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Zero Waste Sugar Industry by Using Bio-tower

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Abstract **-** In recent years we have been moving towards more and more industrial development. As a result we are facing environmental pollution problems. The waste water emanating from this highly processed industrial processes which are putrescibles in nature. Hence treatment of such waste water is essential before disposal of river, stream etc. The quality of waste water decides the line of treatment. The study under taken involved the characterization of wastewater and the sugar waste is selected for this purpose. Bio-tower is using in the effluent treatment plant. The supernatant from primary clarifier is further subjected to bio-tower. Bio- tower is provided with plastic media for attachment of bacteria, which increases contact time to bacteria and food (BOD). This plastic media have large surface area and high void age ratio. Effluent will be re-circulate to the bio-tower to maintain wetting rate of plastic media and part of effluent passed to settling tank where the settle particles are taken out from the bottom in the form of sludge. The biological sludge is sent to sludge drying beds for dewatering. The Paper includes case study of Bhenda sugar factory. In this effluent plant they use bio-tower which gives good result other than conventional methods of effluent treatment.

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INTRODUCTION

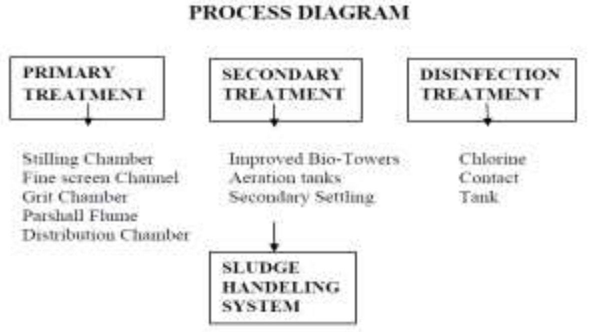
The co-operative sugar factories are not only income generating to sugar producing establishment but they are biggest employers. In 2005-06 there are 173 sugar factories are registered in Maharashtra state out of which more than 90% factories are co-operative sugar factories and situated in western Maharashtra, Marathwada and Vidarbha. Out of which 173 sugar factories more than 50% factories are located in western Maharashtra and these units are successful units and have played vital role in development of western Maharashtra. There are 19 sugar factories in Ahmednagar.

Sugar industry is a seasonal industry operating for maximum of 4-5 months in one season. Industry uses sugarcane as their raw material along with chemical added to increase the face value of the final product. During the process a huge amount of water is also use per day and as result industry generates waste water (effluent) on daily basis. Waste water from the mill house is usually contaminated with oil and grease. The spillage of oil and grease on the floor of mill house from the machinery and equipment is washed away during floor washing. The wastewater, which is generated from process house mainly results from floor and equipment washing and is highly contaminated with additives and other chemicals used at different processing stages. Boiler house mainly contributes to the production of air pollution and have little share in water pollution. Sugar industry is a large water consumer and there is no stage in sugar production where water is not required. Mostly water is required in the sugar mills as cooling water for barometric condensers, boiler feed water, for lime preparation, for dilution in evaporators, etc.

Sugarcane entering the factory contains about 70% moisture. As a result, excess water has to be disposed of, even with the most stringent conditions of water reuse. It has been observed that each ton of cane crushed should procedure about 0.7 m3 of water if sugar and water are completely separated. According to Indian standards, water consumption varies from 1.3 to 4.36 m3 per ton of sugarcane crushed (Trivedi, 1998). Literature suggests (Jakhrani, 2002) that wastewater generated is about 20% of the water requirement. However, this stoichiometry is not done or applied in the mills in question. Based on this ratio, a sugar mill with crushing capacity of 4500 tons of cane per day (TCD) require 9000m^3/day of water with 1:2 ratio and hence the mills generate the wastewater in the range of 1800m$^{3/}$day. The sugar mill wastewater is characterized by its brown colour, burnt-sugar like odour, high temperature, low pH, high ash or solid residues and contains high percentage of dissolved organic and inorganic matter of which 50% may be present as reducing sugar.

IMPROVED BIO-TOWER TECHNOLOGY

Fig. Flow chart of process diagram



Treatment units:

The treatment scheme consists of:
A) Primary Treatment Units, B) Secondary Treatment Units,
C) Solid liquid separation Units, D) Disinfection Arrangement.

A) Primary Treatment Units:
Comprise of Stilling Chamber, Fine Screen Channel, Grit Chamber, Flow estimation game plan and Distribution Chamber Stilling Chamber diminishes the speed of the approaching sewage before it enters the fine Screen channel. Fine Screen Channel is intended to evacuate the particles of size more than 5 mm. Drum sort Fine screens are proposed in the plant. Isolated solids will be tackled transport line and gathered at base through chute. Coarseness Chamber is

intended to evacuate inorganic matter of particular gravity more than 2.5 and size more than 0.15 mm. The settled coarseness is expelled from the chamber by coarseness instrument to the side channel. Coarseness is expelled by coarseness screw from the channel and taken to base through chute. While doing this coarseness is washed with the assistance of coarseness wash pumps to partitioned natural matter connected to coarseness assuming any. After coarseness chamber stream is measured and taken to dispersion chamber to convey the stream to the Improved Bio-Towers.

B) Secondary Treatment Units**:**

Comprise of Improved Bio-Tower, Mixing Chamber and Aeration Tank.2Trickling channels with rock pressing has been a typical basic and low vitality process utilized for auxiliary treatment since mid-1900s. The idea of a streaming channel developed from the utilization of contact channels in England in the late 1890s. Natural development on the media surface changes over the natural waste material into stable by-items, for example, CO_2, H_2O utilizing microorganisms basically the microscopic organisms. The old plants utilized for the most part Rock as the surface for the appended development natural frameworks. This media had impediments because of Heavy weight, elaborate supporting structure, water tight fringe dividers intended to take sidelong push, low voltage, possibilities for stopping, fly aggravation, poor wetting qualities and so forth. Despite the fact that the issues with rock media were driving and expanded utilization of suspended development organic frameworks, the worthwhile of the procedure all things considered kept the frameworks from going into blankness.

Advantages of Attached Growth Fixed Film Bio-Filters over Suspended Growth Activated Sludge Process Plants for Waste Water Treatment

- Attached growth systems are more suitable to take shock loads in terms of hydraulic and organic disturbances as compared to suspended growth systems.
- Very high capacity to take organic load.
- Trouble free operations even under difficult conditions.
- Reliable and consistent nitrification, both in summer & winter operations.
- Low power consumption - to the tune of up to half of conventional ASP and 1/4th of Extended Aeration plant.
- Very low skilled operation, control and maintenance requirements and thus low operation and maintenance costs.
- Low sludge production and easily drainable sludge.
- Much smaller secondary settling tanks due to higher settling rates of the sludge produced.
- Lower residual suspended solids concentration in treated wastewater.
- Cost effective combinations with other treatment methods.
- Improved plastic media design have significantly reduced tower sizes and costs and enhanced their capacities and efficiencies.
- Installation depths up to 6.0 m require no intermediate supports. Higher installation depths with intermediate supports can be provided. This combined with efficient geometry can offer a very compact plant.

General Advantages of Improved Bio-Tower Application:

- Long life of over 30 years - UV stabilized material.
- Large specific surface areas to accommodate large microbial growth.
- Very large voids from 90 to 97%
- Easy to handle and simpler for supporting structure.
- The distribution pattern provides utilization of the complete surface area.
- Depth of bio-tower is Large Nearly 6 to 8 m. & considerable saving of land.
- The liquid has higher detention time about 4 times.
- It has very low resistance to airflow leading to maximum contact of air, waste Water & bio mass.
- Low resistances to airflow and the mixing caused at the cross over points in the fill lead to optimum aeration.
- Good wetting, continuous air movement and thinner biological growths eliminate fly nuisance.
- Due to continuous redistribution of water flow, plastic media has a very high resistance to plugging.
- Settled effluents TSS is much lower with Improved Bio-Tower.
- No elaborate peripheral walls required because modules are self-supporting, only cladding suffices.
- Requires no elaborate under drain system.

FEATURES OF BIO-TOWER:

1) Aeration by natural draught

Plastic Media have expanded the BOD5 expulsion levels 90% separated from expanding the natural and water powered Loading rates. The plastic media offer low imperviousness to air, gives Maximum contact of air, waste and bio mass, give a huge number of hybrid focuses per m3, hence prompting a decent air circulation by common draft or ventilation. The air necessity is met by giving Ventilation openings in the divider, at the base of the Improved Bio-Tower, having a size of 4-6% of the cross-sectional range of the Bio-Filter. Thusly a day by day air volume of more than 100 m3 air for each m3 of fill circles to give the important oxygen to the microorganisms.

Fig.no.5.2.Aeration by natural draught

The Oxidation of Organic matter in waste water and synthesis of new microbial cells takes place in following way:

Oxidation

COHNS + O2 ------------- → CO_2 + NH3 +C5H7NO2 + Other end products
Organic matter Bacteria
New cells

Endogenous respiration

C5H7NO2 + 5O2 ----------→ 5CO2 + 2H2O + NH3 + energy
New cells Bacteria

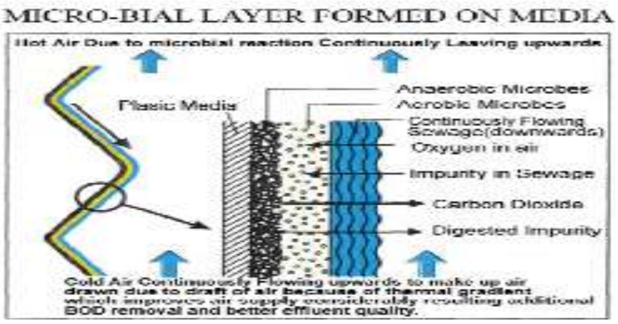


Fig.no.5.3. Micro-bial Layer

2) Simple support system

The modules on the base layer are introduced with the more drawn out sides at right points to the bolster pillars. The module backings can be ostensible 100 to 150 mm shafts at 600 mm or 900 mm focuses. This is conceivable because of the quality of the module that requires underpins at just 2 focuses and it's lightweight. Such basic backings, broadly separated, augment the stream of air and water through the media and the plenum zone, with minimum hindrance. The emotionally supportive network is intended for around 400 kg/m2 per m of media profundity. Beneath the bolster pillars a base piece, with approx. 4% incline, gathers the treated fluid into a focal or fringe channel.

Fig.no.5.4. Support system

3) Longer retention time

The flow characteristics provide about 3 to 4 times more detention time than the other media such as rock, since no free fall of liquid can take place inside the media. Due to this configuration, the wastewater is distributed over the entire surface inside the media, resulting in a thin liquid film. This leads to sufficient time being available for the Biological process and a high reduction of BOD.

4) Low construction cost

The media is self-supporting, strong and can be cut to fit into any regular shaped Improved Bio-Tower. With no lateral thrust or pressure on the peripheral surrounding walls, these walls can be of a cheap construction and of a simple nature. Normally Exterior cladding consists of easily available AC or plastic sheets.

5) Distribution system

The system of interconnected channels in the plastic media makes it possible to use either a rotary distributor or a fixed nozzle system to achieve the desired wetting. The fixed nozzle system can be adapted to any regular shaped media plan including the circular trickling filters and is ideally suited for the rectangular or square tanks. The efficiency is independent of the distribution system at the top since the internal redistribution system in the module starts to operate immediately on the wastewater hitting the top layer. In over 6000 mixing points per m^3, the liquid film is broken up and re-mixed, a turbulence of vital importance for efficient transfer of oxygen and the dissolved organic matter between the liquid and the bio mass.

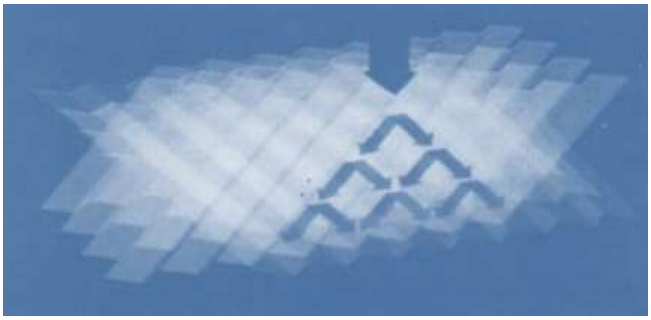


Fig.no.5.5. Distribution system

6) Design of improved bio-towers

In natural treatment of waste waters numerous parameters, for example, the BOD and COD levels, cause, waste and surrounding temperatures, pH, supplement parity, nearness of dangerous matters, and so on communicate in a manner that every plant be composed independently. Household sewage ordinarily contains all the vital supplements and follows minerals for organic activity inside the tower and the outline of Improved Bio-Towers for its auxiliary treatment contrasts to a specific degree from the ordinary configuration of a high rate unit. The outline of an Improved Bio-Tower depends on different configuration comparisons, for example, the changed VELZ mathematical statement for which the estimations of the constants have been tentatively decided and altered for these media. Further, in view of the experimental information gathered throughout the years, outline bends have been produced for the natural stacking for various encompassing temperature ranges. Since it is likewise important to have a base measure of wastewater to use completely all the accessible surface range inside a Bio-channel, plan bends have additionally been created for the water powered burden or the wetting rates for various circulation frameworks and the chose profundities of media. Because of the high effectiveness of these channels, no distribution is ordinarily vital. Nonetheless, distribution of the Bio-channel gushing must be attempted to fulfill the wetting rate proposals in the event that they are not something else.

7) The module

The modular medium for high rate Improved Bio-Tower is manufactured from plastic/ rigid PVC, Which is chemically resistant to water soluble substances occurring in municipal and industrial waste waters. It is also resistant to rot, bacterial, fungal or growths of other microorganisms.

Properties of plastic media:

Fig.no.5.6. Plastic media

- Specific Surface Area (sq m/cum): 90 to 200
- Void ratio : 90 to 97 %
- Number of mixing points per cum: Up to 10000
- Sheet thickness (mm) : 0.3 to 1.0
- Weight kg/cum Dry : 30 to 45
  Wet (operational): 350 to 650

8) Winter time operation and ice formation:

It is realized that settled film or appended development procedures are more steady at lower temperatures because of the different focal points that this framework offers as far as the conditions for the required microbial development. Aside from these points of interest, the high void proportion and geometry of plastic media are key elements is expanding effectiveness and minimizing ice arrangements. Rock and other media show vast, level surfaces where the falling fluid can sprinkle back and frame ice coatings on contiguous surfaces. It is on record, that even in below zero icy spells no ice arrangement on the Improved Bio-Tower surface is watched, notwithstanding when the abutting dividers and region are under a cover of snow.

9) Nitrification:

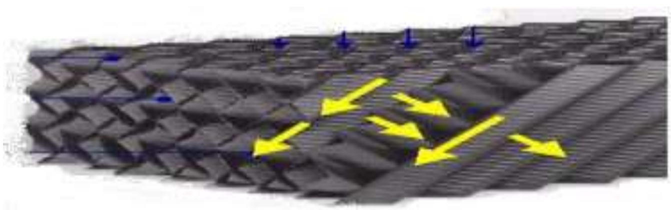


Fig.no.5.7. Nitrification

Cross flow media Improved Bio-Towers with a more compact array of sheets can be used to achieve consistent, high level nitrification (> 90%conversion) when operating at a low BOD waste stream (upto 30 mg/l) containing NH_3-Nconcentrations up to 25 mg/1. This is a highly efficient and cost effective application for which separate design data and curves have been developed. Final effluent NH3-N concentrations in the range of 0.5-2.0 mg/1 can; easily be obtained. Nitrification takes place in following way:

$$2NH_4^{+} + 3O2 \xrightarrow{\text{Nitroso-bacteria}} 2NO2^{-} + 4H^{+} + 2H_2O$$

$$2NO_2^{-} + O2 \xrightarrow{\text{Nitro-bacter}} 2NO3$$

Advantages of "Improved Bio-Tower Technology":

- Only Column-Beam structure suffices Tower can be constructed even up to 9.0 m which saves lot of land.
- Resist shock loads.
- Sludge generated in Improved Bio-Tower is highly thick and having higher density which settles faster leads to smaller clarifier size giving better effluent quality.
- Sludge production is less than that produced in ASP or any other aerobic treatment method requires less sludge handling mechanism.
- No problem of sludge deposition.
- Improved Bio-Tower is continuously aerated due to natural draft thereby avoids any odour related problems. System is always ready to receive effluent in case of interrupted power supply.
- Compared to ASP this energy saving is more than 50-60%.
- Easy operation and maintenance. No foaming problems. No recirculation of sludge required. No skilled staff is required.

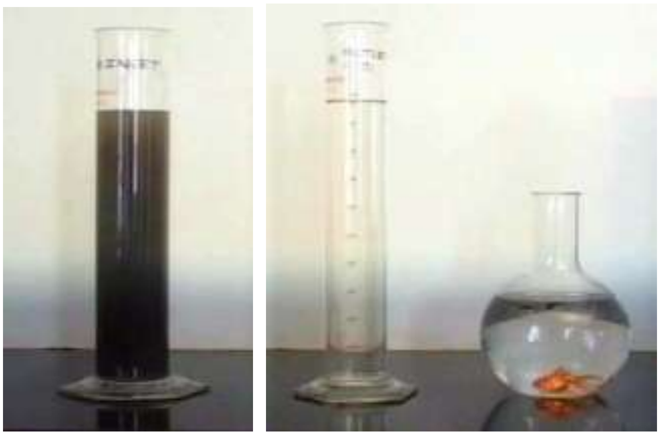


Fig. shows difference between untreated & treated water

Brief Description of proposed scheme of Bhenda Sugar Factory:

1. Screening:

Fig. Screening chamber

Coarse screen or rack is used for removal of pieces of gunny bags, plastics, branches, rubbers, packing materials, gaskets, cotton waste and other floatable. It is used as protecting devices so that large suspended solids and floating material do not damage pumps, agitators, mixers and aerators. Coarse screen have openings ranging from 75mm to 150mm and racks are usually set at an angle of 45°-60°. The cleaning of screens is done either manually or mechanically.

2. Oil &Grease Skimmer:

Oil is float on water because it is lighter than water. This property is used to separate it out. If the oil does not float and a thick film does not develop, the physical removal by big spoon becomes difficult. In such case, the oil & grease escapes out to further downstream units of the ETP to spoil the situation. Removal of oil and grease is necessary to increase treat ability. In an industry oil and grease traps are situated close to the source of oil and grease. Various patterns are available for oil and grease trap. The most common is the one in which inlet is below the surface and outlet is at the bottom with sufficient retention period (10-30min). The oil and grease will be collected in a separate sump, by manually or mechanically, from where it can be removed with the help of a hand pump.

Fig.no. Oil and grease skimmer

3. V-Notch:

Fig.V-Notch

The triangular or V-notch sharp-crested consist of an angular notch cut into a bulkhead in the flow channel. The apex of an angular notch is at the bottom, and the sides are set equally on either side of a vertical line from the apex. The angle of the notch most commonly used is 90°. The discharge equation of a free flowing triangular weir takes the form.

$$Q\ (m^3/S) = 8/15 \times (2g)^{(1/2)} CDh^{(5/2)}$$

Where-h (m) is the head referred to the vortex of the notch

-g=9.81 m/s^2

-CD is the discharge coefficient, which is given by following table.

Head, h(M)	0.050	0.075	0.100	0.150	0.200	0.300
Value of CD	0.608	0.598	0.588	0.588	0.586	0.585

4. Equalization tank:

Equalization is often used for smoothening out individual wastewater stream flow variations so that a composite stream of relatively constant flow rate is fed to the treatment plant and, also to even out variations in effluent feed BOD to the treatment facility.

The equalization tank should not work as settling tank. The solids should be kept is suspension. For this, the water must be in motion. A stirrer, mixer, agitation, or diffused air is employed.

5. Primary Clarifier:

Purpose of this process is to reduce settelable suspended solids content of the wastewater. When a liquid containing such solids is detained without disturbances for a time, particles of higher specific gravity will settle and those with lower specific gravity will float. The floating material will be collected in by skimmer in the scum box. About 50-60% removal of suspended solids and 20-40% of the BOD removal can be achieved in a property designed and operated primary clarifier. Common retention time is 90-150 minutes based on average rate of flow. If these precede a biological treatment unit, 30-60 minute retention time is sufficient. Sugar factory effluent contains bagacillo particle. These should to be separated out before the biological treatment.

Fig.no. Primary clarifier

6. Bio-Tower:

The supernatant from primary clarifier is further subjected to bio-tower. Bio- tower is provided with plastic media for attachment of bacteria, which increases contact time to bacteria and food (BOD). This plastic media have large surface area and high void age ratio. Effluent will be re-circulate to the bio-tower to maintain wetting rate of plastic media and part of effluent passed to settling tank where the settle particles are taken out from the bottom in the form of sludge. The biological sludge is sent to sludge drying beds for dewatering.

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Fig.no. Bio-tower

7. Tube settler:-

The part of effluent from bio-tower is sent to tube settler. The settled particles are taken out from tank in the form of sludge. The biological sludge is sent to sludge drying beds for dewatering.

Fig.no. Tube settler

8. Aeration Tank:

The effluent from anaerobic lagoon is further subjected to aeration tank. The biological treatment of effluent by aeration process with sludge culture is very sensitive. The efficiency depends on pH, temperature, air contact, suspended solid, culture growth, concentration of floc that is optimum mixed liquor suspended solids concentration (MLSS). The microbial culture concentration is to be maintained in the range of 1500 to 4000 mg/L. Hence initial culture development and maintaining of activated sludge rate by recirculation of sludge and addition of cow dung, area, DAP and their mixing is essential. The nutrients are to be in liquid form. The ratio of BOD: N:P is 100:5:1 will be maintained. Care is to be taken not to destabilize the microbial culture.

9. Secondary Clarifier:

Fig.no. Secondary clarifier

It is a cylindrical concrete tank with conical bottom. There is a central well to which water is fed to avoid short-circulating of water into the overflows. The central stirrer is rotated at 2 RPH. Sludge will be collected at the bottom from where is re-circulated to aeration tank and excess sludge is taken on sludge drying beds by pumping. There is circumferential use.

10. Sludge Drying Beds:

Sludge drying beds will be provided for the disposal of sludge from clarifier. The dried cakes will be scrapped off periodically and can be utilized for as mixture.

Fig.no. Sludge drying bed

RESULT:

It is important to know the wastewater characteristics of inlet and outlet of the treatment plant, to know the efficiency of the plant. These outlet parameters can be compared with the BIS (ISI) standards to know whether the treated effluent is in permissible limit or not.

THE PHYSICO-CHEMICAL PARAMETERS OF TREATED AND UNTREATED SUGAR MILL EFFLUENT

Sr. No	Parameters	Untreated Effluent	Treated Effluent	BIS Standards
1	Colour	Dark Brown	Light Brown	------
2	Dissolved Oxygen	0	1.5mg/l	4-6 mg/l
2	P_H	5.0	6.8	6.5-9.0
3	TSS	110	100	600 mg/l
4	BOD_5	98 mg/l	88 mg/l	50 mg/l
5	COD	350 mg/l	255 mg/l	250 mg/l
6	Oil & Grease	16 mg/l	10 mg/l	10 mg/l

DISCUSSION

Colour

According to the present study the colour of the untreated effluent was dark brownish and treated effluents appeared light brownish.

Temperature

The effluent temperature plays an important role in making an effect on certain chemical and biological reactions taking place in water which affects organism and inhabitation of aquatic media.The temperature of untreated effluent was recorded 40°C and treated effluent was recorded 38 °C. The temperature of the discharge should not exceed 35 °C. The high temperature i.e. 40°C of the untreated effluent has adversely affected the germination process.

pH

In the present investigation the pH value of treated and untreated were recorded as 5 and 6.8 respectively. According BIS standards the pH of the effluents should be in range 6.5 to 8.0.Relatively low pH values of both treated and untreated samples are due to use of phosphoric acid and Sulphur dioxide during cleaning of sugar cane juice.If such water is used for irrigation for a longer period the soil becomes acidic resulting in poor crops growth and yield. The factors like photosynthetic exposure to air, disposal of industrial effluent and domestic sewage also affect the pH of the soil

Dissolved Oxygen

The analysis of DO is very important in water pollution control as well as waste water control. Aquatic ecosystem totally depends on DO, various biochemical changes and its effects on metabolic activities of microorganism were very well documented. According to the BIS standard the DO of the effluent should be within the range 4 to 6 mg/lit. In the present investigation the DO of the untreated and treated effluent sample was recorded 1.30 and 2.30 mg/lit respectively which is sufficiently low than the BIS Indian standard values.

BOD

Biochemical Oxygen Demand (BOD) is defined as amount of oxygen required by microorganism while stabilizing biological decomposable organic matter in water under aerobic conditions. In the present investigation the BOD of the untreated effluent was 98 mg/l while the treated effluent recorded 88 mg/l. According to BIS Indian standard the BOD should not exceed the 50 mg/l.

COD

The chemical Oxygen demand test determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The COD is a test which is used to measure pollution of domestic and industrial waste. In the present investigation the COD of the untreated effluents was 350 mg/l while treated effluent was recorded 255 mg/l. In untreated effluent it is appreciably high compared to BIS standard (250 mg/L). This indicated high organic pollutants in the sample.

TSS

The total suspended solids affect the light intensity of water; suspended solids are the cause of suspended particle inside the water body influencing turbidity and transparency. According the present investigation the suspended solids of untreated effluent were 110 mg/l and 100 mg/l respectively.

Oil and grease

In the present investigation oil and grease present in untreated and traded effluent showed 16 mg/l and 10 mg/l respectively this is almost in accordance with the BIS Indian Standard.

CONCLUSION:

Zero waste industry

Shri. Dnyaneshwar sugar industry is zero waste industry. After sugar production, the waste generated from the mill will be sent to the by-product based industry like molasses, bagasses, effluent etc.

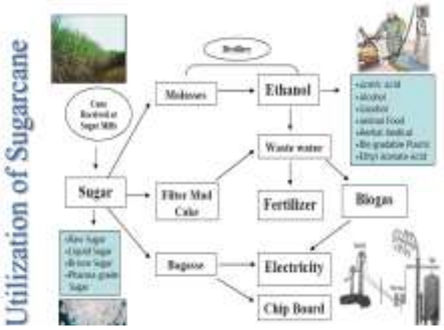
1. Molasses- molasses is waste produced from sugar manufacturing unit which will send to the distillery unit. This waste is very valuable raw material in the distillery unit. Before taking it in plant, fermentation is done. It produced alcohol and spirit. On the other hand alcohol is used to produce various industrial chemicals and supplied to the other industries.

2.Bagasses- bagasses means the fibrous residue of the mill house which is burnt as a fuel in the boiler and create electricity that powers the mill to process sugar from cane juice and alcohol in distillery and excesses bagasses is used as a raw material for production of paper products and a filler material for bio-composting.

3. Effluent- the waste water generated from the industry is called as effluent which is treated in ETP. The treated water is good for irrigation purpose or it can be reused. This industry allows farmers to take that treated water for their farm. Likewise, there is no problem of disposal of this water.

4. Spent wash generated from the distillery, sludge from ETP: spent wash generated from the distillery, sludge from ETP is used as a filler material for bio-composting. The produced compost is then supplied to the farmers at nominal cost.

Therefore, Shri Dnyaneshwar sugar industry is zero waste industry and gaining profit from this.



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