WASTE WATER TREATMENT USING SOIL BIOREACTOR

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Abstract— The main focus of this project is to bring the water to acceptable limits of pollution control board with green technology and economy. For this purpose, we decided to treat the sugar factory waste water using a soil bioreactor. This is a latest green technology to treat water. We are trying to bring the water up to level which becomes suitable for irrigation. The social impact of the project is that farmer will get good quality water for irrigation. Sugar industry will get a very economical and green technology to treating their waste water. So, we are expecting that sugar factories will use this technique.

Keywords—Green technology, economy, waste treatment

I. Introduction (Heading 1- TNR- 10 Bold)

A bioreactor may refer to any manufactured or engineered device or system that supports a biologically active environment. In one case, a bioreactor is a vessel in which a chemical process is carried out which involves organisms or biochemically active substances derived from such organisms. This process can either be aerobic or anaerobic. These bioreactors are commonly cylindrical, ranging in size from liters to cubic meters, and are often made of stainless steel.

A bioreactor may also refer to a device or system meant to grow cells or tissues in the context of cell culture. These devices are being developed for use in tissue engineering or biochemical engineering.

Bioreactors are also designed to treat sewage and wastewater. In the most efficient of these systems, there is a supply of a free-flowing, chemically inert medium which acts as a receptacle for the bacteria that break down the raw sewage. Examples of these bioreactors often have separate, sequential tanks and a mechanical separator or cyclone to speed the separation of water and bios lids. Aerators supply oxygen to the sewage and medium, further accelerating breakdown. Submersible mixers provide agitation in anoxic bioreactors to keep the solids in suspension and thereby ensure that the bacteria and the organic materials "meet". In the process, the liquid's Biochemical Oxygen Demand (BOD) is reduced sufficiently to render the contaminated water fit for reuse. The bio solids can be collected for further processing, or dried and used as fertilizer. An extremely simple version of a sewage bioreactor is a septic tank whereby the sewage is left in situ, with or without additional media to house bacteria. In this instance, the biosludge itself is the primary host (activated sludge) for the bacteria. Septic systems are best suited where there is sufficient landmass, and the system is not subject to flooding or overly saturated ground, and where time and efficiency are not prioritized.

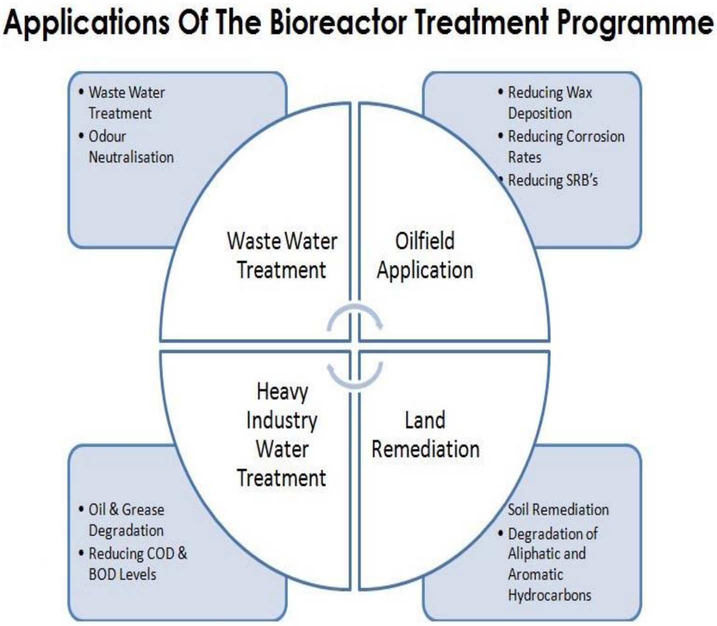
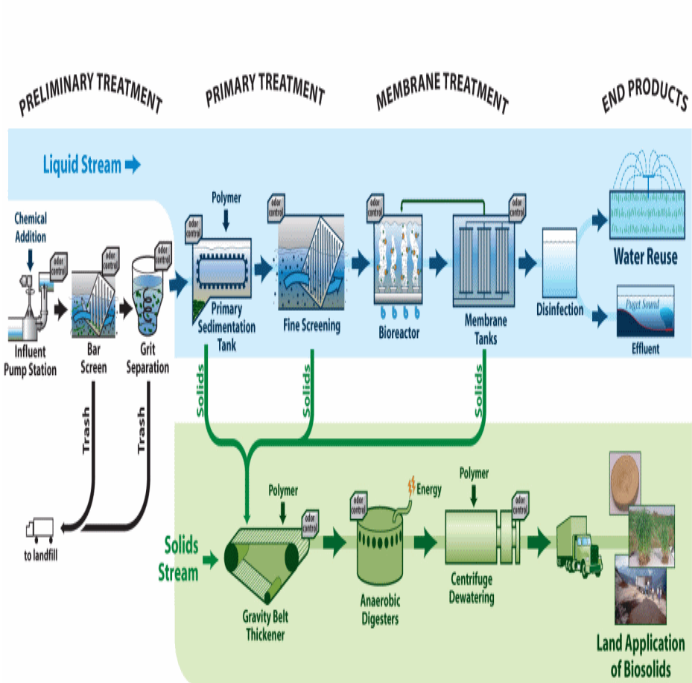


Fig. 1 Applications Of The Bioreactor Treatment Programme

II. Ordinary factory treatment plant

Fig. 2 Sugar factory water treatment plant



III. Sugar Manufacturing Process

Most of the sugar factories in India follows double sulphitation process and produce plantation write sugar. The major unit operations are -

- Extraction of Juice
- Clarification

- Evaporation
- Crystallization
- Centrifugation

Extraction of Juice: The sugarcane is passed through preparatory devices like knives for cutting the stalks into fine chips before being subjected to crushing I milling tendem comprising 4 to 6 three roller mill. Fine preparation with its impact on final extraction ,is receiving special attention the shredders and particularly the furzier are gaining popularly .The mill are modern design ,being equipped with turbine drive, special feeding device ,efficient compound imbibitions system etc. In the best milling practice more than 95% of the sugar in the cane goes into the juice, this percentage being called the sucrose extraction or more simply,the extraction. A fibrous residue called bagasse. with a low sucrose content is produced about 25 to 30% of cane, which contains 45 to 55% moisture.

Clarification: The dark-green juice from the mills is acidic (pH-4.5)and turbid, called raw juice or mixed juice. The mixed juice . The mixed juice after being heated to 65 to 75 c is treated with phosphoric acid ,sulphur dioxide and milk of lime for removal of impurities ion suspension in continuously working apparatus. The treated juice on boiling fed to continuous clarifier from which the clear juice is decanted while the settled impurities known as mud is sent to rotary drum vacuum filter to removal of unwanted stuff called filter cake is discarded or returned to the filed as fertilizer. The clear juice goes to the evaporators without further treatment.

Evaporation: The clarified juice contains about 85% water. About 75% of this water is evaporated inn vacuum multiple effects consisting of a succeeding (Generally four) of vacuum- boiling cells arranged in series so that succeeding body has higher vacuum. The vapors' from the final body go to condenser. The syrups leaves the last body continuously with about 60% solids and 40% water.

Crystallization: The syrup is again treated with sulphur dioxide before being sent to the pan station for for crystallization of sugar. Crystallization takes place in single-effect vacuum pans, where the syrup is evaporated until saturated with sugar. At this point "seed grain" is added to serve as a nucleus for the sugar crystals, and more syrup is added as water evaporates. The growth of the crystal continuous until the pan is full. Given a skilled sugar boiler (or adequate instrumentation) the original crystal can be grown without the formation of addition crystals, so that when the pan is just full, the crystals are all of desired size, and the crystals and syrup form a dense mass knows as "massecuite." The "strike" is then discharged through a foot valve into a crystallizer.

Centrifugation: The massecuite from crystallizer is drawn into revolving machines called. Centrifuges. The perforated lining retains the sugar crystal, which may be washed with water, if desired. The mother liquor "molasses" passes through the lining because of the centrifugal force exerted and after the sugar "purred" it is cut down leaving the centrifuge ready for the another charge of massecuite. Continuous centrifuges may purge low grades. The mother liquor separates from commercial sugar is again sent to pan for boiling and recrystallization. Three stages of recrystallization are adopted to ensure maximum recovery of sugar in crystal form. The mother liquor referred to as final molasses is sent out the factory as waste being unsuitable for sugar under commercial condition from economical point of view.

***WASTE GENERATION**

Waste generation from sugar factories can be categorized as solid waste, liquid waste and gaseous emissions.

1. **Solid Waste:**
   Solid waste from a sugar industry includes bagasse, molasses, press mud, boiler ash sludge from effluent treatment plant.

- **Bagasse:** Bagasse, generated at the rate about 30% of cane crushed, has clarifier value of 1917 Kcal/ kg and is mostly used as a fuel for steam generation in sugar mills. Also, with reducing forest cover, bagasse has become a potential renewable raw material for paper and pulp industry.
  Now a days, bagasse based co-generation projects have gained importance due to the energy shortage. The Ministry of non-conventional energy sources in the Government of India also gives incentive for installation of high-pressure boiler and condensing turbo-generating sets for the purpose of co-generation.
- **Molasses:** Molasses is a very valuable by-product. On an average, the percentage of molasses in sulphitation process is around 4.5% of cane. Molasses contains around 32-35% sucrose, 6-8% glucose, 8-9% fructose, etc.
  Around 85% of molasses produced in the country is utilized for the manufacture of the ethanol. Molasses is also used in cattle feed.
- **Press-mud:** The percentage of filter cake in the factory using sulphitation process is 3-5% on cane and 7-9% on cane in case of carbonation process. The sulphitation cake is useful and being used as manure due to its nitrogen, phosphorus and potash contents.
  Several sugar factories are producing compost by mixing filter cake with distillery spent wash. The carbonation cake is used for landfills.
- **Boiler Ash:** Sugar factories generate ash about 2-2.5% of bagasse burnt in the boiler. This ash is utilized for the making of bricks also utilized for composting with filter cake.

2. **Liquid Wastes:**
   Cold water required in the sugar industry mainly for machinery cooling, daily and monthly cleanings, domestic use and makeup.

Wastewater streams:

The wastewater is generated from different streams. These streams can be described as follows.

- **Mill House:** The effluent consists of water used for cleaning the mill house floor, which is liable to converted by spilled and plashed sugar juice.(This cleaning-up operation will, incidentally prevent growth of bacteria on the juice covered floor) Water used for cooling of mills bearing also forms part of the waste water from this source. Basically, this water contains organic matter like sucrose, bagacillos, oil and grease from the bearing fitted into the mills. It's BOD amounts to 900 to 1000 mg/L, oil and grease amount to 150 to 200 mg/L, and COD around 2500mg/L.

- **Waste water from boiling house:** The waste water from boiling house results from leakages through pumps, pipelines and the washings of various sections such as evaporators, juice heaters clarification and centrifugation etc. The cooling water from various pumps also forms part of the waste water. The BOD of this stream is about 800 to 1000 mg/L and COD is about 2000 to 2500 mg/L.
- **Waste water from boiler blow down:** The water used in boiler contains suspended solids, dissolved solids like Ca-salts, Mg-salts, Na-salts, Fe-salts etc. These salts get concentrated after generation steam from the original water volume. These solids have to be expelled from time to time to save the boiler being covered up by scales.
  This water has following characteristics;
  BOD - 60 to 70 mg/L
  COD - 100 to 1200 mg/L
  SS - 800 to 1500 mg/L
  TDS - 1500 to 3500 mg/L
  Temperature - 90 to 100°C
- **Excess Condensate:** The excess condensate does not normally contain any pollutant and is used as boiler feed water and the washing operations. Sometimes, it gets contaminated with juice due entrainment of carryover of solids with the vapors being condensed in which case it goes into the waste water drain. The treatment requirement in this case is almost negligible and can fresh water or it can be let out directly as irrigation water after cooling it to ambient temperature.
- **Condenser cooling water:** Condenser cooling water is recirculated again unless it gets contaminated with juice which is possible due to defective entrainment separators, faulty operation beyond the design rate of evaporation etc. If it gets contaminated, the water should go into the drain invariably. This volume of water is also increased by addition condensing of vapours obtained from the boiling juice in the pan.
  This water has following characteristics.
  BOD = 100-150 mg/L
  COD = 150-300 mg/L
  pH = 7.0-1.2
- **Soda and Acid Wastes:** The heat exchanges and evaporators are cleaned with caustic soda and hydrochloric acid in order to remove the formation of the deposits of scales on the surface of the tubing. In India, most of the sugar factories let this valuable chemical go into drains.
  The rising of soda and acids wash contribute to amount of organic and inorganic pollutants and may cause shock loads to waste water treatment plants once in a fortnight or so.

3. **Gaseous Emission:**

Sugar mills emit flue gases through boiler chimneys. Small quantity of sulphur-di-oxide gas is emitted from the juice and syrup sulphitors. Bagasse, which is the captive fuel in the sugar industry, does not contain harmful elements like sulphur and the stack gases generated by burning bagasse are free from sulphurous gases. The particulate emission is the only parameter that has to be controlled in sugar industry with the help of wet scrubber/electrostatic precipitators.

Table 1: Characteristics of combined Sugar Factory Wastewater

`Sr. No.	Parameter	Range
1.	pH	4.2-6.0
2.	Total Solids, mg/L	1200-2000
3.	Suspended Solids, mg/L	200-300
4.	COD mg/L	2000-2500
5.	BOD5 at 20 degree C, mg/L	1000-1500
6.	Oil & Grease mg/L	60-100
7.	Sulphates mg/L	200-250
8.	Chlorides mg/L	50-100

Table 2: General Standards for Discharge

Sr. No.	Parameter	Inland Surface water	Land for Irrigation
1.	pH	5.5-9.0	5.5-9.0
2.	BOD5, mg/L	30	100
3.	COD mg/L	250	-
4.	Suspended Solids, mg/L	100	200
5.	Dissolved Solids, mg/L	2100	2100
6.	Oil & Grease mg/L	10	10
7.	Chlorides (as C) mg/L	1000	600
8.	Sulphates (as SO4) mg/L	1000	1000
9.	Sulphite (as S) mg/L	2.8	-

Table 3: Waste water generation from 2500 TCD plant

Sr. No.	Source	Cub. M per day
1.	Mill bearing (External cooling)	100.00
2.	Hot liquor pumps gland cooling	25.00
3.	Daily cleaning and washing	50.00
4.	Laboratory use	6.00
5.	Domestic	90.00
6.	Spray pond overflow	250.00
7.	Excess condensate	346.00
8.	Boiler blow-down	75.00
9.	Periodical cleaning	50.00
10.	Leakages and steam trap	100.00
	Total	1092.00

IV. PRINCIPAL

The various types of cycles in atmosphere and in soil are-

1. Carbon cycle
2. Nitrogen cycle
3. Phosphorus cycle
4. Sulfur cycle
5. Oxygen cycle

1. CARBON CYCLE- The carbon cycle is the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth. Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to making the Earth capable of sustaining life; it describes the movement of carbon as it is recycled and reused throughout the biosphere.

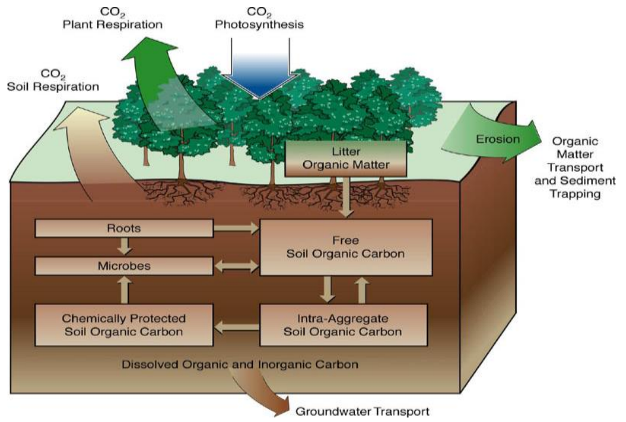


Fig. 3 Carbon Cycle

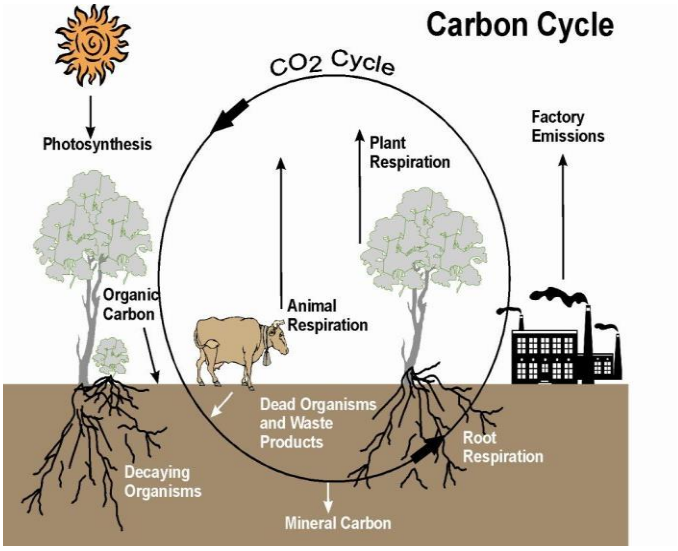


Fig. 4 Carbon Cycle

2. NITROGEN CYCLE- The **nitrogen cycle** is the process by which nitrogen is converted between its various chemical forms. This transformation can be carried out through both biological and physical processes. Important processes in the nitrogen cycle include fixation, ammonification, nitrification, and denitrification. The majority of Earth's atmosphere (78%) is nitrogen,[1] making it the largest pool of nitrogen. However, atmospheric nitrogen has limited availability for biological use, leading to a scarcity of usable nitrogen in many types of ecosystems. The nitrogen cycle is of particular interest to ecologists because nitrogen availability can affect the rate of key ecosystem processes, including primary production and decomposition. Human activities such as fossil fuel combustion, use of artificial nitrogen fertilizers, and release of nitrogen in wastewater have dramatically altered the global nitrogen cycle.

3. Phosphorus cycle- The **phosphorus cycle** is the biogeochemical cycle that describes the movement of phosphorus through the lithosphere, hydrosphere, and biosphere. Unlike many other biogeochemical cycles, the atmosphere does not play a significant role in the movement of phosphorus, because phosphorus and phosphorus-based compounds are usually solids at the typical ranges of temperature and pressure found on Earth. The production of phosphine gas occurs only in specialized, local conditions.

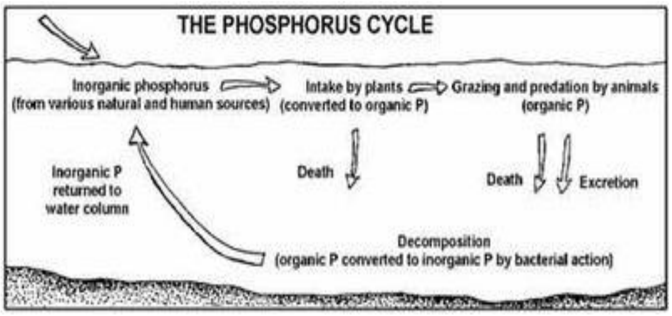


Fig. 5 Phosphorus Cycle

4. Sulfur cycle- The **sulfur cycle** is the collection of processes by which sulfur moves to and from minerals (including the waterways) and living systems. Such biogeochemical cycles are important in geology because they affect many minerals. Biogeochemical cycles are also important for life because sulfur is an essential element, being a constituent of many proteins and cofactors.

5. Oxygen cycle - The **oxygen cycle** is the biogeochemical cycle that describes the movement of oxygen within its three main reservoirs: theatmosphere (air), the total content of biological matter within the biosphere (the global sum of all ecosystems), and thelithosphere (Earth's crust). Failures in the oxygen cycle within the hydrosphere (the combined mass of water found on, under, and over the surface of planet Earth) can result in the development of hypoxic zones. The main driving factor of the oxygen cycle is photosynthesis, which is responsible for the modern Earth's atmosphere and life on earth (see the Great Oxygenation Event).

V. Conclusion

- pH of waste water is between 3-4, after treatment it get between 6-8.
- Chloride of waste water is between 150 ppm - 250ppm, after treatment it get reduced up to 10-40 ppm.
- Sulphite of waste water is between 50 ppm - 100ppm, after treatment it totally get reduced.
- sulphate of waste water is between 200 ppm - 350ppm, after treatment it get reduced up to 10-40 ppm.
- Total Dissolved Solids of waste water is between 700 ppm - 900ppm, after treatment it get reduced up to 100-250 ppm.
- Nitrite of waste water is between 50 ppm - 60ppm, after treatment it get reduced upto 20-30 ppm.
- Chemical Oxygen Demand of waste water is between 800 ppm - 1000ppm, after treatment it get reduced up to 0-40 ppm.
- Biological Oxygen Demand of waste water is between 800 ppm - 1000ppm, after treatment it get reduced upto 20-40 ppm.

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