An Overview of the Impact of Water Pollution on Life, Future Aspects, and Solutions

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Abstract

Natural resources are abundant on earth, which is a blessing for humanity trying to live.

One such item that is absolutely necessary for existence is water. A growing problem throughout the whole planet is water contamination. It becomes polluted from a variety of causes, including urbanisation, sewage, industrialisation, and overpopulation. In recent years, it has become necessary to regulate and manage water contamination in order to ensure that both current and future generations have access to clean water. The treatment of polluted water may be done in a variety of ways, including coagulation, precipitation, filtration, ion exchange, photo catalysis, etc. The enhanced oxidation method known as photo-catalysis is specifically designed to remove organic compounds from wastewater. Thus, different photocatalyst with Pb metal atoms as one component and oxide as another are explicitly explored here.

Keywords: Dyes, Photocatalyst, Pollution Sources, Water Pollution, and Water Pollution Remediation Techniques

INTRODUCTION

Water is a crucial natural resource for all living things worldwide. A change in the physical, chemical, or biological properties of water that might have a negative impact on people or aquatic life is referred to as water pollution.

Nearly 80% of the waste water is discharged back into the environment, most of it untreated, which contaminates rivers, lakes, and seas.

According to Varjani et al., the recent fast growth in industry has increased the flow of toxins into the environment. Waste disposal into waterways results in significant water contamination. There are several ways to measure water contamination, including BOD, COD, DO, pH, etc. A study titled "Water pollution: sources, effects, control, and management" was conducted by Owa. He explained how elements like industrialisation and agricultural practises have harmed the quality of water and led to water pollution. The causes, consequences, controls, and management of water contamination were also covered. High population density, sewage leaks, industrialisation, agricultural waste, pesticides, herbicides and fertilisers, animal waste, inadequate management, deforestation, oil spills, etc. are only a few of the causes of water pollution.

So, the aforementioned criteria are taken into account in this assessment. The numerous traditional and cutting-edge ways that may assist remove pollutants from the environment, such as water, air, soil, etc., and make the world pollution-free, which is urgently needed, are discussed one by one.

METHOD AND MATERIALS

Factors that cause pollution

High population density: Different human activities often cause water contamination, which is made worse by population density.

Consumption rises along with population growth, causing a shortage of drinkable water. Additionally, a variety of human activities contribute undesirable components to the environment and consequently to natural resources, particularly water. Eguabar cited urban overpopulation as the cause of the growing water contamination. The relationship between the rate of population expansion in a watershed region and its impact on the water quality characteristics of a river ecosystem was examined by Chamara et al. They calculated the optimal population density for a watershed in order to preserve the water quality at a suitable level. They decided to examine and analyse The Kelani River in Sri Lanka. The population in the river's basins was found to have the greatest correlation coefficients, which were 0.7, 0.69, and 0.69 (p 0.01) for biochemical oxygen demand (BOD), dissolved oxygen (DO), and total coliform (TC). They came to the conclusion that the human density needed to be under 2375 to maintain bathing and drinking water quality in the watershed and under 2672 to maintain the health of fish and other aquatic species.

Leaking sewage

Water may sometimes get contaminated owing to sewage leaks, which can happen as a result of accidents, subpar workmanship, or natural disasters. Different areas' urbanisation need appropriate sewage control. Use of diverse manmade materials resulted from this. These materials often leak as a result of manufacturing flaws. Municipal sewage is the main cause of the Ganga river's dire situation when it comes to water contamination, according to Dwivedi and colleagues. Nearly 29 sizable cities with a combined population of more than one million people are included in the Ganga. This whole population pollutes the river by discharging sewage effluents into it, which causes the poor water quality. The central pollution control board reported in 2009 that there were more microbes in the drinking and bathing water.

Industrialization:

A new age of industry began with the rise in population, urbanisation, and the demand for development, and it progressively became necessary. After then, the waste began to enter the ecosystem. According to Rajput et al., improperly disposed industrial waste has a negative influence on the area's natural resources. Regular disposal of pesticides, chemicals, used motor oil, and heavy metals contaminates water to a greater degree.

The mercury pollution caused by waste effluents from an Indian thermometer manufacturing was brought to light by Karunasagr. This research measured the amount of mercury present in water, sediment, and fish samples and compared the results with those from Berijam and Kukkal, two more lakes. Kodai water had 356-465 ngl-1 of total mercury (HgT) and 50 ngl-1 of methyl mercury. 276-350 mg/kg HgT with around 6% methyl mercury was detected in Kodai sediment. Lower methylation was found in sediments from Berijam and Kukkal, with HgT concentrations of 189-226 mg/kg and 85-91 mg/kg, respectively. Rajaram, et al. cited situations like Tiruppur and Plachimada and came to the conclusion that the answer is precise discharge standards, and local communities must help to protect their resources.

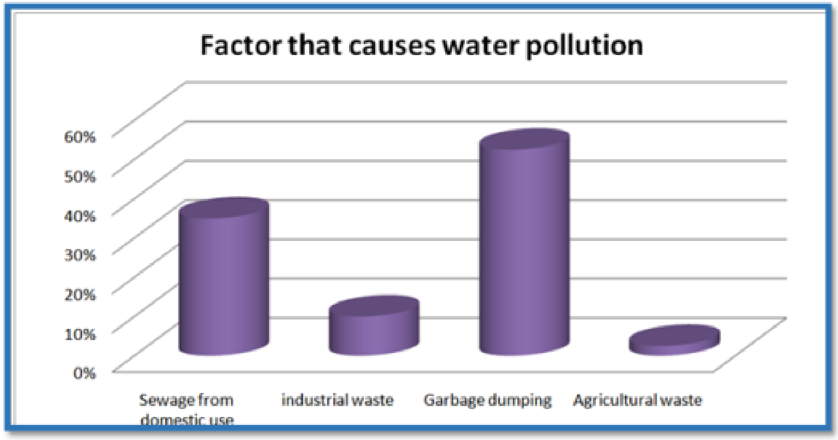
Waste from agriculture

Since the beginning of life on Earth, agriculture and cultivating crops have been fundamental activities for all living things. The need for greenery and crops expanded as population expansion got underway. As a result, manures, pesticides, and other synthetic techniques were compelled to be used, and their overuse resulted in the discharge of these substances into water and other natural resources.

According to Agamuthu's research, agricultural waste is the leftovers from agricultural goods including crops, poultry, fruits, and vegetables that have a lower economic value than the processing costs to make them usable [7]. As a result, the removal of such residues from environmental resources is made more challenging. The sort of agricultural operations that are conducted determine the agricultural waste. According to Dien et al., one of the factors contributing to water pollution is the disposal of empty pesticide bottles and packages that are dumped into bodies of water. According to estimates from the Plant Protection Department, these packing materials still contain 1.8% of pollutants. The environmental harm brought on by agricultural burning and potential uses for crop residue were investigated by Kumar et al.

They stated that when burning straw, carbon, nitrogen, and sulphur are completely burned and released into the atmosphere. When combined with other airborne gases like methane, nitrogen oxide, and ammonia, this can result in severe atmospheric pollution [8]. They came to the conclusion that burning crop waste destroys the nutrients already present in the soil, making it difficult to grow the next crop (Figure 1).

Figure 1. Causes of water pollution



Pollution's impact on water:

When utilised, polluted water has a number of negative consequences on human, plant, and animal health.

Polluted water is unsustainable for aquatic life. Additionally, it is still useless for residential usage (Figure 2).

According to Haldar et al., the Turag River area's local populations are experiencing a variety of health issues, which may be caused by the river's filthy water. The research showed evidence that consumption of certain foods might cause health issues such diarrhoea, dysentery, skin issues, respiratory illnesses, anaemia, yellow fever, cholera, dengue, and pregnancy complications, among others.Thus, it is urgently necessary to purify the water, and several procedures are now being used to accomplish so.

It is necessary to remove these contaminating elements from the water bodies after classifying the contaminants that are present in the water. For this, it is preferable to choose treatment techniques that are simple to use, inexpensive, easy to handle, highly effective, and shouldn't release secondary pollutants.

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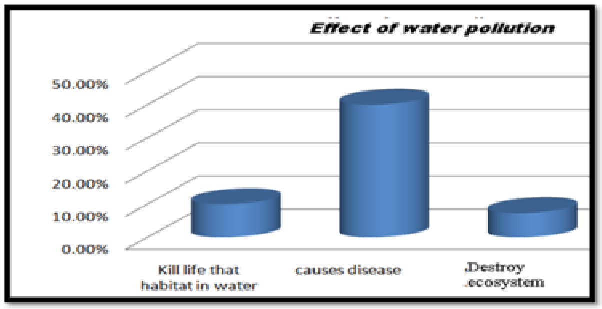
Figure 2. Effects of water pollution



There are several traditional techniques for cleaning contaminants out of aquatic bodies.

Conventional techniques are still used today to remove certain dissolved, suspended, or coagulated contaminants from water. Examples of such techniques include:

- Coagulation/flocculation
- The precipitation
- The filtering
- The absorption
- Solvent removal
- Membrane dissociation
- Exchange of ions
- Photocatalysis and so on.

In the research, an effort is made to evaluate several techniques for removing pollutants from water, particularly those that are coloured, or dyes, which are often discharged into water by textile sector businesses and cause pollution.

One of the factors contributing to pollution is the presence of suspended colloidal particles in the majority of water bodies.

Bratby suggested a number of benefits of treating such water sources using coagulation. It was claimed that the technique is preferable since it is affordable, quick to treat pollutants, and effective for those that are intractable. The technique was also picked because it may be used with a variety of chemicals to remediate dirty water. Furthermore, no additional substance is added to the water throughout the procedure.

Methylene blue and methyl orange dyes were found to have degraded utilising the coagulation technique in laterite soil with a silica component, according to Yen-Yie et al. The decolorizing process was mediated by charge neutralisation, electrical double layer compression, and sweeping flocculation. This research described the breakdown of methylene blue and methyl orange into smaller hydrocarbon molecules as well as the production of silsesquioxane.

According to Moghaddam et al.'s research, dye degradation is accelerated by a drop in pH and does not return as sludge production rises. The researchers came to the conclusion that recycling ferric chloride sludge as a cheap material in the coagulation/flocculation process in wastewater treatment facilities may have certain benefits, including very effective acid red 119 dye removal and financial savings on treatment plant running expenses.

Precipitation is a very straightforward procedure in which a saturated solution of any substance is treated to produce a solid.

Silva and colleagues used the oxidant Mn3O4 to study the methylene blue degradation. They used air as an oxidant to co-precipitate discrete Mn3O4 particles and Mn3O4/Fe3O4 nano-composites, which were produced in the absence and presence of previously synthesised magnetite nanoparticles, respectively. They used this nano-composite to catalyse the N-demethylation of methylene blue, which leads to the formation of thionine as the end result of the oxidative decolonization of methylene blue.

According to Chen et al., the precipitation approach was regarded as a less complicated, more affordable way to significantly lower water COD. They came to the conclusion that under visible light, the constructed photo-catalytic membrane destroyed dye molecules and separated oilwater emulsion. This membrane demonstrated remarkable antifouling and recyclable properties. Acid blue 80 may degrade, according to Zhu et al. Alkaline white mud, with a 95% degrading efficiency, was used to accomplish this.

Filtration, according to Chakraborty et al., is a quick and effective technique. There are numerous different filtering methods, including microfiltration, ultrafiltration, and nanofiltration. According to Cheng et al., decreased graphene oxide-TiO2 nanomaterial may be faked using simple vacuum filtering, which destroys the dye. Large surface area, flexible structure, charge carrier mobility, and high conductivity were all characteristics of this combination.

In microfiltration, germs and suspended particles are removed from process liquid by passing it through a specific membrane with tiny pores. This method of concentrating, purifying, or separating macromolecules, colloids, and suspended particles from solution uses pressure to drive the separation process. Also known as semipermeable membrane filtration, ultrafiltration is a kind of membrane filtration in which factors like pressure or concentration gradients cause a separation across the membrane. It works well to lower the water's silt density index and remove particles that might clog reverse osmosis membranes. It is comparable to reverse osmosis. Another pressure-driven membrane filtering method is nanofiltration. This method is often used to remove organic waste, colour, odour, small amounts of disinfectants, and trace amounts of herbicides from vast bodies of water.

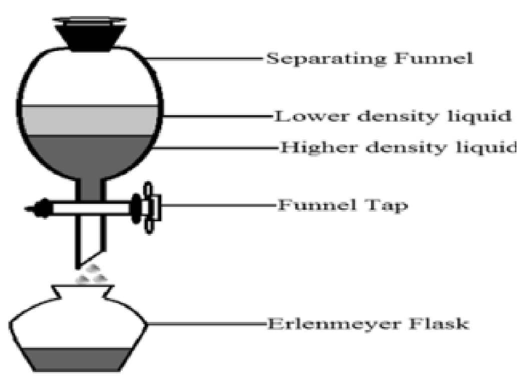
Pollutants, mostly dyes, are present in textile industry effluents. The adsorption technique may be used to remediate such contaminants. Biodegradation may be used to get rid of water-soluble colour, according to Henze et al. Active microorganisms with two activities are used for this purpose: Adsorption on the substance's surface

The degradation of dyes by these microorganisms' generated enzyme.

Pirok, et al. mentioned a several benefits of this procedure, including how well-liked it is by the general population, how many species are accessible, how reasonably priced it is, etc.

Under the solvent extraction process, compounds may be extracted from water based on how well they are soluble in two distinct solvents. This is accomplished by using two solvents, one polar and the other non-polar. Eosin and carminic acid dyes may be removed from contaminated water using DMSO, acetonitrile (a non-polar solvent), and water (a polar solvent), according to Crini. Reverse micelles are a novel method of liquid/liquid extraction that was proposed by Pandit et al., allowing for solvent recovery and dye reuse. They indicated that when surfactant concentration rises, so does the ratio of solvent to aqueous phase volume needed to remove colour. They came to the conclusion that amyl alcohol separates from the aqueous phase of the solvent dispersion more quickly than benzyl alcohol and methyl benzoate (Figure 3).

Figure 3. Solvent extraction apparatus



In order to recycle and reuse the treated wastewater, membrane separation is a valuable and well-known approach. Here, water is filtered using membranes made of various materials and sieve sizes. The sieve size may be measured in microns. According to Choi et al., this method is effective in separating parts with different particle sizes and molecular masses. It might be said that some membranes are selective towards certain materials and hence permit the passage of certain materials. Santos et al. investigated the in situ crystallisation of Cr^{3+} that was embedded on a geopolymer membrane. To treat dye waste water, this was used as a hybrid photo catalyst. Prihodko et al. investigated how the Fe-ZSM-5 catalyst production process affected the surface acidity, nature, and dispersion of iron species during the catalytic wet peroxide oxidation of Rhodamine G dye.

Unwanted ions are swapped out for other, non-contaminating ions using the ion exchange technique, one of the pollutants removal techniques. In a dual cell reactor, Ansari et al. investigated the efficacy of polyaniline-Cl, polyaniline-ClO_4, and polyaniline-SO_4 2- ClO on nitrate removal. Electrically switched ion-exchange technology was used as a safety precaution. Vithal et al. used an easy acid-free ion exchange procedure in an aqueous solution at ambient temperature to generate nanosized Cu^{2+} and Ag^+ doped $Na_2Ti_3O_7$. The degradation of blue dye in waste water effluent was then accomplished using this. They also looked at the Methylene Blue (MB) dye's photocatalytic oxidation caused by visible light.

In addition to all of these cleaning and purifying techniques, it has been shown that sophisticated oxidation processes have significant promise for removing contaminants. Other advantages include the fact that no more chemicals are added to the environment, the production of a free radical chain reaction that continues on its own initiative without the need for further effort, etc. Photo catalysis is the process of accelerating a reaction in the presence of light and a catalyst. By absorbing light photons, pollutants are transformed into inert compounds. Today, photocatalysis is widely applied in many different industries, including solar cells, hydrogen generation, pollutant degradation, and environmental factor purification. It is regarded as an advanced oxidation process. In order to acquire clean, pollutant-free water for use for various reasons like cleaning, washing, cooling, etc., the removal of coloured contaminants from industrial effluents is thus taken into consideration. Another area that needs investigation is the potability of this treated water. Mohammad et al. suggested using pure Cu_2O, Cu_2O/TiO_2, and Cu_2O/ZnO to photodegrade Congo red dye. They provided details of an easy, one-pot solvo-thermal synthesis process that uses these chemicals as reducing and solvent agents.

Floating photo catalyst was investigated by Mohammad et al. as a viable contender for wastewater treatment. The disadvantages of the suspended TiO_2 photocatalysis system may be solved, they further said. Under visible light, TiO_2 and polyvinyl alcohol at a 1:8 ratio degraded the methylene blue colour. Immobilised TiO_2 on stainless steel mesh was employed as a photocatalyst by Grao et al. They looked at five independent factors: the amount of UV radiation, the number of layers of TiO_2-coated mesh, the thickness of the coating, the flow velocity of the water, and the starting dye concentration.

RESULTS AND DISCUSSION

As a powerful solar photocatalyst for the discoloration of organic dye pollutants in wastewater, Roonasi created a barium ferrite/activated carbon composite. Several factors, including temperature, catalyst quantity, radiation intensity, and photocatalyst reusability that influence the discoloration of organic dyes, among others, were taken into account in this research.

It has been shown that a photocatalyst's technique of synthesis has a significant impact on both its activity and how well it reacts with pollutants. Various strategies and procedures have been developed in order to create appropriate photocatalysts for the degradation of organic dyes. Numerous techniques were used for this, including the sol-gel auto combustion process, homogeneous hydrolysis, ultrasonic technology, co-precipitation technique, etc. Some doped materials, such as Mn doped and PVP capped ZnO nanoparticles, Iridium doped ZnO, and 3D flowers made of F-doped titanium dioxide bronze fullerene (F-TiO2 (B)/fullerene), cobalt doped nanotitania photo catalytic system, were also used for degradation. P-Rosaline hydrochloride was degraded utilising barium tungstate as a photocatalyst by Nihalani et al.

In order to increase and accelerate the speed and quality with which a photocatalyst reacts with a pollutant, the mechanism of the overall degradation process was also determined. According to research by Mills et al., photoinduced dye degradation is a process that is sped up by the presence of photcatalysts. According to Carp et al., these reactions are triggered by the absorption of photons with energies that are at least as high as the photocatalyst's band gap energy. It was claimed that to sustain catalytic activity, the continual consumption of hydroxyl radicals during photocatalysis required replenishment. For flow rates up to 20,000 cfm (ft3/min), photocatalytic oxidation has been shown to be more cost-effective than incineration or bio-filtration for treating a stream that contains 500 ppm of volatile organic compounds (Figure 4).

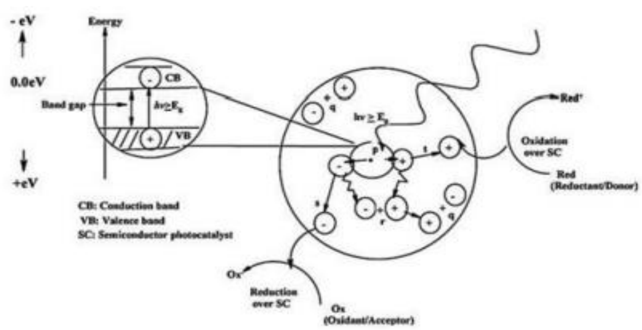


Figure 4. Schematic diagram of photo catalytic process initiated by photon acting on the semiconductor

According to Konstantinou et al., when an electron accelerates from a semiconductor's valence band to the conduction band, a hole is created in the valence band. The organic molecule may be oxidised by the photogenerated holes to make R+, or they can react with OH or H2O to oxidise them into OH• radicals. The resultant OH• radical may oxidise the majority of azo dyes to the mineral end products since it is a highly powerful oxidising agent (standard redox potential+2.8 V).

Liu et al. investigated the electrocatalytic oxidation of o-nitrophenol (o-NP), m-nitrophenol (m-NP), and p-nitrophenol (p-NP) on an acid medium using bi-doped lead dioxide anodes and bulk electrolysis.

Control and management of water pollution

Through the assessment, it was discovered that all contaminants have the potential to directly or indirectly harm water. Thus, a survey on the management and control of water pollution served as the study's conclusion. There are several strategies that may be used to prevent, regulate, and manage the control measures, launch a project or programme, etc., water pollution.

Alguraja, et al. reported using remote sensing and a GIS strategy to address water pollution in the Indian Tamilnadu region's Tiruchirappali Taluk. They advised using a remote sensing research using IRS-1D LISS 111 satellite images and SRTM data, as well as constructing several thematic layers in the block to demarcate the administrative division of the study region.

Sing and colleagues investigated the causes, impacts, and mitigation of water contamination. They provided a list of every control measure implemented by the government and NGOs. Olmstead, et al. analysed policy tools, empirical data, and water pollution prevention in developing nations. In order to prevent water pollution, they discussed a variety of prescriptive and performance-based regulations, voluntary programmes, and other policy tools. Manjula and colleagues investigated the legislation governing ground water contamination in India. They discussed the limitations and lack of consensus of the Act of 1974, which was created to address water contamination. The regulation was determined to be insufficient for the adoption of certain simple solutions, such reverse osmosis, etc.

CONCLUSION

We may deduce that around 71% of the earth's surface is covered with water, and that oceans account for 96.5% of that water. The amount of fresh, drinkable water on earth is just 3%. The amount of industrial waste that is discharged into water is over 70%, while home sewage is responsible for 80% of the water contamination. Large-scale water pollution is a result of several human activities. The health of humans and aquatic life are negatively impacted by water pollution. Nowadays, experts are focusing their study on this problem.

As a result, several treatment techniques, including filtering, are created. To fix this problem, use coagulation, ion exchange, precipitation, adsorption, photocatalysis, etc. These techniques aid in the cleansing and purification of water, and the treated water may be used to many industrial, agricultural, and other uses. More processes must be added to the water before it can be utilised for drinking. The finest pollution-removing agents are thought to be photocatalysts, which are utilised to destroy contaminants found in water. Electrostatic attraction causes certain dye molecules to adhere to the surface of the photocatalyst, where they are then mineralized by non-selective free radicals. The target molecule's adsorption on the photocatalyst surface may thus be seen as a crucial step towards effective photocatalysis and may entirely eliminate the contaminants, leaving behind clean water for continued usage.

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