ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Effect of Sludge Retention Time on Operating Parameters in Submerged Membrane Bioreactor

Rahul Keshav Jadhao[1]* and Shrikant D Dawande[2]

[1]Department of Chemical Engineering, Shri Guru Gobind Singhji Institute of Engineering and Technology, Vishnupuri, Nanded-431606, Maharashtra, India
[2]Department of Chemical Engineering, Laxminarayan Institute of Technology, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur-440033, Maharashtra, India

ABSTRACT

The objective of present study is to elaborate 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 wastewater originating from a hospital and residential quarter has been carried out by 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. In the present study the MLSS is varied from 9 to 14.3 g/l. MLVSS is varied from 6.47 to 10.18 g/l. F/M is varied from 0.08 to 0.20 /day and OLR is varied from 0.94 to 2.14 kg/m^3.day. It is found that MLSS, MLVSS and OLR are increased with increase in SRT and F/M is decreased with increase in SRT.

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

Corresponding author

INTRODUCTION

Membrane bioreactor (MBR) technologies have emerged as one of the innovative and promising solutions for wastewater treatment and reclamation by replacing a secondary clarifier by a membrane separation unit in an activated sludge process. It is well identified that sludge retention time (SRT) is the one of the important issues, which can alter the state of biomass in an activated sludge system [1, 2]. A membrane bioreactor (MBR) system can maintain better performance results in term of biomass compared to a conventional activated sludge system through membrane separation technology, which can achieve perfect solid/liquid separation [3]. But, it is also expect that biomass properties and membrane fouling in a MBR system can be significantly influenced by SRT. Again, many MBR researchers have functioned their systems with longer SRT compared to conventional biological treatment since they supposed that a higher biomass concentration, which was resultant by longer SRT, gave rise to higher treatment efficiency. Some MBR plants were run with an infinite SRT in order to maintain large amounts of biomass [4].

SRT is a vital aspect in the removal of pollutants and in the minimization of the amount of wasted sludge. Long SRT has a profitable advantage and avoid nitrifying bacteria from being washed out of the bioreactor, which improves the nitrification capability of the activated sludge [5, 6]. Knoblock et al. [7] analyzed the relationship between SRT and microorganism specific growth rate in pilot and full-scale membrane bioreactor systems for the treatment of oily wastewater. Trouve et al. [8] reported sludge production in the membrane bioreactor to be lower than in a conventional activated sludge process. Chaize and Huyard [9] investigated the treatment performance change at different SRT. However, most of these studies have concentrated on the conventional type, i.e. recirculated type, of membrane bioreactor, in which membrane modules are allocated outside a bioreactor; there are few reports on submerged membrane bioreactors [10, 11].

In this study, the main purpose of this study was to investigate the effect of SRT 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 has 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 [12]. F/M and OLR are calculated from standard Methods [13].

RESULTS AND DISCUSSION

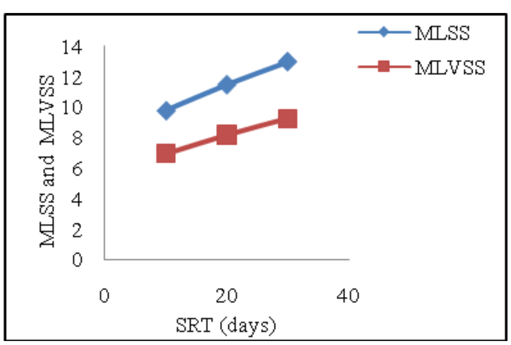
Variation of MLSS and MLVSS, F/M and OLR with SRT

The variation in MLSS and MLVSS with different SRTs and constant HRT 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 variations in MLSS and MLVSS with different SRTs and constant HRT is illustrated in figure 5 and figure 7.

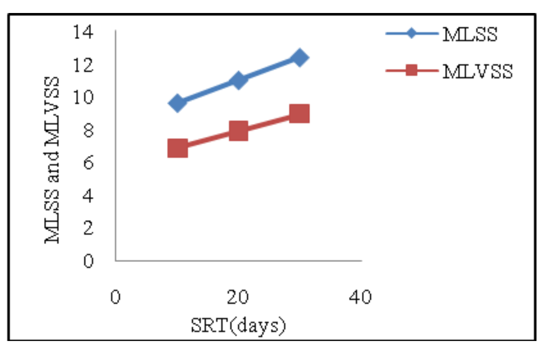
The variation in F/M ratio and OLR with different SRTs and constant HRT is shown in figure 2 and figure 4 for residential quarter wastewater and hospital wastewater respectively in the season-1 and that for season -2 variations in F/M ratio and OLR with different SRTs and constant HRT is illustrated in figure 6 and figure 8.

Season -1

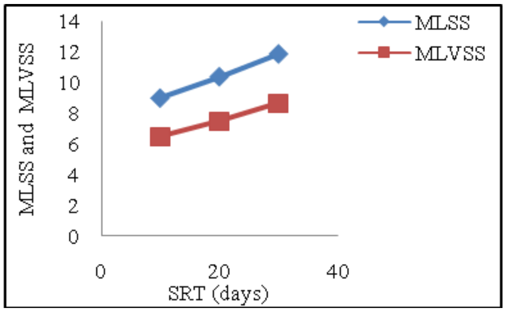
For **residential quarter wastewater**, the variation in MLSS and MLVSS are illustrated in figure 1 and variation in F/M ratio and OLR are illustrated in figure 2.



a) Constant HRT = 4 hours

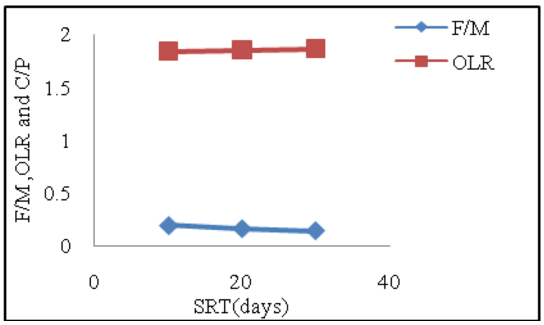


b) Constant HRT = 6 hours

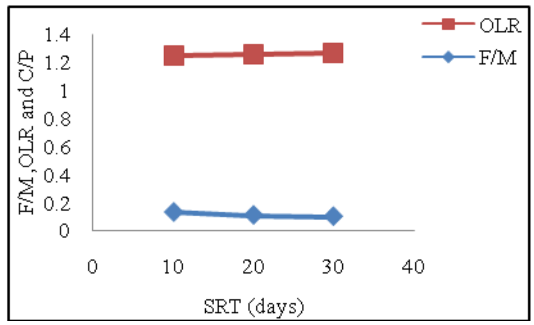


c) Constant HRT = 8 hours

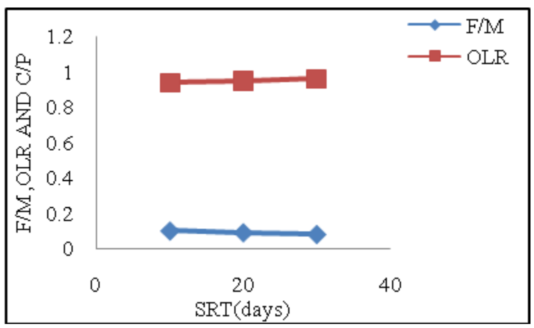
Figure 1: Variations in MLSS and MLVSS with SRT (Season-1)-Residential Quarter



a) Constant HRT = 4 hours



b) Constant HRT = 6 hours



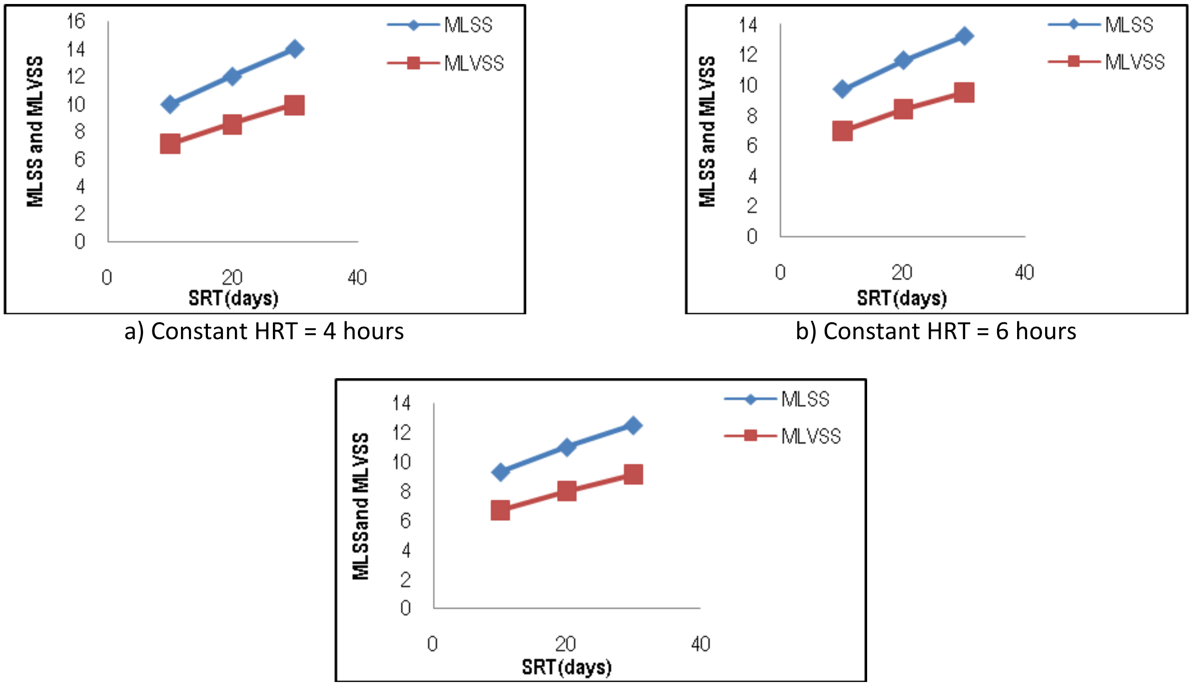
c) Constant HRT = 8 hors

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

During HRT of 4 hours, MLSS and MLVSS in activated sludge vary from 9.8 to 13 g/l and 6.95 to 9.24 g/l respectively for SRT change from 10 to 30 days. For HRT of 6 hours, MLSS and MLVSS in activated sludge vary from 9.6 to 12.4 g/l and 6.86 to 8.95 g/l respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, MLSS and MLVSS in activated sludge vary from 9.0 to 11.9 g/l and 6.47 to 8.65 g/l respectively for SRT change from 10 to 30 days. However, During HRT of 4 hours, F/M ratio and OLR of activated sludge vary from 0.19 to 0.14 /day and 1.84 to 1.86 Kg/m^3-day respectively for SRT change from 10 to 30 days. For HRT of 6 hours, F/M ratio and OLR in activated sludge vary from 0.13 to 0.10 /day and 1.25 to 1.27 Kg/m^3-day respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, F/M ratio and OLR in activated sludge vary from 0.10 to 0.08 /day and 0.94 to 0.96 Kg/m^3-day respectively for SRT change from 10 to 30 days.

ISSN: 0975-8585

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.

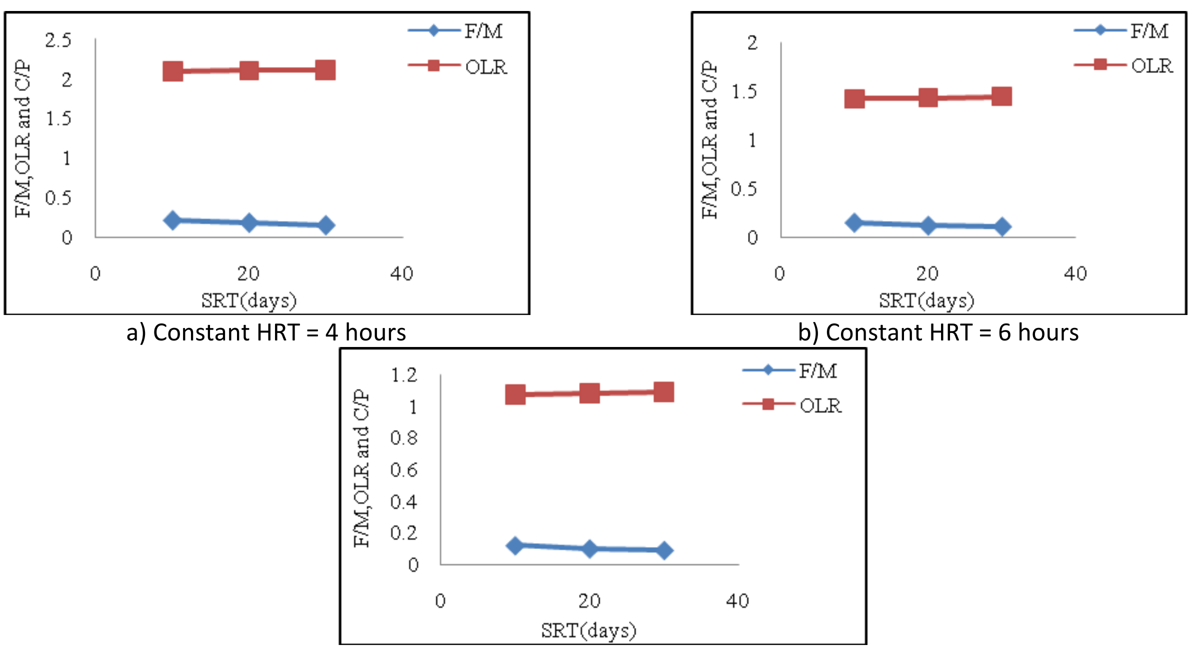


a) Constant HRT = 4 hours

b) Constant HRT = 6 hours

c) Constant HRT = 8 hours

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



a) Constant HRT = 4 hours

b) Constant HRT = 6 hours

c) Constant HRT = 8 hours

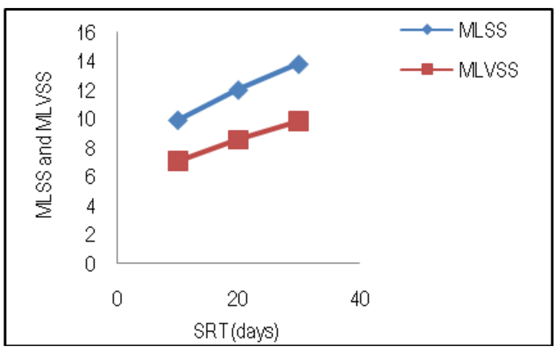
Figure 4 : Variations in F/M and OLR with SRT (Season-1)-Hospital

ISSN: 0975-8585

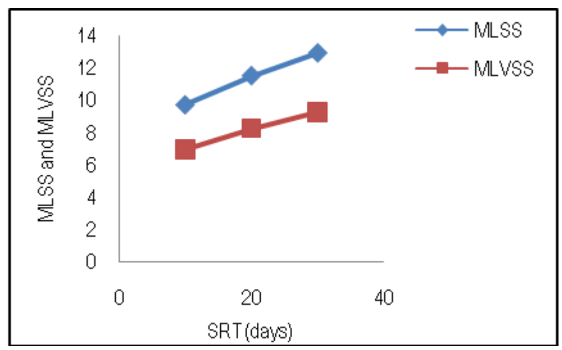
During HRT of 4 hours, MLSS and MLVSS in activated sludge vary from 10 to 14 g/l and 7.1 to 9.94 g/l respectively for SRT change from 10 to 30 days. For HRT of 6 hours, MLSS and MLVSS in activated sludge vary from 9.7 to 13.2 g/l and 6.97 to 9.50 g/l respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, MLSS and MLVSS in activated sludge vary from 9.2 to 12.5 g/l and 6.70 to 9.15 g/l respectively for SRT change from 10 to 30 days. However, During HRT of 4 hours, F/M ratio and OLR of activated sludge vary from 0.21 to 0.15 /day and 2.09 to 2.11 Kg/m^3-day respectively for SRT change from 10 to 30 days. For HRT of 6 hours, F/M ratio and OLR in activated sludge vary from 0.15 to 0.11 /day and 1.42 to 1.44 Kg/m^3-day respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, F/M ratio and OLR in activated sludge vary from 0.12 to 0.09 /day and 1.07 to 1.09 Kg/m^3-day respectively for SRT change from 10 to 30 days.

Season -2

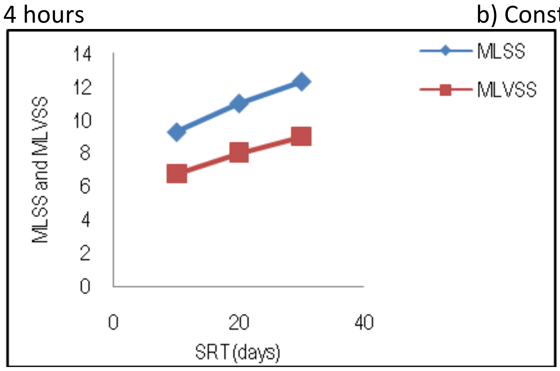
For **residential quarter wastewater**, the variation in MLSS and MLVSS are illustrated in figure 5 and variation in F/M ratio and OLR are illustrated in figure 6.



a) Constant HRT = 4 hours



b) Constant HRT = 6 hours

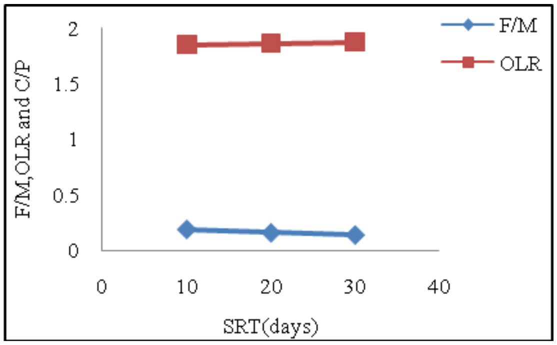


c) Constant HRT = 8 hours

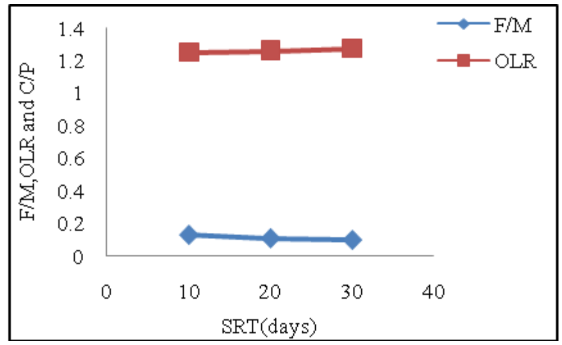
Figure 5: Variations in MLSS and MLVSS with SRT (Season-2)-Residential Quarter

During HRT of 4 hours, MLSS and MLVSS in activated sludge vary from 9.9 to 13.8 g/l and 7.05 to 9.82 g/l respectively for SRT change from 10 to 30 days. For HRT of 6 hours, MLSS and MLVSS in activated sludge vary from 9.7 to 12.9 g/l and 6.96 to 9.28 g/l respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, MLSS and MLVSS in activated sludge vary from 9.3 to 12.3 g/l and 6.77 to 8.99 g/l respectively for SRT change from 10 to 30 days.

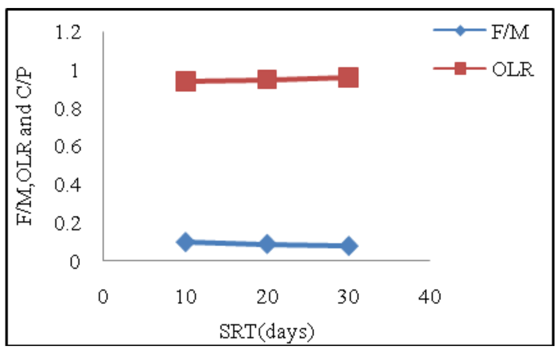
However, During HRT of 4 hours, F/M ratio and OLR of activated sludge vary from 0.19 to 0.14 /day and 1.85 to 1.87 Kg/m^3-day respectively for SRT change from 10 to 30 days. For HRT of 6 hours, F/M ratio and OLR in activated sludge vary from 0.13 to 0.10 /day and 1.25 to 1.27 Kg/m^3-day respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, F/M ratio and OLR in activated sludge vary from 0.10 to 0.08 /day and 0.94 to 0.96 Kg/m^3-day respectively for SRT change from 10 to 30 days.



a) Constant HRT = 4 hours



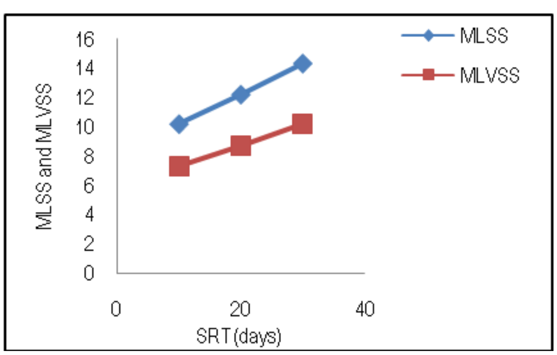
b) Constant HRT = 6 hours



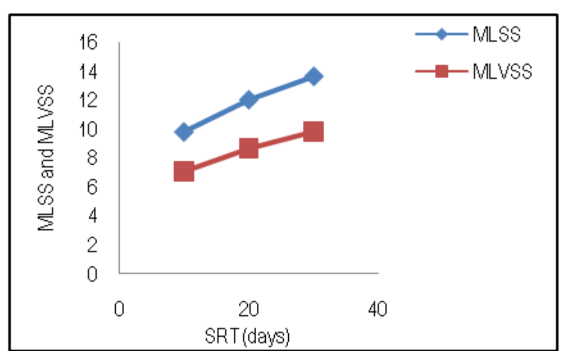
c) Constant HRT = 8 hours

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

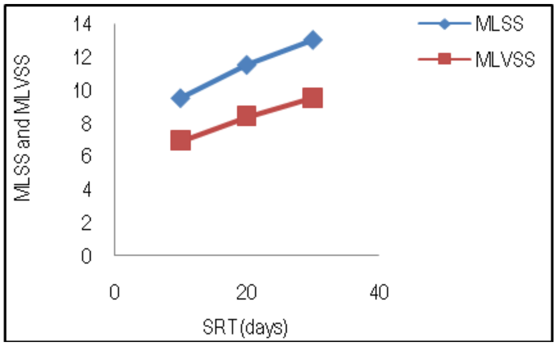
For **hospital wastewater**, the variation in MLSS and MLVSS are illustrated in figure 7 and variation in F/M ratio and OLR are illustrated in figure 5.8.



a) Constant HRT = 4 hours

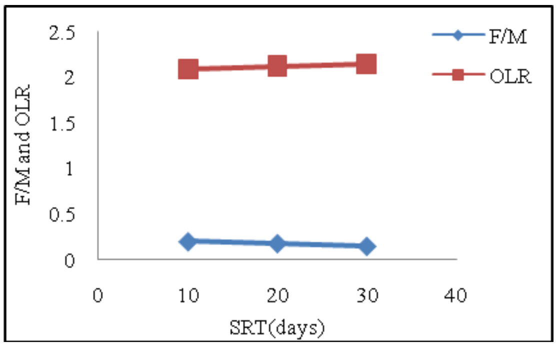


b) Constant HRT = 6 hours

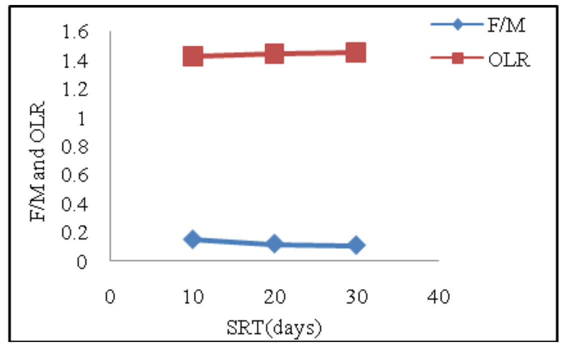


c) Constant HRT = 8 hours

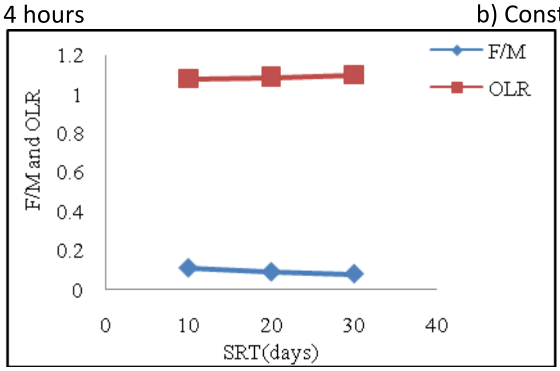
Figure 7: Variations in MLSS and MLVSS with SRT (Season-2)-Hospital



a) Constant HRT = 4 hours



b) Constant HRT = 6 hours



c) Constant HRT = 8 hours

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

During HRT of 4 hours, MLSS and MLVSS in activated sludge vary from 10.2 to 14.3 g/l and 7.26 to 10.18 g/l respectively for SRT change from 10 to 30 days. For HRT of 6 hours, MLSS and MLVSS in activated sludge vary from 9.8 to 13.6 g/l and 7.03 to 9.79 g/l respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, MLSS and MLVSS in activated sludge vary from 9.5 to 13 g/l and 6.92 to 9.51 g/l respectively for SRT change from 10 to 30 days. However, During HRT of 4 hours, F/M ratio and OLR of activated sludge vary from 0.20 to 0.15 /day and 2.09 to 2.14 Kg/m^3-day respectively for SRT change from 10 to 30 days. For HRT of 6 hours, F/M ratio and OLR in activated sludge vary from 0.15 to 0.11 /day and 1.42 to 1.45 Kg/m^3-day respectively for SRT change from 10 to 30 days. With regard to HRT of 8 hours, F/M ratio and OLR in activated sludge vary from 0.11 to 0.08 /day and 1.08 to 1.10 Kg/m^3-day respectively for SRT change from 10 to 30 days.

CONCLUSION

In the present study 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. 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.It is found that MLSS, MLVSS and OLR are increased with increase in SRT and F/M is decreased with increase in SRT. It is also found that the MLSS, MLVSS and OLR is 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 is affected by MLSS, MLVSS, F/M and OLR i.e membrane resistances are increased with increased in MLSS, MLVSS, F/M and OLR. It is also concluded that the membrane fouling tendency is more in hospital wastewater than residential quarter wastewater. Finally, we can conclude that the membrane performance is better in dry season as compare to wet season.

REFERENCES

[1] Peters TA, Gunther R and Vossenkaul K. Filtration and Separation 2000; 18–21.
[2] Bae TH, Han SS and Tak TM. Proc Biochem 2003; 39: 221-231
[3] Choi C, Lee J, Lee K and Kim M. Bioresource Technology 2008; 99: 5397–5401.
[4] Mohammed TA, Birimaa AH, Noora MJMM, Muyibi SA, Idris A. Desalination 2008; 221: 502–510.
[5] Lee W, Kang S and Shin H. J Membrane Sci 2003; 216: 217–227.
[6] Fan X, Urbain V, Qian Y, Manem J. Water Sci Technol 1996; 34 (1–2): 129–136.
[7] Knoblock MD, Sutton PM, Mishra PN, Gupta K and Janson A. Water Environ Res 1994; 66(2): 133–9.
[8] Trouve E, Urbain V and Manem J. Water Sci Technol 1994; 30(4): 151–7.
[9] Chaize S and Huyard A. Water Sci Technol 1991; 23: 1591–600.
[10] Huang X., Gui P. and Qian Y. Proc Biochem 2001; 36: 1001-1006
[11] Huang Z, Ong SL and Ng HY. Water Res 2011; 45: 705-713
[12] Standard Methods for the Examination of Water and Wastewater, 21st ed., 2005 American Public Health Association (APHA), American Water Works Association (AWWA) & Water Environment Federation (WEF), Washington, DC, USA.
[13] Tchnobanoglous G, Burton FL and Stensel HD. Metcalf & Eddy, Inc. Wastewater Engineering Treatment and Reuse , Fourth Edition; Tata McGraw-Hall publishing company limited: New Delhi 2003.