THE ROLE OF CHEMISTRY TO SOLVE THE CHALLENGS OF 21st CENTURY

Report Submitted to,

Abhedananda Mahavidyalaya (Depertment of chemistry)

By

AYAN KARMAKAR (B.Sc Honours, 6th sem)

ROLL NO-210330100010

Reg No- 202101026490 of 2021-22

UNDER THE SUPERVISION OF

DR. TANMAY DAS

ABHEDANANDA MAHAVIDYALAYA
SAINTHIA, BIRBHUM, WEST BENGAL, PIN 731234
Founder: Srimat Satyananda Dev (1965)
(Affiliated to the University of Burdwan and Accredited by NAAC)
Phone: 03462263449 E-mail: abhedanandamahavidyalaya@gmail.com Website: www.abhedanandamahavidyalaya.ac.in

Date: 15.05.2024

Department of Chemistry

Certificate of Project Completion

This is to certify that Mr. Ayan Karmakar, a student of B.Sc. (Hons.) in Chemistry, 6th Semester, Roll No. 210330100010, Registration No. 202101026490 of 2021-22, has successfully completed the project titled: **"The role of Chemistry to solve the challenges of 21st Century"** under the supervision of Dr. Tanmay Das, Department of Chemistry, Abhedananda Mahavidyalaya, Sainthia, during the academic session 2023-2024.

Tanmay Das 15.05.24
Supervisor

15/05/24
Head
Department of Chemistry

Principal
Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

❖ *INTRODUCTION*

Chemistry stand at the forefront of addressing the multifaceted challenges of the 21st century. Playing a pivotal role across diverse sector. From powering our home with renewable energy to developing life saving pharmaceutical, chemistry is the cornerstone of innovation and advancement in today's society. One of the most pressing issues facing humanity is the urgent need for sustainable energy sources to reduce fossil fuel. Chemistry plays important role in this field by driving research and development and renewable energy. Furthermore chemistry is instrumental in addressing environmental challenges such as pollution and waste management, by developing innovative materials and processes. In the realm in healthcare, chemistry is indispensable in the discovery and development of life-saving drugs and treatments.. Chemistry plays a central role in addressing the complex challenges of 21st century.

❖Climate Change Solutions with Advanced Materials

•Climate change is another critical challenges, and chemistry offers innovative solutions.

•Newer technologies, such as carbon capture and utilization(CCU)(fig.1) are emerging as effective tools.

•Chemistry are developing advanced materials like metal-organic frameworks(MOFs)(fig.2) for efficient CO2 capture and conversion.

•These materials not only capture CO2 but also convert them into valuable products like fuels and chemicals.

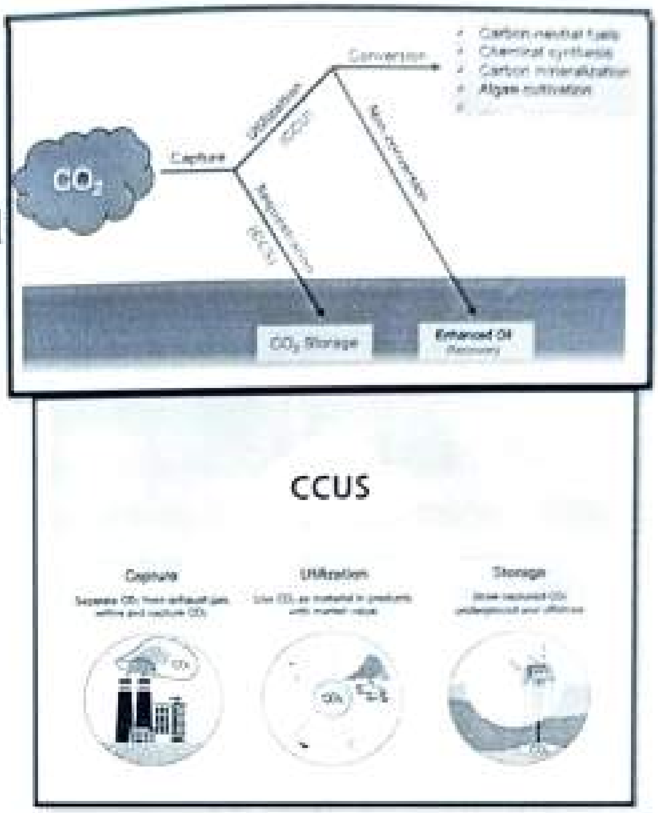


Fig1: -Carbon Capture and Utilization

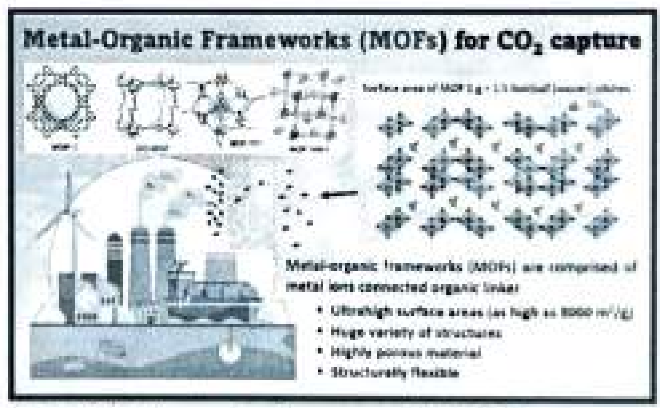
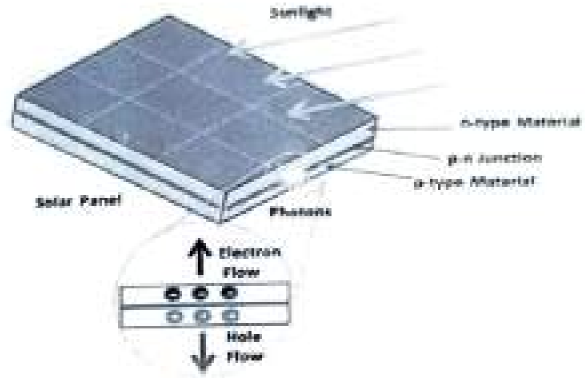


Fig2:- Metal-organic Frameworks(MOFs)

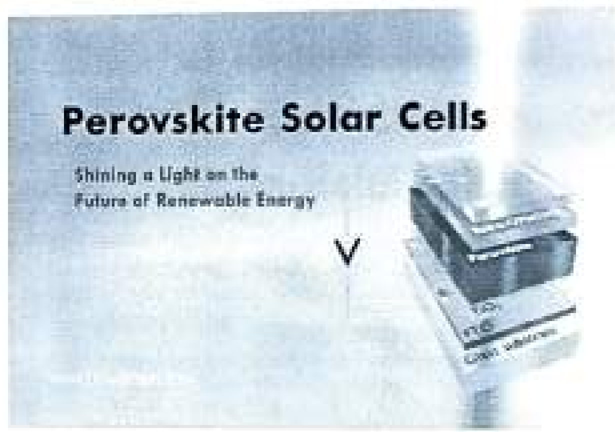
❖RENEWABLE ENERGY(Solar Power)



•Chemistry plays a vital role in the development of solar cells.

•Photovoltaic cells made of semiconductor materials like silicon, convert sunlight into electricity.

• Thin-film solar cells, perovskite solar cells are emerging technologies that offer higher efficiency.



❑Advantages of Solar Cells

•Inexpensive solar cells using nanoscience would help to preserve environment.

•Fossils fuels use would decrease and thus pollution decrease.

•Even billons of people can help to reduce carbon emission.

❖ELECTRIC VEHICLES (Evs)

- Electric vehicles are becoming increasingly popular as a clean transportation option.
- Chemistry is essential in developing batteries for EVs.
- Lithium-ion batteries(fig.3) are the most common type, with cathode materials like lithium cobalt oxide or lithium iron phosphate.
- Advances in battery chemistry, such as solid-state batteries and lithium-sulfur, offer higher energy density and faster charging.

Fig3:-Lithium ion batteries

Solid-State Lithium-Metal Batteries

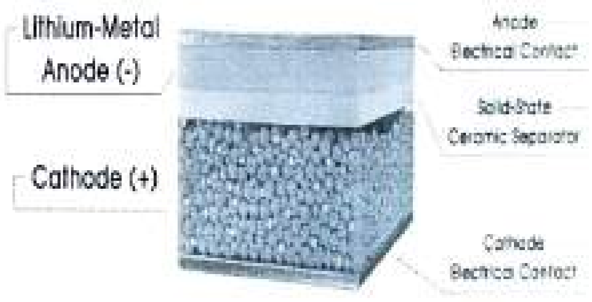
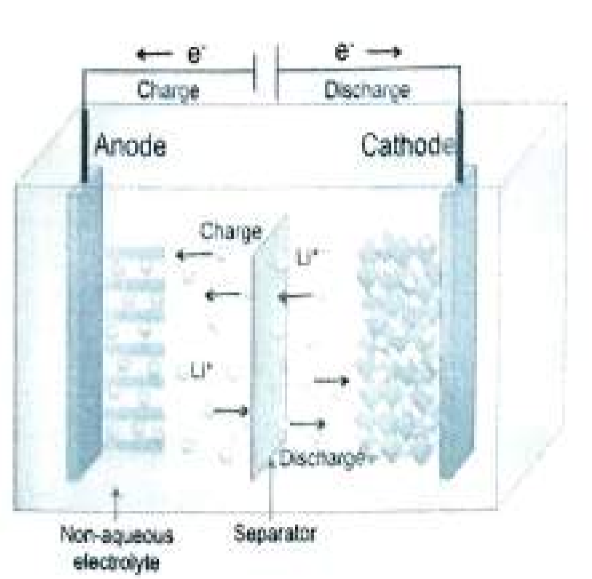


Fig4:- Solid state lithium-metal batteries



❖Chemistry in Medical Field

Chemistry plays crucial role in medical field for developing newer medicines, drugs and vaccines.

•Chemistry in COVID-19 Pandemic

Chemistry played a pivotal role in the development of vaccines(mRNA vaccines, a newer advancement), diagnostic and treatment.

•Chemists also developed antiviral drugs.

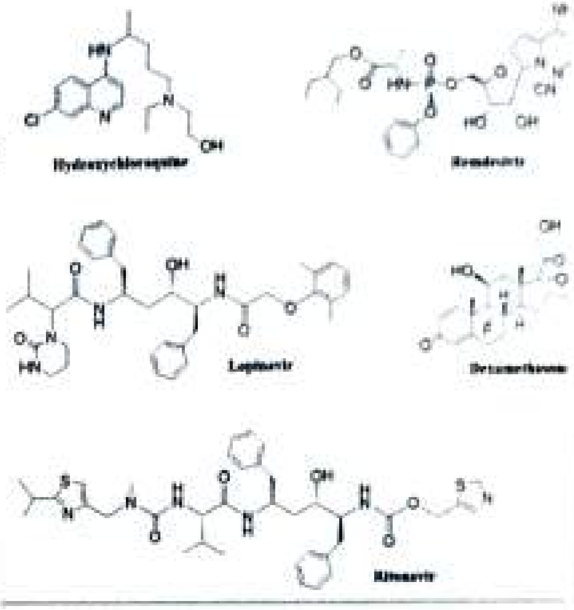
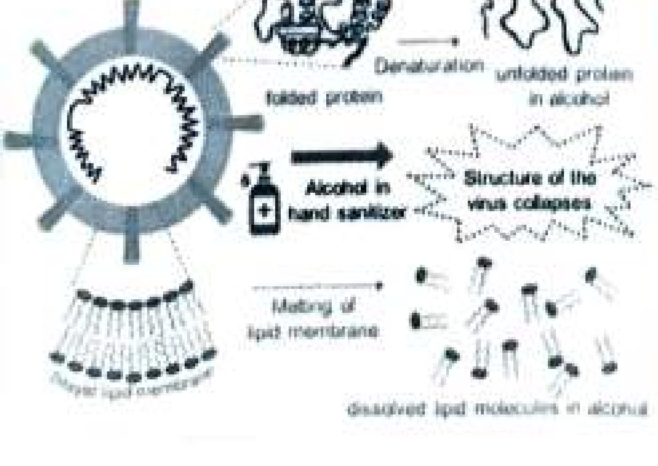


Fig.7:- Chemical structure of therapeutic drugs for COVID-19

•Chemistry enables the production of effective hand sanitizer which is crucial for killings viruses and bacteria.

•Bleach, or sodium hypochlorite, is a powerful disinfectants used to sanitize surface and kill viruses.



❖Cancer Treatment Breakthroughs

•Cancer remains one of the most challenging diseases of our time.

•Chemistry is revolutionizing cancer treatment with targeted therapies and immunotherapies.

•One of the most well-known anticancer drug is Cisplatin(fig). Which is use to in chemotherapy to treat various cancers.

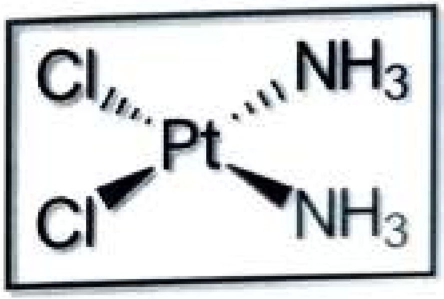
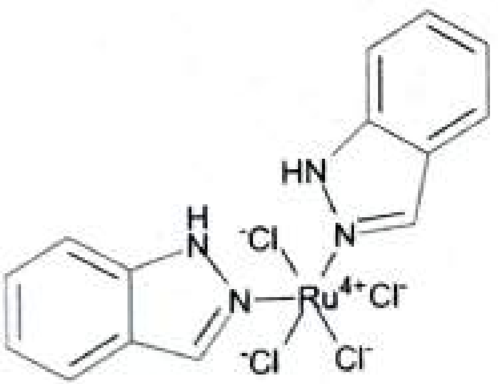


Fig.8:- Cisplatin

•Ruthenium-based compound have shown potential in cancer therapy.

•These compounds can absorb light, leading to generation of reactive oxygen species(ROS) when irradiated light of a specific wavelength. ROS can damage cancer cells.



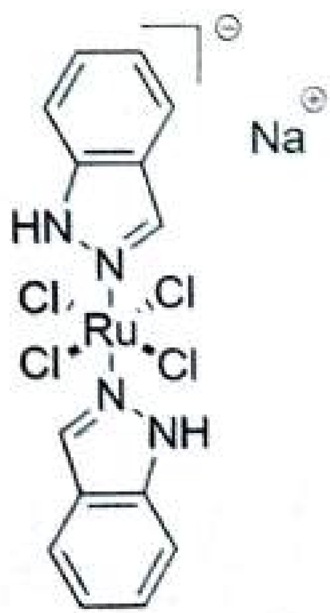


Fig.9:- Ruthenium based anticancer drug (BOLD-100)

❖Detection of cancer by Cancer Biomarker and Fluorescent Dyes

•Cancer biomarker are molecules produces by cells or by body in response to cancer.

•Detecting these biomarker in early stage can improve diagnosis and treatment.

•Fluorescent Dyes are chemical compound that emits light when exposed to specific wavelength of light.

•These dye specifically bind to cancer biomarker ,the attached fluorescent dyes illuminates the presence of cancer cell under specific lighting condition.

•Use for early detection ,diagnosis , monitoring cancer treatment.

•Make surgery more effective

•PSA(prostate cancer),CA-125 (ovarian cancer)

View of localized region of a cancer patient as seen with naked eye (left) or with the aid of tumor-targeted fluorescence dye (right

❖Nuclear Energy for Clean Power

•Nuclear energy is a low-carbon power source that can help mitigate climate change.

•Nuclear energy is generated through controlled nuclear reaction in Nuclear Reactor.

•In nuclear reactor usually fueled by U-235 or Pu-239.

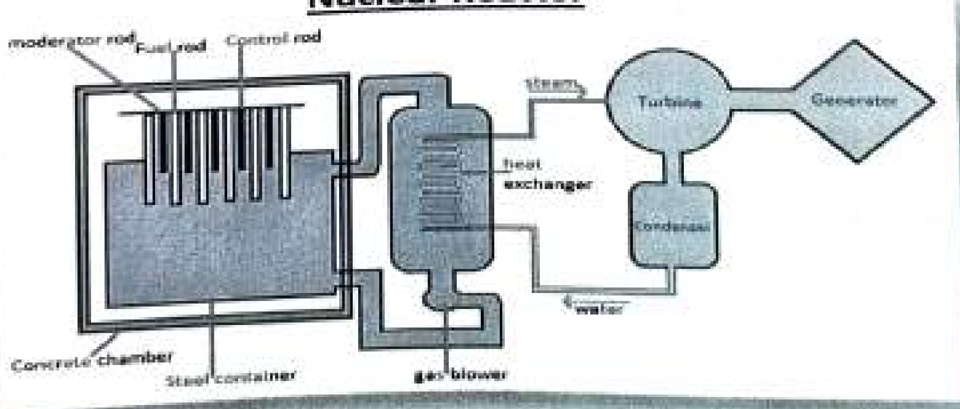
•During fission, heavy atomic nuclei split into smaller nuclei , releasing large amount of energy in form of heat.

$$^{238}_{92}U + ^{1}_{0}n \longrightarrow ^{239}_{92}U \xrightarrow[t_{1/2} = 23\ min]{\beta^-} ^{239}_{93}Np \xrightarrow[t_{1/2} = 2.3\ days]{\beta^-} ^{239}_{94}Pu$$

$$^{232}_{90}Th + ^{1}_{0}n \longrightarrow ^{233}_{90}Th \xrightarrow[t_{1/2} = 23.5\ min]{\beta^-} ^{233}_{91}Pa \xrightarrow[t_{1/2} = 27.4\ days]{\beta^-} ^{233}_{92}U$$

•This heat is used to produce steam, which drives turbines connected to generators to produce electricity.

Nuclear Reactor



Advantage: 1. Large amount of energy can produce

2. Low carbon emission

3. Reduce air pollution.

❖FUTURE DIRECTIONS:

•The future of chemistry holds promise for addressing 21st – century challenges.

•It is likely the chemical sciences will be increasingly required to solve challenges in energy , food production.

•Chemistry might have an increased role in biochemistry and pharmaceutical industry, as well as in the maintenance and development of infrastructure.

•Advances in carbon capture and utilization can help mitigate the effects of climate change.

❖Conclusion :

•Chemistry, with its newer technologies, is at forefront of solving 21st century challenges.

•From climate change mitigation to pollution control and resource sustainability, chemistry offers innovative solutions.

•By harnessing these technologies and embracing sustainable practices, we create a better and more resilient future for generations to come.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my teacher as well as my supervisor, *DR. Tanmay Das* for giving me golden opportunity to work on this wonderful project on the topic of "*THE ROLE OF CHEMISTRY TO SOLVE THE CHALLENGS OF 21st CENTURY*" . I am really very grateful to him for their invaluable guidance and support throughout this presentation.

I would also like to thank my other respected professor of my department and my parents and my friends for helped me to finish this presentation in limited time.

This presentation really helped me to increase my knowledge and skills.

Thank you all for your contributions.

THANK YOU

ENVIRONMENTAL CHEMISTRY: POLLUTION SOURCES, MONITORING METHORDS AND REMEDIATION TECHNOLOGIES

Report submitted to,

ABHEDANANDA MAHAVIDYALAYA (DEPARTMENT OF CHEMISTRY)

SAINTHIA, BIRBHUM

By

BISHAL BALLICK (B.Sc 6th Sem Chem. Honours)

Roll No. 210330100013

Reg. No. 202101026493 of 2021-22

Under The Supervision of,

Dr. Tanmay Das

ABHEDANANDA MAHAVIDYALAYA

SAINTHIA, BIRBHUM, WEST BENGAL, PIN 731234

Founder: Srimat Satyananda Dev (1965)

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Phone: 03462263449 E-mail: abhedanandamahavidyalaya@gmail.com Website: www.abhedanandamahavidyalaya.ac.in

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Tanmay Das 15-05-24
Supervisor

15/05/24
Head

Department of Chemistry

15/5/24
Principal

Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

❖ INTRODUCTION :

Environmental chemistry is the scientific study of the chemical and biochemical phenomena that occur in natural places. It should not be confused with green chemistry, which seeks to reduce potential pollution at its source. It can be defined as the study of the sources, reactions, transport, effects, and fates of chemical species in the air, soil, and water environments; and the effect of human activity and biological activity on these. Environmental chemistry is an interdisciplinary science that includes atmospheric, aquatic and soil chemistry, as well as heavily relying on analytical chemistry and being related to environmental and other areas of science.

Environmental chemistry involves first understanding how the uncontaminated environment works, which chemicals in what concentrations are present naturally, and with what effects. Without this it would be impossible to accurately study the effects humans have on the environment through the release of chemicals.

Environmental chemists draw on a range of concepts from chemistry and various environmental sciences to assist in their study of what is happening to a chemical species in the environment. Important general concepts from chemistry include understanding chemical reactions and equations, solutions, units, sampling, and analytical techniques.

ENVIRONMENTAL POLLUTION AND POLLUTANTS:

- It is caused by the addition of any undesirable substance to water, soil, or air, naturally or by human activities to such an extent that its adverse effects are observed on human beings, animals, and plants.
- Contaminants are substances which are not present in nature but are introduced into the environment by human activities and have adverse effects on environment. For example, methyl isocyanate (MIC).
- Receptors are the medium effected by the pollutants. Human eyes are receptors for smoke released by automobiles which causes irritation in the eyes.
- Sink is medium which interacts with the longlived pollutants and removes the pollution. Sea water acts as the sink for carbon dioxide. The main causes of pollution are increase inpopulation and depletion of natural resources, industrialization, urbanization, and deforestation.

❖ TYPE OF POLLUTION :

Air Pollution

Air pollution is fast becoming one of the most eminent problems we are facing.Once what was only considered a nuisance has now become a global crisis. Everything we have learned about air pollution can be expressed in terms of chemistry. The pollutants go through chemical changes in the atmosphere and become toxic to the biosphere. Let us take a look at atmospheric pollution.

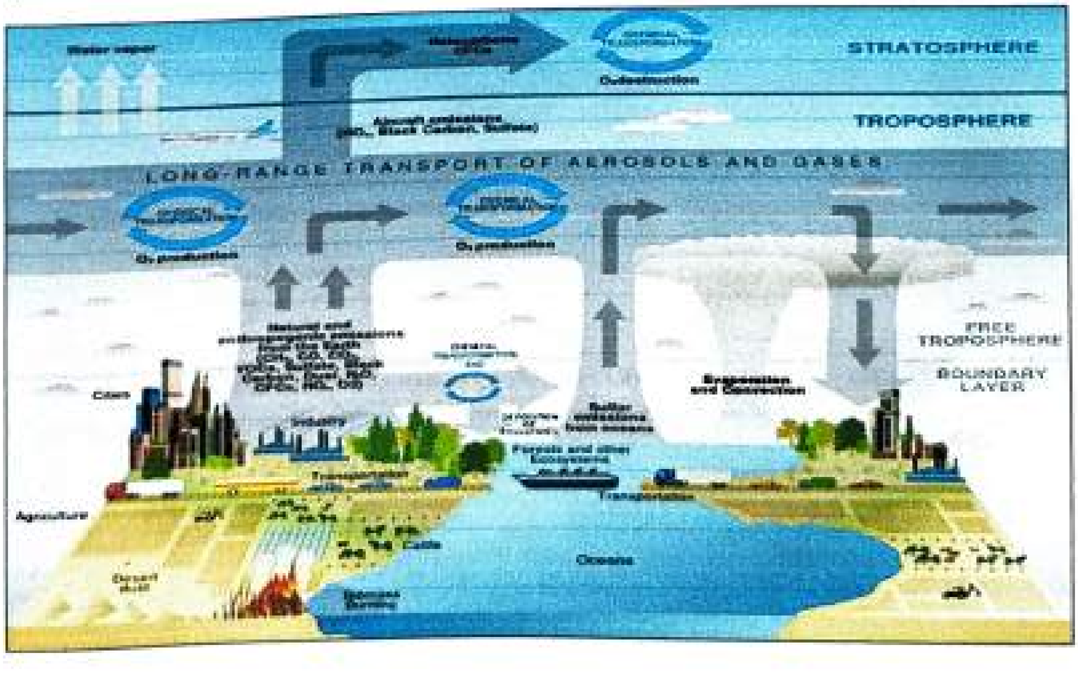
Type of Air Pollution

- Gaseous air pollutants contain oxides of sulphur, nitrogen and carbon, hydrocarbons, ozone, and other oxidants
- .Particulate pollutants contain dust, mist, smoke, smog, fumes, etc.

Atmospheric Pollution

We live on the Earth's surface, in the biosphere. Just above us, enveloping the earth is the atmosphere. The lowest region of this atmosphere is the troposphere. It extends up to 10 km from the Earth's surface and then comes the stratosphere. Everything from wind currents, cloud formation, precipitation etc happens in this two layers.

Hence most of the air pollution also occurs in these two layers of the atmosphere. Most of the pollution that causes us so many problems transpires in the troposphere. This is what we call



atmospheric pollution or tropospheric pollution.

We have already learned that there are various pollutants responsible for the air pollution. In terms of environmental chemistry, these pollutants are broadly divided into two categories – Gaseous Pollutants and Particulate pollutants (solid pollutants). Let us see which specific pollutants we are dealing with.

Gaseous Pollutants:

Oxides of Sulphur

Sulphur dioxide, oxide of sulphur, is a harmful gaseous pollutant that causes:

- Respiratory diseases such as asthma, bronchitis, and emphysema in human beings.
- Irritation in the eyes leads to tears and redness of the eyes.
- Stiffness in flower buds which eventually leads to fall off from plants.

Oxides of Nitrogen

At high temperatures, the unburnt fossil fuel from automobiles leads to the formation of nitric oxide (NO) and nitrogen dioxide (NO2) by reaction between nitrogen and oxygen gases present in the atmosphere as shown below.

At temperatures around 1483K,

$$N_2 (g) + O_2 (g) \rightarrow 2 NO (g)$$

NO reacts immediately with O2 present in the atmosphere, in the troposphere, and ozone in the stratosphere to form NO2.

$$NO(g) + O_2 (g) \rightarrow 2NO_2(g)$$

Oxides of nitrogen lead to lung irritation, acute respiratory diseases, retard the rate of photosynthesis, and corrode metals.

Oxides of Carbon

Carbon Monoxide: It is a highly poisonous gas due to its strong ability to bind with haemoglobin to form carboxhaemoglobin which blocks the transportation of oxygen in

the body or tissues of humans.

Carbon Dioxide: It is a respiratory gas, released into the atmosphere by respiration, burning of fuel, decomposition of limestone, deforestation and volcanic eruptions. The increased level of carbon dioxide in the atmosphere causes global warming.

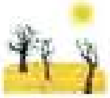
Air Pollution

Particulate Pollutants

Caused due to human activities

Climate

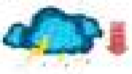
- Climatic disturbance, like



Drought

Volcanic eruption

Reduction of monsoon



Decrease in rain fall

Vegetation and Plant

- Decrease in crop vegetation

- Increase in green house gases i.e. Global Warming

Health

- Cancer

- Failed pregnancy

- Birth defect

- Death

Hydrocarbons

Gasoline | Petrol | Coal | Kerosene

Used as fuels, industries, manufacturing sector

↓

60% air pollution is due to automobiles that run on these hydrocarbon based fuels release NO and Hydrocarbons

↓

This NO is converted to NO_2

↓

$NO_2 \rightarrow NO + O$ (in presence of sunlight)

↓

$O + O_2 \rightarrow O$

↓

$NO + O \rightarrow NO_2 + O_2$

↓

O_3 and NO_2 oxidize hydrocarbons and smog is

Gaseous Pollutants

Oxides of carbon

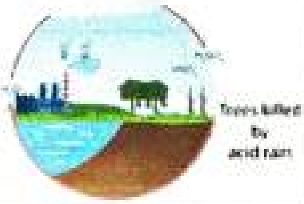
Causes of green house effect

Oxides of Nitrogen

Respiratory disease

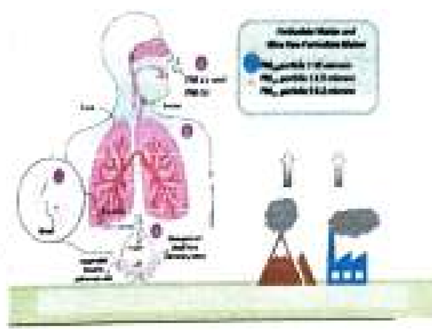
Oxides of Sulphur

Acid Rain



Particulate Pollutants

Particulate matter is the collective of all solid and liquid particles suspended in the atmosphere which are polluting and harmful to our biosphere. These particles originate and various different sources and are of many sizes and compositions. This particulate matter may originate in this form or can even be caused due to gaseous pollutants reacting with elements and becoming particulate matter.



The size and shape of the particulate matter play a big role in how harmful they are to the atmospheric pollution. Let us take a look at a few of these pollutants.

- ***Soot***: Incomplete combustion of coal and charcoal always leaves behind a black powder-like substance. This is soot. It is extremely small in size and toxic in nature. It can travel through our windpipe and settle in our lungs. Soot can cause a variety of diseases from Asthma to Bronchitis. Also, soot contains SO_2 and NO_2 that form acid rain.
- ***Metal Particles***: These oxides are formed during metal reactions. These particles react with other compounds in the air like SO_2 and become highly toxic. If inhaled by humans they have any ill effects on our health. One main harmful effect is that metal particles will reduce blood's ability to coagulate quickly, slowing down the process
- ***Asbestos Dust***: Asbestos is a highly toxic substance. Any activity related to it like manufacturing asbestos sheets or asbestos insulation can release asbestos dust. This is very harmful and a major cause of atmospheric pollution.
- ***Dust Particles***: Dust particles forming in everyday events or construction or agricultural activities etc is also a pollutant. They attach to other pollutants and become more harmful. In humans, they may cause allergies and other respiratory diseases.

Acid Rain

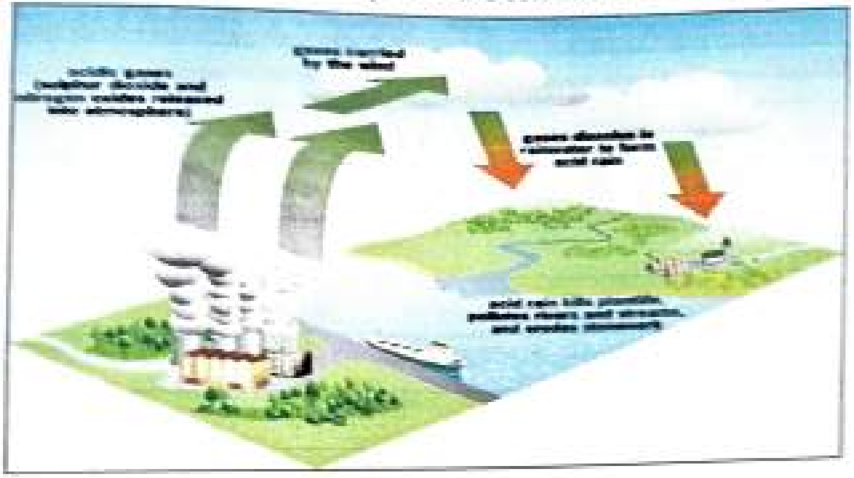
The pH of rain in normal conditions is slightly acidic, which is 5.6 due to the presence of H+ ions formed because of the reaction of rain water and carbon dioxide.

$$H_2O\,(l) + CO_2\,(g) \leftrightharpoons H_2CO_3\,(aq)$$
$$H_2CO_3\,(aq) \leftrightharpoons H^+\,(aq) + HCO_3^-\,(aq)$$

When the pH of rain water is below 5.6, it is known as acid rain. The oxides of nitrogen and sulphur are the major contributors to the acid rain as they undergo oxidation and react with water.

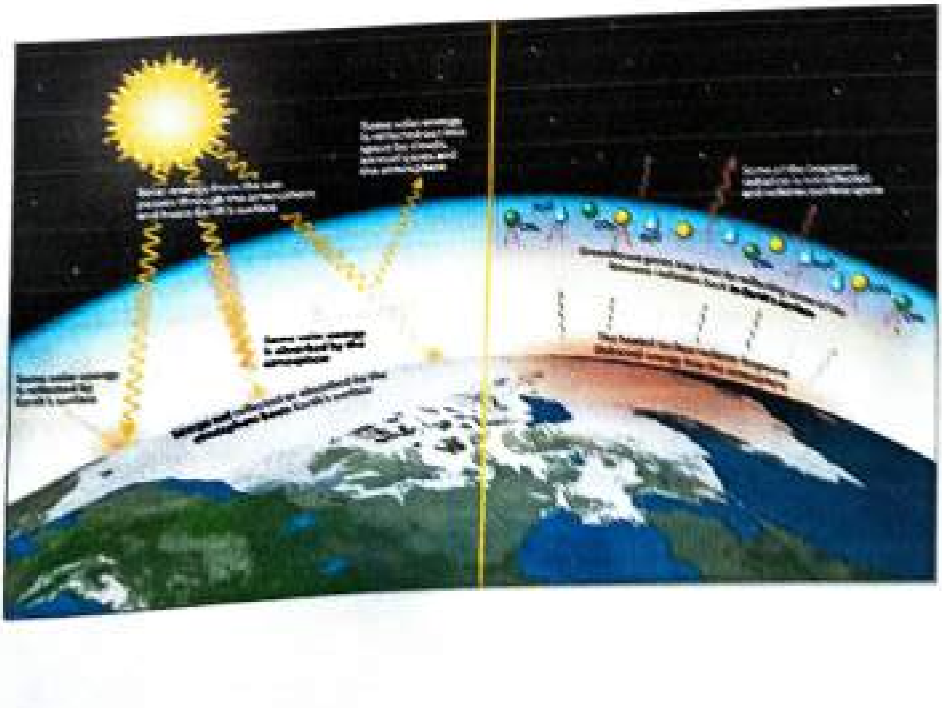
$$2\,SO_2(g) + O_2(g) + 2\,H_2O\,(l) \longrightarrow 2H_2SO_4\,(aq)$$
$$2\,NO_2(g) + O_2(g) + 2H_2O\,(l) \longrightarrow 4HNO_3\,(aq)$$

Acid rain is harmful for agriculture crops, trees, and plants as it dissolves and washes away nutrients important for their growth. It also causes respiratory ailments in humans and animals. Acid rain water also affects the aquatic ecosystem and corrodes water pipelines resulting in the leaching of heavy metals such as iron, lead, and copper into the drinking water. Acid rain also damages buildings, monuments, and other structures made of stone or metals. Taj Mahal is one of the examples of the corrosion caused by acid rain.



Global Warming and Greenhouse Effect :

Most of the solar radiation is absorbed by the earth's atmosphere and the heat that reaches the earth's surface is trapped by some gases such as methane, carbon dioxide, ozone, chlorofluorocarbon (CFC) compounds, and water vapour in the atmosphere. These gases cause increases in the earth's temperature and this causes global warming. Carbon dioxide gas is the major contributor of global warming.



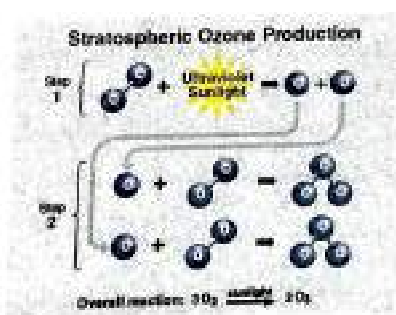
The process of heating the earth's atmosphere when some gases present in the earth's atmosphere traps the heat from the Sun. The gases which contribute to global warming such as methane, carbon dioxide, and ozone are known as greenhouse gases.

Formation and Breakdown of Ozone: Stratospheric pollution is a significant environmental concern, and understanding its impact on the Earth's atmosphere is essential for JEE Main students. One critical aspect of stratospheric pollution is the formation and breakdown of ozone in the stratosphere.

Formation of Ozone:

Ozone (O_3) is a molecule composed of three oxygen atoms. It is vital for life on Earth because it forms the ozone layer in the stratosphere, which plays a crucial role in protecting living organisms from harmful ultraviolet (UV) radiation from the sun. Ozone is naturally formed and maintained through a delicate balance of chemical reactions in the stratosphere. The key reaction responsible for ozone formation is:

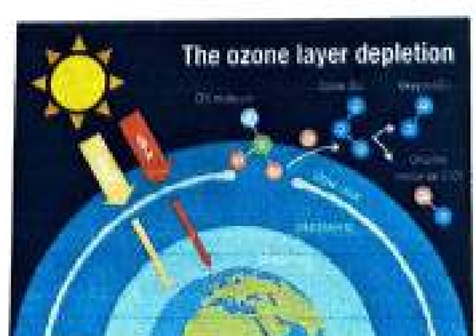
Oxygen Photolysis and zone Formation:



The formation of ozone is an ongoing process, where ozone molecules are constantly created and destroyed in a dynamic equilibrium, maintaining a relatively stable concentration in the stratosphere.

Breakdown of Ozone:

Ozone in the stratosphere is also subject to breakdown through various chemical reactions. While natural processes contribute to ozone depletion, human activities have significantly accelerated the breakdown of ozone. The most well-known contributor to ozone depletion is the release of certain chemicals known as



ozone-depleting substances (ODS). The primary reactions involved in ozone breakdown are:

As a result, ozone molecules are converted back into molecular oxygen (O_2), depleting the ozone layer.

Effects of Ozone Depletion:

Ozone depletion has significant and far-reaching effects on the environment, human health, and ecosystems:

- **Increased UV Radiation**: With a thinner ozone layer, more UV-B and UV-C radiation reach the Earth's surface. This can lead to increased cases of skin cancer, cataracts, and other health issues in humans. UV radiation can also harm animals and plants, affecting ecosystems.
- **Ozone Holes:** Particularly over Antarctica, ozone depletion has led to the formation of ozone holes. These are regions with significantly reduced ozone concentrations, allowing for even more harmful UV radiation to penetrate the atmosphere.
- **Climate Change:** Ozone depletion can influence the Earth's climate. Changes in the distribution of ozone in the stratosphere can affect temperature patterns and wind circulation, potentially impacting weather systems.
- **Aquatic Ecosystems:** Increased UV radiation can penetrate aquatic ecosystems, harming phytoplankton and other aquatic organisms that form the base of the food chain. This can have cascading effects on marine life.
- **Terrestrial Ecosystems:** Ozone depletion can damage terrestrial plants, affecting crop yields and disrupting ecosystems.

❖ Air Pollution monitoring methods:

Air pollution monitoring employs various methods to measure key pollutants such as particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur dioxide (SO2), and ozone (O3):

Particulate Matter (PM):

- Sampling Methods: High-volume samplers collect air onto filters for gravimetric analysis. Real-time monitors use light scattering or beta attenuation.
- Measurement Techniques: Gravimetric analysis weighs particles to determine mass (PM10, PM2.5). Chemical analysis identifies components like metals.

Volatile Organic Compounds (VOCs):

- Sampling Methods: Canisters or sorbent tubes capture VOCs for laboratory analysis. Passive samplers absorb VOCs over time.
- Measurement Techniques: Gas chromatography separates and quantifies VOCs. Mass spectrometry identifies specific compounds.

Nitrogen Oxides (NO_x):

- Sampling Methods: Chemiluminescence measures NO and NO2. Diffusive samplers absorb NO2 for laboratory analysis.
- Measurement Techniques: Chemiluminescent detection quantifies NO and NO2 concentrations. UV absorption measures NO2 levels.

Sulphur Dioxide (SO_2):

- Sampling Methods: Impingers capture SO2 in absorbing solutions. Automatic monitors use spectroscopic methods.
- Measurement Techniques: Titration determines SO2 content. UV fluorescence detects SO2 concentrations.

Ozone (O3):

- Sampling Methods: Chemiluminescence reacts ozone with a reagent emitting light. Absorption spectroscopy measures UV or infrared light absorption.
- Measurement Techniques: Continuous monitors provide real-time data. Passive samplers collect ozone over time for laboratory analysis.

These methods provide crucial data for assessing air quality, guiding regulatory measures, and protecting public health and the environment from the harmful effects of air pollution.

❖ Water Pollution:

The dissolved oxygen (DO) in water has a concentration of up to 10 ppm (parts per million). Polluted water has reduced the concentration of DO in water and the DO below 6 ppm inhibits the growth of fishes and affects aquatic life.

The amount of oxygen required by bacteria to break down the organic matter present in water samples is called biochemical oxygen demand (BOD). Clean water has a BOD value of less than 5 ppm whereas polluted water has a BOD value of 17ppm or more.

Sources of Water Pollution:

Pathogens: Pathogens include bacteria and other organisms present in sewage and animal excreta that enter the drinking water which causes many diseases such as gastrointestinal diseases.

Organic Waste: The organic matter such as leaves, grass, trash etc. and excessive growth of phytoplankton causes water pollution which decreases the DO in water and affects aquatic life.

Chemical Pollutants: The water soluble inorganic chemicals such as cadmium, mercury, and nickel are dangerous to humans as they do not excrete out of the body and affect the kidney, CNS (central nervous system), liver, etc. The organic chemicals from petroleum, oil spills, pesticides, etc. discharge into the ocean and cause water pollution. The addition of these water pollutants in water bodies increases the nutrients in the water which support a dense plant population, which kills an animal or aquatic life due to deprivation of oxygen in the water and subsequently results in loss of biodiversity, this process is known as eutrophication.

International Standard for Drinking Water

The international standard for drinking water is as follows:

- **Fluoride:** The low concentration of fluorides in drinking water causes tooth decay. F - ion helps in the hardening of enamel by converting hydroxyapatite [$3(Ca_3(PO_4)_2)$. $Ca(OH)_2$] into harder fluorapatite [$3(Ca_3(PO_4)_2)$. CaF_2].

The amount of oxygen required by bacteria to break down the organic matter present in water samples is called biochemical oxygen demand (BOD). Clean water has a BOD value of less than 5 ppm whereas polluted water has a BOD value of 17ppm or more.

Sources of Water Pollution:

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Sodium fluorides are added to drinking water to bring its concentration up to 1 ppm. A concentration of more than 2 ppm causes a mottling of teeth and harmful effect to bones and teeth.

- **Lead:** The prescribed upper limit of concentration of lead in drinking water is about 50 ppb (parts per billion). More than the prescribed limit of the lead causes damage to the kidney, liver, reproductive system, etc.
- **Sulphate:** The sulphate of more than 500 ppm in drinking water causes a laxative effect and a moderate level of sulphate has a mild or harmless effect.
- **Nitrate:** The upper limit of nitrate in drinking water is 50 ppm. Excess nitrate in drinking water causes 'blue baby' syndrome or methemoglobinemia.

Maximum Prescribed Concentration of Some Metals in Drinking Water

Metal	Maximum concentration (ppm or mg dm-3)
Fe	0.2
Al	0.2
Cu	3.0
Zn	5.0
Cd	0.005
Mn	0.05

Water Pollution Monitoring:

Water pollution monitoring involves assessing various aspects to determine the quality and safety of water bodies. Chemical pollutants are monitored through sampling and analysis of substances like heavy metals, pesticides, and industrial chemicals, using techniques such as spectrophotometry and chromatography. These pollutants can originate from industrial discharges, agriculture, or urban runoff.

Biological contaminants, such as bacteria, viruses, and parasites, are assessed through microbiological testing methods. These include culture-based methods or advanced techniques like polymerase chain reaction (PCR) for detecting pathogens in water sources, especially crucial for assessing drinking water quality.

Physical parameters are monitored to evaluate the water's physical characteristics, such as temperature, turbidity, pH, and dissolved oxygen levels. These parameters affect aquatic life and indicate the water body's health and ecological balance. Instruments like multi parameter probes and sensors are used for real-time monitoring in situ.

Integrated approaches combining chemical, biological, and physical monitoring provide comprehensive insights into water quality. Continuous monitoring programs and periodic sampling ensure timely detection of pollution events, facilitating effective management and protection of water resources for environmental and public health sustainability.

❖ Soil Pollution

Soil pollution is the presence of harmful chemicals in the soil that affect humans and plant growth.

Sources of Soil Pollution:

Pesticides:

- Prior to World War II, nicotine was used as a pest controlling substance for major crops.
- During World War II, DDT was greatly used as a pesticide as it was very effective to control malaria and other insect-borne diseases.
- Pesticide industries have shifted their attention to herbicides such as sodium chlorate ($NaClO3$) and sodium arsenite ($NA3SO3$) and many others.

Pesticides and herbicides are toxic to mammals and cause damage to multiple organs in humans, birth defects, genetic disorders, etc.

Industrial Wastes

Industrial wastes are categorised as biodegradable and non-biodegradable wastes.

- **Biodegradable Wastes:** The wastes that can undergo aerobic or anaerobic decomposition are known as biodegradable wastes. The biodegradable wastes are generated by cotton mills, food processing units, paperills, and textile factories.

- **Non-biodegradable Wastes**: The wastes that do not undergo decomposition naturally and remain on earth for thousands of years. Non-biodegradable wastes are produced by thermal power plants, many industries such as iron and s teel industry, fertiliser industry, industries manufacturing aluminium, zinc, and copper.

Strategies to Control Environmental **Pollution Waste** Management: The government has taken many steps to manage the waste to control environmental degradation such as the 'Clean India Mission' or 'Swachh Bharat Abhiyan' which implemented two programmes listed below:Swachh Bharat Mission - Urban (SBM-U): It aims at making urban India free from open defecation and achieving 100% scientific management of solid wastes in the country. Swachh Bharat Mission - Rural (SBM-R): It aims at improving the quality of life in rural areas by encouraging sanitation, hygiene, cleanliness, and eliminating open defecation.

Soil Pollution Monitoring **Method:** Soil pollution monitoring involves two key methods:

1. **Contaminant Analysis:** This method focuses on identifying and quantifying pollutants present in the soil. It typically involves collecting soil samples from various locations and depths, then analyzing them in laboratories. Common pollutants assessed include heavy metals (e.g., lead, cadmium), pesticides, herbicides, and organic contaminants. Analytical techniques such as chromatography, spectroscopy, and atomic absorption spectroscopy are used to determine pollutant concentrations accurately.

2. **Soil Health Indicators:** Monitoring soil health involves assessing indicators that reflect the overall quality and functionality of the soil ecosystem. This includes biological indicators (e.g., microbial activity, earthworm abundance), chemical indicators (e.g., pH, nutrient levels), and physical indicators (e.g., soil texture, structure). Changes in these indicators can signal soil degradation or contamination effects. Bioindicators like sensitive plant species or microbial diversity can also be used to assess the impact of pollutants on soil health.

By combining contaminant analysis with soil health indicators, monitoring programs can provide a comprehensive understanding of soil pollution levels, guide remediation efforts, and support sustainable land management practices.

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By combining contaminant analysis with soil health indicators, monitoring programs can provide a comprehensive understanding of soil pollution levels, guide remediation efforts, and support sustainable land management practices.

❖ Noise Pollution:

Noise pollution refers to the excessive and disturbing noise that may have harmful effects on human health and the environment. It is typically caused by industrial activities, transportation, construction, and everyday urban life. Noise pollution can interfere with normal activities such as sleeping, communication, and recreation, and prolonged exposure can lead to stress, hearing impairment, and other health issues. Measures to control noise pollution include soundproofing, noise barriers, and regulations on noise levels in different environments.

Source of Noise Pollution:

Noise pollution can originate from various sources, both natural and man-made. Here are some common sources:

- **Transportation:** Vehicles are a major contributor to noise pollution, with road traffic being the most significant source. The noise is generated from engine combustion, exhaust systems, tire-road interaction (road noise), and aerodynamic effects (aircraft and train noise). Airports, highways, and urban intersections are particularly noisy environments due to the concentration of vehicles.

- **Industrial Activities:** Industrial facilities such as factories, construction sites, and manufacturing plants produce noise from various sources. This includes the operation of heavy machinery, equipment like compressors and pumps, and processes such as metalworking and assembly lines. Noise levels can vary depending on the type of industry and the scale of operations.

- **Urbanization**: Urban areas experience heightened noise levels due to their density and diverse activities. Traffic noise from cars, buses, and motorcycles is pervasive, along with commercial activities like retail and hospitality. Construction activities for new buildings, roads, and infrastructure also contribute significantly to urban noise pollution.

- **Recreational Activities:** Recreational events such as concerts, festivals, and sporting events generate loud noise levels, especially when amplified by sound systems. Additionally, motorized recreational activities such as off-road vehicles (e.g., ATVs, jet skis) contribute to noise pollution in natural environments.

- **Household Sources:** Noise from household appliances such as air conditioners, refrigerators, washing machines, and dishwashers can contribute to indoor noise levels. While individually these may not seem loud, in aggregate they contribute to overall environmental noise.

- **Social Gatherings:** Events like parties, weddings, and celebratio ns can create noise disturbances in residential areas, particularly at night. These social activities often involve music, talking, and sometimes fireworks or other loud entertainment.

- **Infrastructure Development:** Construction activities for roads, bridges, tunnels, and buildings involve the use of heavy machinery such as

excavators, bulldozers, jackhammers, and cranes. These equipment generate considerable noise during both daytime and nighttime operations.

These sources collectively contribute to noise pollution, impacting human health by causing stress, hearing loss, sleep disturbances, and other physiological effects. Noise pollution also affects wildlife, disrupting their communication, migration patterns, and reproduction. Effective management strategies include implementing noise regulations, using sound barriers and buffers, employing quieter technologies, and promoting awareness and education about noise reduction practices.

Monitoring Methods of Noise Pollution:

Monitoring technologies for noise pollution involve various methods and devices designed to measure, analyze, and assess noise levels in different environments. Sound level meters are commonly used instruments that quantify noise levels in decibels (dB), providing real-time data on the intensity and frequency of noise. These meters are portable and can be used for spot measurements or installed for continuous monitoring in specific locations.

Advanced monitoring technologies include acoustic sensors and networks that utilize Internet of Things (IoT) principles to collect and transmit noise data across large areas. These systems can create noise maps, identifying hotspots of high noise pollution and helping urban planners and policymakers make informed decisions. Additionally, noise monitoring software can analyze data trends over time, identifying patterns and correlations with factors such as traffic flow or industrial operations.

Overall, these technologies play a crucial role in understanding the extent of noise pollution, assessing compliance with regulatory standards, and implementing effective strategies for noise management and reduction.

❖ Green Chemistry:

- not a single discipline of chemistry
- Applies innovative scientific solutions to real-world environmental problems
- Results in source reduction because it prevents the generation of pollution
- Reduces the negative impacts of chemical products and processes on human health and the environment
- Lessens and sometimes eliminates hazards from existing products and processes
- Designs chemical products and processes to reduce their intrinsic hazards

How Green Chemistry Prevents Pollution

Green chemistry reduces pollution at its source by minimizing or eliminating the hazards of chemical feedstocks, reagents, solvents, and products.

This is not the same as cleaning up pollution (also called remediation), which involves treating waste streams (end-of-the-pipe treatment) or cleanup of environmental spills and other releases. Remediation may include separating hazardous chemicals from other materials, then treating them so they are no longer hazardous or concentrating them for safe disposal. Most remediation activities do not involve green chemistry. Remediation removes hazardous materials from the environment; on the other hand, green chemistry keeps the hazardous materials from being generated in the first place.

If a technology reduces or eliminates the hazardous chemicals used to clean up environmental contaminants, this technology would also qualify as a green chemistry technology. One example is replacing a hazardous sorbent [chemical] used to capture mercury from the air for safe disposal with an effective, but nonhazardous sorbent. Using the nonhazardous sorbent means that the hazardous sorbent is never manufactured and so the remediation technology meets the definition of green chemistry.

The 12 Principles of Green Chemistry

1. Prevent waste: Design chemical syntheses to prevent waste. Leave no waste to treat or clean up.

2. Maximize atom economy: Design syntheses so that the final product contains the maximum proportion of the starting materials. Waste few or no atoms.

3. Design less hazardous chemical syntheses: Design syntheses to use and generate substances with little or no toxicity to either humans or the environment.

4. Design safer chemicals and products: Design chemical products that are fully effective yet have little or no toxicity.

5. Use safer solvents and reaction conditions: Avoid using solvents, separation agents, or other auxiliary chemicals. If you must use these chemicals, use safer ones.

6. Increase energy efficiency: Run chemical reactions at room temperature and pressure whenever possible.

7. Use renewable feedstocks: Use starting materials (also known as feedstocks) that are renewable rather than depletable. The source of renewable feedstocks is often agricultural products or the wastes of other processes; depletable feedstocks are often fossil fuels (petroleum, natural gas, or coal) or mining operations.

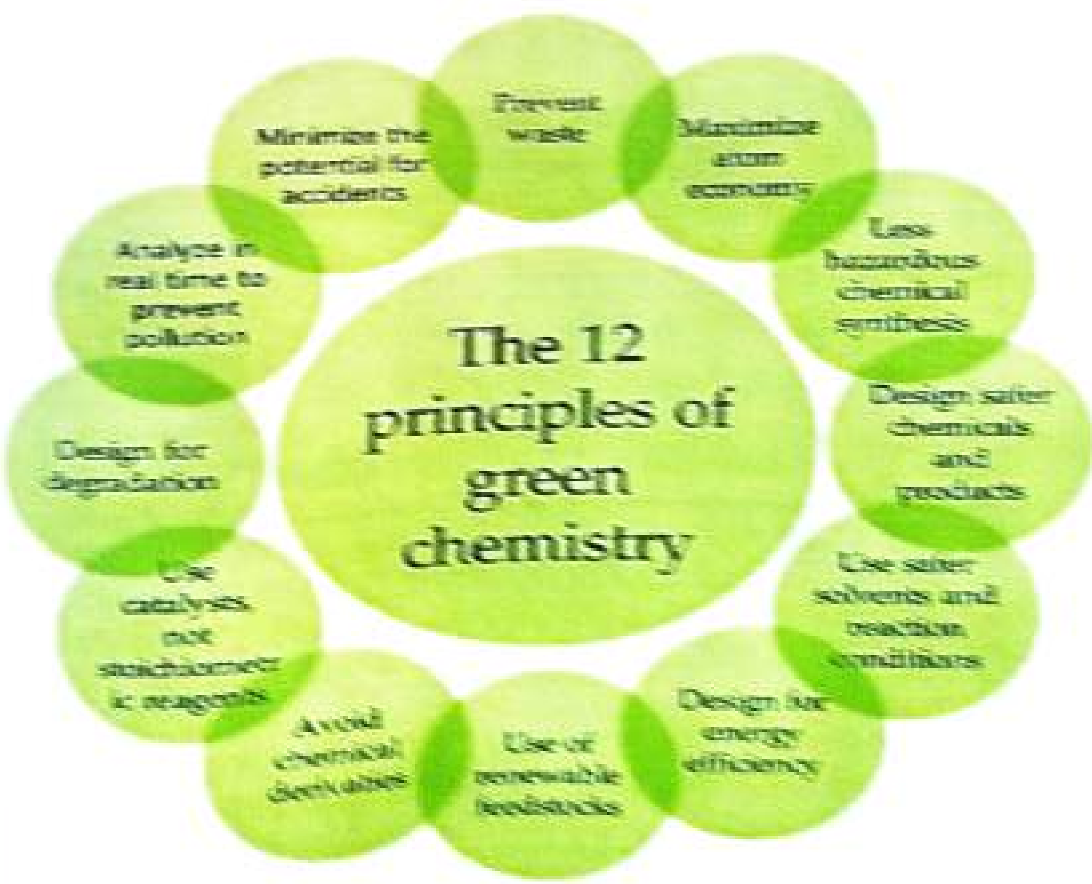
8. Avoid chemical derivatives: Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.

...catalysts, not stoichiometric reagents: Minimize waste by using catalytic reactions. ...sts are effective in small amounts and can carry out a single reaction many times. ...re preferable to stoichiometric reagents, which are used in excess and carry out a ...on only once.

...sign chemicals and products to degrade after use: Design chemical products to break ...to innocuous substances after use so that they do not accumulate in the environment.

...alyze in real time to prevent pollution: Include in-process, real-time monitoring and ...ol during syntheses to minimize or eliminate the formation of byproducts.

...nimize the potential for accidents: Design chemicals and their physical forms (solid, ..., or gas) to minimize the potential for chemical accidents including explosions, fires, ...eleases to the environment.

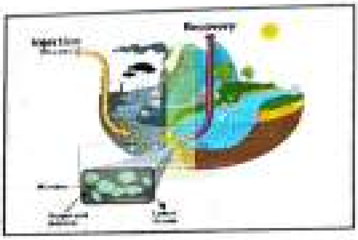


❖ REMEDIATION TECHNOLOGIES :

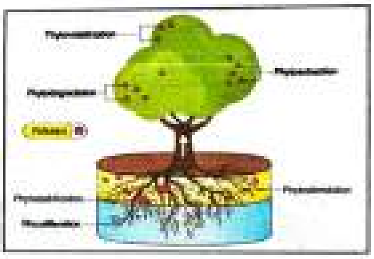
Remediation technologies for environmental pollution encompass a range of methods aimed at mitigating contaminants in soil, water, and air. Here's an exploration of various approaches, including biological, chemical, physical methods, and nanotechnology applications:

Biological Remediation

- **Bioremediation:** Utilizes microorganisms (bacteria, fungi, etc.) to degrade organic pollutants into less harmful substances like carbon dioxide and water. It can occur in situ (on-site) or ex situ (off-site) and is effective for oil spills, hydrocarbons, and certain solvents.

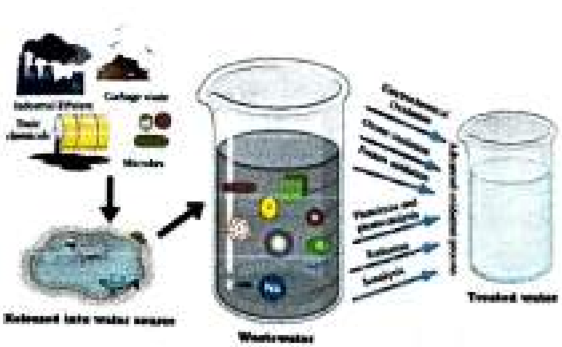


- **Phytoremediation:** Involves plants to absorb, accumulate, and sometimes degrade contaminants such as heavy metals (lead, arsenic) through their roots or volatilize them through their leaves. It's suitable for areas with shallow contamination or where soil disturbance is impractical.



Chemical Treatment

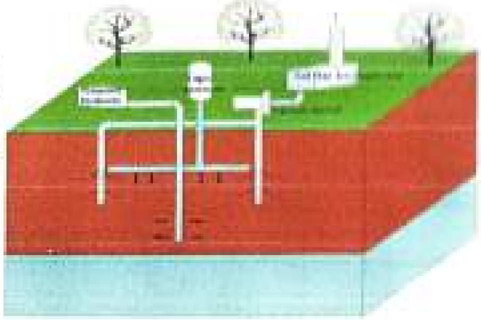
- **Oxidation:** Uses chemical oxidants (e.g., hydrogen peroxide, ozone) to break down organic pollutants into simpler, less harmful compounds. This method is effective for treating groundwater contaminated with solvents or petroleum products.



- **Dredging:** Involves the removal of contaminated sediments from water bodies to reduce the concentration of pollutants. It's often combined with other treatments like stabilization or disposal in landfills.

Physical Methods

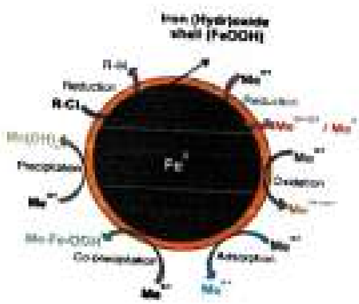
- **Soil Vapor Extraction (SVE):** Involves pumping air or steam into contaminated soil to vaporize volatile organic compounds (VOCs), which are then collected and treated



above ground. It's effective for soil contaminated with gasoline, solvents, or other volatile chemicals.
- **Dredging:** Not only used for sediment removal but also for contaminated soil from water bodies. Dredged material can be treated on-site or transported to facilities for further processing or disposal.

Nanotechnology Applications

- **Nano-iron Remediation:** Involves the use of nanoscale zero-valent iron (nZVI) particles to degrade contaminants such as chlorinated solvents and heavy metals. These particles have high reactivity and a large surface area, enhancing their effectiveness in groundwater and soil remediation.



- **Nano-catalysts:** Utilized in oxidation processes (advanced oxidation processes, AOPs) for breaking down organic pollutants. Nanoparticles like titanium dioxide (TiO2) or cerium oxide (CeO2) act as catalysts when exposed to ultraviolet (UV) light or other activation methods.

Integration and Considerations

- **Combined Remediation Approaches:** Often, multiple technologies are combined to optimize effectiveness and address specific site conditions. For example, bioremediation may be followed by chemical oxidation to treat residual contaminants.

- **Site-Specific Factors:** Successful remediation depends on factors such as the type and concentration of contaminants, soil or water characteristics, and regulatory requirements. Tailoring the approach to these factors ensures efficiency and compliance.

Future Directions

- **Advancements in Technology:** Continued research focuses on enhancing the efficiency and reducing the cost of remediation technologies. Nanotechnology, in particular, holds promise for more targeted and effective treatment of contaminants at smaller scales.
- **Environmental Sustainability:** Emphasis on sustainable practices ensures that remediation efforts minimize secondary environmental impacts and promote long-term ecosystem health.

In summary, remediation technologies for environmental pollution span biological, chemical, physical, and nanotechnological methods. Each approach offers unique advantages and is chosen based on specific contaminant types, site conditions, and regulatory considerations. Ongoing innovation and integration of these technologies are essential for effective environmental stewardship and sustainable development.

❖ CONCLUSION

In the realm of environmental chemistry, the study and mitigation of pollution stand as paramount challenges demanding urgent attention and innovative solutions. Pollution, whether from industrial emissions, agricultural practices, urban development, or waste disposal, poses significant threats to ecosystems, biodiversity, and human health worldwide.

The integration of advanced imaging technologies such as satellite imagery, infrared imaging, drones, and environmental sensors has revolutionized our ability to monitor and understand pollution dynamics across various spatial scales. These tools provide invaluable insights into pollution sources, dispersion patterns, and their impacts on air, water, and soil quality.

Moreover, effective pollution control strategies necessitate interdisciplinary efforts involving scientists, policymakers, industry leaders, and communities. It requires implementing stringent regulations, adopting cleaner technologies, promoting sustainable practices, and enhancing public awareness.

Continued research and innovation in environmental chemistry are essential to develop more effective monitoring techniques, mitigate emerging pollutants, and assess long-term environmental impacts. Additionally, international collaboration and knowledge-sharing are crucial to address global pollution challenges comprehensively.

Ultimately, by leveraging scientific advancements and collective action, we can strive towards a cleaner, healthier environment, safeguarding natural resources for future generations and promoting sustainable development worldwide.

❖ ACKNOWLEDGEMENT:

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THANK YOU

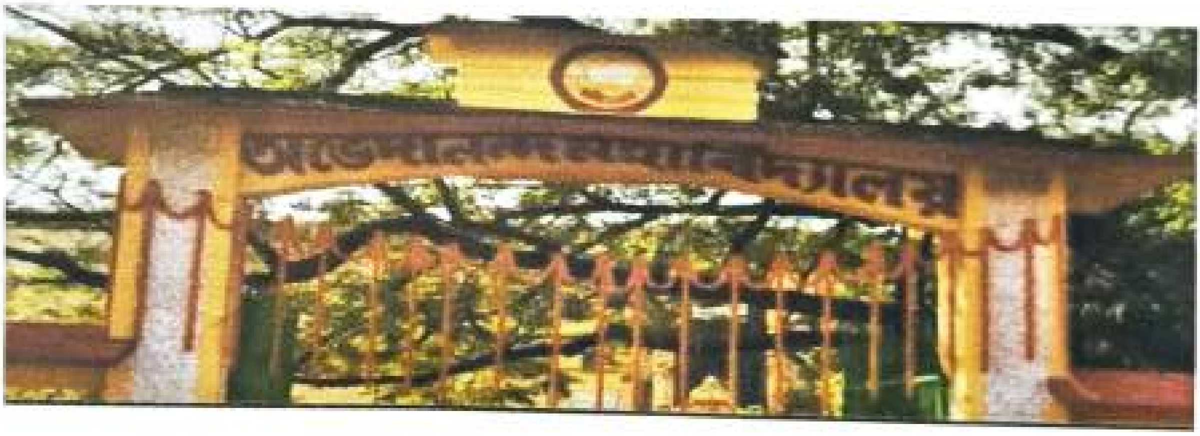
GREEN CHEMISTRY PRINCIPLE:

"Sustainable Development Approaches to Chemical Synthesis and Reduce Pollution":-

Report Submitted to,

Abhedananda Mahavidyalaya (Department of Chemistry)

Sainthia, Birbhum



By,

SHARADINDU SARKAR (B.SC Honours, 6th Semester)

Roll No:- 210330100046

Reg. No:- 202101026531 of 2021-22

Under the Supervision of,

DR.TANMAY DAS (Assistant professor)

Department of Chemistry

ABHEDANANDA MAHAVIDYALAYA

SAINTHIA, BIRBHUM, WEST BENGAL, PIN 731234

Founder: Srimat Satyananda Dev (1965)

(Affiliated to the University of Burdwan and Accredited by NAAC)

Phone: 03462263449 E-mail: abhedanandamahavidyalaya@gmail.com Website: www.abhedanandamahavidyalaya.ac.in

Date: 15.05.2024

Department of Chemistry

Certificate of Project Completion

This is to certify that Mr. Sharadindu Sarkar, a student of B.Sc. (Hons.) in Chemistry, 6th Semester, Roll No. 210330100046, Registration No. 202101026531 of 2021-22, has successfully completed the project titled: **"Green Chemistry Principle: Sustainable Development Approaches to Chemical Synthesis and Reduce Pollution"** under the supervision of Dr. Tanmay Das, Department of Chemistry, Abhedananda Mahavidyalaya, Sainthia, during the academic session 2023-2024.

Tanmay Das 15-05-24

Supervisor

Head 15/05/24

Department of Chemistry

Principal

Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

- **INTRODUCTION**:- **'Green chemistry'** is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. **'PAUL ANASTAS', Is** Known as the father of green chemistry, who defined or obtained the term **'Green Chemistry'** for the first time in **1991**.**'Green Chemistry',** is also known as **"Environmentally Benign Chemistry"** or " **Sustainable Chemistry"**.**'Green Chemistry'** looks at pollution prevention on the molecular scale and is an extremely important area of chemistry due to the importance of chemistry in our world today and the implications it can have on our environment. Scientists **Paul ANASTAS** and **John Warner** formulated the Twelve (12) Principles of green chemistry in **1998,** in the book of **"Green Chemistry Theory and Practice".** These serve as guidelines for chemists seeking to lower the ecological footprint of the chemicals they produce and the processes by which such chemicals are made. This is the Invention, design and application of chemical products and processes to reduce or to eliminate the use of hazardous substances.

"Green chemistry is About....":-

Why Do You Need Green Chemistry??

1. Chemistry is undeniably a very prominent or great part of our daily lives.
2. Chemical developments also bring new environmental problems and harmful unexpected side effects, which result in the need for green chemical products.
3. A famous example is the ' **Pesticide DDT'**.
4. The Green Chemistry program supports the invention of a more environmentally friendly chemical process which reduces any risk or eliminates the generation of hazardous substances.
5. This program works very closely with the twelve principles of **Green Chemistry.**

**Goals or Importance of Green Chemistry:-

1. To reduce adverse environmental impact, try appropriate and innovative choice of material and their chemical transformation.
2. To develop processes based on renewable rather than Non- renewable raw materials.
3. To develop processes that are less prone to obnoxious chemical release, fire and explosion.
4. To minimise by-products in chemical transformation by redesign of reactions and reaction sequences.
5. To develop products that are less toxic and degrade more rapidly in the environment than the current products.
6. To reduce the requirements for hazardous persistence solvents and to improve energy efficiency by developing low temperature and low pressure processes using new catalysts .

☐ Important Twelve Principles of 'Green Chemistry':-

1. **Prevention Of Waste or By Product's:-** It is better to prevent waste **(Fig.1)** than to treat or clean up waste after it is formed in nature. **(Fig.2)**

Fig.1:- Waste Prevention

Fig.2:-Environments Changes with time

2. **Atom Economy**:- ' Atom economy', or 'Atom Efficiency' describes the conversion efficiency of a chemical process in terms of all atoms involved (desired products produced).

$$\% \text{ atom economy} = \frac{Molecular\ Weight\ of\ Desired\ Product}{Molecular\ Weight\ of\ All\ Reactants} \times 100\%$$

- For this reaction, the atom economy should be maximum.

6. **Design For Energy Efficiency**:- Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimised. Possible synthetic methods should be conducted at ambient temperature and pressure.

- *Energy*:- Developing the alternatives for energy generation (Photovoltaic, Hydrogen, Fuel Cells, Bio based Fuels etc) as well as continue the path towards energy efficiency with catalysis and product design at the forefront. **(Fig.6)**

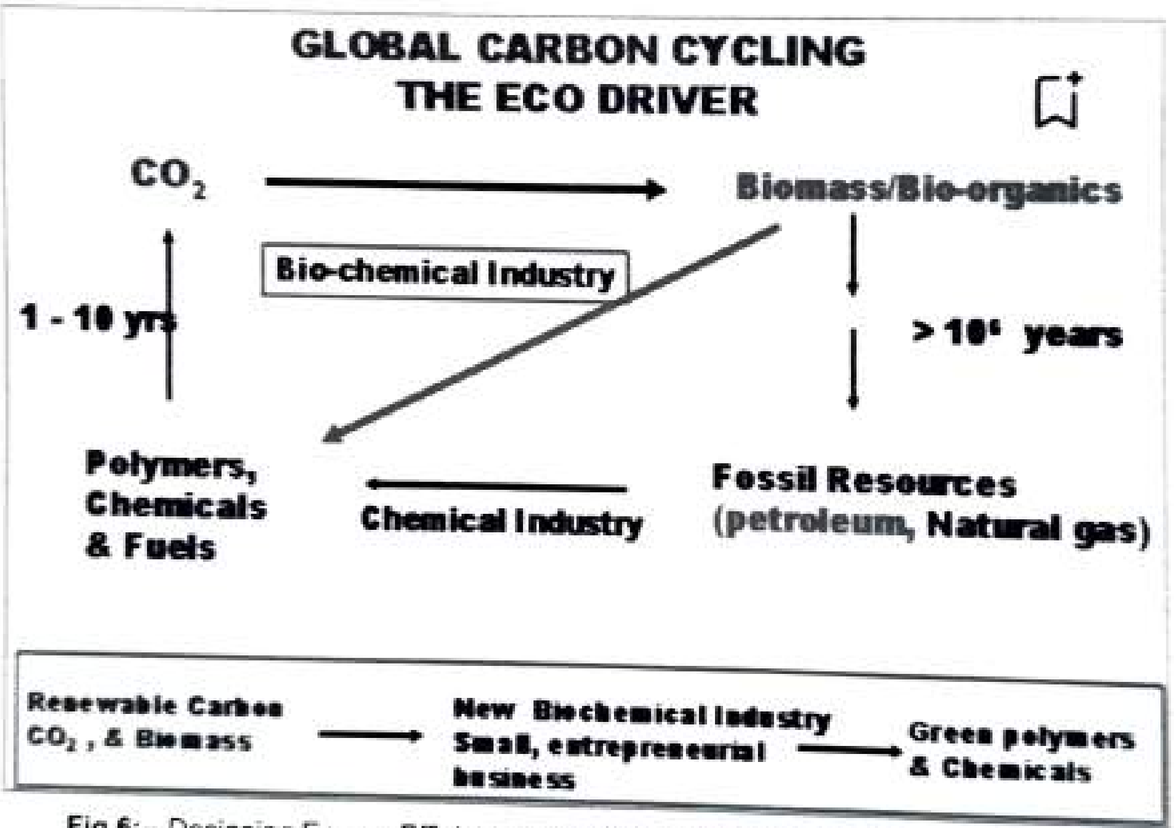


Fig.6:-- Designing Energy Efficiency by Carbon Cycle in Green Polymers Industry

7. **Use of Renewable Feedstock**:- A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable. **(Fig.7)**

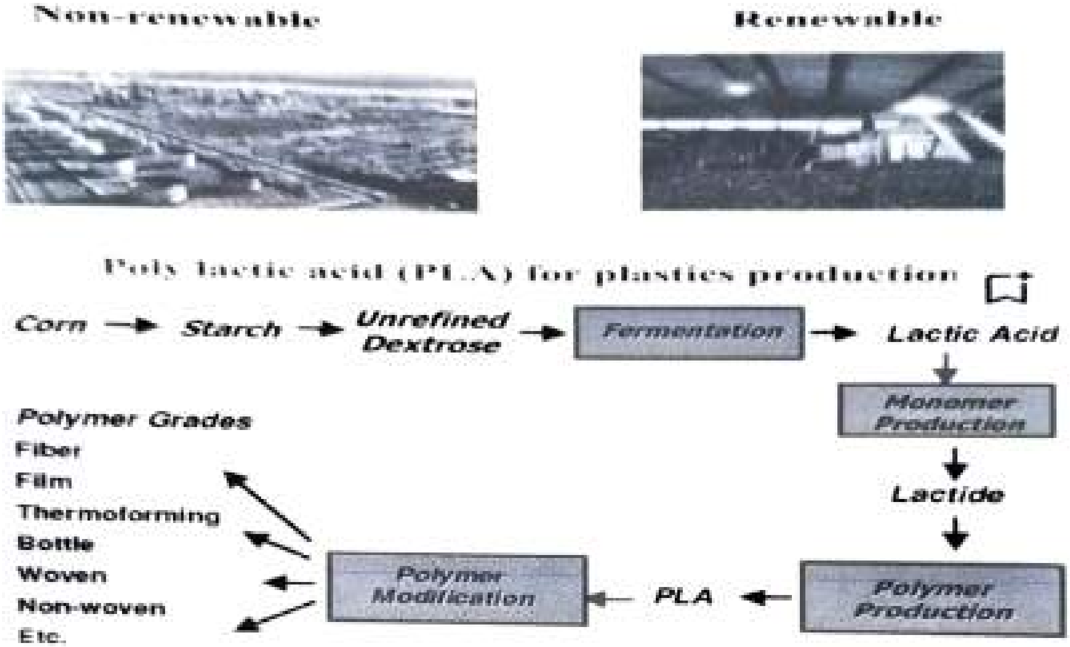


Fig.7:-- Different Energy Source and Plastic Production Economically by **PLA.**

- ***Resources Depletion*** :- Renewable resources can be made increasingly viable technologically and economically through green chemistry. Due to the over utilisation of non-renewable resources, natural resources are being depleted at an unsustainable rate.

8. **Reduce Derivatives**:- Unnecessary derivatization (Using the blocking groups, protection or de-protection and temporary modifications of physical/ chemical processes) should be minimised or avoided if possible, because such steps require additional reagents and can generate waste.

• <u>More Derivatives Involved</u> •

- Additional reagents
- Generate more waste products
- More time
- Higher cost of product's

Hence, it requires reducing derivatives.

9. **Catalysis**:- Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

- <u>e.g</u>:- ' **Toluene**' can be exclusively converted into **P- xylene** (Avoiding O- Xylene and M- Xylene) by shape selective **Zeolite** catalyst. **(Fig.8)**

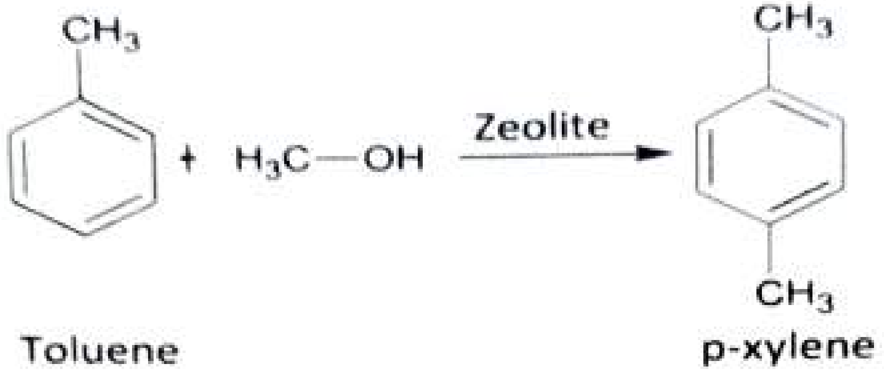


Fig.8:- Catalytic Green Reaction.

10. **Designing of Degrading Product's:-** Chemical products should be designed so that at the end of their function, they break down into innocuous degradation products and do not persist in the environment. **(Fig.9)**

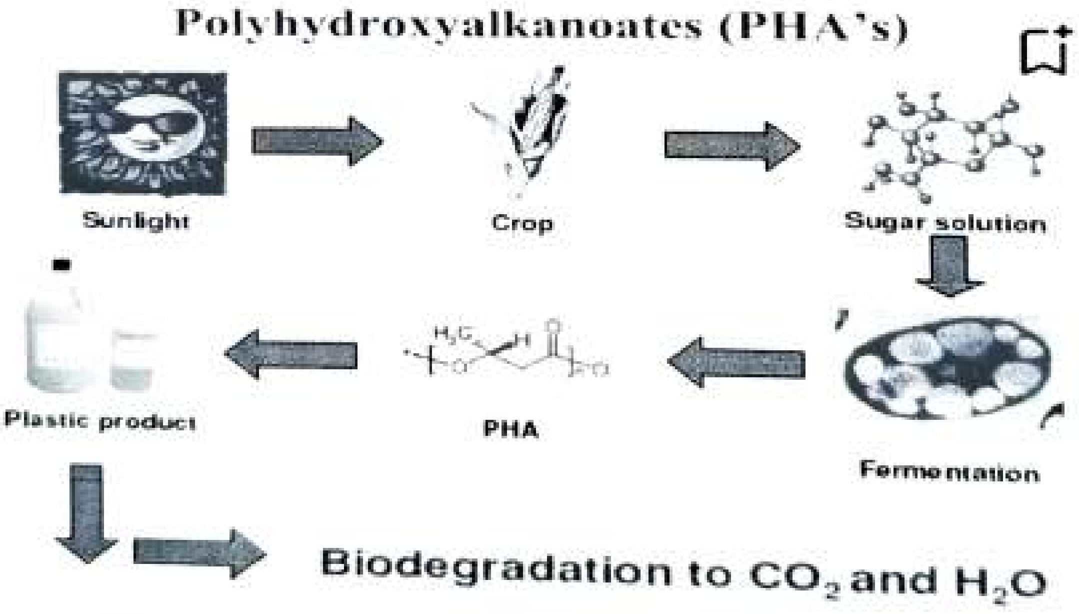


Fig.9:-- Designing of Degrading Products Using **PHA'S** Cycle.

11. **New Analytical Methods:-** " Analytical methodologies need to be further developed to allow for real time in process monitoring and control prior to the formation of hazardous substance ".

12. **Safer Chemicals for Accident Prevention :-** " Analytical substances and the form of a substance used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosions and fires".

☐ Efficiency Parameters used in Green Chemistry :-

1. Reaction Yield

- $$Reaction\ Yield = \frac{Actual\ Yield}{Theoretical\ Yield} \times 100$$
- The reaction should have high percentage of yield.

2. Atom Economy

- Atom economy describes the conversion efficiency of a chemical process in terms of all atoms involved (desired products produced).
- $$Atom\ Economy = \frac{Mol.\ weight\ of\ Desired\ product}{Mol.\ weight\ of\ all\ reactants} \times 100$$
- For the reaction, the atom economy should be maximum.

- Conversion factor:

$$\text{Conversion} = \frac{\text{Amount of reactant reacted}}{\text{Amount of reactant taken}} \times 100$$

- Reaction **Selectivity**

Reaction Selectivity =

$$\frac{\text{Amount of desired product formed}}{\text{Amount of product expected on the basis of reactant consumed}} \times 100$$

Environmental Load Factor:

- It is represented by E and it should be minimum.

$$E = \frac{\text{Total mass of effluent formed}}{\text{Mass of desired products}} \times 100$$

□ The Approaches to Green Chemistry::-

1. **Microwave Irradiation:-** ' Microwave Assisted Organic Synthesis', is defined as the preparation of desired organic compounds from available starting material via. Some procedures involving **Microwave Irradiation**. As it is less hazardous, it is a potential tool of **Green Chemistry**.

- **Examples:-** (I) **Oxidation of Toluene:-** Oxidation of toluene to benzoic acid by heating with alkaline $KMnO_4$, using microwave irradiation, the reaction was completed at **5 minutes.** On the other hand, at normal condition it was taken for completion of this reaction at least **10- 12 hours. (Fig.10))**

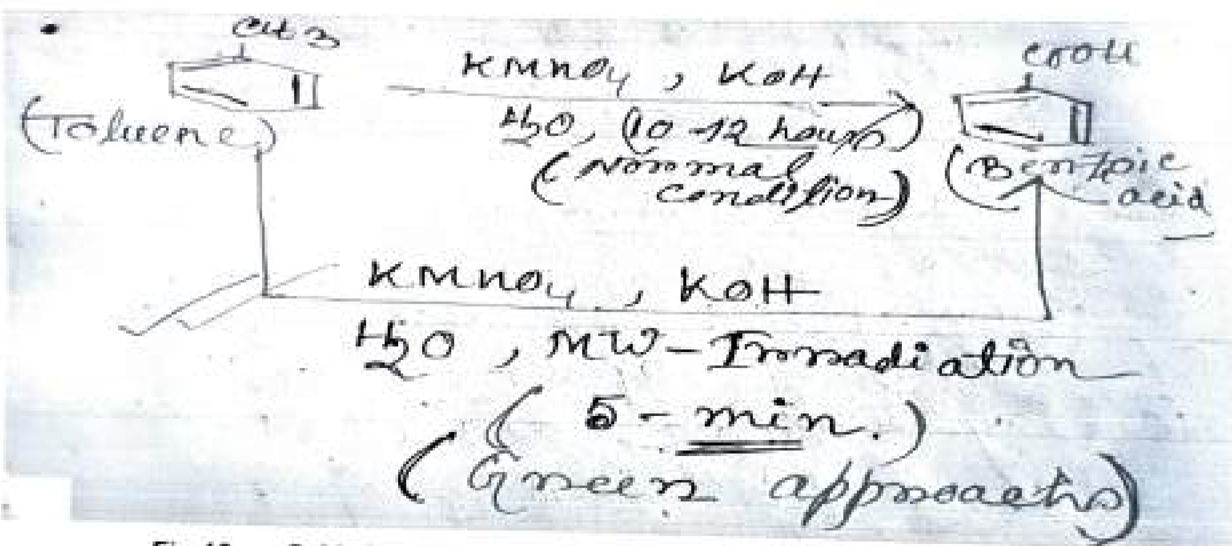


Fig.10:-- Oxidation of Toluene by Greener Approaches vs Normal Approaches.

The same oxidation can also be carried out by microwave Irradiation, at **500K** temperature in the presence of V_2O_5 and TiO_2 **(Fig.11)**

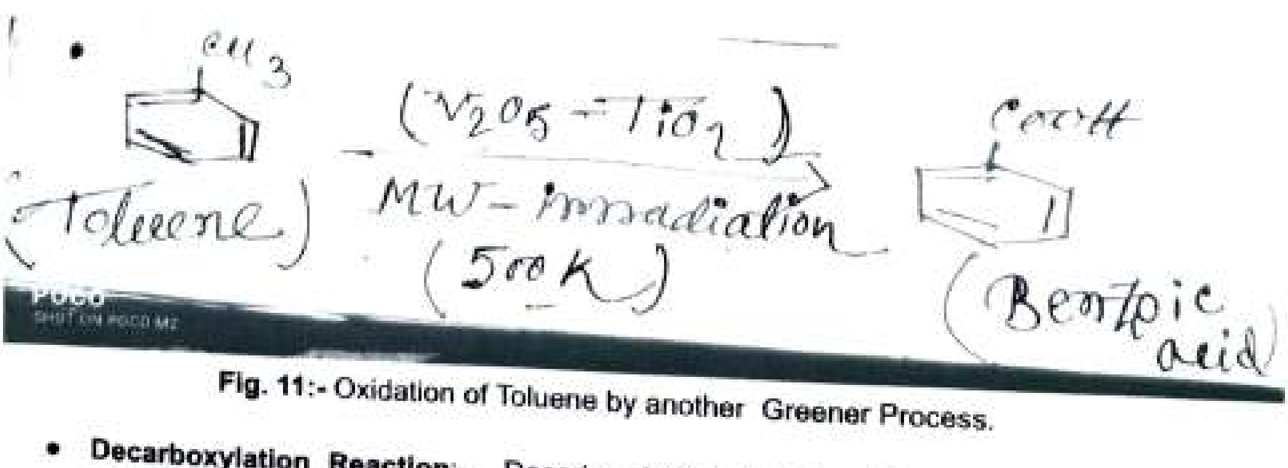


Fig. 11:- Oxidation of Toluene by another Greener Process.

- **Decarboxylation Reaction:-** Decarboxylation of carboxylic acid is commonly carried out by heating in presence of $CuCrO_4$, but the yield is very low. On the other hand, decarboxylation can be achieved efficiently by heating under microwave irradiation, with little use of **Quinoline** in a short time. **(Fig.12)**

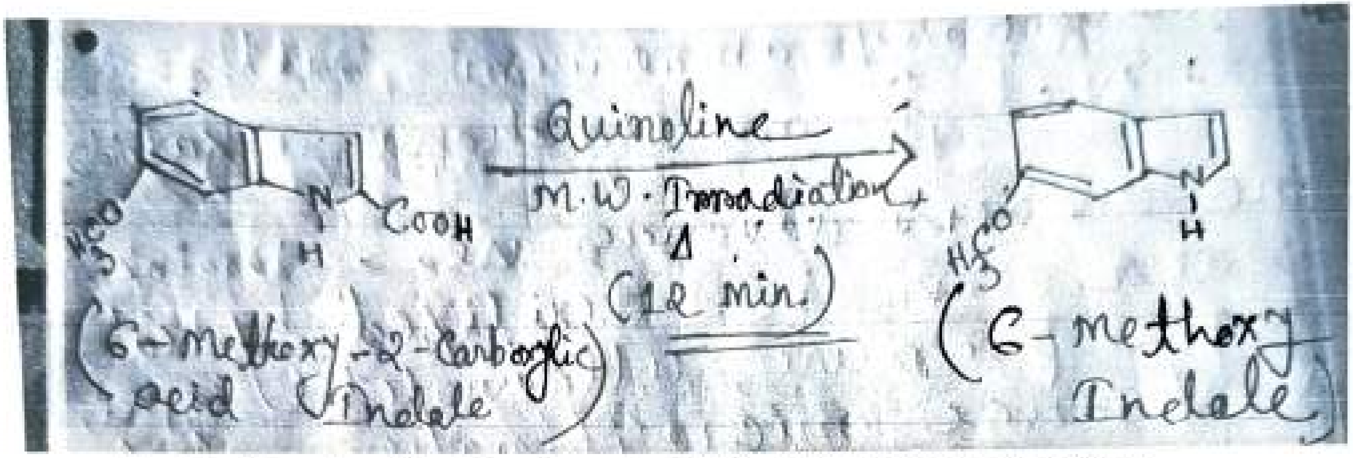


Fig.12:- Decarboxylation Reaction using MW Irradiation in Green Chemistry.

2. **Ultrasound Mediated Reaction:-** Ultrasound is a sound wave with frequencies higher than the upper audible limit of human hearing. The ultrasound Irradiation (also referred to as **Sonochemistry**) is an important tool in the field of organic chemistry. This technique has become extremely popular in promoting various chemical reactions, since the decade of 1990- 1999. The application of ultrasound has been useful in accelerating dissolution, enhancing the reaction rates and increase of product yields etc.

- <u>Example</u>:- (I) **Ultrasound assisted Simmons- Smith Modification reaction:-** In this reaction **Zn** was sonochemically activated to react with **CH_2I_2** to form the carbenoid , which reacts with alkene to give derivatives. **(Fig.13)**

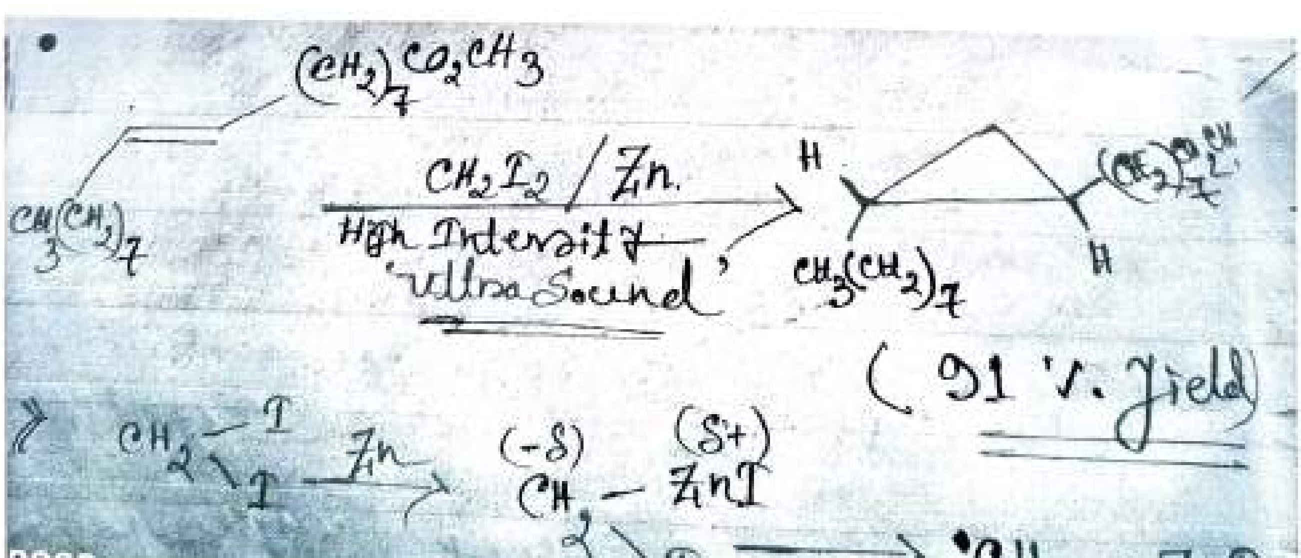
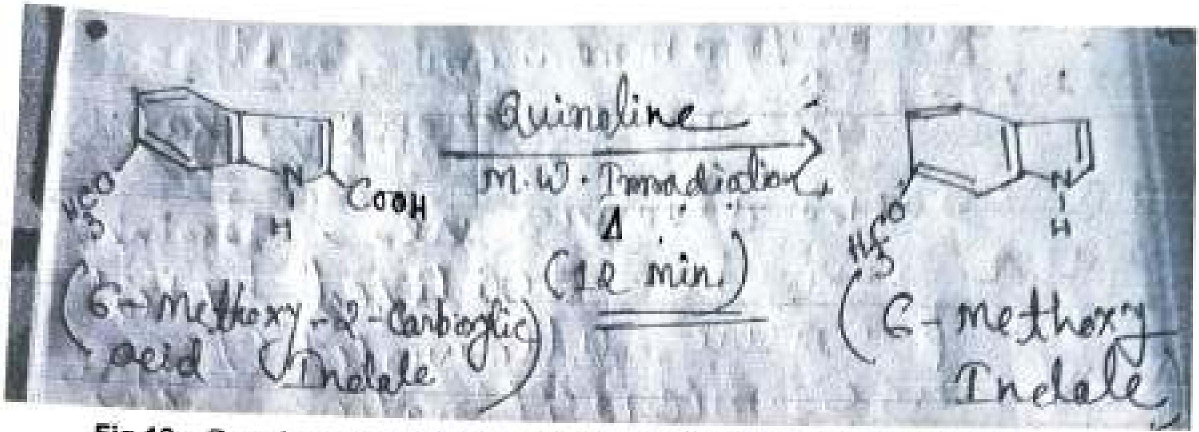


Fig.13:- Ultrasound Mediated Simmons-Smith Modification Reaction.

3. **Ultrasonic Reaction:-** Ultrasonic assisted reaction is an important part in the research field in chemistry. The reaction is dependent on the acoustic cavitation that is the formation, growth and implosive collapse of the bubbles in the solution. Ultrasonic devices are Used to detect objects and measure distances. **(Fig.14)**



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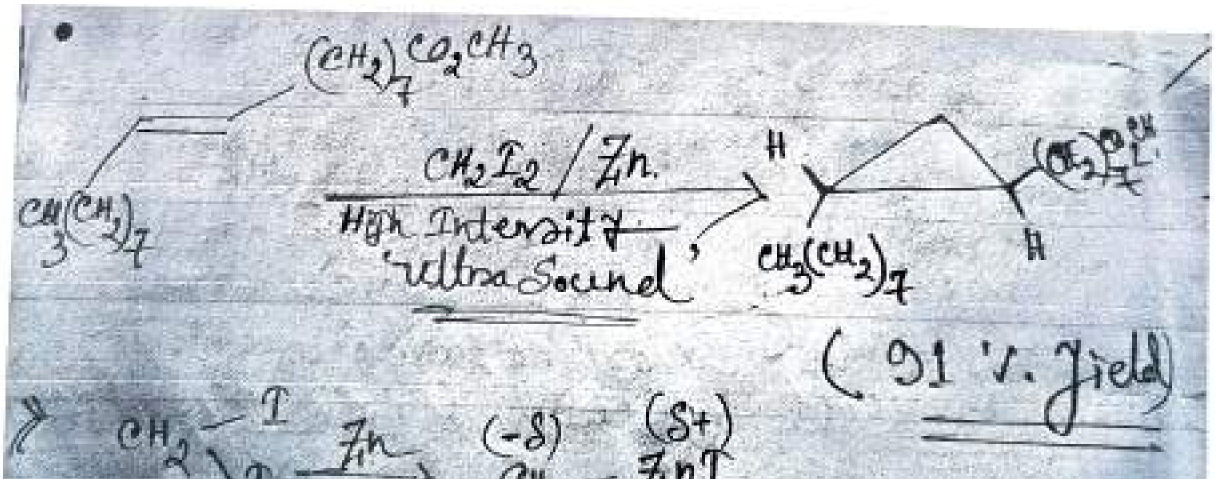

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- **Example**:-

- **Esterification:**
- **This is generally carried out in presence of a catalyst like sulphuric acid, p-toluenesulphonic acid, tosylchloride, polyphosphoric acid, dicyclohexylcarbodiimide etc. The reaction takes longer time and yields are low.**

$$RCOOH + R^{I}OH \xrightarrow[)))]{H_2SO_4,\ R.T.} RCOOR^{I}$$

- **Saponification: can be carried out under milder conditions using sonification. Thus, methyl 2,4-dimethylbenzoate on saponification (20 KHz) gives the corresponding acid in 94% yield (Scheme 2), compared to 15% yield by the usual process of heating with aqueous alkali (90 min).**

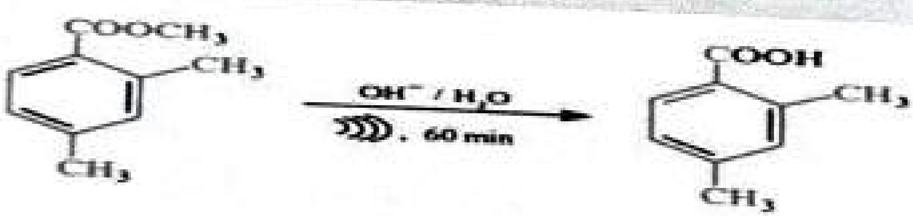

Fig.14:- Ultrasonic Assisted Reactions in Green Chemistry.

□ Recent Advances in Green Chemistry:-

An important recent advance in green chemistry is, of discovery " **Small Organic Molecule as Chiral Organocatalyst**". For this theorem, scientists **Benjamin List** and **David Macmillan** are awarded the **Nobel Prize** in chemistry, in **2021**, for their development of a precious new tool for molecular construction of organocatalysis . This has had a great impact on pharmaceutical research and has made chemistry **Greener**. The advance discoveries theorem are; A plethora of highly effective small molecule organocatalyst have enriched the field of organic synthesis, Including chiral Proline derivatives (L-Proline) , N- heterocyclic carbenes, Thioureas , acids and phase transfer catalysts (PTC) , such as the quaternary ammonium salts derived from cinchona alkaloids. And other advances are; drinking water can be sterilised by Heat, High Pressure, Ultraviolet Light, Membrane microfiltration, Electron beam or pulsed electric fields without the need for chemicals.

☐ CONCLUSION :-

Green Chemistry, not a solution to all environmental problems but this is the most fundamental approach to preventing pollution. **Green Chemistry** applies diagonally the life cycle of a Chemical Product, including its manufacturer, uses, design and ultimately disposal. **Green Chemistry** is very helpful in prevention of pollution at the molecular levels. It gives innovative scientific solutions. It reduces the negative Impacts of chemical product's on humans and the environment. It also plays an important role in the field of pharmaceutical chemistry.

☐ Acknowledgment:-

I would like to express my special thanks and gratitude to my teacher as well as my supervisor, **Assistant Professor, Dr.Tanmay Das,** for giving me this golden opportunity to work on this wonderful project on the topic of " **Green Chemistry Principles and it's Sustainable Approaches to Chemical Synthesis and Reduce Pollution**", at present days all over the world. I am really very grateful to him for his valuable contribution to this presentation and for his teaching and learning that was so important in preparing this presentation.

I would also like to thank my other respected professor of my Department and my parents and my friends, who helped me in finishing this project in a limited time.

This presentation really helped me to increase my knowledge and skills.

WASTEWATER PURIFICATION:

PRESENT METHODS, CHELLANGS AND FUTURE OPPORTUNITIES

Report submitted to,

ABHEDANANDA MAHAVIDYALAYA (DEPARTMENT OF CHEMISTRY)

Sainthia Birbhum

By

SUSMITA MANDAL (B.SC HONOURS, 6TH SEMESTER)

Roll No: 210330100064

Reg. No: 202101026550 of 2021-22

Under the supervision of,

DR. TANMAY DAS

ABHEDANANDA MAHAVIDYALAYA

SAINTHIA, BIRBHUM, WEST BENGAL, PIN 731234

Founder: Srimat Satyananda Dev (1965)

(Affiliated to the University of Burdwan and Accredited by NAAC)

Phone: 03462263449 E-mail: abhedanandamahavidyalaya@gmail.com Website: www.abhedanandamahavidyalaya.ac.in

Date: 15.05.2024

Department of Chemistry

Certificate of Project Completion

This is to certify that Ms. Susmita Mandal, a student of B.Sc. (Hons.) in Chemistry, 6th Semester, Roll No. 210330100064, Registration No. 202101026550 of 2021-22, has successfully completed the project titled: **"Wastewater Purification: Present Methods, Challenges, and Future Opportunities"** under the supervision of Dr. Tanmay Das, Department of Chemistry, Abhedananda Mahavidyalaya, Sainthia, during the academic session 2023-2024.

Tanmay Das 15-05-24
Supervisor

15/05/24
Head
Department of Chemistry

15/5/24
Principal

Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

ABHEDANANDA MAHAVIDYALAYA

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Tanmay Das 15-05-24

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Department of Chemistry

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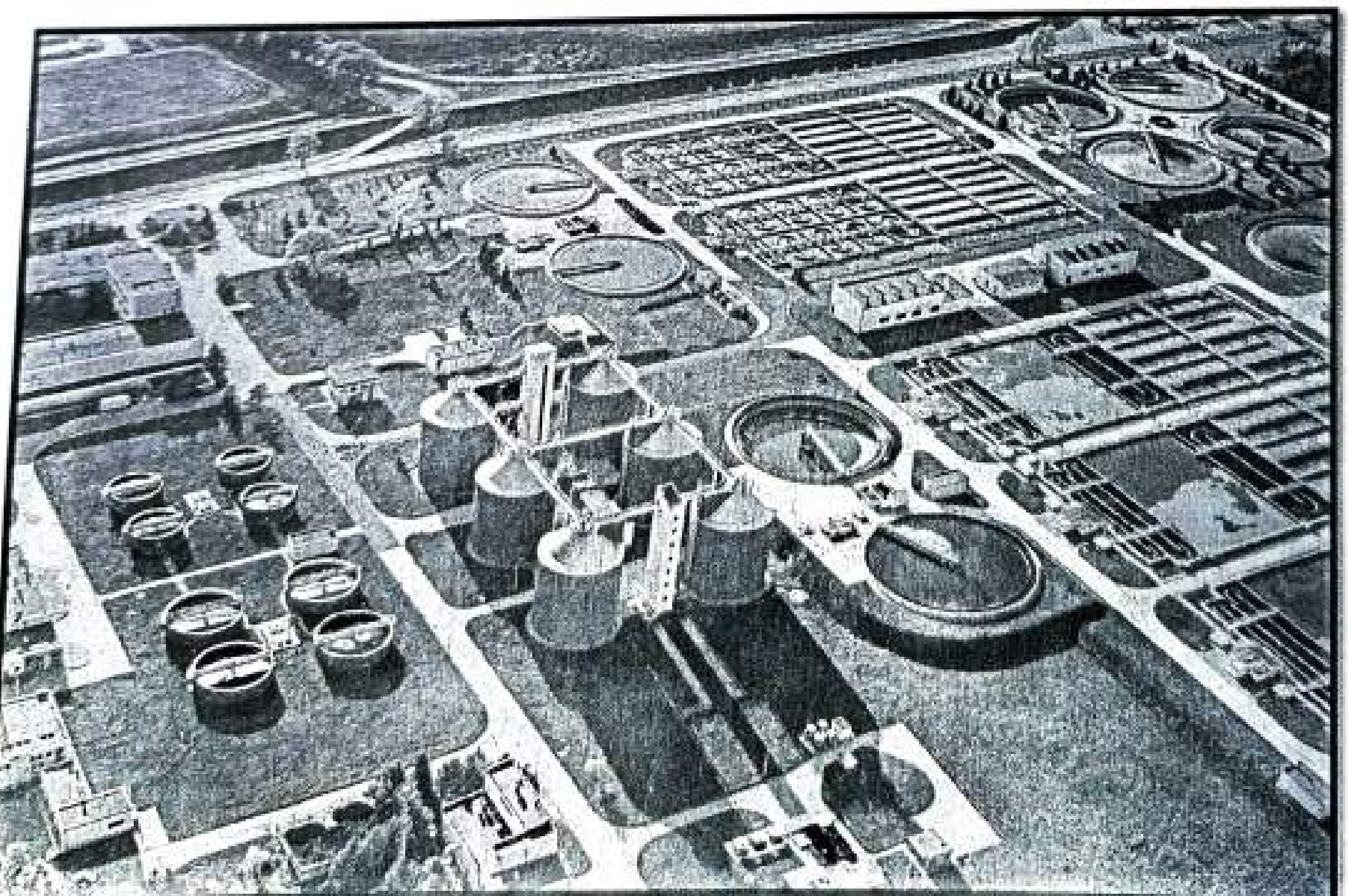
Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

❖ INTRODUCTION:

Wastewater purification, the removal of impurities from wastewater of impurities from wastewater, or sewage, before in reaches aquifers or natural bodies of water, such as rivers, lakes, estuaries, and oceans. Since pure water is not found in nature (i.e., outside chemical laboratories), any distinction between clean water and polluted water depends on the type and concentration of impurities found in the water as well as on its intended use. In broad terms, water is said to be polluted when it contains enough impurities to make it unfit for a particular use, such as drinking, swimming, or fishing. Although water quality is affected by natural conditions, the word pollution usually implies Human activity as the source of contamination water pollution, therefore, is caused primarily by the drainage of contaminated wastewater into surface water or groundwater and wastewater treatment is a major element of water pollution control.



❖ PRESENT METHODS

There are **four different wastewater treatment methods**, and each of these methods has a different treatment process that must start with an assessment and evaluation. The four different industrial water treatment methods are explained below:

1) PHYSICAL METHODS:

Physical water treatment involves the use of physical methods to clean wastewater. This method involves processes like sedimentation, screening, and skimming used for removing the solid in the wastewater. During this process, chemicals are not used at all. Some of the techniques of this methods are:

➢ SEDIMENTATION:

Sedimentation is a wastewater treatment process in which heavy or insoluble particles are collected and separated from the wastewater. The water is separated from the insoluble material settles down at the bottom of the water **(fig. 1)**.

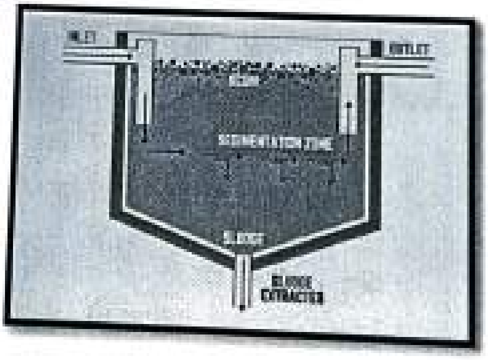


Fig. 1- **SEDIMENTATION**

➢ AERATION:

In this process, the wastewater is treated by providing oxygen to it through air circulation. Oxygen or air is added to the wastewater is several ways including surface, spray, and diffused aeration. The aeration process begins immediately after the oxygen is in contact with the water **(fig.2)**.

Fig. 2
AERATION

2) MECHANICAL METHODS:

Mechanical filtration for wastewater treatment and disposal is one of the most common wastewater treatment methods, and it can be achieved by this method.

- CERAMIC MEMBRANE TECHNOLOGY:

Mechanical filtration for wastewater treatment and deposal are two of the conventional wastewater treatment methods and it can be achieved by either:

a) CERAMIC MEMBRANE TECHNOLOGY:

The ceramic membrane filtration process is the use of ceramic membrane installed housings to filter wastewater. The filtration process will start when the Wastewater begins to move through the membranes. A feed pump is responsible for providing the pressure needed for the water to move through the ceramic membrane (fig. 3).

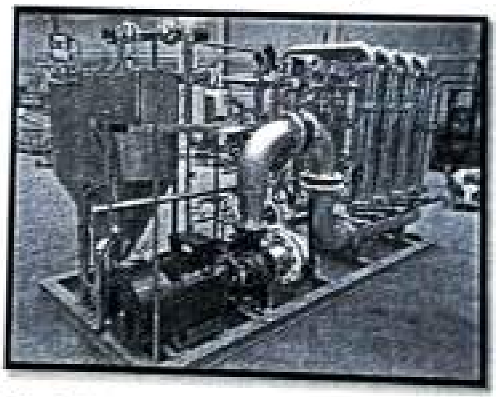


Fig. 3: CERAMIC MEMBRANE TECHNOLOGY

b) SAND FILTER TECHNOLOGY:

This technology has been in existence for more than 200 years. It is more applicable where there are downward flowing fluids that are driven by either gravity or pressure. One downside of this technology is that it may not provide adequate disinfection. The sand filters consist of a large quantity of special grade sand in a large tank (fig. 4).

Fig. 4: SFT

3) BIOLOGICAL METHODS:

This is the use of biological processes to treat wastewater. In this stage, the organic matter like oils, human waste, soap, and food present in the wastewater are broken down. The biological process of wastewater treatment method is divided into three categories:

- AEROBIC:

Here, the organic matter in wastewater is decomposed by bacteria and converted into carbon dioxide. Oxygen and the use of aerobic microorganisms are needed to decompose the organic matter in the wastewater. The aerobic process takes place in an activated sludge reactor where the wastewater is mixed with a lot of aerobic organisms.

Fig-5: AEROBIC

- COMPOSTING:

In this stage, treatment is carried out by mixing the wastewater with sawdust or any other carbon source(**fig.6**)

fig-6: COMPOSTING

- ANAEROBIC:

At this stage, fermentation is used to decompose the organic matter in wastewater instead of oxygen. The microorganisms used for this process do not require oxygen to break down organic matter(**fig.7**)

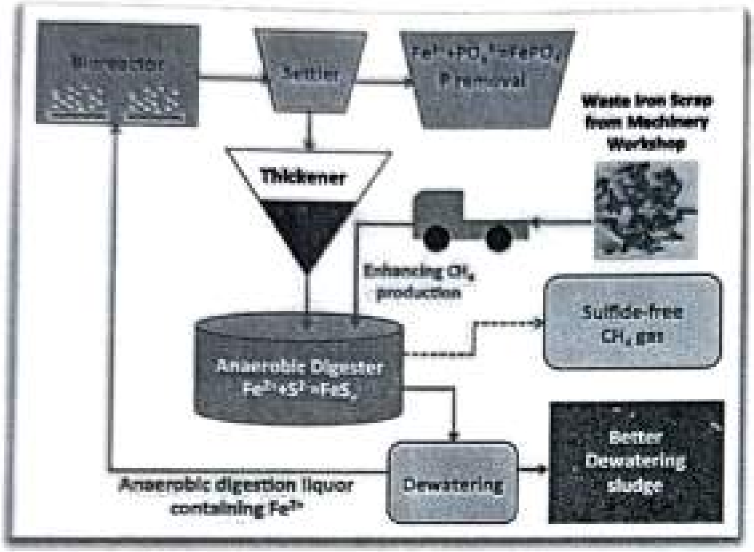


fig-7: ANAERBIC PROCESS

4) CHEMICAL METHODS:

The most common ones are chemical neutralization, adsorption, precipitation, disinfection and ion exchange.

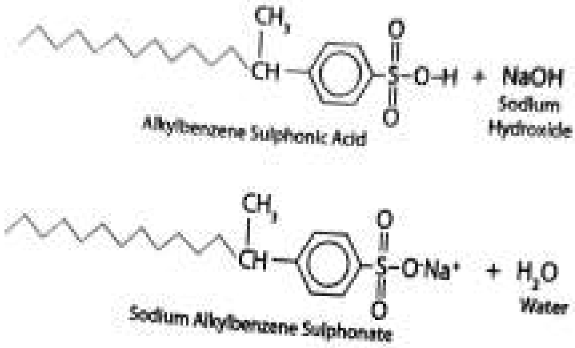
- NEUTRALIZATION:

This is the use of acidic or alkaline to control and keep the pH level of the wastewater around 7. If the water lacks sufficient acidity, then the acid will be added to get the required pH level. Also, if the water lacks sufficient alkaline, a base will be added to the water to get the required pH level.

- **ACID + BASE = SAIT + WATER**

➢ ADSORPTION:

In this method, adsorbents are used to remove soluble molecules from wastewater. Various organic materials like toxic compounds and detergents can be removed by adsorption. **(fig-8)**



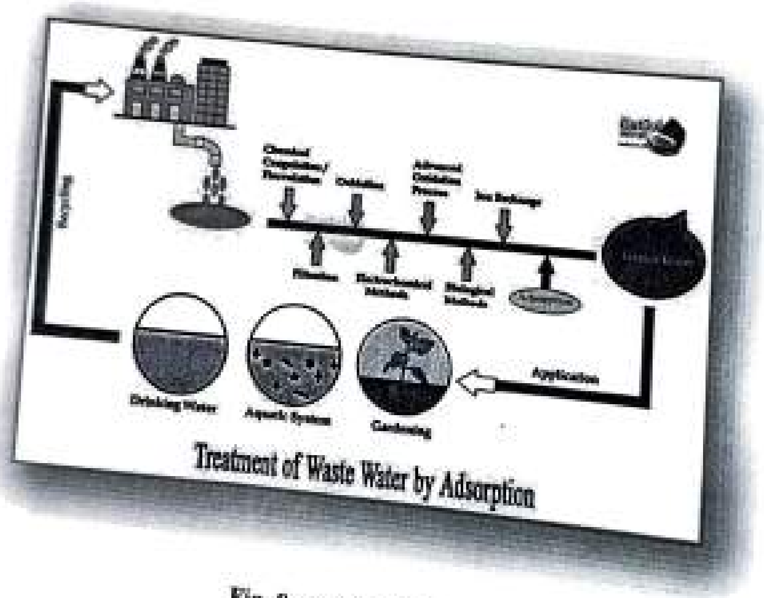


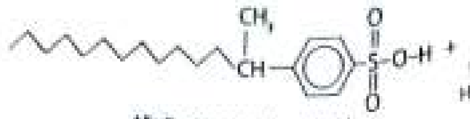
Fig -8: ADSORPTION

➢ ION EXCHANGE:

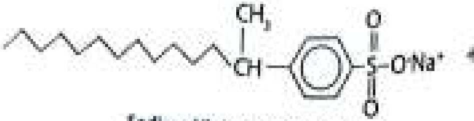
This process is known as a reversible eaction because a charge ion is replaced with another imilarity charge ion. **(fig-9)**

➤ ADSORPTION:

In this method, adsorbents are used to
from wastewater. Various organic materials like toxic
can be removed by adsorption. (fig-8)



Alkylbenzene Sulphonic Acid



Sodium Alkylbenzene Sulphonate

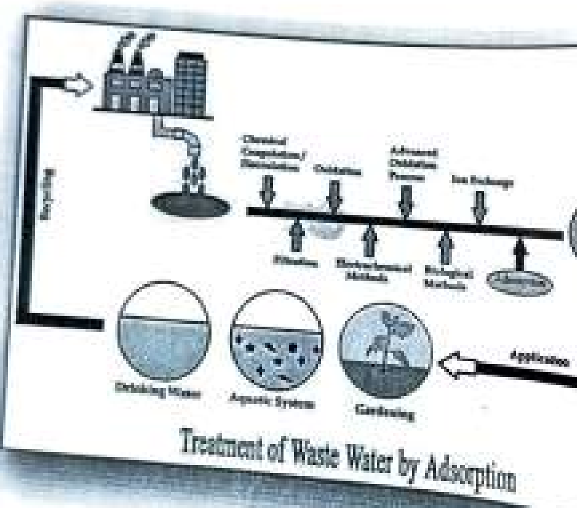


Fig -8: ADSORPTION

...ON EXCHANGE:

...own as a reversi...
...th another...

C. MEMBRANE FILTRATION TECHNOLOGY:

It quite different from the Sono filter treatment process. In membrane filtration technology, a low- or high- pressure membrane system is used to remove contaminants and toxins from the water via- several processes like microfiltration, nanofiltration, ultrafiltration and reverse osmosis. **(fig-13 and 14)**

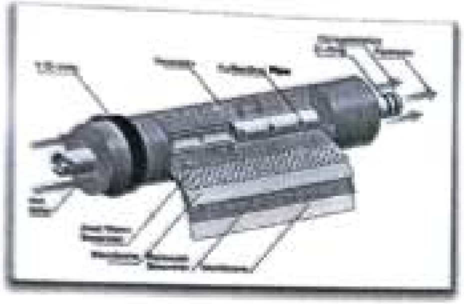


Fig-13

fig-14

D. ULTRAVIOLET IRRADIATION TECHNOLOGY:

This is an industrial wastewater treatment method. The remove contaminants from water by using UV light. This technology purifies water, air, and surfaces by using the high-energy electromagnetic radiation in the spectrum. **(fig-15)**

Fig-15: UV IRRADIATION TECHNOLOGY

❖ <u>CHALLENGES</u>: **(FIG-16)**

1. <u>ENERGY CONSUMPTION:</u>

Energy consumption is one of the largest expenses in opareting a wastewater treatment plant. Wastewater treatment is estimated to consume 2-3% of a developed nation's electrical power, or approximately 60 twh (tera wall) biological treatment, generally in the range of 50-60% of plant usase.

2. <u>STAFF:</u>

Operators of wastewater treatment facilities must be adequately trained and certified individuals. They are on call 24 hours a day and are responsible for overseeing everything from pipes.

3. <u>SLUDGE PRODUCTION</u>:

Sludge is the residue generated during physical, chemical and biological treatment. A major environment challenges for wastewater treatment is the deposal of excess sludge production during the process.

4. <u>FOOTPRINT</u>:

Activated sludge treatment has many challenges, one of the biggest being the footprint it demands. Activated sludge plants are costly to construct and occupy substantial land areas. Primary and secondary processes rely upon vust tracts of land for large and costly seltting tank and aeration basins. Due to population constantly increasing, to populations constantly increasing, municipal wastewater treatment plants need to expand their capabilities too.

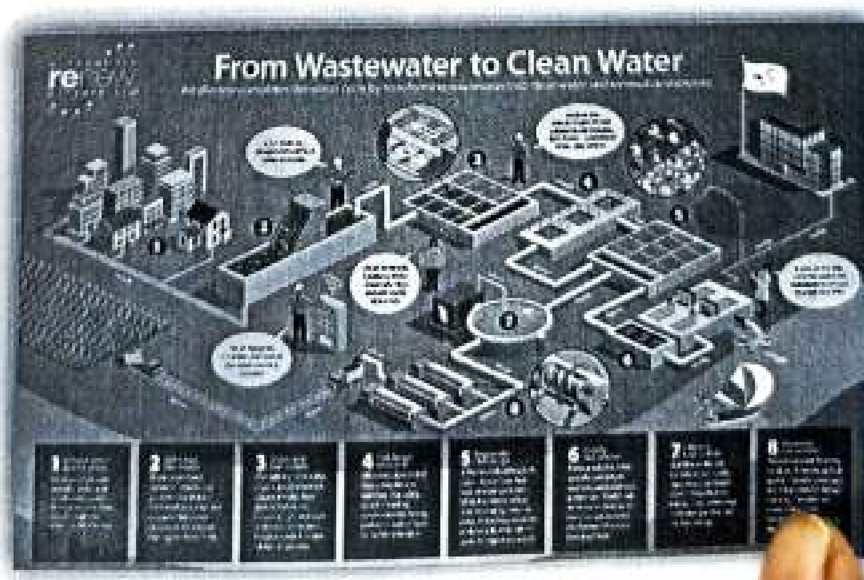


Fig-16:

CHALLENGS

❖ FUTURE OPPERTUNITIES: (fig.17)

- Wastewater treatment plants are slowly evolving.
- In the next decade, successful implementation of technologies will focused intensification.
- New technologies will be focused on gases and bio-based materials.
- Academics need more freedom to develop novel concepts.
- Collaborative platforms that enable demonstration of high-risk technologies is key.

❖ CONCLUSION:

Wastewater treatment is an essential process that is critical in protecting our environment and public health. By removing contaminants from wastewater, we can reduce the risk of water pollution and the spread of waterborne diseases. The study revealed that it sustains some benefits, such as improving soil quality, providing nutrients for plants, and saving expenses of diverting freshwater for irrigation. And to ensure the effective water supply of water into urban areas and prevent the negative effects of poor waste water management in these areas.

❖ **ACKNOWLEDGEMENT:**

I would like to express my special thanks and gratitude to my teacher as well as my supervisor, assistant professor, Dr Tanmay Das, for giving me this golden opportunity to work on this wonderful project on this topic of ***"Wastewater purification: Present methods, Challenges and Future Opportunities"*** at present days all over the world. I am really very grateful to him for his valuable contribution to this presentation and for his teaching and learning that was so important in preparing this presentation.

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THANK YOU

Use of biodegredable polymers to reduce pollution and achieve sustainable development :

Report submitted to,

Abhedananda Mahavidyalaya (Department of Chemistry)

Sainthia, Birbhum

By

SAGARIKA DUTTA (B.Sc Honours, 6th Semester)

Roll No: 210330100037

Reg. No: 202101026522 of 2021-22

Under the supervision of,

Dr. TANMAY DAS

ABHEDANANDA MAHAVIDYALAYA

SAINTHIA, BIRBHUM, WEST BENGAL, PIN 731234

Founder: Srimat Satyananda Dev (1965)

(Affiliated to the University of Burdwan and Accredited by NAAC)

Phone: 03462263689 E-mail: abhedanandamahavidyalaya@gmail.com Website: www.abhedanandamahavidyalaya.ac.in

Date: 15.05.2024

Department of Chemistry

Certificate of Project Completion

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Tanmay Das 15-05-24
Supervisor

Head 15/05/24

Department of Chemistry

Principal

Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

★ ***INTRODUCTION :***

The rise in the global population leads to an increase in the use of plastic, which in turn increases environmental pollution. Synthetic plastics are usually made from non-renewable petroleum-based resources that are non-biodegradable. The increase in the usage of synthetic, non biodegradable polymers in industries, households, and agriculture, causes waste generation and serious environmental issues. Industries, researchers, and technologists were looking forward to the development of a cleaner and more efficient manufacturing process for biodegradable polymers that produces less waste and avoids the use of harmful reagents and solvents. There is an urgent need to develop renewable, eco-friendly, biodegradable polymers to replace the existing synthetic polymers. The current global trend is the development of an efficient and sustainable process for a greener and biopolymer-based future. *Biodegradable polymers are a special class of polymers that decompose under chemical, physical, and biological interaction with microorganisms from the environment, such as bacteria, fungi, and algae. They break down into natural by-products such as CO2, water, and biomass without producing hazardous waste.* The polymers are found both naturally and synthetically and are made largely of ester, amide, and ether functional groups. The first man-made synthetic biodegradable polymer was poly(glycolic acid), which was invented in 1954. Biodegradable polymers can be synthesised by various methods, like ring opening polymerization, condensation reactions, etc. (Fig -1)

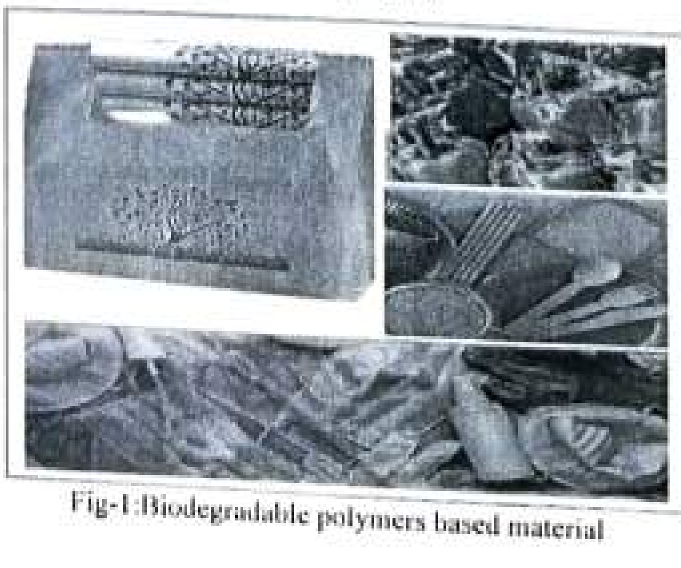
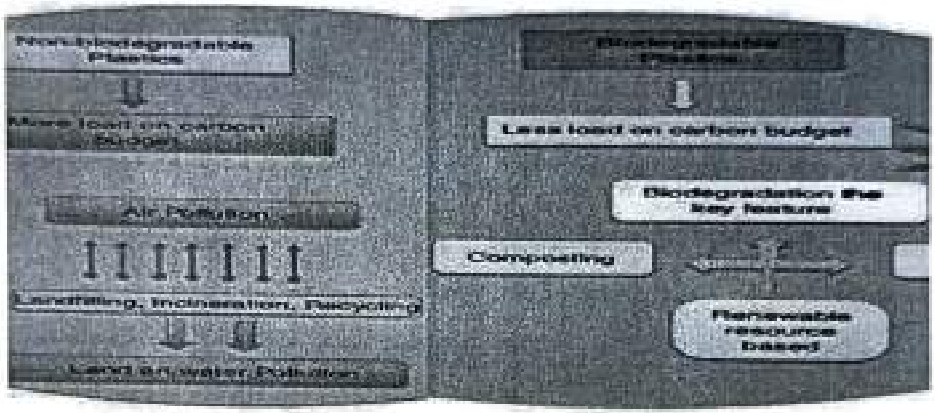


Fig-1:Biodegradable polymers based material

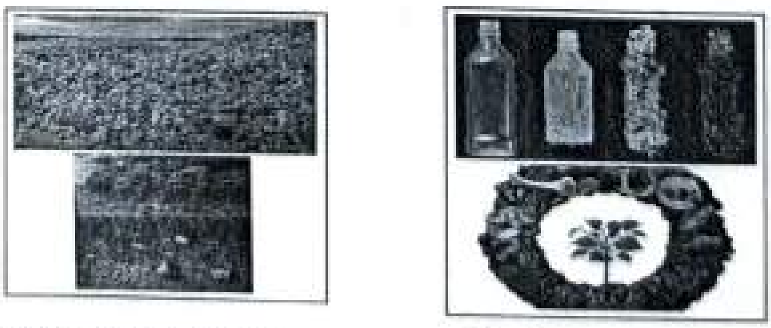
❖ Why are biodegradable polymers required ?

☐ **Reduce pollution:-**

Nowadays, a big and challenging problem is pollution. It can be soil pollution, water pollution and air pollution. One of the reasons that pollution occurs is the use of non-biodegradable polymers. On the other hand, biodegradable polymers undergo a natural degradation process, which significantly reduces the risk of pollution.



1) **Reduce soil pollution :-** In the presence of non-biodegradable polymers, soil can lead to nutrient depletion and hinder the growth of vegetation. When non-biodegradable materials like plastics are properly disposed of in landfills or open spaces, they prevent the penetration of water and air into the soil, disrupting the natural ecosystem. But in the presence of biodegradable polymers in the soil, no pollution can occur. (Fig-2)



Non-biodegradable polymer. Biodegradable polymer

Fig-2: uses after non-biodegradable and biodegradable polymers

2) **Resist pollution on water-bodies**:- Non-biodegradable polymer waste has several consequences for aquatic ecosystems. When non-biodegradable materials like plastic bags, bottles, etc. enter rivers, lakes, and oceans, they pose a significant threat to marine life. The chemicals released from non-biodegradable waste can contaminate water bodies, disrupting the delicate balance of aquatic ecosystems. This problem can be solved by replacement of biodegradable polymers instead of non-biodegradable polymers. Because when biodegradable-based materials enter bodies of water, they break down into natural byproducts without producing any hazardous waste. (Fig-3)

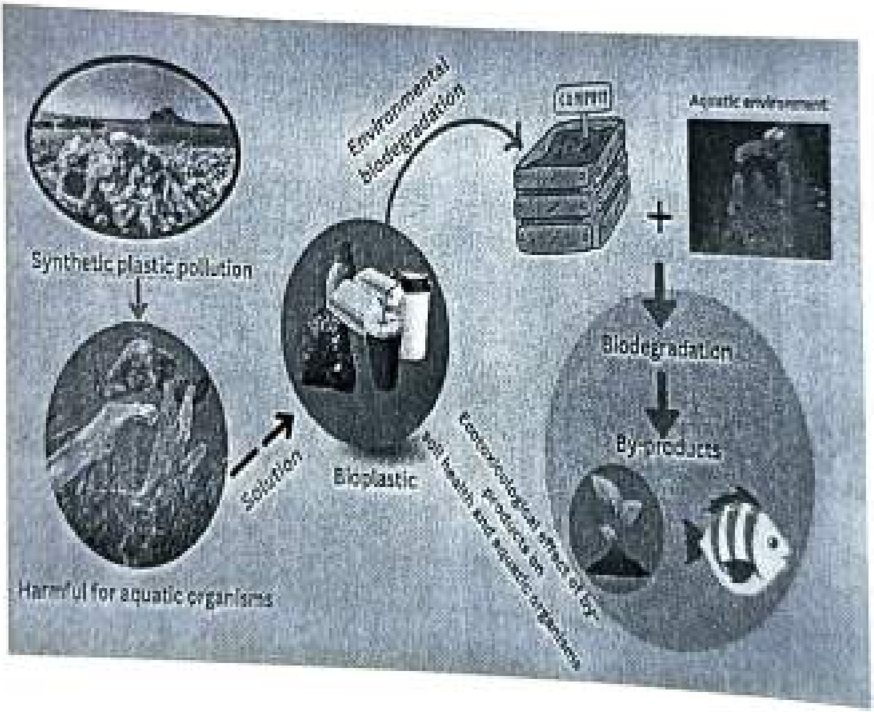


Fig-3: water- bodies pollution

3) **Reduction in carbon emissions** :- One of the most important benefits of using biodegradable polymers to produce plastic bags is the significant reduction of carbon emissions during the production process compared to non-biodegradable polymers, which emit more and more carbon. (Fig-4)

2) **Resist pollution on water-bodies:-** Non-biodegradable polymer waste has several consequences for aquatic ecosystems. When non-biodegradable materials like plastic bags, bottles, etc. enter rivers, lakes, and oceans, they pose a significant threat to marine life. The chemicals released from non-biodegradable waste can contaminate water bodies, disrupting the delicate balance of aquatic ecosystems. This problem can be solved by replacement of biodegradable polymers instead of non-biodegradable polymers. Because when biodegradable-based materials enter bodies of water, they break down into natural byproducts without producing any hazardous waste. (Fig-3)

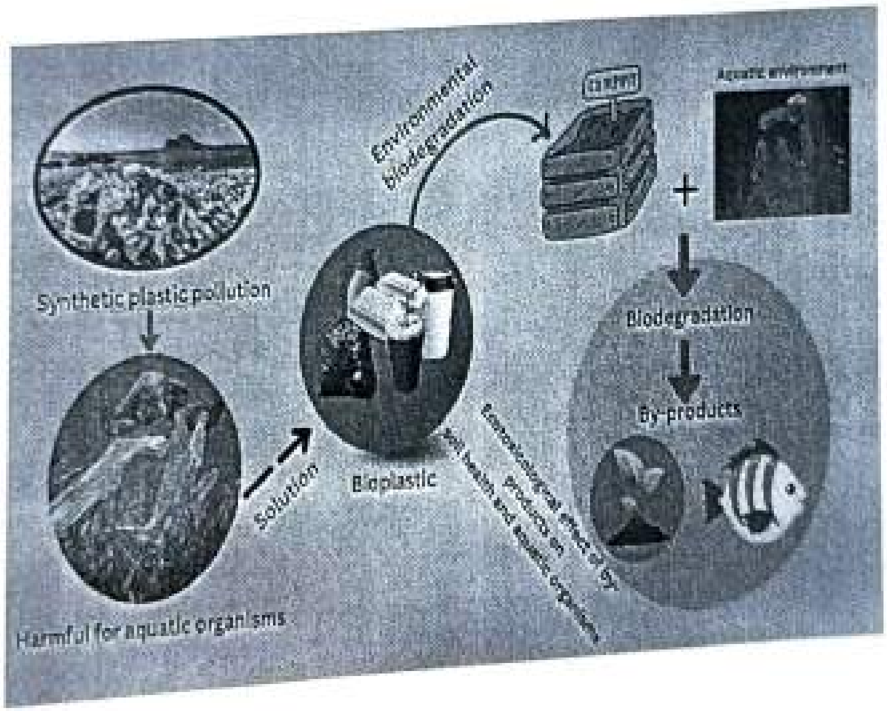


Fig-3: water- bodies pollution

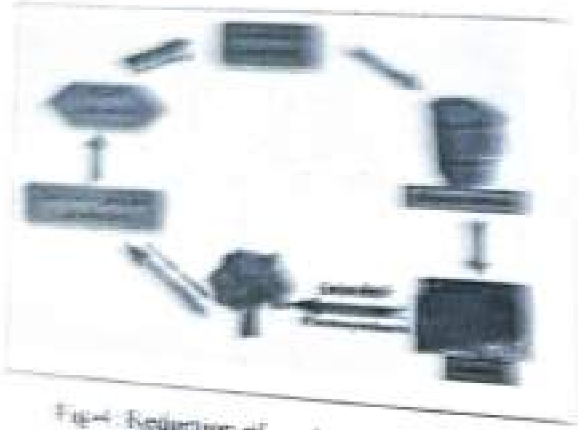


Fig-4: Reduction of carbon emissions

4) **Reducing the effects of global warming:-** The accumulation of non-biodegradable waste and the resulting emissions of greenhouse gases significantly contribute to global warming. On the other hand, biodegradable polymers break down quickly, minimising the accumulation of waste particles without emitting any greenhouse gases. (Fig-5)

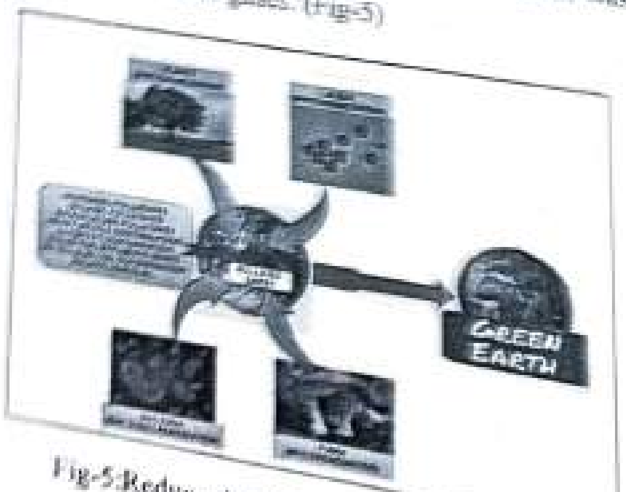
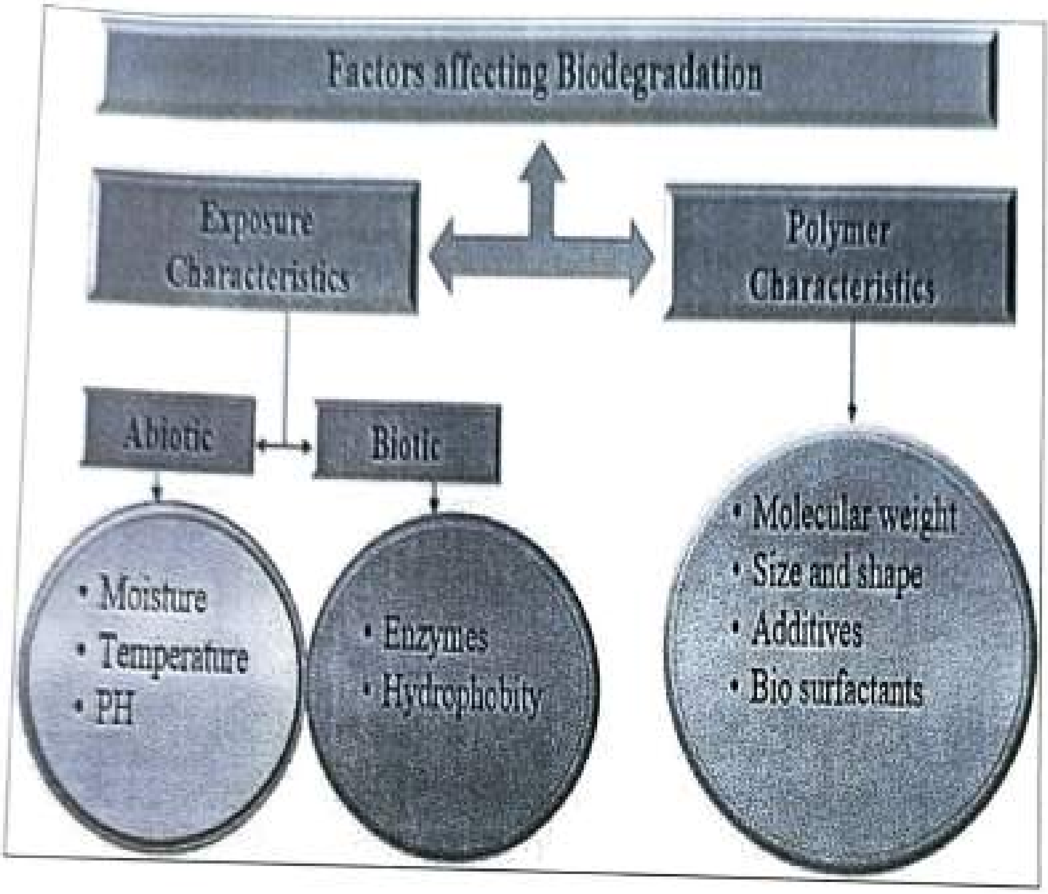


Fig-5:Reduce the effects of global Warming

[] **Easy to recycle** biodegrad...
decompose faster wh...



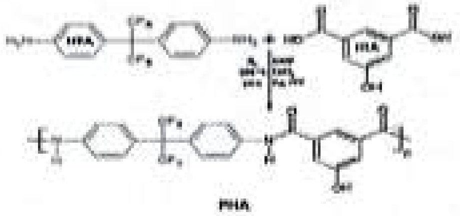
❖ Examples of biodegradable polymers :-

- **Polylactic acid (PLA):-**

  This is a biodegradable thermoplastic polyester belonging to the class of polyhydroxy alkanoates. It is used in textiles, packing, drug delivery, agriculture, electrical appliances, etc. (Fig-7)

- **Polyhydroxy alkanoates (PHA):-**

  There are linear polyesters produced by the bacterial formation of sugars or lipids. It is used as bioplastics, biofuels, implant materials, animal nutrients, and in industries. (Fig-8)



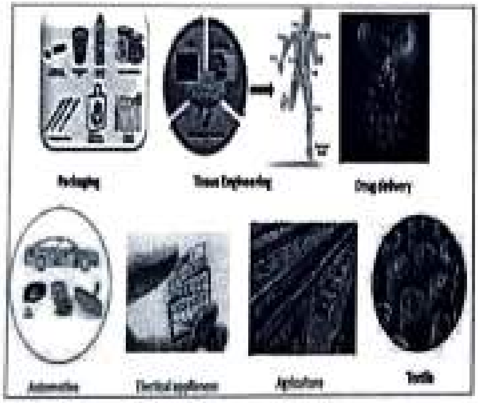


Fig-7: Uses of PLA

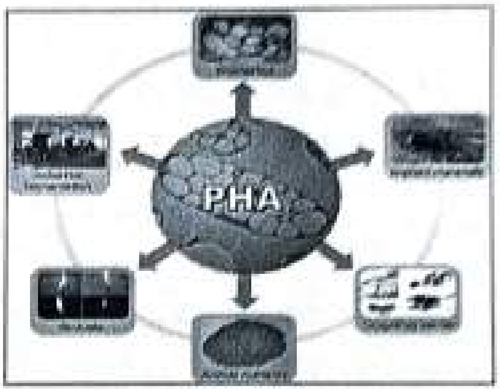
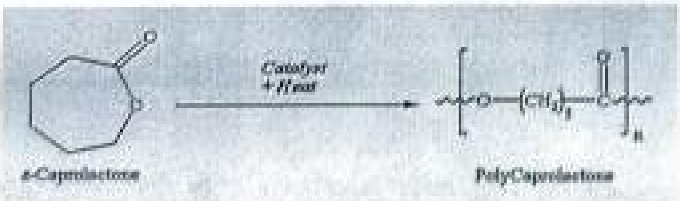


Fig -8: Uses of PHA

- **Polycarolaerone(PCL):-**

  A biodegradable polyester with a low melting point of around 60 °C and a glass transition. (Fig-9)



- **Starch :-** Starch is found in corn, potatoes, wheat, tapioca, and some other plants. It is being used for non-food purposes like making paper, cardboard, textiles, etc. (Fig-10)

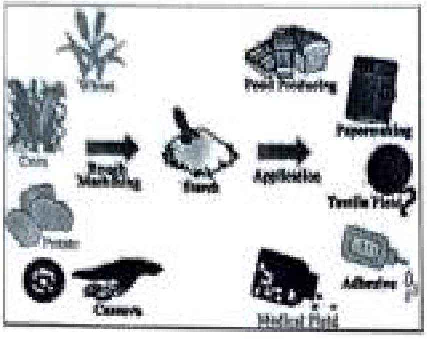


Fig-10: Uses of Starch

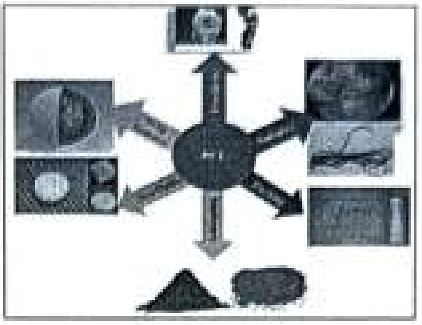


Fig-9: Uses of PCL

- **Mechanism of breakdown :-**

In general, biodegradable polymers break down to form gases, salts, and biomass.

1. **Aerobic Degradation** : Decomposition occurs through reactions in the presence of oxygen and the formation of energy, CO2, and water.

$$C_{polymer} + O_2 \longrightarrow C_{residue} + C_{biomass} + CO_2 + H_2O$$

2. The second mechanistic route is through biological processes into aerobic and anaerobic processes, and through these processes, energy, methane, and water

$$C_{polymer} \longrightarrow C_{residue} + C_{biomass} + CO_2 + CH_4 + H_2O$$

are formed.

❖ Uses of biodegradable polymers to reduce pollution and achieve sustainable development:

1. **Alternative uses of conventional plastics:-** Most parts of conventional plastics are not biodegradable and can persist in the environment for hundreds of years. This has led to the massive accumulation of plastic waste in our oceans, soils, and ecosystems, causing irreversible damage to marine life and terrestrial ecosystems. But biodegradable plastics have the ability to break

down naturally and become nutrients for the soil. These materials degrade in a shorter period of time and improve soil quality. (Fig-11)

Fig-11: Biodegradable plastics

2. **Packing of food and other materials:-** Biodegradable polymers are biocompatible, non-toxic, and highly selective. In the packing industry, they are replacing conventional petroleum-based polymers. The only problem with synthetic polymers is their resistance to degradation in the environment. Biodegradable polymer-based materials are capable of undergoing decomposition. (Fig-12)

Fig-12: uses in packing material

3. **Uses in agriculture:-** Biodegradable polymers are used for seed coating, which serves as a soil stabiliser and seed protector, yields rapidly in water, forms an effective water-soluble film, minimises the required dose of fungicides, and provides excellent control of plant disease, thereby contributing to enhanced plant productivity. It is also used as a super absorbent, which will help absorb moisture in soil.

4. **Used in Wastewater Treatment:** The natural biodegradable polymeric adsorbent can be used to remove toxic dyes. Dyes contamination is found to

7. **Used in the automobile industry:-** In recent years, biodegradable polymers have been extensively used in the automobile industry because of their good mechanical properties, high specific strength, and eco-friendly nature. It is now replacing conventional fibres like aramid, carbon, etc. The biodegradable polymers can be used for both the exterior and interior components of automobiles. It is used in the manufacturing of interior panels in vehicles. (Fig-15)

Fig-15: Biodegradable polymers used in the automobile industry

8. **In Cosmetics :** Nowadays, biodegradable polymers are finding application in the cosmetics industry. Natural and synthetic polymers are extensively used in cosmetic and personal care materials. The major benefit of using biodegradable polymers in the cosmetic industry is that they are usually non-reactive when in contact with the human skin and body. It can be easily broken down, metabolised, and eliminated from the body through normal metabolic pathways. (Fig-16)

Fig-16: Cosmetics product

be one of the serious issues occurring in water bodies, which also affects human health. The amount of fresh water availability decreases with the amount of waste water production. To solve this problem, biodegradable polymers were designed to clean up the dye-contaminated water.

5. **Uses in the Medical Field:-** Biodegradable polymers are used in the manufacturing of medical devices that are used to replace or repair some diseased, damaged, or non-fictional piece of tissue or bone, like joint, hearts, valves, arteries, teeth, ligaments, etc. It is also used in anticancer drug delivery. Chitosan is used as a hemostatic material to stop bleeding, and it is obtained from the exoskeletons of marine animals such as crabs, shrimp, etc. (Fig-13)

Fig-13:- Used in the medical field

6. **Uses in biosensors:-** Nowadays, eco-friendly biodegradable polymeric materials with good mechanical and thermal properties have been developed and used in biosensors. Polyvinyl alcohol is used as a substrate in the manufacturing of sensors, LEDs, photoelectrons, transistors, etc. for the measurement of electrical activity that is produced by the heart, skeletal muscle, brain, etc. (Fig-)

Fig-14: Biosensors

7. **Used in the automobile industry:-** In recent years, biodegradable polymers have been extensively used in the automobile industry because of their good mechanical properties, high specific strength, and eco-friendly nature. It is now replacing conventional fibres like aramid, carbon, etc. The biodegradable polymers can be used for both the exterior and interior components of automobiles. It is used in the manufacturing of interior panels in vehicles. (Fig-15)

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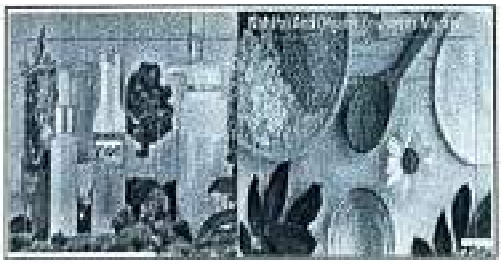

Fig-16: Cosmetics product

❖ Conclusion:-

Biodegradable polymers can be used to replace conventional plastics to improve the environment while also ensuring the long-term availability of petroleum resources. The process made in the area of eco-friendly biodegradable polymers has been impressive. Many companies across the globe are involved in this field of producing a wide variety of products. However, the cost of biodegradable polymers is comparatively high compared to conventional plastic. To overcome this issue, much advanced research has grown as per consumer demand for biodegradable polymer products. With the use of biodegradable polymers, most of the ecological issues like water pollution, global warming, the greenhouse effect, etc. can be controlled to some extent. Most of the biodegradable polymers exhibit antibacterial and antifungal properties. Biodegradable polymers have received much more attention in the last few decades due to their potential applications in fields related to environmental protection and the maintenance of physical health.

❖ Acknowledgement:

I would like to express my special thanks and gratitude to my teacher as well as my supervisor, Assistant Professor, Dr. Tanmay Das, for giving me this golden opportunity to work on this wonderful project on the topic of ***"uses of biodegradable polymers to reduce pollution and achieve sustainable development"*** at present all over the world. I am really very grateful to him for his valuable contribution to this presentation and for his teaching and learning, which were so important in preparing this presentation.

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This presentation really helped me to increase my knowledge and skills.

THE CHEMISTRY OF ALTERNATIVE ENERGY SOURCES : SOLAR CELLS, FUEL CELLS AND BATTERY TECHNOLOGY.

Report submitted to,

Abhedananda Mahavidyalaya (Department of Chemistry)

Sainthia, Birbhum

By

SOUBHIK DAS (B.Sc Honours, 6th Semester)

Roll No: 210330100049

Reg. No: 202101026535 of 2021-22

Under the supervision of,

Dr. TANMAY DAS

ABHEDANANDA MAHAVIDYALAYA

SAINTHIA, BIRBHUM, WEST BENGAL, PIN 731234

Founder: Srimat Satyananda Dev (1963)

(Affiliated to the University of Burdwan and Accredited by NAAC)

Phone: 03462263449 E-mail: abhedanandamahavidyalaya@gmail.com Website: www.abhedanandamahavidyalaya.ac.in

Date: 15.05.2024

Department of Chemistry

Certificate of Project Completion

This is to certify that Mr. Soubhik Das, a student of B.Sc. (Hons.) in Chemistry, 6th Semester, Roll No. 210330100049, Registration No. 202101026535 of 2021-22, has successfully completed the project titled: **"The Chemistry of alternative energy sources: Solar Cells, Fuel Cells Battery Technology"** under the supervision of Dr. Tanmay Das, Department of Chemistry, Abhedananda Mahavidyalaya, Sainthia, during the academic session 2023-2024.

Tanmay Das 15.05.24
Supervisor

15/05/24
Head
Department of Chemistry

15/5/24
Principal

Principal
Abhedananda Mahavidyalaya
Sainthia, Birbhum

★ **INTRODUCTION :**

Alternative energy is any energy source(SOLAR CELLS, FUEL CELLS AND BATTERY TECHNOLOGY) that is an alternative to fossil fuel.

Everyday, the world produces carbon dioxide that is released to the earth's atmosphere and which will still be there in one hundred years time.

This increased content of Carbon Dioxide increases the warmth of our planet and is the main cause of the so-called "Global Warming Effect". One answer to global warming is to replace and retrofit current technologies with alternatives that have comparable or better performance, but do not emit carbon dioxide.

☐ Solar Cells :

❖ The principle of solar cell:-

The solar cells are based on the principle of photovoltaic effect .The Photovoltaic Effect is the photogeneration of charge carriers in light absorbing materials as a result of absorption of light radiation. (Fig1)

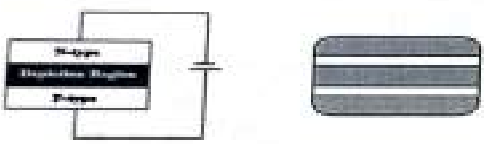

Fig1: Single Solar Cell

❖ Construction Of Solar Cell:

- Solar Cell (crystalline silicon) consists of a n-type semiconductor(emitter) layer and p-type semiconductor layar (base) . The two layer are sandwiched and hence there is formation of n-p junction. (Fig2)
  The surface is coated with anti- reflection coating to avoid the loss of incident light energy due to reflection.

Fig2: Construction Of Solar cells

- **The Working Of Solar Cell:**

- When the solar panel is exposed to sunlight, (Fig 3) the light energies are absorbed by semiconductor materials. Due to this absorbed energy the electrons are liberated and produce the external DC Current . The DC current is converted into 240 volt AC current using an inverter for different applications

Fig 3: Working Of Solar Cells

- **Type Of Solar Cells**: Based on the types of crystal used, solar cells can be classified as -

- ***Mono Crystalline Silicon Cells.***
- ***Polycrystalline Silicon Cells.***
- ***Amorphous Silicon Cells.***

- **Advantage Of Solar Cells:**

- Solar cells are a renewable energy source.
- It is clean and non -polluting.
- They have a long lifetime.
- They have very little maintenance.
- Solar cells do not produce noise and they are totally silent.

- **Disadvantage of solar cells**:

- Solar power can't be obtained at night time.
- Solar sales are very expensive.
- Energy is not stored in the battery
- Air pollution and weather can affect the production of electricity.
- They need a large area of land to produce more efficiently for supply.

☐ **The Fuel Cells:-**

- A fuel cell is a device that generates electricity through an electrochemical reaction, not combustion. In a fuel cell, hydrogen and oxygen are combined to generate electricity, heat, and water.
- Chemical Energy converted to Electrical Energy.

❖ **Construction:-**

- **Anode** - Negative post of the fuel cell. Conducts the electrons that are freed from the hydrogen molecules so that they can be used in an external circuit. Etched channels disperse hydrogen gas over the surface of the catalyst.
- **Cathode**- Positive post of the fuel cell. Etched channels distribute oxygen to the surface of the catalyst. Conducts electrons back from the external circuit to the catalyst Recombine with the hydrogen ions and oxygen to form water.

- **Electrolyte**- Proton exchange membrane. Specially treated material, only conducts positively charged ions. Membrane blocks electrons.

- **Catalyst**-Special material that facilitates reaction of oxygen and hydrogen Usually platinum powder very thinly coated onto carbon paper or cloth. Rough & porous maximizes surface area exposed to hydrogen or oxygen The platinum-coated side of the catalyst faces the PEM.

❖ **Working:-**

- A fuel cell generates electrical power by continuously converting the chemical energy of a fuel into electrical energy by way of an electrochemical reaction. The fuel cell itself has no moving parts, making it a quiet and reliable source of power. Fuel cells typically utilize hydrogen as the fuel, and oxygen (usually from air) as the oxidant in the electrochemical reaction. The reaction results in electricity, by-product water, and by-product heat.

When hydrogen gas is introduced into the system, the catalyst surface of the membrane splits hydrogen gas molecules into protons and electrons. The protons pass through the membrane to react with oxygen in the air (forming water). The electrons, which cannot pass through the membrane, must travel around it, thus creating the source of DC electricity. (Fig:4)

Fig 4: Working Of Fuel Cells

- **Types Of Fuel Cells:-**
- *Alkaline FC (AFC)*
- *Phosphoric Acid FC (PAFC)*
- *Molten Carbonate FC (MCFC)*
- *Solid Oxide FC (SOFC)*

- **Application:-**
- Can be used as power sources in remote areas.
- Can be used to provide off-grid power supplies.
- Can be applicable in both hybrid and electric vehicles.
- Wastewater treatment plant and landfill.
- Cellular phone, laptop and computers.
- Hospitals, credit card centers and police stations.
- Buses, Car, Planes, Boats, Fork lift, Trains.(Fig 5)
- Vacuum cleaner.
- Telecommunication, MP3 players, etc.

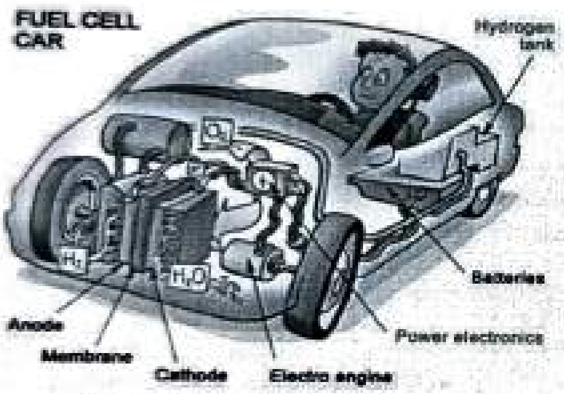

Fig 5: Fuel Cells used in cars.

- **Advantage:**
- Water is the only discharge (pure H_2)
- Higher efficiency than conventional engines.
- Excellent part load characteristics.
- Zero emission.
- Long operating period between failures.
- No rotating parts in the main hardware components.
- Negligible noise pollution.

- **Disadvantage:**
- CO_2 discharged with methanol reform.
- Little more efficient than alternatives.
- Technology is currently expensive.
- Hydrogen is often created using "dirty" energy (e.g., coal).
- Pure hydrogen is difficult to handle.

☐ Battery technology:-

- **Battery:**

- Battery is a device consisting of a series of galvanic cells connected in series or in parallel, which can generate power.
- Convert stored chemical energy into electrical energy.
- Reactions between chemicals take place.
- BATTERIES represent a silent form of energy producing chemical devices, which generate electricity on demand.

- **Importance of Battery:**

- The rapidity with which energy resources and oil fields are consumed at present and in the future will depend on the rapidity with which regions of the world industrialize, the rate of population growth, the ultimate level of human desires to possess material goods and the effort that is made to accelerate production.
- The growing concern with managing the costs of military, space crafts, portable electronics, implantable medical devices, communication technology etc.
- Batteries are portable sources of electricity.

- **Application:**

- Battery Use in Health Instruments.
- Battery Use in the Medical Sector.
- Battery Uses in Logistics and Construction.
- Battery Use in Firefighting and Emergency Response.
- Batteries Uses in Military Operations.
- Battery Use in Vehicle.
- Battery use in camera, light,GPS, laptop,etc. (fig6)

Fig 6: application's

- **Components Of Battery:**

- Anode container. Cathode, electrolyte, separator,

- Anode - Negative terminal -oxidation occurs (lose electrons)
- Cathode-Positive terminal -reduction occurs (gain electrons)
- Electrolyte:
  -is an ion-conducting medium which conducts ions between the electrodes so that the above reactions can take place,
  Current flows out of the battery to perform work.

❖ ***Classification:***

► Three types: Primary, Secondary and Reserve.

- **Primary cell:** Single use, reactions are irreversible, used when long periods of storage are needed, once completely discharged there is no further electrical use.(Fig 7)

Example: Dry cell, Zn - MnO_2, Li - MnO_2 batteries.

Fig 7: Primary battery.

- **Secondary Battery:** (Fig 8)
- Rechargeable batteries.
- Reaction can be readily reversed.
- Similar to primary cells except redox reactions can be reversed.
- Recharging:
  -Electrodes undergo the opposite process than discharging.
  -Cathode is oxidized and produces electrons.
  -Electrons absorbed by anode.

Fig 8: Secondary battery

➢ **Examples of secondary batteries:**
- Lead-Acid Battery. (fig10)
- Nickel-Cadmium Battery (Ni-Cd).
- Nickel-Iron Battery (Ni-Fe).
- Nickel-Metal hydride Battery (Ni-MH).(fig9)

- Lithium-Ion battery (C-LiMxOy).

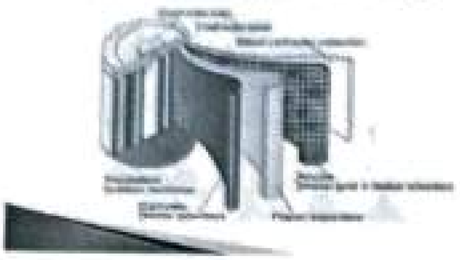

Fig 9

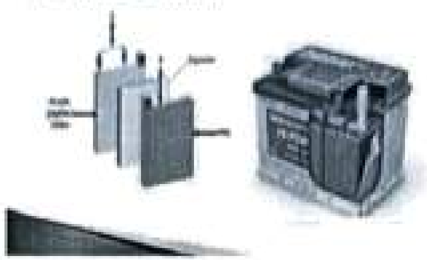

Fig 10

- ***Reserve Batteries:*** A third battery category is commonly referred to as the reserve cell. What differentiates the reserve cell from primary and secondary cells in the fact that a key component of the cell is separated from the remaining components, until just prior to activation. The component most often isolated is the electrolyte. This battery structure is commonly observed in thermal batteries, whereby the electrolyte remains inactive in a solid state until the melting point of the electrolyte is reached, allowing for ionic conduction, thus activating the battery. Reserve batteries effectively eliminate the possibility of self-discharge and minimize chemical deterioration. Most reserve batteries are used only once and then discarded. Reserve batteries are used in timing, temperature and pressure sensitive detonation devices in missiles, torpedoes, and other weapon systems.

➢ ***Examples of reserve batteries***:

- Reserve cells are typically classified into the following 4 categories.
- Water activated batteries.
- Electrolyte activated batteries. (Mg-Ag with magnesium water electrolyte)
- Gas activated batteries.
- Heat activated batteries.
- Lithium ion battery.

➢ ***Advantages of Reserve Battery***:

- Unlimited shelf life.
- High power for a short period of time.
- Better Performance.
- Various design options.

➢ ***Lithium Ion Battery*** :

A lithium-ion battery is a type of rechargeable battery that is charged and discharged by lithium ions moving between the negative (anode) and positive (cathode) electrodes. (Fig 11)

Lithium Ion Batteries:

Fig11: Lithium ion battery.

- ***Construction:*** A lithium ion battery has four main constituents: (fig12)

- **Anode:** Anode material is not purely lithium due to the high reactivity of lithium. The anode is made up of graphite which can store and exchange lithium ions. This type of graphite compounds are called intercalation compounds. The guest molecules can be I_2 K^+ , or Li^+

- Intercalation means the reversible inclusion of a molecule or ion into compounds with layered structure.

  - Example: Graphite has layered structure.

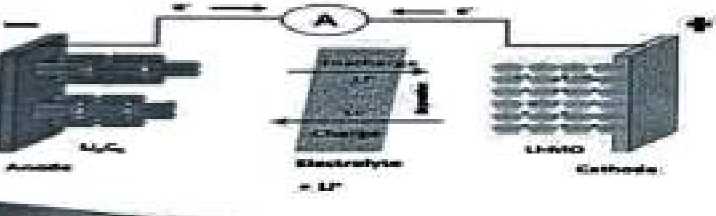

Fig: 12

- **Cathode**: This is the positive electrode and it is typically made from a lithium based metal oxide of some form. There are several different lithium ion battery technologies, so the exact format will change from one type to the next.
- The metal oxides used in cathode are: $LiCoO_2$ $LiNiO_2$, $LiMn_2O4$. Out of these three, $LiCoO_2$ has the best performance but it is toxic and expensive. $LiNiO_2$ is stable but Ni ions may disorder. $LiMn_2O_4$ is comparatively the best and it does not cause environmental pollution.

- **Electrolyte:** The electrolyte is placed between the two electrodes within the cell. Since Li ions react violently with water, therefore a non aqueous electrolyte must be used in Lithium ion batteries. The electrolyte is **$LiPF_6$** dissolved in a mixture of ethylene carbonate and diethyl carbonate. It is often a mixture of organic carbonates such as ethylene carbonate, diethyl carbonate,.

- **Separator:** In order to prevent the two electrodes touching a separator is placed between the anode and cathode. This absorbs the electrolyte, and enables the passage of ions, but prevents the direct contact of the two electrodes within the lithium cell.

- ***Working of the battery***:The traditional batteries are based on galvanic action but Lithium ion secondary batteries depend on an "intercalation" mechanism. This involves the insertion of lithium ions into the crystalline lattice of the host electrode without changing its crystal structure.These electrodes have two key properties. One is the open crystal structure, which allows the insertion or extraction of lithium ions and the second is the ability to accept compensating electrons at the same time. Such electrodes are called intercalation hosts.The chemiaction that takes place inside the battery is as follows, during charge and discharge operation.

$$LiCoO_2 + C_6 \underset{discharge}{\overset{charge}{\rightleftharpoons}} Li_{1-x}CoO_2 + C_6L_x$$

- ***Advantages***:

- High energy density because of the light weight of Lithium.
- High cycle life (500-1000)
- Doesn't self discharge
- High capacity
- long shelf life
- High voltage > 4 Volts
- It can work for a wide range of temperatures - 70°C to 40°C.

- ***Disadvantages:***

- Overcharging or overheating or short circuiting results in fire or explosions.
- For a safe long lasting product, specific safety issues must be taken into consideration while discharging the battery.
- Applications:
- Used in cell phones and other electronic gadgets.

* ***Ocean Battery:***~ The Ocean Battery is a scalable, modular solution for utility scale energy storage that is produced by renewable sources such as wind turbines and floating solar farms at sea. Ocean Battery is a pumped hydro system in a box that provides eco- friendly utility scale energy storage up to GWh scale. The mechanism is based on hydro dam technology that has proven itself for over a century as highly reliable and efficient.

  To store energy, the system pumps water from the rigid reservoirs into the flexible bladders on the seabed. Now the energy is stored as potential energy in the form of water under high pressure. When there is demand for power, water flows back from the flexible bladders to the low pressure rigid reservoirs. Driving multiple hydro turbines to generate electricity. (Fig 12)

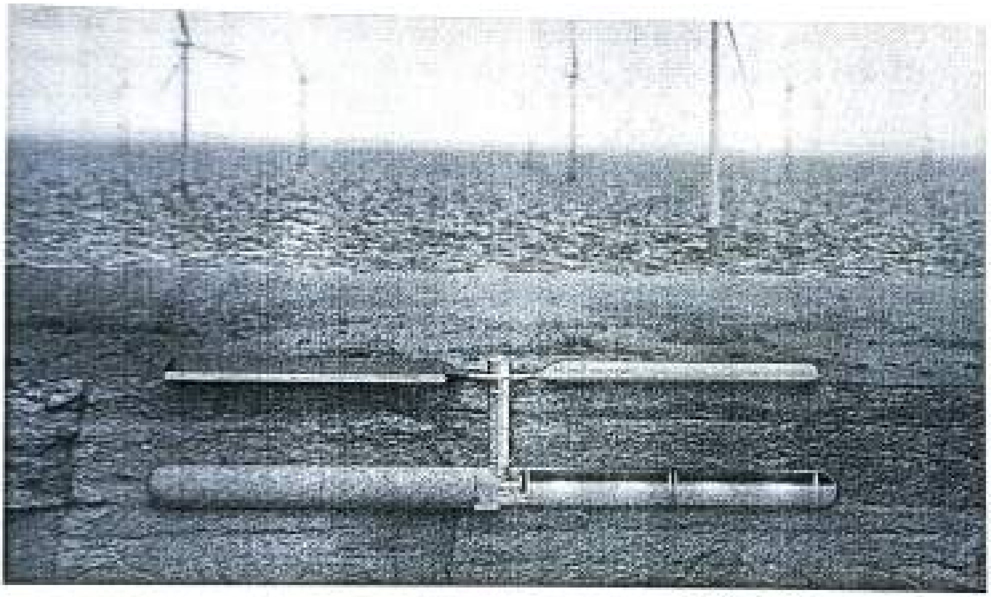

Fig 12: Ocean Battery

- **Working Process:** The battery pumps water from underground reservoirs into flexible bladders, just above the seabed. When there is a demand for power, the water, pressurized by the sea, is routed through hydro turbines in the tube to generate electricity.

- **Advantage:**

- **Eco Friendly:** The technology is sustainable and eco-friendly, the Ocean Battery does not require rare earth materials and uses clean water as the energy carrier. The structure is designed to enhance marine life.

- **Reliable and Affordable:** By applying proven hydro dam technology, we can guarantee a long lifetime of decades and a high round- trip efficiency up to 80%. This makes our technology reliable and affordable.

- **Offshore Storage :** Ocean battery provides utility scale energy storage at the source, it can be deployed in existing and new offshore wind farms. In this way we can reduce local peak loads in the network and optimally match supply and demand.

- **Disadvantage:**

- The Ocean Battery is very expensive.

- ☐ ***CONCLUSION:*** The alternative energy source can conclude that the alternate sources of energy are the future energy sources that will help in sustaining the environment as well as help in minimizing the dependency on conventional energy sources.Renewable energy supplies reduce the emission of greenhouse gases significantly if replaced with fossil fuels. Since renewable energy supplies are obtained naturally from ongoing flows of energy in our surroundings, it should be sustainable.

☐ ACKNOWLEDGEMENT:

I Would like to Express my Special Thanks and Gratitude to my Teacher as well as my Supervisor, **Assistant Professor, Dr.Tanmay Das,** for giving me this GoldenOpportunity to work on this Wonderful Project on the Topic of . ***"THE CHEMISTRY OF ALTERNATIVE ENERGY SOURCES : SOLAR CELLS, FUEL CELLS AND BATTERY TECHNOLOGY".*** at Present Days all over the World. I am Really Very Grateful to him for his Valuable Contribution to this Presentation and for his Teaching and Learning that was so Important in Preparing this Presentation.

I Would also like to Thank my Other Respected Professor of my Department and MyParents and My Friends, Who Helped me in Finishing this Project in Limited Time.

This Presentation Really Helped me to Increase my Knowledge and Skills.