Jr. of Industrial Pollution Control 22 (1)(2006) pp 111-120

BOD REDUCTION USING LOW COST ADSORBENTS

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Key words : BOD, DO, Contact time, Adsorbent dosage, pH, Particle size.

ABSTRACT

Dairy waste water is organic in nature and the bacteriological action on the organic material requires oxygen. BOD data obtained can have wide applications in the environmental engineering practice. The BOD test is the principal test applied to the domestic and the industrial wastewater to determine the strength in terms of oxygen required for the stabilization. It is the only test applied that gives a measure of the amount of biologically oxidizable organic matter present and that can be used to determine the rates at which the oxidation will occur or BOD shall be exerted in the receiving bodies of water. This study focuses the attention on the usage of the low cost adsorbents for the reduction of BOD. Various parameters viz., effect of pH, effect of contact time, effect of adsorbent dose and the effect of particle size on the reduction of BOD are thoroughly studied and the results put forth.

INTRODUCTION

Dairy Industries requires large quantity of water for the purpose of washing of cans, machinery and floor, which produces almost same quantity of wastewater consisting of washing chemicals, milk and the products. Large quantity of wastewater originates due their different operations. The organic substrates in the wastes come either in the form in which they were present in the milk, or in a degraded form due to their processing. As such, the dairy wastes, though biodegradable, are very strong in nature. The dairy wastes are very often discharged intermittently; the nature and the composition of waste also depends upon the type of products produced and the size of the plants. The untreated dairy wastes are often highly polluting due to the oxygen demands they impose when discharged into a stream or the body of water. When DO is insufficient for oxidation of organic matter, the lactose is converted into lactic acid, which in turn lowers the pH to a point when casein gets precipitated. The resultant anaerobic decomposition of the protein yields foul smelling substances that neither support the aquatic life nor the animals can drink this water. This also creates air pollution in the neighborhood. Hence waste disposal, only after its treatment is an important consideration in every plant.

One of the parameters that indicate the oxygen demand is the Biochemical Oxygen Demand, BOD; and defined as the amount of free oxygen required for the biological oxidation of the organic matter under the aerobic conditions. Oxidation ditch, aerated lagoons, activated sludge, trickling filters etc. are the biological methods adopted for the treatment of these dairy waste waters. These give no doubt the good results but, require high initial cost, more maintenance and especially high retention time, skilled personnel and special type of equipments. On the contrary, the low cost treatment methods can be employed with simpler equipments and less maintenance.

It has been recognized by the National Dairy Development Board (N.D.D.B), that the wastewater produced by the different milk processing centers need to be handled with appropriate treatment technology.

Adsorption is highly effective and one of the promising low-cost waste treatment methods, which reduce the parameters well within the disposal standards. It involves nothing more than the preferential partitioning of the substances from the fluid phases onto the surface of the solids. Activated carbon is commonly used as an adsorbent, but owing to its cost and difficulty in procuring, the efforts are being made in the recent years to develop the efficient and low cost adsorbent materials for the removal of organics and heavy metals from the aqueous solutions. These low-cost adsorbent materials range from the industrial wastes to the agricultural waste products and the substances such as flyash. Some of the low-cost adsorbent materials are baggase, fly ash, rice husk ash, activated slag, waste biomass, incineration fly ash, iron oxide coated sand etc.

EXPERIMENTATION

The overall experimentation involves the initial treatment and pretreatment of raw adsorbents and the filtration of the dairy wastewater.

Initial treatment

In the present investigations 05 adsorbents were used. These were the non-conventional adsorbents viz., Rice Husk (RH), Baggase (BG), Wheat Straw Dust (WSD), Saw Dust (SD) and Coconut Jute(CJ) and were collected locally. To study the effect of pH, 300mg of each of these 05 adsorbents were added to the 300mL of pH adjusted dairy waste water samples, which were taken into the BOD bottles to see the reduction of the BOD. During the pH adjustment it was observed that some color was added to the wastewater at low pH and more color was imparted at higher pH. BOD bottles were stirred for nearly half an hour and the contents were later filtered. It was observed that there was no reduction in the BOD, moreover the quality of waste water was deteriorated due to the release of lignin. This necessitates the pretreatment of raw adsorbents.

Pre -treatment

Each of these adsorbents were first washed well with distilled water to remove the dirt and the dust particles and dried at temperature of 80°C for a period of 4 – 5 hours. Dried adsorbents were then soaked separately overnight in 0.1N NaOH solution to remove the lignin content as lignin is soluble in NaOH.

Then soaked in 0.1N CH_3COOH for a period of 2-3 hours to remove the alkalinity caused due to the adherence of NaOH. These pretreated materials were then used as adsorbents. It was observed that a dark red colored solution was obtained with saw dust, a moderate red color solution with coconut jute, a brown color solution with wheat straw dust, turbidity with rice husk and a green color with baggase. This indicates the concentration of lignin in the various adsorbents. Later all the adsorbent materials were washed with distilled water till the wash water became colorless. There after these were sun dried. These pretreated adsorbents were light in weight and imparted faint or no color as compared to the earlier dark color without pretreatment.

Filtration of dairy wastewater

The dairy waste water samples were adjusted to the different pH values and the pretreated adsorbents were added to see the effect of pH on the percentage BOD removal. It was observed that, there was a formation of a microbial layer on the surface of the filtrate. This was observed only between the pH ranges of 6.0 to 8.0. This indicates that the raw waste water requires filtration before the adsorption. Raw wastewater was filtered through the sand column and then using a filter paper to remove the micro organisms. The filtrate was then adjusted to the required pH before the addition of the adsorbents. The adsorbents were then added in the ratio of 1g per liter and stirred for a period of one hour. Sample was filtered through the filter paper to remove the adsorbents and was used for the analysis of BOD. No microbial layer was found. All the experiments were carried out at room temperature i.e. 35^0C (± 5^0C).

RESULTS AND DISCUSSION

Influence of pH on BOD reduction

Filtrate from the sand column was collected and adjusted to the pH between 4.0 and 10.0. From this, 300mL of sample was taken into the 300mL BOD bottle and 300mg of adsorbent was added and stirred for half an hour. After the stirring was over, sample was withdrawn and filtered and the filtrate was used for the analysis of BOD. The graph (Fig.1 and Table 1) shows that the maximum BOD removal of 54.5% obtained at the pH of about 5.0 for RH, whereas with BG, SD and WSD, the maximum reduction was 51.69%, the same for the CJ

Table 1
Effect of pH on %age BOD reduction

FINAL OXYGEN OF THE SAMPLES (grams per liter)

S.No.	pH	WSD-DO	SD-DO	CJ-DO	RH-DO	BG-DO
1.	2	2.9	3.65	3.65	3.4	3.4
2.	4	2.4	2.4	2.9	2.15	2.4
3.	6	2.15	2.15	2.4	2.15	2.15
4.	8	2.27	2.35	2.47	2.37	2.27
5.	10	2.4	2.65	3.15	2.65	2.90

BOD CONTENT OF THE SAMPLES (grams per liter)

S.No	pH	WSD-BOD	SD-BOD	CJ-BOD	RH-BOD	BG-BOD
1.	2	1.55	0.8	0.8	1.05	1.05
2.	4	2.05	2.05	1.55	2.3	2.05
3.	6	2.3	2.3	2.05	2.3	2.3
4.	8	2.17	2.1	1.97	2.07	2.17
5.	10	2.05	1.8	1.3	1.80	1.55

PERCENTAGE BOD REDUCTION

S.No.	pH	WSD	SD	CJ	RH	BG
1.	2	34.83146	17.97753	17.97753	23.59551	23.59551
2.	4	46.06742	46.06742	34.83146	51.68539	46.06742
3.	6	51.68539	51.68539	46.06742	51.68539	51.68539
4.	8	48.8764	47.19101	44.38202	46.62921	48.8764
5.	10	46.06742	40.44944	29.21348	40.44944	34.83146

Initial DO of the sample = 5.25g /L, Final DO of the sample = 0.8g /L
Initial BOD = 4.45g /L.

was about 47% at the pH 6.0. The nature of graph can be explained on the basis that at low and high pH, the active sites or the adsorption centers are altered and also that there is a possibility of the leach out of lignin and the other organic constituents of the adsorbents thus leading to the lower amount of adsorption and thus resulting in the lower percentage of BOD reduction at high and low pH values.

Effect of contact time

The kinetics of adsorption of the adsorbents at their optimum pH values, as determined by the previous graph was studied for the reduction of BOD and are presented in the graph (fig.2 and table 2). It indicated that the adsorbents had reached the equilibrium in 200 minutes and there was no significant change in the equilibrium concentration. Equilibrium time was found to be almost same for BG, SD, WSD, CJ and RH. BOD reduction by RH was found to be 14.70% in 15 minutes and increased to 58.82% in 270 minutes. Whereas the maximum BOD reduction was 61.76%, 64.70%, 61.76% and 61.76% by BG, SD, WSD and CJ respectively,at an equilibrium time of 270 minutes.

The nature of graph can be thought of due to the attainment of equilibrium at certain contact time and thus there was no further adsorption taking place

Table 2
Effect of contact time on %age BOD reduction.

FINAL DISSOLVED OXYGEN (grams per liter)

S.No.	Time in min.	RH	WSD	SD	CJ	BG
1.	15	4.1	4.2	4.3	4.2	4.6
2.	45	4.2	4.4	4.5	4.3	4.7
3.	60	4.3	4.7	4.8	4.5	4.9
4.	90	4.4	4.9	5.0	4.7	5.0
5.	150	5.2	5.5	5.6	5.3	5.3
6.	210	5.6	5.7	5.7	5.6	5.7
7.	270	5.6	5.7	5.8	5.7	5.7

BOD OF THE SAMPLES (grams per liter)

Time in min.	RH	WSD	SD	CJ	BG
15	2.9	2.8	2.7	2.8	2.4
45	2.8	2.6	2.5	2.7	2.3
60	2.7	2.3	2.2	2.5	2.1
90	2.6	2.1	2.0	2.3	2.0
150	1.8	1.5	1.4	1.7	1.7
210	1.4	1.3	1.3	1.4	1.3
270	1.4	1.3	1.2	1.3	1.3

PERCENTAGE BOD REDUCTION

Time in min.	RH	WSD	SD	CJ	BG
15	14.70588	17.64706	20.58824	17.64706	29.4116
45	17.64706	23.52941	26.47059	20.58824	32.35294
60	20.58824	32.35294	35.29412	26.47059	38.23529
90	23.52941	38.23529	41.17647	32.35294	41.17647
150	47.05882	55.88235	58.82353	50.00000	50.00000
210	58.82353	61.76471	61.76471	58.82353	61.76471
270	58.82353	61.7641	64.70588	61.76471	61.76471

Initial DO of the sample = 7.0g /L, Final DO of the blank sample = 3.6g /L
Initial BOD = 3.4g /L

and hence no significant decrease in the %BOD reduction.

Effect of adsorbent dose

The graph (Fig. 3 and Table 3) shows the effect of adsorbent dose on the reduction of BOD. It may be seen that the %age BOD reduction efficiency increases with increase in the adsorbent dose up to some extent and thereafter for further increase in the adsorbent dose there is a small increase in the reduction of BOD. The % reduction of BOD was higher in the case of BG followed by RH, WSD ,CJ and SD in the same order due to their pretreatment and intra particle diffusion. The reduction of BOD by BG had sharply increased from 33.33% to 76.67% with an adsorbent dose from 0.6g /L to 1.8g /L. However, with further increase in the adsorbent dose, there was no appreciable increase in the BOD reduction. Maximum BOD reduction by BG, RH, WSD, CJ and SD was found to be 76.67%, 60.00%, 43.33%, and 40.00% respectively with an

Table 3
Effect of adsorbent dose on the %age BOD reduction

FINAL DISSOLVED OXYGEN (grams per liter)					
AMT(g /liter)	SD	CJ	WSD	BG	RH
2	4.5	4.7	4.7	4.7	4.8
3	4.8	5.0	4.9	5.3	5.1
4	5	5.1	5.1	5.6	5.3
5	5.1	5.2	5.2	5.9	5.4
6	5.1	5.3	5.2	6.0	5.5
BOD OF THE SAMPLES (grams per liter)					
AMT(g /liter)	SD	CJ	WSD	BG	RH
2	2.2	2.0	2.0	2.0	1.9
3	1.9	1.7	1.8	1.4	1.6
4	1.7	1.6	1.6	1.1	1.4
5	1.6	1.5	1.5	0.8	1.3
6	1.6	1.4	1.5	0.7	1.2
PERCENTAGE BOD REDUCTION					
AMT(g /liter)	SD	CJ	WSD	BG	RH
2	26.66667	33.33333	33.33333	33.33333	36.66667
3	36.66667	43.33333	40.00000	53.33333	46.66667
4	43.33333	46.66667	46.66667	63.33333	53.33333
5	46.66667	50.00000	50.00000	73.33333	56.66667
6	46.66667	53.33333	53.33333	76.66667	60.00000

Initial DO of the sample = 6.7g /L, Final DO of the blank sample = 3.7g /L
Initial BOD = 3.0g /L

adsorbent dose of 1.8g /L.

The nature of this graph can be attributed to the attainment of equilibrium. Thus even though there were the active centers available for adsorption to take place, the attainment of equilibrium had halted the process of adsorption and in turn the %age reduction was significant with further increase in the adsorbent dose.

Effect of initial BOD concentration

In the process of adsorption, initial concentration of the pollutants plays an important role because, the resistance to the uptake of solute from the solution decreases with the increase in the initial concentration. The effect of initial concentration on the reduction of BOD is shown in the graph (Fig.4 and Table 4). It is observed that the percentage reduction of BOD increased with increase in the initial concentration of BOD in the sample. Percent reduction increased from 51.33% to 81.71% by BG followed by RH, SD, WSD and CJ from 60 to 79.27%, 58.67 to 75.61%, 57.33 to 73.17% and 49.33 to 68.29% respectively with a decrease in the dilution factor from 1: 30 to 1: 10. As stated above the mass transfer resistance increases (or the diffusivity decreases) with increase in the dilution, thus leading to lower adsorption. And this explains why the %age reduction lowered with increase in the dilution.

Table 4
Effect of initial BOD concentration on %age reduction

FINAL DISSOLVED OXYGEN (grams per liter)								
S.No.	Initial DO(Blank)	Final DO (Blank)	Initial BOD	BG	RH	WSD	SD	CJ
1.	8.3	0.1	8.2	6.8	6.6	6.1	6.3	5.7
2.	8.4	0.3	8.1	6.0	6.1	5.7	6.0	5.2
3.	8.5	0.5	8.0	5.4	5.8	5.6	5.8	5.0
4.	8.6	0.9	7.7	5.2	5.7	5.5	5.7	4.9
5.	8.7	1.2	7.5	5.2	5.7	5.5	5.6	4.9

BOD VALUES (grams per liter)					
Initial BOD	BG	RH	WSD	SD	CJ
8.2	1.5	1.7	2.2	2.0	2.6
8.1	2.4	2.3	2.7	2.4	3.2
8.0	3.1	2.7	2.9	2.7	3.5
7.7	3.4	2.9	3.1	2.9	3.7
7.5	3.5	3.0	3.2	3.1	3.8
PERCENTAGE BOD REDUCTION					
Initial BOD	BG	RH	WSD	SD	CJ
8.2	81.70732	79.26829	73.17073	75.60976	68.29268
8.1	70.37037	71.60494	66.66667	70.37037	60.49383
8.0	61.25000	66.25000	63.75000	66.25000	56.25000
7.7	55.84416	62.33766	59.74026	62.33766	51.94805
7.5	53.33333	60.00000	57.33333	58.66667	49.33333

Effect of particle size

Adsorbent particle size has a significant influence on the kinetics of adsorption process due to the change in the number of adsorption sites. CJ was of long fibers and was cut to the size of 1mm and up to 0.125mm.The reduction of BOD by different particle sizes showed (Fig.5 and Table 5) that the uptake of BOD increases with decrease in the particle diameter. Presence of large number of smaller particles provides the sorption system with a greater surface area available for BOD reduction and it also reduces the external mass transfer resistance. The effect on BOD reduction of different adsorbent particle size is shown in the figure. For the smallest particle size of 75 micron the BOD reduction was found to be 49.18% and 45.90% respectively by SD and RH.

SUMMARY AND CONCLUSION

Though it is reasonable to assume that the powdered activated carbon (PAC) has more adsorption capacity than the five pre treated raw adsorbents used in the present investigation, it is suggested that the use of BG, WSD, SD, RH & CJ over the use of the costly PAC for the reduction of BOD from the dairy industry waste water. These non- conventional adsorbents are easily available

Table 5
Effect of particle size on the %age reduction

	FINAL DO OF THE SAMPLE(grams per liter)					
S.No.	Size(mm)	CJ	BG	WSD	RH	SD
1.	1.0	2.8	3.0	2.9	2.8	–
2.	0.5	3.0	3.2	3.1	2.9	–
3.	0.25	3.3	3.5	3.2	3.1	3.0
4.	0.125	3.5	3.8	3.4	3.3	3.2
5.	0.075	–	–	3.6	3.4	3.5
6.	<0.075	–	–	–	3.6	3.7

	BOD OF SAMPLES(grams per liter)					
Sl.No.	Size(mm)	CJ	BG	WSD	RH	SD
1.	1.0	2.45	2.25	2.35	2.45	–
2.	0.5	2.25	2.05	2.15	2.35	–
3.	0.25	1.95	1.75	2.05	2.15	2.25
4.	0.125	1.75	1.45	1.85	1.95	2.05
5.	0.075	–	–	1.65	1.85	1.75
6	<0.075	–	–	–	1.65	1.55

	PERCENTAGE OF BOD REDUCTION					
S.No.	Size(mm)	CJ	BG	WSD	RH	SD
1.	1.0	19.67213	26.22951	22.95082	19.67213	–
2.	0.5	26.22951	32.78689	29.5082	22.95082	–
3.	0.25	36.06557	42.62295	32.78689	29.5082	26.22951
4.	0.125	42.62295	52.45902	39.34426	36.06557	32.78689
5.	0.075	–	–	45.90164	39.34426	42.62295
6.	<0.075	–	–	–	45.90164	

49.18033

Initial DO=5.25g /L, Final DO of the blank=2.2g /L, BOD of the blank sample = 3.05.

at a very low cost. PAC is known to be effective at low pH, whereas the five adsorbents efficiently work between the pH 6.0-8.0, which is more preferable. Though very high adsorbent dose are reducing BOD by more than 75%, considering the very small percentage of particles it is concluded that the use of the adsorbents available in the natural state will definitely prove to be more economical.

Recovery and regeneration of PAC is difficult, whereas the adsorbents used can be safely disposed off after drying and burning. The process adopted is not only cheaper but requires less maintenance and supervision. Due to the reduction of BOD with the low cost adsorbents there is a considerable reduction in COD but it is necessary to study further.

SCOPE AND LIMITATIONS

There is a vast scope in the field of environmental studies in the wake of growing awareness in an individual, society, community & industry and also because of more stringent rules of the governments for waste disposals.

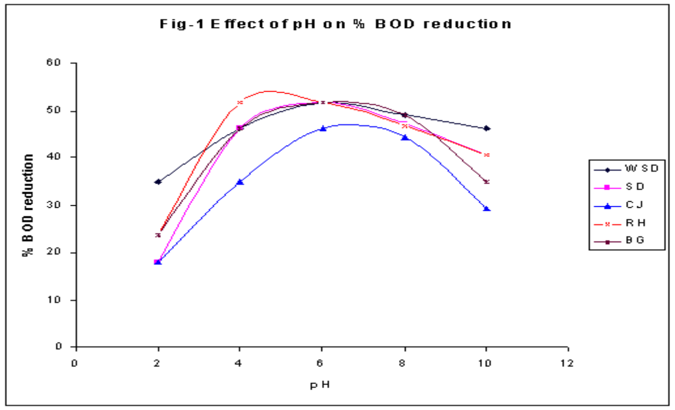

Fig. 1 Effect of pH on % BOD reduction

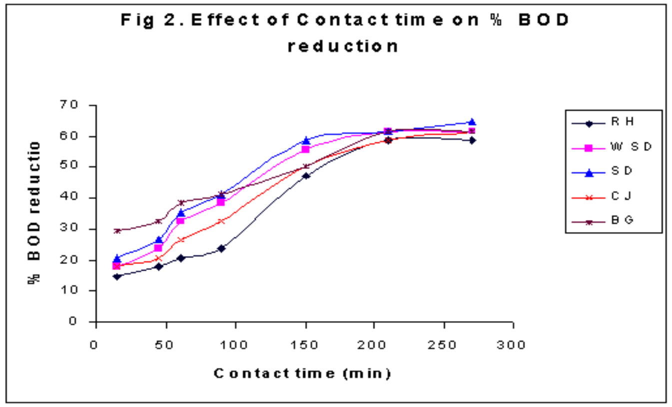

Fig. 2 Effect of contact time on % BOD reduction

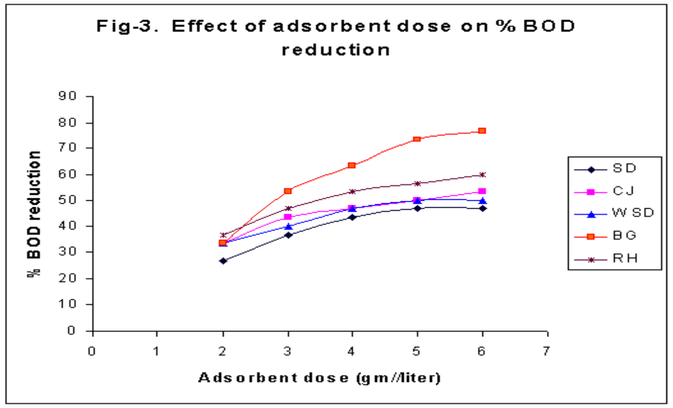

Fig. 3 Effect of adsorbent dose on % BOD reduction

This study promises the low cost treatment of effluents not only for the BOD reduction but for others also. The data generated shall be used in studying the processes and designing the required equipment based on the scale up factor, a prototype and its commercial utilization.

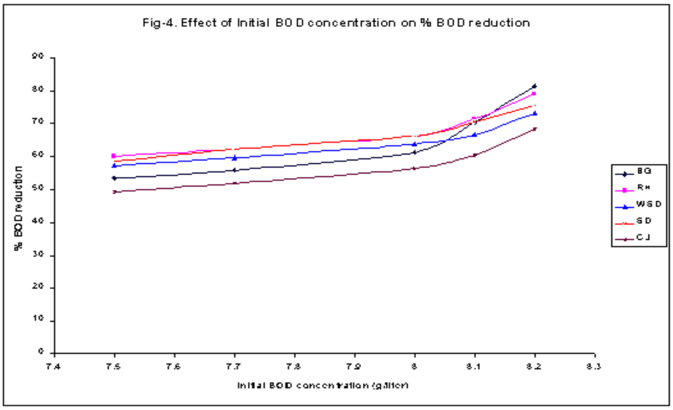

Fig. 4 Effect of initial BOD concentration on % BOD reduction

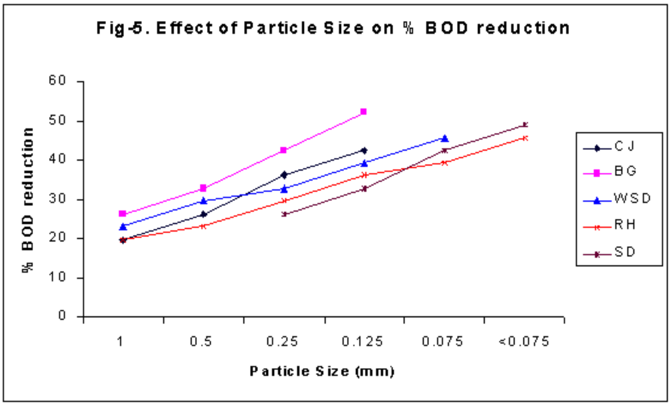

Fig. 5. Effect of particle size on % BOD reduction

The fact that the decrease in the initial concentration of BOD also decreases the efficiency of the BOD reduction is of a considerable thought. This means that for bringing the BOD levels below the disposable standards (<100 ppm) the effluent has to be passed several times in a properly designed adsorption column. But then the retention time increases thus decreasing the capacity of the treatment plant and / or increasing the capital investment.

ACKNOWLEDGEMENT

The author wishes to acknowledge the Karnataka Milk Federation, Dharwad for the supply of the effluent samples and also Mr. Gururaj Kannur, Mr.Vishal Chandankar, Mr.Prashanth for helping in carrying out the experiments.

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