

Removal of Mixed Liquor Suspended Solids by Dewatering of Paper Mill Secondary Sludge using Polymers

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Abstract - The effluent quality of a sewage treatment plant using activated sludge process and finally secondary treatments depends on the flocculation efficiency and settling of the flocs. This study work was performed to determine the parameters such as COD, BOD, Consistency, Sludge Volume Index, pH and Colour in activated sludge process. It was carried out in two phases using Mixed Liquor Suspended Solids Obtained from aeration tank outlet from effluent plant in paper mill. In the primary phase solid polymer sample concentration was varied from 1ppm to 10ppm at 30 degree Celsius. In the secondary phase liquid polymer sample concentration was varied 1ppm to 10ppm at 30 degree Celsius. As a result sludge volume index and consistency were found, COD, BOD and Colour percentage decreases. In the secondary phase the polymer concentration increase, the clear overflow was obtained.

Keywords - Activated sludge, Dewatering, Sludge Volume Index, Flocculation efficiency, Liquid Polymers.

I. INTRODUCTION

SLUDGE dewatering is one of the most important process in sludge treatment and recycle. The dewatering of sludge leads to economical disposal and reuse. The Activated sludge process was developed in 1914. The principles of activated sludge are in forms of flocculation and also characteristics of flocs. The activated sludge consists of colloidal matters, organic substance, cations, microorganisms. The formation of flocs complex by mixing together. They have physical properties such as Density, Sludge volume index, Porosity. The efficiency of the settling process depends on the sludge settling properties such as porosity, density, sludge volume index. The sludge composition can also change the sludge settling properties. Sludge contains partially cationic and partially anionic charge.

There are different dewatering process such a centrifuge, increasing pH, Natural sedimentation. The centrifuge is one of the settling method. But it has high power requirement for large volume of settling and installation cost is high as well as frequent maintenance is needed. It is not suited for continuous settling.

Increasing pH is also one of the method. By adding base with sludge the flocculation process is severe and enhances the settling. But the increasing pH is the major effect to the irrigation land. The high pH liquid spoils the soil characters and degrades the vegetation as well as recycles. It is also not a suitable method of dewatering. Natural sedimentation is other process of settling which have less installation cost but it requires a long time for settling of MLSS present in sludge. So, we consider the polymer as settling enhancement substance. It is also called settling Aid. By adding polymer, the composition remains unchanged and characteristics of secondary sludge also remains unchanged. Only the settling character and flocculation is increased.

Hence different synthetic cationic and anionic high molecular weight polymers are generally employed in sludge settling. The relation between density and porosity of flocs were studied. It was approved that the density reduces and porosity increases, as the floc size increases. This may affect the floc settling. The polymer will enhance the flocculation and flocs weight is increased. Due to increase in density the settling is also enhanced. The anionic polymer plays a vital role for Effluent water treatment, removal of contaminant and the flocs settling as well as dewatering. By adding polymer the long chain polymeric interaction at various concentrations, then the sludge forms flocs and to make settling easy. By adding polymer at various concentration, the Chemical oxygen demand, Biological oxygen demand, Sludge volume index, consistency of settled Mixed Liquor Suspended Solids (MLSS) and supernatant clear liquid is determined.

II. LITERATURE REVIEW

The survey of various treatment processes in water and wastewater treatment shows that temperature and pH are the important factors affecting efficiency of flocculation and settling properties [1]. This study was performed to determine the effects of pH and temperature on settling of the flocs in activated sludge process. It was carried out for three months in two phases, using mixed liquor suspended solids (MLSS), obtained from aeration tank from one of wastewater treatment plants. In the primary phase, the temperatures of samples was increased from 15°C to 35°C. As a result, the sludge volume index (SVI) and effluent suspended solids increased and consequently, COD removal present decreased. In the second phase, the PH was increased from 5.7 to 9. As a result, SVI and

effluent suspended solids decreased and COD removal present increased [4].

On the basis of experiments carried out using an image analysis system and static zone settlement, the alum sludge floc structure and the floc packing status with varied polymer dosages were examined in greater detail to reveal the link with the settling behavior manifested in the “CML30 method” [5]. The results of the image analysis lead to the findings of the floc size with a pattern in initially great increase with low polymer dose and finally a plate as being reached at higher amount of polymer addition [2]. Meanwhile a polymer dosage in the range of 2.0–20.0mg/l (for sludge SS=4595mg/l) can result in the increase of floc fractal dimension (DF) up to an average value of 1.72 (raw sludge DF being 1.06), indicating greater compactness of the floc solids. These floc features controls the settling behavior of the “CML 30 method”, especially in small polymer dosages. However, in large polymer doses, the controlling factor is derived from the floc packing status (referring to the the inter-floc contact manner). This packing status may associate with viscosity of settling medium (supernatant) and the excess polymer in bulk solution. All these affect the sludge floc networked structure in overdosing range.

It has been investigated in a comparative fashion that the effect of cations and polyelectrolytes on the characteristics and final properties of both synthetic and activated sludge [3]. Synthetic sludge was prepared according to established procedures; activated sludge was produced in lab-scale, continuous-flow reactor which was fed with live activated sludge from a wastewater treatment plant. The results from Experiments indicate that cations and polyelectrolytes could influence sludge floc characteristics as they relate to sludge conditioning. The relationship between polysaccharide concentration and cation concentration was examined at laboratory scale during flocculation with both synthetic and activated sludge; an increase in feed cation concentration led to a decrease in final polysaccharide concentration. An increase in cation concentration in the feed to the reactors was also associated with an increase in the bound biopolymer concentration. The changes in the bound biopolymer were explained according to the cation bridging model. The effects of a polyelectrolyte conditioner on sludge conditioning were determined [6]. A qualitative link exists between polyelectrolyte conditioner dosage and sludge conditioning for both types of sludge. The two types of sludge also have very similar sludge conditioning after cationic polymer is added to the reactor. Thus synthetic and activated sludge behave very similarly in terms of their characteristics and sludge conditioning, and synthetic sludge can be used as a surrogate in activated sludge studies. This results of this work also indicate that the formation of cation-polymer complexes and polymer gelation are amongst the most important mechanisms for sludge coagulation-flocculation, and offer a means for optimization of the activated sludge process.

III. PROCESS

A. Collection of Sludge:

The sludge water was collected from an aeration outlet of

effluent treatment plant in paper mill. And it was well shaken by measuring jar. After shaking the jar was kept for settling.

B. Polymers Used:

AQUA TREAT-----7590

ANCOFLAC-----C7513

C. Preparation Of Polymer Solution:

SOLID POLYMER SAMPLE:(AQUA TREAT---7590)

1 gram of solid polymer weighed and mixed with 1000ml of distilled water to make 1000ppm stock solution. After preparation of stock solution, it is kept free from contaminants.

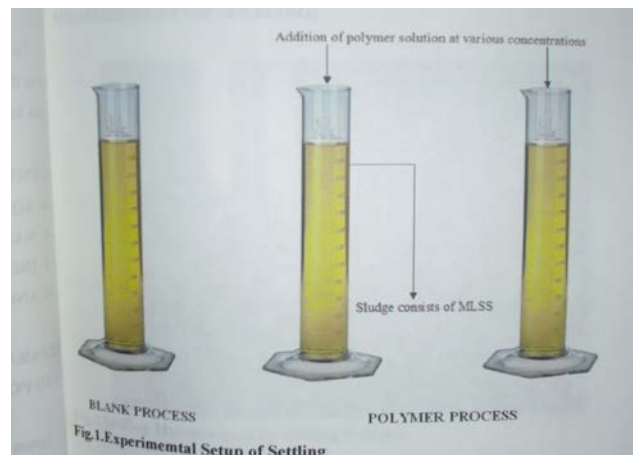
LIQUID POLYMER SAMPLE:(ANCOFLAC---C7513)

10ml of liquid polymer was taken in measuring jar and mixed with 1000ml of water to make 1000ppm stock solution. After preparation of stock solution, it is kept free from contaminants.

D. Experimental Setup:



E. Experimental Diagram



F. Experimental Procedure:

The polymer (AQUA TREAT & ANCOFLAC) solutions are prepared. Sludge was taken in a 1000ml measuring jar and kept for settling for about 45 minutes. For every 5 minutes time interval the amount of clear water formed was noted. The noted time are known as blank values. Then polymer solution

of varying concentration such as 1ppm, 2ppm..... .30ppm are added to the measuring jar containing containing 1000ml of sludge.This setup is then kept for settling for about 45 minutes.Again for every 5 minutes time interval the amount of clear water formed was noted.After completion of 45 minutes, the clear liquid formed was taken out and subjected to determination of parameters such as COD, BOD, Colour, pH. The underflow settled MLSS is taken out and subjected to determination of consistency and SVI.The determination of parameters such as (COD, BOD, Colour, pH, Consistency, SVI) are given below.

G. Experimental Measurements:

1. MEASUREMENT OF SETTLING:

Sludge was taken in a 1000ml measuring jar and kept for settling for about 45 minutes without any disturbances.For every 5 minutes time interval the amount of clear water formed were noted.

2. ADDITION OF POLYMER:

Polymer solution of different concentrations such as 1ppm,2ppm,3ppm,4ppm,5ppm,6ppm,7ppm,8ppm,9ppm,10ppm,15ppm,20ppm,25ppm,30ppm,35ppm are added to the measuring jar containing 1000ml of sludge.After adding polymer the batch was kept for settling for about 45 minutes without any disturbances.For every 5 min time interval the amount of clear water formed is noted and tabulated.

3. PARAMETERS TO DETERMINE:

After completion of 45 min the overflow clear liquid formed was taken out and subjected to determination of parameters such as COD,BOD,COLOUR,pH.Similarly the underflow settled MLSS is taken out and subjected to determination of CONSISTENCY,SVI.

4. DETERMINATION OF COD:

0.4gm of HgSO4 salt is added with 5ml of 0.25 N of k2Cr2O7 solution in a round bottom flask.The overflow sample of about 10ml was added in the mixture.15ml of AgSO4.H2SO4 solution was added in the above mixture.The whole solution was digested for 2hrs using reflux condenser heating mantle.After digestion,the digested mixture was cooled and titrated against 0.1N ferrous ammonium sulphate using ferrion as an indicator.

5. DETERMINATION OF BOD:

Collect the overall sample in a glass container by bubbling compressed air for 30 min.Add 1ml of phosphate buffer,MgSO4,CaCl2 and ferric chloride solution for each litre of dilution water and mix thoroughly.

Neutralize the sample to pH around 7 by using 1N NaOH or H2SO4.Since the dissolved oxygen in sample is likely to exhausted.It's usually,necessary to prepare a suitable dilution of sample according to expected BOD range.

Prepared dilution solution was mixed thoroughly and filled in 2 sets of BOD bottles.It was put in incubator at 27 degree Celsius for 3 days.Then after 3 days the BOD was found by titration against 0.1N ferrous ammonium sulphate using ferrion as indicator.

6. MEASUREMENT OF COLOUR:

Collect 10ml of overflow sample and it was added with

40ml of water and mix it thoroughly and result was compared with the standard color solutions to determine the color range.

7. MEASUREMENT OF CONSISTENCY

Collect 100ml of underflow MLSS sample and it was filtered by vacuum filter and the filtrate dried for about 30 min in an electric hot air oven at 200 degree celsius.After drying the moisture free MLSS was weighed.The consistency was determined.

IV. RESULTS AND DISCUSSIONS

AQUA TREAT---7590

Dewatering(ml)					
TIME	BLANK	1 ppm	2 ppm	3 ppm	
0	0	0	0	0	0
5	0	50	50	40	
10	5	130	100	75	
15	10	220	160	80	
20	10	290	210	180	
25	10	340	290	240	
30	15	370	340	270	
35	15	400	370	300	
40	20	420	400	330	
45	20	440	440	385	

Dewatering(ml)					
TIME	4 ppm	5 ppm	6 ppm	7 ppm	8 ppm
0	0	0	0	0	0
5	30	25	25	20	10
10	50	50	45	40	30
15	90	90	85	70	55
20	125	125	125	100	90
25	160	160	160	145	130
30	210	190	210	185	160
35	230	215	230	200	190
40	250	230	250	230	200
45	290	270	290	235	250

Dewatering(ml)					
TIME	9 ppm	10 ppm	15 ppm	20 ppm	
0	0	0	0	0	0
5	10	10	5	5	
10	25	20	10	10	
15	30	25	10	10	
20	60	30	15	10	
25	70	30	20	20	
30	85	40	20	20	
35	95	40	25	25	
40	95	45	25	25	
45	70	50	30	30	

TIME	25 ppm	30 ppm	35 ppm	
0	0	0	0	0
5	5	5	5	0
10	5	5	5	5
15	10	5	5	5
20	10	10	5	5
25	10	10	10	10
30	20	15	10	10
35	25	15	10	10
40	25	15	15	15
45	25	20	15	15

TIME	4 ppm	5 ppm	6 ppm	7 ppm	
		0	0	0	0
5		30	40	50	55
10		50	75	115	120
15		75	150	190	200
20		105	200	260	275
25		145	270	310	320
30		170	330	360	375
35		205	350	390	405
40		240	390	425	430

Concentration	pH	Consistency	COD
1	7.65	4400	168.71
2	7.65	4380	168.7
3	7.65	4280	168.71
4	7.65	4000	168.71
5	7.65	4100	168.71
6	7.65	4100	168.71
7	7.65	4100	168.71
8	7.65	4100	168.71
9	7.64	4000	168.71
10	7.64	3998	168.7
15	7.64	3990	168.7
20	7.64	3990	168.7
25	7.64	3872	168.7
30	7.63	3872	168.7
35	7.63	3845	168.69

TIME	8 ppm	9 ppm	10 ppm	15 ppm	
		0	0	0	0
5		65	70	70	100
10		120	125	125	310
15		220	235	250	390
20		285	290	300	420
25		335	350	370	510
30		385	395	400	560
35		420	430	430	580
40		435	455	470	585

Dewatering(ml)

Concentration	BOD	COLOUR
1	28	100
2	28	100
3	28	100
4	28	100
5	28	100
6	27.9	100
7	27.9	100
8	27.9	50
9	27.8	50
10	27.8	50

TIME	20 ppm	25 ppm	30 ppm	
		0	0	0
5		190	320	400
10		450	495	520
15		490	510	540
20		520	545	560
25		570	580	585
30		590	585	590
35		600	600	600
40		600	600	600
45		610	610	610

ANCOFLAC---C7513

Dewatering(ml)

TIME	BLANK	1 ppm	2 ppm	3 ppm	
		0	0	0	0
5		0	20	25	25
10		10	40	45	50
15		10	60	60	65
20		10	80	85	95
25		15	100	110	120
30		20	120	140	150
35		20	140	165	185
40		20	165	190	220
45		25	190	220	240

Concentration	pH	Color	COD
1	7.45	100	160.8
2	7.45	100	160.8
3	7.45	100	160.78
4	7.45	100	160.52
5	7.45	50	160.52
6	7.45	50	160.3
7	7.45	50	160.29
8	7.45	50	160.21
9	7.45	50	160.12
10	7.45	50	160.12
15	7.45	50	160.02
20	7.45	50	160
25	7.45	50	159.81
30	7.45	50	159.55
35	7.45	50	159.25

Concentration	BOD	SVI	Consistency
1	28	79	5520
2	28	100	6130
3	28	115.8	6510
4	28	140.2	6920
5	27.8	168.21	7680
6	27.8	191.11	8520
7	27.1	202.15	8570
8	26.6	215.18	8590
9	26.2	251.01	8595
10	26.2	281.71	8600
15	26	291.5	9012
20	25	300.1	9036
25	25	302.15	9041
30	25	302.65	9050
35	25	302.65	9060

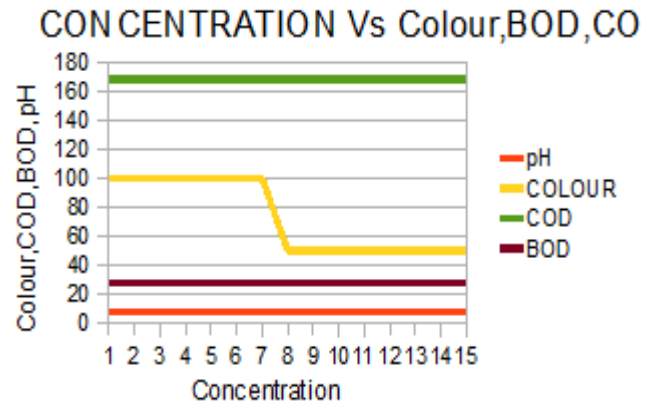


Fig. 3

AQUA TREAT---7590

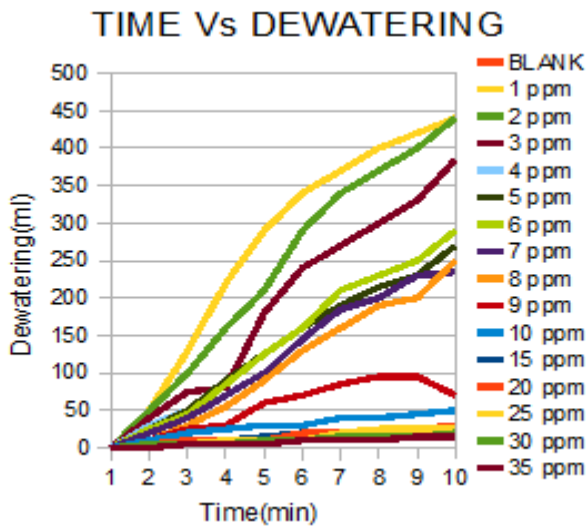


Fig. 1

ANCOFLAC----C7513

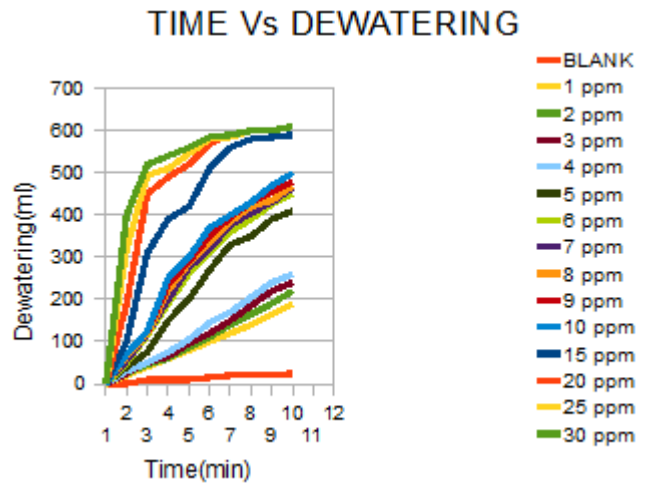


Fig. 4

CONCENTRATION Vs CONSISTENCY

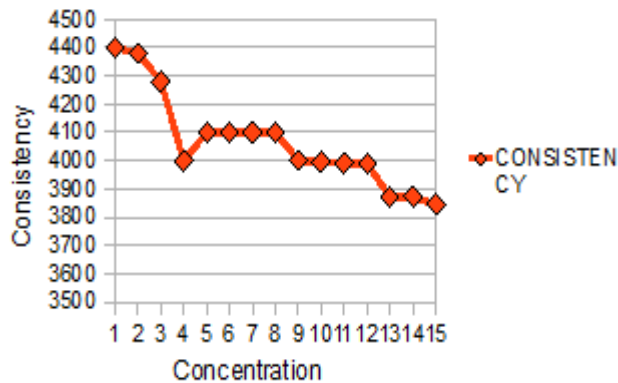


Fig. 2

Concentration vs colour,BOD,COD,SVI,pH

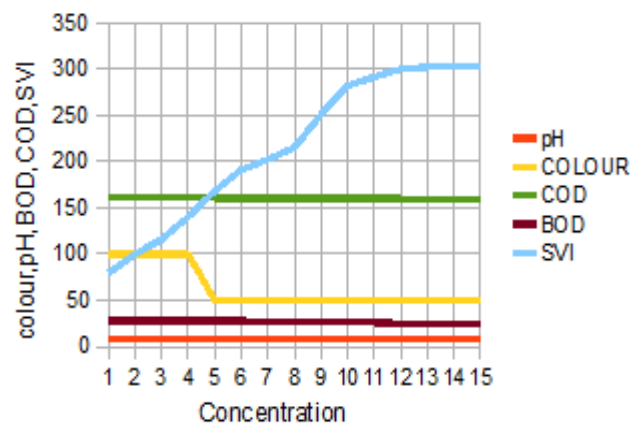


Fig. 5

CONCENTRATION Vs CONSISTENCY

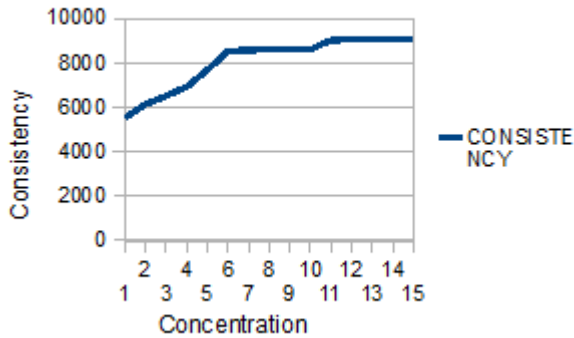


Fig. 6

V. INFERENCE

A. Aqua Treat----7590

The dewatering was decreased by increasing the concentration of the polymer, the maximum dewatering was at 8ppm simultaneously increases in time. (Concentration Vs Dewatering). The concentration of polymer was increased, the pH level of the overflow clear liquid is decreased to neutral pH and after 9ppm of polymer concentration the pH was maintained constant (Concentration Vs pH). This figure shows that the consistency decreased due to increasing the polymer concentration due to the resisting of dewatering gradually (Concentration Vs Consistency). The COD and BOD was decreased when increasing the polymer concentration and removal was attained as 80%. The color of the overflow liquid decreased when the concentration of polymer was increased. The maximum color removal was 50 from 9ppm concentration.

B. Anco Flac----C7513

The dewatering was increased by increasing the concentration of polymer, simultaneously increases in time interval. The maximum dewatering was at 6ppm to 25ppm. After 25ppm it will resist the dewatering due to increasing of anionic nature (Effect of Concentration polymer with respect to Time). The concentration of polymer increased the pH, level of the overflow clear liquid remained constant. The pH was constant from initial concentration of polymer. The consistency increased when increasing the concentration of polymer due to the enhance of dewatering, at every concentration with respect to time. The COD and BOD was decreased due to increase of polymer concentration. Then the COD removal was attained as 90% and BOD removal was attained as 70% at 9ppm of polymer concentration. The color of the overflow liquid decreased when the concentration of polymer was increased. The maximum color removal is 50 from 5ppm concentration (Variation of Colour with respect to respect to Concentration). When the concentration increases the removal of color in the overflow also increased.

IV. CONCLUSION

Paper mill Secondary Sludge treatment is one of the Effluent treatment methods by addition of polymer at various concentrations. The polymer is efficiently used to enhance the sludge settling and formation of flocs is maximum than the natural settling. During settling of MLSS, it is necessary to monitor different parameters such as COD, BOD, pH, Consistency. Both the cationic and anionic polymers are involved in settling. The dewatering efficiency in anionic polymer is maximum when compared to cationic polymer such as ancoflac. When adding the anionic polymer the flocs formation was increased and enhances the settling character. By the experiments the COD removal was upto 80% and pH was maintained around neutral pH and clear overflow is obtained.

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