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Investigating the Treatability of a Compost Leachate in a Hybrid Anaerobic Reactor: An Experimental Study

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***Abstract*—**Compost manufacturing plants are one of units where wastewater is produced in significantly large amounts. Wastewater produced in these plants contains high amounts of substrate (organic loads) and is classified as stringent waste which creates significant pollution when discharged into the environment without treatment. A compost production plant in the one of the Iran's province treating 200 tons/day of waste is one of the most important environmental pollutant operations in this zone. The main objectives of this paper are to investigate the compost wastewater treatability in hybrid anaerobic reactors with an upflow-downflow arrangement, to determine the kinetic constants, and eventually to obtain an appropriate mathematical model. After starting the hybrid anaerobic reactor of the compost production plant, the average COD removal rate efficiency was 95%.

***Keywords*—**Leachate treatment, anaerobic hybrid reactor

I. Introduction

NOWADAYS, due to population growth and industrial and municipal development, the production of human sewage is increasing from day to day. These sewages may threaten human health and the safety of the environment and give rise to social and economic difficulties in the case of loss of a comprehensive schedule as well as loss of appropriate procedures for collection, transportation, treatment, and finally discharge of sewages. One of the main problems encountered is management of leachate produced during collection, transmission, treatment, and disposal of municipal sewages. Leachate diffusion through soil and contact with cellar water may cause numerous difficulties due to the presence of pollutants such as hydrocarbons, heavy metals, microorganisms, and so on. In this research, one of the Iran's provinces which has a population of over 1.6 million, of which 49% is urban and 51% rural, and produces 1000 tons of sewage per day was investigated. Based on the policy of province leaders, it was decided to treat the province residues at two western and eastern sites. A compost production plant in the western zone, based on the implemented design, produces 50 m^3 of wastewater containing high substrate content daily.

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Therefore, considering the wastewater characteristics, in the compost plant of the western zone, a treatment plant with a capacity of 50 m^3/day was established which applies biological and chemical methods of treatment of wastewater obtained from compost. This plant is comprised of an anaerobic reactor including two series batch tanks with an upflow-downflow arrangement and a mixed aerobic reactor, a plug aerobic reactor, two sedimentation tanks, and a chlorination tank with specific volumes. The main objective of this paper is to investigate the treatability of compost wastewater in an anaerobic reactor with upflow-downflow.

II. Materials And Methods

The raw wastewater used in this study is a mixture of wastewater produced by collection, separation, fermentation, and washing of waste treatment apparatus and part of the rainwater diffused into channels connected to the pump station. Table I lists the characteristics of raw wastewater and Table II summarizes other properties of influent raw wastewater.

TABLE I
THE CHARACTERISTICS OF INFLUENT LEACHATE

Parameter	Maximum	Average	Minimum	Standard Deviation
Temperature(° C)	38.5	29.3	23	2.6
pH	7.91	6.46	5.86	0.343
COD(mg/L)	107160	80000	42180	17233
Total solids(mg/L)	165480	77650	41000	45541.24
Total suspended solids(mg/L)	25800	17000	4700	5850.83
Total dissolved solids(mg/L)	160500	60000	27900	48923.14
Total volatile solids(mg/L)	10980	7700	2600	2238.3
TFS(mg/L)	8250	6800	4000	1149.6
Electrical conductance(µs/cm)	48100	37530	23300	5450

TABLE II
PROPERTIES OF RAW WASTEWATER (LEACHATE)

Parameter	Amount
BOD	40100 mg/L
Total nitrogen (TN)	786.58 mg/L
TKN	757.8 mg/L
Organic nitrogen	237.8 mg/L
Ammonia nitrogen	520 mg/L
Nitrate-N	28.78 mg/L
Nitrite-N	0
Total phosphorous	0.52 mg/L
Iron	52.2 mg/L

Lead	1.02 mg/L
Zinc	1.32 mg/L
Copper	0.8 mg/L
Nickel	0.75 mg/L
Cadmium	0.05 mg/L

At first, a hybrid anaerobic reactor was designed. The anaerobic hybrid reactor is a modification of the anaerobic filter (AF) system and is a combination of an upflow anaerobic sludge blanket reactor (UASB) and an AF. This reactor combines an upflow sludge bed region (suspended biomass) with an AF region (fixed biomass). A schematic diagram of the hybrid anaerobic model reactor is given in Fig. 1.

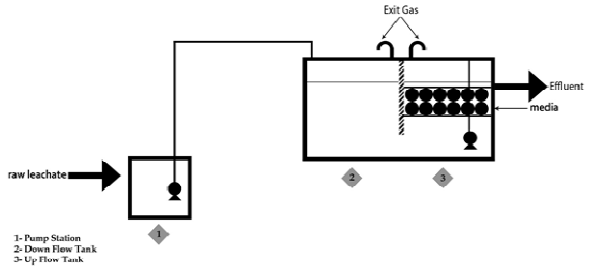

Fig. 1 Diagram of the hybrid anaerobic reactor of this study

The influent is conducted from the pump station to the anaerobic reactor and is fed first into the anaerobic tank from the upper side with downflow through four points, because influent is distributed uniformly along the reactor. The downflow anaerobic tank (second tank) is made of concrete in the form of a rectangular cube; after passing through the second tank, wastewater is charged into the upflow anaerobic tank (third tank) from the bottom side and then overflows to the mixed aerobic tank (fourth tank). Thereafter the flow is fed to the first sedimentation tank and plug aerobic reactor (sixth tank) and finally to the second sedimentation tank. Table 3 summarizes the physical properties of the mentioned tanks. After sedimentation operations, the waste flow runs into the chlorination tank and is then added to acceptable surface water resources.

TABLE III
THE CHARACTERISTICS OF DOWNFLOW-UPFLOW ANAEROBIC TANKS IN THIS STUDY

Characteristics	First anaerobic tank	Second anaerobic tank
Total volume (m^3)	266	266
Retention time (day)	~9.8	~9.8
Height of overflow liquid (cm)	-	25
Height of bed	-	180
Volume of media bed	-	112.5
Volume occupied by each cubic meter of media (m^3)	-	0.035

For proper operation of the anaerobic reactor or digester, the activity of different methanogenic bacteria is required. So it may be useful to feed the heated digester with fresh fertilizer up to 35 ^oC, which is within the range of mesophilic bacteria performance. Fertilizing may be accomplished during commissioning or reduction of digester efficiency [6]. In order to accelerate starting of the reactor in this research, the fertilizer and residual biological sludge from a sewage treatment plant in one of the industrial plant were applied. Therefore, after manual filtering, 3000 L of residual anaerobic sludge from the mentioned plant were pumped via the pump station into tank no. 2. Then 3000 kg of decayed fertilizer were prepared and charged to this tank after removing its leachate. Eventually flow circulation is accomplished from the upper side of the upflow anaerobic tank by circulation pumps (which are used for returning the contents of the upflow tank to the inlet of the downflow tank) and the system is controlled in such a way that by the operation of pumps a uniform concentration of sludge, fertilizer, and wastewater is attained in the anaerobic reactor. The reactor was ready for loading after addition of sludge and fertilizer. The leachate was injected into the anaerobic reactor in a scheduled plan according to specified loading and 1 m^3 wastewater was injected daily into the anaerobic tanks. After obtaining consistency of microorganisms with substrate and allowing around two months to pass, the activity of microorganisms and COD removal was detected and the system's hydraulic regime was shifted from batch to continuous state. It is noteworthy that circulation in the anaerobic reactor proceeded during installation and commissioning. Furthermore anaerobic digestion of strong wastes leads to production of biogas. On starting the anaerobic reactor and COD removal, evidence of gas production was detected from the smell of H_2S gas, generation of bubbles, and foam on the surface of the anaerobic tanks.

III. Results And Discussion

Preparing samples during 5 months starting June ending October 2010, from influent and effluent of anaerobic tanks and performing experimental studies lead to a series of data. The anaerobic reactor was installed under ideal conditions and a steady state was achieved, and then the system was loaded and was affected by parameters such as temperature and pH.
It should be noted that at the last of August the amount of wastewater in sewage of this province was reduced due to management processes carried out during collection of sewages. In fact the collected waste was not transported simultaneously with the accumulated wastewater; rather it was discharged into channels in order to remove the accumulated wastewater and the remaining waste was then carried to the compost plant by special trucks. Therefore it was dried further, and some wastewater was removed. Consequently during treatment these wastes produced less wastewater and the extent of daily loading was reduced. Figure 2 compares the influent and effluent COD concentrations in the reactor. As this graph shows, the maximum, minimum, and average of influent COD concentration in the anaerobic reactor are 107160, 42180, and 80000 mg/L respectively. The observed fluctuations in COD concentrations arise from soluble agents available in wastewater flow. Furthermore the maximum, minimum, and average of effluent COD concentration in the anaerobic hybrid reactor were found to be 12000, 1900, and 3700 mg/L, respectively.

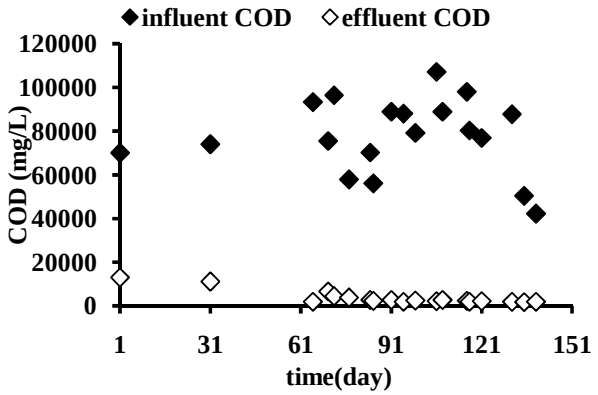

Fig. 2 Variations of influent and effluent COD concentration in the hybrid anaerobic reactor versus time

As Figure 3 shows, the average COD removal with loading rate variation in the anaerobic reactor. It was found to be 95%, with maximum and minimum efficiencies of 98% and 78.57% respectively.

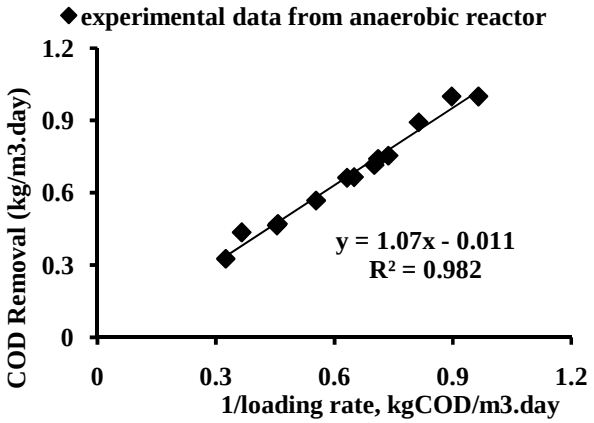

Fig. 3 COD removal in the anaerobic reactor as a function of loading rate

IV. Conclusion

In this study, a hybrid anaerobic reactor with up flow-down flow arrangement containing a support media of PVC type was used in which wastes pass through a bed for attached-growth.

Also in order to create proper mixing, *two circulation* pumps were used for suspended growth within the bed.

- The average COD removal efficiency in anaerobic reactor was found to be 95% with maximum and minimum efficiencies of 98% & 78.57%, respectively.
- The results illustrate that anaerobic hybrid reactor with up flow-down flow could be used in compost leachate treatment plants.

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