

# Removal of Organic Matter from Wastewater by Activated Sludge Process - Review

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**Abstract**—Wastewater is the by-product of municipal, agricultural and industrial activity. The chemical composition of wastewater reflects the origin from which it came. Removal of organic matter from wastewater is essential so that treated water can meet the acceptable quality standards to avoid the water pollution. Various methods are tried by the researchers include activated sludge process, trickling filtration, oxidation pond and anaerobic processes depending on the organic matter type which includes oxygen demanding organic matter and refractory organic matter. In this review the information available on the removal of organic matter by activated sludge process has been represented. The purpose of this paper to summarize this research work, in order to study the effectiveness of activated sludge process at laboratory scale basis. Activated sludge process is the biological aerobic wastewater treatment that uses micro-organisms and air to biologically oxidize the organic pollutants. This uses naturally occurring bacteria and protozoa thus it is eco-friendly as well as economical process. Activated sludge process was found to be effective method with scope for further research in terms of cost effectiveness, good quality effluent, efficient removal of BOD and COD.

**Index Terms**—Activated sludge process, laboratory scale process, organic matter.

## I. INTRODUCTION

Wastewater contaminates with suspended solids, nutrients, heavy metals, pathogens, priority pollutants include dissolved inorganics, refractory organics and oxygen consuming organic matter [1]. Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the aquatic environment [2]. Nutrients both nitrogen and phosphorus, along with carbon are essential nutrients for growth. When discharged to the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, they can also lead to the pollution of groundwater [3]. Heavy metals are usually added to wastewater from commercial and industrial activities and may have to remove if the wastewater is reused [4]. Communicable diseases can be transmitted by the pathogenic organisms [5]. Priority pollutants includes organic and inorganic compounds selected on the basis of their known or suspected carcinogenicity, mutagenicity, teratogenicity or high acute toxicity. Many of these compounds are found in wastewater.

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Depending on the availability of Dissolved Oxygen (DO), biological treatment methods can be divided into aerobic and anaerobic methods. Activated sludge process is an aerobic biological treatment for domestic wastewater as well as industrial wastewater.

The activated sludge process uses a mass of microorganisms (usually bacteria) to aerobically treat wastewater. Organic contaminants in the wastewater provide the carbon and energy required to encourage microbial growth and reproduction; nitrogen and phosphorus are sometimes added to promote this growth. The organic matter is converted into microbial cell tissue and carbon dioxide by thoroughly mixing the wastewater with air in an aeration tank.

The microbes together with the wastewater termed as a mixed liquor. After specified time interval in the aeration tank, the mixed liquor passes into settling tank, where the sludge settles by gravity from the wastewater. This continuous process produces an effluent which may be treated further or discharge to the receiving stream.

The activated sludge process was discovered in 1913 for treatment of domestic wastewaters but due to effectiveness of process it has been adapted for removing biodegradable organics from industrial wastewater. As a result, several Countries are willing to use activated sludge process for the treatment of both municipal and industrial wastewaters.

## II. ACTIVATED SLUDGE PROCESS

### A. Process Description

When activated sludge process is carry out at laboratory scale basis to avoid the effects of pollutants, the raw wastewater is pretreated to remove settled solids or other suspended matter. A steam or air stripper can remove ammonia, phenol while filter removes heavy particulates.

Pretreated wastewater is pumped into the aeration tank where naturally occurring microbes are mixed with the wastewater by agitation process. To increase the speed of process microbes are introduced by injection method.

A specified time is provide for microorganism growth. The bacteria together with some protozoa and other microbes remove small organic carbon molecules by eating them and converted into microbial cell tissues and carbon dioxide. As a result, bacteria grow and the wastewater is cleansed.

The cleansed wastewater is passed to the settling tank or secondary clarifier where activated sludge (wastewater containing microorganisms) is separated from the mixed liquor. The purpose of return sludge is to maintain a concentration of

activated sludge in the aeration tank sufficient for the process development. The cycle of sludge removal from the settling tank is much more important because it loses its activity due to the death of microorganisms resulting from lack of oxygen of bottom of tank.

After settling of effluent clean water is discharged through the outlet of the settling tank. Then after the final sampling and analysis of treated water, it will be discharged into a receiving stream.

### B. Wastewater Analysis

Wastewater sampling and analysis form an important cause it helps to select the proper treatment process as well as the quality of wastewater. The quality standard usually depends upon whether water will be reused or discharged into a receiving stream. Various parameters considered while treating effluent are Biodegradable Index, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), turbidity, pH, etc.

#### *Biodegradable Index:*

Biodegradable matter is generally organic material such as plant, animal matter and other substances originating from living organisms, artificial materials that are used by microorganisms. The capacity of natural environment to chemically breakdown a substance is known as biodegradability. Biodegradable index is the ratio of BOD<sub>5</sub> to COD. When this ratio is greater than 0.5 then the effluent is easily biodegradable. When this ratio is within the range of 0.4 to 0.5, the effluent is average biodegradable and within the range of 0.2 to 0.4 effluent is slowly biodegradable. While effluent is not biodegradable when this ratio is less than 0.2. Biodegradable Index helps to decide where effluent is treated by biological processes or not [6].

#### *Dissolved Oxygen (DO):*

Aquatic ecosystem totally depends on Dissolved oxygen (DO), various biochemical changes and its effects on metabolic activities of microorganism were very well documented. The concentration of DO in a water sample is significantly influenced by: *Temperature:* As water temperature increases, DO decreases (i.e., as water gets warmer, it holds less oxygen); *Salinity:* As water salinity increases, DO decreases; *Atmospheric Pressure:* As pressure increases, DO also increases [7].

Its presence was essential to maintain variety of forms of biological life in water and effect of the system. According to the BIS standard DO of the effluent should be within range of 4 to 6 mg/lit. DO can be measured by digital DO meter or by Winkler test for dissolved oxygen [8].

#### *Biochemical Oxygen Demand (BOD):*

The typical wastewater treatment plant depends on microorganisms in the wastewater to decompose waste. The Biochemical Oxygen Demand or BOD, is the amount of dissolved oxygen which is used up by these microorganisms and is roughly equivalent to the amount of "food" (organic matter) found in the wastewater. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water [9].

The biological oxidation is a very slow process during oxidation; organic pollutants are oxidized by certain microorganisms into carbon dioxide and water using dissolved oxygen. Hence BOD is based on the principle that if sufficient oxygen is available, and aerobic decomposition (i.e., stabilization of organic matter) by microorganisms will continue until all waste is consumed. BOD level is 100 ppm or more than that then water is considered as very polluted which contains organic waste. The BOD of the wastewater can be measured by BOD test which is also known as "BOD<sub>5</sub>" since it is based on the accurate measure of DO at the beginning and end of a five-day period in which the sample is held in dark, incubated conditions (i.e., 20 °C or 68 °F) [10].

#### *Chemical Oxygen Demand (COD):*

The amount of oxygen needed to consume the organic and inorganic materials is called the Chemical Oxygen Demand (COD). It is a measurement of the amount of material that can be oxidized (combined with oxygen) in the presence of a strong chemical oxidizing agent. The COD test should be considered an independent measure of the organic matter in the wastewater sample rather than a substitute for the BOD test. The advantage of this test is that it is relatively fast and the results are reproducible. The disadvantage is that not all of the measured COD can be degraded biologically. Normal range of COD found in activated sludge effluent is 30 to 70 mg/lit. It can be measured by using sealed and heated (i.e., closed reflux) low range (3 to 150 ppm) or high range (20 to 1500 ppm) pre-prepared vials that change color from orange to green based on the amount of oxidation and that are read using a laboratory colorimeter [11].

The real advantage of the COD test is that it is a measure of the energetics which are useful for a biological reaction. Microorganisms degrade pollutants in biological systems so that they can grow and reproduce. They need two major things: carbon and energy for growth as well as lesser quantities of macro nutrients, nitrogen, phosphorus and sulfur. We can understand the nature and extent of the biochemical reaction occurring by tracking the flow of carbon and the flow of the energy in a system [12].

#### *Turbidity:*

Turbidity is the property of absorption of light or its scattering by suspended material in water. The turbidity of sample is thus measured from the amount of light scattered by the sample taking a reference with standard turbidity suspension. The higher the intensity of scattered light the higher is turbidity. Formazin polymer is used as the primary standard reference suspension [13].

Both absorption and scattering are influenced by size and surface characteristics of the suspended material. Turbidity often indicates the presence of dispersed and suspended solids like clay, organic matter, silt, rock fragments, algae and other microorganisms. Also soaps, detergents and emulsifying agents produce stable colloids that result in turbidity, and discharge of such a contaminated water may increase the turbidity of natural bodies of water [14].

Turbidity can be measured by turbidity meter. Jackson Turbidity Unit (JTU) was based on light absorption being equal

to the turbidity produced by 1 mg SiO<sub>2</sub> in 1 liter of distilled water. Nephelometric Turbidity Unit (NTU) is based on light scattering principle. Turbidity determination is used to evaluate the performance of water treatment plants [15].

#### pH:

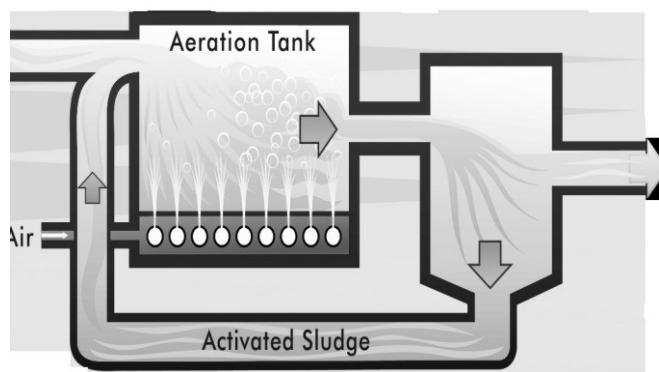
The pH of incoming water or mixed liquor must be steadily controlled for proper microorganisms' growth. A neutral pH is maintain by adding a caustic or acid, usually 25% by weight in solution. Supplemental nutrients in the form of Nitrogen (urea) and Phosphorus (phosphoric acid) are added on an as-needed basis, such as when the raw wastewater is an insufficient source of required nutrients [16].

The pH is one of the important biotic factor that serves as index for pollution. If such water is used for irrigation for a longer period the soil becomes acidic resulting in poor crops growth and yield. When contaminated wastewater is discharged into receiving stream it affects the aquatic life. According to BIS standard the pH of the effluents should be in range 6.5 to 8. It can be measured by digital pH meter or by pH paper [17].

#### C. Experimental Setup

When activated sludge process is carry out at laboratory scale basis the model designing is as per the requirement. The experimental setup involves aeration tank, settling tank or secondary clarifier, compressor for air supply (optional). Material of Construction for aeration tank and settling tank is stainless steel, and dimensions of the model is as per land requirement.

The process flow diagram for laboratory scale Activated Sludge Process is as shown in figure.



Activated sludge process has simple arrangement which requires low land and low installation cost. It gives good quality effluent and capable of removing 80% of biodegradable organics.

### III. CONCLUSION

This study shows that the effluent can be pure within the permissible level after a specific interval of time. The biological and chemical organisms can be reduced up to a large extent. It uses air (or oxygen) and microorganisms for wastewater treatment thus it is ecofriendly process and self-sustaining system. For small scale industry it can be the cost effective process. The effect of different parameters like temperature, pressure can be neglected as microorganisms can adapt

surrounding environment, however it may affect the DO concentration. If sludge disposal can control by advanced technique then this process can be the most convenient biological process.

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