# MSC S3: ENVIRONMENTAL POLLUTION AND TECHNOLOGY : 16P3EVST09

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Topic – Water pollution

# Advanced Waste Water Treatment

Removal of Dissolved Organic and Inorganic Substances by –

1. Precipitation,
2. Ion Exchange,

## 1. Precipitation

- Chemical precipitation is the most common method for removing dissolved metals from wastewater solution containing toxic metals.

- To convert the dissolved metals into solid particle form, a precipitation reagent is added to the mixture.

- A chemical reaction, triggered by the reagent, causes the dissolved metals to form solid particles

- Filtration can then be used to remove the particles from the mixture. How well the process works is dependent upon the kind of metal present, the concentration of the metal, and the kind of reagent used.
- In hydroxide precipitation, a commonly used chemical precipitation process, calcium or sodium hydroxide is used as the reagent to create solid metal hydroxides.
- However, it can be difficult to create hydroxides from dissolved metal particles in wastewater because many wastewater solutions contain mixed metals.

- Precipitation can be broadly divided into two categories:
- (1) chemical precipitation and
- (2) coprecipitation/adsorption.

- Chemical precipitation is a complex phenomenon resulting from the induction of supersaturation conditions

- Precipitation proceeds through three stages: (1) nucleation, (2) crystal growth, and (3) flocculation

**Coprecipitation/Adsorption**

- When a solid phase is precipitated from solution, impurities that are normally soluble under the conditions of the precipitation may adsorb onto nuclei or crystals and be removed with the parent solid as a single phase.

- This phenomenon is known as coprecipitation. Coprecipitation/adsorption is a co-removal process for removal of contaminants from wastewaters.

- **Also applied for the removal of heavy metals**.
- Chemical precipitation involves transforming a soluble compound into an insoluble form through the addition of chemicals

- Following are the advantages of precipitation/ coprecipitation contaminant removal processes:
- (1) low cost for high volume,
- (2) process is often improved by high ionic strength, (3) it is a reliable process well suited to osmotic control.

- Limitations include the following:

- (I) stoichiometric chemical addition requirements;
- (2) high-water-content sludge must be disposed of;
- (3) part per billion effluent contaminant levels may require two-stage precipitation;
- (4) processing is not readily applied to small, intermittent flows;
- (5) coprecipitation efficiency depends on initial contaminant concentration and surface area of the primary floc.

- Treatment of these wastewaters is usually accomplished through hydroxide precipitation; nearly 75% of the plating facilities employ precipitation treatment (primarily hydroxide treatment) as the treatment technique scheme for removal of heavy metals from solution.
- Chemical precipitation is the most common technique used for treatment of metal-containing wastewaters

## 2. Ion Exchange

- This technique has been used extensively to remove hardness, and iron and manganese salts in drinking water supplies.

- It has also been used selectively to remove specific impurities and to recover valuable trace metals like chromium, nickel, copper, lead and cadmium from industrial waste discharges.

- The process takes advantage of the ability of certain natural and synthetic materials to exchange one of their ions.
- A number of naturally occurring minerals have ion exchange properties.
- Among them the notable ones are aluminium silicate minerals, which are called zeolites.

- Synthetic zeolites have been prepared using solutions of sodium silicate and sodium aluminate.

- Alternatively synthetic ion-exchange resins composed of organic polymer with attached functional groups such as $–SO_3^- H^+$ (strongly acidic cation exchange resins), or - $COO^- H^+$ (weakly acidic cation exchange resins or $-N^+ (CH_3)_3 OH^-$ (strongly basic anion exchange resins) can be used.

- In the water softening process, the hardness producing elements such as calcium and magnesium are replaced by sodium ions.

- A cation exchange resin in sodium form is normally used. The water-softening capability of cation exchange can be seen when sodium ion in the resin is exchanged for calcium ion in solution.

$$2\,Res\,SO_3^-\,Na^+ + Ca^{2+} \rightarrow (Res\,SO_3^-)_2\,Ca^{2+} + 2Na^+ \quad \text{..........................}(2)$$

(where "Res" represents resin phase)

- The product water thus has high sodium content, which is not likely to be troublesome unless the original water is very hard.

- When the exchanger is saturated, it has to be regenerated to allow reuse of expensive resin.

- Regeneration can be achieved by sodium chloride solution which removes Ca2+ and Mg2+ ions from the resin.

- Since for regeneration large amounts of NaCl has to be used, appreciable amounts of sodium chloride can be introduced into sewage by this route.

- This problem can be overcome by using weakly acidic cation exchange resin such $ResCOOH^+$ .

- These cation exchangers having -COOH as functional group are useful for removing alkalinity along with hardness.

- Alkalinity is generally manifested by bicarbonate ion. This ion is sufficiently basic to neutralise the acid of weak cation exchange.

- Another advantage with these resins is that these can be regenerated almost stoichiometrically with dilute strong acid, thus avoiding pollution problem caused by excess NaCl.

- This technique has also been successfully applied to the recovery of chromate from waste water in pigment manufacturing.

- The removal of inorganic solute is essential for complete water recycling.

- The effluent from secondary waste treatment contains 300-400 mg/L more dissolved inorganic material than does municipal water.

- The removal of these bulk inorganics can be efficiently done by reverse osmosis and electrodialysis .