Determination of Active Biomass in Activated Sludge of Different STPs in India

Mohd. Asfar*, Rubia Zahid Gaur**, S.Shakeel Afsar****, Anwar Ali Khan***, Abid Ali Khan** **, Basileios Diamantis*****, Beni Lew**, A.A.Kazmi******

* Department of Chemistry, IIT Roorkee, India
** Volcani Centre, ARO, Bet Dagan, Israel
(E-mail: *benilew@volcani.agri.gov.il*; *rubsgaur@gmail.com*)
***Ministry of Env. & Forest, UP Govt. Lucknow, India
(E-mail: *envanwar@yahoo.com*)
****Department of Civil Engg., JMI, New Delhi, India
(E-mail: *dee.abid@gmail.com*)
*****Department of Civil Engg, Univ. of Thrace, Xanti, Greece
(E-mail: *bdiamant@env.duth.gr*)
******Department of Civil Engg., IIT Roorkee, India

Abstract
The fraction of active biomass in activated sludge process based sewage treatment plants (STPs) has been studied. This study especially focussed on the degradation of active biomass during sequential exposure of sludge to different aeration conditions. The different sludge fractions in terms of active biomass (quantified based on VSS measurement), were quantified. The relative amounts of active biomass did not changed when exposed to different aeration conditions in sequencial batch reactors (SBRs), which indicates that short SRT and starvation in the during settling did not promote the degradation of a specific sludge fraction.

Keywords
Active biomass, Activated sludge, Sewage treatment, VSS

INTRODUCTION

Sewage contains enough amounts of suspended solids, organic and inorganic pollutants which must be treated and transformed into acceptable end products and treated water for the discharge into the receiving water bodies. During treatment of the sewage, significant amount of excess activated sludge (containing more than 99% water) was generated in the process. The Activated Sludge Process (ASP) or its variant such as sequencing batch reactor (SBR) has been extensively applied to sewage treatment in India. The large amount of excess sludge produced from ASP based STPs becomes a waste management problem to the municipal bodies. This sludge is undesirable for three main reasons namely, biological instability due to its high content of biodegradable material that will undergo decomposition once aeration is stopped, its poor hygienic quality due to the presence of pathogenic microorganisms, its low concentration in solids require dewatering prior to further treatment or disposal (Metcalf and Eddy,2003).

Sludge handling, treatment and disposal are the primary concern for most of the countries. According to Kelessidis and Stasinakis, (2012) the increase of the annual sewage sludge production is expecting to exceed 13 million tons Dried Solids (DS) in world by 2020. Therefore, for most of the Govt./ or municipalities, the first priority is to reduce the sewage sludge for waste management. Various technological options are available to reduce and/or treat sewage sludge in large and small scale installations. However, still a challenge in order to efficiently reduce sludge production at such treatment facilities.

The SBRs were investigated for the sewage sludge reduction which has alternating oxic, anoxic and settling cyclic operation. The SBR has several advantages such as easy application, small footprint and high effluent quality (Khan et al. 2011). The SBR could be easy installed into existing STPs and its operation should not be more complex than the previously existing technologies at the STPs. The alternating of the oxic/anoxic/anaerobic environments in SBR processes has been studied to reduce sewage sludge production in several configurations. Despite its several advantages, scanty

information was observed about sludge reduction. According to Mahhendraker and Viraraghvan (1995) and Spanjers et al. (1996) the oxygen uptake rate (OUR) for a given sludge shows good indicator of the active biomass fraction.
Therefore, an attempt has been made to investigate the active biomass fraction at the existing ASP based full scale STPs in order to gain confident about the sludge reduction.

MATERIALS AND METHODS

Samples Collection

Return activated sludge samples were collected from different states of India viz Uttarakhand (18 million liter per day (MLD) - conventional activated sludge plant treating municipal sewage at Hardwar, 3 MLD SBR based STP at Rishikesh); Uttar Pradesh (25 MLD - SBR at Sector 50, Noida, 33 MLD – SBR, Sector 54, at Noida); Punjab (105 MLD – SBR at Ludhiana).

Experimental Setup

To assess the biodegradable fraction of activated sludge from different plants, six different sludges were aerated in six different 2-liter batch reactors and all batch reactors were housed in a chamber where temperature was maintained 13-30^{o}C. Experiments were performed in two seasons' winter and summer in order to check the temperature effect. Samples of 50 mL of mixed liquor were withdrawn daily to measure the concentration of suspended solids in the mixed liquor.

Sample Analysis

Samples of 50 mL of mixed liquor were withdrawn daily to measure the concentration of suspended solids in the mixed liquor. The aeration was maintained through diffusers, in order to maintain DO concentration of 6-8 mgO_2/L. Parameters namely; pH and dissolved oxygen (DO) were continuously monitored by HQ Series portable DO/pH probes (Model 40 D Hach, USA). The activated sludge obtained from different STPs was investigated for pH, DO and MLSS. All analytical testing were done according to APHA (1989).

RESULTS AND DISCUSSION

Rate Constant and Active Biomass in Activated Sludge

A total of 6 batch aerobic digestion tests, each of 30 days duration, were conducted to determine decay rate constant and active biomass of the sludge mixed liquor. The parameters were determined using the VSS-based method for all tests. For continuously-fed or batch-fed flow systems the change in suspended solid per unit time is given by;

$$\frac{dX}{dt} = -k_d X \qquad (1)$$

Where ,

X= Mixed-liquor volatile suspended solid (MLVSS) ,mg/l

k_d = degradation rate constant,day

The equation can be integrated between definite limits as follws:

$$\int_{X_o}^{X_t} \frac{dX}{dt} = -k_d \int_0^t dt \qquad (2)$$

The final equation after solving the above equation came as:

$$X_t = X_o e^{-k_d t} \qquad (3)$$

Where, X_o = concentration of MLVSS at time t = 0

X_t = concentration of MLVSS at time t = t

The above equation is use for calculating the digestion rate constant in the batch study of aerobic digestion process.
The digestion rate constant at any temperature can also be calculated by the equation given by Van't Hoff-Arrehenus equation:

$$K_T = K_{25}\,\Theta^{T-25} \quad (4)$$

Where, K_T = Rate constant at T°C, K_{25}= Rate constant at 25°C,
Θ = A constant ranging from 1.02 to 1.07

Values of Rate Constant at 25^{0}C

Table 1 and 2 summarises the values of (Kd) for the sludge of different STPs. The degradation constant (Kd) of different samples were calculated by plotting on double log graph between degradable solids and time (days) and subsequently the Kd values were determined at 25^{0}C by applying above formula, after temperature correction.

Table 1. **Value of K_d at 25^{0}C of sludge sample from 18 MLD- STP, HARIDWAR**

Days	MLSS (mg/l)	MLVSS (mg/l)	VSS/MLSS	kd (d^{-1})	kd@25 ^{0}C (d^{-1})
0	11212	7724	0.69	-	-
10	10077	6440	0.64	0.03	0.04
30	8390	5700	0.68	0.035	0.038

Table 2. **Value of K_d at 25^{0}C of sludge sample from 3 MLD- STP, RISHIKESH**

Days	MLSS (mg/l)	MLVSS (mg/l)	VSS/MLSS	kd (d^{-1})	kd@25 ^{0}C (d^{-1})
0	2485	1860	0.75	-	-
10	1970	1350	0.68	0.099	0.13
30	1240	785	0.63	0.084	0.11

The Kd of other STPs viz, Uttar Pradesh (25 MLD - SBR at Sector 50, Noida, 33 MLD – SBR, Sector 54, at Noida); Punjab (105 MLD – SBR at Ludhiana) were reported in Table 3. The Kd values were affected by the level of the MLSS maintained in the aeration tank and DO concentration. An increased in MLSS concentration indicate the increase in Kd value.

Table 3. **Value of K_d at 25^{0}C of sludge sample of various STPs**

STPs Location	MLSS (mg/l)	MLVSS (mg/l)	VSS/MLSS	kd (d^{-1})	kd@25 ^{0}C (d^{-1})
Sector 50-Noida	3050-3250	2860-3000	0.75	0.076	0.12
Sector 54-Noida	3100-3400	2450-2700	0.68	0.099	0.14
Punjab	3340-4200	2854-3100	0.63	0.084	0.16

Variation of oxygen uptake rate (OUR)

The variations in the activity with sludge age was also been observed (Fig.1). The oxygen uptake rate (OUR) of the sludge with shorter sludge age was observed higher than the sludge with a longer sludge retention time (SRT). Results of the present study indicate that the higher OUR observed for the STPs running at a shorter SRTs. Results were supported by the study carried out by Spanjers et al. (1996).

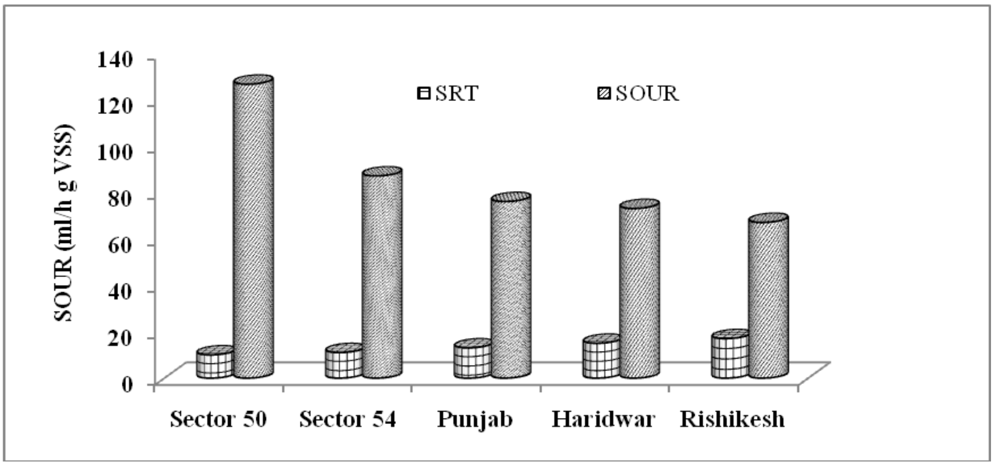

Figure 1 Variation of SOUR with SRT of Different STPs

CONCLUSIONS

The fraction of active biomass monitors in various STPs. The SBR systems can achieve a 51.7% reduction of sludge yield, reducing the excess sludge production and active biomass yield 67.1%, compared with the CAS system. The SBR showed a higher metabolic activity in their active biomass than the CAS system. The active biomass level could be controlled with SOUR and helps to regulate the excess sludge wastage.

REFERENCES

APHA, (1989) Srandard methods for examination of water and wastewater, 17th edition, Washington, USA

Huang, J.Y.C., Cheng, M.D. (1984) Measurement and new applications of oxygen uptake rates in activated sludge processes. *J.WPCF;* 56(3), 259-265.

Kelessidis, A., Stasinakis, A.S., (2012) Comparative study of the methods used for treatment and final disposal of sewage sludge in European countries. *Waste Manage*. 32, 1186–1195.

Khan, Abid Ali, Gaur, Rubia Zahid, Tyagi, V.K., Khursheed, Anwar, Lew, Beni, Kazmi, A.A., Mehrotra, Indu (2011) Sustainable options of post treatment of UASB effluent treating sewage: A Review. *Resource, Conservation and Recycling;* Vol. 55 (12); 1232-1251.

Mahhendraker, V., Viraraghvan, T., (1995) Respirometry in environmental engineering. *Environmental Science and Health*; A 30(4), 713-734.

Spanjers, S., Vanrolleghem, P., Olsson, G., Dold, P., (1996) Respirometry in control of activated sludge process. *Water Sci. Tech.*; 34 (3-4); 117-126.