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A STUDY ON THE PHYSICO-CHEMICAL CHARACTERISTICS OF SUGAR MILL EFFLUENTS

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Abstract — *This paper presents the performance of Upflow Anaerobic Sludge Blanket (UASB) Reactor in treating sugar industry effluent. The physico-chemical profile of effluent from sugar mill was determined. The parameters measured are temperature (40°C), colour, pH (7.5), BOD (83 mg/l), COD (321 mg/l), D.O (2.83 mg/l), total dissolved solids (2679.3 mg/l), total suspended solids (301.7 mg/l), total solids (2981 mg/l), chloride (211 mg/l), sulphate (649 mg/l) and oil & grease (14 mg/l). According to the permissible level suggested by Bureau of Indian Standards, almost all the water quality parameters in the sugar effluents have been found to be very high and well above the permissible limits. This study revealed that the effluent discharged from the sugar industry is highly polluted and exceeds the prescribed limits for irrigation and public use.*

Keywords- *pH, BOD, COD, D.O, Permissible level, Bureau of Indian Standards*

I. INTRODUCTION

Sugar is one of the most significant substrates for human diet and it is a vital product of the human life. India was the first to begin with the manufacture of sugar following the process of pressing sugarcane to extract juice and boil it to get sugar crystals. Sugar industry is one of the most significant agro based industries in India and is greatly responsible for creating major impact on rural economy in particular and general country economy. Depend on the availability of sugarcane; manufacturing of sugar from sugarcane is a seasonal operation, which lasts from October to May. Beet can also be used for producing Sugar, but the manufacturing activity being limited to about 100 days per year. As a result of its seasonal nature, sugar industries create peculiar problems for pollution control. A significantly huge volume of waste is generated during the production of sugar and contains a high amount of pollution load, mostly in terms of suspended solids, organic matter, and press mud, bagasse and air pollutants. Generally, several chemicals are used in sugar industries for coagulation of impurities and refining of end products. So, the Indian Sugar Industry comes under the classification of "Red" which represents highly polluting industries. Sugar industries effluents are characterized by high Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Dissolve Solids. Generally, Wastewater from sugar industry contains carbohydrates, nutrients, oil and grease, chlorides, sulfates, and heavy metals. Wastewater from sugar industry, if discharged without treatment, poses pollution problem in both aquatic and terrestrial ecosystems. Also, sugar industry wastewater when not treated completely produces unpleasant smell when released into the environment.

II. MATERIALS AND METHODS

For this study, the wastewater was collected from sugar industry in 10 liter can at the source and appropriately sealed. It was preserved for long period by the addition of chemicals to analyse in the laboratory. For the assessment of various Physico-Chemical characteristics, a standard procedure given by APHA was used.

Upflow Anaerobic Sludge Blanket Reactor (UASBR)

The experimental setup consists of Upflow Anaerobic Sludge Blanket Reactor, which is made out of plexi glass. The cylindrical portion of the reactor is 1.8 m height and 0.12 m diameter. The top of the reactor is hermetically sealed to avoid air entrapment. Bottom portion of the reactor is filled with fujino support media. The reactor is fed from the influent tank by means of a peristaltic pump of miclin's make and model pp-15. The influent to the reactor is at its bottom and the reactants move from the bottom, passing through the packed media. The reactor is provided with sampling ports at zones viz., hydrolysis, acidogenesis and methanogenesis in the reactor. Separate ports were provided for desludge at bottom and for scum removal at top. An agitator is provided at the influent tank to ensure the proper mixing of wastewater. The treated effluent from the reactor is obtained by overflow through effluent pipe, and at the top the gas got separated at GLSS and collected in a gas collector.

A. Colour

In the present study, the colour of the unprocessed effluent was dark brownish and processed effluent appeared in light brownish [1]. Colour is a qualitative characteristic that can be used to measure the general form of wastewater [2]. Colour is a very significant factor for aquatic life for the production of food from the sun rays. Due to the dark colouration, the photosynthesis activity is found to be reduced and also affects the other parameters like temperature, D.O, B.O.D. etc.

B. Temperature

The temperature of the effluent plays an imperative role for its effect on certain chemical and biological process taking place in water which affects the organism and inhabitation of aquatic medium [1]. It depends upon season, sampling time, etc. The water released from the industry, which is normally high in temperature and affects the land harmfully [3]. In this study, the temperature of untreated effluent was recorded as 40°C and treated effluent was recorded as 34°C [1]. The temperature of the discharge should not exceed 35°C. If the untreated effluent has high temperature (40°C), will adversely affects the germination process [1].

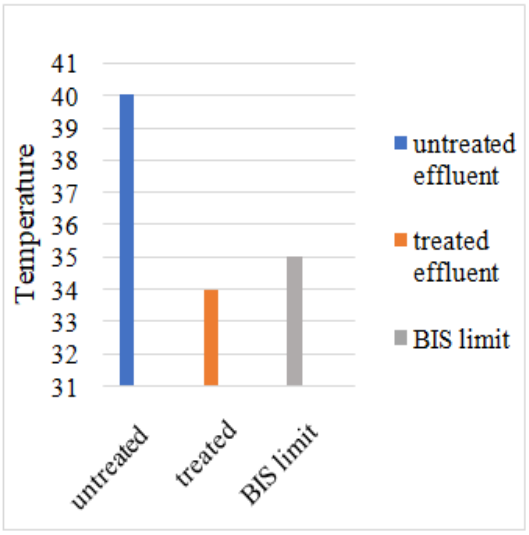

Fig. 1 Comparison between Treated and Untreated Temperature

C. pH

pH is the value expressed in the negative logarithm of the hydrogen ion concentration. Its value ranges from 0 to 14. 7 indicates neutral, less than 7 indicates acidic and above 7 indicates basic or alkaline. The broad narration in the pH of effluent can affect the biological reaction rate and endurance of several microorganisms [3]. pH is the one of the most essential biotic factor that serves as an pollution index [3]. If such water is used for irrigation purpose for a long period of time, the soil becomes acidic nature resulting in poor crops growth and yield [1]. The factors such as photosynthetic exposure to air, releasing of industrial wastewater and domestic sewage will affect the pH value of the soil [1]. In the present study, the pH value of treated effluent was recorded as 7.0 and untreated effluent was recorded as 7.5 respectively. According to BIS standards, the pH value of effluents should be in range 6.5 to 8.0 [1]. During the cleaning process of sugar cane juice, the use of phosphoric acid and Sulfur dioxide will lower the pH values of both treated and untreated effluents [1].

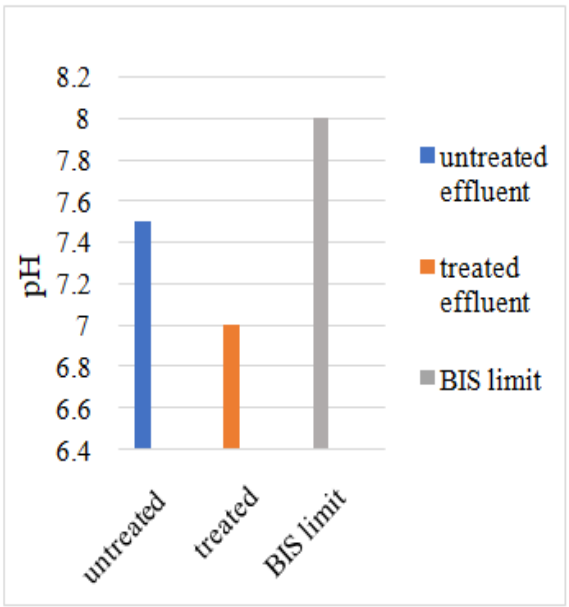

Fig. 2 Comparison between Treated and Untreated pH

D. Dissolved oxygen

It is one of the most essential parameter in water quality analysis. Dissolved Oxygen is an indicator of physical and biological process going in water. The Dissolved Oxygen level in natural water as well as waste water depends on physical, chemical and biological activities of the water body. In water pollution control as well as waste water control, the investigation of Dissolved Oxygen plays an important role. Aquatic environment is entirely depends on dissolved oxygen, various biochemical changes and its effects on metabolic activities of microorganism were very well recognized [3]. Its presence was necessary to retain a variety of forming of biological life in water and effects of water discharged into water body are mostly determined by oxygen balance of the system [3]. According to BIS standard, the Dissolved Oxygen of the wastewater should be within the range 4 to 6 mg/lit. In the present study, the Dissolved Oxygen of the untreated effluent was recorded as 2.83 mg/lit and treated effluent was recorded as 3.91 mg/lit respectively, which is sufficiently lower than the BIS Indian standard values [1].

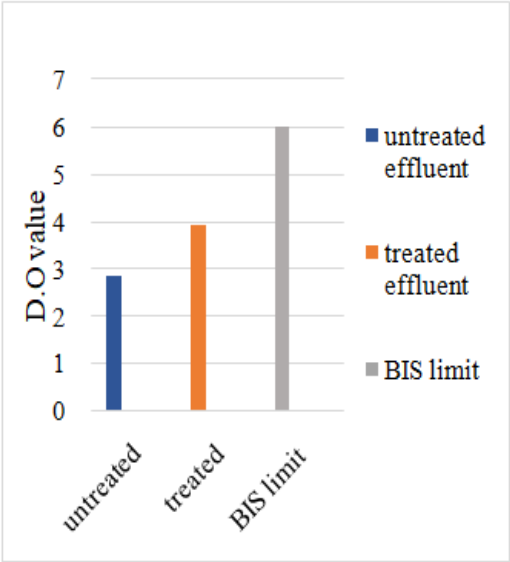

Fig. 3 Comparison between Treated and Untreated Dissolved Oxygen

E. Total Solids (T.S)

The term solid refers to the substance either filterable or in filterable that remain as residue upon venerating and subsequent drying at a particular temperature employed for drying and ignition. Based on method of application, there are different forms of solids are defined for their determination. In wastewater total solids, total dissolved solids and total suspended solids are generally composed of carbonates, bicarbonates, chlorides, sulphates, nitrates, Ca, Mg, Na, K, Mn and organic matter silts and other water polluting particles which increase the concentration of total solids. In the present study, the range of total solids for untreated effluent was recorded as 2981 mg/lit and treated effluent was recorded as 2641 mg/lit respectively [3].

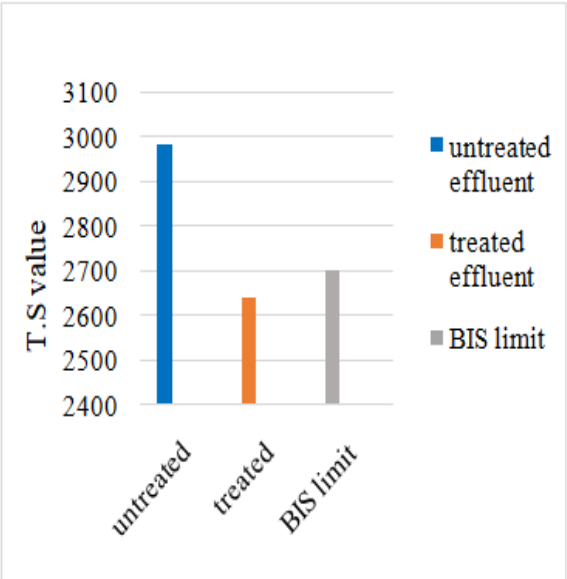

Fig. 4 Comparison between Treated and Untreated Total Solids

F. Total Dissolved Solids (T.D.S)

In summer, the concentration of total solids was maximum, which increased in rainy season whereas in winter it was found as minimum value probably because of stagnation. The concentrations of total solids in waste water represent the colloidal form and dissolved specters. The feasible reason for the variations in values of total solids and subsequent value of dissolved solids are due to the convent collision of the colliding particles. The collision rate for aggregated process is also influenced by pH of these effluents. In the rainy season, low concentrations of total dissolved solids are obtained due to dilution of wastewater with rain water [Hosetti et.al, (1994)]. In the present study the total solids for untreated effluent was 2679.3 mg/l and 2379 mg/l for treated effluent. The Total Dissolved Solids values for both samples are much higher than BIS Indian Standards (2100 mg/L) [3].

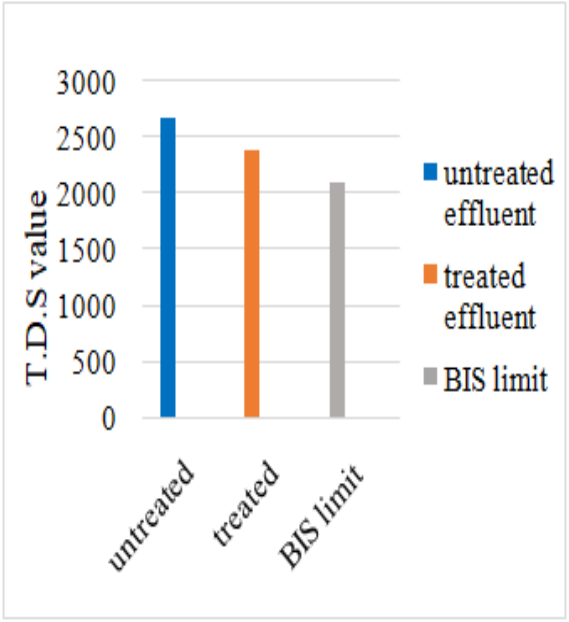

Fig. 5 Comparison between Treated and Untreated Total Dissolved Solids

G. Total suspended solids (T.S.S.)

The light intensity of water is affected by the Total Suspended Solids. Suspended solids are reason for the suspended particles inside the water body influencing turbidity and transparency. Wastewaters from the different industries may have different amount of solid particulate matter either as suspended solids or total dissolved solids. In the present investigation, the suspended solid for untreated effluent was 301.7 mg/l and 262 mg/l for treated effluent respectively.

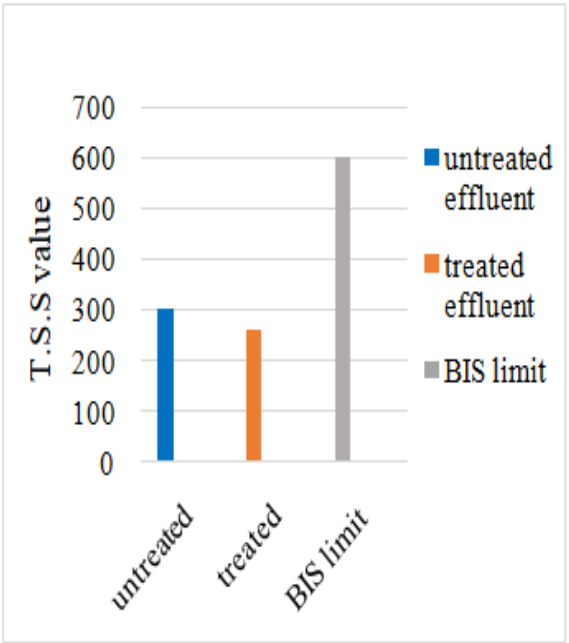

Fig. 6 Comparison between Treated and Untreated Total Suspended Solids

H. Biochemical Oxygen Demand (B.O.D)

Biochemical Oxygen Demand (BOD) is defined as the amount of oxygen required by the microorganism to biologically degrade the organic matter in water under aerobic conditions. The biological oxidation process is a very slow process during oxidating organic pollutants are oxidized by certain microorganism into carbon dioxide and water using Dissolved Oxygen. Therefore, low dissolved oxygen value is the measure of BOD relation. Biological oxygen demand is an essential parameter that indicates the extent of water pollution, by the oxidizable organic matter and the oxygen is used to oxidize inorganic material likes sulphides and ferrous ions [3]. In the present study, the BOD of the untreated effluent was recorded as 83 mg/l and the treated effluent was recorded as 72 mg/l. According to BIS Indian standard, the BOD should not exceed the 30 mg/l.

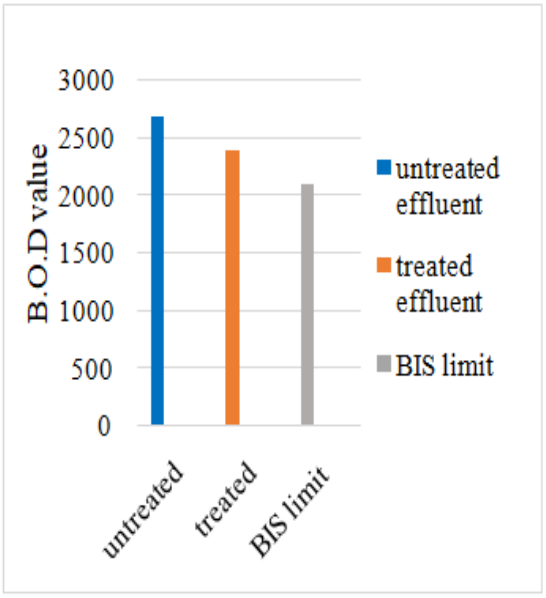

Fig. 7 Comparison between Treated and Untreated Biochemical Oxygen Demand

I. Chemical Oxygen Demand (C.O.D)

The Chemical Oxygen Demand (COD) test determines the oxygen required for the chemical oxidation of organic substance with the aid of strong chemical oxidant. The Chemical Oxygen Demand (COD) is an experiment, which is used to evaluate the pollution level of domestic and industrial waste. The waste is calculated in terms of quality of oxygen required for oxidation of organic matter to produce carbon dioxide and water. It is a fact all organic compounds with few exceptions that they can be oxidized by the activity of strong oxidizing agents under acidic conditions. COD is useful in investigative toxic condition and existence of biological resistance substances. The conjugation of BOD test, with the COD test is helpful to indicate the toxic conditions and the existence of biological resistance. In the present study, the COD of the untreated effluents was recorded as 321 mg/l and the treated effluent was recorded as 259 mg/l. In untreated effluent the COD level is noticeably higher than to BIS standard (250 mg/L). This indicates the high organic pollutants exist in the sample.

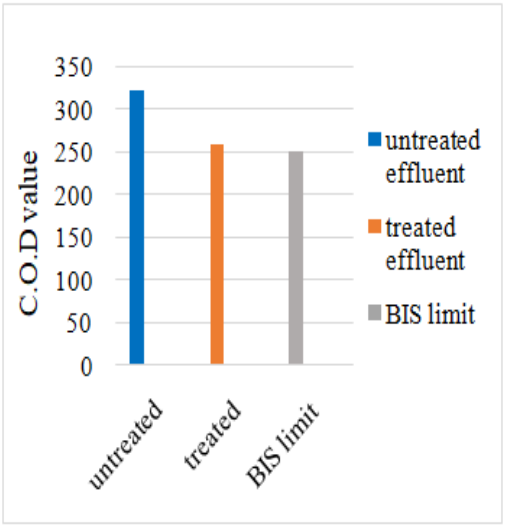

Fig. 8 Comparison between Treated and Untreated Chemical Oxygen Demand

J. Chlorides

In natural water, the presence of Chlorides is usual. The existence of chloride in natural water attributed to dissolution of salt deposits releasing of wastewater from chemical industries, oil well operations, sewage discharges, initiation drainage, contamination from refuse leachates, and sea water invasion in coastal area. In the present investigation, the Chlorides in untreated effluent were recorded as 211.66 mg/l and in treated effluent were recorded as 181 mg/l. This is well within the limits of BIS Indian Standard.

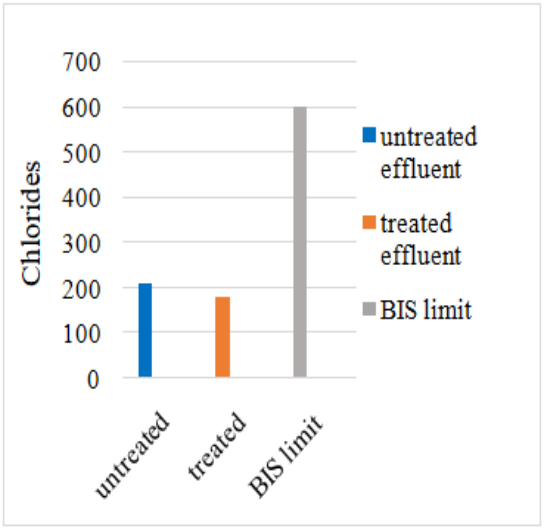

Fig. 9 Comparison between Treated and Untreated Chlorides

K. Sulphate

Sulphate is one of the most active occurring in natural water. It may come into natural water through weathering of deposits. It may be leached from sedimentary rocks and also from sulphate deposits like gypsum and anhydrate. Wastewaters from the certain industries are also major sources for sulphate into the receiving water. Sulphate can also be produced by factorial or by an oxidizing action as in the oxidation action or in the oxidation of oregano sulphur compounds. Sulphur itself has never been a preventing factor in aquatic system, the standard levels of sulphates are more than sufficient to meet plants needs. Odours are easily greater when water is over loaded with organic waste to the point that oxygen is reduced, the SO4 is an electron acceptor is frequently used for the disintegration of organic matter and H2S is produced causing bad smell of rotten egg [Welch 1980]. In this present study, sulphate in untreated effluent was recorded as 649 mg/l and treated effluent was recorded as 341.5 mg/l. According to BIS Indian standard the sulphate level should not exceed the 100 mg/l. High amount of SO42- in both treated and untreated effluents is attributed to the use of sulphur during crystallization process.

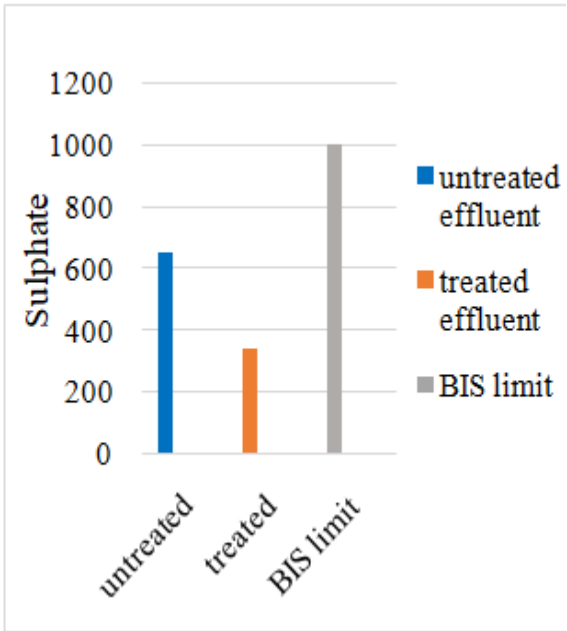

Fig. 10 Comparison between Treated and Untreated Sulphates

L. Oil and Grease

It is present in the water can be extracted in petroleum also which is immiscible in water and can be removed by a separatory funnel. Oil, grease, fats and waxes are dissolved in appropriate solvent and separated from the aqueous phase. The solvent film is then evaporated and the residue is weighed as oil and grease. In the present investigation, oil and grease present in untreated effluents was recorded as 14 mg/lit and treated effluents was recorded as 9 mg/lit respectively.

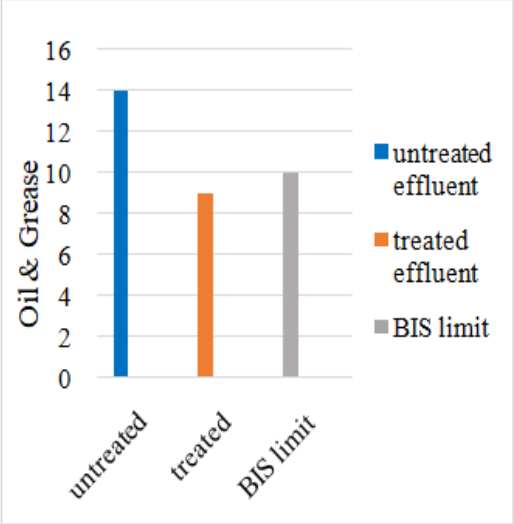

Fig. 11 Comparison between Treated and Untreated Oil and Grease

III. CONCLUSIONS

The untreated effluent from sugar industry contains high amount of COD, BOD, TSS, TDS, TS and low content of DO which is harmful to plants. So it is not permissible for irrigation purpose. Untreated waste water from sugar industry shows higher values of cod and low value of do. The treated effluent from the sugar industry, which is well balanced of chemicals if it is diluted with fresh water, then it is suitable for irrigation purpose. Effluent which is discharged from sugar industry is treated and then it may be utilized for industrial processing again. Recycling of waste water is achievable in sugar industry and it is economically cost-effective for sugar industry. The treated effluents from sugar industry are not extremely polluted and they satisfy the ISI standard values and hence it can be used for irrigation purpose.

IV. ACKNOWLEDGMENT

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