Low-Cost Treatment of Sugar Industry Wastewater

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Abstract— **Water security may be regarded as a first step toward achieving food and energy security. Efficient use of fresh water resources and recycling of wastewater after proper treatment are viewed as tools to achieve water sustainability. A Lot of water is used by Sugar Industries for washing, cleaning & for working of Boilers. Sugar industry can have good potential to treat and reuse its effluents for Irrigation purpose. This potential is not realized by prevailing Conventional effluent treatment technologies because of high capital and operation cost of treatment process. The daily discharges of harmful effluent effect from a sugar mill are around 5000 cu.m/day. We have therefore focused on the development of a Low-Cost treatment technology that would help to overcome these limitations & improve the quality of waste water. We have used the alga Spirulina, Natural Coagulant M.Oleifera, Low cost adsorbent sugarcane bagasse fly ash. Experiments using Spirulina showed 91 % reduction in COD, Natural coagulant such as M.Oleifera dosage helps for the removal of turbidity 88.7% at the optimum dose of 0.6 gm/ml & Adsorbent Bagasse Fly-Ash helps to adsorb the BOD content . The results reflect that treated effluent satisfy the BIS standard values & therefore can be used for Irrigation Purposes.**

keywords-Spirulina, Natural Co-Agulant, M.Oleifera, Adsorbent, BOD, COD,BIS.

I. INTRODUCTION

A. *General-*

Water is an essential part of all living organisms. Among the whole water availability, only 3% fresh water is available on the earth. In the available fresh water sources, entries of pollutants have been significantly increased from industries and domestic/anthropogenic activities. In this scenario the conservation strategies plays an important role in the conservation of fresh water bodies as well as water quality. Huge quantity of fresh water will be consumed for the production process which will be held in the industry. In the mean while the amount of consumption of fresh water is equal to the amount of discharge.

B. *Sugar Manufacturing Process-*

Sugar cane is normally harvested manually in India. The sugar canes are cut into pieces and crushed in a series of rollers to extract the juice in the mill house. The milk of lime is then added to juice and heated, when all the colloidal and suspended impurities are coagulated; much of the color is also removed during this lime treatment. The coagulated juice is then clarified to remove the sludge. The sludge is further filtered through filter presses and then disposed of as solid waste. The clarified juice is then preheated and concentrated in evaporators and vacuum pans. The partially crystalized syrup from the vacuum pan known as ―massecuite is then transferred to the crystallizers, where complete crystallization of sugar occurs. The massecuite is then centrifuged to separate the sugar crystals from the mother liquor. The spent liquor is discarded as Black Strap Molasses. The sugar is then dried and bagged for transport.

C. Case Study of Sugar Industry ETP

To study & see the Sugar Manufacturing Process & Conventional Treatment Plant practically, we have visited to Bhimashankar Co-operative Sugar Manufacturing Industry,TalukaAmbegaon, District Pune. Firstly we observed the sugar manufacturing process from crushing,extracting to boiling & packaging. We found that as Sugar Manufacturing is a seasonal & time limited process & to help farmers to finished the sugarcane cutting within time the Industry itself exceeds the limit of overall production. The Sugar Manufacturing Industry has capacity of 2500 metric tonnes/day but it manufactures around 5000metric tonnes/day of sugar which is exactly twice of the capacity & hence the ETP which was designed as per Manufacturing Capacity was definitely going to face the major problem of wastewater treatment. Then we visited the ETP which is very near to Industry. We observed the Conventional Treatment Plant working, & found that Industry requires about 4.5 lakh liter fresh water daily only for backwashing, other purposes of fresh water are Cleaning, Steam generation to operate Turbines to produce electricity & around 22 lakh liter/day waste water is the effluent of Industry. So it seems very difficult to treat the waste water by ETP of 10 lakh liter treatment capacity only. The parameters are reduced 50-70% in which pH is made neutral and are BOD,COD,TDS,TSS are reduced up the some extent to meet the NPCB values. The most major problem starts after treatment. i.e of Disposal of waste water & Percolation. Only 6 acres of land is made available by farmer in which they use this treated waste water for Irrigation purpose only. We found that if the waste water is well treated & if quality is improved the disposal problem will be solved & we can save our environmental from harmfull effects of waste water.

II. LITERATURE REVIEW

Sugar industry can have good potential to treat and reuse its effluents. Conventional Treatment Technologies require substantial amount of energy (electricity) as well as chemicals and labors. The alga— Spirulina—was our choice to (1) treat the effluent and (2) use the sugar mill effluent as its growth medium. Experiments using Spirulina at secondary treatment stage showed 91 % reduction in chemical oxygen demand in 108-h treatment time. Further, biochemical analysis of Spirulina harvested from the sugar mill effluent treatment tanks revealed that the harvested biomass has high protein levels. Reduction of COD over 50 % was achieved in 24 h. In addition, nitrogen, phosphorous, and potassium of effluent acted as nutrient for Spirulina growth. Due to this, these inorganic elements were significantly reduced during the treatment. Therefore, the industry may seriously invest in ETP and operate it sensibly. Reduction of COD/ BOD of

SME and growth of Spirulina are interdependent and therefore beneficial to the sugar industry.(Sugar mill effluent treatment using Spirulina for recycling of water, saving energy and producing proteinA. B.Deshmane, V. S. Darandale, D. S. Nimbalkar, T. D. Nikam, V. S. Ghole et al October 2015).

Turbidity imparts a great problem in water treatment. Moringa oleifera, Cicerarietinum, and Dolichos lablab were used as locally available natural coagulants in this study to reduce turbidity of synthetic water. The tests were carried out, using artificial turbid water with conventional jar test apparatus. Optimum mixing intensity and duration were determined. After dosing water-soluble extracts of Moringa oleifera, Cicerarietinum, and Dolichos lablab reduced turbidity to 5.9, 3.9, and 11.1 nephelometric turbidity unit (NTU), respectively, from 100NTU and 5, 3.3, and 9.5,NTU, respectively, after dosing and filtration. Natural coagulants worked better with high, turbid, water compare to medium, or low, turbid, water. Highest turbidity reduction efficiency (95.89%) was found with Cicerarietinum. About 89 to 96% total coliform reduction were also found with natural coagulant treatment of turbid water. Using locally available natural coagulants, suitable, easier, and environment friendly options for water treatment were observed. (Reduction of Turbidity of Water Using Locally Available Natural Coagulants by Asrafuzzaman, A.N.M.Fakhruddin, and Alamgir Hossain et al September 2011)

The problem of water pollution can only be minimize by clarify the industrial waste water at the place of its generation point by some chemical or biological treatment method. During present study the low cost material fly ash i.e. the waste of thermal power station which itself produce pollution of environment is used for purpose of water pollution control. Fly ash with specific surface area of 6177.15cm2/gm is used as a clarifier to the combined waste water of Sugar mill at room temperature. The different dosage of fly ash is kept in contact for 24 hours and analyzed before and after treatment. Fly ash of the thermal power station removes 20.88% BOD contributing components of the waste water. At room temperature fly ash works as an adsorbent and follow Freundlich and Langmuir isotherm models. The straight line nature confirms the applicability of isotherm. The Freundlich constant K an intercept on X- axis is related to adsorption capacity is found to be 0.25 while the slope 1/n is related to adsorption intensity is found to be 11.4454. The straight line of the Langmuir plot gives intercept on Y- axis called b x 103 L/mg i.e. adsorption energy is 0.7510 and the calculated adsorption capacity θ0 mg/gm is 9.(Removal of BOD contributing components from Sugar Industry Waste water using Bagasse Fly Ash-Waste material of Sugar Industry Milan M. Lakdawala* and B. N. Oza)

III. MATERIALS & METHODS

A. *Spirulina*

Wastewater from the sugar manufacturing processes was freshly collected from Sugar Industry. The effluent was brought to the laboratory and stored at 40C. It was used the next day for corresponding experimental batch. Cold-stored effluent was allowed to reach ambient temperature before commencing experimentation. Pure culture of Spirulina was obtained from Agriculture Science Centre located at Babhaleshwar, District Ahmednagar, MaharashtraState, India. Rectangular tanks (open photo-bioreactor) made up of glass of dimension 60cm (L) X 30cm(B), 45cm(H) were used for the experiments. Aerators were used for continuous supply of air to the medium in the tanks, at the rate of 3 L/min. A rotator device was prepared by mounting a simple steel paddle on a motor for six rotations per minute (RPM) & two tanks for continuous stirring of the medium present in the tank. Lutron make light meter was used to measure the light (in lux). Other instruments such as pH meter and spectrophotometer (Hach make, model DR 2000) were used for Sugar effluent treatment. Initial pH of the effluent was in the range from 3.6 to 4.1. Because algal cultures are maintained between pH 7 to 9, lime [Ca(OH)2—0.1 g/L of effluent] was used to adjust the pH of the effluent, potassium alum dosing was also carried out (*0.29 g/L of effluent), to settle suspended solids. This was mainly to reduce the possible interference of suspended solids from effluent in photosynthetic activity of Spirulina. The settled solids were removed by simple filtration using filter paper. The initial and final (after completion of effluent treatment) characteristics of effluent were determined in accordance with standard methods (Eaton et al2005). Experimental setup Five glass tanks labeled A,B,C,D and E were used for the experiment. In each tank, 10 L of above-described SME was poured. In tanks A and B, 1.5 L of Spirulina was added to the effluent. For tanks C and D, Spirulina was added to the effluent in a quantity of 0.250 L every day. This was to maintain exponential nature of growth pattern of Spirulina; some of the culture need to be recycled. Tank E was used as a control, i.e., without Spirulina—water was added in lieu of Spirulina. Air was supplied using aerators to tanks B and D. The supply of air was to support aerobic bacteria presumed to be present with Spirulina culture (Ciferri 1983) and in the effluent or introduced in the medium through air. In case of tanks A and C, the effluent with added Spirulina was continuously mixed by pre-fabricated rotation device. Cell density of Spirulina equivalent to 0.590 ± 0.010 O.D (at 660 nm) was maintained uniform for tanks A, B, C and D using a spectrophotometer. All tanks were kept under natural environmental conditions outside the laboratory. Sun was the source of light, and the tanks were 90 % covered by a shed net only at the top. Shed net permitted only 25 % of light to pass. This was to avoid photo-inhibition due to excessive light, nuisance of birds feeding on algae, avoid green-house effect inside the tank and minimize evaporation losses. Light energy was measured at the surface of the medium using a light meter. Treatment time Bio-chemical oxygen demand and chemical oxygen demand are important qualitative indicators of wastewater. According to effluent discharge norms of Ministry of Environment and Forests, Government of India (General Effluent Standards Schedule-VI, dated May 19, 1993), wastewater having BOD equal to or less than 100 mg/L can be utilized for irrigation purpose. It was not possible to measure BOD on a daily basis. Therefore, COD was used as a key test parameter, as it could be measured every day within few hours. The end point of experiment was COD (of filtrate of SME) reduction of[80 % of initial value or COD value of 250 mg/L, whichever occurred earlier. Filtered effluent samples from all the tanks were collected after 12-hrs intervals for testing of COD and BOD, nitrogen (N), phosphorous (P), and potassium (K) were measured only at the initial and final stages of the experiment.

B. *Natural Coagulants*

Preparation of natural co-0agulants-The seeds pods of M. Oleifera, CicerArietinum and Tamarind Seeds are collected and dried naturally by sunlight and remove the seeds from the hulls manually. The dried seeds were ground to fine powder by domestic blender. This powder was sieved through 600 micro meter sieve.

Coagulation-Flocculation Process-Jar test is the most widely used experimental methods for coagulation-flocculation. A conventional jar test apparatus was used in the experiments to coagulate sample of turbid water used in natural co-agulant. It was carried out as a batch test, accommodating a series of six beakers together with six-spindle steel paddles. Before operating the jar test the sample was mixed homogenously.

Process of Coagulation

1) Take 500ml of sample in each of the 6 beakers.

2) Add varying doses of coagulants (natural and chemical) of 0.05 to 5 mg/l in different beakers simultaneously.

3) Switch ON the motor and adjust the speed of paddles to about 100rpm and rapid mixing is done for 1-2 minutes.

4) Reduces the speed of paddles to about 30 to 40 rpm and continues slow mixing for 20 minutes. This corresponds to process of flocculation.

5) Switch off the motors and allow it to settle 20-60 minutes. This corresponds to sedimentation or settling of impurities.

6) Collect the supernant from each beaker with the help of pipette without disturbing the sediments and the measure the percentage of turbidity removal using the turbidity-meter.

7) Turbidity removal corresponding to various doses of natural co-agulant measured and the least dose producing maximum removal was designated as optimum coagulant dose.

8) Optimum system pH was found by adding optimum coagulant dose and the pH of the sample was varied from 5 to 9 and the pH value producing maximum turbidity removal was determined.

C. Adsorbent Bagasse Fly Ash-

In modern thermal power station pulverized coal is used and fly ash is obtained as a waste product in large quantities. Fly ash is also known as pulverized fuel ash. It was washed to remove excess fines and oven dried at 1000C for 24 hours before its use in experiments. It is gray colored material having specific surface area 6177.15 cm2/gm. Its chemical composition is approximately as SiO2 - 51 to 55%, Al2O3 – 26 to 28%, Fe2O3 -3 to 6%, CaO -3 to 5 %, MgO – 3 to 5% and S as SO3 trace. The known quantity (1 liter) of sample is treated with different amount of fly ash viz 2, 10, 20, 50, 100, 150, 200 gm/L stirred well and kept in contact for 24 hours at room temperature. Then the samples were filtered and analyzed for various physico-chemical characteristics. This study was especially concentrated on BOD removal. The method for determination of BOD practicable is 5 Day Incubation Iodometric titration method contains DO (Dissolved Oxygen) measurement followed from 'Standard methods for the water and waste water.

IV. RESULTS

1. Spirulina(COD reduction of sugar mill effluent)- As mentioned earlier, the experiment was replicated three times. A pre-defined end point (mentioned earlier at ''Treatment time'') for the experiment (SME treatment) was COD reduction of more than 80 % of its initial value or COD value of less than 250 mg/L. In this experiment, 53 and 50 % of COD reduction of SME was achieved in just 24-h time, in tanks A and B, respectively. For tank A, overall COD reduction of 91 % (final COD was 195 mg/L ± 12) was achieved in 108-h treatment time. In the same treatment time, COD reduction of SME in tank B was of 89 % (final COD was 242 mg/L ± 9). Most striking observation of this experimental set was COD reduction of SME by 81 % for tank C (provided with external rotation device) and 77 % for tank D in 108 h (provided with aerator). In these two tanks, instead of adding a bulk amount of Spirulina at start up, the same was provided freshly in a small amount i.e., 250 ml every day, in the SME. Reduction in BOD of SME was highest in tank A that was 91.3 %, followed by 89.4 % for tank B, 84.9 % for tank C and 81.2 % for tank D.

2. *Natural Coagulant- M. Oleifera*-The jar test operations using different coagulants were carried out in different turbidity ranges namely higher- (90– 120)NTU, medium-(40–50)NTU, and lower-(25–35)NTU of synthetic turbid water. The efficiency of the extracts of Moringaoleifera, Cicerarietinum, and Dolichos lablab made them used as natural coagulants for the clarification of water, Dose of Moringaoleifera (mg/L) Doses started from 50mg/L to 100mg/L for corresponding six beakers. Turbidity was measured before and after treatment. The raw water turbidity was 100NTU. Turbidity reduced to 13.1, 12.7, 10.6, 10, 9.2, and 5.9 NTU corresponding to 50, 60, 70, 80, 90, and 100mg/L Moringaoleiferadoses respectively. After filtration, turbidity reduced to 11.2, 10.9, 9.1, 8.6, 7.9, and 5 NTU, respectively. And, after filtration, it was 14.1, 13.8, 13.5, 12.9, 12.8, and 12.6 NTU, respectively. Moringaoleifera work well in higher-turbidity water than lower- and medium-turbidity water. Turbidity reduction increases with increasing doses.

Table 1- Reduction Efficiency of Turbidity using Natural Coagulant M. Oleifera

Dose used(in mg/lit)	% of Turbidity Reduction
50	85.00
60	87.77
70	89.23
80	90.00
90	91.39
100	93.40

3. ADSORBENT- FLY ASH:

The pH of the sample increased with increase in dosage i.e from 7.05 to 7.97. Conductance and hardness decreased upto 50 gm/L and then remain constant for higher dosages. Conductance decreases from 3.9 m mho (initial) to 3.33 m mho and hardness decreases from 2610 mg/L (initial) to 2060 mg/L. The alkalinity decreased considerably from 2625 mg/L (initial) to 1700 mg/L with increasing amount of fly ash. Chloride content reduced slightly upto 187.441 mg/L from 104.936 mg/L (initial) by 10 gm/L of fly ash. The initial COD content of the waste water was 4979.52 mg/L is reduced to

3734.64 mg/L with 200gm/L of fly ash and remains the same at 400gm/L. the BOD content in the initial stage was 1410.5 mg/L is decreased to 1116 mg/L by 150gm/L of fly ash and remain constant for higher doses.Table 2. shows the influence of dose variation of fly ash onto various physico-chemical characteristics of the combined waste water of Sugar Industry at room temperature.

PARAMETER	DOSE (in mg/l)	TREATED effluent (in mg/l)
pH	100	7.60
COD	100	3903.97
BOD	100	1133.43
Hardness	100	2102.00
Chlorides	100	190.56

V. CONCLUSION

This study demonstrates the viability of experimented technology for the treatment and recycling of SME. Use of Spirulina is a simple, less energy-consuming technology option treats the effluent by reducing its COD up to 91 % in 108 hr. Reduction of COD over 50 % was achieved in 24 hr. Protein production is immensely important to encourage the industry for generating revenue and recover the cost of effluent treatment. Therefore, the industry may seriously invest in ETP and operate it sensibly. Reduction of COD/ BOD of SME and growth of Spirulina are interdependent and therefore beneficial to the sugar industry. Using some locally available natural coagulants, for example, Moringaoleifera, significant improvement in removing turbidity and total coliforms from synthetic raw water was found. Maximum turbidity reduction was found for highly turbid waters. After dosing, water-soluble extract of Moringaoleifera, Cicerarietinum, and Dolichos lablab reduced turbidity to 5.9, 3.9, and 11.1 NTU, respectively, from 100 NTU and 5, 3.3, and 9.5 NTU, respectively after dosing and filtration. It was also found that these natural coagulants reduced about 89–96% of total coliforms. Among the natural coagulants used in this study for turbidity reduction, M. Oleifera was found most effective. It reduced up to 95.89% turbidity from the raw turbid water. The final combined waste water of Sugar manufacturing unit is highly polluted having higher BOD value. Sugar mill is treated with finely divided low cost material fly ash at room temperature for 24 hours of contact duration the following results are achieved. The initial COD content of the waste water was 4979.52 mg/L is reduced to 3734.64 mg/L with 200gm/L of fly ash and remains the same at 400gm/L.

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