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Investigation of Using Fixed Activated Sludge System for Removing Heavy Metals (Cr, Ni and Pb) From Industrial WasteWater

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Extended Abstract

The operation of fixed activated sludge system for treatment of wastewater containing heavy metal compounds (chromium, lead and nickel), by using of fixed activated sludge (FAS) system is studied in this research. A Plexiglas tank consisted of three sections including a downward-flow aerated reactor, an upward-flow aerated reactor and a gravity sediment unit, fed with the synthetic wastewater. The results showed that COD removal efficiency in the FAS is about 96% and the acclimation time for microorganisms is short.

While chromium, lead and nickel removal efficiency in the fixed activated sludge at concentration of 1 mg/lit is 84%, 75% and 80%, respectively, by increasing concentration of them to 5 mg/lit, the removal percentage increased to 90%, 84% and 87%, respectively. When concentration of chromium, lead and nickel increased to 10 mg/lit, the removal efficiency became 85%, 95% and 92%, respectively. Concentration of heavy metals (chromium, lead and nickel) at 50 mg/lit; caused the removal efficiency of 86%, 96% and 95.1%, respectively. By rising concentration of heavy metals up to 100 mg/lit, the removal ratio efficiency became 86%, 97.6% and 97%, respectively. At each stage, increasing of heavy metal concentration (chromium, lead and nickel) caused to decreasing of COD and MLSS removal efficiency at the beginning of period but COD and MLSS removal efficiency re-increased by micro-organisms acclimation to changes. However this increase is less than best previous stage condition of COD removal efficiency and showed a downward trend.

Therefore, heavy metal compounds removal in the fixed activated sludge is not just a biological process, indeed some part of these compounds are removed by adsorption on sludge. Altough this part is negligible in comparison with biological removal of these compounds.

Heavy metals which are found in the sewage of many industries like petrochemical industries, refinary plants, paper mills and chemical industries, disrupt the wastewater treatment plants performance by affecting microorganisms and synthetic reactions due to their toxicity. Consequently, the concentration of these compounds exceed the maximum contamination level (MCL) in the effluent of wastewater treatment plants and causes many health and environmental problems.

Since the ability of some microorganisms for degrading of heavy metal compounds are proved, biological treatment is widely used for removing heavy metals from industrial wastewaters. Bioreactors with fixed activated sludge beds are one of suitable methods in this subject.

In this research, the performance of activated sludge bioreactors with fixed beds is reviewed for removal of three heavy metal compounds i.e. chromium, lead and nickel in industrial watewaters. Fixed activated sludge system (FAS) is a composition of activated sludge system and trickling filter which media are used for forming biofilms in the aeration tank to enhance the treatmnet performance.

A synthetic solution is prepared to provide a wastewater with a COD of 550-600 mg/L.

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The concentration of heavy metals in the prepared wastewater is 1, 5, 10, 50 and 100 mg/L and it is used in three phases. The fixed activated sludge reactor with PVC media is used for the experiment. The details of reactor are indicated in Table 1.20 liters activated sludge, which is taken from sludge return line of a municipal wastewater treatment plant, added for reactor start-up. The operation is done in three phases; in phase II and III, heavy metals including Chromium, Nickel and Lead are added with specific concentrations. The detail of each phase is as follows:

Table 1: Reactor Characteristics

Item	Description	dimensions
1	Total length	51.3 cm
2	Total width	33.0 cm
3	Total height	59.5 cm
4	Each part length	15.7 cm
5	Effluent depth	53.7 cm

Phase I: Investigation of fixed activated sludge reactor compatibility with fed wastewater and microorganisms acclimation with environmental conditions in 50 days
Phase II: Investigation of fixed activated sludge reactor performance for treating of Chromium contaminated wastewaters for 60 days
Phase III: Investigation of fixed activated sludge reactor performance for treating of Chromium, Nickel and Lead contaminated wastewaters with various concentrations for 60 days
The hydraulic retention time is 8 hours. COD, MLSS, TSS and pH were measured for monitoring of microorganisms acclimation in phase I. Fixed activated sludge reactor performance for treating of heavy metals is investigated in phases II and III via measuring of COD, MLSS, TSS, pH and Chromium, Nickel, Lead concentrations. All experiments were performed based on Standard Methods for the Examination of Water and Wastewater 1998.
The result of this study is presented in six sections:
1) Microorganisms acclimation period with environmental circumstances in activated sludge reactor with attached growth system showed COD removal of 49.1% in the first day of operation and increased up to 94.7% at the last day (Figure 1).
In this period of time, the MLSS concentration decreased from 740 mg/L at the beginning of cycle to 940 mg/L at the end of acclimation period.

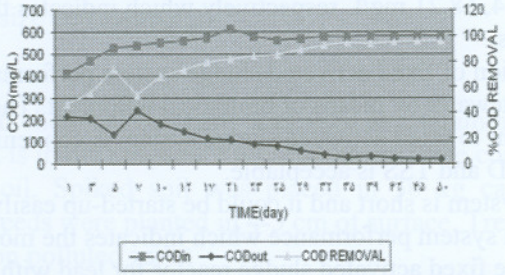

Fig. 1: COD in the fixed activated sludge reactor during acclimation period

While the removal efficiency of COD at the beginning of operation is low, it increased after a while which indicated the short term of microorganisms acclimation with the influent wastewater.
2) Evaluation of activated sludge reactor performance by adding only Chromium: When the concentration of chromium is 1 mg/L, the COD removal is 87%. The MLSS and TSS concentration in the reactor is 560 mg/L and 160 mg/L respectively. The pH of reactor content is 7.42. When the concentration of chromium is 100
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mg/L, the COD removal is 68%. The MLSS and TSS concentration in the reactor is 360 mg/L and 140 mg/L respectively. The pH of reactor content is 7.48.Although COD removal efficiency increases in each period, the removal efficiency decreases by rising COD concentration in the effluent.

3) Evaluation of activated sludge reactor performance by adding Chromium, Nickel and Lead simultaneously: The COD removal is 85%. The MLSS and TSS concentrations in the reactor are 560 mg/L and 140 mg/L respectively. The pH of reactor content is 7.28. When the concentration of heavy metals (Chromium, Nickel and Lead) was 100 mg/L, the COD removal is 65%. The MLSS and TSS concentration in the reactor was 360 mg/L and 140 mg/L respectively. The pH of reactor content is 7.41 (Figure 2).

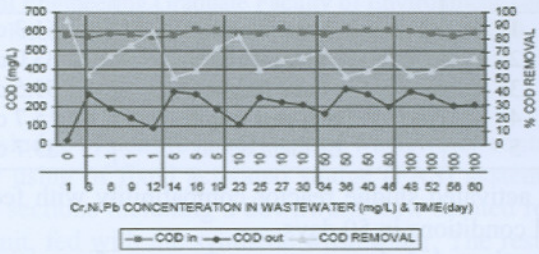

Fig. 2: COD in the fixed activated sludge reactor in the presence of Chromium, Nickel and Lead

4) Investigation of Chromium removal: Chromium was added as $K_2Cr_2O_7$ with a concentration of 1, 5, 10, 50 and 100 mg/L in the second phase. The results showed 66% removal efficiency for chromium when the concentration was 1 mg/L. By increasing the chromium concentration to 100 mg/L, the removal efficiency increased to 86.8%.

5) Investigation of Chromium, Nickel and Lead removal simultaneously: Chromium, Nickel and Lead were added as $K_2Cr_2O_7$, $Pb(NO_3)_2$ and $NiSO_4$with a concentration of 1, 5, 10, 50 and 100 mg/L in the third phase. The results showed 84%, 75% and 80% removal efficiency for chromium, nickel and lead respectively; when the concentration was 1 mg/L. By increasing the heavy metal concentration to 100 mg/L, the removal efficiency increased to 86%, 97.06% and 97% .

6) Specifying the heavy metals in the sludge and supernatant: When the concentrations of heavy metals are 1, 5, 10, 50 and 100 mg/L, the chromium concentrations in the dried sludge are 8.94, 34.68, 113.2, 536.5, 924.25 mg/L and in the supernatant are 4.3, 7.2, 37.5, 104.4, 324.8 mg/L respectively; the lead concentrations in the dried sludge are 13.35, 69.11, 214.2, 1009.8, 1544 mg/L and in the supernatant are 9.66, 30.34, 41.8, 209.8, 270 mg/L respectively; the nickel concentration in the dried sludge are 53.02, 363, 1072.6, 1699.4 mg/L and in the supernatant are 9.24, 13.5, 38.5, 88.4, 68.21 mg/L respectively which indicates the bioaccumulation characteristics of these heavy metals .

The purpose of this study is evaluation of fixed activated sludge system performance for removing heavy metals (Cr, Ni and Pb) from industrial wastewater by means of biological treatment. The results indicated that:

A-In case the composition of influent to fixed activated sludge system is convenient; the treatment performance of mixed sewages for removing COD and TSS is acceptable.

B-The acclimation period for this system is short and it could be started-up easily.

C-Chromium has more influence on system performance which indicates the more toxicity of this compound.

D-The lead removal efficiency in the fixed activated sludge reactor for lead with a concentration up to 100 mg/L is more than 97%. The performance for nickel removal for same concentration is more than 97% as well. The chromium removal percentage is about 85% for the similar concentration.

E-The COD removal in the presence of heavy metals with a concentration of 10 mg/L is very successful in this system (i.e. 80% COD removal efficiency).

F-Microorgaisms in the reactor not only consume the heavy metals but also adsorb these compounds partial

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Key words
Aerobic biological treatment, Industrial wastewater, Media, Heavy metals