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Laboratory Scale Study for Treatment of Waste Water Using Activated Sludge Process

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ABSTRACT

A study was conducted to evaluate the feasibility of Activated Sludge Process (ASP) for the treatment of synthetic wastewater and to develop a simple design criteria under local conditions[1]. A bench scale model comprising of an aeration tank and final clarifier was used for this purpose. The model was operated continuously for 210 days. Settled synthetic wastewater was used as influent to the aeration tank. Chemical Oxygen Demand (COD) of the influent and effluent were measured to find process efficiency at various mixed liquor volatile suspended solids (MLVSS) and hydraulic detention time (θ)[2,3]. The results of the study demonstrated that an efficiency of above 90% for COD could be obtained if the ASP is operated at an MLVSS concentration of 3000 mg/l keeping an aeration time (θ) of 1 hour.

Key Words: Activated Sludge. Synthetic waste water, COD, Mixed Liquor volatile suspended Solids (MLVSS).

INTRODUCTION

All industries in general and Chemical industries in particular pollute the surrounding environment by discharging solid, liquid and gaseous waste materials which are very harmful to human beings, aquatic life.. In the present study, treatment of waste water will be investigated to reduce the level of pollution. Usually the extent of pollution is measured in terms of the Biological and Chemical Oxygen Demands (COD & BOD) and Suspended Solids. (SS). The treatment is divided into three stages Primary, Secondary and Tertiary. In the primary stage coarse materials are separated by using filtration. During the secondary treatment particularly dissolved organic pollutants are removed by aerobic or anaerobic methods using microorganisms (Biological). The treated effluent should have a BOD value of 60 mg/l and a Suspended Solid content of 30 mg/l. In the third stage the BOD and SS are further reduced to 20 and 10 mg/l respectively by filtering the treated effluent from the secondary stage through sand, charcoal and /or activated carbon[2].

Activated sludge is a process in sewage treatment in which air or oxygen is forced into sewage liquor to develop a biological floc which reduces the organic content of the sewage. In all activated sludge plants, once the sewage has received sufficient treatment, excess mixed liquor is discharged into settling tanks and the supernatant is run off to undergo further treatment before discharge. Part of the settled material, the sludge, is returned to the head of the aeration system to re-seed the new sewage entering the tank. This fraction of the floc is called R.A.S - Return Activated Sludge. The remaining sludge, also called W.A.S - Waste Activated Sludge, is further treated prior to disposal[5].

AIMS

In a sewage treatment plant, Activated Sludge process can be used for one or several of the following purpose:

1. Oxidizing carbonaceous matter: biological matter
2. Oxidizing nitrogenous matter: mainly ammonium and nitrogen in biological materials.
3. Removing phosphate
4. Driving off entrained gases carbon dioxide, ammonia, nitrogen etc.
5. Generating a biological floc that is easy to settle.
6. Generating a liquor low in dissolved or suspended material

OBJECTIVES

We cannot allow wastewater to be disposed of in a manner dangerous to human health and lesser life forms or damaging to the natural environment. Our planet has the remarkable ability to heal itself, but there is a limit to what it can do, and we must make it our goal to always stay within safe bounds. That limit is not always clear to scientists, and we must always take the safe approach to avoid it.

Basic wastewater treatment facilities reduce organic and suspended solids to limit pollution to the environment. Advancement in needs and technology have necessitated the evolving of treatment processes that remove dissolved matter and toxic substances. Currently, the advancement of scientific knowledge and moral awareness has led to a reduction of discharges through pollution prevention and recycling, with the noble goal of zero discharge of pollutants.

Treatment technology includes physical, biological, and chemical methods. Residual substances removed or created by treatment processes must be dealt with and reused or disposed of in a safe way. The purified water is discharged to surface water or ground water. Residuals, called sludges or biosolids, may be reused by carefully controlled composting or land application. Sometimes they are incinerated.

Experimental Setup

The general arrangement of an activated sludge process for removing carbonaceous pollution includes the following items:

1. Aeration tank where air (or oxygen) is injected in the mixed liquor.
2. Settling tank (usually referred to as "final clarifier" or "secondary settling tank") to allow the biological flocs to settle, thus separating the biological sludge from the clear treated water.

This is illustrated in the following Diagram:-

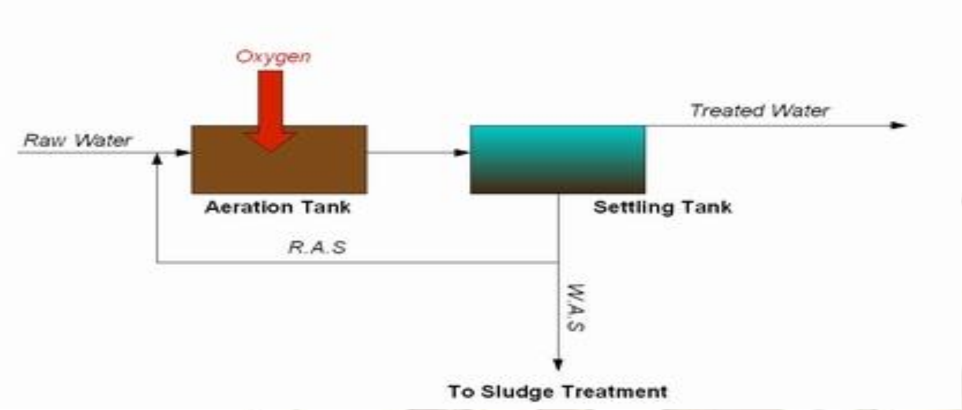

Figure1. Generalized arrangement of an activated sludge process

A laboratory scale bubble column reactor made up of glass having approximately 15 cm diameter and 1 m height with bottom sealed and top open with a provision of an overflow to hold atleast 10 L of waste water was used in this study. It consists of an aeration tank (bucket) of 15 L capacity. One aerator like that of fishpond with very fine bubbles and provision for uninterrupted power supply for aeration was used. The waste water fed as influent to the bubble column reactor was brought from Pentakali Dam, Dist: Buldana, 10Km Chikhli - Mehakar Road.

MATERIAL AND METHODS

Determination of COD and suspended solids were carried out by using $k_2Cr_2O_7$, ferrous ammonium sulphate, H_2SO_4. The COD was calibrated using exactly 1gpl pure glucose solution (add 1gm glucose in distilled water and make up volume 1 liter). Here the data was collected and studied related to COD only.

Composition of Synthetic Wastewater

Following are the composition of Synthetic Wastewater for mg/l solution

Glucose: -	1000
Urea: -	225
Magnesium Sulfate: -	100
Potassium Phosphate: -	1000
Calcium chloride: -	64
Ferric Chloride: -	0.5

1) Chemical Oxygen Demand

Principle:

Most of the organic matters are destroyed when boiled with a mixture of potassium dichromate and sulphuric acid producing carbon dioxide and water. A sample is refluxed with a known amount of potassium dichromate in sulphuric acid medium and the excess of dichromate is titrate against ferrous ammonium sulphate. The amount of dichromate consumed is proportional to the oxygen required to oxidize the oxidizable organic matter.

Procedure

Place 0.4g $HgSO_4$ in a reflux tube. Add 20ml or an aliquot sample diluted to 20 ml with distilled water. Mix well, so that chlorides are converted into poorly ionized mercuric chloride. Add 10ml standard $K_2Cr_2O_7$ solution and then add slowly 30 ml sulphuric acid which already containing silver sulphate. Mix well, if the colour turns green, take a fresh sample with smaller aliquot. Final concentration of concentrated H_2SO_4 should always 18N.

Connect the tubes to condenser and reflux for 2 h at 150^{o}C. Cool and wash down the condensers with 60ml distilled water. Cool and titrate against standard ferrous ammonium sulphate using ferroin as indicator. Near the end point of the titration color changes sharply from green blue to wine red. Reflux blank simultaneously with the sample under identical conditions.

Calculation

$$\text{COD, mg/l} = \frac{(V_1 - V_2) * N * 8000}{V_0}$$

Where,
V_1 = volume of Fe $(NH_4)_2$ $(SO_4)_2$ required for titration against the blank, in ml;
V_2 = volume of Fe $(NH_4)_2(SO_4)_2$ required for titration against the sample, in ml;
N = Normality of Fe $(NH_4)_2(SO_4)_2$;
V_0 = volume of sample taken for testing, in ml.

2) Total Suspended Solids

Principle:-

A well-mixed sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, it may be necessary to increase the diameter of the filter or decrease the sample volume. To obtain an estimate of total suspended solids, calculate the difference between total dissolved solids and total solids.

Calculation:-

$$\text{mg total suspended solids/L} = \frac{(A\text{-}B) \text{ X } 1000}{\text{Sample volume, ml}}$$

Where
A = weight of filter + dried residue, mg, and
B = weight of filter, mg.

3) Sludge Volume Index

The sludge volume index (SVI) is the volume in milliliters occupied by 1 g of a suspension after 30 min settling. SVI typically is used to monitor settling characteristics of activated sludge and other biological suspensions. Although SVI is not supported theoretically, experience has shown it to be useful in routine process control.

Sludge volume index (SVI) is an indication of the sludge settleability in the final clarifier. It is a useful test that indicates changes in the sludge settling characteristics and quality.

By definition, the SVI is the volume of settled sludge in milliliters occupied by 1 gram of dry sludge solids after 30 minutes of settling in a 1000 ml graduated cylinder or a settleometer.

A liter of mix liquor sample is collected at or near the outlet of the aeration tank, settled for 30 minutes in a 1 liter graduated cylinder, and the volume occupied by the sludge is reported in milliliters.

The SVI is computed by dividing the result of the settling test in ml/liter by the MLSS concentration in mg/L in the aeration tank times 1000.

Calculations:-

$$\text{SVI} = \frac{\text{Settled sludge volume (ml/l) X 1000}}{\text{Suspended solids (mg/l)}}$$

Experimental Results

Table1. The reduction of COD of the 1 gpl solution as a function of time under batch condition.

Sr. No	Dilution Factor	Time (hour)	COD (mg/l)	MLVSS(mg/l)
1	4	0	1200	458
2	3	2	751	680
3	3	4	470	897
4	3	6	258	1060
5	3	8	94	1170

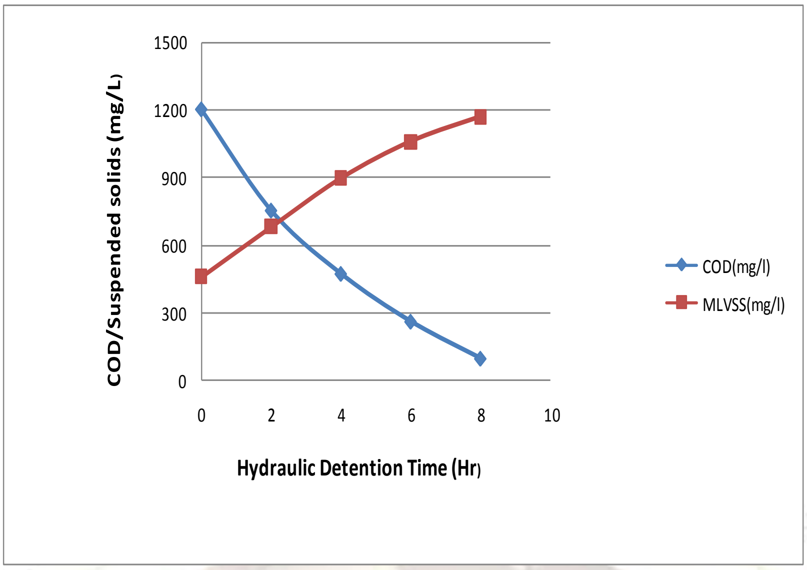

Figure2. Relationship among Hydraulic Detention Time (hrs) and COD/Suspended solids (mg/l).

Table 2. COD determination of 1 gpl solution of SWW at different concentrations of MLVSS.

Sr. No	Time (min)	MLVSS (mg/l)	Influent COD(mg/l)	Effluent COD (mg/l)	COD Removal Efficiency (%)	SVI(ml/g)
1	60 45 30 15	1200 1200 1200 1200	1200	465 610 725 840	61.25 49.16 39.58 30	70 67 61 57
2	60 45 30 15	1500 1500 1500 1500	1200	340 490 620 670	71.66 59.16 48.33 44.16	67 50 48.32 44
3	60 45 30 15	2100 2100 2100 2100	1200	136.84 186 235 385	88.59 84.5 80.41 67.91	45 43.2 41.9 34.54
4	60 45 30 15	2500 2500 2500 2500	1200	112.30 163 226 367	90.64 86.41 82.5 70.8	48.9 44 32.3 28.47
5	60 45 30 15	3000 3000 3000 3000	1200	71 110 210 350	94 90.8 82.5 70.8	40 31.8 29.97 28.1

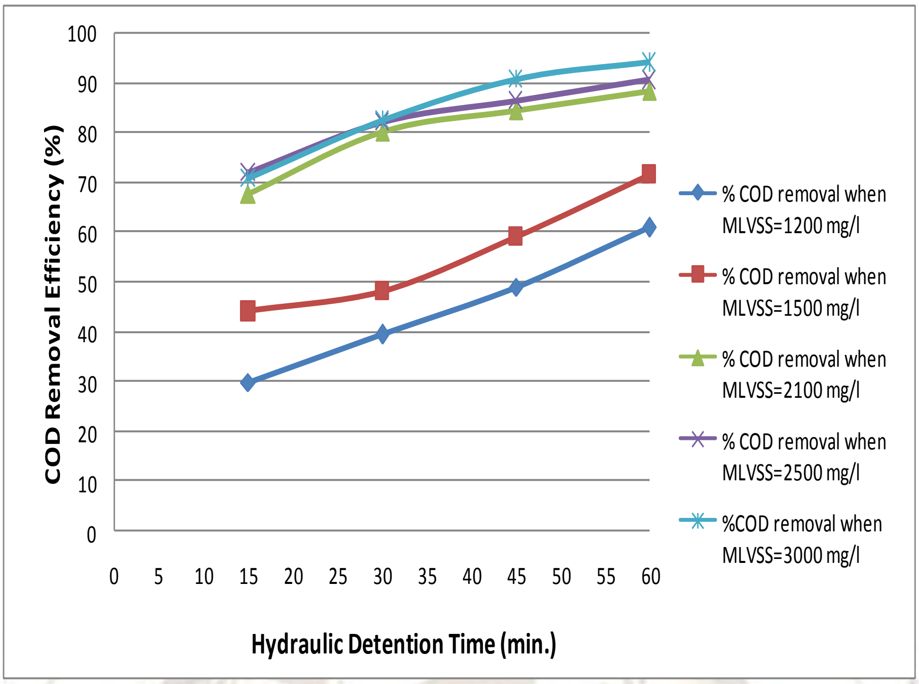

Figure3. COD removal efficiency Vs Time at various concentrations of MLVSS.

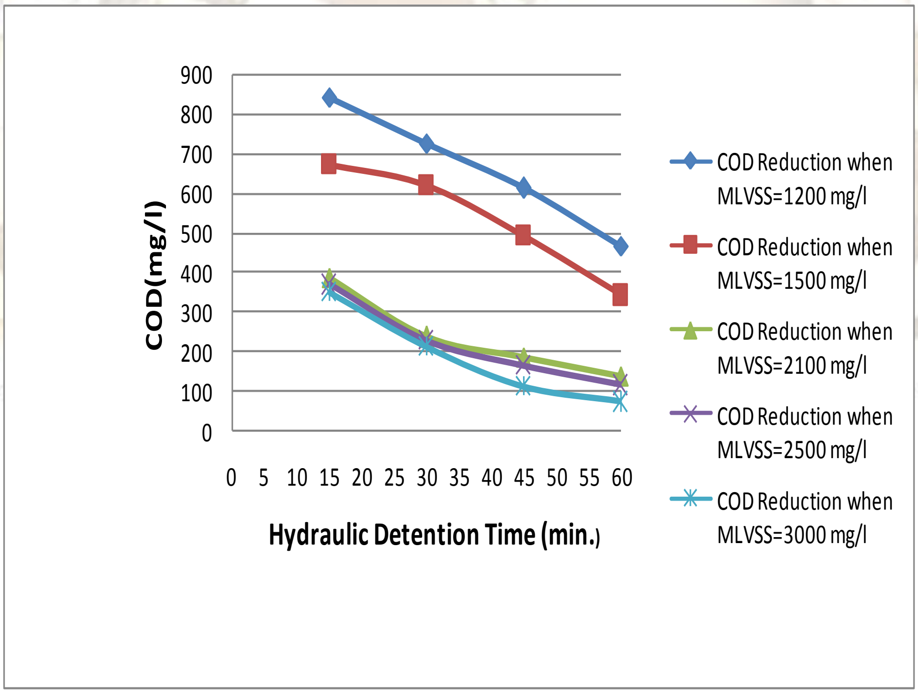

Figure4. COD reduction Vs Time at various concentrations of MLVSS.

RESULTS AND DISCUSSION:

The treatment efficiency of reactor in terms of COD removals was studied for concentrations of 1200,1500,2100,2500,3000 mg/L at θ of 60, 45, 30 and 15 minutes. It was noted that the process efficiency improved with increase in MLVSS concentration and θ.The removal efficiencies at different MLVSS and time are given in table 2. Thus the results indicate that for optimal operation, Activated sludge process should be operated at MLVSS concentration of 3000 mg/L and time value of 60 minutes.

The data in Table 2 are graphically represented in Figures 3 and 4, which reveal that a maximum COD removal efficiency of 94% was achieved at MLVSS concentration of 3000mg/l and θ of 60 minutes (1 hour).

The result shown in table 2 indicates that the amount of COD reduction was variable throughout the experiment. The minimum reduction was about 30% when concentration of MLVSS was 1200 mg/l and the maximum above 90 % when concentration of MLVSS was 3000 mg/l. The overall efficiency of the removals is indicated by % reduction of COD in figure3.

DISCUSSION

The activated sludge methods of waste water treatment are the most economical and widely used for removing organic components from waste water. The pollution load was estimated by Chemical Oxygen Demand (COD). A result obtained in this study has indicated that the percentage reduction of COD reached upto 94% in effluent, reduction from 1200 mg/l to 3000mg/l.

CONCLUSION

A study was conducted to evaluate the feasibility of Activated Sludge Process (ASP) for the treatment of synthetic wastewater and to develop a simple design criteria under local conditions. A bench scale model comprising of an aeration tank and final clarifier was used for this purpose. The model was operated continuously for 210 days. Settled Synthetic Wastewater was used as influent to the aeration tank. Chemical Oxygen Demand (COD) of the influent and effluent was measured to find process efficiency at various mixed liquor volatile suspended solids (MLVSS) and hydraulic detention time (θ). The results of this study demonstrated that an efficiency of above 90% COD was obtained by operating A.S.P. at an MLVSS concentration of 3000 mg/l keeping an aeration time of 1 hour. The study can be used for the treatment of different types of industrial waste water and the COD reduction, which will meet to the standard discharge value of COD, set by Maharashtra Pollution Control Board (MPCB).

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