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Efficiency of anaerobic stabilization ponds for phenol removal from oil refinery wastewater

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ABSTRACT

Phenol is toxic, carcinogenic, and carcinogenic, and a teratogenic. Therefore, remove phenol from oil refinery wastewater before it is discharged. The main objective of the present investigation was to evaluate the effect of temperature and phenol concentration on anaerobic waste stabilization pond (WSP) efficiency for the treatment of oil refinery wastewater. In this study, phenol concentrations of 100, 200, 300, and 400 mg/L and a temperature range of 10°C–13°C were surveyed. Parameters such as phenol, COD, and BOD pH were investigated. Out of these parameters, phenol concentration and temperature were found to affect WSP efficiency. The efficiency of the anaerobic WSP increased when the phenol concentration decreased. Results also showed that the efficiency of the anaerobic WSP in low temperatures decreased. Hence, the efficiency of anaerobic ponds for the the removal of phenol from oil refinery wastewater is improved when temperatures are high and phenol concentrations are low.

Introduction

Phenol, which has a sweet taste and tar-like odor, is one of the hydroxy compounds of aromatic hydrocarbons. Its molecular weight is 94.11 g/mol and it is soluble in organic solvents [1,2]. Phenol is one of the most common organic pollutants and can range from one to several hundred mg [1,3]. Various industries generate phenol, including petroleum refineries, chemical and petrochemical plants, coke ovens, foundry operations, pulp and paper plants, and pharmaceutical manufacturers [4,5].

Phenols are also present in domestic wastewater discharges [6]. Therefore, wastewaters containing phenolic compounds can cause serious water pollution owing to their ecological aspects, poor biodegradability, and high toxicity [3]. The maximum permissible concentration of this pollutant in potable water is 0.002 mg/L. According to the Environmental Protection Agency (EPA), the maximum permissible concentration of phenol in wastewaters must be less than 1 mg/L [3].

Various methods have been widely applied for removing phenol and phenolic compounds from wastewaters, such as chemical oxidation, physicochemical reaction, adsorption, and biological treatment [1,3]. Biological treatment is a practical and low-cost solution for treating phenolic compounds compared with chemical methods; in biological treatments, various populations of microorganisms in the activated sludge are able to degrade the phenol [7]. Waste stabilization ponds (WSPs) are a cost-efficient method for both industrial and municipal wastewater treatment, especially in developing countries [8]. Nowadays, WSPs have been used in many parts of the world as a series of anaerobic, facultative, and maturation ponds [9–11]. Anaerobic ponds are the smallest units in the series that operate without the presence of dissolved oxygen. Under anaerobic conditions, the major products are CO_2 and CH_4 [12]. They are sized according to their volumetric organic loading, which may receive volumetric organic loadings in the range

100 to 350 g BOD_5/m^3. day, depending on the design temperature. Anaerobic ponds are designed to have a depth of 2–5 m, a hydraulic retention time (HRT) of 2–5 days, and an optimum pH of less than 6.2 [13,14]. The main aim of the present study was to design an anaerobic pond at pilot scale for treatment of the Kermanshah oil refinery's wastewater.

Materials and Methods

This experimental study was carried out at pilot scale (Fig. 1). The WSP had a volume of 200 liters and was made of fiberglass plating. Experiments were performed at ambient air temperatures ranging from 10°C to 13°C. The average temperature of the pond was kept at 11±2°C. In this study, the HRT of the anaerobic pond was 5 days and the hydraulic load of the system was 40 L/day. The anaerobic pond's inlet was positioned 30 cm below the pond's surface. The pond was loaded daily with the wastewater output from the oil and grease separator unit at the Kermanshah oil refinery. The Kermanshah oil refinery's raw wastewater contained a COD = 622 mg/L, a BOD_5 = 204 mg/L, and a pH = 7.9. Before the launch of the system, it underwent seeding and inoculation measures. A seeded sludge was prepared by adding 1.5 liters of sewage sludge and a liter of previously prepared sludge from the oil refinery plant to the system's input before loading the system with wastewater. The WSP was ready for launching after 3 months of seeding. To adjust the anaerobic pond's loading within the defined ranges and increasing the amount of phenol, molasses was used. The pond's loading was adjusted proportionally to the specified amount for each stage simultaneous with the increase in amounts of phenol and molasses. In this study, phenol was added to the pilot's input in various concentrations (100, 200, 300, and 400 mg/L). Then, phenol was measured for each sample using a Varian spectrophotometer (model UV-120-20) at wavelengths of 500 nm. Also the COD, BOD, and pH were measured for each sample. The chemicals were purchased from Merck Co., Germany. To clarify the phenol volatility theory, the pond's surface was isolated with a layer of paraffin and plastic cover and the system's performance was evaluated.

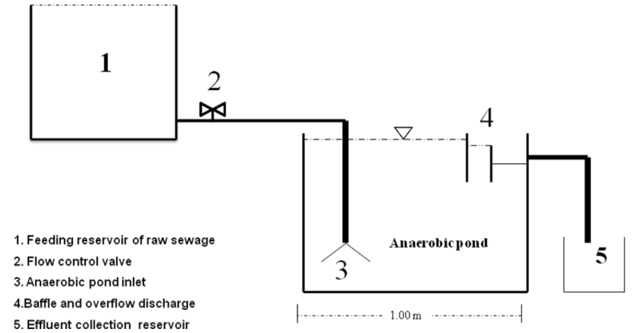

Figure 1. Schematic diagram of pilot anaerobic stabilization pond system

Five consecutive samples showed that the performance rate of the anaerobic pond is almost equal in both open and closed conditions. After selected parameters were determined, the removal percentage of the pollutants under study was calculated for each run. In this study, 2400 samples were measured. Descriptive statistics used for presenting data and analytical statistics (e.g., t-test and ANOVA) were applied for comparison of the WSP's efficiency in the removal of different phenol concentrations using SPSS ver. 12. All sampling procedures and parameter analyses were carried out according to standard methods [15]. Operational conditions of the anaerobic pond system are based on experiments by Almasi and Pescod [16].

Results

Table 1 shows the Kermanshah oil refinery's wastewater characteristics of the anaerobic WSPs' influent and effluent at low temperatures for treatment.

The anaerobic conditions during the process were confirmed by oxidation-reduction potential (ORP-246). Regarding the system's loading volume at cold temperatures, the concentrations were 100, 118.55, 131.74, and 143.48 $grBOD_5/m^3$.day, respectively. The standard loading volume of anaerobic ponds is 100–400 $grBOD_5/m^3$.day.

Results indicated that the studied parameters including phenol concentration dramatically affected the WSP's efficiency in oil refinery wastewater treatment (Fig. 2).

Specifically, the system's the system's efficiency

Table 1. Wastewater characteristics of influent and effluent of anaerobic stabilization pond in different concentrations of phenol

Parameter	Phenol concentrations (mg/l)							
	100		200		300		400	
	Effluent	influent	Effluent	influent	Effluent	influent	Effluent	influent
pH	7.07±0.3	7.9±0.5	7.1±0.3	7.95±0.3	7.1±0.2	7.9±0.3	7.18±0.3	7.95±0.3
BOD_5	292±26	521±25	365±29	607±29	427±23	680±23	529±38	740±60
COD	850±121	1613±203	1091±105	1902±71	1316±57	2085±64	1691±194	2406±254
Phenol (mg/l)	95±12	176±12	174±10.	272±9	262±15	373±14	367.3±1	466.6±15
Volumetric Loading rate ($grBOD_5/m^3.d$)	-	104.2	-	121.54	-	136.01	-	148.12
TCOD/TBOD	2.92	3.09	2.98	3.13	3.08	3.06	3.19	3.25

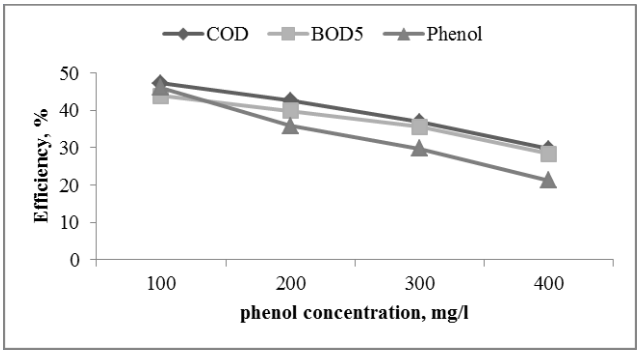

Figure 2. Efficiency of anaerobic pond of Kermanshah oil refinery in different concentrations of phenol

Discussion

The current study's results showed that the removal of BOD_5 and COD from urban sewage by an anaerobic WSP had efficiencies of 45% and 50%, respectively. In Papadopoulos study, the COD/BOD ratio in the system's input and output were 2.07 and 2.05, respectively [17]. In our study, the increase of COD removal compared with BOD removal can be attributed to the multiphase state of the oil wastewater, in which layers have settled along the surface and are potentially volatile. Moreover, some of the layers are separated from the liquid owing to their hydrophobic property and precipitate in the water column of the reactor or remain suspended in the liquid column. Another advantage of this system is the biodegradation of resistant materials. Owing to bacterial hydrolysis, these compounds are converted into catechol, aldehydes, and acids, and they can be degraded by a WSP. For this reason, besides the higher removal of COD in the reactor effluent compared with BOD_5, the COD/BOD_5 ratios were identical in both the input and the output of the anaerobic bioreactor. These results are consistent with the study by Papadopoulos et al. [17]. The closeness of our study's results in BOD_5 and COD removal in relation to the results of other authors like Mara [18] and Azbar [19] is evident. Almasi and Pescod have shown that the rate of BOD_5 and COD removal under cold conditions were 62.3% and 48.95%, respectively [16]. The results of the study conducted by Gao et al. showed that in domestic wastewater, the COD removal efficiency decreased with decreasing temperature [20].

In recent years, research on various methods of biological treatment, including the biodegradation of oil refinery effluents in a pilot-scale rotating biological contactor (RBC), has been performed. Results indicated that the TCOD removal efficiency by this system was 99% [20]. Also, results of the study by Alemzadeh et al. showed that phenol removal efficiency from oil refinery effluent using a laboratory-scale RBC system was 99.9% [21]. On the other hand, the results of the study by Rahmani et al. showed that the highest efficiency of phenol removal with a 50 mg/L initial concentration was obtained using a UV/TiO_2 process (80%) [22]. It is worth mentioning that the technology used in the abovementioned study is expensive and requires specialized experts, whereas our study utilized the simplest and most flexible environmental technology. In a study by Ramos et al. using a laboratory-scale facultative stabilization pond in which wastewater with high phenol content was used to remove different concentrations of phenol, the results showed that the highest and lowest rates of phenol removal relates to 1000 mg/L (92%) and 4000 (22%) mg/L concentrations, respectively [23]; for the use of anaerobic ponds for phenol removal, however, no independent study was found. The optimal conditions resulting from this study were evaluated considering the performance of anaerobic ponds in oil wastewater treatment and the decrease in the output's phenol concentration. The highest efficiency of phenol removal in this study was obtained from a phenol concentration of 100 mg/L (93.58%) after 5 days.

According to the results, we can conclude that increases in phenol concentration reduce an anaerobic stabilization pond's system performance owing to the increased toxicity of the phenol on bacteria when treating oil refinery wastewater.

The results showed that in cold conditions, the efficiency of an anaerobic pond in oil wastewater treatment with different concentrations of phenol is relatively low. This can be related to the low growth activity of microorganisms and the slow reaction rate of the decomposition of dissolved materials by them. Besides, phenol as part of organic compounds forming BOD_5 and COD is dissolved into solution and lacks the potential of sedimentation in anaerobic ponds; this finding is consistent with the study by Saqqar and Pescod [23]. On the whole, it can be concluded that anaerobic stabilization ponds, if properly operated, show favorable performance in removing organic compounds at different phenol concentrations in warm temperatures.

Conclusion

Considering the advantages of WSP systems, such as flexibility, simplicity of operation, and relatively high efficiency, it is evident that they can provide a better alternative when compared with expensive and complex systems. Since the WSP's efficiency for removing phenol and phenolic compounds was better in comparison with the conventional biological treatment method, it can be concluded that anaerobic pond systems, which are a cost-effective option, can be employed for the treatment of petrochemicals and oil refinery wastewaters containing phenol.

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Conflicts of interest

There are no conflicts of interest.

References

[1] Al-Malack MH, Anderson CK, Almasi A. Treatment of anoxic pond effluent using crossflow microfiltration. Water Research. 1998; 32(12): 3738–46.
[2] Bajaj M, Gallert C, Winter J. Biodegradation of high phenol containing synthetic wastewater by an aerobic fixed bed reactor. Bioresour Technol. 2008; 99 (17): 8376–81.
[3] Chion T, Lau SY, Khor EH, Danquah MK. Enzymatic approach to phenol removal from wastewater using peroxidases. OA Biotechnology. 2014; 10; 3 (1): 9- 14.
[4] Brown N, Shilton A. Luxury uptake of phosphate by microalgae in waste stabilization ponds: current understanding and future direction. Rev Environ Sci Biotechnol. 2014; 13 (3): 321–8.
[5] Moussavi GH, Mahmoudi M, Barikbin B. Biological removal of phenol from strong wastewaters using a novel MSBR. Water research. 2009; 43 (5): 1295-302.
[6] Almasi A, Sharafi K, Hazrati S, Fazlzadehdavil M. A survey on the ratio of effluent algal BOD concentration in primary and secondary facultative ponds to influent raw BOD concentration. Desalination and Water Treatment. 2015; 53(13): 3475-81.
[7] Pradeep NV, Anupama S, Arunkumar JM, Vidyashree KG, Ankitha K, Lakshmi P, Pooja J. Treatment of sugar industry wastewater in anaerobic downflow stationary fixed film (DSFF) reactor. Sugar Tech. 2015; 16 (1): 9-14.
[8] Prieto-Contreras LF, Avelar-González FJ, Loera-Muro VM, Quiñones-Valles C, Loera-Muro A, Ramírez-López EM, Esparza-García F, Guerrero-Barrera AL. Bioflocks structure from enriched lab-scale stabilization ponds used to remove high chromium concentrations. Int.J.Curr.Microbiol.App.Sci. 2015; 4(1): 625-34.

[9] Campbell PK, Beer T, Batten D. Life cycle assessment of biodiesel production from microalgae in ponds. Bioresour Technol. 2011; 102 (1): 50–6.
[10] Almasi A, Dargahi A, Amrane A, Fazlzadeh M, Mahmoudi M, Hashemian A. Effect of the retention time and the phenol concentration on the srtabilization pond efficiency in the treatment of oil refinery wastewater. Fresenius Environmental Bulletin. 2014; 23(10): 2541-8.
[11] Badrot-Nico F, Guinot V, Brissaud F. Taking wind into account in the design of waste stabilisation ponds. Water Sci Technol. 2010; 61(4): 937–44.
[12] Quiroga FJ. Waste stabilization ponds for waste water treatment, anaerobic pond. Available from: http://home.eng.iastate.edu/*tge/ce421521/Fernando%20J.%20Trevino%20Quiroga.pdf.
[13]Miguel P, Mara D. Waste Stabilization Ponds: International Water and Sanitation Center. University of Leeds. Leeds, UK. 2004.
[14] Kayombo S, Mbwette TSA, Katima JHY, Ladegaard N, Jorgensen SE. Waste stabilization ponds and constructed wetland design manual. UNEP International Environmental Technology Center UNEP-IETC with the Danish International Development Agency (Danida), 2005.
[15] APHA, AWWA, WPCF. Standard method for the examination of water and wastewater. 21th ed. American Public Health Association. Washington DC. 2005.
[16] Almasi A, Pescod MB. Wastewater Treatment Mechanisms in Anoxic Stabilization Ponds. Wat. Sci. Tech. 1996; 33(7): 125-32.
[17] Papadopoulos A, Parissopoulos Papadopoulos GF, Karteris A. Variations of COD/BOD5 ratio at different units of a Wastewater Stabilization Pond Pilot Treatment Facility. 7th International Conference on Environmental Science and Technology Ermoupolis, Syros island, Greece, Sept 2001.
[18] Mara.DD. Sewage Treatment in Hot climates. John wiley, London, UK. 1976.
[19] Azbar N, Tutuk F, Keskin T. Biodegradation performance of an anaerobic hybrid reactor treating olive mill effluent under various organic loading rates. Int Biodeterior Biodegrad. 2009; 63 (6): 690–8.
[20] Tyagi A, Suid MT. A Pilot Study of Biodegradation of Petroleum Refinery Wastewater in Polyurethane-Attached RBC. Process Biochemistry 1993; 28 (2): 75-82.
[21] Alemzadeh I, Vossoughi F, Houshmandi M. Phenol Biodegradation by Rotating Biological Contactor. Biochemical Engineering. 2002; 11 (1): 19-23.
[22] R. Rahmani. A survey on the possibility of photocatalistic degradation of phenol using UV/TIO2 process, J. of Water and Wastewater. 2006; 58: 32-7.
[23] Saqqar MM, Pescod MB. Modeling Performance of anaerobic wastewater stabilization ponds. Water Science and Technology. 1995; 31 (12): 171-83.