Muncipal Wastewater of Nag River Treatment By Membrane Bioreactor : A Simple System

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***Abstract*—** An integrated laboratory-scale aerobic membrane bioreactor was used to treat municipal wastewater of Nag river at different HRTs from Nag river located at Nagpur city of India. The experiments were performed at hydraulic retention times from one day up to 15 days the performance of the reactor was evaluated based on the removal of organic matter COD, BOD, TDS and PH changes. The average COD, BOD, TDS removal efficiencies for wastewater were 90.50%, 81.90 %, 91.95 % respectively and PH changes from 4.5 to 7.6 on same HRTs. The relationship between the organic removal rate and HRT was found linear. The study demonstrated the influence of HRTs and suitability of MBR for treatment of Nag river wastewater.

***Keywords*—** Nag river, MBR-Membrane Bioreactor, Municipal Wastewater Treatment, BOD, COD, TDS removal, etc.

I. Introduction

IN recent years, different processes of purification of wastewater from various industrial or laboratory based processes has been of prime significance due to limited quantity of water available for direct use. Hence, maintaining the quality of drinking water is very essential to the public health. Although wastewater treatment is a common practice for supplying good quality of water from a source of water, the high price of purification, necessity of utilizing the waste products, and maintaining an adequate supply of good quality water have been the major issues. Municipal and industrial liquid/solid wastes differ mainly in their physical, chemical and biological characteristics. [3, 5, 7,14]. The Nag River, a tributary of the Kanhan River, flows in a serpentine path and is therefore named "Nag", the Marathi word for snake. And hence, the river and city is named as Nagpur.. While others says that the river flows through the old city of Nagpur and hence the city is named after this river. "Pur" is a common suffix given to cities, villages and towns across India, and is often simply translated "city" The seal of Nagpur Municipal Corporation depicts a cobra in the water of a river. The river wastewater is usually comprised of a high volume of greatly acidic matter which presents many disposal and treatment problems. Waste streams generally contain high levels of both dissolved organic and inorganic materials. The discharge of wastewaters is becoming increasingly restricted as pressures from environmental regulations increase and as awareness of the negative impacts of seasonal discharges of water containing high nutrient and organic loadings into water courses spreads [12,14].The objective of the present research was to enhance the Aerobic / anaerobic treatability of river wastewater effluent in MBR and was studied the influence of hydraulic retention time (HRT) on treatment operational parameters, COD, BOD, TDS and pH changes were investigated and good quality of effluent has been achieved.

II. Materials & Methods

TABLE I
CHARACTERISTICS OF THE MUNICIPAL WASTEWATER OF NAG RIVER

Parameters	**Value range**	**Removal Efficiency %**
Biological oxygen demand (BOD), mg/l	15500	88.90 %
Chemical oxygen demand (COD), mg/l	23400	90.50 %
pH	4.5 – 7.6	40.78%
Total Dissolved Solids (TDS), mg/l	12200	91.95 %
Color	Greenish Black	

The reactor was operated at mesophillic temperature 25–40 ^{0}C. The influent used for the experimental purpose was collected from nag river flowing from Sitabardi region located at Nagpur city. The influent COD concentration maintained constant, so that proper assistance of results can be done. The Wastewater at pH 6.5 was fed into reactor. Different dilutions were prepared using distilled water. pH of influent was adjusted to 7-7.6, using a 6M NaOH solution. Work was carried out using a constant COD of raw effluent changing the detention time and studied the COD, BOD, TDS removal by the reactor.

Seed Sludge: The initial inoculums for seed culture 900 ml were the mixture of influent and mixed mesophilic sludge (38^{0}C) from the bed of an anaerobic digestion bioreactor which was obtained from the rural cow dung biogas plant near by Nagpur region. This is used as the inoculums in the Membrane Bioreactor.

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TABLE II
CLASSES OF PRESSURE DRIVEN MEMBRANE [10,14]

Process	Driving Force	di(nm)	Species Rejected
Microfiltration >50nm	10-25psi	100-20,000	TSS, Protozoa, Bacteria, Viruses
Ultrafiltration 2-50nm	10-100psi	2-10	Macromolecules, Colloids, Proteins
Nanofiltration <2nm	100-500psi	0.5-2	Small molecules, Hardness, Viruses
Reverse Osmosis <2nm	100-1500psi	0.3-0.5	NaCl, Mg^{2+}, Ca^{2+}, SO_4^{2-}, NO^{3-}, Color

III. EXPERIMENTAL SET UP

The experimental setup consists of feed waste tank, bioreactor, membrane module and an air tight container followed by a vacuum pump. The reactor was operated at mesophillic temperature 30 – 40 ^{0}C. The schematic diagram of the lab-scale Membrane bioreactor is as shown in fig.1. The bioreactor is made up of cylindrical still vessel placed vertically, so that minimum floor area is required. The reactor has an internal diameter of 15.2 cm with a height of 90 cm. An 10 L reactor was used for the experiment, out of which 1.5 L volume occupied by packing material. Thus remaining volume of the bioreactor was available for the liquid phase. The total volume of the reactor 15 L was used. In the pilot trial, the activated sludge is pumped along the membrane surface at high velocity ensuring adequate turbulence thereby minimizing membrane fouling and enhancing cleaning efficiency. The permeate is removed from the activated sludge through the membrane wall, which provides an absolute barrier, producing an MBR permeate free from bacteria and suspended solids.

Analytical Methods:

The sample was poured in the beaker and electrode dipped in it to read the pH of the sample. Total dissolved solids(TDS) etc all remaining parameters are measured by following standard methods, 2540B, 2540D, 2540E respectively.

Open reflux method was followed for the determination of COD of the sample. pH was measured by using the electronic digital pH meter which gives the value of pH of the sample directly. (7,14)

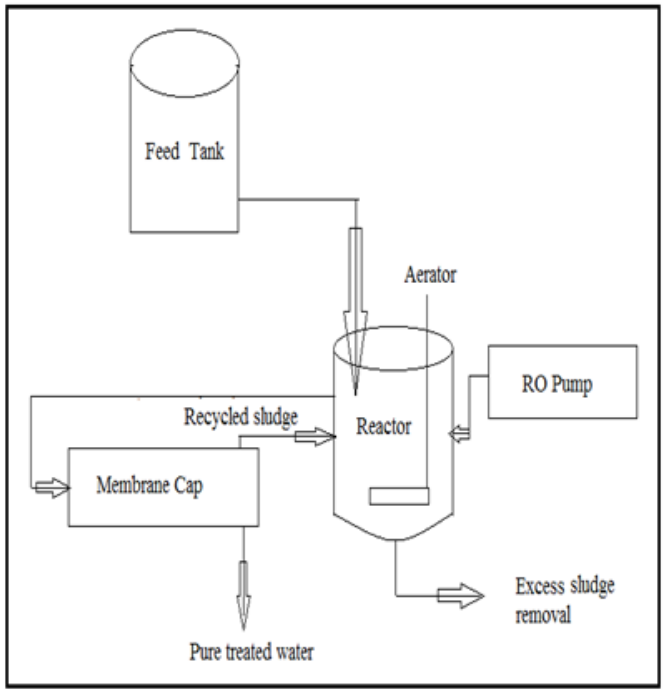

Fig. 1 Schematic diagram of the Membrane Bioreactor used to treat municipal wastewater of Nag river.

TABLE III
EXPERIMENTAL RESULTS OBTAINED IN MBR SYSTEM FOR MUNCIPAL WASTEWATER OF NAG RIVER TREATMENT AT DIFFERENT STAGES.

Stages	DO (mg/l)	COD (mg/l)	BOD (mg/l)	TDS (mg/l)	pH	Color
Initial	0	23400	15500	12200	4.5	Greenish black
Pretreatment	0	15800	9800	8400	7.6	Colorless
50% Dilution (Influent) (Day -0)	2.8	7900	10100	4200	7.6	Colorless
Day -5	3.7	3800	5500	2450	7.6	Colorless
Day -10	4.9	1100	1850	1100	7.4	colorless
Day -15 (Effluent)	6.2	750	1120	338	7.3	colorless

IV. PROCEDURE

As discussed earlier, the experimental setup consists of a waste container, membrane module and an air tight container followed by a vacuum pump. Firstly, the reactor is tested by noting its COD, DO, BOD, TDS values as the initial ones. The stillage after being tested is made more basic by the addition of 1N NaOH.

Now the wastewater is again tested by noting its COD, DO, BOD, TDS values, which are found to be lower than the initial ones, along with the noticeable removal of color. The stillage is now diluted with 50% water by volume. There is a further drop in all parameters.

The wastewater is now fed into the reactor, with the membrane module submerged in it. Into the reactor, 1.08 liter of bacteria, provided by the industry itself, was added (as 108ml of solution is enough to for the digestion of 1liter of

wastewater). The wastewater is then passed through the set of membranes, placed in the RO membrane module thus purifying the water to a large extent. The clear treated water is then collected in an air tight container, to maintain all parameters and keep it constant. This process of collecting clear water from the container of wastewater (containing membrane module), to the air tight container, is processed with a vacuum pump. The MBR permeate is discharged directly to the local burn (water course) without the need for any further treatment.

V. Results & Discussion

Fig.-2- COD reduction is of prime importance while treating the wastewater. Its value reduced drastically as shown in the fig.1. The reduction was marginal during the first five days; however, it was exponential after 5th day. The overall efficiency after the treatment was found to be 90.50%. Yamini et al (2008) also showed similar reductions in the value of COD while treating the waste with MBR equipped with mesh filter [22]. However, the nature of graph varied to a large extent for Shoutong Zhang et al (2005) when they did similar treatment, but at comparatively higher temperatures.

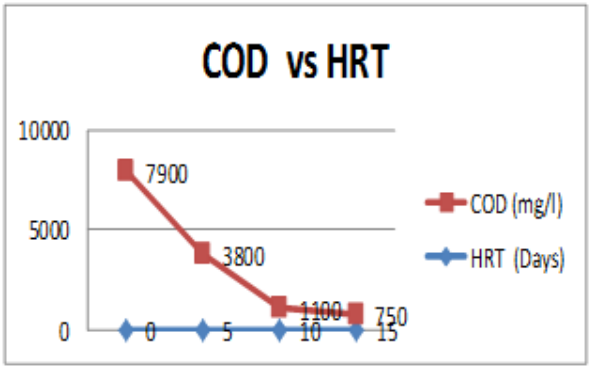

Fig. 2 Influence of HRT on COD Removal Efficiency

Fig,-3- indicates that the removal of BOD cannot be completely eliminated. Rather, a certain value remains, no matter what treatment is enforced upon the waste. The variation of BOD with the hydraulic retention time was found to be as shown in the above graph. In the first five days, the reduction of BOD was drastically lowered, however, during the next ten days, it was moderate. The overall efficiency of removal of BOD was found to be 81.90%. Higher efficiencies were obtained by other scientists due to MBRs constituting of various efficient membrane modules [11].

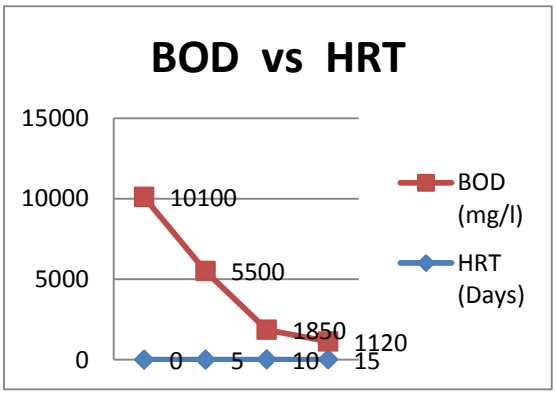

Fig. 3 Influence of HRT on BOD Removal Efficiency

Fig.-4- shows that the TDS removal is as essential as the removal of COD or BOD. Consistent treatment with MBR showed high reduction in the values of TDS. When the sample was treated for low retention time, the removal of dissolved solids was found minimum. However, as the retention time was increased, the efficiency increased exponentially. After a particular reduction was achieved, the retention time showed no effect on the removal of TDS. The final efficiency of TDS was found to be 91.95%. Various studies based on the removal of TDS showed similar results.

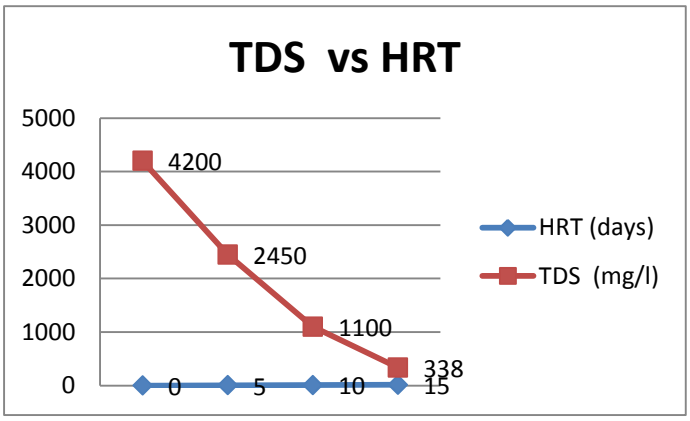

Fig-.4 : Influence of HRT on TDS Removal Efficiency

Fig.-5- represents the initial value of pH was found to be 4.6, when bought from the wastewater. However, due to difficulties in treating acidic solutions using membrane technologies (for the fear of damage of membranes), the waste was made basic by the addition of 1N NaOH. The pH was brought to a value of 7.6, and maintained constant for efficient and easy treatment of the waste. Comparison with the work of others showed that the addition of base was essential in order to obtain efficient treatment.

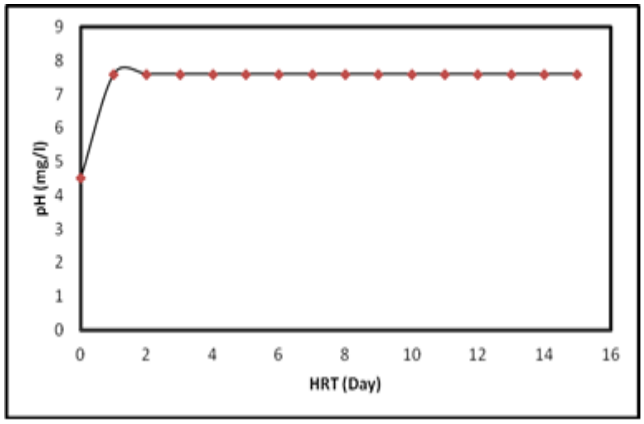

Fig. 5 Influence of HRT on pH

VI. Conclusion

1. This work is mainly focused on the treatment of municipal nag river wastewater, obtained from sitabardi region of Nagpur city, using a Membrane Bioreactor with RO process. The work involved pretreatment with activated charcoal sand filter followed by dilution, at 25-35℃. The waste was then fed to the membrane bioreactor, equipped with a nylon 6,6 membrane with a 0.2µm pore size, where biological substances were added in order to facilitate digestion of the waste. The following conclusions can be drawn from this study

2. The bioreactor is able to display an efficiency of 70.50%, 81.90% and 91.95% for the reduction of COD, BOD and TDS efficiently. The Total Suspended Solids is nil after pretreatment hence not included as part of assessment. The color of solution changes from dark brown to colorless when treated with activated charcoal. Also, the pH of the solution changes from 4.5 to 7.6, after the addition of NaOH.

3. The main advantage of this work is that, the MBR technology has proven optimal for treatment of such kind of river municipal wastewaters. The entire process is found to be cost effective, as the overall cost of the set-up is marginally less, as compared to the conventional set-ups used, for similar efficiencies.

4. Hence it may be conclude that, this method, if given more time for research, could give substantial improvements without much increase in the cost.

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