol (58-59). Squalene can be extracted from RBOFAD through bio hydrolysis, bio esterification and molecular distillation method. For these purpose, biocatalyst Amano-30 and NS 40013 were used. Molecular distillation method was applied in two stages, initially at 175±2⁰C and 2-3 Pascal for 1 h and finally at 185±2⁰C and 2-3 Pascal for 1 h. The final product contained 96.52±0.81% squalene as determined by HPLC technique. The density, refractive index and flash point of the final product were 0.852±0.008 g/mL, 1.478±0.006 and 110±0.870C respectively with very low acid value (<0.05±0.001), peroxide value (<0.1) and anisidine value (0.3±0.002).

Deodoriser distillate

Soybean oil deodoriser distillate (SBO DD): SBODD is another waste of vegetable oil refining industries. SBO DD can be utilized for the synthesis of novel functional food ingredients which contains TAGs, DAGs and MAGs along with sterols, tocopherols and hydrocarbons (60). SBODD is an excellent source in this respect for the valuable compounds such as phytosterols, tocopherols, sterols and hydrocarbons (mainly squalene), which can be recovered and used as food additives (61-

64). Their commercial value however, is mainly dependent on their tocopherol content (65). Different deodoriser distillates or fatty acid distillates are used for this purpose like soybean, canola and sunflower (66-67), palm (68-70), rice bran oil (71) etc. SBODD, one of the important by products of vegetable oil refining industry, has been considered as an important source for the preparation of functional foods as it contains sterols, tocopherols and hydrocarbons.

For the purpose of preparation of novel functional foods from SBODD, it has been bleached first and after that, bleached SBODD is treated for enzymatic esterification at 65±2 ^{0}C under reduced pressure for 8 hrs in the presence of 5% non-specific immobilized lipase NS 40013 (Candida Antarctica) with glycerol in different ratios as shown in Fig. 2. The product was purified in a molecular distillation unit (SIBATA Scientific Co. Ltd., Japan, Model – MS 300) at 153-155^{0}C temperature and 18-20 Pascal pressure.

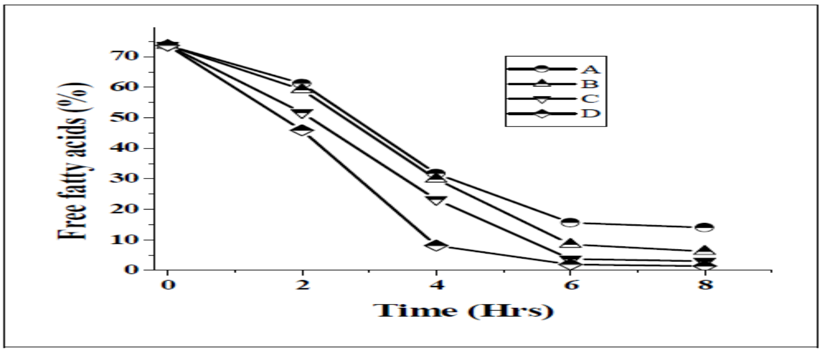

Fig. 2. Enzymatic glycerolysis of SBODD for functional foods.

[Enzyme used: lipase NS 40013 (*Candida antarctica*), Temperature: 63±2^{0}C, Time: 8hrs]

The undesirable free fatty acids and other volatile compounds were removed through this method. Free fatty acids and glycerides were identified by the Gas – Liquid Chromatographic method and standard column chromatographic IUPAC method respectively. The compositions of the purified products (A, B, C, D) after molecular distillation are analysed and found that product A, B, C and D contained 42.1, 42.0, 41.7 and 32.5% TAGs, 25.4, 29.9, 36.0 and 45% DAGs and 12.2, 11.9, 9.9 and 9.4% MAGs respectively as shown in Table 4. Also, product A, B, C and D contained 12.5, 11.2, 10.1 and 9.6% unsaponifiable matters respectively as appended below.

Table 4: Composition of functional foods from SBODD

Product	TAGs (% w/w)	DAGs (% w/w)	MAGs (% w/w)	Unsap. Matters (% w/w)
A	42.1±0.97	25.4±0.12	12.2±0.32	12.5±0.26
B	42.0±0.89	29.9±0.35	11.9±0.24	11.2±0.19
C	41.7±0.73	36.0±0.61	9.9±0.11	10.1±0.24
D	32.5±0.22	45.0±0.75	9.4±0.09	9.6±0.31

It has been observed from Table 4 that product A, B and C can be considered as TAG rich functional foods and product D can be considered as DAG rich functional foods. So by simply varying the concentration of glycerol in the reaction mixture, products of desired composition can be manufactured. Moreover, TAG/DAG rich products along with higher amount of unsaponifiable matters are regarded as functional foods with required commercial value. Unsaponifiable matters contains mainly tocopherols, sterols, hydrocarbons and others as shown in Fig. 3.

Canola oil deodorizer distillate (CODD): CODD is another waste of vegetable oil refinery industry which can be utilized as a source of environment friendly fuel. CODD was utilized for the production of biodiesel through bioprocess technology. This process technology is clean, safe, environment-friendly and easy to separate. Moreover, biocatalyst may be recycled which helps to reduce the process cost.

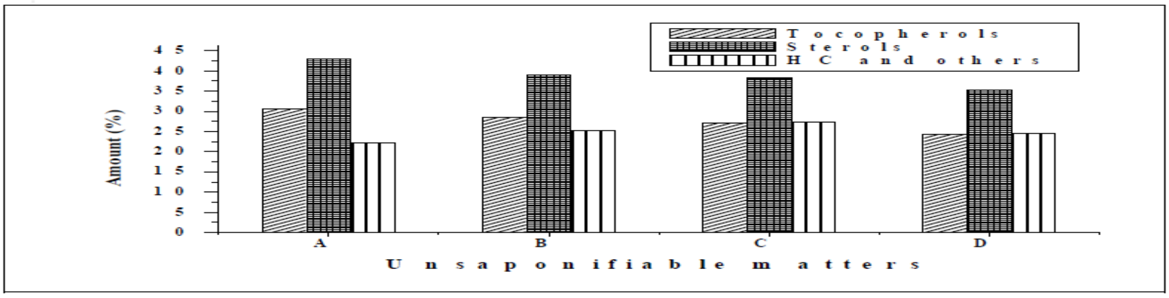

Fig. 3. Distribution of unsaponifiable matters in the products A, B, C and D.

With an objective to convert CODD to biofuel, initially biocatalyst Lipase AY Amano 30 (*Candida rugosa*) was used for the biohydrolysis of neutral glycerides to fatty acids present in CODD and finally Novozyme 40013 (*Candida antarctica*) was used for bioesterification of fatty acids and methanol to get biodiesel. The parameters applied for biohydrolysis reactions are 40⁰C temperature, 60% water content in the presence of 5% Amano 30 enzyme for 6 hrs.

Bioesterification between hydrolysed CODD and methanol has been performed for the preparation of biodiesel maintaining the reaction parameters of 4:1 molar ratio of methanol to hydrolysed CODD, temperature 60⁰C, mixing intensity 600 rpm for 4 hrs and 5% enzyme Novozyme 40013. Maximum conversion has which has been achieved by maintaining these reaction parameters are nearly 94%. Figure 4 below shows the typical analysis of time study vs conversion of biodiesel from CODD.

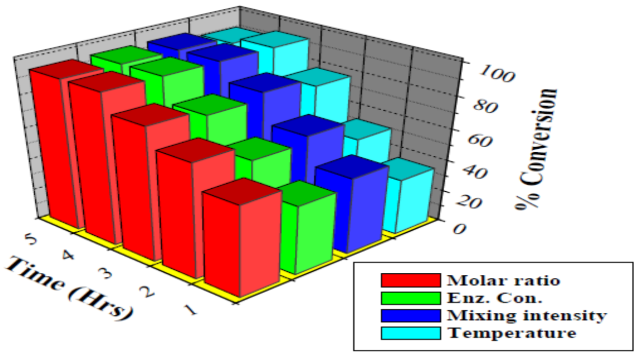

Fig. 4. Typical analysis of time study vs conversion of bioesterification reaction between hydrolysed CODD and methanol

Table 5 below shows the characteristics of CODD biodiesel produced through biohydrolysis and bioesterification method.

Table 5: Characteristics of CODD biodiesel

Characteristics	Biodiesel	Diesel fuel	Test method
Density (gm/cc)	0.852±0.001	0.840	ASTMD-4052-96
Flash point (⁰C)	217±0.748	56	ASTMD-93
Fire point (⁰C)	222±0.635	62	------------------
Kinematic viscosity @40⁰C (Cst)	4.74±0.011	3.02	ASTMD-445
Specific gravity	0.879±0.004	0.85	---------
Calorific value (Kcal/Kg)	3674±1.985	4285	ASTM-6751
Acid value (mg/KOH)	0.56±0.014	0.36	ASTMD-64-01
Moisture (%)	0.02	0.02	--------------
Cetane number	40±0.211	49	ASTMD-6751

Conclusion

Vegetable oil refinery byproducts/wastes are a good source for the production of different value added products which exert beneficial effect for the society. Conversion of different environment friendly products from these wastes encourages us to avoid the misuse of these wastes which may be harmful for the society as a whole. Different environment friendly procedure have been discussed for this conversion where the biocatalyst can be reused for the sake of environment. Reuse and recycle are another good thinking for saving our mother environment which is utilized in the present process. Fatty acid distillates and deodorizer distillates, used here, are waste materials in the industry which have a strong potential to contribute environment friendly value added products. Present process technology not only helps the utilization of industrial wastes but also saves the environment by eliminating different harmful chemicals which gives a ray of hope of future green earth.

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Recycling of plastics and environmental sustainability

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Introduction

Plastics are, by and large, the most important materials for utility and industrial products nowadays. Plastics were originally regarded as the substitutes for metal, wood, ceramics, etc. but now it is considered as an indispensible material in the various fields of engineering, railway, textiles, automobiles, telephone, buildings, household commodities, etc (1-3). The plastics or polymer industry has emerged as one of the basic industries which reflect the consumption of the material worldwide and also the increasing magnitude of production worldwide. They are considered superior to other materials in terms of strength, flexibility, lightness, transparency, corrosion resistance, electrical insulation, durability and low cost (4-6). With the advancement of technology and modernization of scientific tools, numerous plastics have been developed and implemented in all sectors of human livelihood. An extensive use in global scenario triggers the production of numerous plastics materials and their corresponding products designated for universal applications. However, the extensive commercial use of plastics triggers the possibility of hitting the environment adversely at large (7-8). In the present scenario, an average consumer has high per capita consumption of plastics owing to the needs and around all of them fall under the category which can defeat the natural decay processes. This results in the accumulation of non-biodegradable plastics material that tend to persist in the natural environment (9). A part of the disposable plastics content are recycled but the major share of it are either used in land filling, incinerated or improperly disposed (10). The rising plastics accumulation poses a serious environmental threat to the global ecosystem. Concerns about usage and proper disposal of plastics enhances the probable sustainability of wildlife, humans, flora and fauna. However, the non-sustainability of plastics can be abated by some solution measures as material reduction, application of Green Chemistry, reduction in littering, development of bio based feedstocks and in extensive recycling (11-12).

Recycling of plastics are done to recover waste or scrap plastic and reprocess the same into some useful and functional products. The purpose of recycling focusses on reducing the high rate of plastics dumping and pollution and also to minimize the production of brand new materials which augments the total plastic content of the globe. This adopted process can eventually also minimize the practice of landfilling and ocean filling of plastic waste and contribute more towards a pollution free environment (13).

Rapid technological innovation and advanced processing techniques made plastics recycling simpler and cost effective. Newer technologies involving sophisticated detectors and high level software enhanced the productivity and the accuracy of the entire recycling process (14, 15). However, there are also certain challenges associated with the plastics recycling process industries. In this chapter, an endeavor has been made to present the idea of different types of plastics and the recycling ventures related to it (16). The need and awareness of plastics recycling in global context needs to be addressed and facts related to the circumstantial scenario has been highlighted in this text.

Plastics in use

In the modern world of today, plastic materials have effectively penetrated in all spheres of domestic and commercial applications (17-19). The inflow of plastic items into the market have revolutionized the concept of material usage and have established itself as one of the most effective alternative materials to replace the conventional constituents like metal, ceramics, wood, leather, etc. Plastics contribute enormously to a wide range of commodity and engineering applications (20). Due to their versatility, durability and ease of manufacturing, water resistant behavior, etc. they can be applied for generating a huge range of products. The diverse spectrum of utility of plastic materials enabled the replacement of the conventional traditional substances like metals, wood, leather, ceramics, etc. In the recent years, plastic products are on an increasing demand as they are economic and easy to handle. Continuous innovation in this class of material has helped to revolutionize the world of polymers by providing improved lifestyle facilities and modifying the quality of life (21-23). In this aspect, it can be truly remarked that the advancement of plastic technology has by and large influenced mankind in formulating their mode of lifestyle with increasing per capita consumption of the plastic material.

Some of the common plastic materials which are in use and plays a significant role can be briefly referred to in this context. Polyethylene (PE) is the most commonly used plastic which can be obtained in different forms like Low density polyethylene (LDPE), High density polyethylene (HDPE), Medium density polyethylene (MDPE), Linear low density polyethylene (LLDPE) and Ultra high molecular weight polyethylene (UHMWPE). A number of recyclable plastic items like bags, bottles, bottle caps, boxes, packaging items, films, toys, etc. can be derived out of it (24). Polypropylene (PP), another very commonly used plastic and which can be recycled, is specifically resistant to heat, physical damage and corrosion. Hence it finds extensive use as food containers, ropes, furniture, piping, etc. (25). Polyvinyl chloride (PVC) is a polymer with profound applications both in household as well as commercial purposes. It is available in both rigid and flexible forms and is applicable for a variety of items like pipes, door and window frames, wire and cable insulation, sheets and others. However, the limitation of using PVC is that it has got poor impact strength, poor thermal stability and difficult processibility (26-28). These problems are somewhat overcome by the use of modifiers which may be polymeric or non-polymeric in nature. Methacrylates and acrylates play a significant role in this regard contributing as the processing aid as well as the impact modifier. This is also analogous to rubber toughening of glassy polymers and as manifested, the increase in strength properties of PVC are associated with a reduction in its flexibility properties (29-31).

Polyethylene terephthalate (PET) as shown in Fig 1, again a very commonly used polymer for bottles, packaging and tapes as well as for clothing, etc. is another recyclable polymer (32). Polystyrene (PS), another widely used plastic utilized to manufacture plastic cutlery, CD cases, packing materials, foamed containers for food and drink, can be recycled and henceforth contribute to its reduction in consumption (33). Nylons or polyamides are another class of polymer plastics which retains the potential of recyclability and paved its way into varied domestic and commercial arena in the form of nets, ropes, toothbrushes, clothing and guitar strings (34). Polyurethane is another commonly used polymer for furniture, shoe soles, football coatings and in paints and varnishes. Besides the mentioned few, a series of plastic materials are used which holds the capability of getting recycled and hence contribute to the reduction in generation of the virgin material (35).

Fig. 1. PET bottles

Fig. 2. Products from thermoplastics and thermosets

Types of recyclable plastics

Plastic materials cover a wide range of applications today. Of the entire varieties of the plastic materials used, there are some which responds to recyclability, while the others do not. Based on the behavior towards thermal exposure, plastics are distinguishable as thermoplastics and thermosets. The thermoplastic types can usually be segregated under the recyclable category. Plastics which remain soluble and fusible under repeated cycles of heating and cooling are thermoplastics which can be repeatedly recycled (36-38). Thermosets have got one time use capability and these kind of plastics cannot be used over and over again.

Thermoplastics are mostly formed by addition polymerization processes and usually possess linear or branched structures. In them, the adjacent polymer chains are held together by weak forces like Vander Wall's forces, dipole-dipole interactions or hydrogen bonds. They soften on heating and harden or stiffen on cooling. On prolonged heating, these polymers melt and can undergo remoulding, recasting, reshaping and recycling. They are usually soft, weak and less brittle and are soluble in some organic solvents. A feature of thermoplastics lies in the fact that during moulding and recycling, their chemical composition does not change (39-40). The thermoplastic recyclable materials which are commercially used are polyethylene, polypropylene, polystyrene, PVC, nylon, polyester, etc.

On the contrary, as in Fig 2, the other variety which includes the thermosets, are manufactured by condensation polymerization process. They have three dimensional cross linked network structures and hence do not soften on heating but become hard. In these polymers, the adjacent polymer chains are held together by cross links which are strong covalent bonds. On heating for a longer period, these polymers start burning. Thermosets cannot be remoulded, recast, reshaped or recycled. They are usually hard, strong and more brittle and are insoluble in any solvent. During moulding in such plastics, further polymerization and crosslinking occur (41-43). Polymers under this domain covers plastics like bakelite, epoxy, urea-formaldehyde, melamine-formaldehyde, etc.

Plastics pollution and the environment:

The overall lowering of environmental qualities caused due to the increasing content of disposable plastic wastes, poses a serious threat to the environmental ecosystems. On the land, it poses a drastic threat to the plants, animals and human beings who are based on land. Moreover, the toxic, harmful chemicals of plastic can seep into the soil and poison the underground water or the surrounding water sources. A substantial amount of plastics are also dumped in the oceans as depicted in Fig 3 and Fig 4, which is considered to be the earth's last sink. A part of them flows from land and also the trash is carried to the oceans by the flowing rivers which acts like a conveyer belt in conveying the trash downstream to such a large extent. When the trash reaches the seas, they remain in the coastal waters but if somehow they are trapped in the ocean currents, they may be transported across the world (44-47).

In the oceans, the plastic materials are broken down into microplastics (often less than one fifth of an inch) by the action of sunlight, wind and waves. These kind of microplastics have spread across the globe which is a global threat to varied ecosystems. Numerous reports have come up with the deaths of fishes to birds and other aquatic animals including the endangered ones. Also, once they are drifted across the oceans, it is almost impossible to retrieve plastic waste (48-49).

In this context, the best solution to limit plastic pollution is by an improved way of management system which accommodates recycling as one of the major tools. Also unnecessary production of single use plastics should be limited for ensuring a place in the drive for sustainable development.

Fig. 3. Marine plastic pollution

Fig. 4. When disposal of plastic waste becomes a major concern

Recycling techniques of plastics

Recycling of plastics is the usual method which is followed for the recovery of thermoplastics. Recycling is preferred to incineration as the latter is responsible for evolving toxic gases and residual ash which contains lead and cadmium. The process of recycling is thus advantageous in reduction of the environmental hazards and saving of both material and energy.

The technical aspect of the recycling process involves traditional and advanced recycling processes which are again categorized under primary, secondary, chemical recycling, etc. In the primary recycling processes, the original plastic products are reused but in this case, recyclability is limited on the number of recycles for each material (50-53).

Secondary recycling is the mechanical recycling or the traditional recycling which is exclusively applicable for thermoplastics. This recycling method involves melting of the plastics and processing them into new plastic products. The process of injection moulding is normally adopted to generate new products after the recyclers melt the plastic. However, prior to the melting down of plastics, they are sorted automatically or manually to make sure that all the contaminants have been removed. But nowadays, plastics recycling have become more convenient and cost effective due to the continuous innovations in recycling technologies. Such advanced technologies may involve the utilization of recognition software, reliable detectors, sophisticated decisions that collectively contribute towards enhanced productivity and accuracy. In this secondary recycling process, the virgin and reprocessed materials may also be blended to originate polymers with superior properties (54-55). The main disadvantage of this method is the heterogeneity of the plastic waste and the deterioration of polymeric properties with every recycle of the polymer resin.

The chemical recycling process is also another relevant process in which the polymers are converted into their monomers or reduced down to oligomers by chemical processes. This can also be considered to be a process of advanced recycling and techniques like pyrolysis, gasification, cracking, hydrolysis, photodegradation, etc. may be implemented to breakdown the polymer chains into minor units. However, of the major processes suggested, the processes of glycolysis and methanolysis are commonly in use (56-58). Polymers like polyethylene terephthalate (PET), polystyrene (PS), polyethylene (PE), polypropylene (PP), etc. undergo recycling by these methods wherein the polymers are degraded into their respective monomers with substantial yield.

Additionally, another recycling process involves recovery of the plastic's energy content. This is an energy recovery process where the evolved energy is represented by incineration. Although a substantial volume of energy is generated by this process, still it is absolutely imperfect from the environment and ecological point of view. Release of airborne toxic materials like dioxins is highly probable which can impose an absolute environmental threat (59-60).

Common recycled plastics

The commonly used plastics which offer a range of applications can be recycled on a large scale with specific identification codes as specified by ASTM International. The plastics undergoing recycling are coded by ASTM International as given in Fig 5, the ones which are discussed here (61-62). One of the very popularly known reused plastic is polyethylene terephthalate (PET) which has the properties of excellent clarity, strength and toughness along with characteristic barrier properties. PET bottles are drastically popular for water and soft drinks, jars, etc. This polymer has gained tremendous importance in the area of recycling as out of the total plastic waste produced, a major share is held by the PET bottles as stated (63).

High density polyethylene (HDPE) is another important polymer which is extensively recycled. Its mechanical strength, stiffness, toughness, moisture resistance are some of the properties which it provides making it a widely accepted recycled polymer. It finds uses in electronics, pipelines, bottles, etc. Additionally, low density polyethylene (LDPE) can also be recycled and used in carry bags, films, flexible containers and many more. It is easy to process and is tough and flexible (64).

Due to the ease of blending and profound versatility, polyvinyl chloride (PVC) is a well-known recyclable plastic which can be used for piping, electrical insulation for wires and cables, non-food packaging items, etc. (65-67) For reusable microwaveable ware, kitchenware, containers, disposable items, polypropylene (PP) finds extensive usage which constitutes a popular recyclable material. In addition to the strength and toughness which it displays, PP is also resistant to heat, chemicals, grease and oil (68).

Polystyrene polymer is another significant recyclable plastic and is remarkable for its clarity and versatility. It is widely used for making disposable trays, cutlery, cups and take away containers (69). Apart from the above mentioned plastic polymers, some other polymers have also earned the reputation of recyclability such as polycarbonate or acrylonitrile-butadiene-styrene copolymer (70). Several unbreakable and special purpose items are produced from PC or ABS globally (71). These polymers as stated thus contribute to the major share of the plastics which are recycled.

Fig. 5. The plastics undergo recycling with standard specified codes

Limitations of plastics recycling

Although the recycling of plastics is designated as the most suited alternative for offering a cleaner environment, there are some limitations of the process as well. The sorting of plastics as to the recyclable versus the non-recyclable ones becomes a major concern. As there are thousands of variations available, combining different types of plastics ultimately renders it useless for recycling (72). Recycling is not the permanent solution to the problem of plastic pollution. It is a reprocessing technique before the materials are either destined for landfilling or incineration which is obviously treacherous to the environment. In this regard, it is associated with high health risks especially with polymers like PVC which contains chlorine and releases a very carcinogenic substance dioxin when incinerated.

Additionally, with each recycling number, the quality or properties which the material offers, deteriorates and after a certain number of recycles, becomes absolutely unfit for use (73).

Conclusion

Plastics recycling are by and large the most effective movement to control the unbounded material waste generated everyday. It ensures the most effective way of providing plastic free environment and offering a sustainable environment as a whole. The most commonly used plastics which can be recycled comprising of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polystyrene (PS), etc. as mentioned finds extensive usage in daily used products. Hence recycling of these polymers aids in effective reduction of plastic pollution on a large scale. Effective recycling techniques are adopted to ensure maximum possible recycling in order to maximize the reutilization of plastic waste material and minimize the dumping of the same.

Acknowledgement

I acknowledge the sites available on the internet for all the images which has been presented in the text through Google search.

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Plastic pollution in the ocean: problem and possible solutions

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Introduction

Plastic pollution in the ocean has been a growing concern for the last few decades. Plastic bags and micro beads are a significant source of this pollution. Although research outlining environmental, social and economic impacts of ocean plastic pollution is growing, few studies have examined policy and legislative tools to reduce plastic pollution, particularly single-use plastics (plastic bags and micro beads). In this book chapter we are trying to focus on the plastic pollution in the ocean and its possible solutions. There are so many international market-based strategies and policies to reduce plastic bags and micro beads. Policies to reduce micro beads began in 2014 whereas for plastic bags began much earlier in 1991. There are also recommendations for bans and levies to ensure policies, having positive impact on ocean pollution.

Nowadays plastics are major issue in the ocean environment, and urgent action is required to diminish this deteriorating situation (1, 2). It was investigated that in 2010, an estimated 4.8–12.7 metric tons of plastics entered into the oceans globally (3). In 2014 a study done by 5 Gyres Institute for six years, revel that 5.25 trillion plastic particles (weighing 269,000 tons) are floating in the sea surface. Although the contribution of plastics in man-made garbage is roughly 10% by mass (4), it has been estimated that plastic debris accounts for 60– 80% of marine litter (5) in some areas it reaches 90–95% (6, 7, 8). Due to its non-biodegradable property the lifespan of plastic is estimated to be hundreds to thousands of years (9). In 2014, UNEP announced the anxiety over the threat of widespread plastic waste to ocean life. The problems for the plastics have been reported in the ocean environment since the 1970s (10, 11). However, recently plastic pollution has been as a global problem in the ocean life (12- 16). Subsequently, plastic pollution in the ocean has become a significant environmental concern for governments, scientists, non-governmental organizations, and members of the public worldwide (17).

Within few years, world population has been more than tripled which inevitably causes the mass consumption and therefore to plastic packaging. This resulted in the dumping of a huge amount of waste which is very difficult to degrade, which, for most of it, reaches the oceans. Plastics are accumulation in all five oceans. As plastics continue to flood on the surface of the ocean, it highly affects the biological environment of marine species. One of the reasons that plastic pollution is such a huge problem because it does not go away, plastics are forever. Most of the plastic products contain plasticizer, UV stabilizer, antioxidants and flame retardants to maintain their properties. Small pieces of plastics are often consumed by fish, turtles and mammals resulting in their death. It kills up to a million of seabirds in a year. We all need to take responsibility and use plastics as much less as we can. The identified countries (China, Philippines, Indonesia, Vietnam and Thailand) should develop their waste management as the 60% of plastic waste is coming from these countries. Getting right waste management improves the ocean health and also it can increase the economy and prevent the food chain contamination. So I tried to discuss the whole thing in my journal and give some possible solutions.

Eight million metric tons of plastic trash enters the sea (Fig. 1) from land every year, it is equivalent of five plastic bags filled with trash for every foot of coastline in the world across our seven seas (18-20). Plastic trash dispersed almost everywhere but concentrating in huge swathes in the midst of global currents breaking down into smaller and smaller pieces ingested by species (Turtles, Dolphins, Seals, Sea Lions, Whales) across the marine world and sinking to the bottom of the sea (21, 22). Fig. 1 show plastic trash enters in to the sea and Fig. 2 shows smaller pieces of plastic ingested by species (Turtles, Dolphins, Seals, Sea Lions and Whales).

Fig. 1. Plastic bottle in the sea

Anyone can make plastic anywhere in the world and sell it anywhere else in the world there are no restrictions over that. We can't solve the damage in few years it would take at least some decades but at least we can do is not making the situation worse and follow a waste management rule to prove a 'one size fits all' solution. If we look all over the world we will see a diversity of strategies to Reduce, Reuse, Recycle and clean up our waste. Such strategies may be most effective when guided by the best science. I have tried to briefly discuss about the main causes of the plastic pollution and give some solutions; at best it will stop the situation from getting any worse (23-25).

Fig. 2. Species affected by plastic pollution

Why plastic is so harmful for the environment?

Picture yourself as a bacterial cell looking for food. You find some leaves, and a half-eaten bread, a dead animal, all of which either you can eat. But, all of a sudden, you come across something you've never seen before. In your millions of years evolving, you've never encountered something like this and don't have the mechanisms needed to break it down and use it for energy or nutrients. All the other food is gone, and you can't find anything else to eat, so you die.

This story outlines one of the reasons why plastics last so long, and it comes down to how plastic is made. When plastic is made, crude oil or other fossil products are heated to high temperatures to form strong polymers from the fossil products' monomers (26, 27). According to Organic Chemist Kenneth Peters, these polymers are not found too often in nature due to the fact that their carbon-to-carbon bonds are very strong and require a lot of energy to make. Therefore, plastic has mainly been introduced into the environment in the last few decades and it's foreign to many microorganisms. This means that it's not easily broken down into its elemental components or recycled into the environment. Even metals, which not many microorganisms break down, are able to be recycled back into the environment through "oxidation", aka rust (Fig. 3) (28-30).

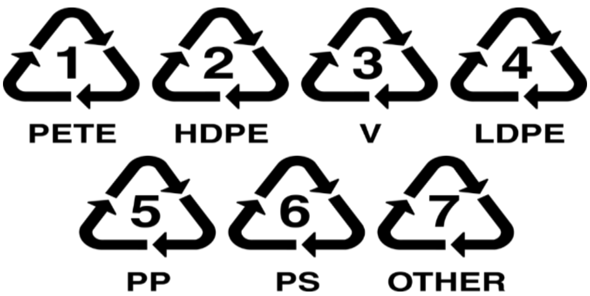

Fig. 4. Plastic identification codes (from 1 to 7)

Fig. 3. Metal recycled back into the environment through "oxidation".

But plastics beat Mother Nature in this area too, making them perfect for the containers. The molecules that make up plastic are actually resistant to oxidation and many other chemical reactions because of the strength between the monomer bonds (covalent C-C bond in most cases). Since it is resistant to bacteria, enzymes, oxidation, and water exposure, it is hard to get plastic to biodegrade at all (31-33). So plastic thrown out in the oceans ends up damaging the ecosystem. Many animals mistake plastic for food and end up eating plastic. Along with the poisonous Bisphenol-A that plastic releases when it breaks down, these plastic components taken in by animals work their way up the food chain until they get to us (34-36).

Dr. Marc Goldstein from Cornell University states that some of the plastic components eaten by us through the food chain can cause problems such as infertility and birth defects (37). Even more disturbing is that many plastics buried end up polluting ground drinking water when they degrade and much of the plastic discarded ends up in the ocean, where currents concentrate it into places like the Texas-sized "trash vortex" off the coast of California.
But plastic isn't indestructible. Its polymers can be completely broken by sunlight in as little as a few years under perfect conditions. Also, new research has found bacteria that could actually completely break down plastic into the molecules it needs, a small amount of water, and carbon dioxide. Yet one of the biggest benefits of using plastic is its ability to not break down in things like food containers and water pipes, so it's difficult to avoid using it (38, 39).

Problems in recycling plastic
The biggest problem in recycling plastics is they are not biodegradable so that soft-drinks bottle or plastic wrappers that you just throw away and not biodegradable (40-42).
This means the fate of most plastics is to go into landfill sites or our OCEANS where it will take hundreds possibly thousands of years to degrade. Many people think that recycling the plastic is the absolute solution but the problems with recycling plastics are they have to be manually sorted which is a labor and energy intensive process. Mixed polymers are found in a range materials, so they cannot be recycled and are often dumped once a plastic has been recycled once it can be come down cycled whereby its quality is decreased the fact is that plastic recycling rates are far below other recycling rates but the industry has improved in recent years. Worldwide there are seven different groups of plastic polymers. They have been given a plastic identification code (from 1 to 7) (See Figure 4) which people use for recycling. You can find these numbers in most of the packaging or plastic materials. The different types of plastics will be recycled by different municipalities or even by different countries in some cases.

It's difficult to recycle plastics with numbers one and two, in this system the higher numbers are known as rigid plastics so the disposal of plastics is a tricky one. There are not many that might be done to dispose of them other than reducing, recycling or reusing (43, 44). One way is that the plastic can be burned or incinerated. This produces useful energy but plastic contains halogenated polymers like Teflon, PVC, etc. Toxic fumes like Hydrochloric acid are released

when these polymers are burnt for an instance (Fig. 5) (45). It is hugely problematic as it produces severe respiratory diseases. In addition burning of polymers produces CO_2 (Carbon dioxide) the greenhouse gas which contributes to global warming. And also if we use the polymers as a fuel for energy production then it will output twice as much CO_2 as compared to fossil fuels.

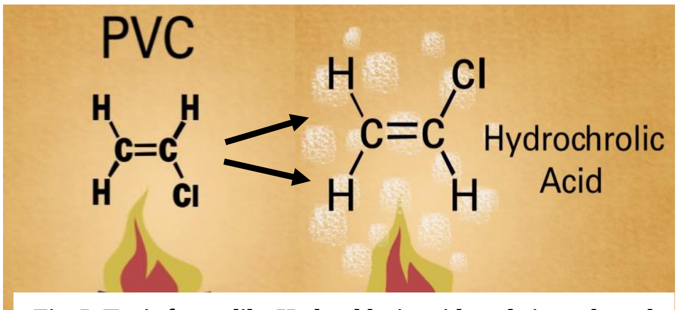

Fig. 5. Toxic fumes like Hydrochloric acid are being released

Some people blindly think that the use of bio plastics is the solution of this all but it has few problems. A bio plastic is a biodegradable polymer, this means it's compostable and it can be broken down by the bacterial action when it is disposed (Fig. 6). This is the main benefit but there are still issues with bio plastics. Bio plastics often come from non-renewable raw materials like poly lactic acids, maize, starch, cellulose and these are plant derived materials and so the question arises that we should use the land to grow crops for food or to supply the raw materials for the bio plastic manufacturing instead. We said that bio plastics are readily compostable but that is in terms of other polymers however bio plastics are not nearly as readily compostable as regular natural material. If you toss a bio plastic spoon into your compost and think it will be dirt in a few months then you'll be very disappointed. In summary plastic disposal has a lot of issues with regards to landfills, recycling. However, bio plastics do not present themselves as the better alternative because there are issues of land usage, the quality of the buyer plastic and how it is composted (46, 47).

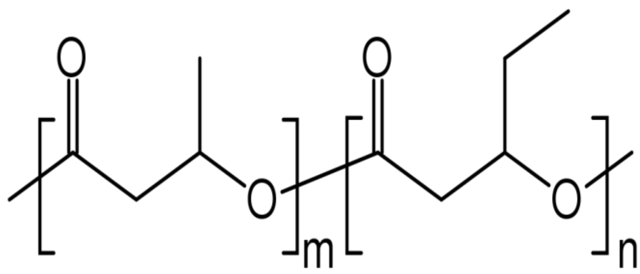

Fig. 6. Poly (3-hydroxybutyrate-co-3-hydroxyvalerate):

Plastic debris in the oceans

The ocean has become a global dustbin for all the waste we generate. Ocean debris is all the man-made stuff that ends up in the ocean, from plastic bottles, metal cans to fishing net (Fig. 7). All that trash is killing and injuring sea ecosystem, leaching chemicals, impeding navigation and even ending up in our food. Plastics break down into small particles that resemble fish eggs, fish consume those particles; we eat the fish and by that the plastic ends up in our body. That's why the accumulation and possible impacts of microplastic particles in the ocean have been recognized as an emerging environmental issue (48-51). Some scientists are concerned about the potential impact of releases of persistent bio-accumulating and toxic compounds (PBTs) from plastic debris.

Fig. 7: Farms off the Pacific coast of South America are an important source of plastic debris in the region.

Microplastics are considered as plastic particles smaller than 5 millimeters in diameter (53). Persistent, bio-accumulating and toxic substances (PBTs) have a range of chronic health effects, including endocrine disruption, mutage nicety and carcinogenicity (54, 55). A subset is regulated under the Stockholm Convention on Persistent Organic Pollutants (POPs).

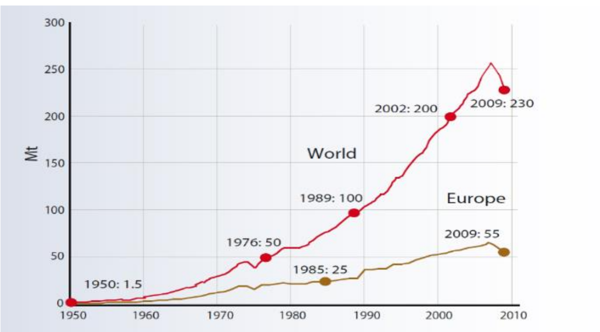

Fig. 8. Growth in plastics production

Fig. 9. Polluted beach affecting the tourism

The tourism and fishing industries are equally affected by the ocean debris, they are mostly affected economically because it affects their business (56). The tourism industry is affected by plastic washing up on beaches and the fishing industry is affected by plastic entering nets, fouling propellers and other equipment. Despite, global efforts to stem the flow of plastic debris it continues to accumulate and impact the ocean ecosystem. To reduce the quantity of plastic entering the ocean, existing management system need to be made more effective and all aspects of waste treatment and disposal need to be improved. Generally common types of plastics are buoyant and have been transported by ocean currents to the remotest place on the globe, including the Arctic and Antarctic (57). Media has only focused on reports of the relatively high incidence of plastic debris in areas of the ocean referred to as 'convergence zones' or 'ocean gyres' [58, 59, 60]. These sources are thought to be the main supply of ocean debris, but there are different main sources by region it varies. For example, fisheries and shipping are significant contributors in the southern North Sea and the East Asian Seas region (61, 62). In general, more litter is found closer to high population areas with low grade waste management, including a greater proportion of consumer plastic items such as bottles, shopping bags and personal hygiene products (63,64,65).

Reduce usage of single use plastic: In our daily life we often use plastic products we don't re-use. A polyethene bag or a plastic straw can be used more than once. The best way to prevent this is to use plastic products which can be reused. Reusable cups, bags, straws can help use reduce our gross plastic waste. The more we re use plastic products our tendency to discard these will decrease automatically.

Recycle properly: Only nine percent (9%) of plastic is recycled worldwide. To save the climate and the fauna we must be aware of our usage of plastics. Plastic bottles, bags and other plastic materials are dumped every year in the sea. Just by recycling them this problem can be cut short by a big margin.

Seashore clean-up: 1/3 of the total plastic waste come to sea from beaches and seashores. People went there to spend some good time but end up messing the beaches. To prevent this many NGOs or clubs arrange a seashore clean-up program to clean the seashore and make it as plastic free as possible. Moreover, many beaches around the world have been declared as a plastic free premise which means any kind of plastic product is prohibited there.

Avoid products containing micro beads: Tiny plastic particles are called microbeads. This one of the biggest reasons of plastic pollution nowadays. These are found face scrubs, toothpastes, body lotions and various products. These things flow through our sewers and end up in the ocean which harms the sea life a lot. If we use organic products more often it can reduce the microbeads by a big margin. We must stop using sanitary products which contains plastics, it is harmful for both nature and us.

Spread the awareness: In order to change the world we need to change the people around us at the first place. Charity begins at home, so we must start spreading awareness from the smaller circle like our home or neighbourhood. We must let people know what the cons of using plastic products excessively are and how it can affects the sea life as well as our life. We must let people know the ways to minimize plastic usage. Let's face the fact that we are highly dependent on plastic usage right now. Stop using plastic at the first go may not be possible but with time we can adapt the plastic free lifestyle. We the human beings, find it difficult to a daily routine but with right dedication it is not impossible. We still lack the awareness about our world; once it is restored the world will become a much better place.

NGO/Industrial initiatives

Algalita Marine Research Foundation: Nowadays Several NGOs are focusing on plastic debris in the ocean. The Algalita Marine Research Foundation has been prominent since 1997 in conducting ocean surveys and promoting research projects, initially in the North Pacific and extending into the North Atlantic and Indian Oceans. It is one of a number of NGOs that supports the 5 Gyres initiative, which is currently investigating the distribution of microplastics and POPs in each of the five main ocean gyres in conjunction with Pangea Expeditions and the UN Safe Planet Campaign.

Oceana: Oceanais a Washington D.C based group focusing to save ocean. Oceana gives efforts to end up the major sources of ocean pollution such as oil, mercury, aquaculture and shipping emissions.

Adidas: The company has revealed that they have sold over one million shoes made from ocean trash. Adidas in one of the biggest companies with this environmental friendly initiative. The shoes use a yarn developed by Parley that transfers the ocean plastic in mouldable polymers which is used to construct the shoes.

Conclusion

In this book chapter we have tried to sum up some of the problems which plastics creates by polluting our ocean and this problem is ever growing, so we must adopt both source reduction and clean-up strategies which modern science has to offer now. We have to organise awareness programme on "Why Plastic is so Harmful" and have to make some strong policies to ban the product. We have tried our best to sum up some solutions in this Book chapter.

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A study on the effect of COVID 19 pandemic in carbon management

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Introduction

Predictions were made earlier in the year as the pandemic was getting in full swing that CO_2 emissions would be greatly reduced due to the enforced drop in economic activity, travel, electricity consumption. The Covid-19 crisis in 2020 triggered the largest annual drop in global energy-related carbon dioxide emissions since the Second World War. Despite sharp drops early in the pandemic global emission of carbon dioxide picked up in the second half of the year. This paper studies the effect on Covid 19 pandemic as a boon to control carbon emissions or it is a temporary phase which may accelerate due to slowdown of carbon reduction projects and rapid recovery of economy.

Government policies during the COVID-19 pandemic have drastically altered patterns of energy demand around the world. Quéré et. al. (1) discussed on temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement and it explained that many international borders were closed and populations were confined to their homes, which reduced transport and changed consumption patterns. The population confinement is leading to drastic changes in energy use, with expected impacts on CO2 emissions. Many researchers (2-17) worked on the effect of CO_2 emission in our environment.

As per the article (18) infographic shows, global emissions are down by 6.3 percent. The largest contributor to this drop is the reduction in ground transport use down by 15.9 percent on 2019 and accounting for roughly half of the overall decrease. In Figure 1 the individual countries for which data has been published, Spain has shown the largest decrease compared to 2019, as of September 30. Many researchers (19-32) has worked on global carbon emission. But in this pandemic year where COVID-19 has blowout throughout the world, its effect has changed the global carbon emission and correspondingly the emission of greenhouse gas. This is discussed by many contemporary researchers (33-45). A statistical survey has been made about the drop in economy throughout the world by (46-51).

Thus in this paper we will study whether the Covid 19 has reduced the carbon emission or will it accelerates after the pandemic situation gets over.

After hitting a low in April, global emissions rebounded strongly and rose above 2019 levels in December. The latest data show that global emissions were 2%, or 60 million tonnes, higher in December 2020 than they were in the same month a year earlier. Major economies led the resurgence as a pick-up in economic activity pushed energy demand higher and significant policies measures to boost clean energy were lacking.

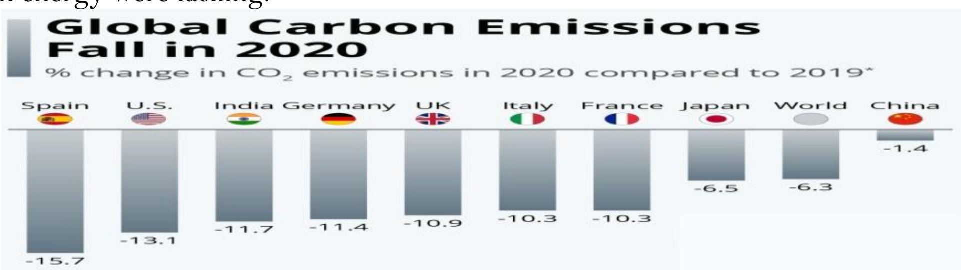


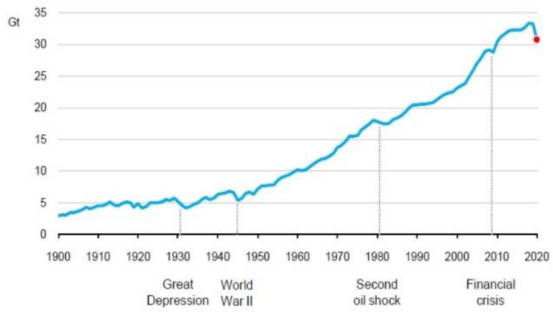
Fig. 1. Global Carbon Emission fall in 2020

The rebound in global carbon emissions toward the end of last year is a stark warning that not enough is being done to accelerate clean energy transitions worldwide. If governments don't move quickly with the right energy policies, this could put at risk the world's historic opportunity to make 2019 the definitive peak in global emissions.

Effect of COVID and carbon management

2020 was pivotal for international climate action and it began with high hopes but these numbers are a sharp reminder of the immense challenge we face in rapidly transforming the global energy system. In past crises of last 70 years, including the 2008 Global Financial Crisis, have all been associated with temporary drops in emissions, these reductions have been more than compensated by stronger growth of emissions in the following years (Fig. 2).

Emissions in China for the whole of 2020 increased by 0.8%, or 75 million tonnes, from 2019 levels driven by China's economic recovery over the course of the year. In India, emissions rose above 2019 levels from September as economic activity improved and restrictions were relaxed. In Brazil, the rebound of road transport activity after the April low drove a recovery in oil demand, while increases in gas demand in the later months of 2020 pushed emissions above 2019 levels throughout the final quarter. Emissions in the United States fell by 10% in 2020. But on a monthly basis, after hitting their lowest levels in the spring, they started to bounce back. In December, US emissions were approaching the level seen in the same month in 2019. This was the result of accelerating economic activity as well as the combination of higher natural gas prices and colder weather favouring an increase in coal use.



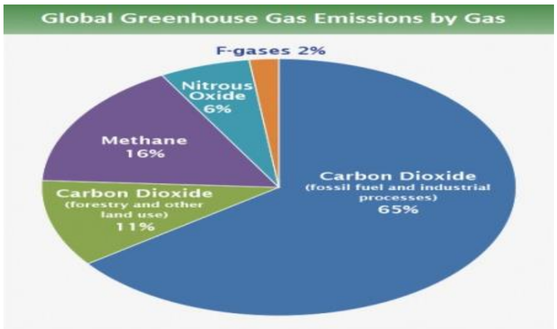


Fig. 2. Trends of Carbon Emission **Fig. 3. Proportion of Greenhouse Gas Emission**

Further the analysis of the key factors responsible for carbons emission and different ways used by countries to mitigate its effect is discussed below.

At the global scale, the key greenhouse gases emitted by human activities (Fig. 3) are:

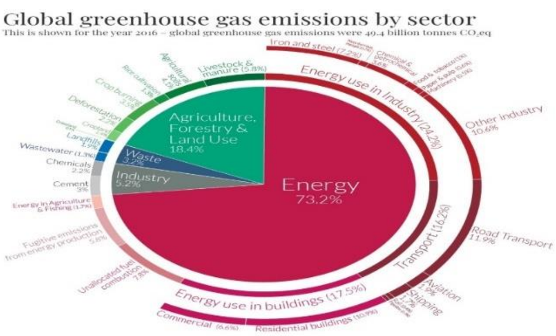
2 **Carbon dioxide (CO_2)**: Fossil fuel use is the primary source of CO_2. CO_2 can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation,

3 **Methane (CH_4)**: Agricultural activities, waste management, energy use, and biomass burning all contribute to CH_4 emissions.

4 **Nitrous oxide (N_2O)**: Agricultural activities, such as fertilizer use, are the primary source of N_2O emissions. Fossil fuel combustion also generates N_2O.

5 **Fluorinated gases (F-gases)**: Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Global emissions by economic sector: Global greenhouse gas emissions can also be broken down by the economic activities that lead to their production. As per data available from 2016 charts the distribution is given as follows:



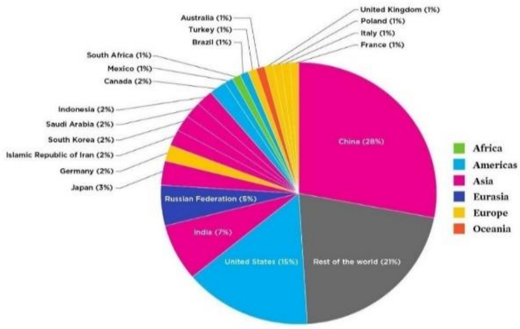


Fig. 4. Global Greenhouse Gas Emission **Fig. 5. Country wise CO2 emission**

Global greenhouse gas emissions can also be broken down by the economic activities that lead to their production. As per data available from 2016 in Figure 4 charts the distribution is given as follows:

Energy use in industry (24.2%): Energy-related emissions from the manufacturing of iron and steel, fertilizers, pharmaceuticals, refrigerants, oil and gas extraction, tobacco products and food processing. Non-ferrous metals, conversion of wood into paper and pulp, the production of machinery. Mining and quarrying, construction, textiles, wood products, and transport equipment

Transport (16.2%): This includes a small amount of electricity (indirect emissions) as well as all direct emissions from burning fossil fuels to power transport activities. These figures do not include emissions from the manufacturing of motor vehicles or other transport equipment – this is included in the previous point 'Energy use in Industry'.

Energy use in buildings (17.5%): Energy-related emissions from the generation of electricity for lighting, appliances, cooking etc. and heating.

Unallocated fuel combustion (7.8%): Energy-related emissions from the production of energy from other fuels including electricity and heat from biomass; on-site heat sources; combined heat and power (CHP); nuclear industry; and pumped hydroelectric storage.

Fugitive emissions from energy production (5.8%): Fugitive emissions are the often-accidental leakage of methane to the atmosphere during oil and gas extraction and transportation, from damaged or poorly maintained pipes, coal mining , use of machinery in agriculture and fishing.

Direct Industrial Processes (5.2%): Cement (3%): carbon dioxide is produced as a by-product of a chemical conversion process used in the production of clinker, a component of cement. Chemicals & petrochemicals (2.2%): greenhouse gases can be produced as a by-product from chemical processes

Wastewater (1.3%): Organic matter and residues from animals, plants, humans and their waste products decomposes to produce methane and nitrous oxide.

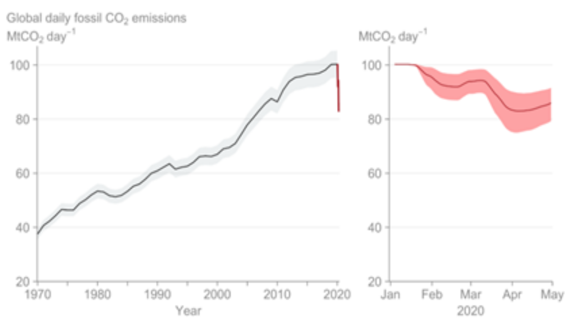
Landfills (1.9%): Landfills are often low-oxygen environments. In these environments, organic matter is converted to methane when it decomposes.

Agriculture, Forestry and Land Use (18.4%): Agriculture, Forestry and Land Use directly accounts for 18.4% of greenhouse gas emissions. The food system as a whole – including refrigeration, food processing, packaging, and transport – accounts for around one-quarter of greenhouse gas emissions.

Emissions by country

The world's countries emit vastly different amounts of heat-trapping gases into the atmosphere. The Figure 5 shows carbon dioxide (CO_2) emissions from the combustion of coal, natural gas, oil, and other fuels, including industrial waste and non-renewable municipal waste. Developed nations typically have high carbon dioxide emissions per capita, while some developing countries lead in the growth rate of carbon dioxide emissions. These uneven contributions to the climate crisis are at the core of the challenges the world community faces in finding effective and equitable solutions to global warming. According to preliminary estimates by the World Meteorological Organization (WMO), the annual global carbon dioxide (CO_2) emission reduced 4.2-7.5 per cent in 2020.

According to the estimate report at the global scale Figure 6, an emissions reduction at this scale will not cause atmospheric CO_2 to go down. CO_2 will continue to go up, though at a slightly reduced pace (0.08-0.23 ppm per year lower).



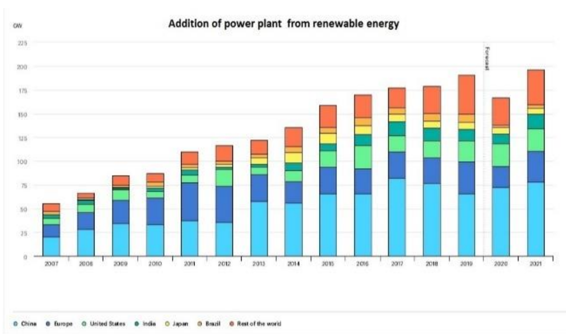


Fig. 6. Fall in Global Carbon Emission in 2020

Fig. 7. Addition of Power plant from renewable energy source in different Countries

Renewable power sources have so far demonstrated resilience in the face of the Covid-19 crisis. In figure 7 the share of renewables in global electricity supply reached nearly 28% in the first quarter of 2020, up from 26% during the same period in 2019.Despite this resilience, renewables' growth is expected to slow down in 2020. The world is set to add only 167 gigawatts (GW) of renewable power capacity this year – 13% less than in 2019. This decline reflects delays in construction due to supply chain disruptions, lockdown measures and social distancing guidelines, as well as emerging financing challenges. The majority of delayed utility-scale projects are expected to come online in 2021, but installations of rooftop solar PV for businesses and households may continue to be depressed in the medium term without strong government support.

Beyond electricity, renewables have been less resilient. Transport biofuel production is expected to contract by 13% in 2020 – its first drop in two decades. Renewable heat consumption is also likely to decline in 2020, mainly due to lower activity in the industrial sector. Adding to these difficulties, low oil and gas prices are making biofuels and renewable heat technologies less cost-competitive.

Governments have an unprecedented opportunity to accelerate clean energy transitions by making investment in renewables a key part of stimulus packages to reinvigorate their economies. Investing in renewables, whose costs continue to fall rapidly, can stimulate job creation and economic development while reducing emissions and fostering further innovation.

Carbon reduction projects

A carbon offset is playing a pivotal role in reducing carbon emission where an individual company or organization directly or indirectly (by funding projects in other locations) removes greenhouse gases from the atmosphere or prevents a certain quantity of greenhouse gases from being released. Four major types of Carbon offset projects are undergoing for reduction carbon footprint

1. Forestry and conservation: Reforestation and conservation have become very popular offsetting schemes. Credits are created based on either the carbon captured by new trees or the carbon not released through protecting old trees. These projects are based all across the world; from growing forests right here in the UK to replanting mangroves in Madagascar, to "re-wilding" the rainforests of Brazil. Forestry projects are not the cheapest offset option, but they are often chosen for their many benefits outside of the carbon credits they offer.

Effect of COVID 19: Conservation was particularly hard hit in tropical countries. Many NGOs pulled out of field projects, conservation livelihood models dependent on ecotourism and research evaporated, and governments in countries like Brazil and Indonesia relaxed environmental regulations and law enforcement, unleashing a spasm of illegal logging, mining, land invasions, and forest clearing. Deforestation in Brazil, which was already trending upward before COVID, hit the highest level since 2008. The pandemic has resulted in several conditions that would be expected to favour a rise in deforestation. Prices for most major commodities that drive deforestation, including palm oil, soy, and timber, have increased since the start of the year. Additionally, government stimulus in tropical countries, where it exists, has been oriented toward infrastructure and supporting existing industries. Government priorities have also shifted to health and social programs, diverting resources from environmental law enforcement.

2. Renewable energy: Renewable energy offsets help to build or maintain chiefly solar, wind or hydro sites across the world. By investing in these projects, a company is boosting the amount of renewable energy on the grid, creating jobs, decreasing reliance on fossil fuels, and bolstering the sector's global growth.

Effect of COVID 19: In Fig. 8 we see that global renewable electricity capacity additions were over 11% lower in the first half of 2020 than in the first six months of 2019: developers connected an estimated 40 GW of solar PV, 17% less than last year, while wind expansion was down nearly 8%. Conversely, hydropower capacity additions increased in the first half of 2020, mostly owing to the commissioning of large-scale projects in the People's Republic of China ("China"). The impact of lockdowns and movement restrictions varied by country and technology, and Fig. 9 shows that in most countries not only did renewable energy developers not halt construction, but they accelerated their installation activities once restrictions were eased to make up for delays. New wind installations in China declined by 50% and solar PV by 25% in the first three months of 2020. As the pandemic began to recede and lockdown measures were eased, China's growth regained momentum with utility-scale PV, wind and large hydropower plants being installed at a faster pace.

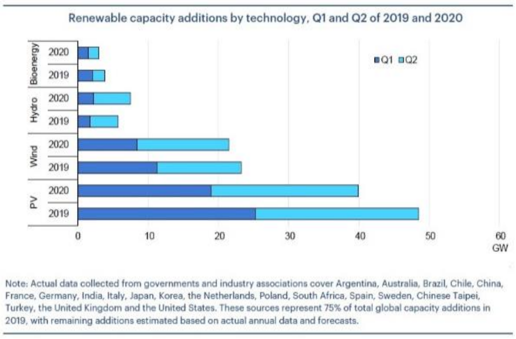


Fig. 8. Addition of Renewable capacity addition

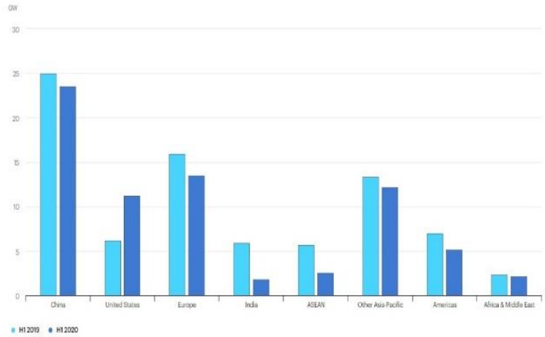


Fig. 9. Addition of renewable capacity addition by countries

3. **Community projects:** Community projects often help to introduce energy-efficient methods or technology to undeveloped communities around the world. There are many potential benefits to these projects that far surpass carbon credits. Projects like this do not only help to make entire regions more sustainable, they can provide empowerment and independence that can lift communities out of poverty. This means that projects that were, at one time, purely philanthropic can now provide organisations with direct benefits like carbon credits. For example, the female-led Water, Sanitation and Hygiene (WASH) project in Ethiopia provides clean water to communities by fixing and funding long-term maintenance for boreholes. Families will no longer have to burn firewood to boil water, which will protect local forests, prevent carbon emissions and reduce indoor smoke pollution.

Effect of COVID 19: Analysis shows that the impact of COVID-19 influenced the following aspects: a) health effects; (b) psychological aspects; (c) opportunity for new projects; (d) opportunities for new research; (e) sharing social and sustainable aspects with the community; (f) creating new working methods at the university; and (g) actions for the community and partnerships h) funding for projects . Government should engage local communities to implement national climate policies by giving incentives and employment.

4. **Waste to energy:** A waste to energy project often involves capturing methane and converting it into electricity. Sometimes this means capturing landfill gas, or in smaller villages, human or agricultural waste. In this way, waste to energy projects can impact communities in the same way efficient stoves or clean water can.

Effect of COVID 19: Broadly defined, WTE facilities include the approximately waste combustors around the nation that produce steam or electricity from municipal solid waste (MSW), anaerobic digestion facilities that process organic waste such as food waste, animal manure or wastewater sludge to produce renewable natural gas (RNG), and landfills that produce electricity from the methane they generate. RNG from landfills, agricultural wastes, wastewater, and other sources has increased about 30 percent annually over the last few years. The impacts of Covid-19 and the federal, state, and local government orders addressing the pandemic are very likely to: (1) extend project development and construction timelines, and (2) reduce and alter the generation of MSW and other types of non-agricultural waste around the nation in the near future, and potentially over the longer term.

Conclusion

For Covid-19 recovery from slowdown, governments are spending at an unprecedented scale with good percentage of GDP in 2020. Most governments have focused on funding rescue measures to reboot businesses and jobs in their immediate economic response to Covid-19, with only a few including conditions that encourage businesses to decarbonize. Additional stimulus must focus on recovery and rebuilding, accelerating an energy transition in the power sector, transport, and urban planning. Without this, the likely drop in emissions from the lockdown will rise again without a green recovery. A long-term strategy may be the most convincing and coherent way of articulating to the international community about ongoing development needs (which are unlikely to be exhausted by 2050). It is imperative that the focus remains on not only a 'green recovery' but a resilient one that is beneficial over the long-term. The reduction in GHG emissions in 2020 due to Covid-19 is likely to be significantly larger than the 1.2% reduction during the global financial crisis in the late 2000s. But, 2020 is currently on track to be one of the warmest on record, with wildfires, droughts, storms and glacier melt only intensifying. A fall of 7% in CO_2 emissions this year means only a 0.01 degree C reduction of global warming by 2050. On the brighter side, the report says there is scope for course correction now. Investing in zero emission technologies and infrastructure, reducing fossil fuel subsidies, not building any more coal plants, promoting nature-based solutions like large-scale landscape restoration and reforestation could put emissions in 2030 at 44 $GtCO_2e$ which would mean a 66% chance of keeping global temperature rise to below 2 degree C compared to pre-industrial levels. However, UNEP's Emissions Gap report shows that a green pandemic recovery can take a huge slice out of greenhouse gas emissions and help slow climate change.

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Development of clean and smart campus in India

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Introduction

Nowadays it is a major concern that the campus should be clean and smart. So this is our aims to engage the stakeholders specially the students to draw their attention towards immense scope and potential that the Technology offers for abstract objectives such as cleanliness, sustainability, environment etc. The rising use of technologies especially IOT, robotics, cloud and automation have immense potential to re-model a campus in to a clean and smart campus. The clean and smart campus can optimize the use of energy and water consumption. Clean and Smart campus can produce smart citizens, who can lead our nation towards clean and smart.

Smart Campus will emphasize mainly on the three aspects 1) reduce consumption of natural resources (such as paper, gas, energy etc. 2) Alignment of the latest digital trends like IoT, Big Data and Cloud Networking to achieve various aspects of sustainability in the campus, specifically to contribute to United Nations SDGs 3) Create an ecosystem to 'smartly' connect and share the information with each other at campus and national level.

Clean Campus will emphasize on four areas 1) Cleanliness in and around the campus and waste minimization. 2) Water conservation and management including waste water management and reuse, rain water harvesting, etc., 3) Environment-friendly activities adopted and practiced by the campus 4) Greenery within the campus to provide pollution free air and carbon-sink.

The topic of smart and clean campus has been in air since 1992 after the agenda 21 was passed in the earth summit of Rio de Janeiro. A green campus is a place where environmental friendly practices and education combined to promote sustainable and eco-friendly practices such as power, water and cleanliness in the campus. An institute should strive to develop a smart and clean campus on a self – sustainable basis in the areas of power, water and cleanliness. The clean and smart campus concept offers an institution the opportunity to take the lead in redefining its environmental and economic culture and developing new patterns by creating sustainable solutions to environmental, social and economic needs of the human being. Clean campus is often the first step institution/universities take towards sustainability. In India the cause of development for the smart and clean campus is being supported by the government and the government has prepared certain guidelines for the colleges or university to follow under the regulation of AICTE with the help of TERRE policy center and SCCN (Smart Campus Cloud Network).

The main emphasis for making a green campus is put on the energy conservation and waste management acts laid by the government. The waste management acts are E-Waste rules 2016 clearance, Hazardous Waste rules 2016 clearance, Solid Waste rules 2016 clearance, Bio-Medical waste rules 2016 clearance, Air act 1981, Water act 1974, Environment protection act 1986.

Development of a smart campus

Some of the most important points to make a smart campus are energy, water, travel and transport, biodiversity and waste management.

Energy: Sustainability in energy can be achieved through the production of electricity and lower consumption of electricity. The present method of producing electricity are still the thermal power plants that produce almost 38% to 61% of the total electricity that we still use today. This electricity is mainly produced using coal, peat and natural gas (1). This leads to the use of a lot of fossil fuel and sooner or later the reserves of these fuels will become empty leading to a crisis of fuels to produce electricity. So the way to produce sustainable electricity is harvesting the solar energy of which only 1% is used by the life on earth other 99% is reflected back in space, so, we may use this enormous energy to produce all the energy we need on the planet. So to start this of we may put up solar panels and build up energy efficient electrical appliances that will use much lower electricity than that being produced.

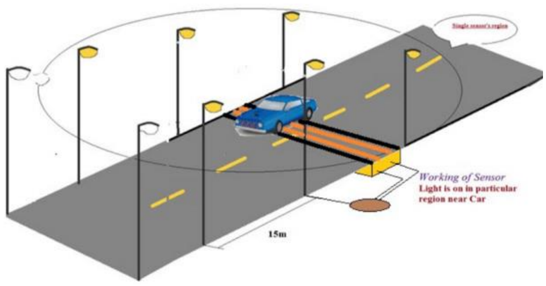
Solar power: This is a renewable never-ending source of power that can be harvested for clean energy without damaging the environment. This is also very cost effective (2). This area of clean energy development also provides an area for innovation, research and development (3). To harvest the solar energy the main components required are storage cells, solar panels and area to set up the solar power station in the campus, for this we will have to use as much space we get properly. To harvest the solar power across the campus, we need as much as area that can be provided to set up the power station for the campus as the watts of power produced by the solar panels is very less. To get the adequate amount of energy from the solar radiation we can also think of mounting the solar panels on the lamp posts present in the campus with attached storage cells and smart lighting system. Solar panel can be installed in the rooftop of the building (Fig. 1).

Fig. 1. Solar Panels are installed in the rooftop of the building.

To harvest the solar power for the buildings we can use the terraces to put up the solar panels and also the shades outside the buildings to put up the solar panels where either the shades can itself be made of the panels orthe assembled panels can be directly attached to the shades. The storage of all these can be done in a massive inverter type battery that can store the energy harvested by the solar panels and also connect to the main circuits of the building when necessary(4,5).

Smart lighting system: For any campus to become a energy efficient campus this is one of the most important thing because to keep the lights switched on all the time in the night a huge amount of energy is wasted and this can only be reduced when the lights turn off when not in use (6,7). The smart lighting system (Fig. 2) consists of a programmable processor that can control the whole process, a passive infrared sensor, and the lights. All this can be mounted on the lamp posts (8). The infrared sensors detect the movement of a set dimension of object and initialize the processor. If the movement is detected close to the sensor the lights turn on and as the target moves away the lights start turning off (9). Figure 3, shows the block diagram of lighting control system. The lights can also be timed to light up at a particular time of the day or photo sensors and LDRs can be used (10, 11).

Energy efficient electrical devices: The next most important thing to note is the use of energy efficient appliances to save or lower the use of energy that the appliances in the campus use, so that the energy produced inside the campus is enough to run them and so that no more energy is needed from external sources (companies that provide electricity). This way the campus can also become self-



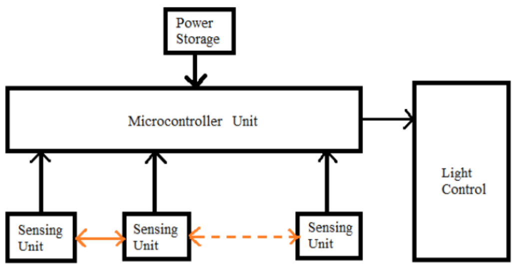


Fig. 2. Smart lighting system **Fig. 3. Block diagram of microcontroller unit**

sustained and also run on clean energy (12, 13). The energy efficient devices should be selected by checking the number of stars printed on the appliance. The more the stars the more the energy efficient the device is.

Setting up biogas plant: Biogas is another important thing of concern; this is the only fuel that can replace fossil fuel (14). All the fossil fuel needs in the campus like cooking, running heavy appliances can be done by the use of bio gas (15). The process of making bio gas is very simple and also cheap in the long run. The most common form of bio gas setup is the dome shaped bio gas plant used for domestic purposes. Figure 4, represents the diagrammatic representation of Biogas Plant.

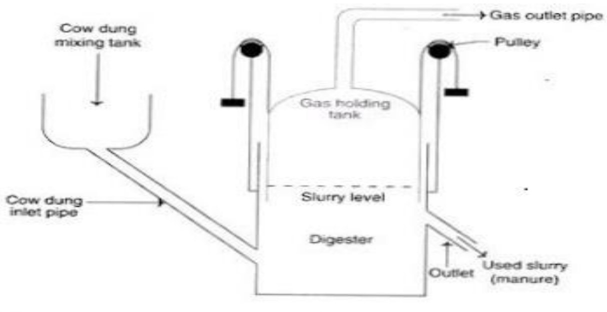


Fig. 4. Biogas Plant (Gobar gas Plant)

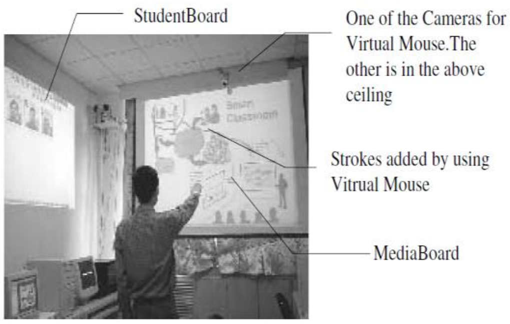


Fig. 5. Modern Class room

In the process:

1. The slurry is poured down in the mixing tank,
2. This enters the digestion tank,
3. The slurry undergoes anaerobic digestion. The bacteria that help the process are – mesophilic, thermophilic and cryophilic.
4. The gas is collected in the centre tank above the slurry level and this part is known as gas holding tank.
5. The gas is collected through the outlet pipe controlled by a valve
6. The manure is collected from the digester from a second outlet (16).

Transport inside the campus: The transport inside the campus is also a great campus to keep the campus clean. Ideally the campus should be free of any pollution but since that may not be possible so the emission inside and around the campus should be controlled and kept in check all throughout. To do this the best ways possible are as follows-

1. The premises should be declared as low emission zone and the vehicle that enter or leave the premises should have proper pollution certificates from the government (17).
2. The transport facilities inside the campus should run on electricity as much as possible. So the promotion of electric vehicles inside the campus should be taken with great enthusiasm (18-20).
3. We may also use solar vehicles inside the campus. These are special vehicles that run on very less electricity and also have solar panels attached on the roofs to charge the battery (21).

Modern Classroom: Some of the main points to be covered under this topic is the modern way of teaching which is mostly done using the audio visual methods. The key points to develop a modern classroom are free unlimited Wi-Fi, CCTV surveillance inside and around the campus, lesser use of papers and Modern Classrooms (Fig. 5)

Free unlimited Wi-Fi: This has become perhaps the most important feature from the perspective of a student, because it is the internet where we students and also the teachers can connect with other fellow students or fellow teachers across the globe and share vital information and new ideas that can bring about innovation across the world and improvise many new technologies and improve the existing once. Not only this, on the internet the students get to connect with many famous personalities and get a chance to exchange their thoughts to learn even more and get new ideas and find innovative solutions for problems. Through the internet we also get access to millions of books and journals to study and clear the concepts any time we want. So this addition of free Wi-Fi is a must to develop a smart campus to provide students the opportunity to connect with the world (22-25).

CCTV Camera in and around the campus: CCTV surveillance is an important criterion now a days due to the various problems that occur in and around the campus. CCTV is the only way to monitor all the incidents that happen in and around the campus because not many people are available to keep a watch all over the campus if the campus is spread over a very big area. It can also be used to keep in check the various incidents of ragging and other humiliations that are faced even now in a few campuses around the country (26-28).

Lesser use of paper: This is a very important factor nowadays. Looking at the scenario of the recent incidents all around the world, the most important factor behind all those catastrophes is global warming and the most important reason behind global warming is deforestation or the reduction in tree cover all around the world. So by the lesser use of paper we save the trees from being cut down as well as use the latest technologies available for educational purposes by using e-books instead of using classic books made of paper. We also get to use more than one book that way and also get those books mostly for free as the price of making the book reduces to zero (29). This way we not only make a smart campus but we also come a step closer to make the campus clean and green. The classrooms equipped with all the technologies to provide a better learning experience is called a modern classroom. The modern amenities required for this are smart boards, projectors, computers, LAN connections for all students for faster file transfer within the classroom, etc. New IOT based learning can also be implemented for further improvement to keep at par with the already advancing technologies (30). To make the classrooms more modern and smart we may also apply collaborative learning (31, 32).

Collaborative learning has the four main characteristics which are:

1. Sharing the vast knowledge the teachers have to the students in such a way that they can understand and build on it properly.
2. Sharing ability of the students is also an important thing in collaborative learning. It allows the students to share their innovative ideas with the faculties and teachers to find solutions to problems and enhance and develop the existing technologies using their ideas. This may also help in talent cultivation and also help in boosting the innovative ideas that spring up in the younger minds.
3. Mediation is also a very important point because it is mediation that helps or speeds up the process of data and idea transfer from the teachers to the students and vice versa. If the mediation keeps happening in real time the learning process of the students increases and if the mediation process is slow the students require a lot more time than usual to process and understand the lessons they learn in class. Here if the data transfer happens through LAN on the classroom than the data transfer happens in real time through the optical cables used in the LAN connection, so here the students will learn as they here the lecture of their teacher as they will have all the material that the teacher is teaching them (33).
4. Heterogeneity is also another point as the groups or classrooms that contain students from all segment of culture and society learn to adjust and work with people of different segments that makes them a better team leader or a team participant because he or she will know the importance of such people in the group and they will also know how to respect them (34).

Development of a clean campus: Cleaning is one of the most important measures to make a clean campus. Essential daily and/or weekly campus cleaning includes:

1. Sweeping and mopping all the hard surface of classroom dormitory building.
2. Vacuuming floors and carpets properly.
3. Cleaning the walls, windows of rooms and buildings throughout campus.
4. Maintaining hand soaps and toiletries in public and dormitory rest rooms.
5. Maintain the drains to assure that floors drain and dry properly after cleaning.
6. Proper storage of cleaning equipment.
7. Use of effective and safe cleaning products in restrooms, cafeterias and food preparation spaces.
8. Creation of cleaning schedules should be checked and maintained by cleaning staff.

Water conservation

In the recent years water scarcity has become a very important global concern (35). The availability of fresh water throughout the continents is a very big concern as the majority of the world's population

does not have access to fresh water or at least face the problem of water scarcity for a month in the entire year. This problem of water can be solved by conserving and replenishing the fresh water reserves in the world. For this to happen we must try to implement this methodology in the campus so that we can not only make the campus clean but also help the society by this process.
Some of the various steps that can be taken:-

1. Using sensor fitter taps- These taps have infrared sensors fitted on them to locate the position of hands around the taps, when the hands come close to the tap, water starts flowing from the tap and when the hands are taken far from the tap the water stops. This will help in stopping the wastage of water with the help of smarter technology.
2. Water recycling- This process helps to recycle used water inside the campus for various purposes (See Figure 6)
3. Rain water harvesting- This process will help to replenish the fresh water storages in and around the campus.

The main processes of water recycling:

1. Primary process- This involves the implementation of various barrier or mechanical processes to filter the water.
2. Bar screens- The waste water is passed through a frame of bars to remove large objects like sticks.
3. Grit chamber- in this process air bubbles are passed through the water to help settle down small particles.
4. Primary clarification- in this process the water is stored to let the large solid debris settle at the bottom of the tank and the clear water is removed for further filtration.

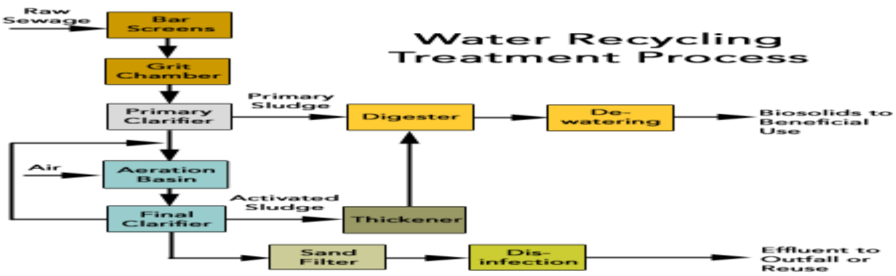


Fig. 6. Diagrammatic representation of Water Recycling Treatment Plant

1. Secondary process- In this process the rest of the filtration is done.
2. Aeration basin- the water after primary process is treated with oxygen so that the microorganisms digest the bio degradable wastes.
3. Final clarifiers- now after aeration the solids are settled in the final clarifiers.

4. Advanced treatment and disinfectants: In this process the water is filtered for any other solid materials that remain, and the water is mixed with disinfectants like chlorine to treat the water of any harmful microorganisms. This can be done in the following ways- Sand filters, Disinfectants and DE chlorination and Outfall (36, 37)

Waste management: This is also a major concern to keep the campus clean. If the campus is having litter here and there the campus feels unclean. So the process of waste management should be the first major concern to keep the campus clean and tidy and this also maintains the hygiene in the campus. It has been observed that the garbage creates an unsanitary condition for individuals and creates a horrible smell around the environment due to flooded waste each and every day that leads some hazardous in the society. With the help of the IoT based waste management system we can identify the bin which is full of waste material and that can be clean fast (40). The process of waste management is not only how to classify waste but also how to reuse it. This can only be done by the help of all the people in the campus. The methods that can be followed are-

- Segregation of waste by the material it is made of- A college campus is the place where many people reside, so there will be a variety of wastes, so the waste should be segregated first on the material it is made up of. There should be at least 3 type of bins at regular gaps in the campus, they should be bio degradable waste can, plastic and glass can, and metal scrap

- The waste management system in the campus should work on the mechanism of recycling or reusing the wastes rather than throwing them.
- The biodegradable waste can be reused as follows:-

1. The cooking wastes can be used to feed the animals and birds in the campus
2. The other wastes like the food wastes and other biodegradable wastes can be used to make manure by composting them and these can be used as fertilizers for the plants in the campus.

- Recycling the plastics to make innovative objects or invent new technologies that reuses that plastic for better purposes as follows:-

Fig. 8. Road of Plastic

Fig. 9. Making Fuels out of Plastic

- Making roads of plastics (Fig. 8) (41)
- Making fuels out of plastics by using the process of pyrolysis (Fig. 9) (42, 43)
- Recycling the glass to make other glass objects by remolding them into useful objects and trying new combinations with glass to try and make it stronger.
- Reusing the metal scraps to make better objects and also trying out new combinations to make alloys or other such stuff for different uses. These scraps can also be used to make furniture, and other crafts (Fig. 10).

Fig. 10. Reusing the metal scraps

Fig. 11. Biodiversity of the campus

Biodiversity

This is also an important fact that decides the vibes of the campus. The biodiversity of the campus makes the campus look very clean and also provides a very good atmosphere for the students. The biodiversity includes both flora and fauna in the campus. The trees in the campus helps reduce the pollution levels in the campus and if all the steps are properly implemented the campus alone can keep the pollution index of the area a lot lower than present situations in the long run (Fig. 11) (44).

Conclusion

In this book chapter, we have tried to sum up as much as important points and value of the development of such campuses in the country to develop a self sustained environment that can not only benefit the students but also the society to develop a better environment and pollution free atmosphere in and around the campus. I believe that if these points are followed in developing the campuses the outcome would be more valuable than the investment is concerned and this would also start a chain of development of processes that are more concerned to the future of the young minds as well as the planet.

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Effect of Environmental Parameters on the water quality of Narmada River, Hussain Shah Lake, The Ganges, and Some Water Samples Collected from North-East India: A Study

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Introduction

Water is the main requirement for human and industrial growth. New water demand increases because of an increased limit of industrialization. Most of the industries use river water; in another way, river water is also used for human and agricultural purposes. Industries are ejecting waste on the river that would be the main reason for the river's water pollution. It affects human life as well as aquatic life. Many such reports of such an organization, e.g., WHO, CPCB, BIS, ICMR, said that 70% of river water contaminated and that water is below the quality level for human use (1,2). Different approaches to saving river water have been mentioned in this literature (3-5). In (6), they approached a method for determination of water quality with a practical and useful purpose. Some of the different biological, physical, and chemical parameters for determining the water quality indices using various mathematical equations (7). There are two mandatory steps for the calculation of water quality indices. The first one is the transformation of the selected water quality characteristics into sub-index values. Second is the aggregation of these values for the water quality index value. Various studies on the water quality indices were reported in the literature by many researchers (8-21). Another side researchers have introduced a water quality index method for India. That indexes use from 0 to 100 from highly; in water to unpolluted water (22-24). National Sanitation Foundation water quality Index (NSFWQI) and Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI)in this study has made a study for the case of Narmada River, it is reported as the largest river in India. This report has contained the physicochemical and biological parameters on the quality of water.

River Yamuna is crossing the Capital of our country New Delhi, and a research paper has concluded that the Yamuna river is one %or the area has been covered inside Delhi. However, it contains 50% of the total pollutant found in the river (25). Delhi is the most vital state, as well as capital situated in Northern India. Urbanization is growing very fast. In that case, the census has reported that in the year 2001, there is 13.9 million ofthe population, and in the year 2011, the community has reached 16.8 million (Census of India, 2011). For up growing and increasing population purposes, there are much-needed urbanization as well as industrialization is going on, in the top metro cities, that occurs Heavy metal pollution in India's rive (26-28). There are two sources of entering heavy metals in the rivers, either natural or anthropogenic sources (28). The various experiment has been done on the heavy metal finding purpose, most of the cases in river Yamuna there have merely presented the heavy metal concentrations.

Hussain Sagar lake is situated in Telangana. This is a human-madelake in Asia, built by Hussain Shah Wahi, in the year of 1562, under the ruling of Ibrahim QuliQutub Shah. The only problem on the lake is the excessive amount of Sulphateand pHosphate, which leads to the growth of cyanobacterial algal blooms andaquatic weeds. Eutrophication of the lake causes decompositionof the aquatic plants and algae, depletion of dissolved oxygen leading to massive fish kill (29-31). In this context, a comprehensive study has been initiated for monitoring pollution and purification. The aim of the present study has been undertaken for the present study of various physiochemical parameters, which are the leading cause of water pollution as well as the water crisis.

Study Area

Narmada's route is Madhya Pradesh, Gujarat, Chattisgarh, and Maharastra, and finally, it is going to Arab Sagar, as we can see in fig-1. It covers nearly 3% of the geographical area of the country. There are eight (08) water quality stations at Barmanghat, Dindori, Handia, Hoshangabad, Madleshwar,Manot, Garudeshwar, and Sandia on the mainstream of river Narmada. In comparison, ten (10) water quality stations are locatedat its tributaries viz., Orang, Banjar, Sakkar, Burner, Sher, Ganjal, Uri, Kundi, Hiran, and Goi. Narmada River has 41tributaries (22 and 19 are on the left and right bank). Out of 41 essential tributaries, the Burner, Banjar, HiranTawa,ChotaTawa, Orang, and the Kundi River are the major tributaries. (*Source: Central Water Commission, Ministryof Water Resources, Narmada Basin, Version 2.0, March, 2014.*).

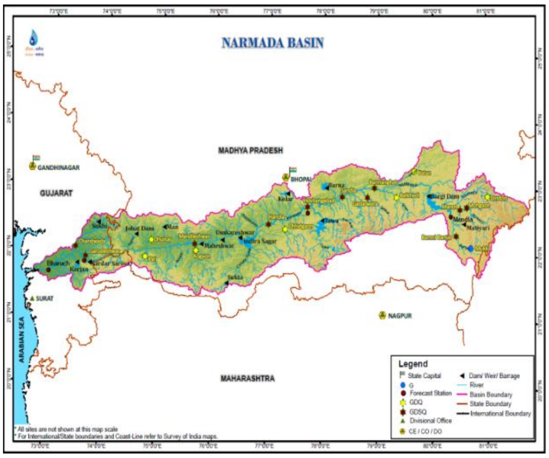


Fig. 1. Narmada Basin's flow routes inside of different states. (Collected from Internet)

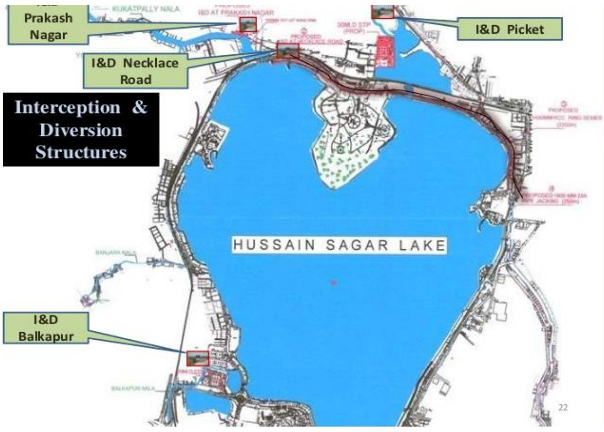


Fig. 2. Hussain Sagar lake and surroundings. (Collected from Internet)

Hussain Sagar lake is located at 17.45°N 78.5°E, 510 m above the sea level. The lake connects the twin cities of Hyderabad and Secunderabad, and it was initially used as a source of drinking and irrigation water from 1894–1930. The maximum surface area of the lake is 5.7 km2, the present water spread area is 4.81 km2, the basin area is 240 km2, shoreline length is 14 km, storage volume at spill level is 28.6 × 106m3, average depth at full capacity is 5.2 m, and the road bund level is 5.18 m. In addition to stormwater, due to rapid residential and industrial growth in its catchment area, the lake is fed by four significant drains (*nalas*), which act as feeding channels. A million liters per day (MLD) of domestic sewage and solid waste is discharged into the lake through Balkapur (13.3 MLD), Banjara (6 MLD), Kukatpally (70 MLD) and Picket (5.7 MLD) *nalas*. In addition to untreated sewage, Kukatpally*Nala*also discharges industrial effluents. The primary source of litter includes polythene bags, plastic cups, food wrappers and covers (32-37).

The River Ganga (2,525 km long) is the largest river basin in India, covering 26.2 percent of India's total geographical area. The river originates from the Himalayas and reaches the head of its delta at Farakka (in West Bengal) below the Rajmahal bend. Below Farakka, the river bifurcates into the River. Padma (flowing southward to Bangladesh) and the River Bhagirathi (Ganga), which flows southward over the deltaic plain of West Bengal to reach the Bay of Bengal (38,39). The hydrological characteristics of the River Ganga in West Bengal.

Fig. 3. River Ganges Route in different cities, Top view. (Collected from Internet)

Materials and Methods of Analysis: Water quality management on the upper surface is not an easy task. Through this analysis, we can save the life of aquatic animals as well ashuman being also. It is measured through some of the parameters, like, Turbidity, ph, temperature, Dissolved and Suspended solids, dissolved oxygen, compounds of phosphorus and nitrogen, anion and cation analysis, BOD (biochemical oxygen demand), COD (chemical oxygen demand).

pH: According to various renowned sources like WHO, ICMR, CPCB, BIS, the range of pH lies between 6.5 TO 8.5. If the quantity is less, than it will not have the minerals and vitamins for the daily need of a human being. If the limit exceeds 8.5, then it causes the water salty and will be the reason for eye irritation. Skin disorder will happen when the border goes beyond 11. The rainwater has a pH of 5.5 to 6, and it will not affect human health. For aquatic animals, the range must be at 3.5- 4. (40,41).

Dissolved oxygen: Dissolved oxygen controls the biological parameter due to aerobic and nonaerobic phenomenon, and that signifies the life of aquatic as well as human beings (42). If there are low values of DO, then the marine life will be disturbed. (Cox, 2003).

Biochemical oxygen Demand: The standard is given by CPCB and BIS, that the allowable limit is 2-3 mg/lit. BOD is used for the determination of oxygen for stabilizing household and industrial purposes. (43). Disposal from industries will contaminate river water and groundwater. According to those drinking waters, BOD should not increase more than 6 mg/ lit. The range of DO lies between 4 to 6 mg L^{-1}ensures better aquatic lifein the water body (41-43).

Turbidity: The increasing quantity of turbidity will result in the interference between the penetration of light. This will destroy the aquatic life, and this will also deteriorate the quality of surface water. In the session of monsoon, massive soil erosion will occur, and suspended soils increase the turbidity. Which affects the river and aquatic life? (44-46). Due to this reason who icmr and BIS proposed a maximum range of turbidity that is between 2.5 to 5.

UV- VIs Spectroscopy: Ultraviolet-visible (UV-VIs) spectroscopy is one of the most popular analytical techniques because it is very versatile and able to detect nearly every molecule. With UV-Vis spectroscopy, the UV-Vis light is passed through a sample, and the transmittance of light by an example is measured. From the transmittance (T), the absorbance can be calculated as A=-log (T). An absorbance spectrum is obtained that shows the absorbance of a compound at different wavelengths. The amount of absorbance at any wavelength is due to the chemical structure of the molecule.

Ion Chromatography: The term chromatography is the generic name for a wide range of physio-chemical separation processes in which the components to be separated are distributed between a stationary and a mobile phase.An analytical method where a substance mixture is appearing in just one color is divided in a way that different colors become visible. The technique is used to separate chemical substances that are chemically quite similar and though challenging to separate.

In Greek, Chroma = Color, Graphy = To write

Water Quality Index: There are many such methods to calculate Water quality index, including physicochemical and biological parameters. Were reported in this paper. (47-53).

Weighted Arithmetic Water Quality index (WAWQI): Horton, in 1965 has proposed the WAWQI method. He used eight parameters like nitrate- nitrogen, ph, dissolved oxygen, phosphate, biological oxygen demand, turbidity, temperature, and total dissolved solids.

$$WAWQI = \frac{\sum_{i=1}^{i=n} Q_i W_i}{\sum W_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

W_i= unit weight for each water quality parameter;

1. = proportionality constant;

Q_i= the quality rating scale for each parameter;

Q_{actual}= estimated concentration of*i*th parameter in the analyzed water;

Q_{ideal}= the ideal value of this parameter in pure water,Q_{ideal}= 0 (except pH = 7.0 and

DO = 14.6 mg L^{-1});$S_{standard}$= recommended standard value of*i*th parameter;

9. = number of water quality parameters.

National Sanitation Foundation Water Quality Index (NSFWQI): The National Sanitation Foundation WQI used nine different parameters namely, Nitrate-Nitrogen (mg L^{-1}), pH (units), Dissolved Oxygen (% saturation), Fecal Coliform (colonies/100 mL), Phosphate (mg L^{-1}), Biological Oxygen Demand (mg L^{-1}), Turbidity (NTU), Total Dissolved Solid (mg L^{-1}) and Temperature (°C).

$$NSFWQI = \sum_{i=1}^{n} W_i Q_i \quad \text{.................................... (2)}$$

Where,

- = number of water quality parameters;

Q_i= sub-index for ith water quality parameter;

W_i= weight (in terms of importance) associated with the ith water quality parameter.

Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI): Canadian Council of Ministers of the Environment (CCME) (2005) has proposed a method for the calculation of WQI using three factors (Scope, Frequency, and Amplitude). This formula is the modification of the mathematical expression given by the British Columbia Ministry of Environment, Lands, and Parks, and Alberta Environment. Four variables sampled four times must require for the calculation of WQI using CCMEWQI. Canadian Council of Ministers of the Environment WQI used eight parameters Nitrate-Nitrogen (mg L^{-1}), pH (units), Dissolved Oxygen (mg L^{-1}), Phosphate (mg L^{-1}), Biological Oxygen Demand (mg L^{-1}), Turbidity (NTU), Total Dissolved Solids (mg L^{-1}) and Temperature (°C) for the calculation of WQI. The various mathematical equations used for the three factors are as follows:

1. Scope: F_1 (range) defined as the ratio of several failed variables to the total number of variables.

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}}\right) \times 100 \quad \text{.................. (3)}$$

2. Frequency: F_2 (frequency) represents the percentage of individual tests that do not meet the objectives (failed tests):

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}}\right) \times 100 \quad \text{.................. (4)}$$

1. Amplitude: F_3 (amplitude) represents the amount by which failed test values do not achieve their goals. F_3 is calculated in three steps as follows:
   a. The expression for the cases when the test value must not exceed the objective and must not fall below the objective is given by

$$\text{excursion}_i = \left(\frac{\text{Failed Test Value}_i}{\text{Objective}_j}\right) - 1 \quad \text{.................. (5)}$$

$$\text{excursion}_i = \left(\frac{\text{Objective}_j}{\text{Failed Test Value}_i}\right) - 1 \quad \text{.................. (6)}$$

This step is comprising of summation of excursions calculated in step (i) divided by the total number of tests and is given by the following expression:

$$nse = \frac{\sum_{i=1}^{n} \text{excursion}_i}{\text{Number of tests}} \quad \text{.................. (7)}$$

- ➢ F_3 is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives(NSE) to yield a range between 0 and 100.

$$F_3 = \left(\frac{nse}{0.01nse + 0.01}\right) \quad \text{.................. (8)}$$

The F_1, F_2, and F_3 from the step (i), (ii) and (iii) are being used to calculate the CCME water quality index and is given by the following form:

$$CCMEWQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F}}{1.732}\right. \quad \text{.................. (9)}$$

Case Study

Narmada River heady metal analysis: According to (24,25) they have used all chemicals as per analytical grade and obtained from merk India. De-ionized water was used in various water quality protocols followed in the study. For substantial metal estimation, 50 ml of well-mixed acid mixed with the samples that have taken. HNO3 was added to it. Now the mixture put into 900 temperatures; after that, the volume will be reduced to 10-20 ml. After that final volume was made upto 50 ml of solution. The digested filtrates were used for the metal quantification using the Atomic Absorption Spectrophotometer (Shimadzu AA-6300), with the setting of different characteristic wavelengths of metals using hollow cathode lamps and directly aspirating the digested samplesinto the air–acetylene flame. The instrument was calibrated by analyzing the known concentration of heavy metals. Standard solutions (1000 mg L^{-1}) procured from Merck were serially diluted to obtain the desired concentrations, and for each metal, a multi-point calibration graph was prepared. During the analysis, a blank was run after every ten samples to examine the instrument's performance for minimization of any errors.

Statistical data analysis of Narmada River: Analysis of Variance (ANOVA) and post hoc (Tukey T-test) was used to analyze the significant variation inheavy metal concentration among different sampling sites and different seasons for all studied heavy metals (normallydistributed).Pearson correlation matrix was applied to identify the relationship between the seven elements (significance level0.05 and 0.01).Principal component analysis (PCA) was employed to infer the possible source of heavy metals. It has emergedas a useful tool for a better understanding of the relationships among the variables (metal concentration in the presentstudy) and for revealing groups that are mutually correlated within a data body assisting in the identification of sources of various pollutants. To determine the suitability for conducting PCA, Kaiser-Meyer-Olkin (KMO) and Barlett's tests of sphericity have to be initially performed on the water quality data. KMO test is a measure of sampling adequacy, and its value lies between 0 and 1. Smaller values close to 0 indicate inappropriateness of conducting the PCA, benefits more than 0.6 are considered satisfactory, while values close to 1 increase the reliability of PCA. Barlett's test of sphericity's used to determine whether the correlation matrix is an identity matrix. If the correlation matrix is found to be anidentity matrix, then all correlation coefficients become zero, and variables become unrelated. In this scenario, PCAbecomes inappropriate and unsuitable for data analysis. $P < 0.05$ is considered significant for Barlett's test (53).The data were statistically analyzed using the statistical package, SPSS 16.0 (SPSS, USA).

UV – Vis Spectroscopy for Iron Contamination in collected samples: Ultraviolet-visible (UV-VIs) spectroscopy is one of the most popular analytical techniques because it is very versatile and able to detect nearly every molecule. With UV-VIs spectroscopy, the UV-VIs light is passed through a sample, and the transmittance of light by an example is measured. From the transmittance (T), the absorbance can be calculated as A=-log (T). An absorbance spectrum is obtained that shows the absorbance of a compound at different wavelengths. The amount of absorbance at any wavelength is due to the chemical structure of the molecule. UV-Vis can be used in a qualitative manner, to identify functional groups or confirm the identity of a compound by matching the absorbance spectrum. It can also be used in a quantitative manner, as the concentration of the analyte is related to the absorbance using Beer's Law. UV-Vis spectroscopy is used to quantify the amount of DNA or protein in a sample, for water analysis, and as a detector for many types of chromatography. Kinetics of chemical reactions are also measured with UV-Vis spectroscopy by taking repeated UV-Vis measurements over time. UV-Vis measurements are generally made with a spectrophotometer. UV-Vis is also a very popular detector for other analytical techniques, such as chromatography, because it can detect many compounds. Typically, UV-Vis is not the most sensitive spectroscopy technique, because not a lot of light is absorbed over a short path length. Other spectroscopy techniques such as fluorescence have higher sensitivity, but they are not as generally applicable, as most molecules are not fluorescent. UV-Vis has a similar sensitivity to other absorbance measurements, such as infrared spectroscopy.

The Beer-Lambert Law: According to the Beer-Lambert Law, the absorbance is proportional to the concentration of the substance in solution. As a result, UV-visible spectroscopy can also be used to measure the concentration of a sample. The Beer-Lambert Law can be expressed in the form of the following equation:

$$A = \epsilon cl \quad \text{.................} \quad (10)$$

Where **A** = absorbance, **l** = optical path length, i.e., the dimension of the color cuvette (*cm*), **c** = concentration of solution (mol dm^{-3}) and **e** = molar extinction, which is constant for a particular substance at a particular wavelength ($dm^3\ mol^{-1} cm^{-1}$)

Result Analysis: UV visible spectrophotometer of SPECORD 205 with the specification as a double beam spectrophotometer designed for measurements in the spectral range 190-1100 nm. The internal wavelength calibration with a holmium oxide filter provides a high wavelength accuracy and reproducibility. In the combination of Win ASPECT software, the SPECORD is particularly suitable for the use in routine laboratories with high sample throughput. Here sample 1: -0.89, sample 2: -0.90, sample 3: -0.89 and sample 4: -0.77.

Ion Chromatography Result for collected water samples from North East India is shown in figure 4 to 7.

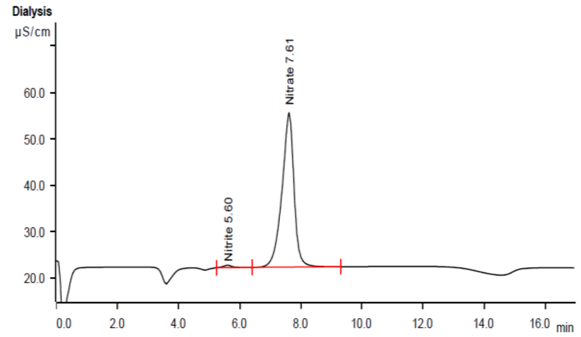


Fig. 4. Sample 1

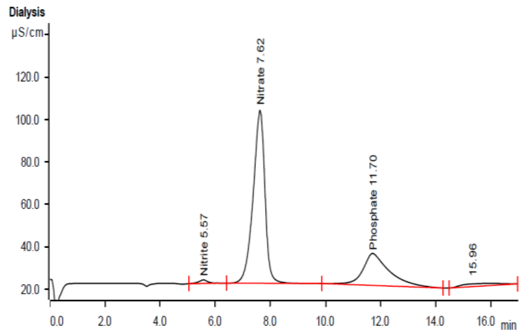


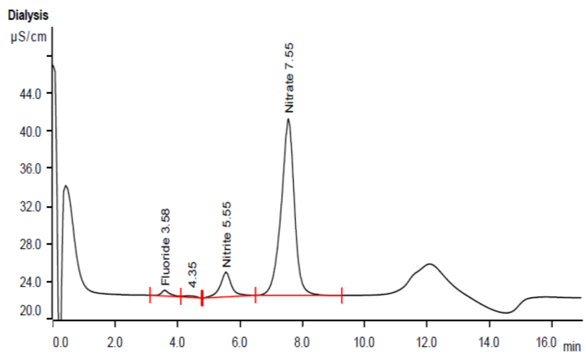
Fig. 5. Sample 2

Sample 1

Sample type	Index	Conc. (moles/lt)	Vol. (cm3)	Dilution (mg/lit)	Sample amount	Area	Ident
Std. 1	1	1.000	100.0	1.0	1.0	n.d	Std. 1
Std. 2	1	5.000	100.0	1.0	1.0	n.d	Std. 2
Std. 3	1	10.000	100.0	1.0	1.0	n.d	Std. 3

Sample 2

Peak No	Retention time (Min)	Area(µS/cm) x min	Height (µS/cm)	Con. (ppm)	Component name
1	5.567	0.6643	1.709	-688.459	Nitrite
2	7.620	40.4757	81.632	37.149	Nitrate
3	11.708	16.6868	15.116	27.088	Phosphate
4	15.963	1.9343	1.022	invalid	---



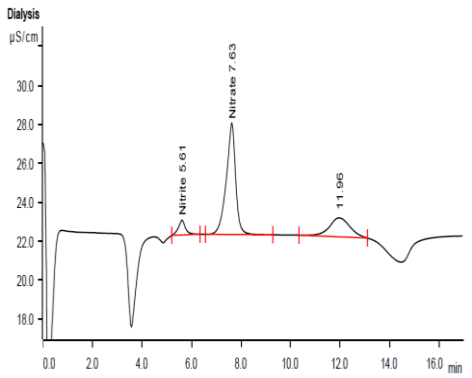


Fig. 6. Sample 3 **Fig. 7. Sample 4**

Sample 3

Peak No	Retention time (Min)	Area(µS/cm) x min	Height (µS/cm)	Con. (ppm)	Component name
1	3.578	0.1958	0.615	Invalid	Fluoride
2	4.352	0.0759	0.151	Invalid	
3	5.547	1.1010	2.640	-1150.560	Nitrite
4	7.550	9.2168	18.767	8.003	Nitrate

Sample 4

Peak No	Retention time (Min)	Area(µS/cm) x min	Height (µS/cm)	Con. (ppm)	Component name
1	5.613	0.2524	0.772	-252.692	
2	7.625	2.5056	5.734	1.745	Nitrite
3	11.957	0.9426	0.969	invalid	Nitrate

Conclusion

Different parameters are observed like physical-chemical & biological parameters for Narmada Rivers, Hussain Shah Lake, The Ganges, some water samples from North-eastern India. There are different water quality parameters like Nitrate-Nitrogen, pH, dissolved oxygen, Phosphate, biological oxygen demand, chemical oxygen demand, turbidity, total dissolved solids, etc. are measured.

After all the experiments, Narmada has to be found safe water usage for human consumption in summer as well as winter. For assessment of water quality of River Narmada, various Water Quality Index (WQI) such as Weighted Arithmetic Water Quality Index (WAWQI), National Sanitation Foundation Water Quality Index (NSFWQI) and Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) has been used in this study. On comparison of these methods for evaluation of the water quality of the Narmada River at different sites, the WAWQI method provides a better idea about the water quality. (55)

In the case of Hussain Sagar lake E coli. Bacteria were found that indicate the fecal contamination of lake water. Hence the water is not suitable for human consumption, also found some harmfull bacteria samples that will be affectfull for human health. The lake water can be disinfected with regular chlorination to reduce the bacterial load, and the free residualchlorine levels should be checked for effective treatment. Regular monitoring of lake water and applying appropriatecorrective actions (54) including dredging of sediments, construction of new sewerage treatmentplants, discharging treated water into the lake, tertiary level cleaning of the lake, expansion of sewerage lines in thecatchment area, up-gradation of sanitary conditions of people living in the catchment area and lake vicinity are neededto improve the quality of lake water.

Some of our testing water samples are collected from North-East India. We tested those samples in Ion- chromatography, for the finding of harmful Anions. As per the table, as produced before, there are some salts presented on the samples like Sulphate, Phosphate, Nitrate, Nitrite. Those have a certain allowed level of quantity that is being measured by WHO. Nevertheless, we see in the table some of their samples are greater than the danger level. Although those salts are not affected by humans quickly, if they take water for a long time that will affect significant diseases of genetically that will affect their future generation also.

Acknowledgment: The authors are very much thanked Narula Institute of Technology and DRL, DRDO for helped us for collecting and testing samples and providing laboratory facilities.

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Holding Lens on Urbanization: A Brief Analysis on Urban Ecology

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Introduction

Sustenance of living beings on earth is primarily determined by the relationship between the living organisms and the physical environment. To understand these relationships, we need to seek help from a branch of Environmental science, named "Ecology", while the ecosystem prepares the ground to get into this relationship that keeps 'life' going in the Earth.

In this chapter we're going to focus on Urban ecology. The urban areas where the majority (nearly half) of the world's population has turned to be the basic concern of most of the developed and developing countries throughout the world. In order to give a better life to the people living in cities and to preserve nature we need to examine closely the relationship between living beings and nature. Study of urban ecology and urban ecosystems will help us to achieve our aim (1-2).

Modern urban ecological science is comparatively a new discipline. The contrast between Ecology in cities and ecology of cities has led emphasis on the increasing scope of urban ecosystem research. Ecology in cities focuses on terrestrial, arboreal and aquatic particles within cities and suburbs. Ecology of the city differs from ecology in the city by considering the whole urban mosaic as a social ecological system. Ecology of urban ecosystems includes the social, biological and constructed components. The shift of paradigm between Ecology in the city and ecology of the city represents increased complexity thus moving the focus from biotic communities to holistic socio-ecological systems. Ecology for the city includes the knowledge generated by both ecology in the city and ecology of the city. This may help in the enhancement of the research and in advancement of the social goal of urban sustainability. Urban heterogeneity is the key urban feature. Ecology for the city encourages ecologists to engage with other specialists and urban dwellers to shape a more sustainable urban future (3). The Ecology of the cities and suburbs accounts the health and well-being, benefits of urban green spaces, vegetated areas and water bodies.

There are renewable and important precedents, ecology as a whole seemed to awaken the urban areas as a legitimate habitat for study. There is an increasing understanding that humans and their actions are components of all ecosystems virtually (4). The understanding of urbanization as one of the four main global transformations of the biosphere triggers the shift the paradigm of ecology. This shift is followed by the transition of Earth's human population from predominantly rural to urban in the last decade of the 20th century and first decade of the 21st century. The cultural shift in the paradigm of ecology helps in the growth and evolution of urban ecological science, the increasing reach and rates of economic and cultural globalization and growing concern about sustainability in the cities and towns (5).

As urbanization is continuing at an alarming rate, it's not only threatening biodiversity but also increasingly removing the people away from the natural environment. This is directly linked to undesirable health diseases like obesity, diabetes, depression, heart attack and mental fatigue; these are interlinked with the changed socio-cultural lifestyle of the urban people. Many studies have demonstrated a connection between nature and individuals' health. Urban green spaces are certainly an important barrier between healthy and unhealthy lifestyle (6). Thus, for the sustenance of living organisms on earth and for their healthy living, special attention is to be given on the study of ecology. Specifically, the urban ecology as the urban area is the habitat of the majority of living organisms with the widespread of urbanization throughout the world.

Ecology

Ecology is the study of environmental science. It includes human science, population, ecosystem, community and biosphere. Ecology is the relationship between living organisms and environment (7).

Fig. 1. Ecology.

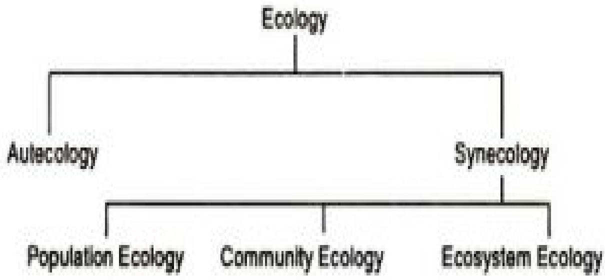


Fig. 2. Subdivisions of Ecology.

Urban Ecology: Urban ecology includes individual organisms, population, communities, landscapes and surrounding infrastructure. It also defines the urban ecosystem as a part of the global environmental, biochemical and human demographic system. Urban ecosystem is a part of urban ecology that encompasses cities or densely populated suburbs. The large urban ecosystems are generally concentrated in developed countries like countries of Europe, United States of America and countries of Asia like India, Japan and China (8**).** Large urban areas have always been the characteristics of the industrialized countries of Europe and North America. Presently the urban growth prominently noticed in Africa, South and East Asia and Latin America. We can mark the megacities where the population is more than 12 million as the seat of the urban ecosystem.

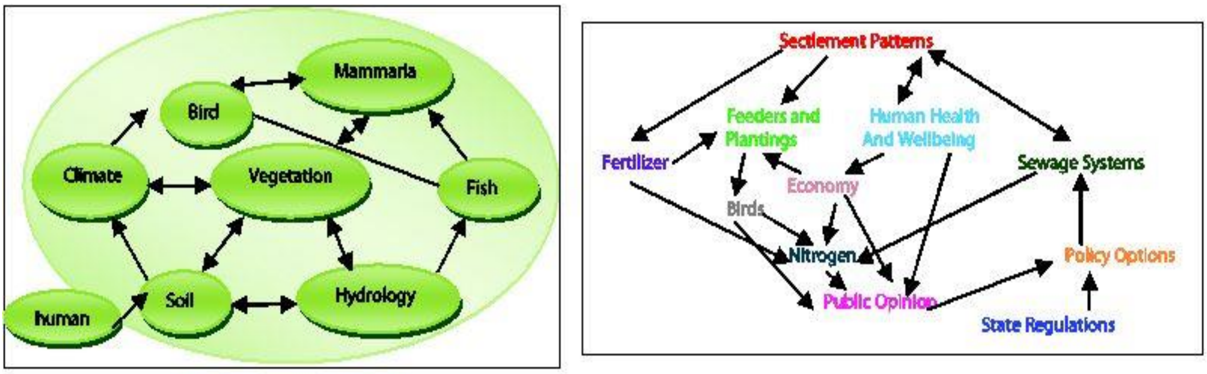


Fig. 3. Relationship between Ecology in the city and ecology of the city for urban area.

Importance of Urban Ecosystems: In the near future the population of the cities will increase by 2 million. At present, about half of the humans on earth live in urban areas. By next 10 years according to the CIA world factbook, 60% or almost two thirds of people will live in cities. This will result in the scarcity of space to live in. People will need breathable air, drinkable water and food which have to be supplied from outside of the cities. In the period of twenty-five years, scientists have recognized that interactions between the living and non-living components of these urban ecosystems is more important in the near future of all life on earth, including ourselves (9,10).

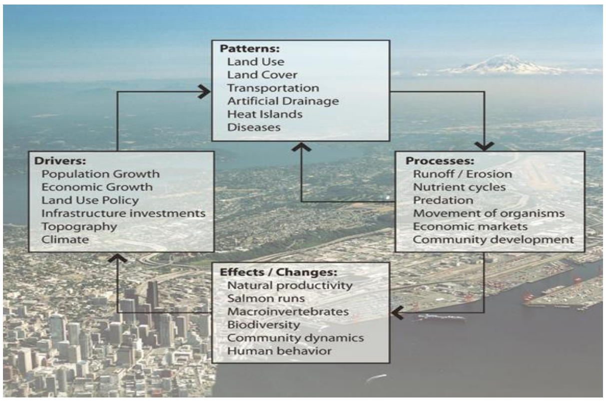


Fig. 4. A plan of urban ecology

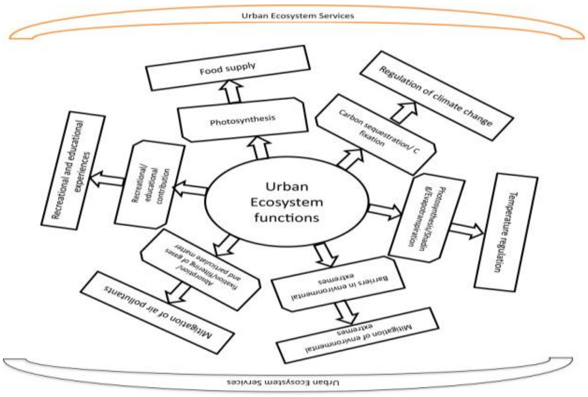


Fig. 5. Structure of Urban ecosystem

The structure of Urban Ecology: "The study of ecosystems that include humans living in the cities and urbanization landscapes". This field can be emerging, interdisciplinary and has a goal to understand in which ecological process, human beings can co-exist in the human dominated systems. It also helps the societies to become more sustainable with their efforts. The planning of Ecological survey emerged as a professional decorum that applied knowledge of the open spaces in urban areas to enhance biological diversity that originates from green patches in cities. Urban ecosystems like all other ecosystems are made of biological components such as plants, animals and other forms of life and physical components (soil, water, air, climate and topography) (11). These components are complementary to one another within a specified area in all ecosystems. In urban ecosystems, the biological complex also includes human populations, their demographic characteristics, their institutional structures and the social and economic tools which they employ. The physical complex includes buildings, transportation networks, wide area surfaces (e.g., parking, roofs and landscaping), the alteration of the environment that depends on human making. The physical components of urban ecosystems include energy use, import, transformation and export of materials which are not related to beneficial products (such as transportation and housing) but also pollution, wastes and emergence of heat.

Methods for Urban Ecology:

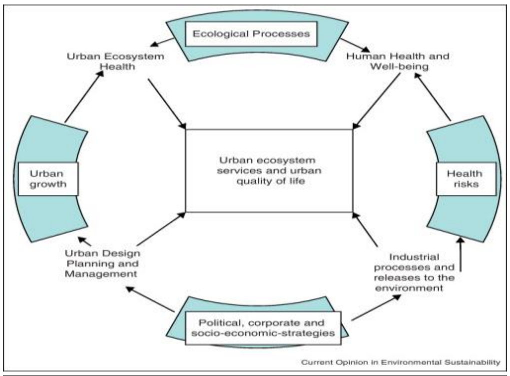


Fig. 6. Ecosystem in urban areas.

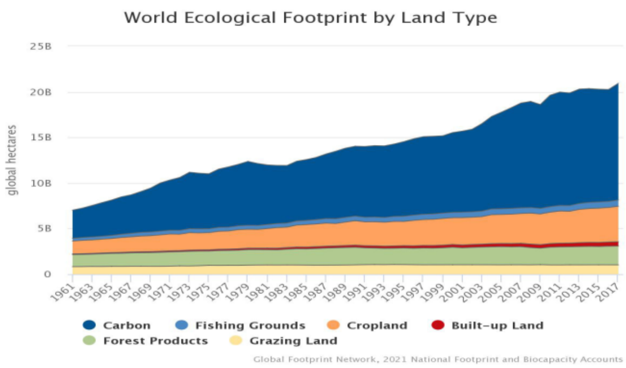


Fig. 7. World Ecological Footprint by Land Type

The methods for urban environmental problems may be presented by the number of scientists or Ecologists. According to the journal which was written by Groove in the year 1997, suggested a particular point that has indirectly explained a city as layered, overlapped and nested arrangements of subsystems, systems that are organized in hierarchical processes.

The general principles that found in each step can be explained in the following manners: -

System Approach: This type of approach is beneficial to examine the relation between particular environmental processes and social and natural systems. It provides a hierarchical method to describe the relationship as a whole.

Biological analysis: In this approach there are some of the principles such as balance, competition and the ecological processes of succession and dominance. Others include resilience, resistance, persistence and variability.

Material Flow Analysis: These include flow of materials and energy, studies of metabolism and studies of ecological footprint.

Spatial Analysis: These types of principles such as spatial heterogeneity and scale differentiation, some methods like watershed analyses, landscape and urban land cover models and tools (e.g., GIS and remote sensing)

Social analysis: It is based on social differentiation, social identity, socio-cultural hierarchy, access and allocation of resources like wealth, power, status and knowledge. It is also based on methods like rapid rural appraisal, surveys, etc. and tools like transects, flow diagrams, decision trees, Venn diagrams etc. The methods that are used to study urban ecology include chemical and biochemical techniques, statistical analysis of temperature, heat mapping, remote sensing and long-term analysis of ecological research sites.

Human Impact on Urban Ecology:

- The temperature of urban ecosystems is often more than other ecosystems surrounding them. Excess of concrete in urban areas has resulted in less percolation of rainwater inside the soil and mostly runoff after rain and storms.
- Heavy metals, calcium dust, particulates and human made organic compounds like fertilizers, pesticides and contaminants from pharmaceutical and personal care products are also made off in cities.
- Urban animal communities are dominated by medium size generalists such as raccoons, coyotes, opossums, skunks, foxes and other animals capable of serving access to a wide range of environmental conditions. Urban habits tend to be dominated by introduced plant and animal species that have a long history of association with humans and show adaptation to urban conditions (12).

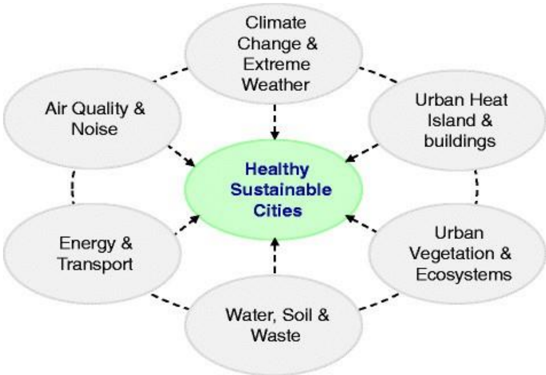


Fig. 8. Human impact on urban ecology.

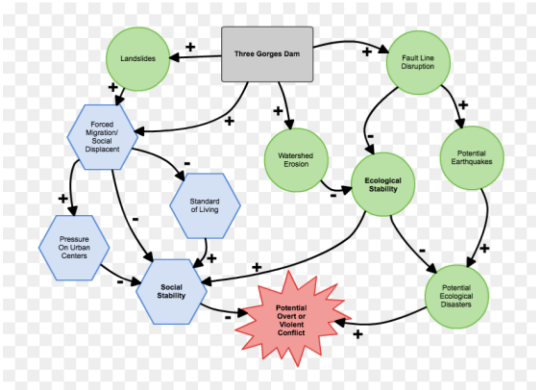


Fig 9: Human impact on Biodiversity.

Major effects of Urbanization on Environment: According to the study of the department of Economics and social affairs most of the global population already live in cities and it will become two thirds by 2040 and lead a modern lifestyle and escape from the hardships and backwardness of rural life. This leads to immediate urbanization but the accumulation of many people in a short space raises several urbanization issues like poor quality of air and water, insufficient supply of water, waste disposal problems and sanitation problem demands of urban environments (13).

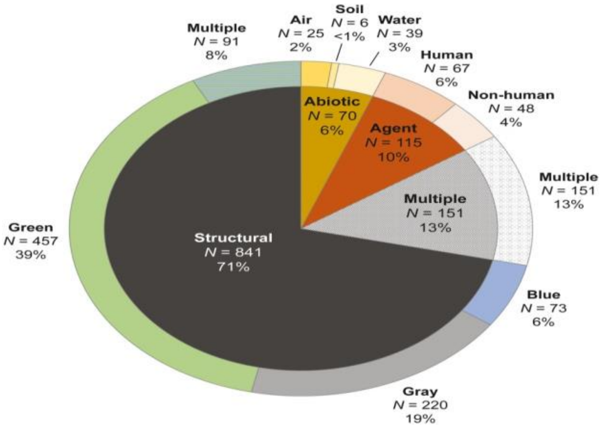
Environmental effects of urbanization: Urban people change their environment through their intake of food, energy and water. The lifestyle of urban people plays a key role in polluting the environment where they live and in turn the polluted urban environment affects the health and the quality of life of the urban population (14).

Biodiversity

As the cities grow in number, density and spatial extent, it simultaneously increases its impact on the environment and ecology of the urban areas. Uncontrolled urban expansion of engulfing the forests, wetlands and agricultural lands in turn leads to habitat clearing, degradation and fragmentation of the landscapes (15).

Extinction of Species: Extinction of species of the Global extinction refers to the loss of species occurring due to no surviving individual on the earth. The extinction of any species is an irreversible loss of a part of the biological richness of the Earth. Over exploitation is also another primary cause for the decline of biodiversity and depletion of different species. Every species contributed to the ecosystem, some species are more vulnerable to extinction and have greater impact than others (16). Urbanization leads to the destruction of the Habitat of some species which finally results in the extinction of those species from earth.

Health hazards and Epidemics: Urbanization leads to reduced physical activity and unhealthy nutrition. The World Health Organization (WHO) stated very recently that non-communicable diseases like heart disease will be 69% percent of all death in developing countries (17). Neural paralysis and Obesity are also going to be a threat to the urban people. We can see from the records that the epidemics that were rampant throughout the world, taking lives of billions of people, had originated mostly in the slums and the unhealthy food habits of the slum dwellers. Epidemics are always fatal and snatched the precious lives of the people. We all are going through the deadly SARS Covid pandemic throughout which took away the lives of millions of people.



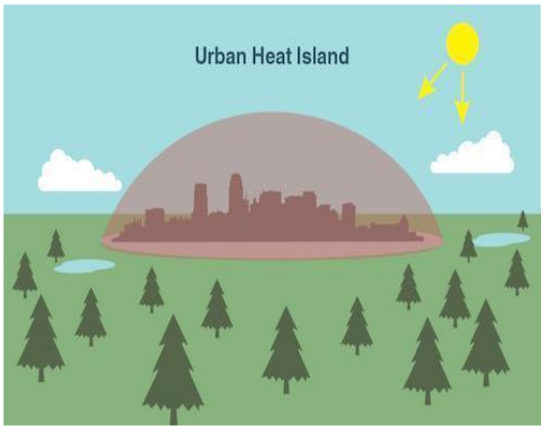
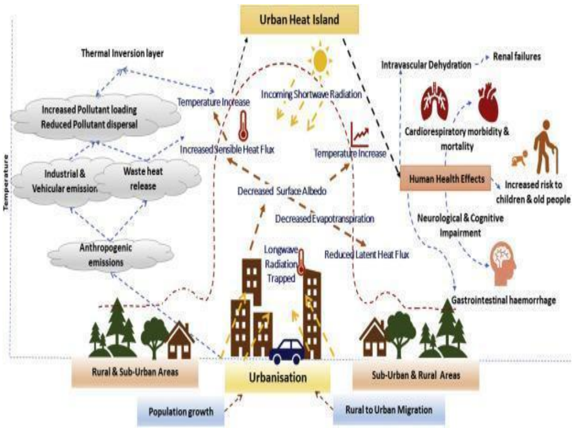


Fig. 10. Pie chart representing biodiversity. Fig. 11. An illustration of an urban heat island.

Urban heat island (UHI) effect: It is one of the common phenomena which occurs in metropolitan regions. In urban areas, most of the houses and buildings are made of concrete walls, cement, and metal surfaces that absorb rather than reflect the heat energy of the sun. Here, these areas face higher temperatures in the climate than nearby rural areas (18). This effect also leads to a smoggy climate. This is because lots of plants and trees, farmlands covered with different crops are found in the outlying areas of the urban cities. These plants, trees, and crops undergo the transpiration process which in turn makes the atmosphere cooler than the metropolitan cities. Due to this effect, human beings suffer heat-related illness such as exhaustion, respiratory difficulties, heat strokes etc (19).

Greenhouse gases

Different gases which trap heat inside the Earth's atmosphere are known as greenhouse gases. These gases absorb the infrared rays emitted from the Earth's surfaces and radiate back again to the surface of the Earth. This phenomenon leads to the greenhouse effect. Few examples of greenhouse gases are carbon dioxide (CO_2), sulphur dioxide (SO_2), methane (CH_4), water vapour (H_2O), ozone(O_3), chlorofluorocarbons (CFCs), nitrous oxide (N_2O), etc. The sources of these gases can appear in different forms like a solid and biological waste; forest fires; combustion of fossil fuels such as coal, oil, natural gas; deforestation; production and transportation of coal; landfills; land degradation; emission of harmful gases from the chimneys of different factories, industries, cottages, vehicles, construction, etc (20). These gases are initially present in the atmosphere in low concentration. The capacity of the heat trapped in the Earth's atmosphere can be measured through the Annual Greenhouse Gas Index (AGGI). This provides standardized information about how human activity has affected the climate system through greenhouse gas emissions (21).



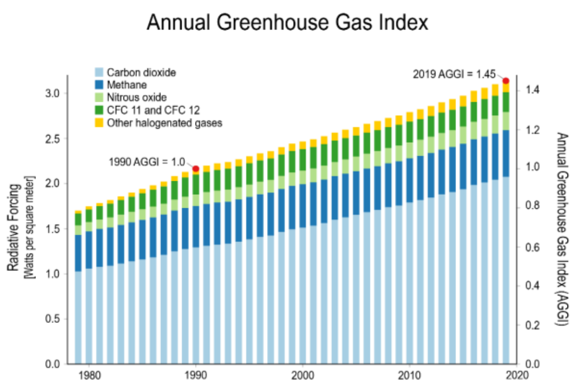


Fig. 12. Urban Heat Island effects **Fig. 13. Annual Greenhouse Gas Index indicating Radiative forcing and AGGI**

Ways to improve urban ecology

With awareness of climate change on the rise, cities across the world are coming under scrutiny for their large carbon footprints and unsustainable designs. Now that people know better, civil engineers are working to resolve the underlying problems by improving infrastructure and making cities more sustainable, more resilient, and more enjoyable for their residents. Read on to find out how.

Promoting urban agriculture: By preserving agricultural land in urban areas, we can shorten supply chains and the amount of CO2 emitted when transporting food from rural to urban areas. Producing and selling more fresh food within the city itself can reduce the environmental impact of food distribution, increase opportunities for inclusive local supply chains and improve access to nutritious foods, for example through farmers' markets (22-24).

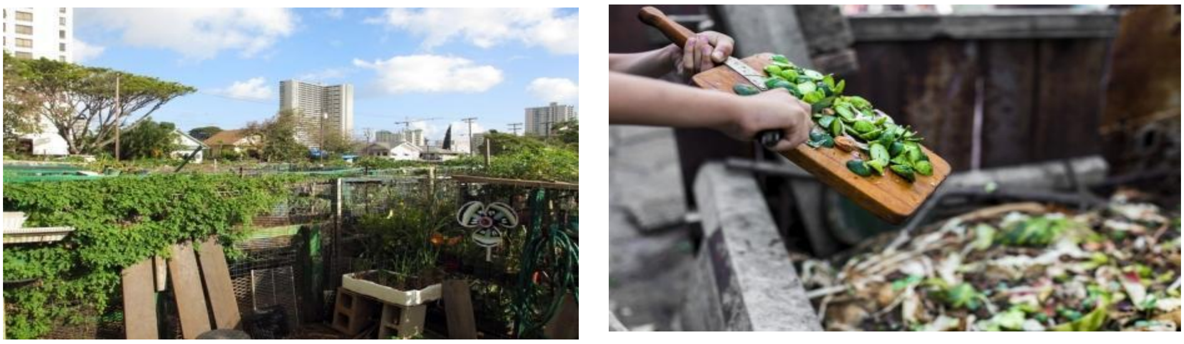


Fig. 14. Compost initiatives can give new purpose to wasted food.

Encouraging healthy diets: Lifestyles and dietary patterns are strongly influenced by the types of food available and their affordability. In cities where there is a large choice of fast food and convenience options, available food is often energy-dense and highly processed. This is a growing trend. In lower middle-income countries, the consumption of processed food with little nutritional value increased by 5.45 percent annually between 1998 and 2012. National governments and city administrations in developing countries face the problem of having to deal with under-nutrition, but also with the health effects of obesity which is increasing at an alarming rate. However, all cities can play a greater role in ensuring healthy diets.

Reducing and managing food waste: People in urban areas consume up to 70 % of global food supply, but much of it gets wasted. Although the causes of food waste vary from one region in the world to another, generally inappropriate food planning, inadequate packaging, improper storage and cultural practices - all of these are responsible for that.

In addition, food waste that is not recycled or reused in filling up the landfills. There, it decomposes and generates methane, a greenhouse gas that is more harmful to the planet than CO2. Citywide measures for recovering safe and nutritious food and redistributing it through charities and food banks, composting or utilizing discarded food to generate energy can make a huge impact in reducing food waste (25).

Boosting green spaces for healthier environments and improved lifestyles: As urban areas continue to expand, green spaces are disappearing. More than just for aesthetic appeal, trees and green areas are essential for improving air quality, mitigating urban temperatures, encouraging physical activity and improving overall health. Air pollution, rising local temperatures and sedentary lifestyles can increase the probability of cardiovascular and respiratory diseases, obesity and fuel the spread of new pathogens. Food systems need to be planned and managed together with the green environment, in order to curb pollution, encourage healthy diets and physical activity.

Introducing ecological areas in the urban landscapes

The biodiversity in the cities is very much influenced by the presence of green spaces, green roofs and walls along with tree-lined streets. In order to maintain the different ecosystem services including wildlife and human populations, existence of landscapes with sufficient size, diversity and distribution is essential. The green infrastructure in the urban landscape consists of recreation parks and gardens, unmanaged natural open spaces, wetlands and rural lands, the quality of life for most urban dwellers is closely related to the amount of green areas where they live. Since these areas provide people with opportunities for social relations, recreation and experiencing nature which affect them both emotionally and physically. The structure of green spaces and biodiversity are quite different from each other in rural and urban areas as in Europe. The presence of natural flora in the cities, the establishment of habitats suitable to the animals adapted to the urban conditions and ecological studies for the protection and development of ecosystems are considered as environmentally ethical studies, as they protect the natural resources. Meanwhile, these areas are places which are increasing the quality of life in the city and allowing the social interaction of the residents (26, 27).

Betterment of Urban climate

Cities are generally warmer than open lands and forests as walls and roofs of the buildings and asphalt pavements have higher radiation surface than open lands yielding a higher amount of solar energy absorbed. Meanwhile, the precipitation falls into the cities and flows away to the sewage system through asphalt roads and squares quickly. As a result of this, the solar radiation is more effective on these surfaces than humid ground in the open lands and heat up more yielding higher degrees of warming. As the terrestrial radiative heat loss from these city structures is slower, the temperature of the cities is higher (28). Urban landscapes change the direction and speed of the winds coming from the surrounding. For that reason, differences occur between air flow on the cities and on the forests as well as open fields. The buildings in cities which are much taller than the average height increase the number of the calm days in the city and worsen the ventilation. These tall structures are the sources of the calm air (29), increased temperature and vapour pressure. In fact, this has a negative effect on the living conditions of the city resident. However, tall buildings do not always reduce the speed of the winds, on the contrary, it is stated that they may improve the circulation of the wind. For this, the large brows of the buildings should be perpendicular and their narrow brows should be parallel to the direction of the wind.

Betterment of Urban wildlife

Wildlife in cities is generally undervalued (30). In recent years urban wetlands, abandoned industrial sites, roadside verges, vacant lots and derelict lands, ruins, allotment gardens and cemeteries - together with arboreta, residential gardens and villas, botanic gardens and individual balconies have begun to be seen as potential conservation areas for urban biodiversity. Dense population and infrastructure are two factors putting pressure on biodiversity in cities. What is necessary is to establish a balance between the urban green and tailor-made green areas. At this point, 'double inner-city development' can be used; this means to combine the existing developed areas with conservation, supporting the presence, character and availability of green spots and vacant spaces; and, strengthening the green infrastructure like street-trees, green walls and roofs. These will facilitate the way to access green areas in and out the city. Wild fauna inside the cities can be a positive demonstration of the richness of the green; on the other hand, this can be a challenge in some cases
Rich diversities in urban landscapes can come to the fore as original communities. Urban green is an important part of urban landscape, which offers the opportunity to contact wildlife in addition to environmental and socio-ecological benefits, regarding the quality of human life. Urban green areas are ecologically complex structures; their values can be defined in terms of goods and services within society. What is essential is to pick bio-indicators that can be accessed and relied on to create a proper/balanced urban ecosystem, through integrating wildlife and biological parameters to human well-being.

Increasing Wildlife Habitat Connectivity

The implementation of wildlife corridors throughout urban areas (and in between wildlife areas) would promote wildlife habitat connectivity. Habitat connectivity is critical for ecosystem health and wildlife conservation yet is being compromised by increasing urbanization. Urban development has caused green spaces to become increasingly fragmented and has caused adverse effects in genetic variation within species, population abundance and species richness. Urban green spaces that are linked by ecosystem corridors have higher ecosystem health and resilience to global environmental change. Employment of corridors can form an ecosystem network that facilitates movement and dispersal. However, planning these networks requires a comprehensive spatial plan (31).

Urban wildlife corridors could serve as a potential mitigation tool, it is important that they are constructed so as to facilitate wildlife movement without restriction. As humans may be perceived as a threat, the success of the corridors is dependent on human population density proximity to roads. In a study performed by Tempe Adams, remote-sensor camera traps and data from GPS collars were utilized to assess whether or not the African elephant would use narrow urban wildlife corridors. The results of the study indicated that elephants tended to move through unprotected areas more quickly, spending less time in those areas. Using vehicular traffic as a measure of human activity, the study indicated that elephant presence was higher during times when human activity was at a minimum.

It was determined that formal protection and designation of urban corridors by the relevant governing bodies would facilitate coexistence between people and wildlife at small spatial scales. However, the only way this co-existence could be feasible is by creating structural connectivity by implementing proper wildlife corridors that made easy movement between habitat patches.

Conclusion

Nowadays, mankind is moving towards the process of urbanization. It has become one of the important factors in the growth of human civilization. The present century has witnessed not only economic growth but also urban transformation on a global scale. Almost 67% of the world's population will be living in urban areas by the end of 2040 (32). Urban Ecology has not only created a high impact on the climate and nature but also on the living and non-living environment. The advancement in technology, as well as the social, economic, and cultural world, has made the urban reality very complex (33). Several methods and techniques are being used to study and adopt urban ecology. The urban planners and architects must combine their knowledge with the environmentalist, ecologists, capitalists, etc. to move to a better approach for the establishment of a healthy community. Investments in green infrastructures are necessary for the future of the city in terms of quality of life and a healthier urban environment. Considering that green infrastructures are made of natural elements and built environment, the actual chance is to improve the quality of built spaces. It is well known that, in quite every city worldwide, the majority of the built environment is on private property, and therefore, a strategy based on the specific intervention that is feasible in private lots must be found. Every kind of 'green' intervention involves a significant economical investment that might be compensated with a reduction of expenses (in case of buildings, energetic performance improvements) or with specific public policies that include direct and indirect financial benefits. The actual real estate and development crisis forces integration between these two kinds of interventions because the policy is effective only if it creates long-term benefits.

It is necessary to define proper policies that can be applied in parts of the city with high density and high covered ratio (where parameters as Biotope Area Factor are particularly low) but the landscape sensitivity of a specific context such as historical centers must be considered (34). Another aspect that must be considered is the fragmentation of properties, which is more diffuse in residential contexts with medium and high density; so, the policy must consider different benefits that have an immediate impact on all involved subjects. Looking at worldwide applications and case studies, and considering the effectiveness of specific and composed policies, facts demonstrate that green infrastructures can be improved in private properties as well.

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GREEN RECOVERY OF METALS FROM E-WASTE

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Introduction: E-waste or electronic waste is generated when an electrical equipment is no longer in use and discarded. Robinson defined E-waste as any device connected to a power source that no longer satisfies the current owner to the purpose for which it was created [1]. E-waste comprises a broad range of electronic equipments starting from most modern small electronic devices to the large household electronic devices. Some common E-waste items are Cell phones, Smart phones, Desktop Computers, Computer Monitors, DVD, Televisions, Video Game Systems, Printers, Remote Controls, Television Remotes, Electrical Cords, Lamps, Treadmills, Smart Watches, Cords and Cables, WiFi Dongles etc.

Environmental impact of improper disposal of E-waste:

- Disposal of the E-waste has become a serious environmental issue due to the presence of deadly chemicals as well as toxic metals. Informal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution. Computers and most electronics contain toxic materials such as lead, zinc, nickel, flame retardants, barium, and chromium. Printed Circuit Boards is an important part of most of the electronic and electrical equipments contains many valuable metals along with several hazardous metals. Unscientific disposal of PCBs creates environmental problems and can cause human health hazard as well [2-4].
- In many countries e-wastes are used as landfill which can be dangerous as toxic metals gradually leaches out under different environmental condition and pollute water bodies. Heavy metals like mercury, lithium, lead and barium can even reach groundwater. When these heavy metals reach groundwater, they eventually make their way into ponds, streams, rivers and lakes.
- Incineration of e-waste releases toxic chemicals into the air.

Recycling of E-waste not only reduces the environmental issues but also returns many important materials for further use. Recovery reduces the demand for virgin materials as E-waste contains valuable metals (Cu, platinum group) as well as hazardous elements like Pb, Sb, Hg, Cd, Ni etc. Electronic waste may now be considered as a 'secondary ore' or 'artificial ore' for the concentrations of precious metals. Recycling e-waste can significantly decrease the demand for mining heavy metals and reduce the greenhouse gas emissions from manufacturing virgin material.

Position of India in producing e-waste

India is ranked 5th in the world among top e-waste producing countries following USA, China, Japan and Germany. Maharashtra ranks highest among the states followed by Andhra Pradesh, Tamil Nadu, Uttar Pradesh, West Bengal, Delhi and Karnataka in the amount of e-waste generated. Mumbai, the business capital of the country, produces the most e-waste at 96,000 metric tonnes (MT) every year.

Metal reccovery processes from e –waste

The various techniques available till date for recovery of metals from E-wastes are Mechanical [5], Pyrometallurgical [6], Hydrometallurgical [7] and Biometallurgical [8-9]. Most of the above mentioned processes are successfully utilized for extraction of different metals from PCBs.

Mechanical method includes disassembling, dismantling, chopping, shredding, crushing etc. These steps are achieved by using machineries like shredder, pregranulator, granulator etc. After this, the separations of metal from the non-metals are achieved. But mechanical processes are considered to be more as pre-treatment step before further processing rather than metal recovery technique. Pyrometallurgical and Hydrometallurgical processes are the traditional and popular methods to recover non-ferrous metals as well as precious metals from electronic waste in the past two decades. Generally, when the metals are present in a complex matrix with other non-metals and ceramics etc, it is often difficult to recover them implementing the physical/mechanical recycling processes. In that case, pyrometallurgy is the option. Printed circuit boards (PCB) are complex and is easier to recycle using these methods.

A typical pyrometallurgical treatment process includes

- Scraps are crushed and burned in a furnace which removes plastic parts
- Refractory oxides form a slag phase together with some metal oxides
- Materials entering the reactor are immersed in a molten metal bath (1250°C) which is churned by a mixture of supercharged air (up to 39% oxygen).
- This process converts iron, lead and zinc into oxides which become fixed in a silica-based slag.
- The slag is cooled and milled to recover more metals.

However, pyrometallurgical treatment leads to the formation of brominated and chlorinated di-benzo furans and dioxins due to the presence of halogens in the plastic parts of electronic waste [10].

On the contrary Hydrometallurgical method is more exact, more predictable and more easily controlled. In this method metals are leached in form of soluble salts by means of acid, alkali or other solvents. Four kinds of leaching processes are available, namely (i) cyanide leaching [11] (ii) halide leaching [12] (iii) thiourea leaching [13] and (iv) thiosulfate leaching [14].

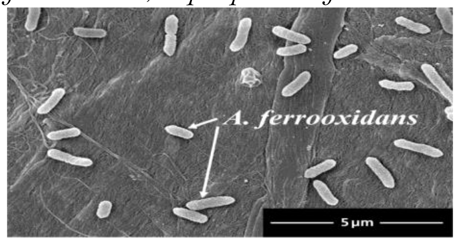
The leachate are then subjected to separation and purification i.e. precipitation of impurities, solvent extraction, adsorption and ion-exchange to isolate and concentrate the metals. Electro-refining process, chemical reduction or crystallization are usually opted for final recovery of metals [15-16].

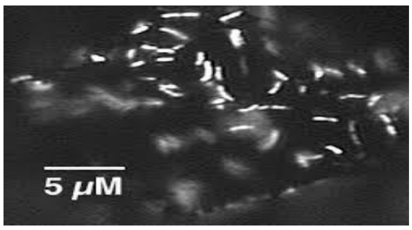
Hydrometallurgical route is successfully utilized for recovery of Copper and other precious metals such as gold, silver etc as well as rare earth metals [17, 18]. Aqua regia is used as leaching agent for recovery of gold from printed circuit board. Hydrometallurgical processes are also associated with risks of environmental impact due to the toxicity of the reagents used and the generation of large amount of by-products [19]. These processes are also expensive and energy intensive processes.

Thus both the traditional techniques of electronic waste recycling, pyrometallurgical as well as hydrometallurgical not only causes significant secondary pollution but also capital intensive, energy intensive[20,21]. Development of green and sustainable technology for recovery of the materials is the need of the hour. The biotechnological methods can be used as an alternative. The advantage of biological methods over chemical processes is its selectivity in regard to different metal groups, simplicity of technological process, low energy requirement and lesser chance of creating negative impact on environment [21-23].

Biometallurgy are technologies where microorganisms are utilised to recover metals from low grade ores and as well as E-waste [24]. Biometallurgy includes two promising processes i.e. Bioleaching and Biosorption. In the course of the last few years, there was a lot of research done on the bioleaching of metals from the wastes. Currently, bioleaching is used not only to recover metals from ores, but also from other sources, such as electronic waste, including PCB [24-26]. Hong and Valix (2014) recommended bioleaching as a promising technology to recover metals from PCB which is low cost as well as ecofriendly [27].

The microorganisms utilized in the bioleaching process are mostly chemolitho-autotrophic bacteria. These groups of microorganisms derive energy from reduced compounds of mineral origin. The microorganisms commonly used for metal recovery from e-waste, are *Acidithiobacillus ferrooxidans*, *Leptospirillum ferrooxidans*, *Acidithiobacillus thiooxidans* etc [28].





Typically bioleaching occurs in four steps — a) Acidolysis, b) Complexolysis, c) Redoxolysis and d) Bioaccumulation [29]. Researchers have utilized this technique to recover Gold, Aluminum, Copper, Nickel, Zinc and Lead from E-waste [30-35].

Direct Method: In this method microorganisms directly oxidize metals and solubilize the metals.

$MS + H_2SO_4 + 0.5O_2 \rightarrow MSO_4 + S^0 + H_2O$

$S^0 + 1.5O_2 + H_2O \rightarrow H_2SO_4$

Indirect Method: In the indirect action mechanism, ferric ion (Fe^{3+}) acts as the oxidizing agent for minerals. Microorganisms are indirectly related to the process by helping in regenerating Fe^{3+} from Fe^{2+}. $MS + 2Fe^{3+} \rightarrow M^{2+} + 2Fe^{2+} + S^0$

$2Fe^{2+} + 0.5O_2 + 2H^+ \rightarrow 2Fe^{3+} + H_2O$

According to Liu et al.[37], indirect method is more acceptable to the researchers. The indirect process can be contact biooxidation and non-contact biooxidation [36]. In contact mechanism, bacteria remains adhere to the metal and form a biofilm between the two. Inside this biofilm, Fe^{2+} is oxidized by bacteria to Fe^{3+} and the metal is dissolved by Fe^{3+} [37]. It has been proved that the formation of biofilm is important in bioleaching of metals [38]. The concentration of ferric iron and H^+ in biofilm is much higher than that in solution, which could greatly increase the dissolution rate of the metal [39]. In non-contact mechanism, the bacteria are no need to adhere to the ore whereas the Fe^{3+} which is produced by bacteria plays key role in the dissolution of ore.

The efficiency of this process is highly dependent on microorganisms, solid-liquid-gas mass transfer and reactor design.

Brandl et.al. collected dust collected during the shredding processes of electronic scrap and investigated bioleaching using a mixed culture of *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans* [40]. They introduced a two steps process which reduced the toxic effects on microorganism. Initially biomass was produced under optimal condition and then electronic scrap was added in different concentrations and the cultures were incubated. The leaching results confirmed that at scrap concentrations of 5 and 10 g/L, respectively, *Thiobacilli* were able to leach more than 90% of the available Al, Cu, Ni, and Zn. However at higher concentration, metal mobilization was reduced. Pb and Sn were not detected in the leachate. It was proposed that Pb precipitated as $PbSO_4$ and Sn precipitated probably as SnO. In the leaching process, $Fe_2(SO_4)_3$ formed by *A. ferrooxidans* oxidizes the elemental copper contained in PCBs to cupric ion. The bioleaching mechanism of copper from printed circuit boards shreds by A. *ferrooxidans* has been also investigated by Choi et al., 2004[44]. Hong and Valix studied the bioleaching of copper from E-waste using A. thiooxidans. Almost complete mobilization of Cu achieved after 14 days at 30℃ [27]. Zhu, et al. studied bioleaching of metals from E-waste by using a mixed culture of acidophilic bacteria. They showed Fe (II) concentration had a significant effect on Cu recovery. Under the optimal condition of 12 g/l pulp density, 12 g/l initial Fe (II), and initial pH 2 96.8% of Cu was recovered [12].

The first report of an ecofriendly method for bioleaching of important base metals from E-waste was by Arshadi M *et.al* [41]. They studied the bioleaching of important base metals like Cu, Ni, and Fe from a mixture of spent PCBs using adapted *Acidithiobacillus ferrooxidans* in the bubble column bioreactors.

The adaptation process was done on 1- 15 g/L Erlenmeyer flasks for 187 days, and then the concentration of E-waste was increased to 40 g/L in the bubble column bioreactors through a period of 44 days. Parameters like aeration rate, initial ferrous sulfate concentration, and solid waste loading that significantly affected bioleaching yields. 54% of Cu (6% dissolution/d), 75% of Ni (8% dissolution/d), and 55% of Fe (6.1% dissolution/d) were recovered simultaneously under the optimum condition of 20 g/L of solid content, 1.5 vvm of aeration rate, and 40 g/L of the initial concentration of ferrous sulfate after only 9 days. The results proved 100% recovery of each metal is possible separately, 100% of Cu and Fe are extracted maximally on the 4^{th} and 13^{th} day, respectively. Ni is recovered maximally 96% on the 17^{th} day.

In a very recent study bioleaching of spent PCBs in a stirred tank reactor (batch mode) were compared with a double-stage continuous bioreactor. The first stage of the continuous bioreactor was a bubble column in which a BRGM-KCC acidophilic consortium comprising *Leptospirillum ferriphilum* and *Sulfobacillus benefaciens* was used to oxidise Fe(II) into Fe(III). The resulting liquor was used to leach out metals contained in PCBs in the second stage of the bioreactor with mechanical stirring. The use of two distinct stages allowed the bacteria to adapt gradually to the PCBs and reach high dissolution yields, *i.e.* 96% Cu, 73% Ni, 85% Zn and 93% Co. PCB scraps could be increased up to 1.8% (w/v) in the double-stage bioreactor, without reducing the efficiency. Biomass concentration in the second stage and adaptation of the microorganisms to the toxicity of the metals were sufficient for only the second stage to be used. Under these conditions, the dissolution kinetics was stable, even when iron was provided only by the comminuted PCBs [42].

Arshadi et al.[43] also studied bioleaching from a combination of E-waste. They introduced the best combination of different types of E-waste (including mobile phone, computers, central processing units, fax machine, copy machine, and television) to recover the maximum amount of Cu, Ni, and Fe as the most important metals inhibiting gold recovery. They studied bioleaching of heavy metals from mobile phone printed circuit boards using adapted *Acidithiobacillus ferrooxidans.* The adaptation phase (10% v/v inoculum) began with 1 g PCB powder per 1L culture medium and continued for 55 days to a level of 20 g PCB powder per 1L medium. To maximize simultaneous extraction of Cu and Ni initial pH, initial Fe^{3+} concentration, pulp density and particle size were optimized under a multi-objective optimization strategy using the central composite design of response surface methodology. An initial pH of 1, initial Fe^{3+} concentration of 4.18 g/l, pulp density of 8.5 g/l and particle size of 114.02 μm (#100 mesh) were determined as the optimal conditions. Under optimal combination Cu, Ni, and Fe were recovered respectively 100%, 54%, and 100%.

A rapid metal leaching process of heavy and precious metals from waste printed circuit board powder was proposed by U. Jadavh et.al., where 100% solubilisation of all the metals were observed [45]. They treated the PCB powder with 0.1 M sodium hydroxide (NaOH) solution for removal of the chemical coating. The NaOH treated PCB powder was further subjected for metal leaching using an *Aspergillus niger* culture supernatant and hydrogen peroxide (H_2O_2). The 3.18% H_2O_2 concentration was found to be optimum for metal solubilization. An increase in temperature (80°C) reduced the time required for metal solubilisation. Optimization of all these parameters considerably decreased the leaching period to 2 h.

Hudec et al. studied biorecovery of Cu, Ni, and Zn from E-waste using *Acidiphilium acidiphilium.* The E-waste was crushed at the particle size of 0.8 to 1.7 mm. *A. acidiphilium* was able to leach Cu and Ni from shredded PCBs, but Ni recovery was not possible[46].

Wang et al. [47] examined bioleaching of Cu, Pb, and Zn from PCBs using a pure culture of A. ferrooxidans. The main purpose of their research was the recovery of Cu and Ni as well as examination of the characteristics of the sample before and after bioleaching process. To evaluate the changes of the sample chemical analysis, FTIR, FE-SEM and XRD were performed. Biorecovery of all the metals were increased by decreasing both sieve fraction of the sample and pulp density. After a period of 9 days copper solubilized 99%The results proved the great potential of the bio-hydrometallurgical route to recover heavy metals from electronic wastes.

Sumana Sannigrahi et.al [48] studied the biodegradation of waste printed circuit boards (diode and resistors) with five strains *Magnetospirillum* sp. The samples were treated with the bacterial strains of *Magnetospirillum* sp. (RJS2, RJS5, RJS6, RJS7 and MSR-1) individually and in consortia for 12 days. Atomic absorption spectroscopy (AAS) analysis revealed the isolate RJS2, MSR-1 and RJS6 showed maximum recovery of cadmium (97%) and nickel (99%) from diode. The researchers further developed two groups of consortia MAG1 and MAG2 with the strains. MAG1 exhibited better recovery of metals i.e. 100% nickel from diode and 90% cadmium from resistor. M.Arshadi & S.M.Mousavi [43] examined bioleaching of heavy metals from mobile phone printed circuit boards using adapted *Acidithiobacillus ferrooxidans.* To maximize simultaneous extraction of Cu and Ni from MPPCBs, initial pH, initial Fe^{3+} concentration, pulp density and particle size factors were optimized using the central composite design of response surface methodology. An initial pH of 1, initial Fe^{3+} concentration of 4.18 g/l, pulp density of 8.5 g/l and particle size of 114.02 μm (#100 mesh) were determined as the optimal conditions. Under these conditions, 100% extraction of Cu and Ni was achieved.

Biosorption: Biosorption has emerged as a low-cost and often low-tech option for removal or recovery of base metals from aqueous wastes. Biosorption is adsorption of metals by means of adsorbents prepared from waste biomass or abundant biomass. Metal recovery from E-waste by biosorption has been achieved by using algae (*Chlorella vulgaris*), fungi (*Aspergillus niger*), bacteria (*Penicilium chrysogenum*), hen eggshell membrane, ovalbumin, alfalfa etc [49-51] The mechanism of biosorption is complex and not fully understood. The biomass may be used in its "natural state" or modified.

There are certain factors that affect the process

a) Type of biological ligands accessible for metal binding,

b) Type of the biosorbent (living, non-living),

c) Chemical, stereo- chemical and co-ordination characteristics of the targeted metals

d) Characteristics of the metal solution such as pH and the competing ions [52].

Researches on biosorption of precious metals mainly focused on gold.

Bulgariu et.al.[53] adopted biosorption process for recovery of cadmium. Algae waste obtained after oil extraction was activated by alkaline treatment and used for cadmium(II) removal in batch and column systems. For batch systems, the effect of initial cadmium(II) concentration and contact time was studied at pH 5 and 8 g biomass·L^{-1}. For column studies, the alkaline treated algae waste biomass was mixed with an industrial ion exchanger resin (Purolite A-100) to prevent the clogging of column. Five biosorption/desorption cycles have yielded between 98.83 and 92.39% biosorbent regeneration.

S. Paul et.al. [54] conducted their study using sulfate-reducing bacteria for 10 days in batch process where initial concentrations of Cd^{2+} were 20, 40 and 60 mg/L. They maintained a pH of 7.0 ± 0.2, temperature 30 ± 0.5 °C and stirrer speed 120 rpm. Analysis of extracellular polymeric substance revealed that protein secretion was enhanced. They collected the biosolids, freeze-dried it for morphological analysis which revealed the formation of CdS nanoparticles (JCPDS card #00-042-1411) in range of 2–6 nm. Similarly, combined effect with 5, 10 and 20 mg/L Ni^{2+} at 20 mg/L Cd^{2+} were also investigated.

Hybrid Technology: Generally biological leaching is a cost effective technique but time consuming and also in most of the cases complete recovery of metal alone by biological leaching is not possible. Chemical leaching is comparatively rapid and efficient but it has its own environmental issues even the future prospects of associated nanoremediation are also uncertain [55]. Most of the recovery method discussed are found to be metal specific i.e. leaching of gold by thiourea may be the most realistic substitute.

A hybrid (integrated) technique, combining both chemical and biological methods so that they complement each other, would allow the rapid, efficient and economical extraction of metals while also being eco-friendly. With the help of such processes, valuable metals of high purity can be recovered from waste PCBs and other electronic waste.

Harikrushnan et al. they proposed an integrated (hybrid) model for the recovery of copper, nickel and zinc from waste PCBs using a combination of biometallurgy and hydrometallurgy. The hybrid method was compared against the individual chemical and biological methods and proved to be a better method than the other two, being rapid, efficient, economical and eco-friendly[56].

Other Green Methods: Biosorption using biomaterials like chitosan derivatives provides an alternative for recovery of precious metals from solution as they have relatively higher adsorption capacities. Biomaterials based adsorbents, such as cross-linked polysaccharide gels and chemically modified persimmon tannin gels, have been investigated for precious metal recovery [57, 58], with high gold adsorption capacities of 7.57 and 7.7 mmol/g, respectively. Most adsorbents, however, are often tested in pure metal solutions or in the presence of a limited number of competing metals.

Although porous polymers are particularly effective toward the capture of metal contaminants, those with porphyrin linkers have great potential in precious metal recovery [59]. Yeongran et.al reports a porous porphyrin polymer that captures precious metals quantitatively from PCB leachate even in the presence of 63 elements from the Periodic Table. They prepared the nanoporous polymer using a two steps process and without any costly catalyst. Gold could be recovered 10 times the theoretical limit, reaching a record 1.62 g/g. With 99% uptake taking place in the first 30 min, the metal adsorbed to the porous polymer can be desorbed rapidly and reused for repetitive batches. [60]. Dipali Rahangdale and Anupama Kumar [61] provide a sustainable solution to the recovery of Cd from nickel-cadmium battery waste. Their work utilizes the affinity of the biopolymer chitosan towards different metals. Stability of chitosan in acidic medium was improved by grafting it with a suitable grafting agent and crosslinking. Further, it was used for the synthesis of acrylamide grafted chitosan based Cd ion imprinted polymer (CdIIP) using Cd as template and epichlorohydrin (EPI) as crosslinker for the selective recovery of Cd.

Conclusion: Development of sustainable and green technologies for recovery of metal from E –waste is possible with the help of biometallurgy. Biometallurgy proved to be the most environmentally friendly as well as a green technology (generates less amount of waste).
But industries are reluctant to accept the bioleaching technology due to the prolonged leaching time. Also a very few articles are currently available on the final purification of the metals from the E-waste liquor. Hybrid technology involving combination of hydrometallurgy using safer chemicals and biological leaching, will complement each other. A Germany company named Biotechnology Research and Information Network is engaged in identifying metal-extracting microbes and put them to work and have identified more than 50,000 microbes. The recovery of gold from electronic waste is a major target for BRAIN, but the company also has its sights set on other waste streams that contain valuable metals which would otherwise be lost, or heavy metals that pose health and environmental risks. More industries should come forward to accept the greener methods. Undoubtedly, the industrial implementation of these methods will certainly create job opportunities. The society will be benefited from the use of recycled products and by the use of green technologies which will definitely led us towards social sustainability.

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ISBN:978-93-89817-48-5