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Waste water (Sewage) Treatments: Article

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A B S T R A C T

The excess amount of organic load present in sewage may not suitable for the final disposal into the water bodies. The BOD level in sewage is the direct indication of the amount of organic load present in sewage. The reduction of BOD level is a task for the industries as the excess organic load might result with the accelerated Eutrophication in water bodies. Hence the proper treatment is essential for sewage before its final disposal so that DO level can be maintained, which in turn, promotes the aquatic life system in water bodies. The current article discusses the sequence of treatments for waste water (sewage) and act as a guide for the proponent, industrialists and stakeholders of the industries.

Keywords: BOD, Eutrophication, Primary Treatments, Secondary Treatments, Sludge digesters, Tertiary Treatments

1. Introduction

Varying amounts of industrial and laboratory wastewaters can be collected and treated with the sanitary sewage [3]. The primary purpose of the treatment of sewage is to prevent the pollution of the receiving waters [10]. Many techniques have been devised to accomplish this aim for both small and large quantities of sewage. In general, these processes are divided into three stages: preliminary (physical), primary (physical) treatment and secondary (biological) treatment. Figure –1 provides a schematic of a typical wastewater treatment plant. Minimally, wastewater should receive primary (physical removal/settling) and secondary (biological) treatment, which can be followed by disinfection before discharge. More advanced processes (advanced or tertiary treatment) may be required for special wastes [1]. When the effluent from secondary treatment is unacceptable, a third level of treatment, tertiary treatment, can be employed. There are many basic types of sewage treatment plants employing both primary and secondary treatment stages that are in use today for treating large quantities of sewage.

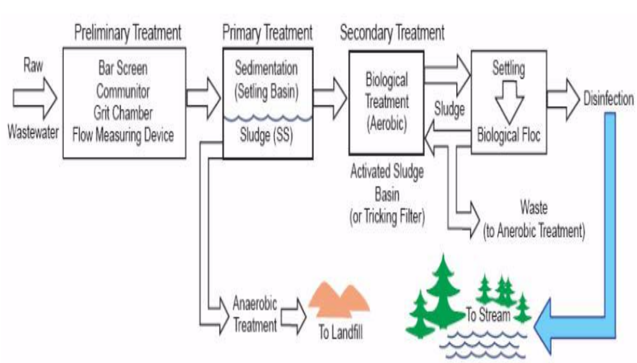

Figure 1: Schematic of a typical wastewater treatment plant

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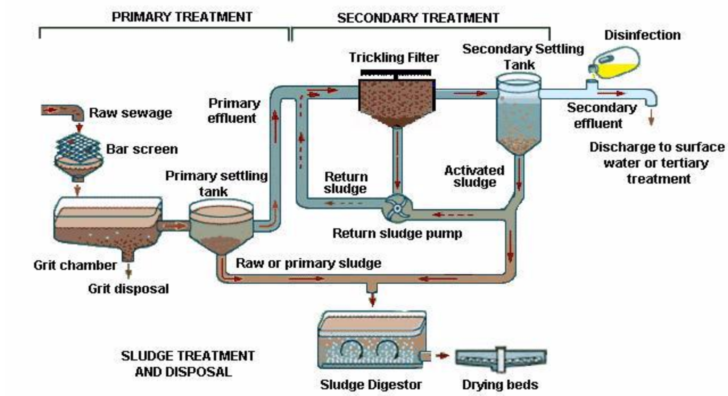

Figure 2: Wastewater treatment based on a trickling filter system

Bar Screens: A grating of steel bars spaced about 2–4 cm on centre is placed at an angle to the flow of sewage through an open channel (*see* figure 2–3). The raw influent first goes through a self-cleaning screen and then into one end of a shallow and rather fast moving basin so that sand and gravel can settle out. Often skimmers rotate around the surface of the basin to remove oils that may have been flushed into the system. The screen removes coarse and floating solids from the sewage. The screen must be cleaned regularly and the removed solids must be burned, ground and digested, or buried. Many systems have a grinder known as a *communator* used either with or instead of a bar screen for grinding large particles which might clog the pumps [2].

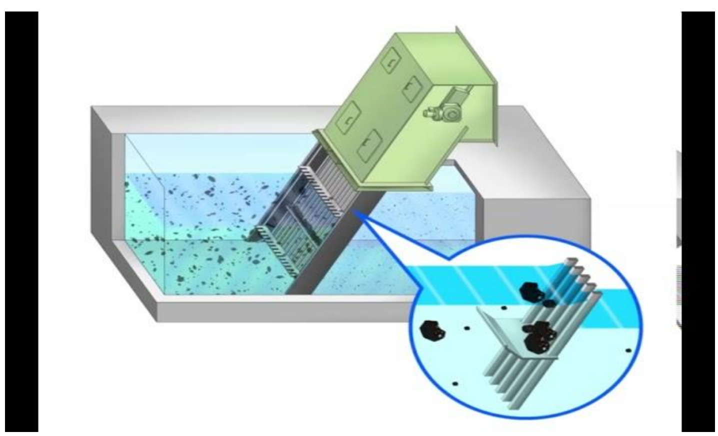

Figure 3: Bar screen

Grit chamber

A chamber in which the velocity of waste flow is reduced to a point where the denser sand and other grit will settle out, but the organic solids will remain in suspension (figure 4). The settled material is buried or used for fill [4].

Figure 4: Grit chamber

Primary settling tanks (or basins)

These are usually large tanks in which solids settle out of water by gravity (refer figure 5 and 6) where the settle-able solids are pumped away (as sludge), while oils float to the top and are skimmed off [5]. It operates by means of the velocity of flow is reduced to about 0.005 m so that the suspended material (organic settleable solids) will settle out. The usual detention time is 11/2–21/2 hours. Longer periods usually result in depletion of dissolved oxygen and subsequent anaerobic conditions. Removal of suspended solids ranges from 50–65 per cent, and a 30–40 per cent reduction of the five-day biochemical oxygen demand (BOD) can be expected [5, 10].

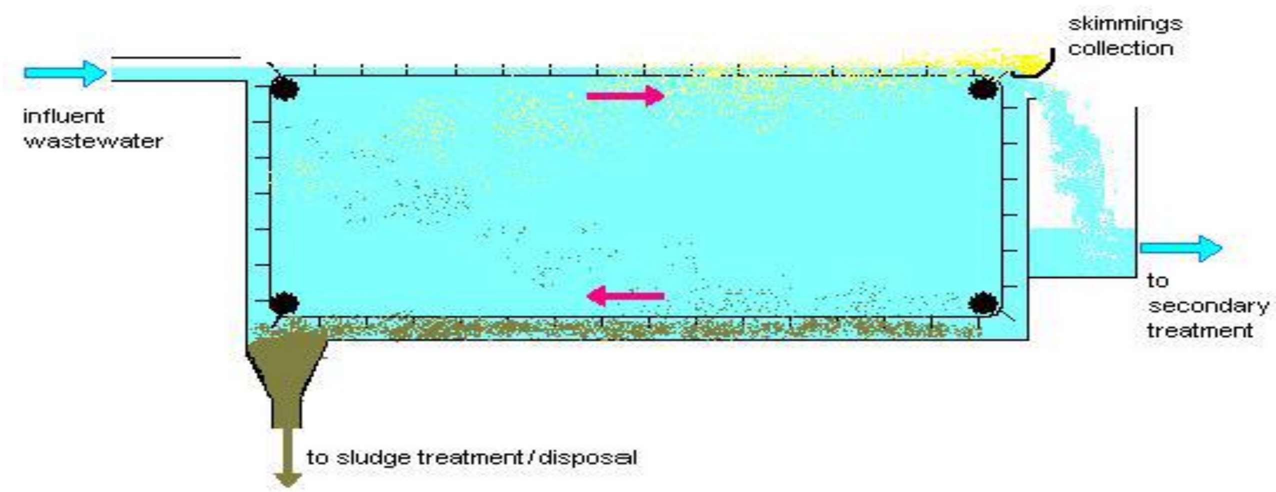

Figure 5: Primary settling tank schematic

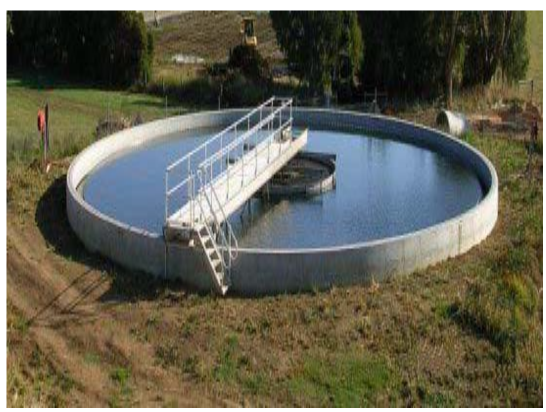

Figure 6: Primary settling tank

Sludge digesters

The sludge which settles in the sedimentation basin is pumped to the sludge digesters (figure 7) where a temperature of 30–35ºC is maintained. This is the optimum temperature for the anaerobic bacteria (bacteria that live in an environment that does not contain oxygen). The usual length of digestion is 20–30 days but can be much longer during winter months. Continual adding of raw sludge is necessary and only well-digested sludge should be withdrawn, leaving some ripe sludge in the digester to acclimatize the incoming raw sludge [6].

Figure 2–7: Sludge digester

Drying beds

Digested sludge is placed on drying beds of sand (figure 2–8) where the liquid may evaporate or drain into the soil. The dried sludge is a porous humus-like cake which can be used as a fertiliser base.

Figure - 8: Drying beds

Trickling filters

The liquid effluent from the primary settling tank is passed to the secondary part of the system where aerobic decomposition completes the stabilization [7]. For this purpose, a trickling filter (figures 9 and 10) is used. A trickling filter is a fixed bed, biological filter that operates under (mostly) aerobic conditions. Pre-settled wastewater is 'trickled' or sprayed over the filter. As the water migrates through the pores of the filter, organics are degraded by the biomass covering the filter material [7]. The Trickling Filter is filled with a high specific surface-area material such as rocks, gravel, shredded PVC bottles, or special pre-formed filter-material. A material with a specific surface area between 30 and 900m2/m3 is desirable. The filter is usually 1–3 m deep but filters packed with lighter plastic filling can be up to 12 m deep. Pre-treatment is essential to prevent clogging and to ensure efficient treatment. The pre-treated wastewater is 'trickled' over the surface of the filter. Organisms that grow in a thin bio-film over the surface of the media oxidize the organic load in the wastewater to carbon dioxide and water while generating new biomass [7].

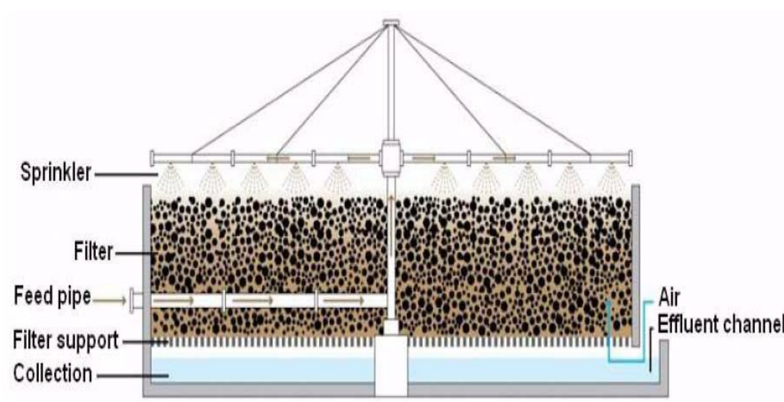

Figure - 9: Trickling filter

The incoming wastewater is sprayed over the filter with the use of a rotating sprinkler. In this way, the filter media goes through cycles of being dosed and exposed to air. However, oxygen is depleted within the biomass and the inner layers may be anoxic or anaerobic. The ideal filter material has a high surface to volume ratio, is light, durable and allows air to circulate. Whenever it is available, crushed rock or gravel is the cheapest option. The particles should be uniform such that 95 per cent of the particles have a diameter between seven and 10 cm. Both ends of the filter are ventilated to allow oxygen to travel the length of the filter. A perforated slab that allows the effluent and excess sludge to be collected supports the bottom of the filter. The bed consists of crushed rock or slag (1–2 m deep) through which the sewage is allowed to percolate. The stones become coated with a zoogloea film (a jelly-like growth of bacteria, fungi, algae, and protozoa), and air circulates by convection currents through the bed. Most of the biological action takes place in the upper 0.5 m of the bed. Depending on the rate of flow and other factors, the slime will slough off the rocks at periodic intervals or continuously, whenever it becomes too thick to be retained on the stones. A secondary settling basin is necessary to clarify the effluent from the trickling filter. The overall reduction of BOD for a complete trickling filter system averages around 80–90 per cent [7].

Secondary settling tank

With the majority of the suspended material removed from the sewage, the liquid portion flows over a weir at the surface of the secondary settling tank (figure 11). Chlorination of the effluent from the secondary settling tank takes place in accordance with state and local laws. Depending on the location most laws require that a free available chlorine (FAC) residual (usually 0.2 mg/L) be maintained after a 30-minute contact period. This contact period is obtained through the use of chlorine contact chambers which are designed to provide a 30-minute detention time. From the chlorine contact chamber the treated sewage is normally discharged into a receiving body of water [1].

Figure - 11: Secondary settling tank

2. **Activated sludge system**

Activated Sludge is a multi-chamber reactor unit that makes use of (mostly) aerobic microorganisms to degrade organics in wastewater and to produce a high-quality effluent. To maintain aerobic conditions and to the keep the active biomass suspended, a constant and well-timed supply of oxygen is required. Activated sludge systems (figures 12 and 13) normally make use of bar screens and/or comminutors, grit chambers, primary settling tanks, secondary settling tanks, and digesters, which are operated in the same manner as those of trickling filter systems [8]. They differ from the trickling filter systems in that they make use of an aeration tank instead of a trickling filter. Different configurations of the Activated Sludge process can be employed to ensure that the wastewater is mixed and aerated (with either air or pure oxygen) in an aeration tank. The microorganisms oxidize the organic carbon in the wastewater to produce new cells, carbon dioxide and water. Although aerobic bacteria are the most common organisms, aerobic, anaerobic, and/or nitrifying bacteria along with higher organisms can be present. The exact composition depends on the reactor design, environment, and wastewater characteristics. During aeration and mixing, the bacteria form small clusters, or flocs. When the aeration stops, the mixture is transferred to a secondary clarifier where the flocs are allowed to settle out and the effluent moves on for further treatment or discharge. The sludge is then recycled back to the aeration tank, where the process is repeated.

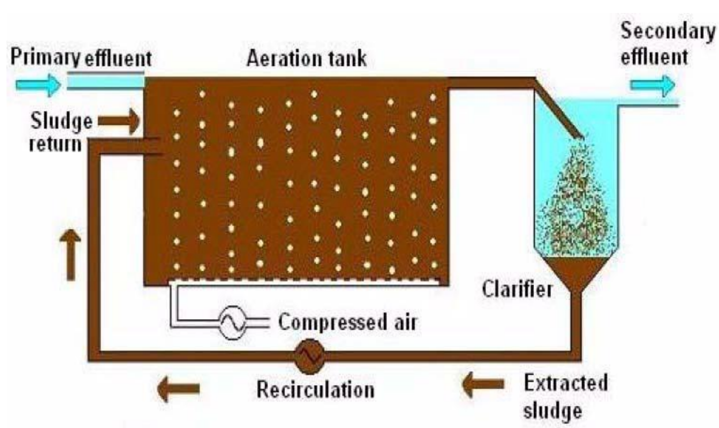

Figure - 12: Activated sludge system example one

Compressed air is continually diffused into the sewage as it flows through the aeration tank. This provides both a source of oxygen for the aerobic bacterial floc that forms in the tank and the turbulence necessary to bring the waste and the bacteria into contact. Aerobic bacteria attack the dissolved and finely divided suspended solids not removed by primary sedimentation. Some of the floc is removed with the sewage that flows out of the aeration tank and carried into the secondary settling tank. Here the floc settles to the bottom of the tank, and is later pumped back into the aeration tank. The liquid portion then flows over a weir at the surface of the settling tank to be chlorinated and released to a receiving stream [8].

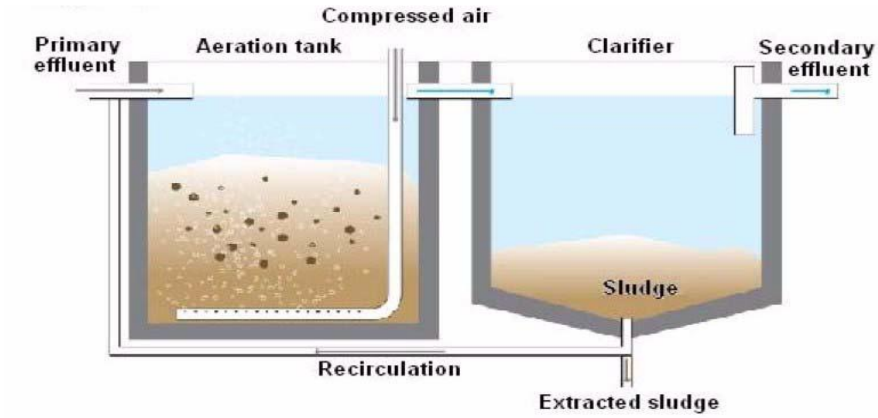

Figure 13: Activated sludge system example two

Rotating biological contactor system

Rotating biological contactor systems (figures 14, 15 and 16) normally make use of bar screens and/or comminutors, grit chambers, primary settling tanks, secondary tanks, and digesters, which are operated in the same manner as those of trickling filter systems [8]. The rotating biological contactor (RBC) is a simple, effective method of providing secondary wastewater treatment. The system consists of biomass media, usually plastic, that is partially immersed in the wastewater. As it slowly rotates, it lifts a film of wastewater into the air. The wastewater trickles down across the media and absorbs oxygen from the air [8]. A living biomass of bacteria, protozoa, and other simple organisms attaches and grows on the biomass media. The organisms then remove both dissolved oxygen and organic material from the trickling film of wastewater. Any excess biomass is sloughed-off as the media is rotated through the wastewater. This prevents clogging of the media surface and maintains a constant microorganism population. The sloughed-off material is removed from the clear water by conventional clarification. The RBC rotates at a speed of one to two rpm and provides a high degree of organic removal [8].

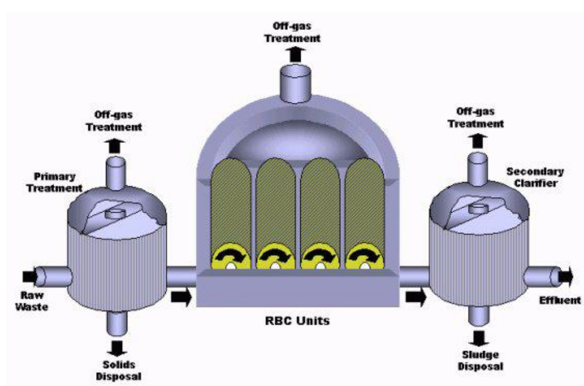

Figure - 14: Rotating biological contactors preceded by pre-treatment and followed by secondary sedimentation

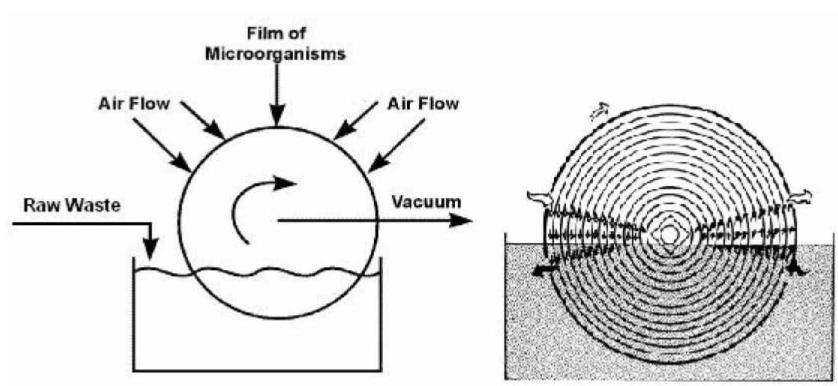

Figure - 15: Rotating biological contactor

Figure -16: Rotating biological contactor

Imhoff tank system

Imhoff tank systems normally make use of bar screens and/or comminutors, grit chambers, primary settling tanks, secondary settling tanks, and digesters, which are operated in the same manner as those of trickling filter systems [8]. An Imhoff tank is a combined sedimentation or settling tank and digestion tank (figure 17). It consists of an upper compartment for settling out solids from slowly flowing sewage and a lower compartment for anaerobic digestion of the sludge. The upper compartment forms a channel with an approximately 20 cm slot in the bottom. Sides of the slot have a 1 horizontal to 1 1/2 vertical slope and are overlapped to prevent gases formed by digesting sludge from escaping into the upper or 'flowing-through' compartment. With an average flow, solids settle in the upper compartment in two to two and a half hours, pass downward through the slot, and settle to the bottom of the lower compartment where they are digested. Accumulated solids are removed periodically through a sludge draw-off pipe having its inlet about 30 cm above the tank bottom. Design of the upper or 'flowing-through' compartment is based on the retention period. The lower or digestion compartment is designed to hold 85 litres per capita below a plane 45 cm beneath the bottom of the slot. If sludge from secondary settling is returned to this compartment for digestion, the capacity of the compartment must be increased to 130 L per capita [8].

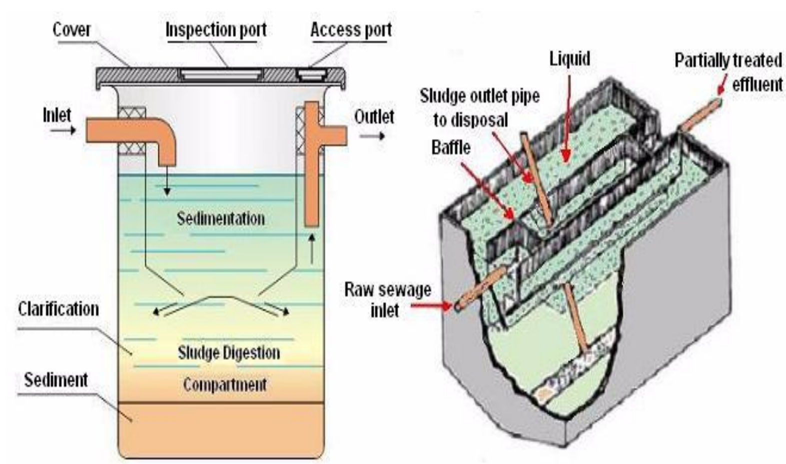

Figure -17: Imhoff tank schematic

Sewage oxidation pond

Sewage oxidation ponds (lagoons) offer economical secondary sewage treatment with relatively low initial cost. These ponds are 0.8–1.2 m in depth, and may be used singly, in parallel, or in a series following primary treatment (figures 18 and 19). Their use is particularly suited to locations with available land and warm climates [8]. Their ability to absorb shock loads and ease of operation and maintenance make them desirable treatment units. Biological life in ponds uses the organic and mineral matter in the sewage for food to produce more stable products. The products often stimulate abundant growth of algae and other vegetation. The lagoons will develop an odour similar to freshwater ponds in wooded areas. Allowable loading can vary from 125–2000 persons per hectare depending upon the location. Where complete treatment is to be provided by ponding, the cells are known as raw sewage lagoons, with depths of 1–1.5 m and reduced loading [8].

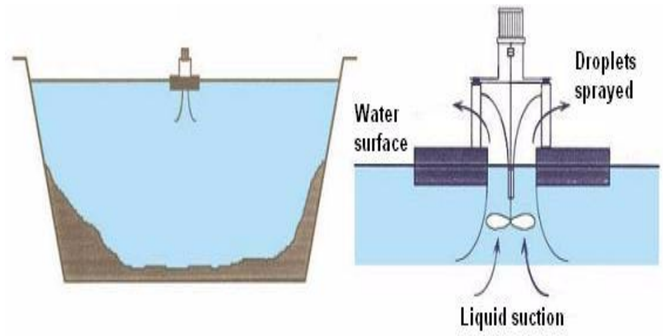

Figure - 18: Sewage oxidation ponds schematic

Figure –19: Sewage oxidation ponds

Tertiary treatment

Increasingly, the effluent from secondary treatment systems is unacceptable because of increased recreational, domestic, and industrial requirements on the receiving body of water and more stringent stream standards [9]. In such cases tertiary treatment can be employed to further reduce the solids and organic content of the effluent. This treatment can employ conventional processes with an increased detention time to allow for greater removals, or the operations installed for tertiary treatment can involve more exotic and expensive equipment such as electrodialysis units or ion exchange columns. In tertiary treatment, emphasis is placed on absorptive processes, such as the use of activated carbon; more efficient oxidation, as with ozone; foam separation of impurities; and demineralization using reverse osmosis or distillation [9].

3. Conclusion

The Sequence of treatments for sewage is fundamental to reduce the concentration of organic load and the BOD level. The Well treated effluent (after the removal of Suspended solids, Nutrients, Dissolved solids, Organic matter and Toxic compounds) can be directly taken to the water bodies so that the accelerated Eutrophication can be controlled. This article helps to understand the techniques which improve the effluent quality, to meet stringent effluent standards for reuse as a ‘Valuable Water Resource’.

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