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Effect of Organic Shock Loading On Extended Aeration System

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Abstract- The effects of short-term organic shock loads on the performance of a laboratory scale extended aeration system working at 18 h HRT was studied by increasing the influent chemical oxygen demand (COD) to 2times the normal values. Each short-term organic shock load was applied for a period of 6 h, after which normal loading conditions were resumed. The maximum effluent COD concentration obtained was 95, and 105mg/L under the shock loads of 1500 and 2000 mg COD/L, respectively. The system recovered quickly from shock loads; recovery time proportional to the magnitude of shock loads.

Keywords- Dynamic behavior, Extended aeration system, Organic shock loads, Recover time and sewage treatment plant.

I. INTRODUCTION

Sewage treatment plants should be able to cope with the changes in the composition of wastewater and the daily fluctuation in flow. Reactor stability against shock loads is one of the most important design characteristics as wastewater treatment plants are designed based on average flow rates and average biochemical oxygen demand (BOD) loadings, with little or no recognition of peak conditions. The stability assessment is necessary to provide valuable information for the evaluation of plant performance and to offer a guide to process design [1].
The activated sludge process is one of the most popular and cost-effective wastewater treatment processes. As compared to other industrial waste water treatment processes, the activated sludge system suffers from more frequent and severe environmental variations such as hydraulic and organic shock loads [2]. Wastewater treatment plants help to reduce negative impact on the environment by improving the quality of effluent. Different technologies are used in waste water treatment, and one of the tasks is to find the most environmentally sound option, taking into account the use of resources and energy during construction and operation of the treatment system [3].
To improve operational performance and to achieve more effective control a better quantitative understanding in terms of process dynamics is required. The effects of short-term organic shock loads on the performance of a laboratory scale extended aeration activated sludge process studied by increasing the influent chemical oxygen demand (COD).
Intensive study is carried out based on the lab scale model to assess the impact of organic shock loading on plant dynamic behavior. Microbial response is studied against the organic shock loading. Experimental results show the behavior of extended aeration system under organic shock loading which may be considered in development of control policy for safer and better operating performance.

II. MATERIALS AND METHODS

2.1 Experimental setup

The experimental setup is consisting of the following components: primary settling tank, aeration tank, secondary settling tank, air compressor. Activated sludge reactor will be made up of acrylic sheet size65.8 cm X 21.9 cm X 16 cm and secondary settling tank of size 15cm X 10cm and depth 16cm. The model is designed for flow of 30 lit/day as continuous flow type of model. Air is supplied by a high-power aquarium pump via an aquarium diffuser tube to simulate field diffuser grid. In normal operation, all of the sludge settled in the settling chamber will return to the aeration chamber and hence the calculations of MLVSS, Mean Cell Residence Time etc. are all based on the aeration chamber volume.

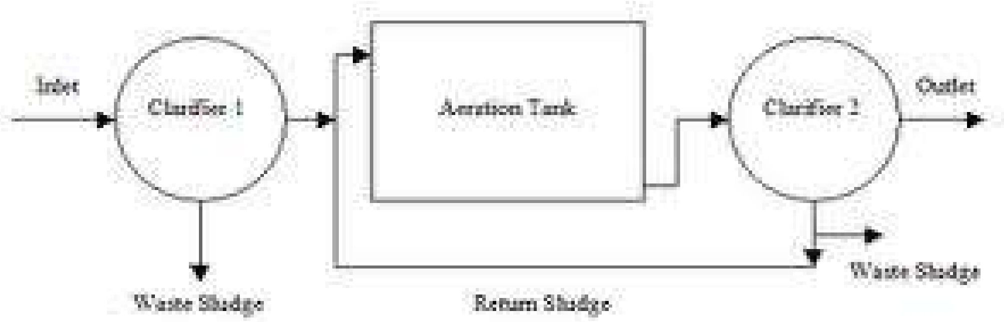

Fig.1 Schematic diagram of lab scale model of extended aeration system

2.2 Feed Composition

1gm of glucose in one litre of water gives 1 gm/lit of COD [4]. The synthetic sewage was a modification of OECD standard sewage [5] and it was prepared prior to each feeding by mixing (in tap water) the following different components (For 900mg COD/l): 18 g /l glucose, 6 g /l $(NH_4)_2SO_4$, 6.3 g /l KH2PO4, 1.2 g /l $MgSO_4.H_2O$, 0.12g/l $MnSO_4.H_2O$, 0.09 g /l CaCl2, 0.006 g/l $FeCl_3.6H_2O$[6]. Likewise for different organic shock loadings glucose concentration increased and other nutrients kept constant. Therefore synthetic wastewater sample was prepared by adding glucose into water along with other essential nutrients like Calcium chloride, Magnesium sulphate etc. through different compounds. Before feeding the synthetic wastewater to model, it was analyzed in the laboratory for COD.

2.3 Startup and operation of the reactor

For start-up of an Extended Aeration process Lab scale model, it was feed by activated sludge brought from The CETP Thane-Belapur Association situated at Koparkhairane, Navi Mumbai. Initially, seed of sludge is collected from the sludge recirculation line and aerated vigorously until an agglomerated mass of sludge is formed. It is then fed on a batch basis with the synthetic sewage with increasing amount day by day.08/01/2015 onwards, activated sludge was applied to the system till 25/02/2015 with low organic loading for acclimatization purpose. Initial 48 days period was given for seeding purpose to develop growth & initial built up to plant. Pseudo steady state (PSS) condition was assumed to have been achieved when the variation in successive effluent COD values was observed to be insignificant [7]. Influent COD concentration was maintained 900 mg/l.

Continuously monitoring is done of the influent and effluent characteristics of Extended Aeration process Lab scale model for average organic loading and for shock loading. The model was run on average organic loading and suddenly applied the organic shock loading for short duration. The performance of model was checked at shock loading. Organic shock loading was applied to the model for 6hr duration along with synthetic sewage and effluent characteristics are analysed every hours till the system resumed to normal condition.

III. RESULT AND DISCUSSION

3.1 Extended aeration reactor performance at pseudo steady state

The performance of the reactor observed at normal operating condition (PSS at 17.84 h HRT) is given in Table 1.The PSS COD removal efficiency of model was around 96%. This was because of the comparatively higher proportion of easily biodegradable incoming organic load.

Table1. Conditions of aeration tank at PSS.

Sr. No.	Parameters	
2.	DO (mg/l)	1-2
3.	pH	7.2-7.8
4.	MLSS (mg/l)	5000
5.	MLVSS (mg/l)	3800

Table2. Performance of model at PSS

Sr. No.	Parameters	Influent	Effluent
1.	COD (mg/l)	900	40-80
2.	pH	6.5-7.5	7.6-8.3
3.	DO (mg/l)	4	1-3
4.	Efficiency (%)		96

3.2 Performance of extended aeration model at shock load

Fig. 2 shows the influent and effluent COD various organic shock loads. In all the cases the effluent COD concentration increased with the duration of shock load. The maximum effluent COD concentration obtained were 175 mg/l and 300 mg/l at the end of shock loads of 1500 mg/l and 2000 mg/l respectively. The effluent COD concentration increased with the duration of shock load, it reaches maximum at the end of shock loads and when normal loading conditions were resumed after the shock load, the effluent COD concentration started decreasing. The reactor recovered to PSS conditions in about 7, 18 h after removing the shock loads of 1500 and 2000 mg COD/l respectively. Uneven biomass distribution limits the ability of reactor to respond under shock loads. Shock loads that result in full substrate penetration expose organisms to very high concentrations of substrate which they may not be able to metabolize.

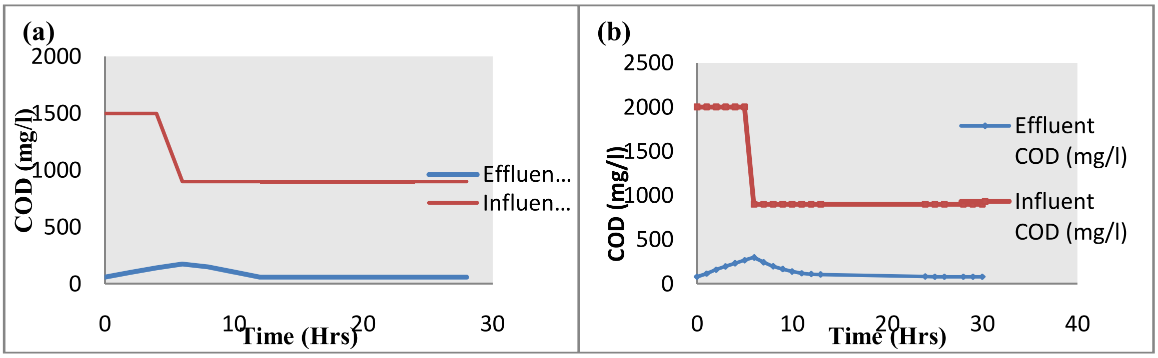

Fig. 2 Variation of effluent COD under the organic shock load of (a) 1500 mg COD/l and (b) 2000 mg COD/l

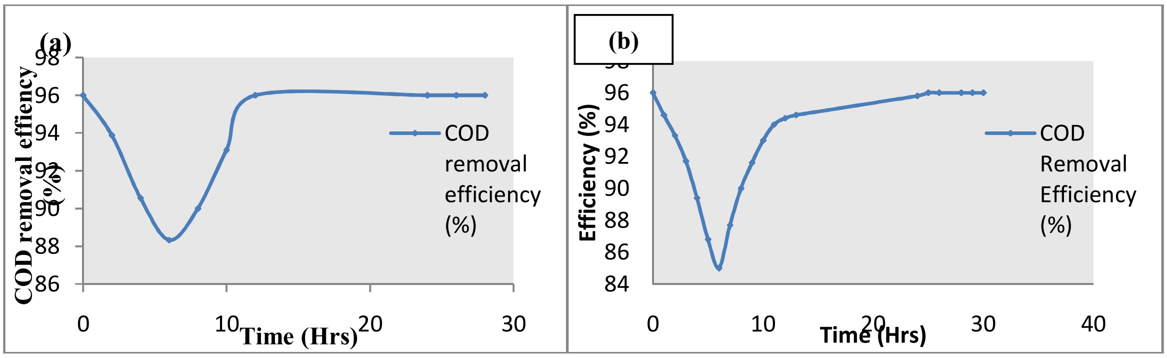

Fig. 3 COD removal efficiency (%)under the organic shock load of (a) 1500 mg COD/l and (b) 2000 mg COD/l

Figure4. Show that the dynamic response of the MLVSS and the DO concentration in opposite direction. The DO concentration, on the other hand, is determined by combination of mass transfer limitations in terms of the aeration and increased oxygen consumption due to higher biomass production. Similar observations were reported by Tyagi and Y. G. Du (1996).The main reason for the increase of MLVSS with organic shock is because of the significant increase of readily biodegradable substrate concentration though the DO concentration is decreased with the organic shock.

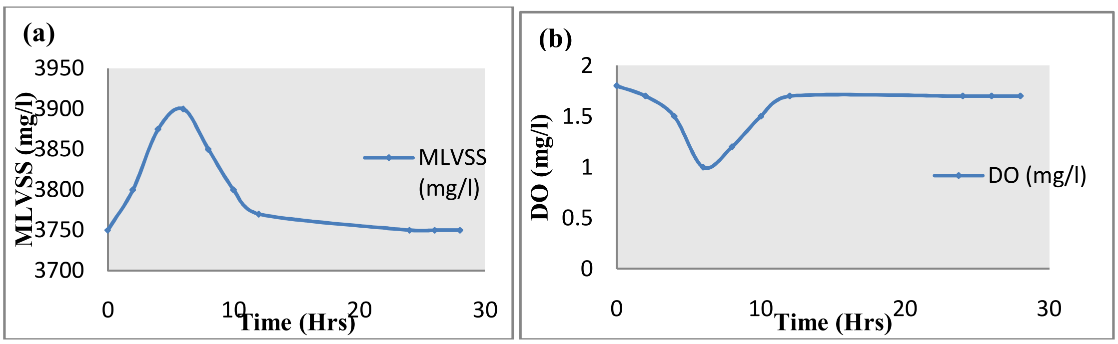

Fig. 4 Concentration of (a) MLVSS mg/l and (b) DO mg/l in the reactor under the organic shock load of 1500 mg COD/l

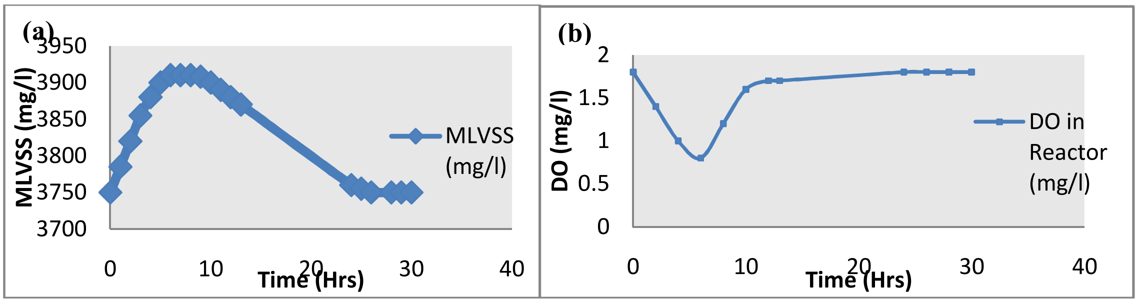

Fig. 4 Concentration of (a) MLVSS mg/l in the reactor and (b) pH of effluent under the organic shock load of 2000 mg COD/l

II. CONCLUSIONS

In all the cases the effluent COD concentration increased with the duration of shock load. The maximum effluent COD concentration obtained were 175 mg/l and 300 mg/l at the end of shock loads of 1500 mg/l and 2000 mg/l respectivelythe effluent COD concentration started decreasing when normal loading condition were resumedThe reactor recovered to PSS conditions in about 7, 18 h after removing the shock loads of 1500 and 2000 mg COD/l respectively. Experimental results showed the behavior of extended aeration system under short term organic shock loading which may be considered in development of control policy for safer and better operating performance.

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