Extended Abstract

The activated sludge process is the most used biological wastewater treatment method in the industries. The separation of solids in the activated sludge process is a very important function in order to provide well-clarified effluent and concentrated solids that are returned to the biological treatment system or are wasted to the solids processing facilities.

There are two main types of settling problems: (i) bulking sludge due to the proliferation of filamentous bacteria and (ii) poor flocculation properties, e.g. formation of small and light flocks. In most cases, large, dense and strong flocks are desirable for good settling and compaction of activated sludge. Two commonly used measures developed to quantify the settling characteristics of activated sludge are the sludge volume index (SVI) and the zone settling velocity (ZSV). The sludge volume index (SVI) is the volume in milliliters occupied by 1 g of a suspension after 30 min settling. SVI values below the 100 mL/g are typically associated with good settling sludge. Also 100<SVI≤150 would indicate moderate sludge settling and sludge of the SVI over 150 mL/g is often classified as bulking sludge. The ZSV is the settling velocity of the sludge/water interface (Vi) at the beginning of the sludge settle-ability test.

Powdered activated carbon is one of the famous adsorbents that have been used in the field of water and wastewater treatment, but using this material is expensive. Also, clay is one of the famous mineral materials. Some of the natural additives have been used as adsorbents for removal of dyes and heavy metals in industrial wastewaters. In a research, laboratory batch and continuous-flow experiments were run at 20 °C on primary treated wastewater using charcoal and kaolin added to activate sludge bioreactors. Results revealed that additional amount of charcoal or kaolin enhances organic removal and improves sludge settle-ability.

There are the problems of poor sludge settling in the majority of wastewater treatment plants in Iran; it is probable that using of natural wastes would enhance the sludge settling. Natural additives have very high compatibility with environment due to the being naturally. It can be understood that these natural additives are harmless to the environment.

Second phase of Shahinshahr Wastewater Treatment Plant usually has severe sludge settling problems, and the mixed liquor (ML) of this plant was selected for the experiments of this research. Walnut shell is washed completely using clean water and then rinsed with distilled water. After drying walnut shell at 105° C for 24h, these materials milled in a grinder. The milled materials were separated with a sieve of NO.40 (particle size 425 μm) and then transmitted particles used for experiments. There weren't any preparation processes for powdered activated carbon and clay for conducting the experiments. Experiments in this research conducted in five separated steps:

1) Determination of optimum dosage for each additive to reduce SVI values to 100 mL/g,
2) Determination of zone settling velocity in the pilot scale,
3) Determination of influence of sludge return on the SVI reduction,
4) Determination of influence of sludge return on the quality parameters of output supernatant.
Hosseinlou, R. and Taebi, A. 2015) Determination of influence of coagulation-flocculation on the SVI values. Dissolved oxygen (DO) in the wastewater samples adjusted in 1.7 mg/L.

In the step 1 of experiments, 1, 1.5, 2, 2.5, 3, 3.5 g/L of additives added to ML samples, and the SVI of these samples determined. Optimum dosage for different additives reduced SVI to 100 mL/g (88 percent decrease). Optimum dosages of different additives are shown in table 1.

<table>
<thead>
<tr>
<th>type of suspension</th>
<th>optimum dosage (g/L)</th>
<th>average ZSV (m/h)</th>
<th>correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>control sample</td>
<td></td>
<td>1.222</td>
<td>0.992</td>
</tr>
<tr>
<td>activated carbon</td>
<td>1.713</td>
<td>3.732</td>
<td>0.990</td>
</tr>
<tr>
<td>clay</td>
<td>1.863</td>
<td>3.827</td>
<td>0.990</td>
</tr>
<tr>
<td>walnut shell</td>
<td>2.362</td>
<td>2.765</td>
<td>0.991</td>
</tr>
</tbody>
</table>

Settling column used for determining of ZSV in the second step of experiments was a 200 cm high Plexiglas cylinder, and 20 cm diameter. The zone settling velocity (ZSV) obtained by linear regression of the interface height versus time data.

In the steps 3 and 4 of experiments, we had 250 mL returned sludge and 750 mL fresh wastewater in each step. After adding the optimum dosages of different additives to these ML samples, SVI values, and also pH, turbidity, sCOD, and TSS of output supernatant determined.

In the final step of experiments, jar tests were used to determine the influence of velocity and time of mixing on the SVI. Different mixing velocities and times of tests were: 1) rapid mix: 100 rpm for 3 min, slow mix: 60 rpm for 10 min 2) 100 rpm for 2 min followed by 30 rpm for 20 min 3) 200 rpm for 2 min and then 40 rpm for 15 min.

At first, 1, 1.5, 2, 2.5, 3, 3.5 g/L of powdered activated carbon, clay, and walnut shell added to ML samples, and their corresponding SVIs determined. Optimum dosages of different additives are shown in Table 1. Average initial values of SVI for control (blank) sample was 823 mL/g. Optimum dosages for different natural additives reduced SVI to 100 mL/g (88 percent decrease). Natural being of walnut shell was one of the striking advantages of this material in reducing of SVI values and controlling the sludge bulking. Therefore, this material didn't have harmful effects on the biomass of activated sludge.

In the step 2, optimum dosages of different natural additives added to wastewater samples and corresponding ZSVs were determined. Average values of ZSV for control (blank) sample was 1.222 m/h. ZSV values for different additives have presented in table 1. From table 1, we can find that different additives increased ZSV of control (blank) sample up to 2 to 3 times. With this increase in ZSV, surface overflow rate (SOR) is also increased up to 2 to 3 times. This means that we can overload the secondary sedimentation tanks without modification in existing structures and without loss of their efficiencies.

In the step 3 of experiments, the influence of sludge return on the sludge settle-ability determined. Optimum dosages presented in table 1 for powdered activated carbon, clay, and walnut shells were used. The results showed that the effects of these additives in reducing SVI remained with sludge return.

In the step 4 of experiments, we added optimum dosages of different additives to ML samples. Then, influence of two stage sludge return on pH, turbidity, sCOD, and TSS of output supernatant assessed. Results showed that powdered activated carbon increased pH values, but walnut shell and clay didn’t have significant influence on pH. Sludge return with different additives didn’t have significant influence on turbidity, and only clay caused an increase in the value of turbidity in the stage of without sludge return. Sludge return with different additives didn’t have significant influence on sCOD. Sludge return caused a decrease in the TSS of output supernatant.

Minimum SVI obtained for samples without jar test in the final step of experiments. Two effective factors in coagulation- flocculation process: i) mixing velocity ii) mixing time, didn’t have influence on SVI. We
Comparison of Influence of Walnut Shell, Clay and Powdered Activated Carbon

concluded that these additives don’t act as coagulant- flocculent, while probably act as ballasting agents and because of this mechanism a significant reduction in the values of SVI will occur.

At the end, we can conclude the following results:

1) Additives that have been used in this research caused a significant reduction in the value of SVI; therefore, these materials have the required potential to solve the sludge bulking problem in the wastewater treatment plants of Iran. In addition, walnut shell and clay have high compatibility with environment.

2) Average values of SVI for control (blank) sample was 823 mL/g. Optimum dosage for different additives reduced SVI to 100 mL/g (88 percent decrease).

3) Average values of ZSV for control sample was 1.222 m/h. Different additives increased ZSV of control sample up to 2 to 3 times. With this increase in ZSV, surface overflow rate (SOR) is also increased 2 to 3 times. This means that we can overload the secondary sedimentation tanks without loss of their efficiencies.

4) Sludge return caused an improvement in activated sludge settle-ability conditions. Powdered activated carbon increased pH values, but walnut shell and clay didn’t have significant influence on pH. Sludge return with different additives didn’t have significant influence on turbidity and sCOD, and only clay caused an increase in the value of turbidity in the stage of without sludge return. All additives reduced TSS of output supernatant.

5) Two effective factors in coagulation- flocculation process: i) mixing velocity ii) mixing time didn’t have influence on SVI. We concluded that these additives don’t act as coagulant- flocculent, while probably act as ballasting agents and because of this mechanism a significant reduction in the values of SVI will occur.

6) Walnut shell and clay had the same improvements with powdered activated carbon on the sludge settle-ability. We should consider that powdered activated carbon is an expensive adsorbent. On the other hand, walnut shell and clay are affordable and natural; therefore, walnut shell and clay can be alternatives for powdered activated carbon.

Key words

Sludge volume index, Zone settling velocity, Walnut shell, Clay, Powdered activated carbon