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The Effects of Temperature and PH on Settlability of Activated Sludge Flocs

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Key Words: Activated sludge, flocculation, temperature, pH

ABSTRACT

The effluent quality of a sewage treatment plant using activated sludge process and finally secondary treatment depends on the flocculation efficiency and settling of the flocs. The survey of various treatment processes in water and wastewater treatment shows that temperature and pH are the important factors affecting efficiency of flocculation and settling properties. This study was performed to determine the effects of pH and temperature on settling of the flocs in activated sludge process. It was carried out for three months in two phases, using mixed liquor suspended solids (MLSS), obtained from aeration tank from one of wastewater treatment plants in Tehran. In the primary phase, the temperature of samples was increased from 15°C to 35°C. As a result, the sludge volume index (SVI) and effluent suspended solids increased and consequently, COD removal percent decreased. In the second phase, the pH was increased from 5.7 to 9. As a result, SVI and effluent suspended solids decreased and COD removal percent increased.

INTRODUCTION

Historically, the activated sludge principles has been developed, since 1914 (2,7). It was assumed that acclimated microorganisms in aeration tank increase the treatment efficiency (6). Recently, many investigations have been done on activated sludge and the effects of various factors on this system.Whereas, the main principles of activated sludge is microbial growth in flocculated forms, therefore, the efficiency of the system depends on physical and biologicall characteristics of flocs (3,7).

Activated sludge is a heterogenic compound, consisting microorganisms, colloidal matter, organic polymers, mineral particles and cations; thus, determination of floc structures and interactions between them is very complex task(5). Since, physical properties of flocs such as density, prosity and size have many important roles in rate of settling and SVI, many studies have been focused in this field.

In 1971 the relation between floc size andrate of settling was investigated (4).

In 1987-1992 and 1993 the relation between density and prosity of flocs were investigated(3). It was approved that the density reduces and prosity increases, as the floc size increases. This may affect the floc settling (3). Generally, the floc formation is completed by release of the natural poly electerolites.These poly electerolites consist of proteins and polysaccharides which are produced during the decomposition and bacterial death in endogenous phase (4). Also, these extracellular polymers play critical role in wastewater treatment, removal of contaminant and floc settling. In addition, these compounds have a key role in sludge treatment, sludge dewatering in biological digesters (4). Until recent years, these extracellular polymers were ignored and many researchers classified these compounds as volatiles and/or carbohydrates (6). Recently, isolation and extraction of these compoundswas carried out by sonic processes or combination of sonic processes and cationic ion exchange resins.

The findings indicate that proteins are the most important constituent of extracellular polymers which have been analysed by pyrolises, HPLC, and mass spectrophotometeric procedures (4).

The next findings indicate that polysaccharides are also present in the structure of these compounds, which was confirmed by gas chromatography and flame ionization. Since, main structure of these polymers consists of polysaccharides, proteins and lipids, and also this structure is severely affected by temperature; therefore, variation in temperature results in changed in polymer structure and bacterial cell wall. This in turn causes the variation in extracellular polymers and surface charge of bacteria, and in high temperature, extracellular polymers viscosity is decreased which results in reduction of biofloculation and settling (4). The studies on activated sludge systems show that most of biological systems and bacteria are activate in pH 4-9 (8). Also, the pH in biological systems affects the enzymatic activities. Since, the released extracellular polymers have negative and nutralized charge in the most pH ranges and most of bacteria in pH 7 have isoelectric state, hence increasing the negative charge results in the increase of pH above the isoelectric point, which causes the increase of the active sites on the polymer surface and extracellular polymers. The increase of pH above the isoelectric point elongates the polymeric chain length and also induces the ability for bridging between bacterial cells, and ultimately improvement of biological floculation occurs (4).

MATERIALS AND METHODS

In order to evaluate the effect of temperature and pH on biological flocs, mixed liqour suspended solid (MLSS) was obtained from aeration tank of a wastewater treatment plants by

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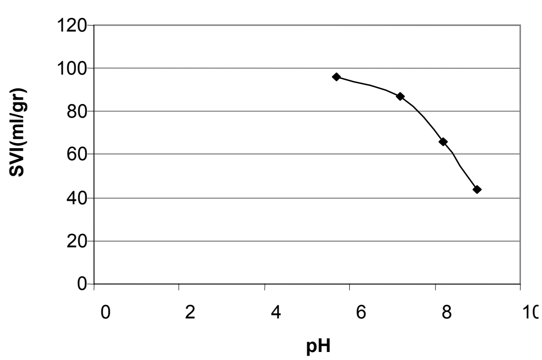
grab sampling. Sampling was carried out every three days in a week and 30 samples were taken and transported to laboratory within 30 minutes. To adjust the pH of the samples, 2N NaOH was used and also temperature was controlled.
Prior to the changes in temperature and pH, MLSS concentration was determined and in order to ensure having a good aeration in the tank, DO amount was measured by portable oxygen meter at the sampling point. In the following stage, with the change in the above parameters and allowing for these dimentation of samples, COD and suspended solids (SS) in effluent and sludge volume index were measured. The range of pH and temperature was 5.7-9 and 15-35°C, respectively.
The study was performed at two phases: In the first phase, the impact of temperature variation; and in the second phase, the influence of pH variation were investigated. All the methods were performed according to Standard Method for The Examination of Water and Wastewater (20th Ed.)(1).

RESULTS

Results showed that as the temperature rises from 15°C to 35°C, efficiency for COD reduction lowers from 93% to 87% (Fig. 3) and suspended solids concentration in effluent increased from 43±3 to 67±6 mg/l (Table 1). Also, findings indicate that with increasing pH from 5.7 to 9.0, efficiency for COD reduction increased from 87% to 96% (Fig. 4) and amount of SS in effluent decreased from 87±6 mg/l to 49±4 mg/l(Table 2). The effect of temperature in SVI revealed that with rising temperature from 15°C to 35°C, this index increases from 40 ml/gr to 130 ml/gr. Also, with the increaseof pH from 5.7 to 9.0, SVI decreased from 96 ml/gr to 44 ml/gr (Figures 1 and 2).

Fig. 1. **Effect of (pH) on (SVI)**



then its settling, cause the COD reduction and increase of SVI and effluent SS. This means that high temperatures have adverse effects on settling condition. Comparison between the results of the study and the results from studies with the compounds forming the extracellular polymers that influence on biofloculation indicate that this phenomena is the result of structural sensitivity of these polymers against temperature. Noteworthy, their structure mainly consists of polysaccharides, proteins, lipids that are sensitive to the temperature variation, so that high temperature reducestheir viscosity and consequently, biofloculation reduction and settling. Also, as shown in Table 2, Fig.4 and Fig.2 considering the effect of pH on the samples in contrast to temperature, increase of pH have positive effect on system and resulted in reduction ineffluent SS, increase in COD removal efficiency, and lowers the SVI; such that with increasing in pH from 5.7 to 9.0, SVI decreases from 96 ml/g to 44 ml/g and SS in effluent reduces from 88 mg/l to 40 mg/l.
It seems that the positive effects are related to variation in isoelectric states of bacteria, because in high pH, bacteria exit from isoelectric state, resulting in increase of the active sites on cells , exotic polymers, and as aresult improvement in the ability for bridging and biofloculation.
Therefore, in order to improve the wastewater treatment systems operations, it is necessary to consider the effects of high temperature and pH; in particular, for wastewaters with high temperature and low pH.

Fig. 2. **Effect of temperature on SVI**

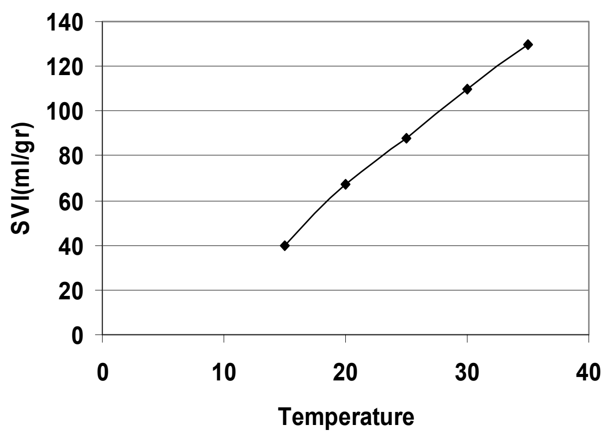


Fig. 3. **Effects of temperature on COD removal**

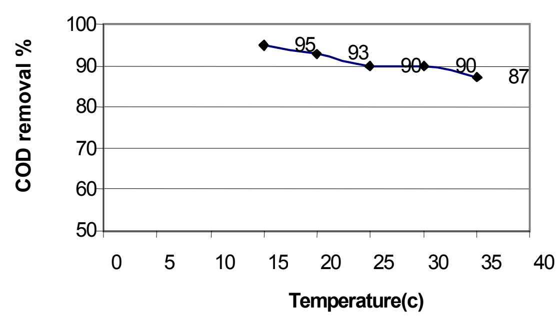


Fig. 4. **Effects of pH on COD removal**

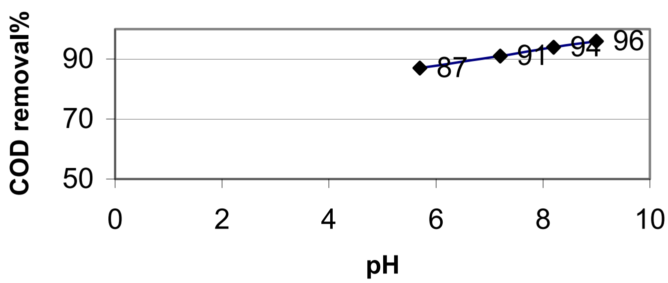


Table 1. **Results of temperature effects on COD removal and effluent SS**

Temperature (º C)	MLSS (mg/l)	COD (mg/l)	COD removal(%)	Eff . SS (mg/l)
15	2960 ± 15	450 ± 12	95	45 ± 3.0
20	2750 ± 10	430 ± 10	93	53 ± 2.5
25	2125 ± 25	460 ± 11	90	60 ± 4.0
30	2350 ± 20	440 ± 7	90	78 ± 2.0
35	1825 ± 8	420 ± 9	87	85 ± 3.5

Table 2. **Results of pH effects on COD removal and effluent SS**

pH	MLSS (mg/l)	COD (mg/l)	COD removal (%)	Eff.SS (mg/l)
5.7	2690±15	450 ± 12	87	88
7.2	3750± 10	430 ± 10	91	76
8.2	2125± 25	460 ± 11	94	51
9.0	2350± 20	440 ± 7	96	40

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