Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2015, 7(5):1326-1332

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Ratio variations of soluble to total organic matters at different units of a full scale wastewater integrated stabilization pond

Meghdad Pirsaheba, Mehdi Ghayebzadeh, Masoud Moradi[a,b], Farmarz Gharagozlou[a] and Kiomars Sharafi[a,c*]

[a]*Research Center for Environmental Determinants of Health (RCEDH), Kermanshah University of Medical Sciences, Kermanshah, Iran*
[b]*Environmental Health Engineering Department, Iran University of Medical Sciences, Tehran, Iran*
[c]*Environmental Health Engineering Department, Tehran University of Medical Sciences, Tehran, Iran*

ABSTRACT

The ability of wastewater stabilization ponds in treating organic materials depends on the fluctuation trend of soluble or suspended organic matter in each unit of a system to discover the material biodegradability. Therefore, this study aimed to evaluate the fluctuation trends of some ratios, including Total BOD/Total COD, Soluble BOD/Total BOD, and Soluble COD/Total COD[1] in a wastewater stabilization pond. In this descriptive-analytical study, 64 samples were taken from raw wastewater and effluent entering to stabilization ponds in both warm and cold months. All measurements were performed according to water and wastewater standard test methods. Results showed a subsided trend in TBOD/TCOD ratio from raw wastewater to the secondary facultative pond effluent in both warm and cold months. The SBOD/TBOD ratio tended to hold declined trends except in the primary facultative pond effluent. Similarly, the SCOD/TCOD ratio went to possess decreased trends except in the anaerobic pond effluent. The differences in the trends of ratios and in the levels and types of contaminant removal could be due to distinctive physical, biological and chemical processes dominated in each pond. The rate and severity of the impact of each of these processes were different in each pond.

Key words: Stabilization ponds, Wastewater Treatment, Soluble Organic Matters, Total Organic Matters, Iran

---

INTRODUCTION

Stabilization pond is one of the natural methods for wastewater treatment, and is the simplest and the least costly method, especially in small communities. This treatment system consists of an anaerobic, facultative pond and two or several maturation ones. In anaerobic ponds, most of the solid waste is deposited and degraded biologically under anaerobic conditions [1,3]. Facultative ponds have three shallow, intermediate and deep layers. There is a symbiotic relationship between anaerobic bacteria and algae in the shallow layer, while in the deep layer with dominant anaerobic conditions, anaerobic bacteria biodegrade accumulated solids [3]. The facultative bacteria also biodegrade the organic matters in the anaerobic part of the intermediate layer. After facultative and anaerobic ponds, maturation ponds are used to polish the facultative effluent and decrease more pathogenic microorganisms [1]. The decreased

[1] **BOD**: Biochemical oxygen demand), (**COD**: Chemical oxygen demand), (**TBOD**: Total biochemical oxygen demand), (**TCOD**: Total chemical oxygen demand), (**SBOD**: Soluble biochemical oxygen demand), (**SCOD**: Soluble chemical oxygen demand)

BOD and COD in wastewater treatment plants help to measure the efficiency of each unit. In most effluents, BOD is less than COD, and elevated BOD5/COD ratio signals a high rate of biodegradation of wastewater [4].

The BOD5/COD ratio in municipal raw wastewater ranges from 0.4 to 0.8, whereas in industrial one reduces to 0.1 due to large presence of nonbiodegradable materials. If the ratio is in the range of 0.15 to 0.35, the biodegradability of wastewater is moderate, but if it is larger than 0.5, it is suitable for biodegradation [5,6].

However, there exists no certain and specific ratio for different wastewater. Because material biodegradation depended on the nature of wastewater (municipal or industrial) alters the BOD5/COD ratio. Thus, determining the BOD_5/COD ratio in raw wastewater plays an important role in choosing the treatment system [7]. Exploring the fluctuation trend of BOD_5/COD ratio in each unit of a wastewater treatment system shows the efficiency of each unit in removing biodegradable and nonbiodegradable materials. Therefore, when a wastewater treatment system tends to fail or when trying to upgrade some units of a treatment system to remove most of the nonbiodegradable matters, exploring BOD_5/COD ratio changes in diverse units of the wastewater treatment system is of utmost importance [8].

The decreased rates of biodegradable and nonbiodegradable matters depend on the different treatment conditions (anaerobic, facultative and aerobic) in various units of stabilization ponds [9]. Since the stabilization ponds in some small communities (that is villages and towns) do not have some units of stabilization ponds (mainly the maturation ponds), examining the impact of each unit on reducing BOD and COD necessitates the present study.

Since there is little information about the variation trend of BOD5/COD ratio in stabilization ponds, this study aimed to discover this variation trend in ponds' series of Gilan-e-Gharb in Kermanshah.

EXPERIMENTAL SECTION

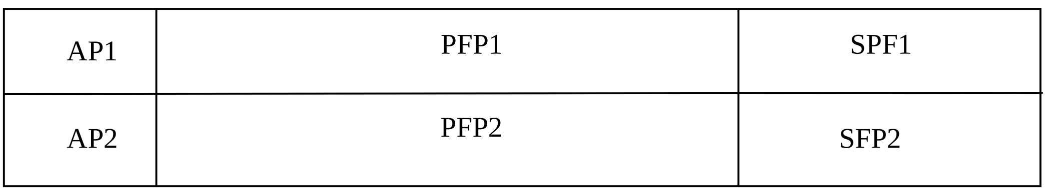
Site characteristics of the wastewater treatment plant

Gilan-e-Gharb is located in the west of Kermanshah with geographic coordinates of 33°-49' and 34°-28' of northern latitude, and east longitudes of 45°-51' and 46°-37' to Greenwich meridian. The city is situated at an altitude of 800 meters above sea level and has a warm climate where the mean temperatures in summer and winter are 32.5°C and 11°C, respectively. The average annual rainfall is 385 mm, and snow is rarely seen in this city.

The Gilan-e-Gharb wastewater treatment plant with a nominal capacity of 3,500 m^3 per day was first activated in 2005. This plant consists of a screening system (manual and mechanical), a flow measurement unit (Parshalflume), two anaerobic, primary and secondary facultative ponds in two parallel series (Figure 1 and Table 1), and a basin chlorinator (with 30-minute hydraulic retention time).

Table 1: Primary and secondary facultative ponds characteristics in two similar parallel series

Type of pond	Width (m)	Length (m)	Depth (m)	Surface loading (Kg BOD/ha.d), volume loading (gr/m^3.d)	Upper level (m^2)	Volume (m^3)	Hydraulic retention time (d)
Anaerobic	30	49	4	100 (volume loading (	1472	12768	1.7
Primary facultative	45	167	1.54	150(Surface loading)	7525	53688	1.7
Secondary facultative	45	167	1.5	87 (Surface loading)	33271	22219	1.7



AP2, AP1: Anaerobic ponds
PFP1, PFP2: Primary facultative ponds
SFP1, SFP2: Secondary facultative ponds

Figure 1: A simple scheme of the wastewater stabilization pond system of Gilan-e-Gharb

Sampling and measurement of parameters

In this descriptive-analytical study, both warm (June, July and August) and cold (December, January and February) months were selected for sampling. Weekly samples were taken from raw wastewater and effluents of the anaerobic, primary and secondary facultative ponds. In the first and third weeks of each month, sampling was carried out from the first series of ponds (AP1, PFP1, SFP1), and in the second and fourth weeks of each month, samples were taken from the second series of ponds (AP2, PFP2, SFP2). Thus, 16 samples in each month and totally 64 samples were taken.

This study measured Total COD, Soluble BOD, Soluble COD, TS, TSS and TDS using water and wastewater standard methods [10]. All chemicals used in this study were provided from Merck, Germany.

Statistical Analysis

Independent *t*-test was used to compare the total mean parameters in two series of ponds. A significant level of less than 0.05 was considered in all statistical tests. One-way ANOVA was also applied to compare the various ratios of interest (Total BOD/Total COD, Soluble BOD/Total BOD and Soluble COD/Total COD) in the four effluent types (wastewater). In this article, S and T stand for (Soluble) and (Total), respectively.

RESULTS

The results marked no significant differences in the overall means of measured parameters and their removal efficiencies during the study in two ponds series. However, significant differences were found in BOD/COD, SBOD/TBOD and SCOD/TCOD ratios among the four effluent types ($P<0.05$). Table 2 and 3 show the mean values of different parameters in raw wastewater and the effluents of stabilization ponds of Gilan-e-Gharb plant in warm and cold months, respectively. Figures 2 to 4 depict the fluctuation trends of the measured ratios.

Table 2: Mean values of different parameters in raw wastewater and the stabilization ponds effluent of Gilan-e-Gharb plant in warm months

Parameters	Wastewater/effluent type			
	Raw Wastewater	Effluent of Anaerobic Pond	Effluent of Primary Pond	Effluent of Secondary Pond
Temperature (C°)	20.16±1.53	20.16±1.50	19.66±2.52	18.5±3.12
pH	7.54±0.08	7.40±0.15	7.77±0.30	8.01±0.33
DO (mg/l)	0.36±0.18	0.25±0.15	2.01±1.07	4.05±0.61
Total BOD (mg/l)	198.3±20.2	128.3±10.4	96.7±12.6	80±18.9
Dissolved BOD (mg/l)	173.5±17.7	96.2±7.8	74.4±9.7	36.7±6.3
Suspended BOD (mg/l)	24.8±3.7	32.1±4	22.3±5.5	43.3±9.3
Total COD (mg/l)	447.66±43.7	284.66±19.75	214.33±20.81	199.66±35.8
Dissolved COD (mg/l)	339±30	239±18.5	141.17±20.2	123±14
Suspended COD (mg/l)	108.67±10.5	67.45±12	72±8.5	76.67±9.2
TS (mg/l)	694±40.51	639.66±23.67	615.33±32.32	602.66±23.25
TDS (mg/l)	569.33±40.07	548±19.52	532.66±23.16	520.33±13.65
TSS (mg/l)	126.33±10.97	91.66±12.74	82.66±15.57	83.33±9.45

Table 3: Mean values of different parameters in raw wastewater and the effluents of stabilization ponds of Gilan-e-Gharb plant in cold months

Parameters	Wastewater/effluent type			
	Raw Wastewater	Effluent of Anaerobic Pond	Effluent of Primary Pond	Effluent of Secondary Pond
Temperature (C°)	18.8±1.44	16.1±1.04	15.5±1.32	15.5±1.32
pH	7.45±0.07	7.22±0.03	7.75±0.21	8.06±0.20
DO (mg/l)	0.20±0	0.11±0.03	2.4±0.66	3.05±1.23
Total BOD (mg/l)	201.6±20.2	111.6±7.6	85±6.6	65±6.7
Dissolved BOD (mg/l)	176.4±17.7	87.1±7.4	68.4±5.1	33.3±3.8
Suspended BOD (mg/l)	25.2±6.7	24.5±5.5	16.6±3.5	31.7±4.8
Total COD (mg/l)	470.16±28.44	268.83±13.51	214.3±8.31	204.5±16.04
Dissolved COD (mg/l)	356±25.2	226±14.5	128±12.5	114±12.1
Suspended COD (mg/l)	113.8±9.2	42.5±5.5	85.6±8.5	90.5±11.2
TS (mg/l)	648.33±18.58	613.33±21.55	587.66±16.62	573.66±12.06
TDS (mg/l)	553±17.35	527.33±19.76	510.33±17.50	501.66±7.77
TSS (mg/l)	95.66±4.16	85.66±3.06	77.66±3.06	73±6.24

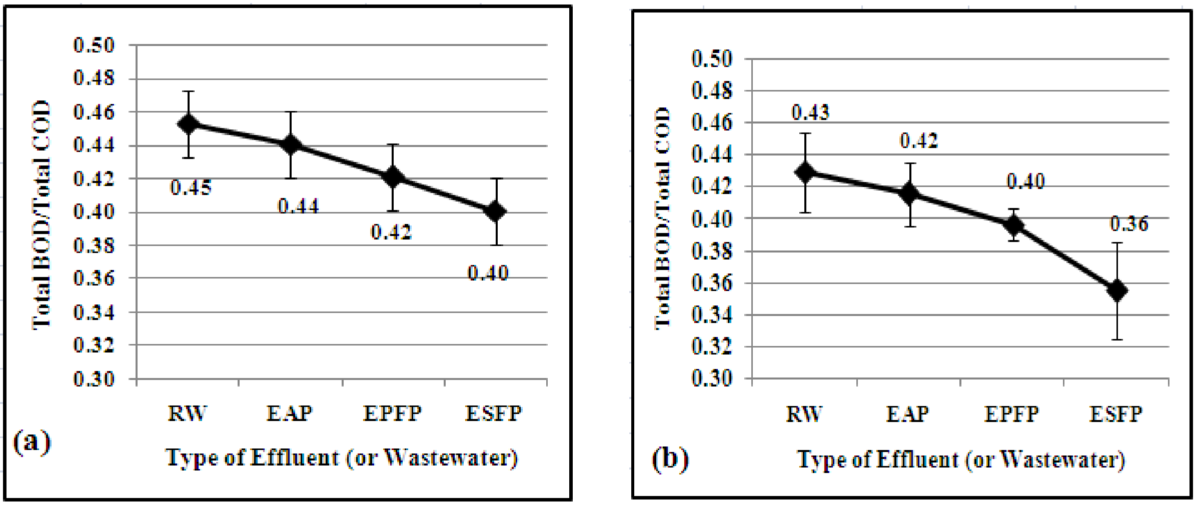


Figure 2: The fluctuation trend of Total BOD/Total COD ratio in different units of stabilization ponds in warm (a) and cold (b) months RW: Raw Wastewater, EAP: Effluent of Anaerobic Ponds, EPFP: Effluent of Primary Facultative Ponds, ESFP: Effluent of Secondary Facultative Ponds

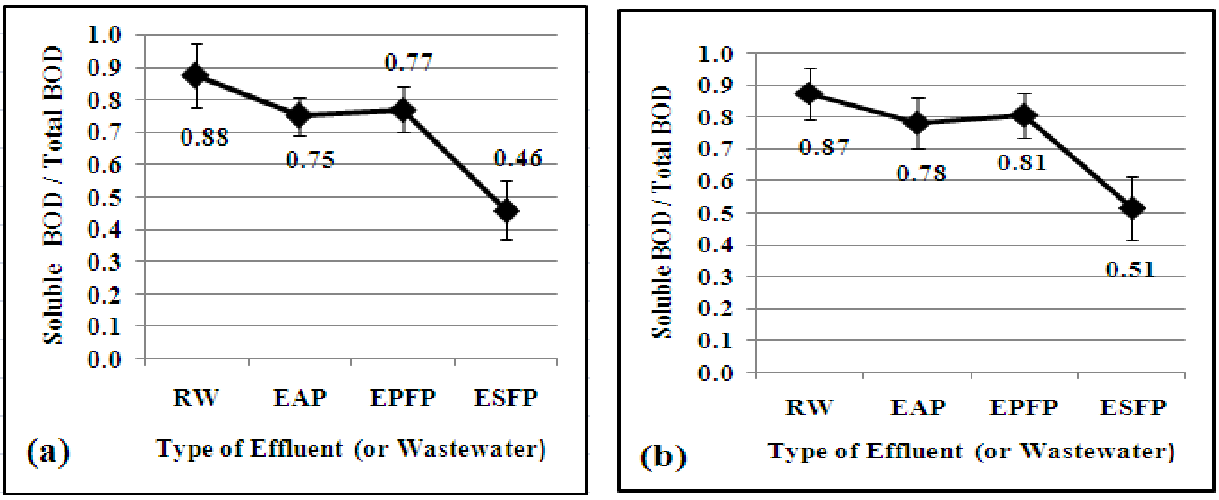


Figure 3: The fluctuation trend of Soluble BOD/Total BOD ratio in different units of stabilization ponds in warm (a) and cold (b) months

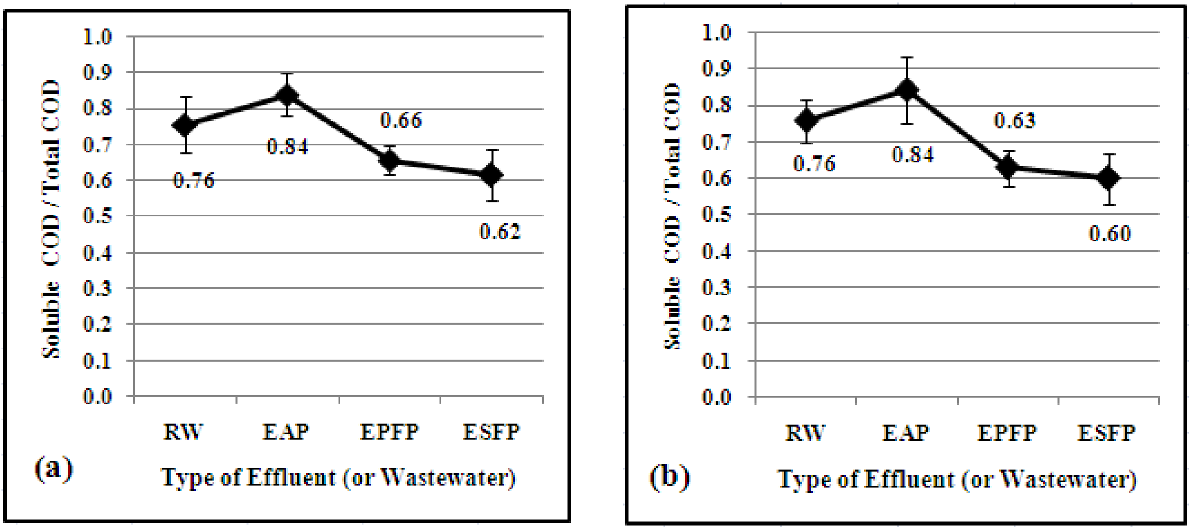


Figure 4: The fluctuation trend of Soluble COD/Total COD ratio in different units of stabilization ponds in warm (a) and cold (b) months

DISCUSSION

The findings showed significant differences in the mean values of TBOD/TCOD, SBOD/TBOD and SCOD/TCOD ratios among four effluent types ($P<0.05$). This may be due to the influence of physical, chemical and biological factors on organic matter decomposition. Besides, the rate of sedimentation, dissolved oxygen, pH, biological activity (aerobic and anaerobic) and other structural features such as depth and surface area were different in anaerobic, primary and secondary facultative ponds.

This is consistent with the results of other researchers. One study reported the influences of algal activity, hydraulic retention time, temperature changes, pH and dissolved oxygen on the efficiency of ponds in removing organic materials [11]. Therefore, differences in these parameters can cause variability in the severity of microbial activity, type of microorganisms in each pond and thus in reducing organic materials and their ratios [12,13].

The results also showed decreased trends of BOD/COD ratio from raw wastewater to the effluent of secondary facultative ponds in both warm and cold months. Even though the large part of biodegradable materials (TBOD) are removed under anaerobic hydrolysis condition, most of the organic suspended solids deposited in the anaerobic pond, reforms to soluble intermediate compounds with low degradability (SCOD) during the anaerobic hydrolysis process [1]. So this helps the anaerobic ponds to have lower rates of COD removal (that is a high decrease of BOD, but a low decrease of COD). Based on these two reasons, more decrements of TBOD/TCOD ratio take place compared to raw wastewater [14].Given that soluble nonbiodegradable materials (part of COD) in anaerobic ponds enter primary facultative ponds, and this reduces more of the residual biodegradable material (BOD), as a consequence the TBOD/TCOD ratio decreases in the overall. Similarly, this ratio will be more reduced in the secondary facultative ponds effluent compared to primary one [1,15].The study of Papadopoulos et al (2001) also showed that in the anaerobic pond, the tendency of compounds' removal via biological oxidation was high. Therefore, there is an elevated biodegradable material removal in these ponds. On the other hand, due to more abilities of aerobic and facultative ponds in biological removal of organic matter than anaerobic ponds, the rate of BOD removal increases in these ponds. The COD/BOD ratio tended to increase from 2.05 to 2.64 after the facultative pond due to high biodegradability of wastewater [13].

However, the results revealed more levels of TBOD/TCOD ratio in the warmer months; this may be due to the more formation of bacterial biomass in primary and secondary facultative ponds in warm months than cold ones and the augmented rate of organic matter biodegradation with growing temperature [16].On the other hand, because of the decrease of microorganisms and algal activity in cold months, the COD removal is 6% less than warm months. This redounds to increase of BOD/ COD ratio in the warmer months. Temperature difference of wastewater moving in waste stabilization ponds during the warm and cold months was about 3 °C that caused the low relatively increase of

COD removal. This issue is true for all regions that have analogous climate (warm weather). Similarly, Pivelli (2008) reported higher rate of COD removal in summer than other seasons and attributed this to the increased microbial activity, thus more COD removal has been occurred in warm seasons than chilled weather [17].Another study suitably showed that COD removal rate was reduced in cold season [18].

According to our study, the mean value of SBOD/TBOD ratio had a roughly increasing trend in the primary facultative pond effluent compared to its previous pond, while a decreased trend was observed in the secondary facultative and anaerobic ponds effluent. The fall of SBOD/TBOD ratio in the anaerobic pond effluent compared to raw wastewater may be influenced by anaerobic conditions on SBOD removal and the subsequent reduction of this ratio in the anaerobic pond effluent. The increase of SCOD/TCOD ratio in the anaerobic pond effluent compared to raw wastewater (unlike to SBOD/TBOD ratio) could be due to anaerobic hydrolysis of settled matter that tended to form low biodegradable soluble intermediate compounds. This variation can help to increase the rate of Soluble COD, but does not affect the rate of Soluble BOD [1,15].

The increased BOD/COD ratio in the primary facultative pond effluent compared to the anaerobic pond effluent might be due to breaking down of organic suspended solids deposited in the bottom of the primary facultative pond, its re-solution, and dissolving the related intermediate organic compounds 15].Regarding the available oxygen rate in the primary facultative ponds that is in the minimum range needed for biological oxidation of organic materials, soluble organic materials produced from hydrolysis of settled organic suspended solids cause to raise SBOD and SBOD/TBOD ratio in the aforementioned ponds. On the other hand, the long retention time in these ponds has caused to settle most part of particulate BOD (suspended BOD), so TBOD (part of particulate BOD) has been decreased, and this would increase the SBOD/TBOD ratio [1,2].Decreased SBOD/TBOD ratio in secondary facultative ponds may have different reasons. Because of the increased amount of oxygen and the subsequent accelerated biological oxidation of organic materials, more soluble matters tend to remove, and the reduced SBOD aids to decrease the SBOD/TBOD ratio [14].Besides, due to solubility of suspended organic matter settled in the bottom of ponds, this ratio in the secondary facultative ponds is less than anaerobic and primary ones. Therefore, reducing SBOD makes the SBOD/TBOD ratio to decrease. Another point is that in secondary facultative ponds, particulate BOD tends to increase due to algal biomass growth. Regarding that the particulate BOD is part of TBOD, the level of TBOD goes to raise and as a result, the SBOD/TBOD ratio reduces [15].The results also showed the lesser SBOD/TBOD ratio in warm months than cold ones. This may be due to more BOD removal (that is more SBOD removal because of its high bioavailability) in the warm months (8%) than the cold ones by more microbial activity (1). This is also consistent with the results of Goyal (2013) in that they found more BOD removal in summer than winter and assigned this to microbial activity regarding the seasonal variations [19].

Based on the results, the increased SCOD/TCOD ratio in the anaerobic pond effluent could be due to forming soluble intermediate compounds with low biodegradability (SCOD) during the anaerobic hydrolysis [1].So by increasing the SCOD, the COD/TCOD ratio in the anaerobic pond effluent serves to increase compared to raw wastewater. The study of Crites has shown that since in anaerobic ponds, most solids representing the TCOD deposit and produce compounds such as organic acids and ammonia that raise COD, the SCOD/TCOD ratio tends to grow in anaerobic ponds effluent [20].

This study revealed the decreased SCOD/TCOD ratio in the primary and secondary facultative pond effluent. Because most part of SCOD goes to decrease during different chemical processes (such as organic material oxidation due to increased pH caused by algal growth during the day or organic material oxidation with a high oxygen level in the secondary facultative pond) and by biological oxidation.

Thus with reducing the SCOD, the SCOD/TCOD ratio tended to increase in the primary facultative pond effluent compared to the anaerobic one. However, with increasing the oxygen level, the accelerated biological oxidation makes more soluble organic matters to decrease in the secondary facultative pond. So this ratio will be more diminished in the secondary facultative pond effluent compared to the primary one [13,21].

CONCLUSION

This study pointed out the influence of anaerobic ponds on removing biodegradable materials (BOD) through anaerobic hydrolysis. However, due to redissolving of nonbiodegradable compounds (SCOD) deposited at the bottom of anaerobic ponds, overall decrease of TCOD by the anaerobic pond is small. Hence, the ratios of

TBOD/TCOD and SBOD/TBOD go to increment in the anaerobic pond effluent, and the SCOD/TCOD ratio increases compared to raw wastewater. Decomposition of settled organic suspended solids in the bottom of primary facultative pond and its redissolution cause to increase the SBOD and settling a large part of particulate BOD (suspended BOD) makes to reduce the TBOD, and eventually increases the SBOD/TBOD ratio. Meanwhile, more BOD removal through settling of suspended solids and biological oxidation reduce the TBOD/TCOD ratio compared to the anaerobic pond effluent.

A large part of SCOD in facultative ponds has been reduced during different chemical processes such as organic material oxidation and this causes to lessen the ratio in the primary and secondary ponds effluent. Based on the mentioned reasons, the ratios of TBOD/TCOD, SBOD/TBOD and SCOD/TCOD in the secondary facultative ponds effluent tends to be lesser than those in the primary one. The differences between the ratios under study in both warm and cold months might be due to more generation of bacterial biomass in primary and secondary facultative ponds in warmer months, and the increased organic materials biodegradation with growing temperature.

Acknowledgments
Authors warmly appreciate the efforts of Deputy of Research and Technology, Kermanshah University of Medical Sciences and thank the staff of the Kermanshah Province Water and Wastewater Company and officials of treatment plants for their cooperation in this study.

REFERENCES

[1] Mara DD, Pearson HW. Waste Stabilization Ponds: Design Manual for Mediterranean Europe. *Lagoon Technology International Ltd, Leeds,* **1998**.
[2] Sharafi K, Fazlzadeh Davil M, Hiedari M, Almasi A, Taheri H. *International Journal of environmental health engenring*, **2012**, 1, 1-5.
[3] Khosravi R, Shahryari T, Halvani A, Khodadadi M, Ahrari F, Abouee Mehrizi E. *Advances in Environmental Biology*, **2013**, 7(6), 1182-1187.
[4] El-Din B, Hegazy E. *Journal of Applied Sciences Research*, **2013**, 9(1), 638-642.
[5] Chan YJ, Chong MF, Law CL, Hassell DG. *Chemical Engineering Journal*, **2009**, 155, 1–18.
[6] Beyene H, Redaie G. *World Applied Sciences Journal*, 2**011**,15(1), 142-150.
[7] Tchobanoglus G, Burton FL. Wastewater Engineering, 4th ed. *McGraw, Hill, Metcalf & Eddy, New York*, **2003**.
[8] Hsieh, Y.H., Wang, K.H., KO, RC., Chang, CY. *Water Science & Technology*, **2000**, 42(5-6), 95-99.
[9] Derayat J, Almasi A, Sharafi K, Meskini H. *Journal of Water and Wastewater*, **2013**, 2, 11-18.
[10] APHA, AWWA and WPCF. Standard method for the examination of water and wastewater. 21th ed. Washington D.C.: *American Public Health Association*, **2005**.
[11] Dasilva F, Desouza R, Araújo A L C. *Brazilian journal of chemical engineering***, 2010**, 27(1), 63-69.
[12] Tyagi VK, Kazmi AA, Chopra AK. *Journal of Water Environmental Research*, **2008**, 80(11), 2111–2117.
[13] Papadopoulos A, Parissopoulos G, Karteris A. Varitions 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**, 369-376.
[14] Ingallinella AM, Sanguinetti G, Fernández RG, Strauss M, Montangero A. *Water Science and Technology*, **2002**, 45(1), 9–15.
[15] Almasi A, Sharafi K, Hazrati S, Fazlzadehdavil M. *Journal of Desalination and Water Treatment*, **2013**.
[16] Amahmid O, Asmama S, Bouhoum K. *Urban Water*, **2001**, 4(3), 252-262.
[17] 17.Pivelli RP, Gunther WMR, Matte GR, Razzolini MTP, et al. *Water Environmental Research*, **2008**, 8(3),205–211.
[18] Al-Sa`ed R, Abu-Madi M, Zimmo O. *Journal of Environmental Engineering*, **2011**, 6(13), 284-90.
[19] Goyal B, Mohan D. *Journal of Water Practice & Technology*, **2013**, 8(1), 94-104.
[20] Crites RW, Middlebrooks EJ, Reed SC. Natural wastewater treatment systems, CRC- Taylor & Francis Group. {A comprehensive explanation on the type and mechanisms of natural wastewater treatment systems}.
[21] Al-Hashimi MA, Hussain HT. *European Scientific Journal***, 2013**, 9(14), 278-294.