Energy Saving Opportunity in a Waste Water Treatment Plant

Deepika Sandhu, Ruchi Pandey

Abstract*— About 90 per cent of sewage and 70 per cent of waste water including industrial and domestic domains in developing countries are discharged without treatment, often polluting the usable water supply and also causes massive harm to the marine life as well, for the very fact that the ultimate destination for all the water sources and streams is ultimately the sea. Although the sewage is 99% pure water, still the approximate 1% is harmful to a very large extent. While talking about the economics, a major part is dedicated to the machinery and installation costs, while a considerable portion is also inclined towards the energy costs. In a conventional waste water treatment plant, working on conventional activated sludge process, a portion of energy is spent in operation of the primary clarifiers. If the Extended Aeration process is followed, the energy spent in the operation of primary clarifiers will not be required and thus, without affecting much of the plant operation, for small establishments. A similar waste water treatment plant working on activated sludge process is in operation at an educational institution, namely Educational Institution in Jabalpur. Originally, the plant is working on Activated Sludge Process. Process modification has been suggested in the research work. Also, an aspect of environmental modeling has been highlighted.

***Keywords*—BOD(Biochemical Oxygen Demand),TSS(Total Suspended Solids), Activated Sludge Process, Extended Aeration Process,Process,Modification,Energy.**

I. INTRODUCTION

Given below is the schematic of the waste water treatment plant working at an educational institution. The various components of the plant in operation have been clearly indicated in the diagram. As can be seen in the schematic diagram, the waste water treatment plant has the following units:

1. Bar screen Chamber
2. Primary Clarifier for Skimming off flocs
3. Aeration Chamber
4. Equalization Chamber
5. Sedimentation Tank also called as Settler
6. Tube settler
7. Water Collection Tank
8. Activated Carbon Filter
9. Filter
10. Final Water Collection Tank

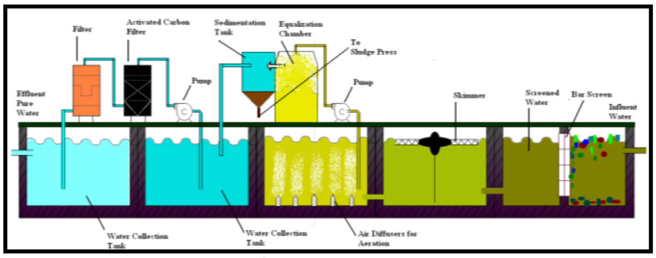

Figure 1: Components of the Waste Water Treatment Plant at site

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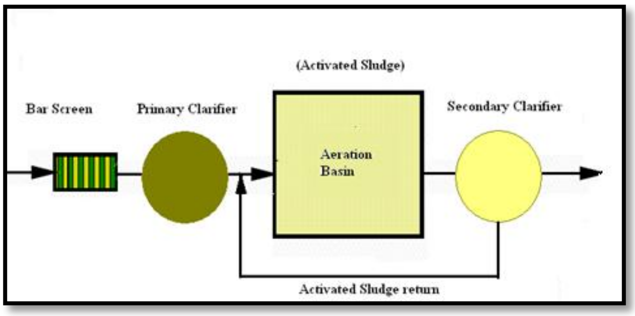
From the above waste water treatment plant, working on the conventional Activated Sludge Process, influent and effluent Biochemical Oxygen Demand (mg/l) and Total Suspended Solids (mg/l) data was determined for twenty two consecutive days.

Process Description of a Conventional Activated Sludge Process



Preliminary treatment

This stage involves removal of easily separable debris and solid material from the waste water, by making use of bar screens and grit removal techniques, such that the higher stages of waste water treatment become more effective. Also called as a rack, a bar screen with rectangular or circular openings consists of parallel bars or rods. Bar screens are fixed in a rectangular channel also called as a screen chamber, wherein at least two bar screens are needed.

Primary treatment

Up to 40% of Biochemical Oxygen Demand reduction can take place, by this process making use of settlement tanks, such that solid material in the waste water can settle down and thus reduce the pollution level of the waste water. This stage physically separates suspended and colloidal material from the waste water. For this stage a sedimentation tank, also known as a primary clarifier is incorporated, and many a time, coagulation and flocculation are also taken into use in order to aid the sedimentation process.

Secondary treatment

This stage is a biological processing stage in which bacteria in presence of aerobic or anaerobic environments converts' organic material into more stable forms, and thus removal of organic matter load from waste water takes place. Also residual suspended material is also eliminated in this stage. As has already been discussed, the secondary treatment can be aerobic or anaerobic, and further can it be suspended growth and attached growth process. The suspended growth process is also called as activated sludge process.

The activated sludge process involves the removal of pollutants namely Nitrogen, Phosphorus and Organic Carbon. This activated sludge process has its own variants. In the Activated Sludge process, microorganisms, which are generally bacteria, are made use of to mineralize and oxidize organic matter.

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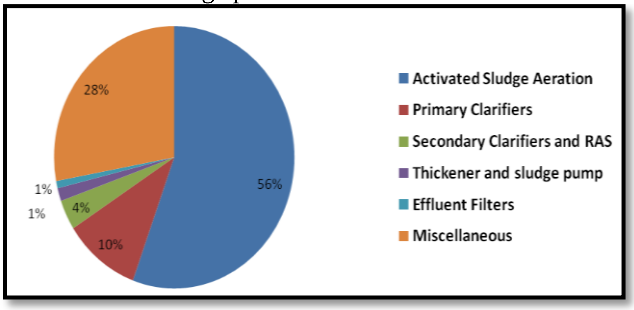
The Activated Sludge process is mainly carried out in an aeration chamber where a mixed liquor of waste water and microorganisms is fed. Here the air is passed at high velocities, so as to form an active mass of microbial floc called as activated sludge.

Process Modification

Basically, the waste water treatment plant installed at Educational Institution in Jabalpur was working on Activated Sludge Process, which was a conventional approach. The conventional Activated Sludge Process includes the various processes which have been elaborated in section 1.5. Given below is an energy usage distribution in a basic activated sludge process.



Source : Waste Water Engineering Treatment and Reuse, Metacalf & Eddy

Figure 30: Energy Usage distribution in a plant working on activated sludge process.

As we can view from the above graph that about 10% of the energy is used in primary clarifiers. Basically, in Extended Aeration process, the Primary Clarifers are eliminated whereas other components of the waste water treatment remain the same.

Thus, the waste water treatment plant at Educational Institution in Jabalpur which was originally made to work on Activated Sludge Process, now is made to work on Extended Aeration Process.

As a result, about 10% of the energy which would otherwise have been spent in operating the skimmer mechanism for the basic plant, is saved.

Biochemical Oxygen Demand Removal Efficiency

Basically, while studying the performance of any system, the most important parameter is the Efficiency. Since a waste water treatment plant is intended to remove the various impurities of waste water, keeping this in mind, in this research work, Biochemical Oxygen Demand also written as BOD Removal Efficiency is considered.

$$\boldsymbol{BOD\ removal\ \eta} = \frac{\boldsymbol{BOD\ removed}}{\boldsymbol{Influent\ BOD}}\ \boldsymbol{x}\ \mathbf{100}\ \% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{Eq.1}$$

Extended Aeration Process

The extended aeration process holds wastewater in an aeration tank for 18 hours or more and the organic wastes are removed under aerobic conditions. Air may be supplied by mechanical or diffused aeration.Mixing is by aeration or mechanical means. This process operates at a high solids retention time, resulting in a condition where nitrification may occur. The microorganisms compete for the remaining food. This highly competitive situation results in a highly treated effluent with low solids production.

The wastewater is screened to remove large suspended or floating solids before entering the aeration chamber, where it is mixed, and oxygen is added. The solids settle out and are returned to the aeration chamber to mix with incoming wastewater. The clarified wastewater flows to a collection channel before being diverted to the disinfection system.This is the process many package plants that schools, housing developments, and small communities use.

Due to the light food to microorganism loading, extended aeration plants are considered one of the most stable wastewater treatment processes. The extended aeration process can accept periodic (intermittent) loadings without upsetting the system. Extended aeration does not produce as much waste sludge as other processes.

Aeration serves two important purposes: supplying the required oxygen to the organisms to grow and providing optimum contact between the dissolved and suspended organic matter and the microorganisms. The aeration system consumes approximately 50 to 65 percent of the net power demand for a typical activated sludge wastewater treatment plant, therefore the efficiency of different aeration systems is an important consideration. The time that the mixed liquor is aerated varies from as little as 30 minutes to as much as 36 hours depending upon the treatment process used. Aeration can be performed mechanically or by using a diffused system. Mechanical aerators physically splash the wastewater into the atmosphere above the tank and create turbulence assuring effective wastewater mixing. Mechanical aerators include brushes, blades or propellers that introduce air from the atmosphere. Surface aerators float at the surface or are mounted on supports in or above the basin. Mechanical aerators tend to incur lower installation and maintenance costs.

A diffused air system introduces compressed air through a perforated membrane into the wastewater. Diffusers are classified by the physical characteristics of the equipment, or by the size of the air bubble. The choice of bubble size, diffuser type, and diffuser placement can have a great effect on the efficiency of the aeration process. Porous (fine bubble) diffusers are attached to the bottom of the tank or positioned just below the surface. They are available in various shapes and sizes, such as discs, tubes, domes, and plates. Fine pore diffusers introduce air in the form of very small bubbles, maximizing the contact time the air bubbles have with the mixed liquor and encouraging mixing while at the same time, discouraging deposits on the tank bottom. These fine pore diffusers produce a high oxygen transfer efficiency, but they are susceptible to chemical or biological fouling and as a result, require routine cleaning. Nonporous (course bubble) diffusers usually have fixed or valved orifices. Due to the larger bubble size, nonporous diffusers produce lower oxygen transfer efficiencies. Other diffusion devices include jet aerators, which discharge a mix of air and liquid through a nozzle, and aspirator aerators that use a propeller on the end of a hollow shaft, creating a vacuum as the propeller draws air from the atmosphere and disperses it into the wastewater.[14]

II. EFFECT OF PROCESS MODIFICATION ON BOD REMOVAL EFFICIENCY

Basically, when the process modification has been done, by eliminating the primary clarifier skimmer mechanism, an advantage has been that approximately 10% of the total energy that is being used up by the waste water treatment plant has been saved. For 22 consecutive days, the Influent and Effluent Biochemical Oxygen Demand was tested for and it was found from the Equation 1, that,

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For Activated Sludge Process the average Biochemical Oxygen Demand Removal efficiency = 95.22%
For Extended Aeration Process the average Biochemical Oxygen Demand Removal efficiency = 94.64%
Which are nearly the same, wherein the Extended Aeration Process consuming about 10% lesser energy than the conventional Activated Sludge Process.

III. CONCLUSIONS

1. About 10% of the energy in a conventional Activated Sludge Process is required to operate the skimmer mechanism of the primary clarifier. The process modification has been done, eliminating the Primary clarifier, thus converting this process into Extended Aeration Process.
2. With the same plant working on Activated Sludge Process, the Biochemical Oxygen Demand removal efficiency is 95.22%, and after process modification, the plant working on Extended Aeration Process shows a Biochemical Oxygen Demand removal efficiency of 94.64%.
3. Even then, the effluent finds its use in the same applications as the effluent with Activated Sludge Process, while saving about 10% of the energy as had been used by the same plant working on Activated Sludge Process.

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