An Overview of Removal of Lead (Heavy Metal) from Industrial waste water

Mrs. Shilpa Chittora[1], **Prof. Sagar Gawande**[2]
[1, 2] Department of Environment
[1, 2] Anantrao Pawar C.O.E. & R., Pune

Abstract- *Rapid industrialization has not only brought development and prosperity but eventually disturbed the ecosystem. One of the visible impact is in the form of water pollution. Waste effluents from large number of industries viz., electroplating, leather, tannery, textile, pigment & dyes, paint, wood processing, petroleum refining, photographic film production etc., contains significant amount of heavy metals in their wastewater. The aim of the study is to investigate the sources of Lead in industrial wastewater and its effect on human and compare the various methods of Lead removal which includes chemical precipitation, electrochemical reduction, ion exchange, membrane separation, adsorption and reverse osmosis,.*

After comparison Adsorption is investigated as an economical and effective method for the retention of lead from industrial wastewater because it is simple, effective and economic.

Keywords- Heavy metal removal, lead, Industrial wastewater

I. INTRODUCTION

Pollution of water caused due to addition of heavy metals resulting from the industrial activities is increasing tremendously and is a matter of global concern. Heavy metals contaminations could exist in wastes of many industries, such as metal plating, mining operations, tanneries, chloralkali, radiator manufacturing, smelting and alloy industries, wood processing industries, petroleum refining industries, storage battery industries. The heavy metals present in the wastewater is persistent and non degradable in nature. Moreover, they are soluble in aquatic environment and thus can be easily absorbed by living cells. Thus, by entering the food chain, they can be bio accumulated and biomagnified in higher trophic levels also. The heavy metals, if absorbed above the permissible labels, could lead to serious health disorders. Therefore, it is obligatory to treat metal contaminated wastewater before discharging into the environment.

Lead is a heavy, soft, malleable, bluish grey metal. Because of high toxicity of Lead and its widespread presence in the environment it is considered as a priority pollutant. It is an industrial pollutant, which enters the ecosystem through soil, air and water. Lead is a systemic poison causing anaemia, kidney malfunction, tissue damage of brain and even death in extreme poisoning situation.

The conventional methods for lead removal from wastewater includes chemical precipitation, chemical oxidation, ion exchange, membrane separation, reverse osmosis, electro dialysis etc. These methods are not very effective, are costly and require high energy input. They are associated with generation of toxic sludge, disposal of which is expensive and non eco- friendly in nature. Adsorption has emerged out to be better alternative treatment methods. It is said to be effective and economical because of its relatively low cost.

II. INDUSTRIAL WASTEWATER AND LEAD

Lead pollution, spreading over earth and ground water, comes from natural sources and industrial effluents. Natural sources are: seepage from rocks.In to water, volcanic activity, forest fires etc. Processing industries, such as acid battery manufacturing, metal plating and finishing, ammunition, tetraethyl lead manufacturing, ceramic and glass industries and environmental clean-up services treat and disposal of lead contaminated water are the major sources of lead pollution.

Lead is the most significant toxin of the heavy metals.The inorganic forms of lead are absorbed through ingestion by food and water, and inhalation. A notably serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin; dysfunctions in the kidneys, joints and reproductive systems, cardiovascular system and acute and chronic damage to the central nervous system.

According to the World Health Organization (WHO), the maximum permissible limit (MPL) of lead in drinking water is 0.05 mg/L. The permissible limit (mg/L) for Pb (II) in wastewater, given by Environmental Protection Agency (EPA), is 0.05 mg/L. In industrial wastewaters, lead-ion concentrations approach 200–500 mg/L; this concentration is very high in relation to water quality standards, and lead-ion concentration of wastewaters must be reduced to a level of 0.05–0.10 mg/L before discharging to water ways or sewage systems. Hence proper treatment of industrial wastewaters which are releasing lead into the aquatic and land systems is very important.

III. CONVENTIONAL METHODS OF REMOVAL OF LEAD

The conventional processes for removing heavy metals from wastewater include many processes such as precipitation, ion exchange, electro-winning, electro-coagulation, cementation, electro-dialysis and reverse osmosis.

PRECIPITATION

Precipitation is the most common method for removing lead ions up to parts per million (ppm) levels from water. Since the lead ions salts are insoluble in water, when the correct value is added, precipitation caused. This process is cost-effective and its efficiency is affected by low pH and the presence of other salts (ions). The process requires addition of other chemicals, which finally leads to the generation of a high water content sludge, the disposal of which is cost intensive. Precipitation with lime, bisulphite or ion exchange lacks the specificity and is ineffective in removal of the lead ions at low concentration.

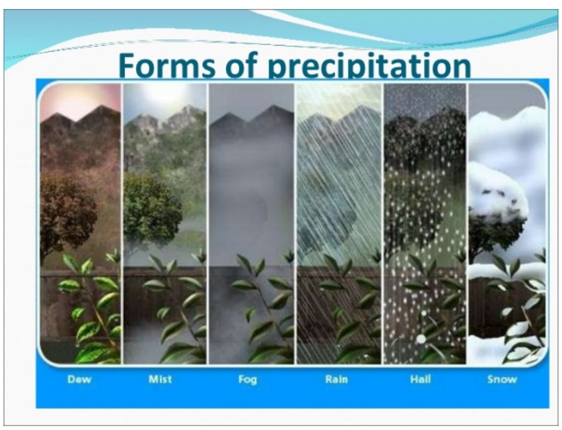

Figure 1.

ION EXCHANGE

Ion exchange is another method used successfully in the industry for the removal of lead ions from effluents. Though it is relatively expensive when compared to the other methods, it has the ability to achieve ppb levels of clean up while handling a relatively large volume. An ion exchanger is a solid capable of exchanging either cations or anions from the surrounding materials. Commonly used matrices for ion exchange are synthetic organic ion exchange resins. The disadvantage of this method is that it cannot handle concentrated metal solution as the matrix gets easily fouled by organics and other solids in the wastewater. Moreover ion exchange is nonselective and is highly sensitive to pH of the solution.

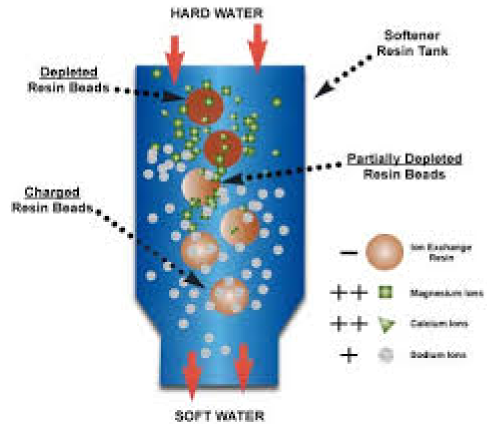

Figure 2.

ELECTRO-WINNING

Electro-winning is widely used in the mining and metallurgical industrial operations for heap leaching and acid mine drainaging. It is also used in metal transformation and electronics and electrical industries for removal and recovery of lead ions. Metals like Ag, Au, Cd, Co, Cr, Ni, Pb, Sn and Zn present in the effluents can be recovered by electro-deposition using insoluble anodes. The disadvantage of this method is corrosion of electrodes which would frequently have to be replaced.

ELECTRO-COAGULATION

Electro-coagulation is an electrochemical approach, which uses an electrical current to remove lead ions from solution. Electro-coagulation system is also effective in removing suspended solids, dissolved metals, tannins and dyes. The contaminants present in wastewater are maintained in solution by electrical charges. When these ions and other charged particles are neutralized with ions of opposite electrical charges provided by electro-coagulation system, they become destabilized and precipitated in a stable form.

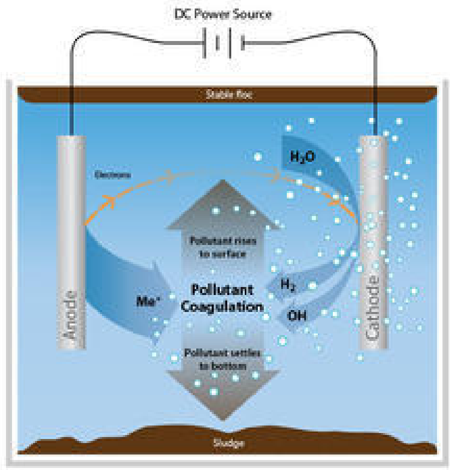

Figure 3.

CEMENTATION

Cementation is a type of another precipitation method implying an electrochemical mechanism in which a metal having a higher oxidation potential passes into solution e.g. oxidation of metallic iron, Fe (0) to ferrous iron (II) to replace a metal having a lower oxidation potential. Copper is mostly separated by cementation along with noble metals such as Ag, Au and Pb as well as As, Cd, Ga, Pb, Sb and Sn can be recovered in this manner.

REVERSE OSMOSIS & ELECTRO-DIALYSIS

Reverse osmosis and electro-dialysis involves the use of semi-permeable membranes for the recovery of lead ions from dilute wastewater. In electro-dialysis, selective membranes (alternation of cation and anion membranes) are fitted between the electrodes in electrolytic cells, and under continuous electrical current, the associated ion migrates, allowing the recovery of lead ions.

The selection of treatment depends on effluent characteristics such as concentration of lead, pH, temperature, flow volume, biological oxygen demand, the economics involved and the social factor like the standard set by government agencies. Although these methods are expensive and they are also associated with several limitations such as generation of sludge, low percentage retention of metal ions, energy consumption and low selectivity which makes the process less suitable for small scale industries.

Thus adsorption is proposed as an economical and effective method for the retention of lead ions from aqueous industrial wastes

ADSORPTION

It is a process of mass transfer process which involves the accumulation of substances at the interface of two phases, such as liquid - liquid, gas - liquid, gas - solid, or liquid - solid interface. The substance being adsorbed is the “adsorbate” and the adsorbing material is termed the “adsorbent”. Adsorption is a separation process in which certain components of the fluid phase are transferred to the surface of the solid adsorbents.

Types of Adsorption:

Following are type of adsorption used for removal of lead content

Physical Adsorption:

It is a result of intermolecular forces of attraction between molecules of the adsorbent and adsorbate. When the intermolecular attractive forces between molecules of a solid and the gas are greater than those between molecules of the gas itself is defined as physical adsorption.

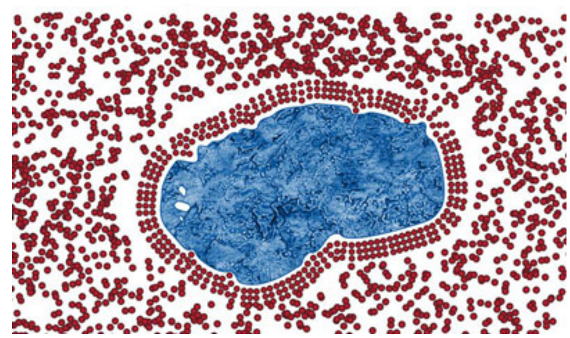

Figure 4. Mechanism of adsorbent unit for wastewater treatment

Chemical Adsorption:

It is a kind of adsorption which involves a chemical reaction between the adsorbent and the adsorbate. The interaction between the substrate and adsorbate surface creates new types of electronic bonds (Covalent, Ionic). Chemical adsorption is also referred as activated adsorption. The adsorbate can form a monolayer. It is utilized in catalytic operations.

Adsorption Dynamics:

It consists of the following consecutive steps

i. Transportation of adsorbate from the bulk structure.
ii. Surface diffusion along the porous surface.
iii. Adsorption of the adsorbate on the internal surface of the pores of the active sites.

Advantages of Adsorption Process:

Low cost: The adsorbent is very economical since they are often made from locally, abundantly and easily available materials.

Metal Selective: The metal sorbing performance of different types of bio-mass can be more or less selective on different metals.

Metal Recycling: If sorbate is a metal ion, it is possible to reuse the metal ion after being desorbed from the adsorbent materials.

Competitive Performance: Performance of adsorption process in terms of efficiency and cost is comparable with the other methods available.

IV. CONCLUSION

The present study showed the various methods for lead removal from industrial wastewater including electrochemical reduction, ion exchange, reverse osmosis, membrane separation, and adsorption. Previously, numerous approaches have been studied for developing cheaper and more effective technologies, both to decrease the amount of produced wastewater and to improve the quality of the treated effluent.

The recent worldwide trend to achieve higher environmental standards favors the usage of low cost systems for treatment of metal content in waste water. According to research various low cost adsorbent derived from agricultural waste or natural products such as rise husk ash, orange peels have been extensively investigated for heavy metal removal from contaminated wastewater. Cost effectiveness and technical applicability are the two important key factors for selecting effective low cost adsorbent for heavy metal removal.

V. FUTURE SCOPE

Using research overview of low cost adsorbent from agricultural waste and industrial waste, an experimental study shall be carried out to check effectiveness of low cost adsorbent.

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