Journal of Advances in Science and Technology
Vol. 18, Issue No. 1, March-2021, ISSN 2230-9659

Water Treatment Methods for Industrial Effluents

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Abstract - The ultimate disposal of wastewater can only be onto the land or into the water. But whenever the watercourses are used for the ultimate disposal, the wastewater is given a treatment to prevent any injury to the aquatic life in the receiving water. Normally, the treatment consists of the removal of suspended and dissolved solids through different units if the treatment plants. The treatment of industrial wastewater may be accomplished in part or as a whole either by the biological processes, as done in the sanitary sewage, or by processes very special for the industrial wastewater only. Depending upon the constituents present in it, the treatment may consist of any one or more treatment (chemical or biological or both) processes. The chemical treatment should be provided only when it becomes unavoidable. The selection of the particular treatment process depends on the effluent requirements and the characteristics of the waste.

Keywords - Groundwater, Wastewater, Toxic Chemicals, Physical Treatment, Chemical Treatment, Biological Treatment.

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INTRODUCTION

In India like other developing countries due to lack of sewage treatment plants generally discharged a considerable amount of wastewater into the nearly lakes, rivers, landmass, etc. polluting the natural resources, soil and groundwater. The treatment of industrial wastewater may be accomplished in part or as a whole either by the biological processes, as done in the sanitary sewage, or by processes very special for the industrial wastewater only. The important factors, which affect the planning for a industrial wastewater treatment plants are (1) the discontinuous and sometimes seasonally discharged wastes, (2) high concentration of the waste and (3) non-biodegradability and toxicity of some wastes. Depending upon the constituents present in it, the treatment may consist of any one or more of the following processes:

(i) Equalization

(ii) Neutralization

(iii) Physical Treatment

(iv) Chemical Treatment

(v) Biological Treatment

When the characteristics of the waste vary in a day and also the discharge rate is not uniform or continuous, the waste may require Equalization before it is subjected to the treatment. When the waste contains excessive amount of acid or alkali (particularly acid), the waste requires neutralization in the neutralization tank. When the industrial waste is treated along with the municipal sewage or discharged into a stream, the waste may be subjected to another prior unit operation, known as Proportioning. Before an industrial waste is subjected to a chemical or biological treatment, or both, it may be required to separate the suspended matter by physical operations like Sedimentation and Floatation. Sedimentation tanks are to be provided only when the waste contains high percentage of settleable solids. Floatation is employed to separate fine particles with very low settling characteristics.

Some of the industrial wastes, amenable to biological treatment, may require prior chemical treatment; some requires only chemical treatment without any biological treatment. Some of the chemical and physico-chemical processes, employed in the industrial wastes treatment, for the removal of dissolved inorganic materials are:

(i) Reverse Osmosis (Hyper Filtration)

(ii) Electro Dialysis

(iii) Chemical Oxidation

(iv) Chemical Precipitation

(v) Adsorption

(vi) Ion Exchange

(vii) Thermal Reduction

(viii) Air Stripping

The chemical treatment should be provided only when it becomes unavoidable. The selection of the particular treatment process depends on the effluent requirements and the characteristics of the waste. The situation of wastewater treatment is not satisfactory even in metropolitan cities. Proper collection and disposal of liquid and solid waste is very important for the overall health of urban cities. It is a pity to note that none of the cities in the country collects and disposes its solid waste in a safe manner. Besides the municipal solid waste, which is organic and inert in composition, the hospital waste, which contains germs of contagious diseases, is not disposed-off properly.

REMEDIES

The fundamental purpose of water treatment is to remove impurities that may be offensive or injurious to health and well being of the individual and community. Water treatment processes used in any specific instance must take into account the quality and nature of the water supply source. The likelihood and degree of contamination in water should also be considered. Blending of contaminated water with the water containing low concentration w.r.t. that constituent is also feasible. Standard treatment methods for removal of chemical and microbiological pollutants are as follows:

pH can be corrected by:

- Addition of acids and alkalis (usually H_2SO_4, HCl, CO_2, $Ca(OH)_2$, Na_2CO_3, KOH and NaOH).
- Neutralizing filter containing calcite ($CaCO_3$) and corosex (MgO) will combat low pH problems, if within the range of 5.6.

The softening of hard water can be achieved by:

- Removal of hardness causing salts of calcium and magnesium
- Conversion of these salts into soluble sodium salts
- Combination of the above mentioned processes
- Use of electrical methods.

The hardness causing substances can be removed from water by the following two ways:

A) **External Treatment:** The external treatment is carried out before the entry of water into boiler. This treatment prevents the boiler problems. It can be achieved by: a) Lime-Soda Process b) Zeolite Process c) Ion-Exchange Process.

B) **Internal Treatment:** The treatment of water inside the boiler is known as internal treatment. It refers to the conditioning of water in boilers itself by addition of chemicals. This is a corrective treatment to remove those salts, which are not removed completely by external treatment of water softening. The colloidal, phosphate, calgon, carbonate, conditioning, etc. are internal treatment methods used.

a. **Softening by Adding Lime (Clark's Method):** The most common method of removing temporary hardness from water is by adding lime to remove hardness. Sufficient amount of lime is added to combine with the free carbon dioxide and then to convert the bicarbonate of calcium into the carbonate and the bicarbonate of magnesium into hydroxide.

Thorough mixing of the lime and water is essential. The lime is added as limewater or more frequently as milk of lime. Adequate lime is necessary for sedimentation to obtain good results. Sometime only setting and decantation is employed, while in other cases, filtration is also performed to remove the last traces of suspended chalk.

b. **Softening by Adding Sodium Carbonate:** Lime treatment does not remove the sulphates, chlorides and calcium and magnesium, i.e. the permanent hardness. In order to remove permanent hardness, soda ash (Na_2CO_3) is added.

Calculated amount of sodium carbonate is added in water. $CaCO_3$ is insoluble in water, whereas $MgCO_3$ is soluble, and thus hardness is not removed completely.

c. **Lime-Soda Process:** The basic principle in this method is to convert all the soluble hardness causing constituents into insoluble precipitates by appropriate chemical treatment and than filter them. If the temporary and permanent hardness are present together, then water can be softened by lime–soda method.

In this process, a suspension of calcium hydroxide (lime) and sodium carbonate (soda) is added to water in calculated quantities based on the concentration of

impurities and their nature and stoichiometry of chemical reactions.

d. **Zeolite Process:** This is the modern process of removing both temporary and permanent hardness of water, zeolite in Greek means "boiling stone". The formula of sodium zeolite is Na_2Z. Zeolite is also known as permutit. Zeolites are of two types:

(i) **Natural Zeolites:** Natural zeolites are nonporous and are derived from green sands by washing, heating and treating with NaOH. The most commonly used natural zeolite is natrolite ($Na_2Al_2O_3.4SiO_2.2H_2O$) and it possesses good durability.

(ii) **Synthetic Zeolite:** The gel structured synthetic zeolites are porous and they can be prepared by heating together solutions of sodium silicate, aluminium sulphate and sodium aluminate. Synthetic zeolites possess higher exchange capacity per unit weight when compared to the natural ones.

$$Ca(HCO_3)_2 + Na_2Z \longrightarrow CaZ + 2NaHCO_3$$
$$Mg(HCO_3)_2 + Na_2Z \longrightarrow MgZ + 2NaHCO_3$$
$$MgCl_2 + Na_2Z \longrightarrow MgZ + 2NaCl$$
$$MgSO_4 + Na_2Z \longrightarrow MgZ + Na_2SO_4$$
$$CaCl_2 + Na_2Z \longrightarrow CaZ + 2NaCl$$
$$CaSO_4 + Na_2Z \longrightarrow CaZ + Na_2SO_4$$

It is seen that sodium zeolite is converted to calcium and magnesium zeolite. In the process, the water becomes free from Ca^{2+} and Mg^{2+}, the main hardness producing cations, but gets more concentrated with respect to sodium salts and the zeolites are said to be exhausted. The regeneration is carried out by washing the bed with a concentrated solution of sodium chloride (brine solution) when the following reactions take place:

$$CaZ + 2NaCl \longrightarrow Na_2Z + CaCl_2$$
$$MgZ + 2NaCl \longrightarrow Na_2Z + MgCl_2$$

Exhausted Zeolite — Regenerated Zeolite

e. **Ion Exchange Process:** i) Cation Exchangers ii) Anion Exchangers.

(I) Dissolved Oxygen can be removed by any of the following methods:

a. By spraying water in a vacuum tower whose sides are heated to produce the effect of high temperature and low temperature and thereby, reducing the amount of dissolved air in water.

b. By adding certain reducing agents to water, thereby, consuming dissolved oxygen. Reducing agents used are usually ferrous sulphate and sodium sulphite.

c. Hydrazine may also be added to water for the deareation. This method suffers from disadvantages of high cost and slow rate of reaction.

d. Another method consists of making iron hydroxide from oxygen available in water and further, this iron hydroxide is filtered water is sprayed through a tower containing iron.

(II) Disinfectant should kill the pathogens quickly at room temperature. It should be inexpensive and non-toxic to humans and should provide protection against only contamination in water during conveyance or storage. Following methods can carry out the disinfections of water.

a. **Chlorination Method:** Chlorine is the most commonly used disinfectant in water treatment chlorine may be added directly as gas or in the form of concentrated solution in water. Correct dosage and sufficient time of contact should be ensured for effective disinfections. Chlorine as gas or as concentrated solution form produces hypochlorous acid (HOCl), which is very powerful germicide.

$$H_2O + Cl_2 \longrightarrow HOCl + HCl$$
$$HOCl + Bacteria \longrightarrow Bacterias\ are\ Killed$$

b. Ozonization Method: The ozone is highly unstable, harmless gas and an excellent disinfectant. It breaks down, liberating nascent oxygen.

$$O_3 \longrightarrow O_2 + [O]$$

(Nascent Oxygen)

The nascent oxygen is very powerful oxidizing agent and kills all bacteria and organic matter present in water.

c. **Bleaching Powder Method:** Chlorine may be added in the form of bleaching powder and nascent oxygen is librated by this reaction.

Liberated nascent oxygen destroys the pathogens by oxidation. The OCl^- ions rupture the cell membranes of the disease-producing microbes.

d. **Boiling Method:** Water becomes free from disease causing bacteria if water is boiled for 10 – 15 minutes.

e. **Chloroamine [$ClNH_2$] Method:** It is an excellent bactericidal. Now days chloramines is used for disinfection of water

because its excess does not produce any irritating odour and is more stable. Moreover, it gives a better taste to treated water.

(III) **Desalination (TDS, TSS and TS):** Water containing high concentration of dissolved salts is called brackish water. Brackish water is unfit for most of the domestic and industrial applications. The process used for the removal of salts is called desalination. Distillation, freezing electro dialysis and reverse osmosis are some of the commonly used techniques for desalination.

a. **Distillation:** This is the oldest method of removing water from saline solution. The brackish water is boiled in huge evaporators and the vapors collected are condensed to get pure water.

b. **Freezing:** Desalination by freezing is based on the separation of pure water in the form of ice leaving the salt in mother liquor when saline water is cooled.

c. **Reverse Osmosis:** The process of desalination can be achieved by reverse osmosis. Osmosis is the process of spontaneous flow of water through a semi-permeable membrane from a dilute to a concentration solution.

In reverse osmosis, the natural process is reversed by placing saline water under hydrostatic pressure (higher osmotic pressure), thus forcing fresh water through the membrane. The membrane is made up of cellulose acetate, methocrylate sulphone or amide polymers. All types of impurities ionic, non-ionic, and colloidal or of high molecular weights are removed in this process.

d. **Electrodialysis:** In this method, the cations and anions of the salts present in brackish water are pulled out by passing direct current through it. The unit consisting of electrodes and the membranes used for compartmentalizing.

When direct electric is passed through the salt solution, the cations and anions move towards the opposite poles through the membrane. The concentration of the salt decreases in the central compartment while it increases in the two side compartments periodically; desalinated water is drawn out from the central compartment while the concentrated brackish water is replaced by fresh samples.

(IV) **Biological Oxygen Demand can be corrected as follows:** Industrial and the domestic wastes is the main culprit to pollute water resources. Organic impurities of sewage are highly putrescible and may deplete dissolved oxygen in water leading to fish mortality, evolution of foul odours and other serious nuisances. The pathogenic organisms in sewage may also cause spread of bowel disease.

The aim of purifying sewage is to reduce the biological oxygen demand (BOD), so that if effluent water runs into pond or river, the indigenous flora and fauna will not die due to lack of oxygen.

A recent development in the biological treatment of sewage is the utilization of natural phenomenon of algal photosynthesis for supplying required oxygen. During photosynthesis, algae utilize CO_2 and water in presence of sunlight and liberate oxygen as follows:

$$6CO_2 + 6H_2O \xrightarrow[\text{Light}]{} C_6H_{12}O_6 + 6O_2$$

The end products constitute free oxygen and carbohydrates required for algal growth. Actually, algae photosynthesis produces surplus O_2, so by algal growth in sewage, this excess. O_2 can be made available for the biological oxidation of sewage without any expense. Sewage contains almost all nutrient elements required for cell. The common algal organisms observed in sewage ponds are green algae, chalamydomonas, scendesnus, chlorella and euglena.

(V) Chloride can be removed by:

a) Filtering the water through a bed of molecular carbon or adding small percentage of activated carbon in water

b) Ion exchange methods

c) Distillation

d) Reverse Osmosis

e) Electrodialysis.

(VIII) Nitrate can be corrected by following methods:

a) Chemical reduction

b) Bacterial de-nitrification

c) Ion-exchange: Some strong base and weak base ion exchange regions are nitrate selective and can reduce nitrate concentration.

(IX) **Fluoride can be removed by:**

a) Precipitation Method: They include the use of lime and alum, aluminium sulphate, polyaluminium chloride, magnesite, semi-calcined dolomite or calcium chloride, polyaluminium hydroxy sulphate (PAHS) etc. Nalgonda technique developed by NEERI (1987) has been used extensively in India at domestic and community level. It involves the

addition of lime and alum followed by rapid mixing, flocculation, sedimentation and filtration.

b) Adsorption and Ion-Exchange Methods: Defluron-2, activated alumina and bone charcoal are most commonly used.

c) Adsorption Methods: They include clay, activated carbon and charcoal as adsorbents.

d) Electro-coagulation, reverse osmosis and electrodialysis.

CONCLUSION

It is concluded that the wastewater and groundwater contain toxic pollutants and have harmful to the health of humans and environment. So, the water treatment plants should be installed in every industry. The Government and Community should do better water management in conserving water. The Govt. should immediately implement strictly the laws for banning industrial pollution. Failure to do so will lead to substantial penalties and fine. Environmental courts should be set up in every district to deal with the cases relating to violations of environmental laws.

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