International Journal of Science, Environment and Technology, Vol. 4, No 2, 2015, 305 – 317

ISSN 2278-3687 (O)
2277-663X (P)

TREATMENT OF TEXTILE EFFLUENT USING SUBMERGED MEMBRANE BIOREACTOR

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Abstract: Climate change makes people to be aware about the environmental pollutions in aspect of Air, Water and Soil components. The environmentally aware countries have forced the other countries to implement the stringent effluent standards for disposal into water stream / water bodies. Hence, modern technology like the application of membrane separation (Micro or Ultra filtration) technique with biological treatment processes (known as membrane bioreactor or MBR) was developed in last decade. But due to minimum sludge handling problem and economical in aspect of space and operating cost, a tremendous growth in the use of MBR to treat the industrial or municipal effluent. It has been observed from the literature review that MBR technology is very efficiently used for the treatment of recalcitrant nature effluent i.e. non biodegradable organic constituents like Textile effluent, Textile effluent or lignin containing effluent.

In this study, the treatment of synthetically Textile effluent was considered by using a submerged membrane bioreactor in the laboratory scale analysis. The work is carried out two phases.

In phase I of the work, the concentration of the synthetic effluent was optimized through the batch process. The synthetic effluent with the optimum concentration will be continuous feed to the submerged MBR for process evaluation in the second phase of the work. The raw textile effluent will have COD in the range of 1500 – 2500mg/L. At the end of MBR treatment COD removal efficiency obtained was about 90%.

Keywords: Textile effluent, MBR, COD, Biological, Efficiency.

1. INTRODUCTION

Water is a natural resource which should be preserved for public health and safety by reducing the contaminants release into the water environment. The total solids (TS) as contaminants are released from the domestic and industrial activities into the water. So putting the importance to reduce the contaminants in the effluent effluent by following the discharge standards for effluent and minimize the negative impacts on water body.

Ion exchange, carbon adsorption etc. are the conventional treatment process, cannot be considered reliable for their disadvantages in process and operation aspects. The membrane technology is applied to separate solids and permeate from the raw effluent. MBRs are the

*Received Jan 29, 2015 * Published April 2, 2015 * www.ijset.net*

advanced treatment technology in view of effluent quality, operability with high mixed liquor suspended solids (MLSS) effluent, wide range of operating conditions such as sludge age and organic loading rates (OLRs) (Marrot et al., 2004).

In the present era, the treatment of textile effluent faces major problem due to presence of recalcitrant organic chemical substances which lead to complicated colour removal and high Chemical Oxygen Demand (COD). So, the breaking these molecules still facing challenging issue. Hence, these recalcitrant nature toxic organic constituents carrying effluent can be treated by membrane treatment process rather than the conventional treatment processes.

Membrane biological reactor (MBR) is a biological reactor which separates suspended biomass and solids by micro filtration membranes with nominal pore sizes (0.1 – 0.4 µm). MBRs are applied widely in effluent treatment as aerobic or anaerobic suspended growth bioreactor for separation active biomass from effluent. Membrane biological reactors have been used for treatment of both industrial and municipal effluent (Brindle and Stephenson, 1996; Van Dijk and Roncken, 1997; Trussell et al., 2000) and for reuse- treated water applications (Cicek et al., 1998)

2. MATERIALS AND METHODS

The selection of the effluent and their characteristics, details of the experimental set-up and experimental programme etc., are presented and discussed below

2.1 Effluent – SELECTION AND CHARACTERISTICS

Selection of Effluent

Textile effluent was prepared at laboratory by dissolving Dye substance obtained from the local market for batch mode operation in several reactors. Their mere presence may cause adverse effects on organisms living in the receiving water body and on the recycling of effluent. From the extensive literature review, it is observed that the treatment of Textile effluent by MBRs still received little or no attention to-date. In this scenario, the selection of textile effluent treatment by MBR has a great significance.

Effluent Parameters Estimated

The experimental parameters were to be considered pH, total solids (TS), total dissolved solids (TDS), volatile suspended solids (VSS), chemical oxygen demand (COD), and Biological oxygen demand (BOD). The effluent was characterized by these parameters based on the Standard Methods for the analysis of Water and Effluent (APHA, 2005) and the results are summarized in Table 2.1. The above parameters were determined for batch mode of operation.

Analytical Procedure

The analytical procedures adopted for the estimation of various effluent parameters and the instruments used, are very briefly described in this section.

(a) pH

pH of all the effluent samples collected were measured immediately within 10 minutes using a portable digital pH meter (accuracy +/- 0.01) consisting of a glass electrode and a digital display inbuilt in the instrument.

(b) Total Solids (TS) and Total dissolved solids (TDS)

A well mixed sample was evaporated in a weighing dish in an oven to 103°C to 105°C and TS of the sample is obtained by the given formula

TS (mg/L) = (w_2-w_1)/ Volume of sample;

Where, w_1 = empty weight of crucible; w_2 = weight of crucible + residue.

For determining TDS, remains of the sample was filtered through a glass fibre filter (1µm, Whatman GF) and subjected to evaporation at 103°C - 105°C, for two hour. The TDS is then obtained using

TDS (mg/L) = (w_2-w_1) / Volume of sample;

where, w_1 = empty weight of crucible; w_2 = weight of crucible + filtrate residue.

(c) Volatile Suspended Solids (VSS)

It is determined by evaporating a dish with well mixed filtrate sample in an oven at 103° C and then weighing it. This dish with solids is again dried in a muffle furnace at a temperature of 550°C ± 50°C for 10 minutes. The weight difference between these represents the VSS

VSS (mg/L) = (W_2-W_1) / Volume of sample; .. (3.3)

where, W_1 = (weight of crucible + filtrate residue before ignition); W_2 = weight of crucible + filtrate residue after ignition.

(f) Chemical Oxygen Demand (COD)

COD represents the amount of oxygen required to oxidize all organic compounds (both biodegradable and non-biodegradable) present in the effluent to CO_2 and water. COD determination requires about 2 hours for digesting the organic compounds in the presence of strong oxidizing agents using COD reflux apparatus. The best suited oxidizing agent is $K_2Cr_2O_7$. After cooling the refluxed sample to room temperature, the excess dichromate was titrated with ferrous ammonium sulphate (FAS). The amount of oxidisable organic matter measured as oxygen equivalent, is then taken as COD and it is calculated as follows:

COD (mg/l) = [(A-B) × molarity of FAS × 8000 / (Volume of sample)]

Where, A = titrate value of blank solution; B = titrate value of the sample.

(g) Biochemical Oxygen Demand (BOD)

The BOD of the effluent was determined by placing the samples with appropriate dilution for 3 days at 27°C. The sample was seeded with an acclimatized culture. The DO content before and after 3 days was found out using Winkler's method and then the BOD of the sample was calculated using equation (3.6)

$BOD_{3,\,27}$ (mg/L) = (DO of blank – DO of sample) x Dilution factor.

2.2 EXPERIMENTAL PROGRAMME

Modes of operation

The experiment setup was intended to simulate the field conditions by operating it under two modes, namely: (i) batch mode and (ii) continuous mode. The experimental investigations were carried out only in the 'batch mode', to study the acclimatization of microorganisms with the synthetically effluent to measure the maximum biodegradability by this process. The 'continuous mode' of operation will be carried out to analyze the efficiency of the treatment process in the second phase of the project. The mode of operation and the various parameters were monitored at the room temperature (27°C – 30°C).

Acclimatization of the synthetic textile effluent

The synthetic effluent and the seed (sewage obtained from a local oxidation pond) are mixed in different ratios for the aerobic micro-organism's growth which are essential for the acclimatization studies and for use in the continuous mode of operation. The different ratios of synthetic effluent and the seed were considered in this study, 1:20, 1:8, 1:4, 1:2.6, 1:2, 1:1.6 and 1:1.3 respectively.

For the batch study, commercially available plastic cans of 10 litres capacity were used, for each ratio. Each can was filled with the synthetic effluent and seed and the remaining volume open for the air diffusion. The batch mode of operation was conducted for 65 days. Various parameters such as pH, TS, TDS, TVS, COD were estimated for the above at intervals of 7 days in initials and 4 days at the final stage. However, consistent values for the above parameters were obtained from 45th day onwards. The above procedure was carried out for all the ratios of synthetic effluent and seed.

Usually help conventional biodegradation processes work faster, or may provide additional, exogenous biological agents to polluted systems and improve the transformation processes (Bathe et al., 2005; Fantroussi and Agathos, 2005). Bioaugmentation has been demonstrated

Table 2.1 Characteristics of the synthetic Textile effluent

Sl.No.	Properties	Results
1	pH	6.80 – 7.20
2	Electrical Conductivity (µS/Cm)	38.2
3	Total Solids (mg/L)	4000
4	Total Suspended Solids (mg/L)	1000
5	Chemical Oxygen Demand (mg/L)	2500

Table 2.2: Relative Merits of Submerged and Side- stream MBRs *(Till, S. and H. Mallia 2001)*

Submerged MBR	Side- Stream MBR
Aeration costs high (90%)	Aeration costs low (20%)
Very low liquid pumping costs (higher if suction pump is used 28%)	High pumping costs (60-80%)
Lower flux (larger foot print)	Higher flux (smaller foot print)
Less frequent cleaning required	More frequent cleaning required
Lower operating costs	Higher operating costs
Higher capital costs	Lower capital costs

Table 2.3 Salient Specifications of the chosen Membrane

Sl.No.	Specification
1	Make- Zenon
2	Configuration – Hollow Fibre
3	Pore Size- 0.04 µm
4	Material- Poly Vinyl Di -Fluoride (PVDF)
5	Surface area- 0.93 m^2
6	Maximum TMP – 62 kPa
7	Maximum TMP back pulse pressure – 55kPa

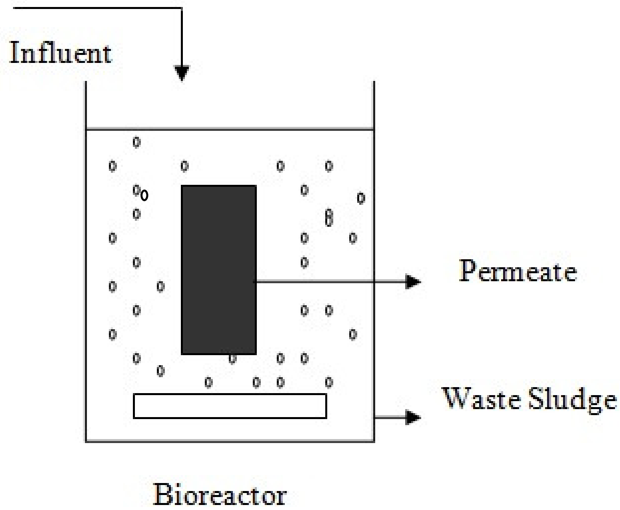


Fig. 2.1 (a) Submerged MBR Configuration (*Ttill, S. and H.Mallia, 2001)*

3.0 RESULTS AND DISCUSSION

3.1 BATCH MODE

pH

Variation of pH during acclimatization of the synthetic effluent under batch mode for various ratios of effluent and seed are given in Table 4.1 and are also shown in Figs. 4.1 The trends in the variation of pH during the entire period of acclimatization is almost similar, for all ratios of effluent and seed.. Beyond 45days steady state condition is attained after the acclimatization period. It can be seen that the pH gets stabilized at 60days, for all ratios of effluent and seed considered. However, 1:16 ratio shows relatively a slightly higher pH during acclimatization than the other ratios considered. pH is found to be within a range ie., 8.5- 8.7, for all ratios considered, at a steady state condition. This range of pH is alkaline and hence favorable for acclimatization of the substrate.

Total Solids (TS)

Concentration of TS during the acclimatization of the effluent for various ratios of effluent and seed is given in Table 4.2 and its variation is shown in Fig. 4.2. It can be seen that there is a continuous increase in the concentration up to 45 days, which is due to the periodic increase in the influent concentration of the effluent. From the above reduction in TS concentration, it is inferred that the ratio 1:1.6 (effluent: seed) is very effective for the acclimatization of the effluent.

Total Dissolved Solids (TDS)

Concentration of TDS during the acclimatization of effluent for various ratios of effluent and seed is given in Table 4.3 and its variation is shown in Fig. 4.3. Due to periodic increase in the influent concentration, there is continuous increase in TDS concentration upto 45 days

Total Volatile Suspended Solids (VSS)

Concentration of VSS during the acclimatization of the effluent for various ratios of effluent and seed is given in Table 4.4 and its variation is shown in Fig. 4.4. The trend in variation of VSS concentration is similar to that of TDS. Hence, 1:1.6 can be considered as the preferred ratio for the acclimatization of the effluent.

Status at the end of Batch Mode of Operation

From the above discussion, the following inferences can be made on the basis of batch mode of operation:

(i) Steady state has attained after 45 days;

(ii) Out of seven ratios for acclimatization of effluent, 1:1.6 (effluent: seed) gives the best desirable result;

(iii) The optimum condition for biodegradability is in alkaline medium.

Fig. 4.1 pH of the synthetic effluent under batch mode for different effluent and seed ratio

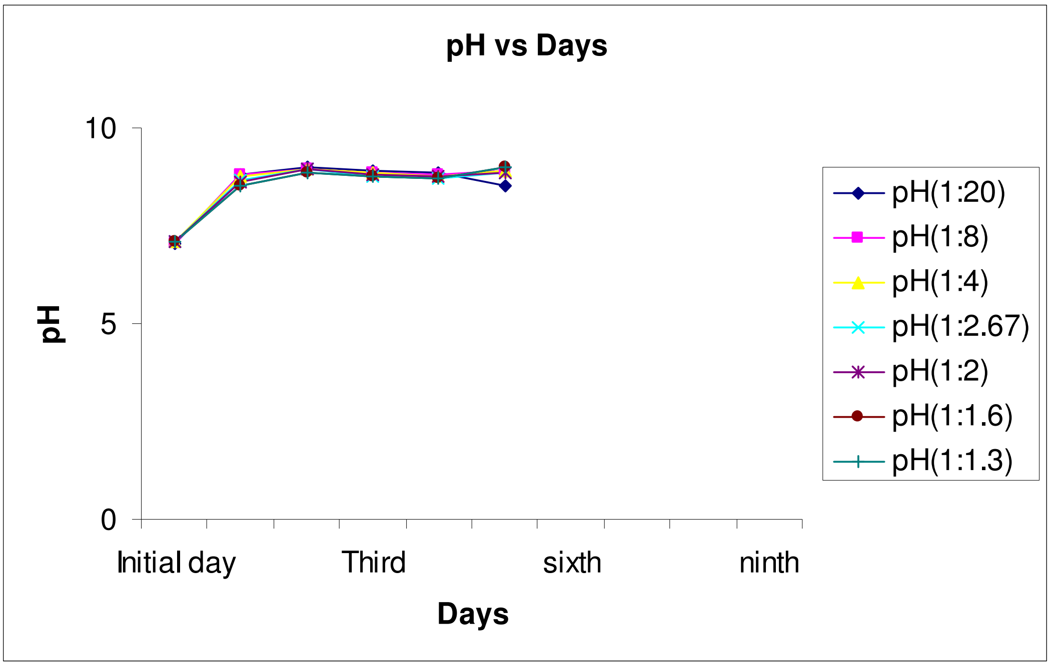


Fig. 4.2 Total volatile solids of the Synthetic effluent under batch mode for different Effluent and seed ratio

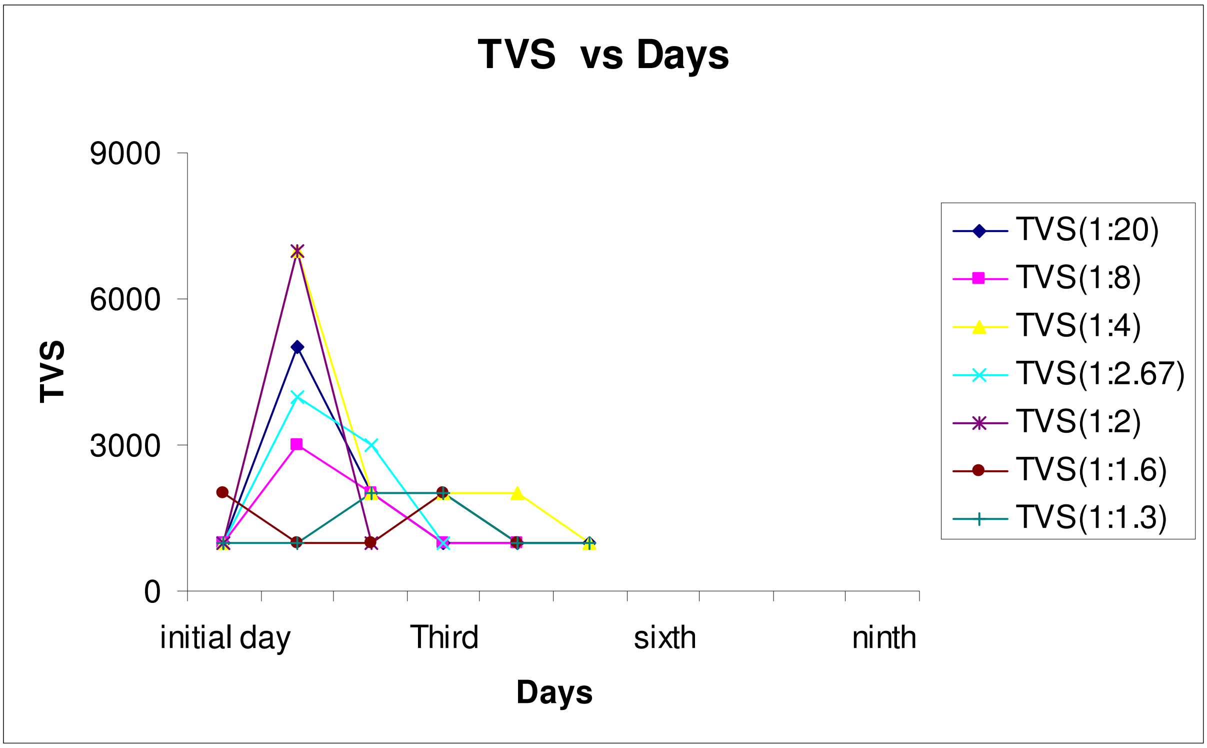


Fig. 4.3 Total dissolved solids of the synthetic effluent under batch mode for Effluent and seed ratio

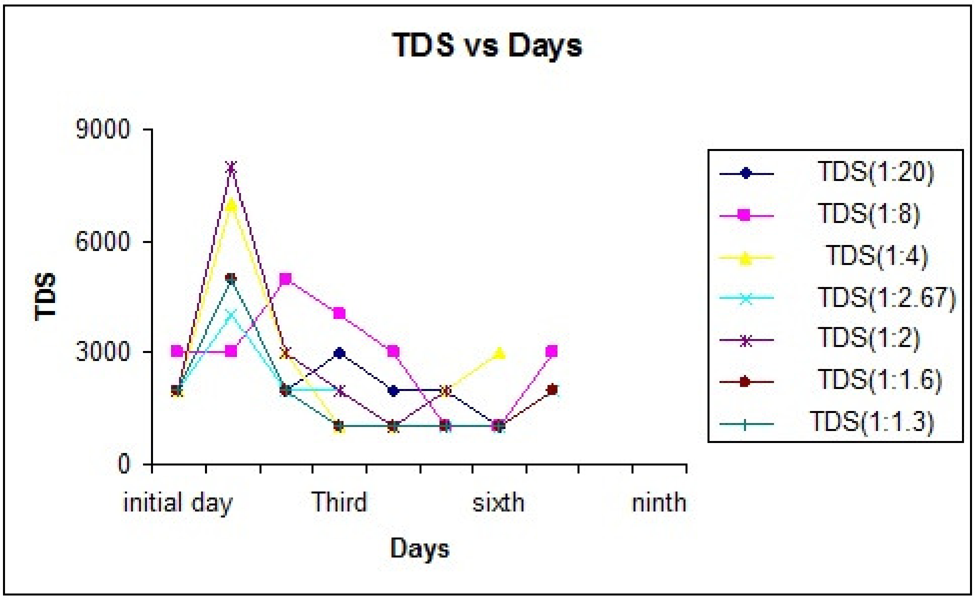
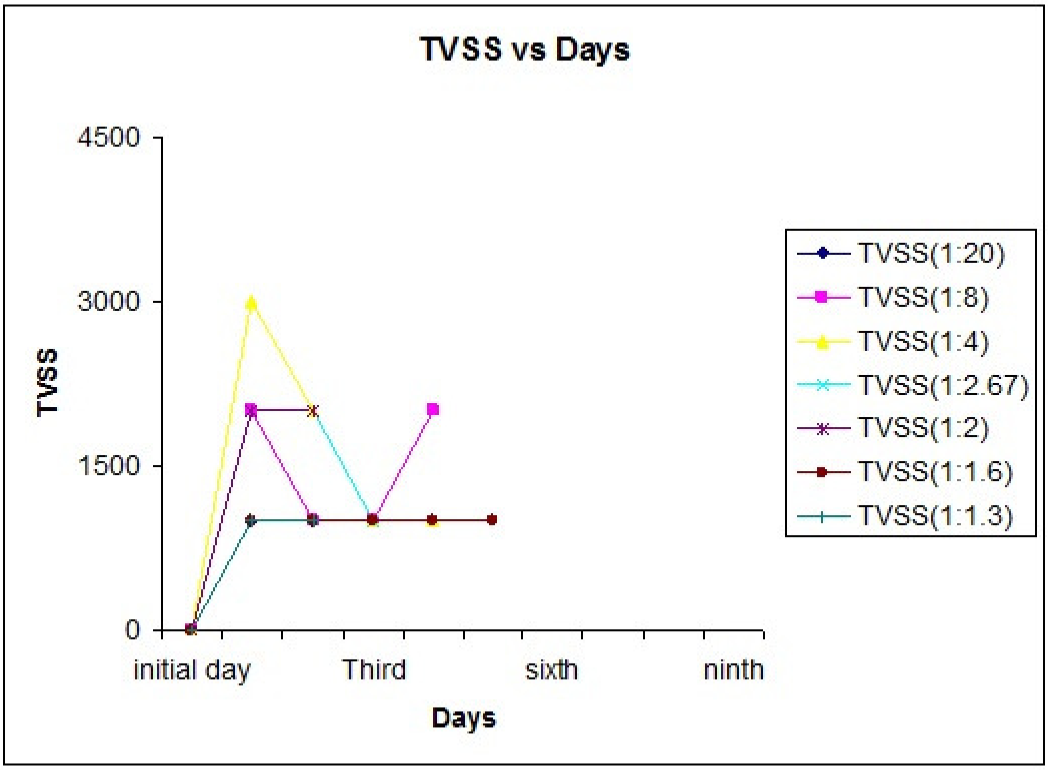


Fig. 4.4 Total volatile suspended solids of the synthetic effluent under batch mode for different effluent and seed ratio



Days	TVS(1:20)	TVS(1:8)	TVS(1:4)	TVS(1:2.67)	TVS(1:2)	TVS(1:1.6)	TVS(1:1.3)
initial day	1000	1000	1000	1000	1000	2000	1000
first	5000	3000	7000	4000	7000	1000	1000
second	2000	2000	2000	3000	1000	1000	2000
Third	1000	1000	2000	1000		2000	2000
forth	1000	1000	2000			1000	1000
Fifh	1000		1000				1000

Table 3.1 TDS values of synthetic effluent in different days

Days	TDS(1:20)	TDS(1:8)	TDS(1:4)	TDS(1:2.6)	TDS(1:2)	TDS(1:1.6)	TDS(1:1.3)
initial day	2000	3000	2000	2000	2000	2000	2000
first	5000	3000	7000	4000	8000	5000	5000
second	2000	5000	3000	2000	3000	2000	2000

Third	3000	4000	1000	2000	2000	1000	1000
forth	2000	3000	1000	1000	1000	1000	1000
Fifth	2000	1000	2000	1000	2000	1000	1000
sixth	1000	1000	3000	1000		1000	1000
seventh		3000		2000		2000	

5. CONCLUSION

5.1 GENERAL

Following conclusions are drawn based on the present study:

1. pH of the medium remains steady i.e. pH: 8.85 at which the micro organisms are active in alkaline medium.
2. At the initial stage, the quantity of biomass is less and but steady i.e. micro organisms are in accumulation phase so electrical conductivity is in steady phase. In final stage, EC curves are downwards as micro organisms are in decay phase.
3. After certain period the TVSS vs. Days curves are in steady stage as total biomass(i.e. new cells and dead cells remain constant in the medium)
4. At steady stage, the total volatile solids remain constant, i.e total volatile solids in initial phase remains low as the micro organisms are in growth phase.
5. From the analysis of above curves, batch no. 6 (1:1.6) synthetic effluent and seed ratio, can be considered as the steady batch reactor in aspect of TVSS, TVS, TDS
6. Acclimatization of the reactor has been observed at about 45 days and that 1:1.6 (synthetic effluent: seed) has given the best result, from amongst the seven ratios of effluent: seeds considered.
7. The best ratio obtained was taken for the further study to be treated in MBR at continuous mode operation
8. COD removal efficiency of about 85 – 90% is obtained from the above study.

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