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Review Article

Role of Physics for Development of Different Techniques for Photocatalytic Degradation of Heavy Metals and Effluents in Water

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Abstract

Several factors contributed to the elevated levels of water pollution in the earth surface increasing the risk of wastewater pollution. Inorganic metal irons and suspended liquid metals are also leads cause of water pollution. Physical treatments for water treatment include the use of effective membrane filters in two ways. Small membrane filter and large membrane filters also used for commercial applications. Different types of nanoparticles are used for the treatment of organic contaminants suspended in the wastewater. The adsorption of a reactive dye through the hydroxyapatite (HAP) leads the excellent filtration of ions in the wastewater. Different types of photocatalytic reactors are used for the treating the large amount of wastewater in effective ways. These included the titanium based photocatalytic reactors that employed the sub-micron TiO2 particles from the treated water which accompany the treatment process. Polymer composites are used for removal of wastewater due to their low operating temperat Nanofiltration also used for removal of wastewater due to the formation of utilizing of the semipermeable membrane allows the fine removal of the different ions and different types of pollutants ure and susceptibility to environmental degradation as compared to other operations.

Keywords: Nanofiltration, wastewater, semipermeable membrane, pollutants, Polymer composites.

INTRODUCTION

Accumulation of organic and inorganic compounds to the water borne bodies increasing the cause of pollution that increased the risk of toxic metals in nearby areas. On the other hand, several factors contributed to the elevated levels of water pollution in the earth surface such as sewage, urban run-off, industrial effluents and agriculture wastewater [1- 3]. Some leading industrial effluents are also major cause of pollution caused by toxic heavy metals. These are sewage treatment plants and industry including food processing, pulp and aquaculture. There is urgently need to reduce the level of water pollution in high risky areas where chance of disease and other infections occurs [4, 5].

Wastewater is mainly caused for water pollution by two types of factors. Organic factors include pesticides, fertilizers, hydrocarbons, phenols, plasticizers, biphenyls, detergents, oils, greases, pharmaceuticals, proteins and carbohydrates [1-3]. While on the other hand, inorganic metal irons and suspended liquid metals are also leads cause of water pollution. Different factors are contributed to the water pollution caused by the dissolved organic matter due to the accusations of dissolved oxygen. This tremendous increase in the dissolved oxygen leads the depletion of natural oxygen necessary for all living organism [6-7].

Toxic pollutants are major source of hazardous metals for the environmental. These pollutants are accumulated in the water source such as polychlorinated biphenyls, polychlorinated dibenzo-pdioxins and dibenzofurans, and some organochlorine pesticides as hexachlorobenzene or dichloro-diphenyl-trichloroethane. These toxic compounds are released by the toxic compounds from industrial materials. The continued sources for water pollution are through industrial sectors. Different methods have been used for controlling the water pollution includes the physical and chemical treatments [8, 9].

Different methods and techniques have been used for treating the wastewater in effective ways. These are photo- oxidation, photo-catalysis, and coagulation, filtration with coagulation, precipitation, ozonation, adsorption, ion exchange, reverse osmosis and advanced oxidation. These methods are commonly used for industrial and commercial applications but some of them are low or poor water filtration capability due to traditional membranes for filtration of ions in water molecules. The other methods are ion exchange and reverse osmosis. Sometimes, these methods are used for local purposes due to economically feasible and some features makes them rendered due to relatively high investment and operational cost [10, 11].

Table-1: Different Methods for degradation of heavy metals and effluents in water

Type of effluents	Methods	Treatment	Purposes/Applications
Wastewater, pollutants and contaminates	photo-oxidation, photo-catalysis, and coagulation, filtration with coagulation, precipitation, ozonation, advanced oxidation	Degradation of heavy metals and effluents in water	Used for the removal of different types of pollutants in water.
Toxic pollutants	Physical treatments	Use of effective membrane filters	Capacity for filtration of ions in the wastewater leads poor separations of toxic pollutants
Wastewater, pollutants and contaminates	Nanotechnology	Different types of nanoparticles are used for the treatment of organic contaminants suspended in the wastewater.	The adsorption of a reactive dye through the hydroxyapatite (HAP) leads the excellent filtration of ions in the wastewater
Heavy Metals	Electrostatic attachment/ Coagulation	Removal of metals	P, Ca, Ni, Cd

Physical Treatment

Physical treatments for water treatment include the use of effective membrane filters in two ways. Small membrane filter and large membrane filters also used for commercial applications. Membrane filters acting as the mechanical filters like sand filtration for achieving the solid-liquid separation. The pressurized air is then pumped into the wastewater that removes the toxic metals from the wastewater in cost effective manners. Sometimes, due to poor membrane capacity for filtration of ions in the wastewater leads poor separations of toxic pollutants. While on the other hand, high or larger membrane capacity for filtration of ions in the wastewater leads archived the excellent separations of toxic pollutants. Finally, pressurized air then remove the small bubbles which adhere to the suspended matter causing them to float to the surface of the water. This method is also conventional as compared to the other traditional methods as it is more reliable and cost effective [12-15].

Nanoparticles

Different types of nanoparticles are used for the treatment of organic contaminants suspended in the wastewater. The adsorption of a reactive dye through the hydroxyapatite (HAP) leads the excellent filtration of ions in the wastewater leads archived the excellent separations of toxic pollutants. It has capacity of 50.3 mg g^{-1} at a pH of 5.0 that is endothermic in nature and has tendency for removal of most of toxic metals present in the wastewater. Some other dyes are also used for large scale removal of organic pollutants and water filtration plants are working in heavy sedation of ions [16-18].

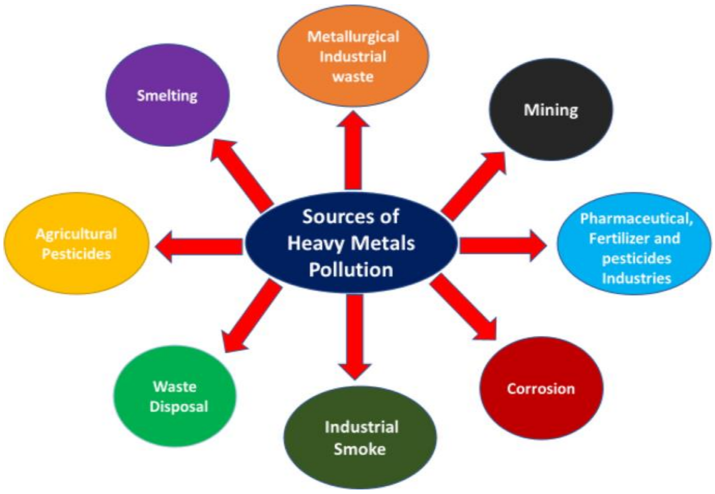

Fig-1: Different Techniques for degradation of heavy metals and effluents in water

Role of Nanocrystalline for Heavy Metals Removal

There are different types of nanoparticles with different efficacies for removal of toxic metals from waste water and effluents. The most abundant and effective type is the nanocrystalline based HAP that have capability for relive of nitrobenzene with the applications of 5 g L^{-1}. The adsorption power for removal of other ions is low in case of HAP based nanoparticles. Nanocrystalline based HAP usually interacts with the surface of water molecules in such a way that nitro groups have been weaken the attraction to the hydrogen bonds between the water molecules. As s results, poor interaction between the hydrogen and oxygen takes place. Nanomaterials are now being utilized in particle filtering, gas absorption and catalytic procedures also employed for the purification of physical devices to minimize the particulate matter or PM, gases precursors, and other contaminants such as VOC and NOx [19, 20].

The other types of nanoparticles are mesoporous silica-alumina (MSA) potentially interacts with the hydrocarbons molecules, aromatic and benzene based compounds. Nanotechnology based mesoporous silica is the form of silica that is characterized by its mesoporous structure in combinations of nanoparticles that helpful for destruction of rough pollutants from industrial water. Amorphous silica (SiO2) is an inorganic material commonly used in semiconductor circuits to isolate different conducting regions that is potentially used for manufacturing of material in microelectronics and chromatography in case of industrial pollutants surface of water molecules in such a way that nitro groups have been weaken the attraction to the hydrogen bonds between the water molecules. As s results, poor interaction between the hydrogen and oxygen takes place [11, 13, 19].

Silver metal ions can cause the serious toxicity as in case of water pollution. It interacts with the ions of the water molecules that cause the degradation of living tissues. Different studies revealed the mechanism of sliver ions interaction with toxicity concerns. Silver nanoparticles are derived from its salts like silver nitrate and silver chloride, and their effectiveness as biocide. Silver ions are small in size due to which they can penetrate the living tissues and triggered the cellular tissues. The mechanisms involved during the bactericidal effects of Ag nanoparticles include. These silver ions also showed the intact interactions with hydrogen bonding molecules of the DNA, makes strong adhesion to the cell surface altering the membrane properties [20-22].

Mechanism of photocatalytic action depends upon on the structure of semiconductor and its conductivity. As semiconductor is comprised of the valance band responsible for the conduction of energy in effective way. The photocatalysis mechanism is extremely oxygen-dependent. When there is stiffened light fall in the semiconductor, photons that stimulates the ions in the valence band that ultimately increase the conduction process. Superoxide is produced during the oxygen reduction in the conduction band. These lead the formation of the free radicals and capturing of the ions and pollutants necessary for the catalytic degradations. It depends upon the different conditions and ions stimulations. Low stimulations of ions lead the poor removal of ions in the wastewater that leads to the poor outcomes. While, high power with intense stimulations of ions leads the efficient removal of ions in the wastewater that leads to the poor outcomes [22-24].

Development of Photocatalytic Slurry Reactors

Different types of photocatalytic reactors are used for the treating the large amount of wastewater in effective ways. These included the titanium based photocatalytic reactors that employed the the sub-micron TiO2 particles from the treated water which accompany the treatment process. This titanium based filtration is widely used for the large removal of heavy metals and principles included the settling tanks (overnight particle settling) or external cross-flow filtration system. This type of filtration has several disadvantages such as increases the cost of the treatment process. Titanium based photocatalytic reactors uses the immobilized TiO2 that is fixed in such a way to support via physical surface forces or chemical bonds. These reactors extend the benefit of not requiring catalyst recovery and permit the continuous use of the photocatalyst [16, 18].

New Photocatalytic Developments for Heavy Metal removal

Different methods and techniques are used for heavy metals removal present in the wastewater. These are arsenic removal with coagulants and ferric sulfate. In these wastewater treatments, arsenic (V) are effectively removed than arsenic (III). The exact mechanism of action of binding of arsenic to the filtrations membranes is unclear. However, microparticles and negatively charged arsenic ions are attached to the flocs by electrostatic attachment during the process [25-27].

Photocatalytic Degradation of Phosphates

Phosphates are another metal present in the wastewater that leads the serious health problems through drinking water and their removal is necessary. These are removed through the mechanism by coagulation by bindings of metal interactions [11, 18, 19].

Photocatalytic Degradation of Mercury

Phosphates is the most toxic form of the heavy metal present in the wastewater that cause the adverse reaction to the body cells through drinking water and their removal is necessary. These are removed through the mechanism by coagulation by bindings of metal interactions. This type of degradation is effective for removal of other heavy metals [22, 25, 26].

Photocatalytic Degradation of Chromium

Chromium that is present in the water in the wastewater that and removed through the mechanism by coagulation by bindings of metal interactions. This type of degradation is effective for removal of other heavy metals [27-29].

Photocatalytic Degradation of Arsenic

Arsenic is the most poisonous and toxic form of metals that present in the wastewater that leads the serious health problems through drinking water. These are removed through the mechanism by metal interactions binding of arsenic groups with the membrane bound chambers and effective for large scale removal [23, 27, 29].

Photocatalytic Degradation of Lead

Leads are another toxic form of metals that present in the wastewater and removed through the mechanism by metal interactions binding. Lead removal is not easy as compared to the other metals as it makes intact combinations to the molecules of the water and hydrophilic makes them difficult to remove [30, 31].

Photocatalytic Degradation of other Metals

Cooper is another metal present in the wastewater are removed through the mechanism by coagulation by bindings of metal interactions [32-34].

Role of Physics in Photocatalytic Degradation

Polymer composites are used for removal of wastewater due to their low operating temperature and susceptibility to environmental degradation as compared to other operations. For example, introduction of the metallic ceramic due to their unique features such as combination of magnetic, electronic, optical, or catalytic properties. Some adsorbents/photocatalysts materials also used for water treatment. These methods are merged with emerging techniques for large scale removal of toxic metals in such a way that toxicity concerns issues remains resolved through metallic nanocompsites [32-34].

Nanofiltration also used for removal of wastewater due to the formation of utilizing of the semipermeable membrane allows the fine removal of the different ions and different types of pollutants. It depends upon the different conditions that allow some particles to enter via the membrane while some of the particles remain insoluble and pass through membrane filters like calcium and magnesium. It functions as a barrier membrane capable of removing particles to remove divalent ions such as calcium it is sometimes referred for industrial water treatment [35, 36].

CONCLUSION

Different methods are used for heavy removal of metals in water and wastewater. Removal becomes difficult due to changing environment and microbial attack. Advances in novel technologies made in order to improve the existing technologies as acute and choric illnesses are caused by heavy metal concentrations in drinking water that exceed the permissible limits fatal to brain, nervous system, and even cancer. Nanotechnology and emerging technologies are needed to address in better ways for controlling the risk pollution.

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