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Effect of Dissolved Oxygen on Microbial Population and Settling of Dairy Activated Sludge

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ABSTRACT
The study was carried out to identify and study the settling characteristics of the dairy activated sludge. The causes and the control measure for the sludge bulking were studied. The activated sludge was generated by running a batch reactor of capacity of 10 liters for a θ_C of 10 days. It was operated until steady state conditions were reached. pH, DO, MLSS and COD were taken as the parameters. The settling studies were carried out for different MLSS concentrations ranging from 2g/L to 20g/L. The addition of Chlorine was selected as the control measure and was added for various doses such as 1 ml, 2 ml and 3 ml of Bleaching powder solution (1 ml of Bleaching powder solution contains 0.515 mg of Chlorine). Settling curves between interface height and time were observed before and after the addition of the Chlorine. From the settling curve the limiting solids flux were obtained. After the addition of Chlorine, there was a considerable increase in the settling velocity that improves the settling nature of the sludge. Area of Secondary settling tank was calculated from the modified solids flux method.

KEYWORDS: Effect, Dissolved Oxygen, Microbial Population, Settling Of Dairy Activated Sludge

I INTRODUCTION

1.1 General

Water pollution by industrial waste water is a serious problem in the world. Industrializations and pollution have been almost synonymous today. In many areas of the world, both developed and developing countries, the environmental issue is the same and it centre around the waste treatment alternatives to be selected which will provide environmental protection without greatly impeding economic growth. Developing countries like India cannot avoid rapid industrialization. It is also very essential to take effective steps to reduce pollution and finally to adopt measure to keep the environment clean for the benefit and well being of making.

Wastewater from different industries possess different characteristics and discharging of the effluents without proper treatment into streams, rivers or an land will lead to serious consequences. There are number of industries in India such as Dairies, Sugar, Distilleries, Tanneries, Textile, Slaughter house, Food and fruit Canning Industries etc., which discharges the waste water biodegradable in nature into public sewers, rivers or into sea and on land with little or no treatment and this causes the environmental pollution. With the growing consciousness of protein in diet, organized efforts to enhance the production of milk and related commodities have given rise to large scale production, collection, processing and distribution of milk through a number of dairies in the country. Diary effluents are readily putrescible and cause considerable nuisance and pollution when discharged in the inland water bodies without adequate treatment. The Diary waste is of biodegradable nature and can be treated with the conventional treatment.

1.2 Dairy Wastewater

With increase in demand for milk and milk products, many dairies of different sizes have come up in different places. These dairies collect the milk from the producers and then either simply bottle it for marketing or produce different milk products according to their capacities. Large quantities of wastewater originate due to various operations during production of milk and milk products. The organic matter in the waste comes either in the form in which they were present in the milk or in a degraded form due to processing. As such, the dairy wastes though biodegradable are strong in nature.

1.2.1 Sources of Wastewater in Dairy

Various processes in dairy lead to waste of various nature and composition. Wash water containing milk drippings, spillages, rinses and washing of cans and equipments, floor washing at receiving station, pasteurization plant and bottle washing are the main sources of dairy waste. Butter and ghee manufacturing waste water consists of washing of churns and small quantities of butter, washes from cleaning and rinsing of vats and discarded whey from cheese processing plant. Whey mineral acids are mainly present in cheese plant waste.

Dairy waste is alkaline in nature when fresh, due to the presence of organic substances in degraded form. Streams receiving dairy waste turn acidic due to decomposition of alkaline fresh waste. This is due to change of lactose to lactic acid under anaerobic condition.

Objectives of the Study

The Secondary Settling tank (SST) has got a critical link with the aeration basin in the ASP. The design of the SST should be made properly considering all the important parameters like θ_c, C_0, C_u and r. Hence an attempt is made.

The objectives of the study are

1. To generate dairy activated sludge by running a batch reactor.
2. To conduct the settling tests on steady state Activated sludge.
3. To determine the settling velocity of sludge for different MLSS concentrations ranging from 2 g/l to 20 g/l respectively with and without the addition of Chlorine.
4. To draw the Solids Flux curve with and without the addition of Chlorine and to determine the Surface area of the Secondary Settling tank.

II MATERIALS AND METHODS

2.1 WASTE SAMPLE AND ACTIVATED SLUDGE

The dairy wastewater and the activated sludge for seeding purpose has been collected from District Cooperative Milk Producers Association, Podikundu, Kannur. The wastewater has been collected from the collection tank where waste from all the places like receiving station, pasteurization plant, bottle washing plant and cheese processing plant are collected. The sludge is taken from the recycle line, which carries the sludge from secondary clarifier to the aeration tank.

EXPERIMENTAL SETUP BATCH REACTOR

A bench scale reactor of 10 liters capacity was used for this study. The reactor was provided with two air diffuser stones at the bottom and connected to air compressor to enable the supply of air to the reactor. A schematic diagram of the reactor is shown in Figure.2.1.& 2.3

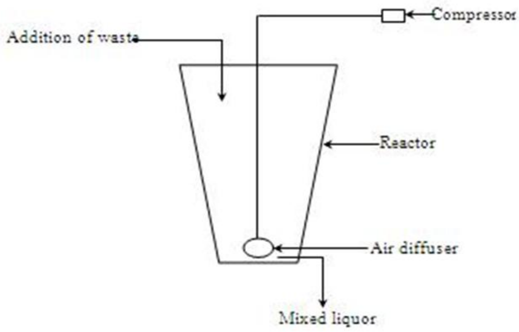

Figure.2.1 Batch reactor

SETTLING COLUMN

A laboratory bench scale model of settling column was used to carry out the batch settling tests. The internal diameter (ID) of the column was 22.5 mm and height was 650mm. The settling column made of glass facilitated the observation of solid liquid interface with respect to time. (Figure..2.2 & 2.4)

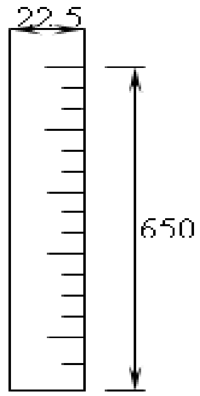

Figure..2.2 Settling column

2.2 EXPERIMENTAL METHOD
WASTEWATER HARACTERIZATION

The characteristics of raw dairy wastewater were analyzed as per the procedure given in standard methods for the examination of water and wastewater in order to obtain the information regarding the general characteristics of the wastewater. The following tests were performed: pH, Chlorides, Sulphates, BOD, COD, Total solids and Suspended solids.

Figure. 2.3 Experimental Batch Reactor Setup

Figure.2. 4 Experimental Settling Column Setup

ACTIVATED SLUDGE PREPARATION

Dairy wastewater was aerated continuously in a batch reactor of capacity 10 liters. The wastewater was added twice a day to the reactor based on F/M ratio of 0.3. The required mean cell residence time was maintained by controlling the wasting of mixed liquor from the reactor ($\theta_c = V/Q_w$). The steady state parameters maintained were mixed liquor suspended solids (MLSS), pH, and COD. The DO was maintained in the range of 2 mg/L throughout the experiment. The reactor was operated until steady state was reached for the mean cell residence time of 10 days.

SETTLING STUDIES

After attaining steady state condition, settling studies were conducted before and after the addition of Chlorine keeping the initial MLSS concentrations ranging from 2 g/L to 20 g/L or mean cell residence time of 10 days. The required MLSS concentrations were prepared by either concentrating or diluting the available mixed liquor. After filling the column with prepared activated sludge of the required initial MLSS concentration, the contents were agitated by stirring, to maintain uniform concentration throughout the depth of the column. The interface height was then recorded as a function of time. A time interval of 2 minutes was kept initially to note the interface height with respect to time. As the fall of interface was rapid initially, the 2 minutes interval was taken up for the first 20 minutes after which it was taken as 5 minutes upto 60 minutes upto 90 minutes.

The settling studies were carried out on dairy wastewater activated sludge before and after the addition of Chlorine using a settling column (22.5mm ID x 650mm Ht.). From the data obtained, a plot between interface height and settling time was prepared. From the plot, the zone settling velocities were calculated as the slope of linear portion of batch settling curve. Settling velocities for various concentrations were found.

III BULKING CONTROL MEASURE CHLORINATION

Chlorination is the most economical, non-specific method to control the excessive growth of filamentous microorganisms causing bulking in Activated sludge plants. The idea of adding chlorine is to expose the sufficient chlorine to damage filaments extending from the floc surface. To the steady state activated sludge, Chlorine (in the form of bleaching powder) is added to different MLSS concentrations from 2 g/L to 20 g/L with different dosages i.e. 1 ml, 2 ml and 3 ml of Bleaching powder solution prepared using distilled water. Note: 1ml of Bleaching powder solution contains 0.515 mg of Chlorine.

PREPARATION OF STOCK SOLUTION

The stock solution by using the Chlorine was prepared by adding 5gm of Bleaching powder in 1000ml of distilled water. The concentration of Chlorine is 0.515 mg / 1ml in the prepared stock solution. Hence for the addition of 0.515 mg, 1.03 mg and 1.545 mg concentrations of Chlorine in the sludge were 1 ml, 2 ml and 3 ml of the stock solution.

SETTLING AREA

Using the solids flux curve modified by Yoshioko, etal, the surface area of the Secondary settling tank was determined with and without the addition of Chlorine using the equation given below.

$A = (1+r)\, Q\, C_0 / SF_L$

Where

A = Area of Settling, m2

SF_L = Limiting Solids flux, $Kg/m^2.hr$

Q = Flow rate, m^3/hr

Q_r = Recycling flow rate, m^3/hr

r = Recycling ratio, Q_r/Q

C_0 = Influent Solids concentration, g/L.

IV RESULTS AND DISCUSSION GENERAL

An experimental study on dairy wastewater activated sludge was carried out to find the nature of settling with or without chlorine added for controlling the filamentous organisms.

4.1 INFLUENT CHARACTERISTICS

The influent characteristics of the waste water analyzed as per the procedure given on standard methods for the examination of water and wastewater are shown in table 4.1.

Table 4.1 - Characteristics of raw dairy waste water

	Parameters	*Value**
1.	pH	6-7
2.	Chlorides	667
3.	Sulphates	1000
4.	BOD	860
5.	COD	1328
6.	Total dissolved	1825
7.	Total Suspended	490

* ***Except pH all values are in mg/L.***

4.2 SETTLING TESTS

Settling tests were performed for the initial MLSS concentrations of 2g/L to 20 g/L respectively. The sludge was prepared for a θ_c of 10 days by running an ASP bench scale laboratory model. Various concentrations of suspended solids were obtained by concentrating or diluting the available sludge. The prepared sludge was loaded in the settling column and observations were made for the settling. The data pertaining to the fall of interface between sludge blanket and clarified liquid with respect to time for different MLSS concentrations with and without adding Chlorine are presented .

Table 4.2 - Values of settling velocities for different initial MLSS concentrations before and after adding Chlorine:

MLSS Concentrations (g/L)	**Settling Velocity (m/hr)**			
	Without adding Chlorine	**With Chlorine (0.515 mg)**	**With Chlorine (1.03 mg)**	**With Chlorine (1.545 mg)**
2	8.127	8.49	9.08	9.84
3	6.338	6.8	7.8	8.26
4	4.681	5.24	5.9	6.65
5	3.708	3.80	4.6	5.4
6	2.642	2.1	3.25	4.2
7	1.616	1.4	2.265	3.18
8	1.229	1.068	1.624	2.4
10	0.733	0.818	1.18	1.85
12	0.5	0.67	0.91	1.182
14	0.342	0.56	0.75	0.936
16	0.223	0.46	0.58	0.816
18	0.165	0.401	0.51	0.708
20	0.142	0.36	0.45	0.634

Interface heights with respect to time was made for different MLSS concentrations with and without adding Chlorine and are given in Figure 4.1,4.2,4.3 & 4.4. From the graphs, it was observed that the interface started falling with a constant velocity up to a particular time. After this, when the sludge entered in to the compression zone through transition zone, the velocity of descend appreciably decreased. The settling velocities for different initial MLSS concentrations and for different dosages of Chlorine addition were calculated as the slope of linear straight-line portion of the corresponding interface curve. The values were given in (Table 4.2).The Solids flux curve for different MLSS concentrations with and without adding Chlorine was calculated. Graph between Solids flux and initial MLSS concentration was made and presented in Figure.4.5,4.6,4.7 & 4.8. From this plot it was observed that the settling velocity was decreasing with increase in MLSS concentrations with and without adding Chlorine, because at higher MLSS concentrations the opportunity for the particles to come closer is high and therefore the inter particle forces are high enough to decrease the rate of settling of mass.

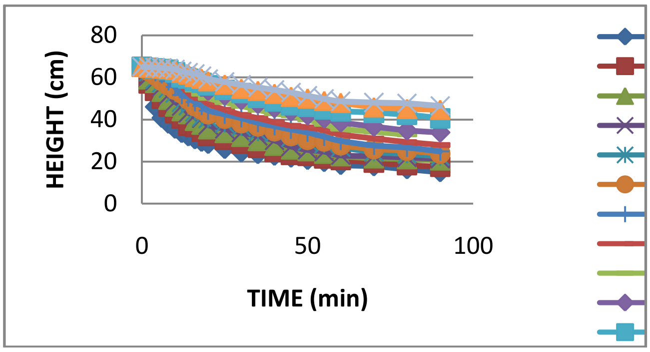

Figure.4.1 Interface height Vs Time (Without Addition of Chlorine)

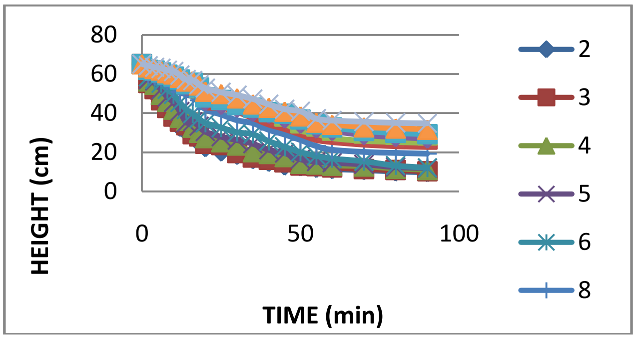

Figure 4.2- Interface Height Vs Time {Addition of Chlorine (0.515mg)}

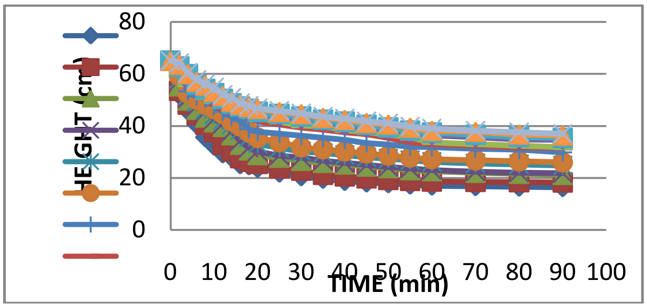

Figure 4.3 - Interface Height Vs Time {Addition of Chlorine (1.03mg)}

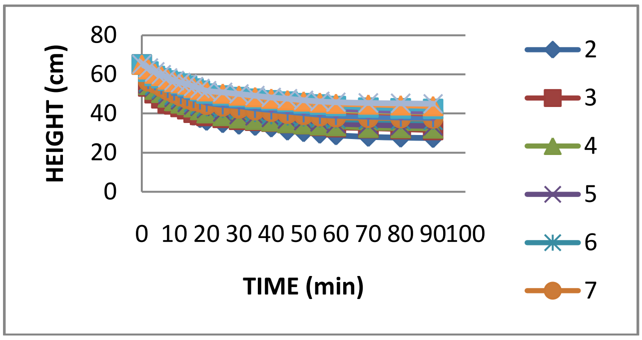

Figure 4.4 - Interface Height Vs Time {Addition of Chlorine (1.545mg)}

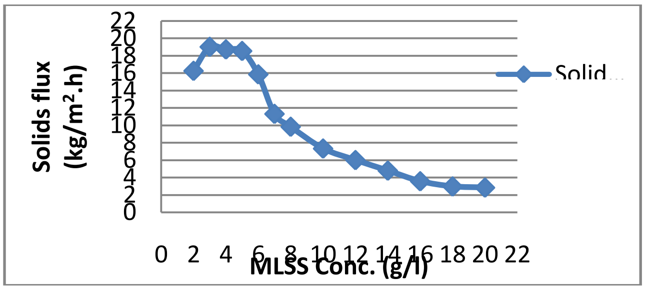

Figure 4.5 - Solids flux Vs MLSS concentrations (Without Adding Chlorine)

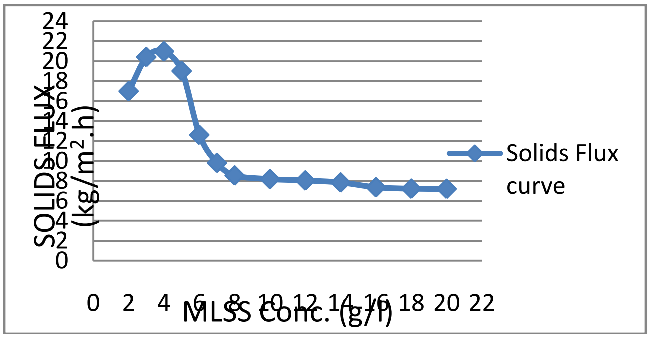

Figure 4.6 - Solids flux Vs MLSS concentrations {Adding Chlorine (0.515mg)}

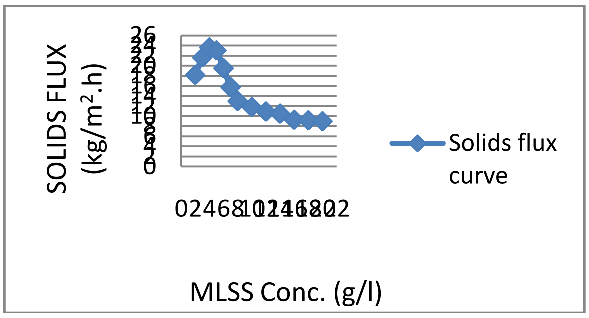

Figure 4.7 - Solids flux Vs MLSS concentrations {Adding Chlorine (1.03mg)}

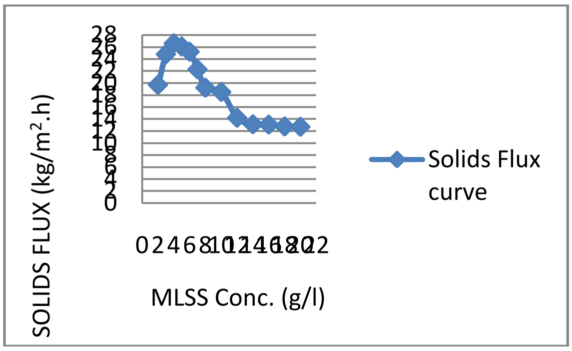

Figure 4.8 - Solids flux Vs MLSS concentrations {Adding Chlorine (1.545mg)}

AREA OF THE SETTLING TANK

The area of the settling tank is obtained by using the solid flux.

$A = Q (1 + r) C_o / SF_L$

Where

Q = discharge flow rate of the waste water (m^3/hr)

r = flow rate

Co = initial MLSS concentration (g/L)

SFL = Limiting Solid Flux, kg/m2.hr

A = Cross sectional area of settling tank, m2

LIMITING SOLIDS FLUX

The limiting solids flux is the linear tangent obtained from the solids flux curve. The linear tangent is drawn from the underflow concentration, C_u.

Underflow concentration, $C_u = C_0 (1+r) / r$

Where,

C_0 = Initial concentration (g/L)

r = Recycle ratio

C_u = Underflow concentration (g/L)

DETERMINATION OF WEIR LOADING RATE

For example adopt 2m as diameter and 3m depth with FB 0.3m. The circular tank with central inlet and radial flow, over flow weir in the periphery,

$\pi D = \pi \times 2m$

	=	6.48 m
Weir loading rate	=	250 (m^3/d) / 6.48
	=	38.5 m^3 / m.d < allowable

Therefore the weir loading rate is within the allowable limit i.e., the allowable rate is 185 m^3 / m.d.

V DISCUSSIONS

The settling velocities and the limiting solid flux were obtained for different concentrations ranging from 2g/L to 20g/L. From the values observed, it was concluded that the settling velocity was decreasing with increase in mass concentration with and without the addition of Chlorine. This is because at higher MLSS concentration, the opportunity for the particles to come closer is high and the inter particle forces are high enough to decrease the rate of settling of the mass.When Chlorine was added generally, it was found that the settling velocity was increasing. When dosage of chlorine was increased, settling velocity was also increased. The Settling velocities of 2 g/L MLSS concentration for different dosages of Chlorine are given below:

For 0.515 mg of Chlorine (1 ml of Bleaching powder solution) = 8.49 m/hr. For 1.03 mg of Chlorine (2 ml of Bleaching powder solution) = 9.08 m/hr. For 1.545 mg of Chlorine (3 ml of Bleaching powder solution) = 9.84 m/hr.

The same was obtained for the other MLSS concentrations except in the addition of chlorine comprising of 0.515 mg, the concentrations of 6 g/L, 7 g/L and 8 g/L, the settling velocity was decreasing when compared to without addition of chlorine which was obtained experimentally. The same was obtained in the solids flux observations..However the result shows that, Chlorine is effective in enhancing the settling of Activated sludge treating dairy wastewater.

VI SUMMARY AND CONCLUSIONS

Effective functioning of the activated sludge process depends on the design of secondary settling tank. The design of secondary settling tank depends on settling characteristics of activated sludge. The characteristics of the waste water were analyzed as per the procedure given on standard methods for the examination of water and wastewater. The settling studies were carried out on dairy wastewater activated sludge prepared for 10 θ_c using settling column (22.5mm ID X 650mm Ht). Settling velocities for various MLSS concentrations with and without adding Chlorine were found and tabulated. From the data obtained, plot between Interface height and Solids flux was prepared and the solids flux curve was obtained. By using the solids flux curve, the area for the secondary settling tank was calculated with and without the addition of Chlorine. Addition of Chlorine as a control measure for sludge bulking was effective as indicated by the increase in settling velocities.

VII CONCLUSIONS

Following conclusions were drawn from the present study:

1. Settling velocity of sludge increases with increase in MLSS concentration.
2. The settling velocity increases considerably after the addition of Chlorine in the sludge when compared with the settling velocity of without adding the Chlorine.
3. The addition of Chlorine in the sludge improves the settling characteristics of the sludge.
4. Area of the SST was determined by using the Solids flux curve and mass balance for solids concentrations.

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