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Study of Bioreactors for Biological Treatment of Wastewater

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Abstract - *Biological Treatment of Wastewater is a secondary process of wastewater treatment which involves removal of contaminants from wastewater with the help of microorganisms like bacteria. Bacteria requires a surface to latch onto in order to carry out the decomposition of the contaminants, so as to expand the surface area for the bacteria, bioreactors are used. Bioreactors are materials which have a positive charge which attract the bacteria having a negative charge. The present condition of India is such that it is generating huge amounts of wastewater which needs to be treated at economical rate, for this purpose an economic and easily available bioreactor is required. This study presents a comparative approach between two biological treatment technologies i.e. Moving Bed Bioreactor (MBBR) and Bio-chord to evaluate the efficiency and to compare them with each other resulting in selection of the most economical and efficient bioreactor for the biological treatment process. This pilot study was conducted at Mankapur STP situated at Pilli River, Koradi Road, Mankapur, Nagpur. A 1600 litres per day capacity wastewater treatment plant was built at site, from which influent and effluent parameters were tested. The conclusion of these tests helped in determining the most economical and efficient bioreactor for implementation purposes.*

Key Words: **Biological Treatment, Wastewater, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Bioreactor, MBBR, Biocord**

1. INTRODUCTION

India's population is deeply vulnerable to changes in water supply. Climate change related effects on the monsoon are having, and will continue to have, huge implications on agriculture, which makes India even more vulnerable as more than 60% of country's population relying on agriculture for livelihood and nearly two-thirds of the cultivated land is rain-fed. At the same time the government has launched ambitious programs such as the 'Smart City Mission' and the 'Make in India' campaign which need to be reviewed from water and environment lens. (India Water Portal, 2019) (thethirdpole.net, n.d.)

Especially in urban areas water resources are under significant pressure due to high water demand and complex consumption patterns within a small but highly-densely populated areas. Currently, we are meeting the demands of most of the cities by transporting water from hundreds of kilometres. This is both inefficient and energy intensive. A local level solution is thus essential for sustainable water management. Practices such as reuse of treated wastewater would be of immense significance in achieving water security. (ENACTUS+, n.d.)

Practically 80% of water supply streams once more into the biological system as wastewater. This can be a basic ecological and wellbeing risk if not treated appropriately yet its legitimate administration could help the water administrators in satisfying the city's water need. As of now, India has the ability to treat roughly 37% of its wastewater, or 22,963 million liters for every day (MLD), against a day by day sewage age of around 61,754 MLD as indicated by the 2015 report of the Central Pollution Control Board. (Bhavin, Bali, Biswas, Tabiyar, & Zaveri, 2018) (thethirdpole.net, n.d.)

The wastewater treatment plant setup primarily for determining best bioreactor is located at STP Mankapur having a capacity of 1600 Litres/day. The source of the plant is Pilli River which flows through the outskirts of Nagpur City and confluences with Nag River near Pawangaon.

1.1 Biological Wastewater treatment

The Biological wastewater treatment is a procedure that appears to be straightforward superficially since it utilizes regular procedures to help with the deterioration of natural substances, however truth be told, it's a complex, not totally comprehended procedure at the convergence of science and organic chemistry. Biological treatment depends on microscopic organisms, nematodes, or other little living beings to separate natural squanders utilizing typical cell forms. Wastewater regularly contains a lot of organic matter, for example, garbage, waste matter, and halfway digested foods. It might likewise contain pathogenic creatures, overwhelming metals, and poisons. The objective of natural wastewater treatment is to make a framework wherein the consequences of deterioration are effectively gathered for legitimate removal. Researchers have had the option to control and refine both aerobic and anaerobic biological procedures to accomplish the ideal expulsion of organic substances from wastewater.

1.2 Effective and Economic Treatment

Biological treatment is utilized overall since it's compelling and more practical than numerous mechanical or chemical forms. The Biological wastewater treatment is regularly an optional treatment process, used to expel any material remaining after primary treatment. In the primary water treatment process, sediments or substances such as oil are removed from the wastewater. The biological processes used to treat wastewater include subsurface applications, such as septic or aerobic tank disposal systems; many types of aeration, including surface and spray aeration; activated sludge processes; ponds and lagoons; trickling filters; and anaerobic digestion. Developed wetlands and different sorts of filtration are additionally viewed as organic treatment forms. (Fluence, 2020)

1.3 Advantages of Biological Treatment

• Lower operating costs compared to alternatives

• Efficient degradation and removal of organic and inorganic compounds

• Improved adaptability to deal with a wide scope of wastewater qualities and streams.

2. MATERIALS

2.1 Primary Materials

Types of Membrane Bioreactors:

• Moving Bed Biofilm Reactor:
According to (McQuarrie & Boltz, 2011) Moving Bed Biofilm Reactor (MBBR)

The moving bed biofilm reactor (MBBR) can work as a 2-(anoxic) or 3-(aerobic) stage framework with light and free-moving plastic biofilm bearers. These frameworks can be utilized for city and industrial wastewater treatment, aquaculture, consumable water denitrification, and, in roughing, secondary, tertiary, and side stream applications. The framework incorporates a submerged biofilm reactor and liquid-solids detachment unit.

The MBBR procedure benefits incorporate the accompanying: (1) ability to meet treatment targets like activated sludge frameworks as for carbon-oxidation and nitrogen expulsion, however requires a smaller tank volume than a clarifier-coupled activated sludge framework; (2) biomass retention is clarifier-independent and solids stacking to the liquid-solids division unit is decreased altogether when compared with activated sludge frameworks; (3) the Moving Bed Biofilm Reactor is a constant flow method that doesn't need an exceptional operational cycle for biofilm thickness, LF, control (e.g., biologically active filter backwashing) (McQuarrie & Boltz, 2011)

• Biocord:

Biocord is a flexible rope of polypropylene material with number of woven rings. The Biocord contains a slight positive charge which help the bacteria, which are negative charge to attach on it. This substrate allows layers of different bacteria to develop on it and mirroring the process that occurs in nature. Biocord Reactors can also be used to treat water bodies such as oceans, rivers, lakes. It is widely used for municipal and industrial sources in japan. The rope shape of Biocord helps to maximizes surface area for biofilm development. Biocord media can be used in anaerobic, anoxic as well as in aerobic process. (Bishop Water Technologies, n.d.)

2.2 Secondary Materials

• 4nos. 200 Litre Capacity Water Drums

• PVC Pipes (1.5inch diameter)

• Plumbing Fittings (Rubber Visor, Ball Valves)

• Steel stand

3. METHODOLOGY

Two pilot plant for Biocord and MBBR is assembled on the site of 4 MLD STP at Mankapur, Koradi Road, Nagpur. It has a total capacity of 1600 Litre/day each.

3.1 Primary Process

The wastewater collected in the 4 MLD treatment plant gets screened from the screening and further the grit chamber process removes the grit material. A flexible PVC Pipe was used to transfer the wastewater from grit chamber to the 2 pilot plants assembled on the site through the siphon. A knob was attached to the siphon pipe to adjust the flow of wastewater.

3.2 Secondary Process

The waste water enter the anaerobic zone followed by aerobic zone. Biocord were placed in both zones with the help of stand hanging vertically. The Biocord attracts the negatively charged bacteria and breaks down the organic matter. The retention time of 12 hours was considered for biological treatment process, among which 6 hours was considered for anaerobic and 6 hours for aerobic process. Same process was adopted for MBBR in which the bio media used was one third of the volume.

The samples are collected from the influent and effluent of the wastewater treatment assembly. Collected samples are analyzed for the important parameters like BOD, COD, TSS and pH. Samples are tested as quickly as possible after its collection. The results which are obtained after analyzing samples from raw influent and treated effluent of the assembly with standard parameters of Central Public Health and Environmental Engineering Organization (CPHEEO).

4. OBSERVATION AND RESULTS

Samples collected during period of one month are tested in the laboratory for four wastewater quality parameters BOD, COD, TSS, TN and pH.

As shown in the table below the values of influent and effluent to be discharged in inland surface water bodies are well withing the permissible limits, hence we can say that Biocord is an economical and efficient material to use for the biological treatment process.

Table -1: Observations of average wastewater quality parameters taken at inlet and outlet (all values are in mg/L)

PARAMETERS	MBBR		BIOCORD	
	INLET	OUTLET	INLET	OUTLET
BOD	60	15	60	6
COD	116	48	116	9
TSS	126	13	126	5
TN	10	3	10	2.6
pH	7.6	7.5	7.6	7.2

Table -2: Percentage removal observed

PARAMETERS	MBBR	BIOCORD
BOD	60% - 63%	80% - 90%
COD	50% - 60%	90% - 95%
TSS	80% - 90%	90% - 95%
TN	70% - 75%	75% - 80%

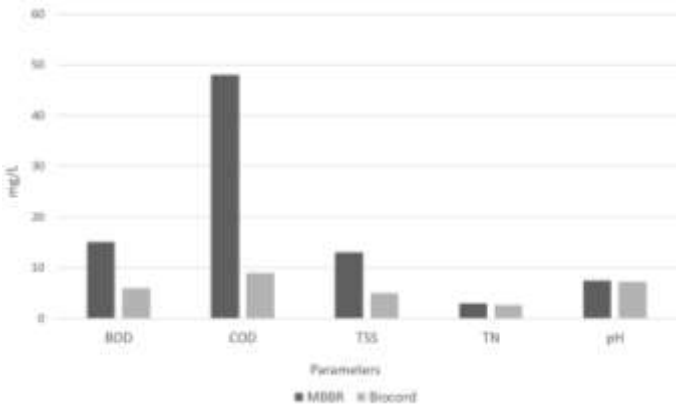

Chart -1: Bar Chart showing Comparison of Outlet Parameters Observed (Lesser Value is a better result)

Advantages of Biocord over MBBR-

- It was seen than much higher amount of biomass was attached on the Biocord as compared to MBBR.
- In case of Biocord it was observed that 90-95% of TSS were removed in the anaerobic zone. Due to its higher removal efficiency there is no need of further sludge treatment in case of Biocord, only quarterly cleaning of the tank needs to be done.
- It was observed that Biocord has higher surface accumulation as compared to MBBR, thus reducing its footprint.

5. CONCLUSION

The major concern in wastewater management is to find an economical and efficient material which will help in the biological treatment of wastewater. The results indicate that Biocord is found to be the most economical and efficient material used in the biological treatment process of wastewater treatment. It should be replaced with high cost materials and with materials having a low treatment efficiency.

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