

## **Membrane BioReactor: Technology for Waste Water Reclamation**

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### **BACKGROUND**

Due to diminishing water supplies and increasing population, waste water reclamation is becoming necessary worldwide to conserve natural water resources. At the same time due to stringent environmental regulations, it is necessary to aim for zero liquid discharge for complex industrial treatment.

The membrane bioreactor (MBR) is a leading edge technology currently being used in countries around the world. Combining conventional activated sludge treatment with low pressure membrane filtration, the MBR proven to be a techno-commercially viable and efficient method of producing reclaimed water from municipal waste water.

In many industrial water reclamation facilities across the world, it is necessary to reduce total dissolved solids (TDS) to make the water usable for irrigation and industrial applications. A recent survey sponsored by WERF (Foussereau, et al., 2002) evaluated over 100 full-scale water reclamation facilities worldwide, which use RO, NF membrane technology as tertiary treatment. A recent literature review identified MBR technology as the newest method of pretreatment for secondary effluent prior to RO treatment (Paranjape et al., 2003).

### **The Membrane Bioreactor Process**

An MBR substitutes the clarifier with ultra-filtration or micro-filtration membrane modules. Unlike the clarifier, the membrane is a microbial barrier that can capture the biomass for recirculation inside the bioreactor. The MBR was first developed and applied to domestic waste water in the 1960's by Dorr-Oliver (Smith et al., 1969).

The MBR offers following benefits over the conventional activated sludge process:

- Smaller space requirements (almost 1/4<sup>th</sup> of ASP)
- Better solids removal (elimination of bulking)
- Disinfection
- Increased volumetric loading
- Production of less sludge due to high sludge age
- High SRT which allows the development of slow-growing microorganisms such as nitrifying bacteria.
- Retention of high molecular weight soluble compounds that improve biodegradation.

The MBR process exists in two different configurations.

1 Side stream MBR: In which membrane modules are placed in series tank on downstream of aeration

2. Submerged MBR: In which membrane modules are place inside aeration tank.

In the in-series MBR configuration, sludge is pumped from an aeration basin to a pressure-driven membrane system outside the bioreactor where the suspended solids are retained and recycled back to the bioreactor and the effluent passes through the membrane. The membranes are regularly backwashed to remove suspended solids build-up and accumulations, and are chemically cleaned when the operating pressures become too high.

In the submerged MBR configuration, a low-pressure membrane is submerged in the aeration basin and operated under vacuum pressure. The membrane is agitated by coarse bubble aeration that helps prevent suspended solids accumulation at the membrane surface. The submerged membranes are either regularly backwashed or relaxed, and are chemically cleaned when the operating pressures become too high.

As very little literature and references are available on use of the MBR for Indian conditions, it is always desirable to conduct pilot studies for domestic and industrial waste water before going in for a full-scale plant.

### **Objectives of MBR pilot plant trial**

*Such a study could address the research objectives listed below:*

- Performance evaluation of the MBR for domestic and different industrial effluent.
- Investigate suitability of the MBR effluent as feed water to the RO process.

- Evaluation of the rate of fouling of the MBR by monitoring the increase in the trans-membrane pressure (TMP) to maintain the required flux.
- Determine the impact of several operational parameters, like hydraulic residence time, MLSS concentration, membrane flux rate on the performance of the MBR system

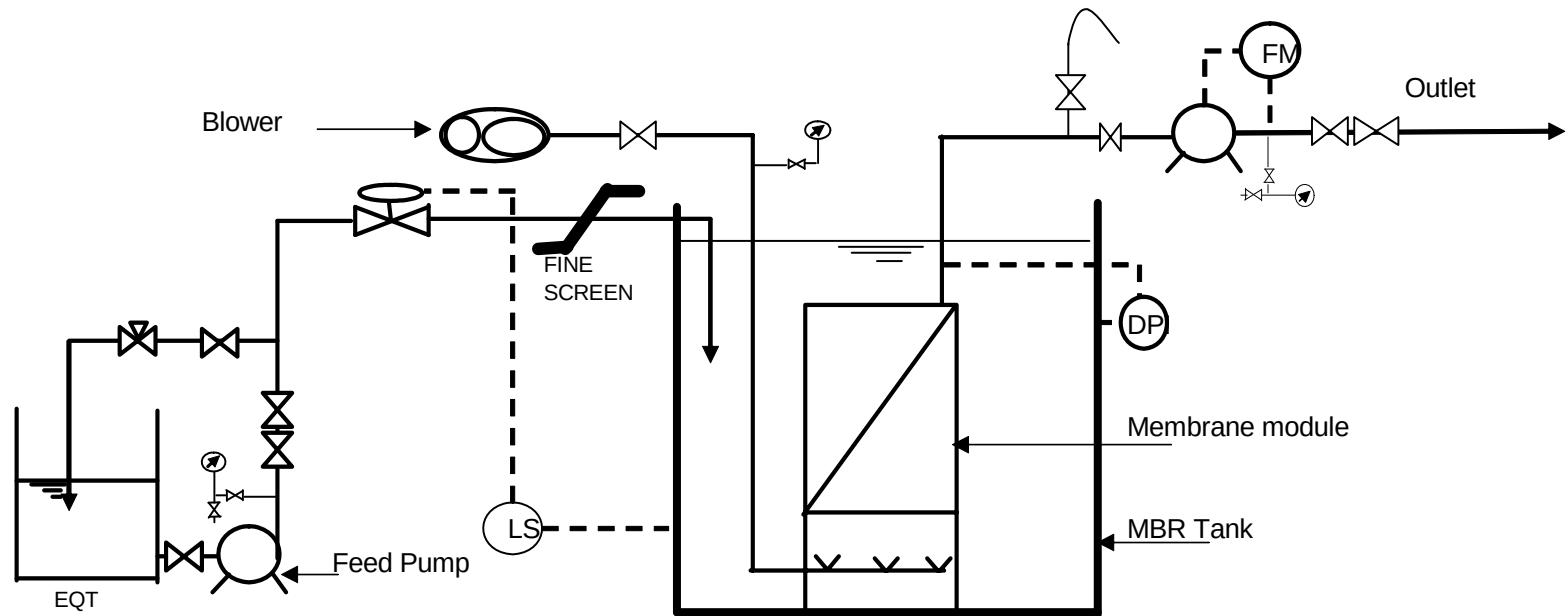
### **Pilot Plant Trials**

***Pilot plant trials have been conducted with following types of effluent..***

1. Domestic waste water.
2. Textile industrial effluent.
- 3.** Tannery industrial effluent

### MBR pilot plant set up:

A general process flow diagram of the MBR pilot plant is as shown:



**Schematic diagram of MBR pilot plant**

**General process description:**

10 m<sup>3</sup> capacity MS tank was used as an MBR tank consisting of flat sheet membranes sandwiching a support panel. Ultra-filtration membranes are made up of rugged PVDF (Polyvinyl Di Fluoride). PVDF has high stability for chemicals and physical strength. The membrane has small and uniform pore size of 0.08 microns. Therefore the rejection property of this membrane is excellent

In the MBR tank, MLSS (Mixed Liquor Suspended Solids) in the range of 10000 to 15000 mg/l is maintained. The high amount of bacteria gives better and complete removal of organic matter from the raw effluent in a relatively small area. Oxygen required for the bacteria is supplied through the blower. The air bubbles supplied from the bottom of the membrane elements continuously scour off cake of activated sludge accumulated on the membrane surface. This air is also used for the oxidation of organic substances.

The filtration is carried out by the suction pump directly sucking permeate water. The permeate water produced is clear and devoid of bacteria and viruses to the minimum levels.

As the membranes are continuously under operation, in course of time they get covered with organic or inorganic substances. Hence chemical cleaning is carried out once in two to three months for removing substances polluting and clogging the membranes. Normal cleaners used are sodium hypo chlorite and citric acid.

**Results and Discussions:**

*Domestic wastewater:*

The plant was running for around 5 months. Flow was increased slowly from 0.75m<sup>3</sup>/h to about 2.5 m<sup>3</sup>/h with the maximum membrane flux of 40-50 l/mh. MLSS was maintained around 10000 PPM with MLVSS to MLSS ratio of 0.75. More than 95 % COD reduction and more than 98% reduction in BOD (figure 1 & 2) was observed throughout the study. SDI at the MBR outlet was around 4-5.

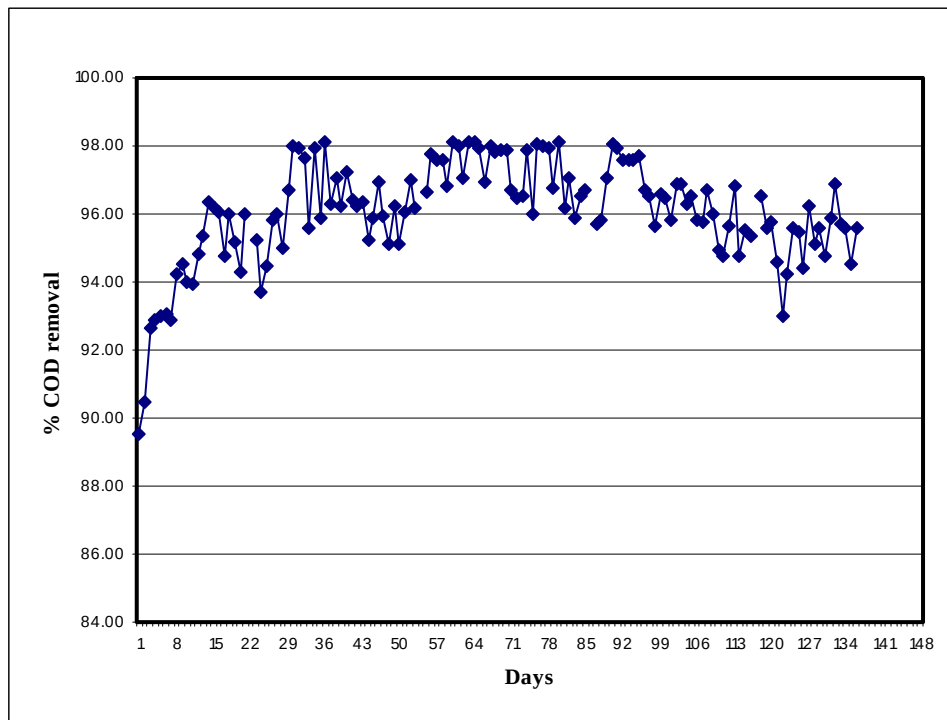


Figure 1: Reduction in COD in MBR for domestic wastewater

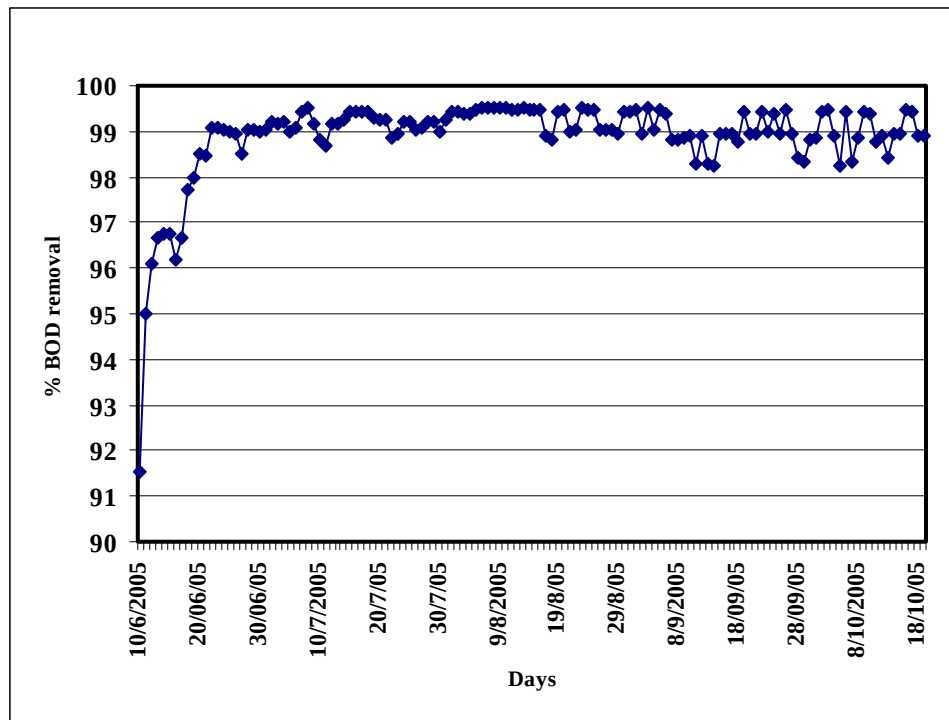


Figure 2: Reduction in BOD in MBR for domestic wastewater

### ***Textile waste water***

***Trials were carried out in two phases; phase - I treating combined effluent collected at Common Effluent Treatment Plant (CETP) by means of biological system (MBR) only. And Phase II - sequential chemical treatment followed by biological system to improve color reduction.***

#### **Phase I Biological treatment**

Plant was started with the flow rate of 700 litres/ h. MLSS was maintained around 7000 mg/l. After getting the outlet COD less than 100mg/l flow was changed to next flow. Likewise performance of the MBR was checked at flow rates from 700 – 1800 lph. Figure 3 shows that at the high flow i.e. 1800 lph COD reduction is 60-70% and BOD reduction is 90-95 %. At the same time from the visual observation it was observed that some amount of colour reduction was achieved in the MBR process.

### Phase II Sequential physico-chemical and MBR treatment chain

In the second phase, studies were done to see the performance of Chlorine as a pretreatment (to enhance color and COD reduction) for MBR. In this studies, the MBR was run for a month, at different chlorine doses ranging from 50 – 200 mg/l and at different flow rates from 600 – 1800 lph. Figure 4 shows that, after chlorine treatment around, 30-40 % of color reduction was achieved, while around 70-75% of color reduction was observed in the whole treatment chain. It is seen that at the high flow rate, reduction in COD after chlorine treatment is fluctuating widely in the range of 10-20%, but it encourages the COD reduction in the combined treatment, which is around 80-90% (Figure 5).

### ***Tannery Industrial Waste Water***

Trial was conducted at tannery Common Effluent Treatment Plant (CETP); primary treated effluent was fed to the MBR. The main aim of primary treatment is to reduce high sulfide content. The plant was running for more than 6 months with the flow of about 1.0 m<sup>3</sup>/h. During first two months, the plant was running with the flux of 8-12 l/m<sup>2</sup>h. Because of high content of sulphide in the wastewater, sludge became light and not so easily settleable. This resulted in reduction in membrane flux. Flux was increased up to about 14-20 l/m<sup>2</sup>h with the TMP of 0.3 -0.33 bar. MLSS was increased up to 12000 ppm. Figures 6 and 7 reveals that 80-85 % COD reduction and more than 95 % BOD reduction was observed during the study. Although reduction of organics is very good in tannery industrial effluent, reduction of colour of MBR permeate is a problem.

Effluent coming from tannery industry is rich in sulfide, even after providing chemical pretreatment for sulfide reduction it was not possible to reduce sulfide up to desired level. Hence it is decided to give extra pre-aeration to effluent to reduce sulfide to sulfate and provide anoxic tank to take care of TKN content of effluent before entering in MBR.

***Conclusion:***

MBR process proved to be the best technology for removal of organic matter (COD,BOD) by biological process. This is true in case of both domestic as well as industrial wastewaters. However, for use of MBR as a pre-treatment of RO in wastewater recycle, polishing filtration needs to be considered to reduce the SDI of RO feed water, to desired value. In case of the textile industry, chlorine as a pretreatment to MBR increases performance of the MBR in terms of colour and COD reduction. However the colour removal unit has to put after the MBR before wastewater feed to RO.

In case of tanneries, industrial effluent reduction of organics is excellent; care has to be taken for reduction of sulfide and TKN in pretreatment to the MBR for better performance of the MBR.

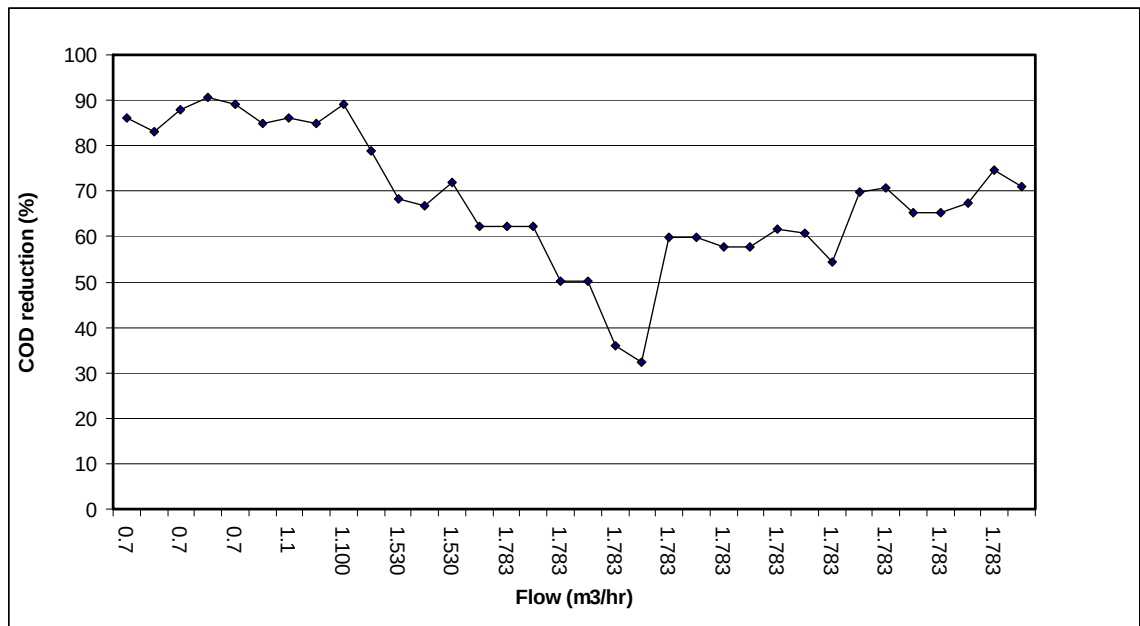


Figure 3: COD reduction in only biological process at different flow rate for textile waste

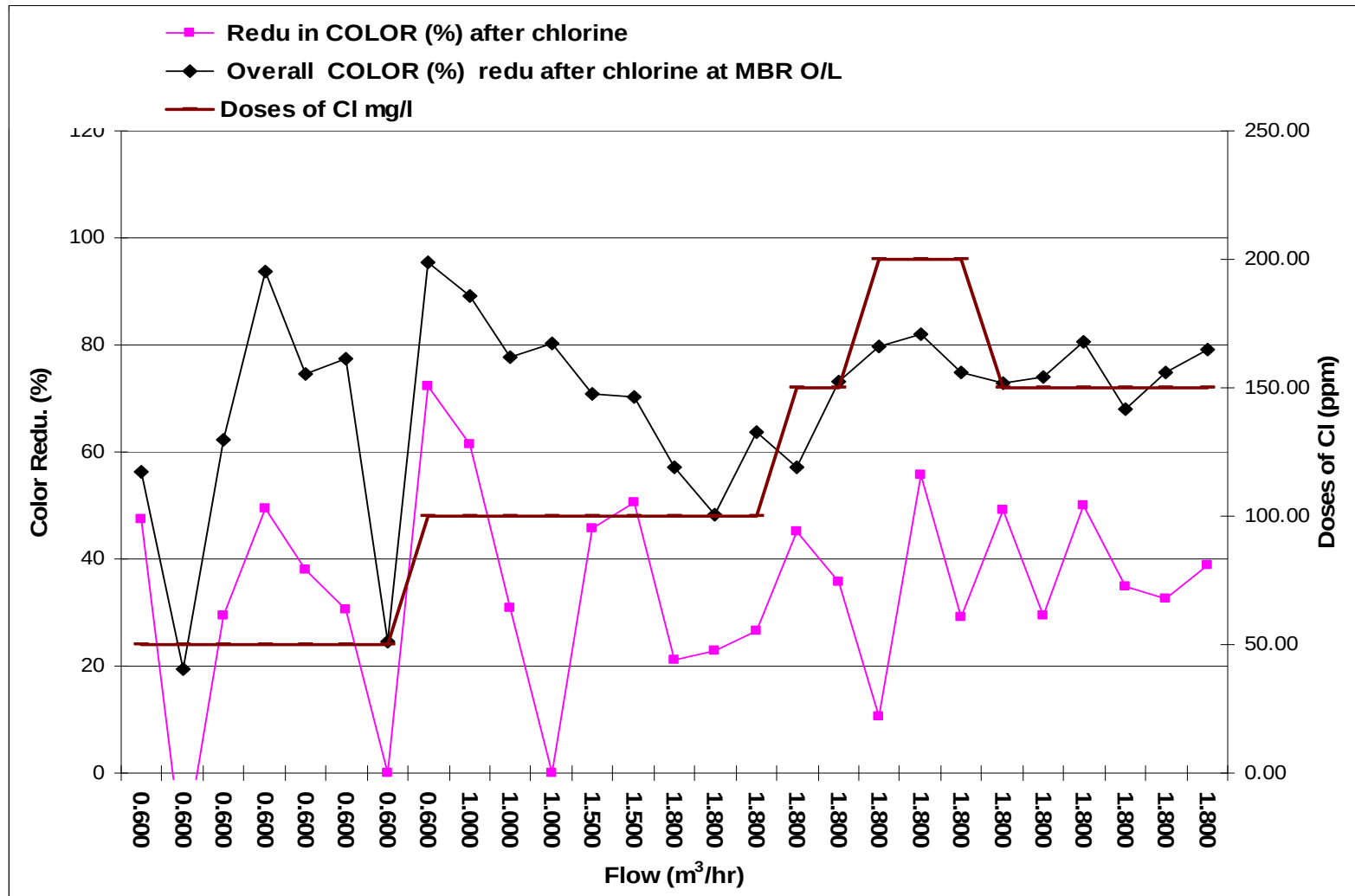


Figure 4 : Reduction in Colour (%) after chlorine treatment and after chlorine followed by MBR process for textile waste

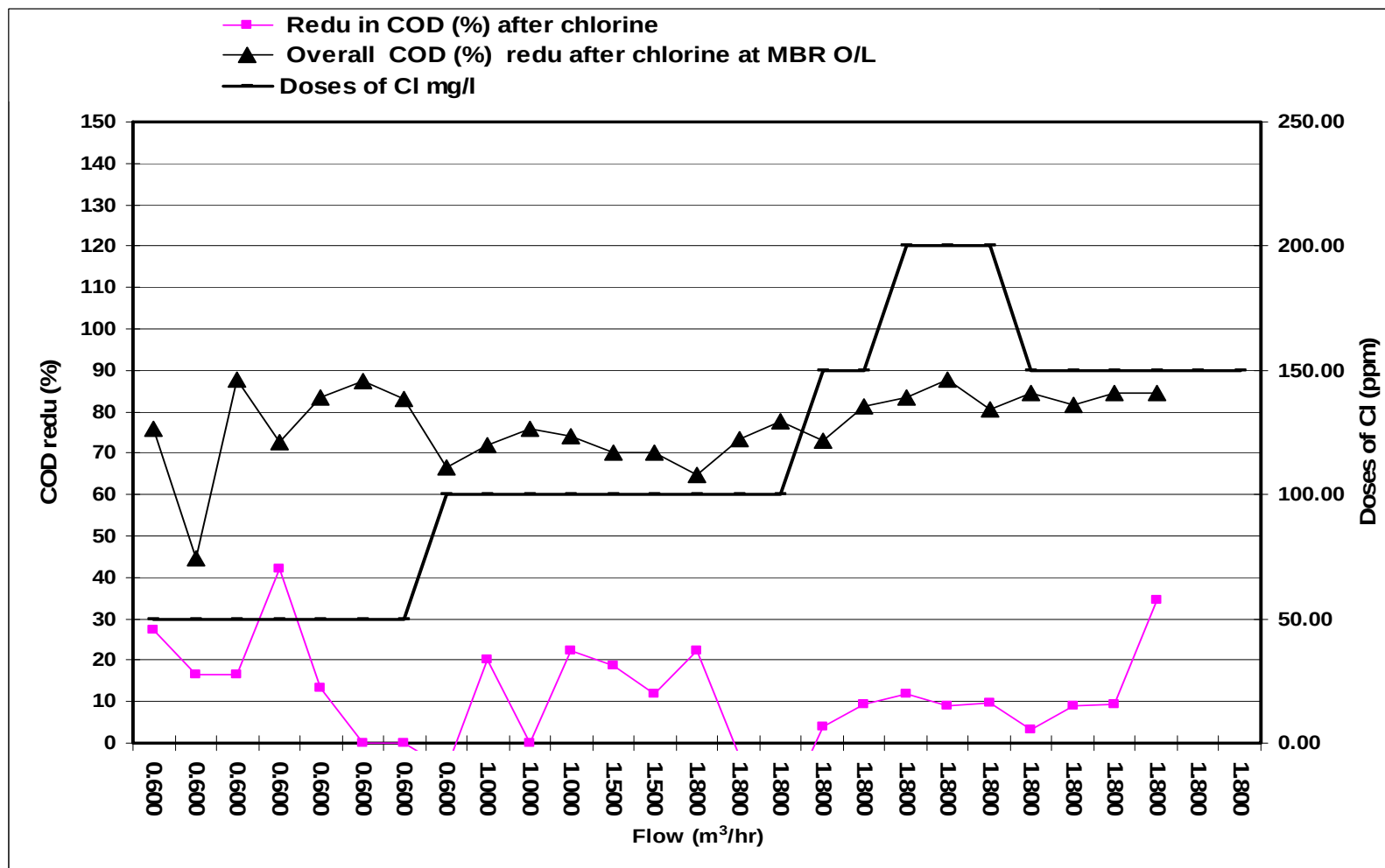


Figure 5: Reduction in COD (%) after chlorine treatment and after chlorine followed by MBR process for textile waste

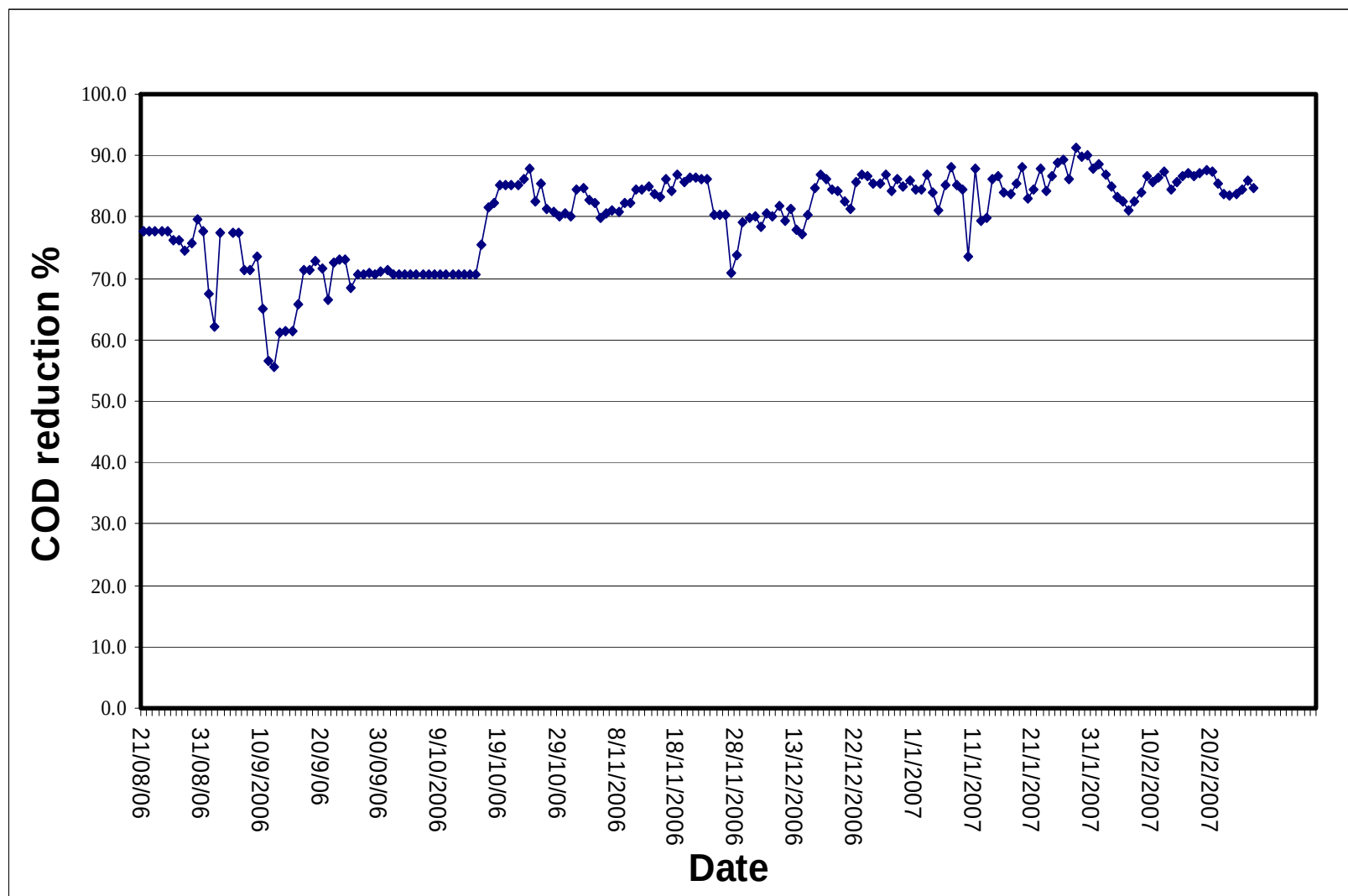


Figure 6 : Reduction in COD (%) MBR treatment for tannery waste

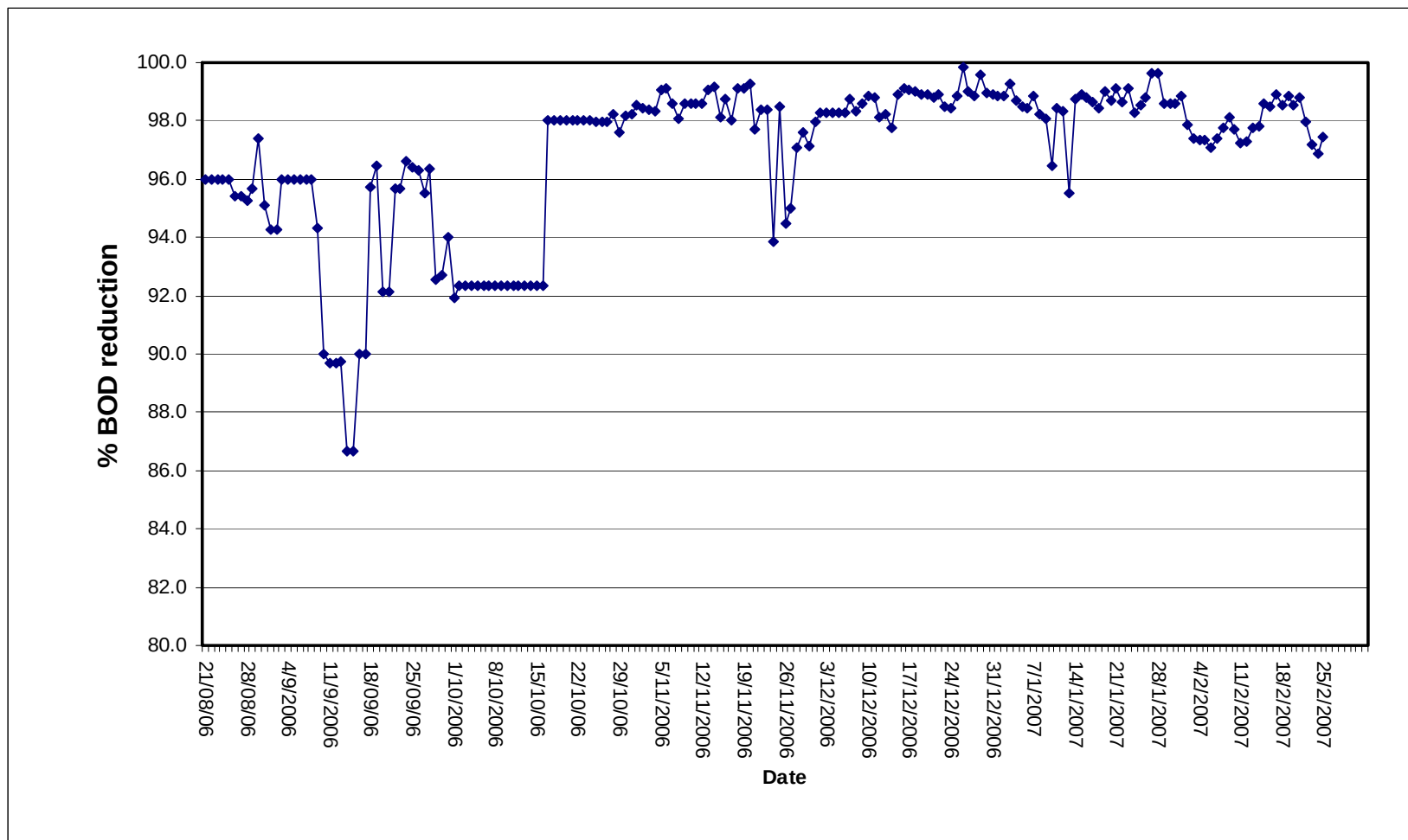


Figure 7: Reduction in BOD (%) in MBR treatment for tannery waste

