Iran. J. Environ. Health. Sci. Eng., 2006, Vol. 3, No. 4, pp. 289-295

OPTIMIZATION OF MOTOR VEHICLE INDUSTRIES WASTEWATER TREATMENT METHODS WITH THE AIM OF HEAVY METALS REMOVAL AND WATER REUSE IN PILOT SCALE

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Received 28 August 2006; revised 10 September 2006; accepted 30 September 2006

ABSTRACT

The waste of motor vehicle industries is mainly the result of washing, coloring and various stages of chassis manufacturing, which include oil, grease, dyestuff, chromium, phosphate and other pollutants. In the present research, extended aeration activated sludge biological treatment plant is being considered and evaluated, for the removal of heavy metals and pollution load from industrial wastes and sanitary wastewaters, and on the pilot scale for optimization of waste treatment method for motor vehicle industries. To accomplish the pilot experiments, the natural waste of Bahman motor vehicle factory is used. Effective factors on efficient removal of heavy metals and pollution load such as concentration of biological mass (MLVSS), COD, BOD, pH in the extended aeration activated sludge biological treatment system, in different ratios of the mixing of industrial waste to sanitary wastewater have been experimented and evaluated. The performance of the above system, in the best of conditions, removes about 90% of pollution load and 65% of heavy metals existing in the industrial wastes. After analyzing the experiments, it is concluded that the removal of heavy metals through biological methods is possible and moreover it is feasible to biologically treat the mixing of motor vehicle industries effluent and sanitary wastewater up to the ratio of one to one, if guided exactly and scientifically.

Key words: Motor vehicle industry effluent, activated sludge, industrial waste to sanitary waste ratio

INTRODUCTION

Virtues of industrial wastewaters completely depend on the type of process and products of the factory. Keeping this fact in mind, the greatest differences between industrial waste and municipal wastewaters could be as follow:

- There is more possibility of existence of toxic chemical compound in the industrial wastewater.
- It has more corrosive characteristic.
- It conveys alkaline or acidic virtues, i.e. the range of pH variations is extensive.
- Living creatures are less likely to exist in it.

According to the performed researches, main polluting compounds of motor vehicle industry's effluent include variety of dye compounds and heavy metals, COD, oil, grease and detergents etc. The staff and trade unit employees use sanitary services such as showers, toilets etc. in their work place. Consequently, a kind of wastewater is produced which is known to us as sanitary wastewater. The sanitary wastewater pollution is mainly a biological pollution and has a more constant combination than industrial wastewater. It is necessary to take some measures to avoid polluting the environment by both industrial and sanitary wastes and to keep their polluting level standardized. Also their refined waste could be used for different purposes. (Gerad Keily, 1998; Metcalf and Eddy, 1991; Qasin, 1999; Standard Methods, 1989).

In performing the present study, the following goals were pursued:

- Assessment and research on the efficiency of the extended aeration activated sludge biological system in the treatment of the different industrial waste to sanitary waste ratios

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- Removal of heavy metals through the biological method of activated sludge.

Review of performed experiments

In this section, with attention to sources available, some of the researches performed by different methods of motor-vehicle industry's effluent treatment, including physical, biological and advanced methods are described.

- GM Company experts prefer to pretreat the wastewater and decant it into the municipal wastewater network. Pretreatment of the GM factories supervised by the company's experts, is described as follows:

The factories' effluent including soluble oil, rinse waste, etc is collected in a big tank. The free oil gathers on the surface and is collected and stored. The produced wastewater enters a mixing tank. Here the refraction of acid is completed. In continuation, pH adjustment and final clarification is performed, and the waste is decanted either to the river or to the municipal wastewater. The following picture shows the treatment diagram in GM factories. (El-Gohary, *et al*., 1989).

- A report published by the experts of the Chrysler Company, points out that different types of industrial waste exist in motor-vehicle industries. These wastewaters include toxic metals, acidic and alkaline wastes, dyed wastes and oily wastewaters, with emphasis on oily wastewaters because of their difficult treatment in motor-vehicle industries. In this report, treatment of oily wastes is thus described:

In preliminary treatment, wastewater is mixed in primary settling tanks, and then is examined in order to determine the best increase of the necessary sulfuric acid. Afterwards, complete-mix is executed. After this stage, the refined wastewater is sampled in the primary settling tanks, and the best conditions for increase of necessary basic and alum for good flotation is determined, and in this case the wastewater enters the flotation unit. The chemical refined wastewater is aerated under pressure and then released in the flotation unit. The output of flotation enters the secondary settling (El-Gohary *etal*., 1989).

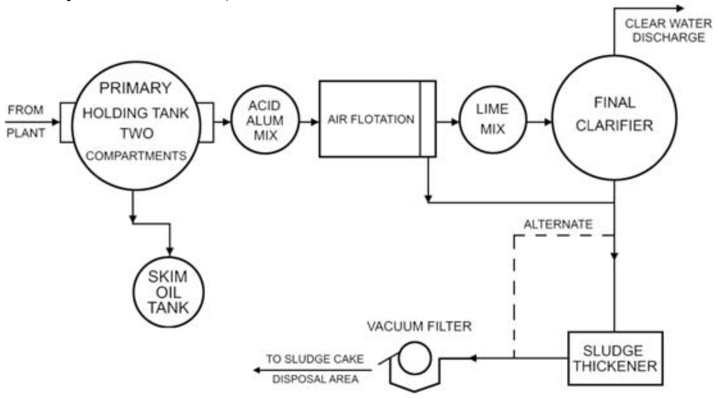

Fig 1: Treatment diagram in GM factories

MATERIALS AND METHODS

In this research, biological treatment of the mixing of motor vehicle industries effluent and sanitary wastewater is studied. Different ratios of industrials effluent to sanitary wastewater have been examined by using extended aeration activated sludge biological treatment plant. The description of pilot specifications and used equipments are given below.

Description of extended aeration activated sludge pilot

Wastewater storage tank: For providing the input food to the biological system, a 220-liter storage is used. For steady inflow and discharge control to the aeration tank, discharge-regulating valves are used to create a steady and controllable flow into the reactor. Aeration and settling storage: Storage made of galvanized sheet with dimension of

100×50×100 cm and useful volume of 360 liters is used. The diffuser aeration system is used for aeration and necessary mixing in this storage. Settling storage is a cube with a dimension of 50×50×100 cm and a useful volume of 165 liters, made of galvanized sheet. The floor of this tank has a pyramid shape and a pump is used for returning the sludge to the aeration tank.

Starting activated sludge pilot

At the beginning of the study according to the volume of the aeration tank and the concentration of volatile suspended solids (VSS), required activated sludge to start the pilot (at least 3000 mg/L) was added from Bahman motor vehicle treatment to the aeration tank. The characteristics of this sludge are given in Table 1.

Table 1: Characteristics of activated sludge

Phosphorous (mg/L)	Nitrogen (mg/L)	pH	MLVSS (mg/L)	MLSS (mg/L)	COD (mg/L)
30	115	7.1	3230	4350	490

For acclimation of microorganisms existing in the aerated tank, the system is aerated for a few days without feeding. Considering high concentration of VSS in starting, this acclimation was performed quickly. When the primary period of acclimation in the aerated tank is over, we can start the settling tank mechanism and guide return sludge flow to the aerated tank (Cavenor-Shaw *et al.*, 1995; Nemerow, 1977). The rate of return sludge from settling tank is %100 and immediate. After the first few days, we enter the sanitary wastewater with an organic loading rate of 0.15 to the system, and then in course of time and considering system efficiency and the rate of acclimation of microorganisms with the conditions, we increase the organic loading rate to 0.35. This operation takes 45 days. Meanwhile, the activity of bacteria is increased and the required readiness for industrial wastewater treatment is obtained. The characteristics of used sanitary wastewater are given in Table 2.

Table 2: Characteristics of feed sanitary waste during adapting time

Parameter	Range of variations	Average
BOD (mg/L)	460-590	525
COD (mg/L)	870-1120	995
Nitrogen (mg/L)	40-85	62.5
Phospherous (mg/L)	8-15	11.5
VSS (mg/L)	200-325	262.5
pH	6.5-7.5	7

Measuring methods

The following measurement parameters were used to investigate system operation and the pilot monitoring:

BOD, COD, pH, DO, MLSS, MLVSS, SVI

The tests mentioned were performed using methods presented in the book: "Standard Methods".

RESULTS

Following the determined aims in this investigation and with tests performed on extended aeration activated sludge biological pilot during 120 days, the following results were gained, which will be discussed.

Changes in the operation of activated sludge biological system during the adapting time

The system efficiency variation is shown in Fig. 2.

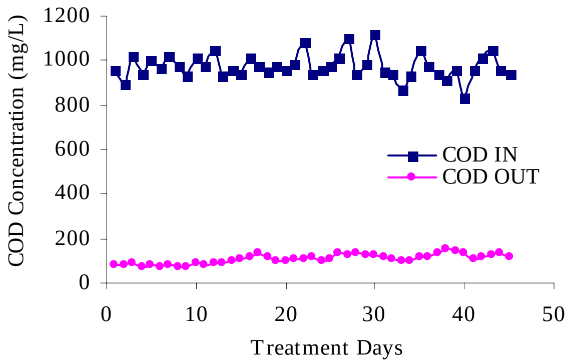

Fig. 2: Comparision between COD of influent and effluent during adapting time of activated sludge pilot

The variation of system influent and effluent COD is shown in Fig. 3. On the primary days of adapting time, considering that the system food had been sanitary wastewater, and the wastewater entering the system had a low organic loading rate, system efficiency was about %92 and the effluent COD average was about 75 mg/L. To reach the research goal, which is biological treatment of the of motor vehicle industries wastewater, high

efficiency in a great organic loading rate was required. Thus the influent wastewater was increased in course of time, so with increasing the rate of feeding, the amounts of active microorganism in the system grow in order to treat industrial waste (Nemerow *et al*., 1991).
We increased the organic loading rate from 0.15 to 0.35 in the first 45 days. Since the needed time for the acclimation of microorganisms and their compatibility with the new conditions was provided, the average efficiency in an organic loading rate of 0.35 was about %88.

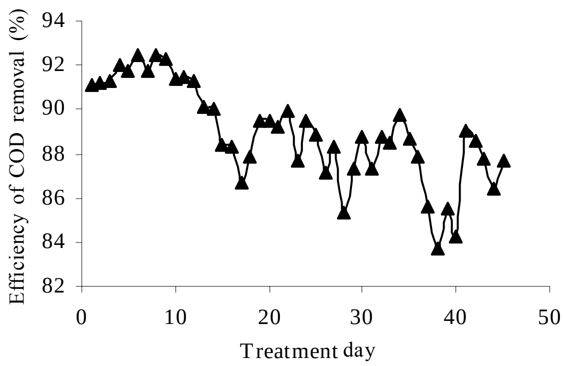

Fig. 3: Variations of COD removal efficiency during adapting time

Evaluating Operation Results of Biological Pilot during the Stable Time

After the output of the system reached the stable condition, the next stage of the research, i.e. the operation of biological system in removal of the pollution loading of industrial wastewater (COD), was performed. With adapting different ratios of industrial wastewater to sanitary wastewater, the efficiency of system in removing pollution was considered. The characteristics of used industrial wastewaters are given in Table 3.

Table 3: Characteristic of feed industrial waste during stable time

Parametere	Range of variation	Average
BOD (mg/L)	110-150	130
COD (mg/L)	830-870	850
pH	7.5-9.5	8.5
TSS (mg/L)	200-400	300
Phosphate (mg/L)	200-300	250
Grease and Oil (mg/L)	12-22	17
Chromium (mg/L)	0.02-0.2	0.11
Nickel (mg/L)	5-8	6.5
Zinc (mg/L)	1-3	1.5
Iron (mg/L)	4.5-8.5	6.5
Manganese (mg/L)	0.15-0.45	0.3

The system efficiency variation in the stable condition is shown in Fig. 4. The variations of the COD influent and effluent are shown in Fig. 5.
After 45 days, when the system gets the ability to digest the organic loading we enter the industrial and sanitary wastewater with a ratio of 1 to 4. Because of the existence of the complex organic compounds in the industrial wastewater and the probability that microorganisms won't have the ability to digest such wastewaters with high volume, the organic loading rate is reduced to 0.05. This act causes the efficiency of COD removal to stay constant with an average amount of 90% and the COD of effluent waste in this condition reaches 85 mg/L.

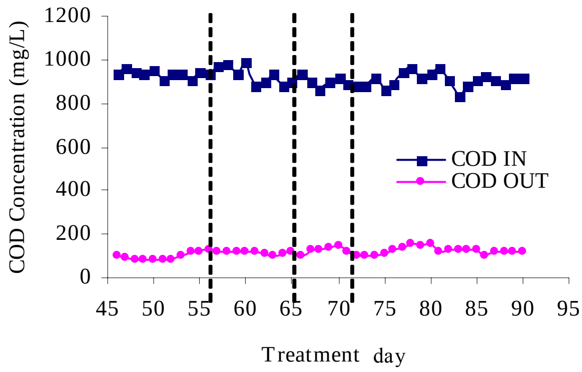

Fig. 4: Comparision between COD of influent and effuluent during stable time

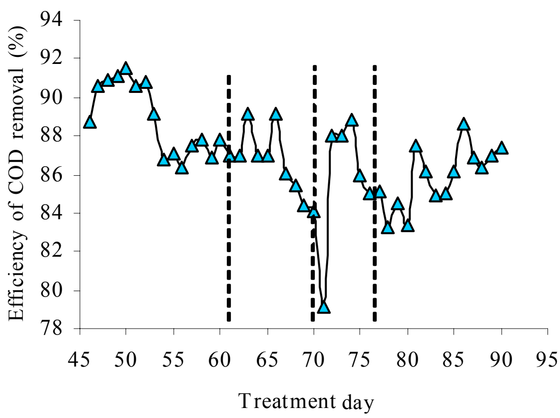

Fig. 5: Variations of COD removal efficiency during stable time

After a week with the system working in the same conditions and the acclimation of microorganisms with new conditions, with the same organic loading rate we increase the mixing of the industrial and sanitary wastewater to the ratio of 1 to 3. At first, the system efficiency decreases a little but in course of time it increases and reaches the average amount of 87%. The COD of effluent waste in this condition is 120 mg/L.

Then after a week with the same organic loading rate (0.05), we increase two wastewaters mixing to the ratio of 1 to 2. The average efficiency of system almost reaches 86% and the COD of the effluent waste reaches 105 mg/L. In the final stage of test, the mixing of the industrial and sanitary wastewater is increased into the ratio of 1 to 1. At first the efficiency of the system decreases and COD of effluent waste reaches 140 mg/L, but as a week passes the efficiency increases and the COD of effluent waste comes up to 105 mg/L. In this step, the organic loading rate is increased at first to 0.1 and after a week to 0.15, which in the first days the efficiency decreases and COD of the effluent reaches 140 mg/L, but in course of time the efficiency increases and gets to the average amount of 87% and COD of effluent waste gets to the average amount of 115 mg/L. Fig.s 6 to 8 show the variations of results versus time.

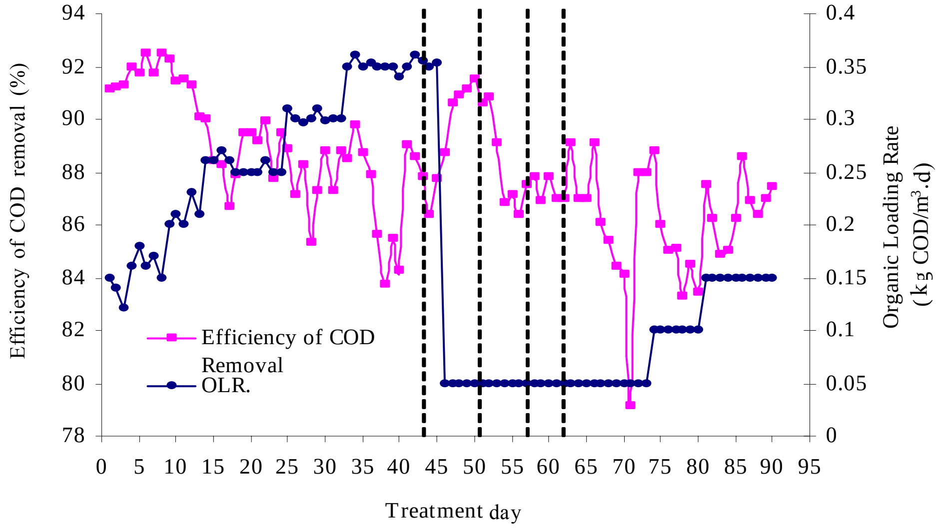

Fig. 6: Variations of COD removal efficiency and organic loading rate vs. time

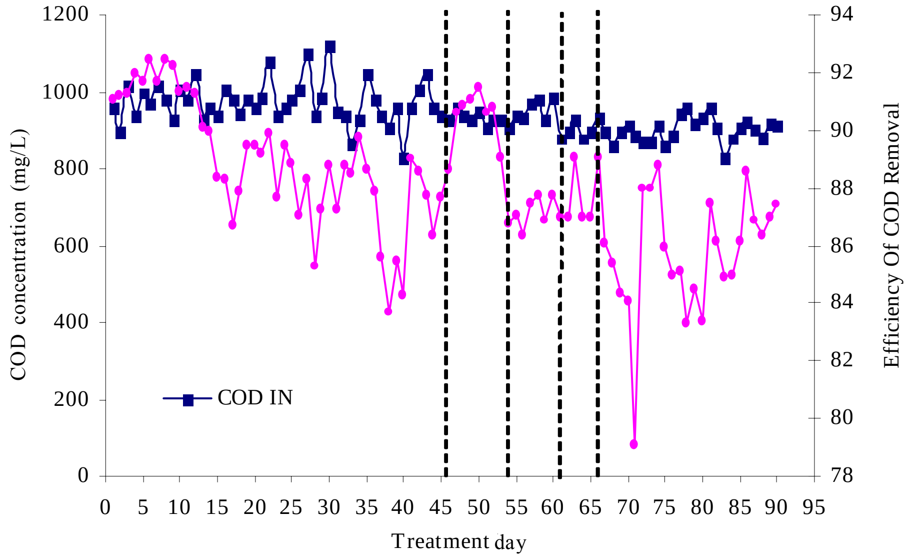

Fig. 7: Variations of influent COD concentration and COD removal efficiency vs. time

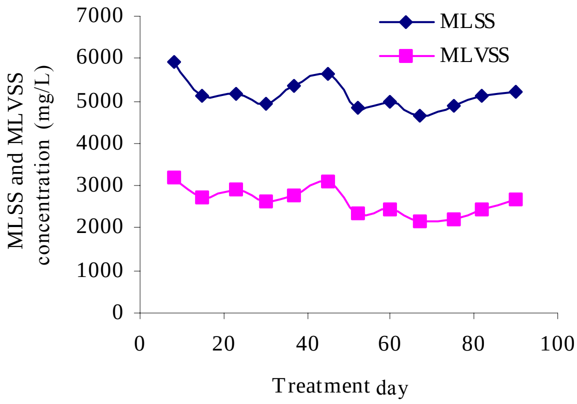

Fig. 8: Variations of MLSS, MLVSS and concentration vs. time

Table 4 shows the results of heavy metals tests in the pilot influent and effluent. By increasing the rate of VSS in the system, the efficiency of the heavy metal removal increases as well. Table 5 shows the amount of MLSS and MLVSS for different ratios of industrial waste to sanitary wastewater.

Table 4: Experiment results of existing heavy metals in influent and effluent of pilot

Parameters / TEST NO.	Ind./Mun.	MLVSS (mg/L)	Input			Output		
			Iron	Zinc	Nickel	Iron	Zinc	Nickel
1	0.25	3115	5.7	1.3	6.5	1.8	0.85	1.95
2	0.33	2342	5.2	1.35	6.1	2.2	1.02	2.45
3	0.5	2423	6.1	1.5	5.8	2.35	1.05	2.3
4	1	2240	6.5	1.15	5.59	2.7	0.95	2.75
5	1	2725	5.9	1.4	6.3	2.6	1.1	2.7

Table 5: MLSS and MLVSS concentrations in different industrial wastes to sanitary ratios

Day	Ind./Mun.	OLR. (KgCOD/m^3-day)	MLSS (mg/L)	MLVSS (mg/L)	SVI	F/M (KgCOD/Kg MLVSS-day)
8	0	0.15	5938	3173	85	0.05
15	0	0.26	5130	2717	92	0.09
23	0	0.25	5187	2917	87	0.08
30	0	0.3	4920	2650	98	0.11
37	0	0.35	5375	2762	86	0.12
46	0.25	0.05	5654	3115	78	0.016
53	0.34	0.05	4843	2342	106	0.02
60	0.5	0.05	4985	2423	109	0.02
67	1	0.05	4632	2240	104	0.02
75	1	0.1	4870	2350	102	0.04
82	1	0.15	5120	2725	93	0.06
90	1	0.15	5235	2880	92	0.05

DISCUSSION

The activated living mass in the activated sludge system has a considerable tendency to absorb all metals such as copper, chromium, nickel, zinc, iron and manganese. Connection of heavy metals to the activated sludge is mainly because of physical and chemical forces and only a small part of biological mechanism participates in action and reaction of microorganism mass. Toxicity removal and metals absorption by activated sludge probably takes place in the bacteria's cell septum through following processes:

- Physicochemical connection to outer cell polymer
- Physical connection to insoluble sulfides made in the system or the primary settling storage
- Forming insoluble salts
- Forming metal hydroxides
- Forming insoluble complexes in which heavy metals are the central core.

Discussion of this research on the pilot scale are as follows:

- Using extended aeration activated sludge biological plant, with exact and scientific conducting; it is possible to efficiently treat mixing of industrial waste and sanitary waste with the ratio of 1 to 1.

- To remove the heavy metals by activated sludge biological plant, high MLVSS in the system is necessary. By the gathering of these conditions, heavy metals existing in the motor vehicle industries effluent can be removed to a suitable amount. For the complete removal of the heavy metals from the industrial waste, an advanced treatment such as sand filter or activated carbon filter is required and the biological treatment is unable to remove the heavy metals completely.

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