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DESIGN OF WATER TREATMENT PLANT

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ABSTRACT

The course covers fundamentals of the various processes involved such as coagulation,flocculation, sedimentation, filtration and disinfection. It also describes the methodology for the removal of undesirable items such as hardness, iron and manganese, and taste and odour. In addition, it describes the handling and feeding of chemicals and management of wastes produced in the treatment plant.

***Keywords**: Water treatment plant, Process.*

I. INTRODUCTION

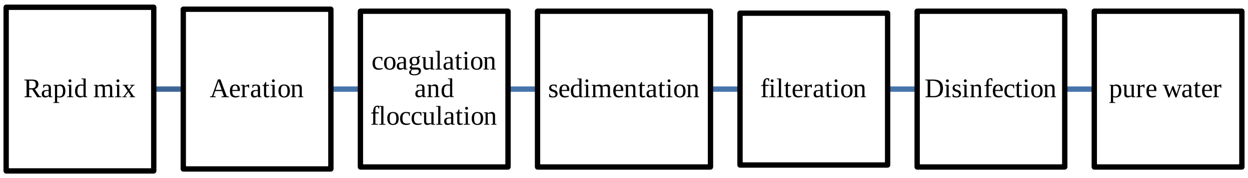
Evidence of man's desire to improve the quality of water is found in the earliest recordings ofknowledge. In 1804, the first known filter to serve an entire city was completed at Paisley, Scotland. In 1832, the first water purification plant for an American city was built for Richmond Virginia. The half century beginning in 1913 has been described as one distinguished for its consolidation and expansion of existing water treatment knowledge. During that span, the number of water treatment plants on public water supplies in the United States increased from several hundred to more than 10,000.

In the design of water treatment plants, the provision of safe water is the prime goal. Water treatment plants have demonstrated the ability to produce safe water under adverse conditions. They must also produce water which is appealing to the consumer. Ideally, appealing water is one that is clear and colourless, pleasant to the taste, and cool. It is non-staining, and is neither corrosive nor scale forming. The consumer is principally interested in the quality of water delivered to the tap in his home or place of business, as opposed to the quality at the treatment plant. Therefore, water utility operations should be such that quality is not impaired as water flows from the treatment plant through the distribution system to the consumer. Another objective of water treatment is to build facilities that are reasonable with respect to capital and operating costs. To accomplish this, various alternatives must be investigated, including performance and cost studies, and an optimum design is evolved based upon sound engineering principles and in full consideration of the abilities of operating and maintenance personnel.

Typical water sources for municipal supplies are deep wells, shallow wells, rivers, natural lakes, and impounding reservoirs. Water treatment processes selected must consider the raw water quality. Deep well source satisfies the municipal water quality factors such as safety, temperature, appearance, taste and odour, and chemical balance. It has relatively uniform quality of water and hence the treatment processes employed are the simplest. Excessive concentrations of iron, manganese, hardness, hydrogen sulphide, chlorides, sulphates, and carbonates exist in well waters. Quantity of the well water depends upon aquifer permeability, well spacing and depth, seasonal changes in river flow, and pumping rates. About 1/4th of the nation's population is served by well water source.

Larger cities are dependent on surface supplies. Water quality in rivers depends on the character of the water shed; pollution caused by municipalities, industries, and agricultural practices; river development such as dams; the season of the year; and climatic conditions. A river water treatment plant must be capable of handling day-to-day variations in quality and the anticipated quality changes likely to occur within its useful life. The quality of water in a lake or reservoir depends on the physical, chemical, and biological characteristics. Size, depth, climate, watershed, and degree of eutrophication, influence the nature of an impoundment. Treatment process used depends on the raw water source and the quality of finished water desired. Many chemicals are employed in the treatment. The specific chemicals selected for treatment are based on their effectiveness to perform the desired reaction and cost. The most important consideration in designing water treatment plant is to provide flexibility.

Natural water polluted either by human activity or by nature, is likely to contain dissolved organic and inorganic substances; biological forms, such as bacteria and plankton; and suspended inorganic material. The principal water treatment unit processes employed to remove these substances are as follows:



II. PROCESS OF PURIFICATION

1. *Rapid Mix*

Rapid mix, or flash mix or quick mix is the process by which a coagulant is rapidly and uniformly dispersed through the mass of the water. The process usually occurs in a small basin immediately preceding or at the head end of the 'coagulation basin'. This process is used to generate a homogeneous mixture of raw water and coagulants which result in the destabilization of the colloidal particles in the raw water to enable coagulation. Mixing is provided by pumps, venture flumes, air jets or rotating impellers (paddles, turbines, or propellers). Where possible, the rapid mix should be a two-compartment unit. Design parameters for rapid mix are as follows:

- Mixing intensity
- Detention time
- Power
- Basin dimensions

2. Coagulation

Coagulation is the widely used process to remove the substances producing turbidityin water. Coagulation is a chemical process in which particle charge is satisfied while flocculation is a physical process which agglomerates particles that are too small for gravity settling so that they may be successfully removed during the sedimentation process. Coarser components such as sand and silt can be removed from water by simple sedimentation. Finer particles such as colloidal matter and finely divided suspended matter cannot be removed from water by plain sedimentation in tanks having ordinary dimensions. So they must be flocculated to produce larger particles that are settling able. The process of coagulation may find use in the softening of hard water with lime or lime and soda ash and removal of colour producing substances such as colloidal metallic hydroxides or organic compounds having a much smaller particle size. Coagulation treatment depends upon many factors such as pH, turbidity, chemical composition of the water, type of coagulant, temperature, and mixing conditions. Of these, pH is the most important factor. Coagulation should be carried out within the optimum pH range for the particular water. For certain waters it may be necessary to adjust the pH with acid, or lime, or soda ash, etc. The selection of type and dosage of the chemical coagulant must be made by experimentation, most commonly with jar tests. Commonly used coagulants include those which are iron or aluminium-based, lime, and polymers. Aluminium sulphate, commonly known as alum, is effective for pH values of 5.5 to 8.0. Sodium aluminate is used in special cases or as an aid for secondary coagulation of highly coloured surface waters and in lime soda softening to improve settling. Ferrous sulphate in conjunction with lime is effective in the clarification of turbid waters and other reactions which have a high pH, such as lime softening. Ferric sulphate reacts with alkalinity and is effective over a wide pH range. It removes colour at a low pH and iron and manganese at a high pH. Ferric chloride also Reacts with alkalinity but has limited use in water treatment.

3. Sedimentation

Sedimentation or clarification is the removal of particulate matter, chemical floc, and precipitates from suspension through gravity settling. The removal of particulate matter is accomplished in settling tanks(also called sedimentation tanks or sedimentation basins, or settling basins or clarifiers). Water clarification is a vitally important step in the treatment of surface waters. Poor design of the sedimentation basin will result in

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reduced treatment efficiency that may subsequently upset other operations. Sedimentation usually finds application in two principal ways in water treatment: plain sedimentation and sedimentation following coagulation and flocculation or softening. Plain sedimentation is used to remove settle able solids that occur naturally in surface waters. These solids settle without any previous treatment. Plain sedimentation is usually used as a preliminary process to reduce heavy sediment loads prior to subsequent treatment processes such as coagulation. This preliminary sedimentation is often also referred to as pre-sedimentation. Sedimentation following chemical coagulation and flocculation is used to remove settleable solids that have been rendered more settleable by chemical treatment, such as the addition of coagulants to remove colour and turbidity and the addition of lime and soda ash to remove hardness. This type of sedimentation follows presedimentation (if used) and aeration and precedes filtration.

4. Filtration

Water filtration is a physical and chemical process for separating suspended and colloidal impurities from water by passage through a porous medium, usually a bed of sand or other granular material. Water fills the pores of the medium, and the impurities are left behind in the openings or upon the medium itself. The filtration removal mechanisms include, in general order of importance, adsorption, flocculation, sedimentation, and straining. For effective filtration, pre-treatment producing floc particles that are small enough to penetrate the bed are necessary.

Type of Filters

- *Slow sand filter*
- *Rapid sand filter*
- *Pressure filter*

5. Disinfection

Disinfection of water involves specialized treatment for the destruction of harmful (pathogenic) and otherwise objectionable organisms. Disinfection has been practiced for destruction of pathogenic organisms, more particularly, bacteria of intestinal origin. The survival time of pathogenic organisms depends upon temperature, pH, oxygen and nutrient supply, dilution, competition with other organisms, resistance to toxic influences, ability to form spores, and others. Water disinfection does not necessarily imply sterilization (complete destruction) of all living organisms. Elemental chlorine is commonly employed in municipal treatment applications. Water disinfection is also practiced by means of storage or by the application of heat, irradiation by ultraviolet rays, applying metal ions such as copper and silver, and oxidants such as halogens, and ozone etc. Chlorine is shipped in liquid form, in pressurized steel cylinders ranging in size from 100 lb to 1 ton. One volume of chlorine liquid yields 450 volumes of chlorine vapour. The moist gas is corrosive and so all piping and dosing equipment must be non-metal or resistant to corrosion.

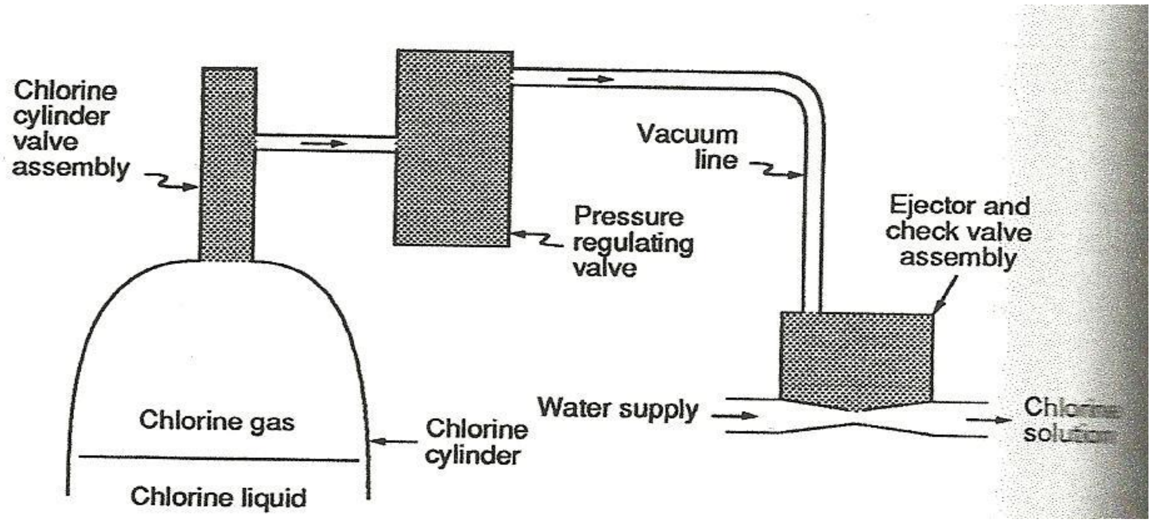

Fig No.01 Chlorination Flow Diagram

III. MANAGEMENT OF WATER TREATMENT PLANT RESIDUES

A residue is a remnant, a substance which remains after another part has been taken away. In watertreatment practice, where suspended and dissolved constituents are separated from water in order toEffect purification, a variety of residues remain after the product water is disposed.

Occurrences of the following type of residues are common in water treatment plants:

- Residues from chemical coagulation – aluminium and ferric hydroxides are the chief constituents of sludge from water treatment plants practicing chemical coagulation. The residue may also contain particulate matter, both organic and inorganic. The sludge is stable since it does not undergo active decomposition or promote anaerobiasis. Most of the matter entrained in coagulation is inorganic in nature and consists of fine sand, silt, and clay.
- Residues from softening – the residue most frequently consists of calcium carbonate, magnesium hydroxide, and unreacted lime. These residues are generally stable, dense, inert, and relatively pure.
- Residues from backwashing of filters – due to filter washing operations, a large volume of wash water containing a low solids concentration is produced. About 30 to 40 percent of the total solids produced in a water treatment plant appear in the backwash water. When activated carbon is applied directly prior to filtration, the filter backwash water will also contain the bulk of the carbon applied. Hydrous oxides of aluminium, iron, manganese, and magnesium; carbonates of calcium and iron; plus silicate material form the largest fraction of the solids. Organic matter may be present in the form of algae, plankton, slime-forming bacteria, and spent activated carbon.
- Residues from Iron and manganese removal – hydrated ferric and manganic oxides are precipitated in the process of removing iron and manganese. Volume of solids produced is very small.
- Spent diatomaceous earth – the amount of solids accumulated is small. The solids produced are primarily pure silica and are easily dewatered. Spent brines from regeneration of Ion-exchange units – the volume of brine residue may range from 3 to 10 percent of the treated water. The residues consist primarily of the regenerate salt, sodium chloride, plus the calcium and magnesium ions displaced from the exchange resin. Approximately 50 percent of the solid residue is sodium chloride and the remainder is entirely calcium and magnesium chloride.

IV. CONCLUSION

On the successful completion of this research, the following outcomes are concluded:

- Water treatment is process that is done on wastewater to remove the contaminates and other impurities.
- Water purification process like Water Treatment Plant are not only good for plant but are key to the future of our organization.

The first and most important purpose of water treatment plant is to clean water which is used for domestic purpose.

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