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Effect of Hydraulic Retention Time on Operating Parameters in Membrane Bioreactor System for Wastewater Treatment

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ABSTRACT

The aim of present study is to study effect of sludge retention time (SRT) on operating parameters such as Mixed Liquor Suspended Solids (MLSS) and Mixed Liquor Volatile suspended solids (MLVSS), Food to Micro-organisms ration (F/M ratio) and Organic loading rate(OLR) for hospital wastewater and residential quarter wastewater. The experiments have been performed on laboratory-scale hollow fiber submerged membrane bioreactor (MBR) for two different seasons. The two seasons considered was dry season i.e. summer season and another is wet season i.e. rainy season. For hospital wastewater , the MLSS is varied from 9.2 to 14.3 g/l. MLVSS is varied from 6.70 to 10.18 g/l. F/M is varied from 0.08 to 0.21 /day and OLR is varied from 1.07 to 2.14 kg/m^3.day. For residential quarter wastewater , the MLSS is varied from 9 to 13.8 g/l. MLVSS is varied from 6.47 to 9.82 g/l. F/M is varied from 0.08 to 0.19 /day and OLR is varied from 0.94 to 1.87 kg/m^3.day. It is found that MLSS, MLVSS, OLR and F/M are decreased with increase in HRT.

Keywords: Food to Micro-organisms ratio, Hydraulic Retention Time , Mixed Liquor Suspended Solids, Mixed Liquor Volatile suspended solids, Organic loading rate

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INTRODUCTION

In recent years, the integration of a membrane and the activated sludge process, or membrane bioreactor (MBR), has emerged as one of the innovative and promising solutions for wastewater treatment [1]. Submerged Membrane bioreactor (MBR) assembly is consisted of the membrane modules that are allocated into a bioreactor and the filtration is obtained with suction from a pump. Since this type of membrane bioreactor is more compact and energy saving, it has attracted great attention in recent years [2].MBRs use ultrafiltration or microflltration membranes for the complete retention of sludge, which leads to an increased microbial concentration in the reactor [3, 4].

MBR systems have been used to treat various types of wastewater with a chemical oxygen demand (COD) concentration ranging from about 100 to more than 40,000 mg/L and a hydraulic retention time (HRT) varying from 4 h to several days [5]. Fallah et al (2010) studied the effect of HRT on SMBR for a synthetic wastewater having a chemical oxygen demand (COD) and styrene concentration of 1500 mg/L and 50 mg/L, respectively. At two hydraulic retention times (HRTs) of 24 h and 18 h, the MBR was operated. It was found out that the removal efficiency of COD and styrene for both HRTs was consistently higher than 99%. [6]

In addition, Membrane bioreactor (MBR) system is characterized by short hydraulic retention time (HRT), small sludge production and perfect nitrification, which are induced from high mixed liquor suspended solids (MLSSs), condition [7]. For this reason, MBR has been widely applied to remove organic pollutants as well as nutrient in wastewater [7]. In some case ,by substituting the settling tank in a conventional activated sludge process with a membrane filtration device, all micro-organisms are retained in the bioreactor and the hydraulic retention time (HRT) becomes completely independent on the sludge retention time (SRT) [7,8]. High sludge concentration can therefore be achieved even in a short HRT. [8]

These researches introduced the alternating anoxic and oxic conditions in a submerged MBR by intermittent aeration for simultaneous removal of carbon and nitrogen [9, 10]. The key idea of this study is to examine the effect of HRT on effect of sludge retention time on operating parameters such as Mixed Liquor Suspended Solids and Mixed Liquor Volatile suspended solids, Food to Micro-organisms ration and Organic loading rate for wastewater originating from a hospital as well as residential quarter have been carried out by laboratory-scale hollow fiber membrane bioreactor (MBR) for two different seasons.

MATERIAL AND METHODS

A Submerged MBR assembly (100 L/day in Capacity) was fabricated to investigate applicability of membrane technology for Indian conditions. The feed substrates for the MBR reactor were the hospital wastewater collected from the drainage of a hospital on regular basis. For the reactor assembly, re-denitrification scheme (denitrification tank with a volume of 36 L) had been adopted for nitrogen removal, and a membrane module was immersed in the nitrification tank (volume 49 L). The permeate extraction regime was an alternate relaxation (2 min) followed by a suction phase (8 min). Aeration was carried out at the bottom of filtration module using a coarse diffuser in order to reduce fouling processes by turbulent flow generated along membranes. Mechanical cleaning was achieved by means of air bubble blowing at the bottom of the module. Permeate was withdrawn under suction from the membrane using a piston pump. To avoid the entrainment of air, nitrogen gas was introduced to maintain anoxic condition.

The seed biomass was initially acclimatized to aerobic and subsequently to anoxic conditions in batch mode. The 77 L reactor was subsequently seeded at a ratio 4:1. The reactor was operated under ambient conditions for which the temperature ranged between 29 to 31^{O}C (Average of 30^{O}C) for the entire operation period of three months. The hydraulic residence time (HRT) was varied as 4, 6 and 8 h and the SRT in successive tests was set at 10, 20 and 30 days, respectively. BOD, COD, MLSS and MLVSS were determined according to the procedures outlined in the standard methods [11]. F/M and OLR are calculated from standard Methods[12].

RESULTS AND DISCUSSION

Variation of MLSS and MLVSS, F/M and OLR with HRT

The variation in MLSS and MLVSS with different HRTs and constant SRT is shown in figure 1 and figure 3 for residential quarter wastewater and hospital wastewater respectively in the season-1 and that for season -2 variation in MLSS and MLVSS with different HRTs and constant SRT is illustrated in figure 5 and figure 7.

The variation in food to micro-organisms ratio (F/M ratio) and organic loading rate (OLR) with different HRTs and constant SRT is shown in figure 2 and figure 4 for residential quarter wastewater and hospital wastewater respectively in the season-1 and that for season-2 variation in F/M ratio and OLR with different HRTs and constant SRT is illustrated in figure 6 and figure 8.

Season -1

For residential quarter wastewater, the variation in MLSS and MLVSS are illustrated in figure 1 and variation in F/M ratio and OLR are illustrated in figure 2.

During SRT of 10 days, MLSS and MLVSS in activated sludge vary from 9.8 to 9.0 g/l and 6.95 to 6.47 g/l respectively for HRT change from 4 to 8 hours. For SRT of 20 days, MLSS and MLVSS in activated sludge vary from 11.5 to 10.4 g/l and 8.17 to 7.49 g/l respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, MLSS and MLVSS in activated sludge vary from 13 to 11.9 g/l and 9.24 to 8.65 g/l respectively for HRT change from 4 to 8 hours. However, During SRT of 10 days, F/M ratio and OLR of activated sludge vary from 0.19 to 0.10 /day and 1.84 to 0.94 Kg/m^3-day respectively for HRT change from 4 to 8 hours. For SRT of 6 hours, F/M ratio and OLR in activated sludge vary from 0.16 to 0.09 /day and 1.85 to 0.95 Kg/m^3-day respectively for HRT change from 4 to 8 hours. With regard to SRT of 8 hours, F/M ratio and OLR in activated sludge vary from 0.14 to 0.08 /day and 1.86 to 0.96 Kg/m^3-day respectively for HRT change from 4 to 8 hours.

For hospital wastewater, the variation in MLSS and MLVSS are illustrated in figure 3 and variation in F/M ratio and OLR are illustrated in figure 4.

During SRT of 10 days, MLSS and MLVSS in activated sludge vary from 10 to 9.2 g/l and 7.1 to 6.70 g/l respectively for HRT change from 4 to 8 hours. For SRT of 20 days, MLSS and MLVSS in activated sludge vary from 12 to 11 g/l and 8.54 to 8.04 g/l respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, MLSS and MLVSS in activated sludge vary from 14 to 12.5 g/l and 9.94 to 9.15 g/l respectively for HRT change from 4 to 8 hours. However, During SRT of 10 days, F/M ratio and OLR of activated sludge vary from 0.21 to 0.12 /day and 2.09 to 1.07 Kg/m^3-day respectively for HRT change from 4 to 8 hours. For SRT of 20 days, F/M ratio and OLR in activated sludge vary from 0.18 to 0.10 /day and 2.10 to 1.08 Kg/m^3-day respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, F/M ratio and OLR in activated sludge vary from 0.15 to 0.09 /day and 2.11 to 1.09 Kg/m^3-day respectively for HRT change from 4 to 8 hours.

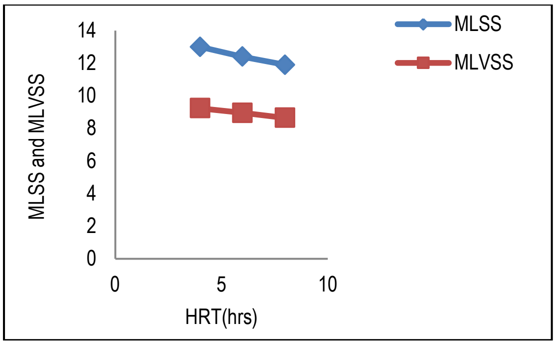
Season -2

For residential quarter wastewater, the variation in MLSS and MLVSS are illustrated in figure 5 and variation in F/M ratio and OLR are illustrated in figure 6.

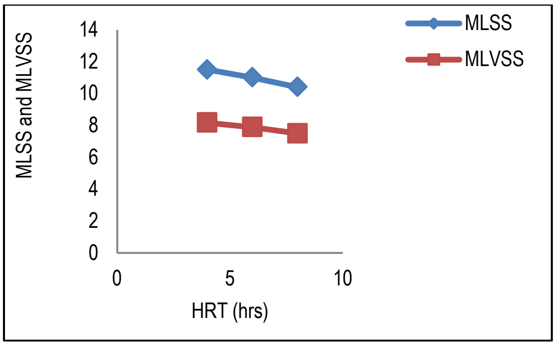
During SRT of 10 days, MLSS and MLVSS in activated sludge vary from 9.9 to 9.3 g/l and 7.05 to 6.77 g/l respectively for HRT change from 4 to 8 hours. For SRT of 20 days, MLSS and MLVSS in activated sludge vary from 12 to 11 g/l and 8.53 to 8.03 g/l respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, MLSS and MLVSS in activated sludge vary from 13.80 to 12.3 g/l and 9.82 to 8.99 g/l respectively for HRT change from 4 to 8 hours. However, During SRT of 10 days, F/M ratio and OLR of activated sludge vary from 0.19 to 0.10 /day and 1.85 to 0.94 Kg/m^3-day respectively for HRT change from 4 to 8 hours. For SRT of 20 days, F/M ratio and OLR in activated sludge vary from 0.16 to 0.09 /day and 1.86 to 0.95 Kg/m^3-day respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, F/M ratio and OLR in activated sludge vary from 0.14 to 0.08 /day and 1.87 to 0.96 Kg/m^3-day respectively for HRT change from 4 to 8 hours.

For hospital wastewater, the variation in MLSS and MLVSS are illustrated in figure 7 and variation in F/M ratio and OLR are illustrated in figure 8.

During SRT of 10 days, MLSS and MLVSS in activated sludge vary from 10.2 to 9.5 g/l and 7.26 to 6.92 g/l respectively for HRT change from 4 to 8 hours. For SRT of 20 days, MLSS and MLVSS in activated sludge vary from 12.2 to 11.5 g/l and 8.67 to 8.40 g/l respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, MLSS and MLVSS in activated sludge vary from 14.3 to 13 g/l and 10.18 to 9.51 g/l respectively for HRT change from 4 to 8 hours. However, During SRT of 10 days, F/M ratio and OLR of activated sludge vary from 0.20 to 0.11 /day and 2.09 to 1.08 Kg/m^3-day respectively for HRT change from 4 to 8 hours. For SRT of 20 days, F/M ratio and OLR in activated sludge vary from 0.18 to 0.09 /day and 2.12 to 1.09 Kg/m^3-day respectively for HRT change from 4 to 8 hours. With regard to SRT of 30 days, F/M ratio and OLR in activated sludge vary from 0.15 to 0.08 /day and 2.14 to 1.10 Kg/m^3-day respectively for HRT change from 4 to 8 hours.



a) Constant SRT = 30 days



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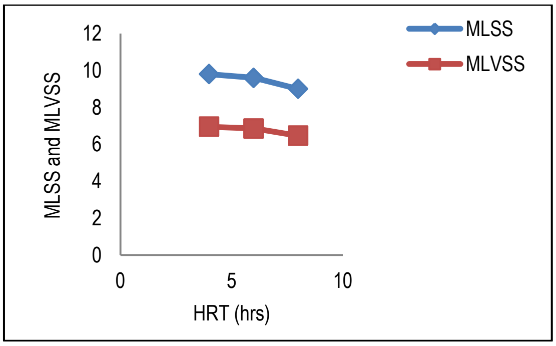
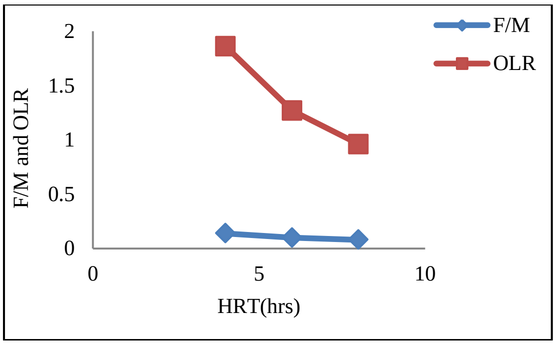


c) Constant SRT = 10 days

Figure 1: Variations in MLSS and MLVSS with HRT (Season-1)-Residential Quarter



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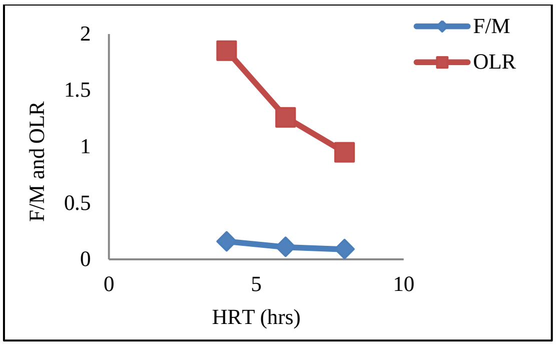

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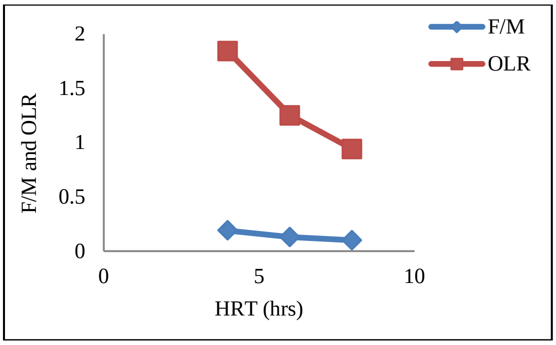
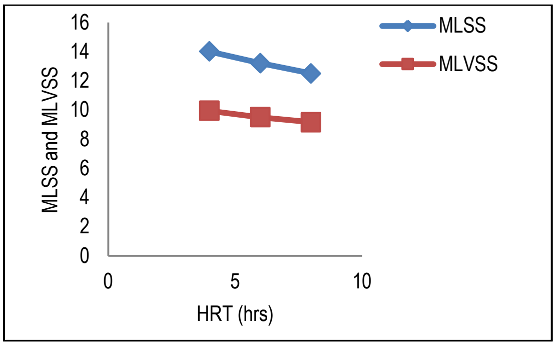


c) Constant HRT = 10 days

Figure 2: Variations in F/M and OLR with HRT (Season-1)-Residential Quarter



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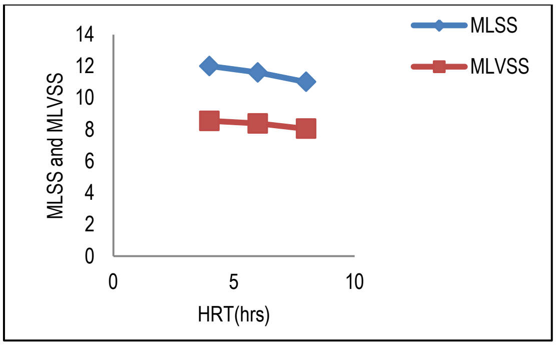

b) Constant SRT = 20 days

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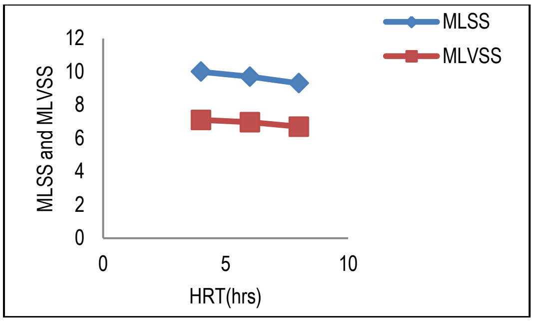
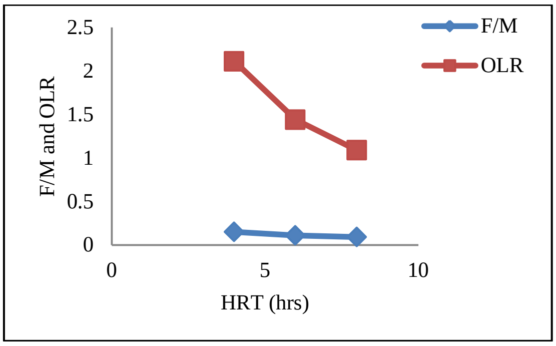


c) Constant SRT = 10 days

Figure 3 : Variations in MLSS and MLVSS with HRT (Season-1)-Hospital



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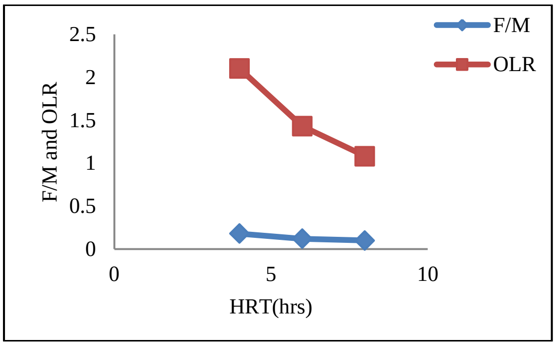

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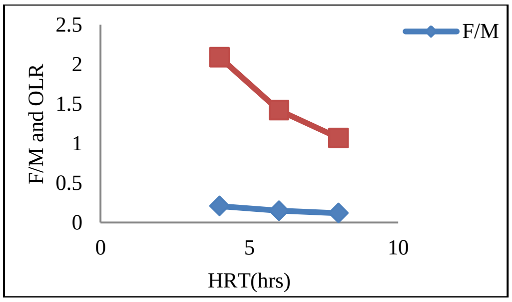

c) Constant SRT = 10 days

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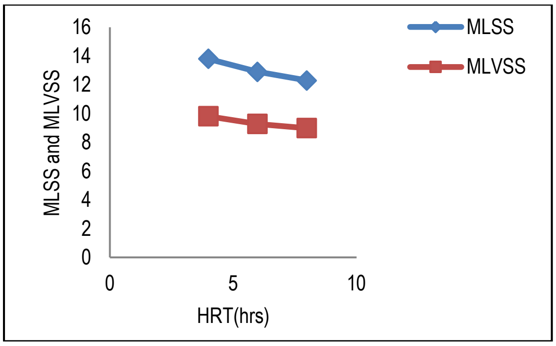
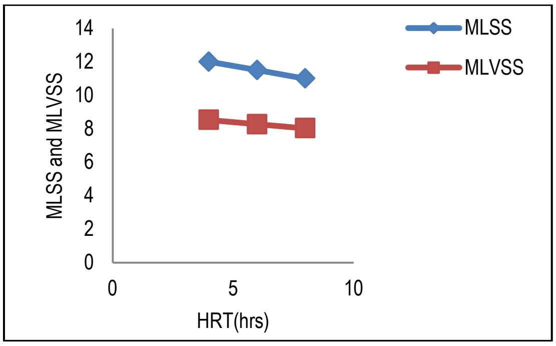
Figure 4: Variations in F/M and OLR with HRT (Season-1)-Hospital



a) Constant SRT = 30 days



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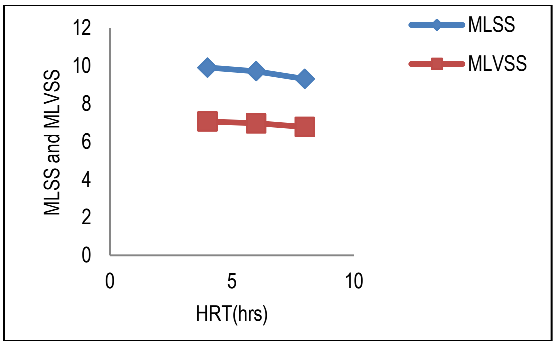
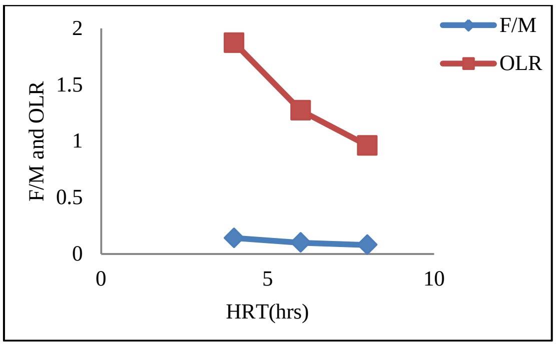


c) Constant SRT = 10 days

Figure 5 : Variations in MLSS and MLVSS with HRT (Season-2)-Residential Quarter



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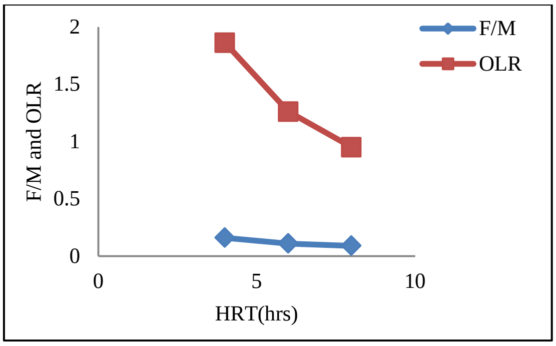
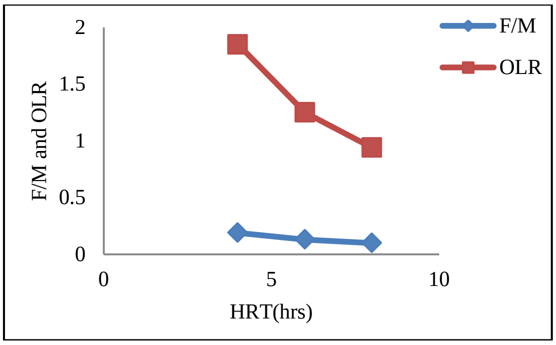
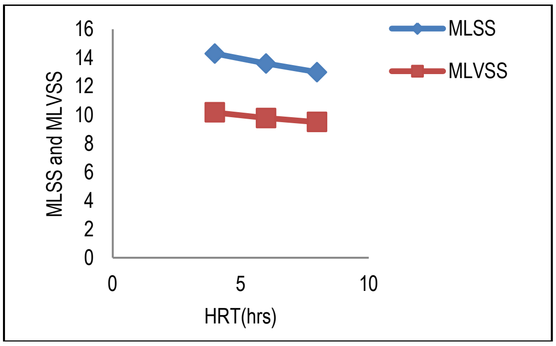


b) Constant SRT = 20 days

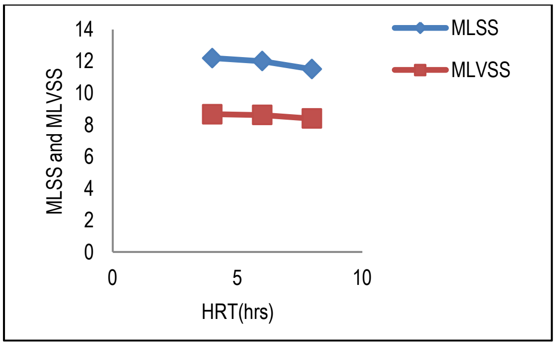


c) Constant SRT = 10 days

Figure 6 : Variations in F/M and OLR with HRT (Season-2)-Residential Quarter



a) Constant SRT = 30 days



b) Constant SRT = 20 days

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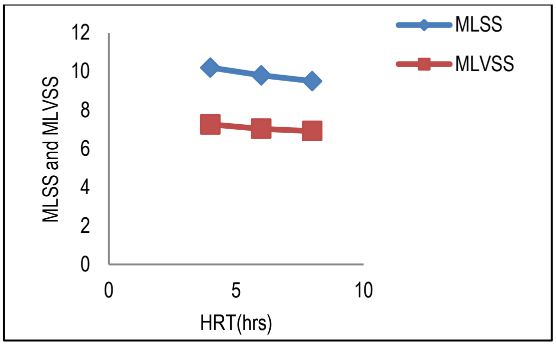
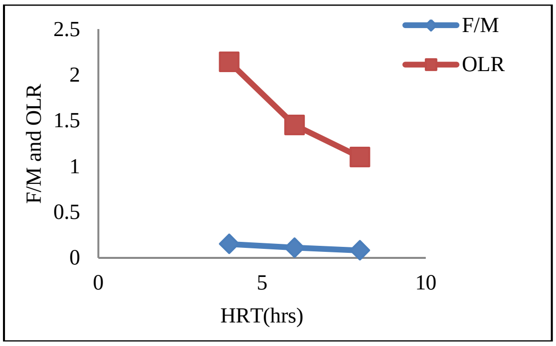


b) Constant SRT = 10 days

Figure 7: Variations in MLSS and MLVSS with HRT (Season-2)-Hospital



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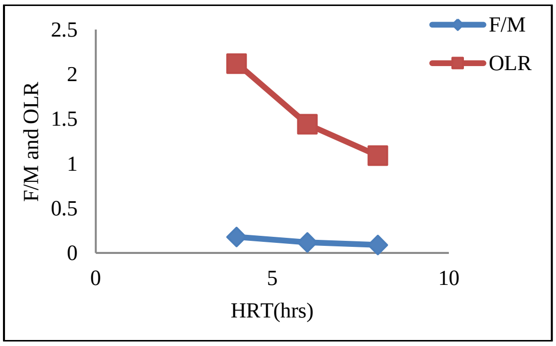

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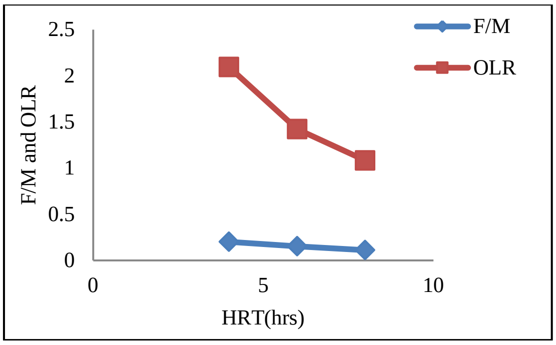

c) Constant SRT = 10 days

Figure 8: Variations in F/M and OLR with HRT (Season-2)-Hospital

CONCLUSION

The aim of present study ,for hospital wastewater , the MLSS is varied from 9.2 to 14.3 g/l. MLVSS is varied from 6.70 to 10.18 g/l. F/M is varied from 0.08 to 0.21 /day and OLR is varied from 1.07 to 2.14 kg/m^3.day. For residential quarter wastewater , the MLSS is varied from 9 to 13.8 g/l. MLVSS is varied from 6.47 to 9.82 g/l. F/M is varied from 0.08 to 0.19 /day and OLR is varied from 0.94 to 1.87 kg/m^3.day. It is found that MLSS, MLVSS, OLR and F/M are decreased with increase in HRT.

It is also found that the value of MLSS, MLVSS and OLR are more in hospital wastewater than residential quarter wastewater. The F/M ratio is almost equal for hospital wastewater and residential wastewater. From the studies, it is concluded that membrane fouling tendency is more if the HRT is short and vice versa. It is also concluded that the membrane gives better performance in residential quarter wastewater as compare to hospital wastewater. In the end, it is also observed that membrane is affected more in wet season than dry season.

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