Performance Evaluation of Effluent Treatment Plant for Sugar Mill Effluent

[1]Baraniya.C, [2]Dr.Jodhi.C
[1]PG Student, Department of Civil Engineering, Annamalai University.
[2]Assistant Professor, Department of Civil Engineering, Annamalai University.

Abstract : Sugar industry plays a significant place in the Indian economic development. Nevertheless, the wastewater generated from these industries stand a high degree of pollution load. Generally, Sugar Industry is one the most polluting industry in the environment. The sugar industry wastewater is characterized by its brown colour, low pH, high temperature, high BOD, high COD, odour problem, total solids, and high percentage of dissolved organic and inorganic matter. So this untreated wastewater will create problem to the environment. The analyzed parameters are pH, COD, BOD, TS, TSS, TDS, Oil and Grease. Initial concentrations of COD, BOD, TSS, TS, and TDS are 5132mg/l, 2095mg/l, 831mg/l, 5122mg/l, and 4583mg/l respectively. After treatment of effluent the removal efficiency of COD, BOD, TDS, TSS, TS, Oil and Grease are 97%, 95.25%, 74.75%, 88.2%, 81.19%, 65.41% respectively.

Keywords **- BOD, COD, TS, Oil and Grease, removal efficiency.**

I. INTRODUCTION

Sugar industry is a water intensive industry. It is a seasonal industry working for maximum of 5-6 months in one season. This industry uses sugarcane as their raw material besides with a variety of chemicals added to increase the face value of the end product. Huge amount of water is used per day during the process and as a result industry produces waste water on daily basis [1]. Sugar industry wastewaters are characterized by high biological oxygen demand (BOD), chemical oxygen demand (COD), and total dissolve solids. Generally, effluent from sugar industries consists of carbohydrates, nutrients, oil and grease, chlorides, sulphates, and heavy metals.

If effluent from sugar industries is not treated appropriately, it contains considerable amount of TDS and TSS. This water cannot be useful for irrigation purposes. There are many investigations which point out that, the infiltration rate decreases with increased loading of BOD, TDS & TSS. A TDS of 500-1000 ppm may have harmful effect on sensitive crops. Due to high concentration of solids in the wastewater, the dissolved oxygen available to germinating seeds of plants gets depleted. This results in reduction of energy supply reaching them through anaerobic respiration. This manifests into decrease in growth and development of the seedlings. In view of the above facts, it is reasonably evident that the sugar industry is a major contributor to the environmental pollution and has typical problems. This causes complexity in employing biological pollutional abatement systems which should otherwise remain very suitable for treating such wastes [2]. In this paper the removal efficiency of BOD, COD, TS, TSS, and TDS in Sugar Effluent treatment plant was studied.

Once the concentration of pollutants in the effluents is determined, the wastewater treatment system can also be adapted as per the up-to-date modern technology to reduce the maximum concentration of pollutants in the effluent [3].

1.1 Sugar Manufacturing Process

Milling, Clarification, Evaporation, Crystallization, and Centrifugation are the steps involved in the manufacturing of sugar. In milling process, the juice is extracted by crushing the sugarcane. During milling process, a few amount of water is added to crushing the sugarcane which is known as imbibitions water, to amplify the effectiveness of juice extraction process. After the juice extraction, fibrous residue, which is known as bagasse, is usually utilized as coal for boiler after drying. The juice extracted is very turbid and green in colour. $Ca(OH)_2$ and SO_2 is used to clarify and bleach the extracted juice followed with clarification by continuous clarifier.

The clear juice is decanted and the juice remaining in the sludge is recovered by sending the thickened sludge to the rotary drum vacuum filter. Water is added to increase the efficiency of process during the filtration process and the de-watered sludge which is known as 'press mud' is leftover and utilized as fertilizer. Under vacuum, the remaining water is evaporated. The residues in the vacuum pans is called 'massecuite', which is then centrifuged, washed, dehydrated, screened, and packaged.

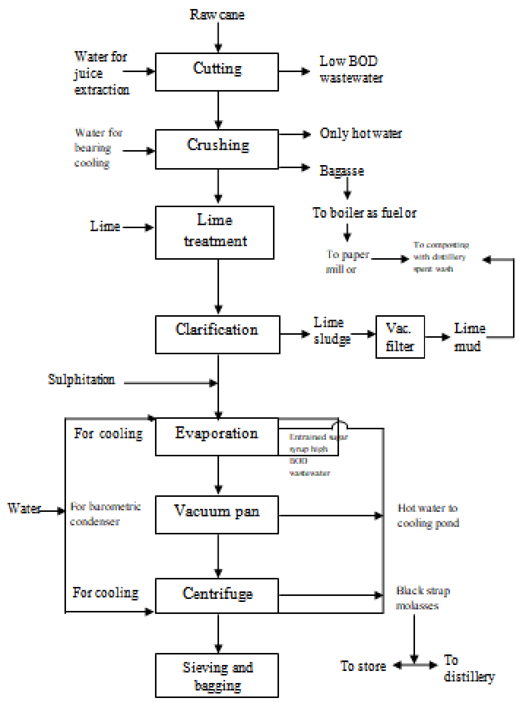

Figure. 1 Cane Sugar Manufacturing Flow Diagram

1.2 Sources of waste water

In view of generated wastewater amount and quality, sugar industries are the one of the largely polluting industries. Amount of wastewater generated depends on the cane crushing ability of the industry and management of water. In India Sugar industries produces about 1,000 L of effluent for one ton of sugar cane processed.

In Sugar industry, wastewaters are generally produced during cleaning operations. Huge volume of wastewater are usually generated during washing of milling house floor, various division of boiling house like evaporators, clarifiers, vacuum pans, centrifugation, etc. Moreover, wash water used to filter cloth of rotary vacuum filter and periodical cleaning of lime water and SO_2 producing house becomes the part of effluent.

NaoH and Hcl are used for the periodical cleaning of heat exchangers and evaporators to get rid of scales on the tube surface which contributes organic and inorganic pollutant loadings to effluent. Leakages from pumps, pipelines, centrifuging house are also contribute to producing the wastewater. Apart from this, wastewater is also generated from boiler blow down, overflow of spray pond and from condenser cooling water which is released as wastewater when it gets polluted with cane juice.

1.3 Sources of effluents in a sugar industry

The waste water produced from different sub-streams is classified as follows:

1.3.1 Mill House

The wastewater contains water used for cleaning the mill house floor which is answerable to be transformed by spills and contented sugar juice (This clearing up process will resist the augmentation of bacteria on the juice-covered floor). In addition, Water used for cooling of mills also forms part of the effluent from this source. Mostly this wastewater consists of organic matter like sucrose, bagacillo, oil and grease from the bearings fixed in to the mills.

1.3.2 Boiling House

The effluent from boiling house results from leakages through pumps, pipelines and washings of different section like evaporators, juice heaters, clarification pans, crystalling action, and centrifugation etc. The cooling water from different pumps also forms the part of water.

1.3.3 Blow-down

The water used in boiler consists of suspended solids, dissolved solids like calcium, magnesium, sodium, fatty salts etc. These salts get concentrated after stream generation from the original water volume. These solids have to be expelled time to time to protect the boiler from the scales formation.

1.3.4 Excess Condensate

Generally the excess condensate does not contain any noxious waste and is used as boiler feed water and the washing operations. Sometimes it gets polluted with juice due to distraction of leftover solids with the vapours being condensed; in that case it goes in to the effluent outlet. In this case, the treatment requirement is nearly negligible and can replace fresh water or released directly as irrigation water after cooling it to ambient temperature.

1.3.5 Condenser cooling water

Condenser cooling water is recirculated once more, otherwise it gets polluted with juice, which is feasible due to flawed entrainment separators, Faulty operation beyond the design rate of evaporation etc. If gets polluted and the water should go into the drain unnoticeably. The water volume is also increased by extra condensing of vapour trained from the boiling juice pan.

1.3.6 Soda and Acid Wastes

Caustic soda and hydrochloric acid are used to clean the heat exchangers and evaporator with the intention of eradicating the formation of scales deposits on the surface of the tubing. In India, most of the sugar industries let this expensive chemicals go into the outlet. The soda and acid wash contribute significant amounts of organic and inorganic pollutions and may cause shock loads to waste water treatment once in a fortnight or so.

1.4 Effect of wastewater

After a few hours of stagnation, the fresh wastewater from the sugar industry decomposes quickly. It has been found that it causes significant problems when their waste water gets an access to the water courses, predominantly the small and non-perennial rivers in rural areas. Secondary pollutions such as unpleasant odours, black colour, and mortality of fishes caused by the rapid depletion of oxygen due to biological oxidation followed by anaerobic stabilization of the waste. No difficulty of discharge of this effluent into sewers is arises, as most of the sugar factories are located in the un-sewered rural areas [2].

II. MATERIALS AND METHODOLOGY

2.1 Sampling method

Water sample will be collected in such a way that the sample truly represents the water source or the main body of water or wastewater. Sampling is one of the most significant and primary steps in collection of representative effluent sample from an effluent treatment plant. The consistency of laboratory examination and tests depends upon the method of sampling. A thing concerned in the appropriate selection of sampling site depends on the intention of the study. Generally, a quantity of sample between 2 and 3 litres is adequate for a fair complete investigation.

2.2 Physical and Chemical methods

Physico-chemical parameters such as pH, electrical conductivity, COD, chloride, magnesium, sulphate, calcium and TDS were comparatively high in the sugar industry wastewater and severely affected the seed germination [4]. The sugar industry wastewater is characterized by its brown colour, low pH, high temperature, high BOD, high COD, odour problem, total solids, and high percentage of dissolved organic and inorganic matter**.** Some general parameters are to be analysed to determine the performance and evaluation of sugar industry effluent treatment plant.

Table 1. Analytical Methods adopted for sugar industry wastewater analysis

Sl. No	Parameter	Method Used	Experiment Used
1.	pH	Electrometric	Digital pH meter
2	Total Solids	Gravity metric method	Gooch Crucible and electronic Balance, Burner
3	Total Dissolved Solids	Gravity metric method	Gooch Crucible, Centrifuge machine, Electronic Balance, Burner
4	Suspended Solids	Gravity metric method	Gooch crucible, Electronic Balance, Burner, Centrifuge Machine

5	BOD5 @ 20°C	Dilution Method	Volumetric glassware's, BOD Bottles, Incubator
6	COD	Open reflux method	COD apparatus, Round Bottom Flask

Table 2. Typical composition of Sugar Industry wastewater

Sl. No.	Parameter	Average Values	Effluent Standard for discharge on inland Surface Water	Effluent Standard for discharge on land for irrigation
1	pH	10.69	5.5-9.0	5.5-9
2	TS	4530(mg/L)	-	-
3	TDS	3758(mg/L)	-	-
4	TSS	772(mg/L)	100	200
5	BOD	1988(mg/L)	30	100
6	COD	5102(mg/L)	250	-
7	Oil and grease	14	10	10

2.3 Effluent Treatment Plant

In sugar industry, consumption of huge volumes of water and production of organic compounds as liquid effluents causes major environmental problems. The insufficient and haphazard disposal of this wastewater into soils and water bodies has inward much attention since decades ago, due to the environmental problems related to this practice. The sugar industry is amongst those industries with the major water demands and in addition, it is an essential source of non-toxic organic pollution [5].

The Effluent Treatment Plant units used sugar industries are:

a. Screen Chamber cum Oil & Grease tank
b. Equalization Tank
c. Mixing Tank
d. Aeration Tank with aerator
e. Clarifier
f. After dilution
g. Sludge Drying Bed.

2.3.1 Screen and Oil & grease

Screening is the primary unit operation in ETP which removes the solids from the effluent. Whereas Oil & Grease trap removes the oil & grease from the influent which may cause harm to pumping unit, hazard to biological treatments and floating substances like grease, oil, fats etc. from sugar industry effluent. And also reduces the COD and BOD values. Removal efficiency of COD and BOD are 36.51% and 22.8% respectively.

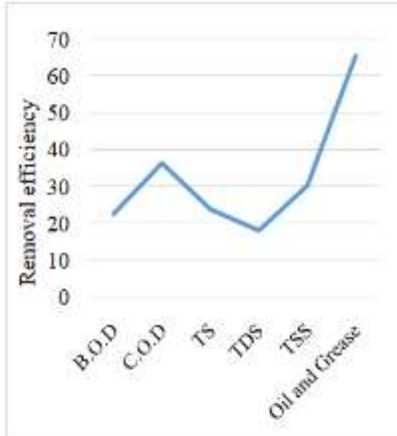

Figure. 2 Removal Efficiency of Screen Chamber

2.3.2 Equalization Tank

Equalization tanks may be used for temporary storage of diurnal or wet-weather flow peaks. Basins offers a place to temporarily hold the receiving wastewater during the plant maintenance and a means of diluting and distributing batch discharges of poisonous or high-strength waste which may otherwise restrain the biological secondary treatment (including moveable toilet waste, vehicle holding tanks, and septic tank pumpers). An equalization basin necessitates variable discharge control, typically contains provisions for bypass and cleaning, and may also include aerators. If the basin is in downstream of screening and grit removal, the cleaning may be an easier process.

2.3.3 Mixing Tank

Generally mixing tanks are provided for the thorough mixing of the influent wastewater which if held in the equalization basins. The mixing is carried out with the aid of mechanical stirrers.

2.3.4 Aeration tank

Aeration is the process by which air is distributed through, mixed with or dissolved in a liquid or substance. Therefore, aeration tank are provided to aerate the effluent by the biological treatment of the waste can be carried with higher efficiency. The primarily treated wastewater would be collected in the aeration tank for degradation of organic matter with the aid of micro-organism. The micro-organism was developed and maintained in the Aeration tank in conjugation with oxygen transferred through Diffused Aeration System. Here reduction of BOD is 83.89% and which increases the purification of wastewater.

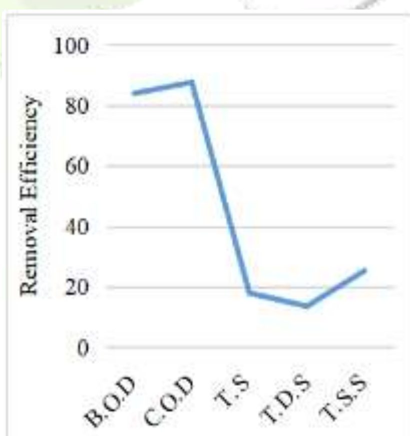

Figure. 3 Removal Efficiency of Aeration Tank

2.3.5 Clarifier

Clarifiers are settling tanks built with mechanical means for constant removal of solids being deposited by sedimentation. Generally, a clarifier is used to eliminate the solid particulates or suspended solids from wastewater for clarification. High-strength impurities, discharged from the bottom of the tank are known as sludge, whereas the particle that floats on the surface of the wastewater is called as scum. The removal efficiency of suspended solids is 23.49% and total solids removal efficiency is 27.32%.

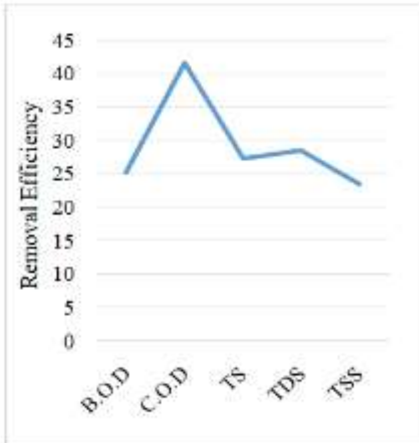

Figure. 4 Removal Efficiency of Clarifier

2.3.6 After Dilution

After clarification, the fresh water is added to the treated wastewater. And then which is used for irrigation purposes. The removal efficiency of BOD, COD and TSS are 15.19%, 20.53% and 68.31% respectively.

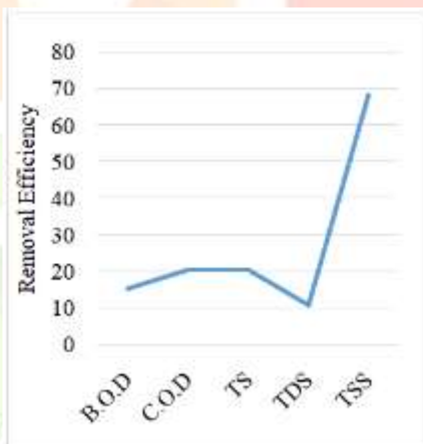

Figure. 5 Removal Efficiency of dilution Point

2.4 Sludge Drying Bed

The sludge drying beds are used for dewatering the settled sludge. The remaining sludge from the clarifier is discharged to sludge drying beds at intervals so that the concentration of MLSS is maintained in aeration tank. These are the sand beds of 250 mm of sand over about uniformly thick well-graded gravel layer, underlain by perforated drainage lines spaced 2.5 to 6 m apart. The bed should slope towards the discharge end at rate of 1 in 200.

2.5 Overall efficiency

The overall efficiency of treatment plant for BOD_5, COD, TSS, TS and TDS are 95.25%, 97%, 88.2%, 81.19% and 74.75%.

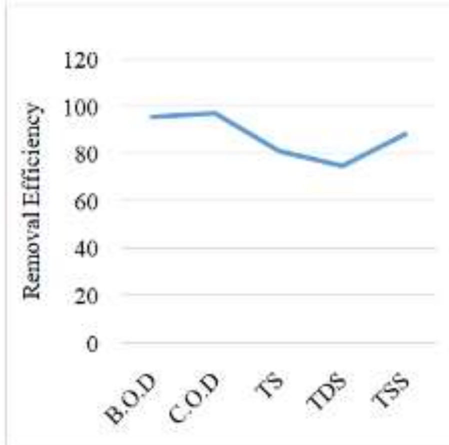

Figure. 6 Removal Efficiency of treatment plant

III. CONCLUSIONS

The screen chamber cum Oil and Grease trap removes oil and grease, BOD, COD, TS, TDS and TSS are 65.41%, 22.8%, 36.51%, 23.9%, 18.2% and 30.4%. The removal efficiency of Aeration for BOD, COD, TS, TDS and TSS are 83.89%, 87.58%, 17.83%, 13.48% and 25.23% respectively. The removal efficiency of clarifier for BOD, C.O.D, TS, TDS and TSS are 25.29%, 41.63%, 27.32%, 28.47% and 23.49% respectively. The removal efficiency of after dilution for BOD, COD, TS, TDS and TSS are 15.19%, 20.53%, 20.48%, 10.81% and 68.31% respectively. Overall efficiency of treatment plant for removal of COD, BOD, TSS, TS and TDS are 97%, 95.25%, 88.2%, 81.19% and 74.75% respectively.

This study concerned with the sugar manufacturing process and ETP for sugar industry. It can be concluded that, the overall performance of the effluent treatment plant was acceptable. The individual units are also performing well and their removal efficiencies are satisfactory. The effluent which is untreated exhibits high COD, BOD, TDS and low contents of DO which is toxic to plants, so it is not tolerable for irrigation. Treated wastewater of sugar industry which is well balanced of chemicals if it is diluted with fresh water, will be suitable for irrigation purposes. The treated wastewater meets the permissible levels for discharge into inland surface water. Therefore, it can be said that the plant is working efficiently. This treatment plant is high potential for reducing pH, Temperature, TSS and COD.

REFERENCES

[1]. Abdul Rehman, Memon, Suhail Ahmed Soomro and Abdul Khaliq Ansari, "Sugar Industry Effluent –Characteristics and Chemical Analysis", Journal of App.Em.Sc:1(2), pp.152-157, April 2006.
[2]. M. Narayana Rao and Amal K Datta, "Wastewater Treatment-Rational Methods of Design and Industrial Practices, Third Edition, Oxford & IBN Publishing Co. Pvt. Ltd., New Delhi, India.
[3]. D. Shiva Kumar and S Srikantaswamy, "Evaluation Of Effluent Quality Of A Sugar Industry By Using Physico- Chemical Parameters, International Journal of Advanced Research in Engineering and Applied Sciences, Vol. 4; No. 1; 2015, ISSN: 2278-6252.
[4]. Sajani Samuel and S.M. Muthukkaruppan, "Physico-Chemical Analysis of Sugar Mill Effluent, Contaminated Soil and its Effect on Seed Germination of Paddy (OryzasativaL.), International Journal of Pharmaceutical & Biological Archives IJPBA, Vol. 2, Issue 5. Sep – Oct.
[5]. M. Rais, A. Sheoran, "Treatment of Sugarcane Industry Effluents: Science & Technology issues, M. Rais Int. Journal of Engineering Research and Applications, Vol. 5; No. 1(Part 2); 2015, ISSN: 2248-9622.
[6]. A.S. Tanksali, "Treatment Of Sugar Industry Wastewater By Upflow Anaerobic Sludge Blanket Reactor, International Journal of Chem Tech Research, Vol. 5; No. 3; 2013, ISSN: 0974-4290.
[7]. U.S. Hampannavar and C.B. Shivayogimath, "Anaerobic treatment of sugar industry wastewater by Upflow anaerobic sludge blanket reactor at ambient temperature, International Journal of Environmental Sciences, Vol. 1; No. 4; 2010, ISSN: 0976-4402.
[8]. Jai Prakash Kushwaha, "A review on sugar industry wastewater: Sources, Treatment Technologies, and Reuse". Desalination and Water Treatment (2013) 1–10.
[9]. Kolhe, "Physico-Chemical Analysis of Sugar Mill Effluents", International Research Journal -Issn-0974-2832.
[10]. Mrunalini M. Powar, Vijay S. Kore, Sunanda V. Kore and Girish S. Kulkarni, "Review on Applications of UASB Technology for Wastewater Treatment", International Journal of Advanced Science, Engineering and Technology. Vol 2, Issue 2, pp 125-133 ISSN 2319-5924.

[11]. Pradeep Kumar Poddar, Omprakash Sahu, "Quality and management of wastewater in sugar industry". Applied Water Science, March 2017, Volume 7, Issue 1, pp 461–468.

[12]. C.B. Shivayogimath, T.K. Ramanujam, "Treatment of distillery spentwash by hybrid UASB reactor". Bioprocess Engineering 21 (1999) 255-259. Springer-Verlag 1999.

[13]. Weqar A. Siddiqui and Muhammad Waseem, "A Comparative Study of Sugar Mill Treated and Untreated Effluent- A Case Study". Oriental Journal of Chemistry- Vol. 28, No. (4): Pg. 1899-1904 (2012).