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APPLICATION OF DOWNFLOW ANAEROBIC UPFLOW OXIC SUBMERGED BIO-FILM REACTOR (DAUOSBR) IN REMOVING PHOSPHORUS, NITROGEN, ORGANIC MATTER, TURBIDITY AND TOTAL SUSPENDED SOLIDS FROM HOSPITAL WASTEWATER

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Abstract

Aerobic treatment processes using attached media have been studied extensively to remove organic matter from wastewater and also denitrification process. The objective of this study was to assess the ability of down flow anaerobic up flow oxic submerged bio-film reactor (DAUOSBR) to remove phosphorus, nitrogen compounds, BOD_5, COD, turbidity and total suspended solids from the Farabi Hospital wastewater. The present work involved designing and building a reactor loaded with down flow anaerobic up flow oxic submerged bio-film reactor, thereby a total of 450 samples were taken from the inlet and outlet of the treatment plant to evaluate the efficiency of the system. The results on stage of the operation (three parts) showed that the removal rate of COD, BOD5, TSS, Phosphorus and turbidity at the third stage and Nitrogen, TKN at the second zone were excellent. Comparatively the average removal efficiency of the mentioned parameters (except COD and TSS) showed a significant difference within three retention times ($P<0.05$). This system has exhibited high performance and capacity with regard to the removal of the selected parameters from hospital wastewater. Thus, the optimal times of 3.6 h and 1.4 h under aerobic and anaerobic conditions for the removal of ammonia nitrogen as well as 4 h and1. 5 h under aerobic and anaerobic conditions for the removal of phosphorus, organic matter, suspended solids and turbidity, were obtained, respectively.

Key words: hospital wastewater, nitrogen compounds, organic matter, phosphorus, submerged bio-film

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1. Introduction

The aerobic treatment processes using attached media have been studied extensively to remove organic matter from wastewater and also convert ammonium to nitrate during the nitrification process. In fact, such processes have become the focus of attention of many engineers and designers of sewage treatment plants. However, Xiangchun et al. (2013) studied on one-stage Aerobic Moving Bed Biofilm Reactor (MBBR) and a combined reactor containing an Anoxic Gravel-Bed Biofilm Reactor (GBBR) for removal of pollution from the heavily polluted river water.

They found that the GBBR system worked better than MBBR in removing COD, ammonia and TN from river water, which obtained 6-16%, 32-59%, and 9-31%, respectively. Also they found that the incorporated GBBR-MBBR was more capable and lower-cost compared to the one-stage MBBR for

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treatment of heavily polluted river water (Li et al., 2016; Xiangchun et al., 2013).

The fixed-bed growth processes are classified into non-submerged attached growth, attached suspended growth, and aerobic submerged attached media processes. The main advantages of bio-fixed film processes include satisfactory response to load fluctuations, suitability of the system for small-sized reactors, and providing microbial growth conditions at an especially low rate (Casellas et al., 2006; Gonzalez et al., 2007; Metcalf and Eddy, 2003). The aerobic submerged attached growth process consists of three parts which include media, bio-film and liquid, with the size and type of media representing important factors that affect the performance and operation of the system. In this system the clarifier zone is not used, meanwhile, the inlet suspended solids and additional solids resulting from the biomass growth in the system are trapped and must be removed periodically.

The significant advantages of the submerged fixed growth system are as follows: less land use; ability to treat dilute wastewater and filter solid materials; produce high quality effluent; lack of sludge settling and resulting problems related to sludge settling like the activated sludge process (Aslan and Simsek, 2017; Metcalf and Eddy, 2003; Mehrdadi et al., 2006; Nicolella et al., 2000).

Comparatively, per capita, domestic water consumption is approximately 150-200 L per person per day, while usual water usage in hospitals is approximately 750 L per bed per day (Azizi et al., 2016). Thereby, large volumes of water used in hospitals lead to the formation of a considerable volume of wastewater potentially containing various hazardous components like toxic chemicals, metabolized and anti-tumor drugs, antibiotics, radioactive isotopes, organ compounds, enteric pathogens including bacteria, viruses and helminthes, which can easily reach water resources and supplies that are available for human consumption, as well as most of hospitals wastewater are mixed into an aquatic environment such as municipal, industrial and medical centers wastewater can cause pollution and health problems for people (Emmanuel et al., 2005; Majlesi and Yazdanbakhsh, 2008; Pirsaheb et al., 2015; Rezaee et al., 2005). Indeed, the contact of hospital pollutants with the elements of the aquatic ecosystems puts in evidence a danger which is bound to the existence of hazardous substances, i.e., which have the potentiality to exercise negative effects on the environment and the living species (Wen et al., 2004). Several biological processes have been used in HWWTP, namely the Activated Sludge Biological Contactor (ASBC) (Greentech Co. Ltd. 2008), Anaerobic Aerobic Fixed Film Bioreactor (A2F2B) (Rezaee et al., 2005), Anaerobic - Aerobic Biofilter (A2B) (Said, 2000), and Submerged Membrane Bioreactor (SMB) (Wen et al., 2004) .

According to the characteristics of hospital wastewater and importance of treating it before entering the municipal wastewater collection system or any other receiving water body, and also due to the limited availability of hospital land to build treatment plants, the application of aerobic submerged fixed growth with high performance and the subsequent use of less land have been introduced and investigated intensely (Emmanuel et al., 2005; Greentech Co. Ltd., 2008; Wen et al., 2004). Accordingly, research data relating to the wastewater activated sludge, and submerged attached growth, to treat hospital, are rather limited, So the objective of this study was to assess the ability of down flow anaerobic up flow oxic submerged bio-film reactor (DAUOSBR) to remove organic matter (BOD_5 and COD), suspended solids (TSS), turbidity, nitrogen and phosphorus compounds from the Farabi Hospital wastewater in Kermanshah.

2. Materials and methods

2.1. Pilot plant reactor

The fiberglass reactor was built according to the schematic illustration in Fig. 1. This reactor provided a biological system with an anaerobic type of down flow anaerobic up flow oxic submerged bio-film reactor growth. The useful volume of the system was 40 L comprised of an anaerobic (11L) and an aerobic (29L) zone, which were separated with installed and impermeable baffled glass, at a 2 cm distance from the bottom of the reactor to direct the flow from anaerobic to aerobic zone (a). Also settling zone in the volume of 10 L attached to the aerobic zone as a monolithic reactor of anaerobic, aerobic and settling was designed and constructed. The upper part of the wall between aerobic and settling zone contained a slot with size of 1×10 cm^2 (b), which directed flow from the aerobic zone to the settling part. The effluent flow out from the settling through the wall consisted of a hole with 1 cm diameter (c) (Fig. 1). Accordingly, the reactor with the aerobic downflow anaerobic up flow oxic submerged bio-film reactor growth system required media. Therefore, the pieces of flexible tube with a length of 1-1.5cm and specific surface area of >600 m^2/m^3 for attaching the bio-film was chosen in this study to fill out the pre-reaction and reaction zones with the media. In order to prevent displacement of the flexible tube, and released production gas by biological processes a polyethylene plate consisting of meshes with diameters less than the size of tube pieces was used to cover the reactor media bed.

Also, aeration of reactor was provided with two different diameter plastic tube blowers (a larger- - diameter plastic tube was used as a main branch and a plastic tube with a smaller diameter used as the sub-branch) installed at the bottom of the reactor. To prevent air flow to the pre-reaction part, one side of the smaller plastic tube was closed, and the other side connected to a larger plastic tube by a T-pipe. Finally, the air pump with a flow rate of 75 L/min was connected to the larger tube. In order to eliminate and prevent hydraulic drop, fine bubble aeration was carried out on the smaller tube to allow emulsified aeration. After operating and loading the system with activated sludge from the treatment plant at the Rojin

Tak company in Kermanshah, the raw wastewater which was provided by the Farabi Hospital was fed into the system at the three aerobic hydraulic retention times (HRT) of 2.9, 3.6 and 4 h and three anaerobic HRT of 1.1, 1.4 and 1.5 h, respectively. The removal efficiency of phosphorus, nitrogen compounds (ammonia nitrogen, TKN, nitrate, nitrite) in raw and treated wastewater was measured at each retention time in the reactor. The raw wastewater from the hospital was continuously fed to the reactor by the peristaltic pump (Haydlf model).

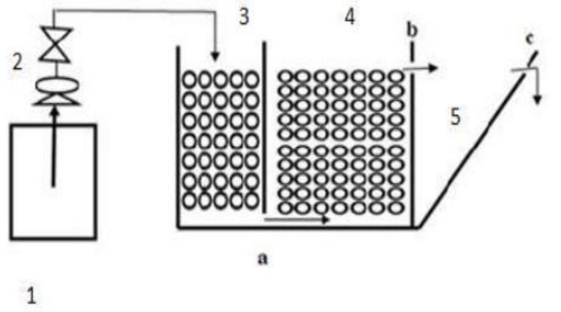

Fig 1. The schematic diagram of the submerged activated sludge growth reactor system (1 - Raw wastewater storage tank; 2 - Wastewater flow meter valve; 3 – Feeding storage tank and flow meter rate; 4 - Anaerobic reactor; 5 - Aerobic reactor)

2.2. Reactor set up

The reactor was fed with activated sludge (2000 mL), provided by the treatment plant at the Rojin Tak company (MLSS: 11000mg/L, MLVSS: 8500 mg/L). Glucose was used as a source of carbon at a dosage of 40 g, and chemical fertilizers of ammonium nitrate (0.1g) and ammonium phosphate (0.5 g), were used as the sources of nitrogen and phosphorus, respectively. So that, to start up the reactor about half of it was loaded with the sludge and the other half part with hospital wastewater. Whenever a microbial bio - film was taking place, the sustainability of the biological system and a COD removal of up to 80% were achieved, follows that the reactor was loaded with the raw wastewater from Farabi Hospital.

2.3. Operating system

Following installing the operating system, the process of the reactor containing raw wastewater from the Farabi Hospital was begun. Sampling was undertaken under optimized operational situation, when the COD and turbidity levels of the effluent reached 100mg/L and 5 NTU, respectively. In order to achieve an optimized operational environment during aerobic down flow anaerobic up flow oxic submerged bio-film reactor system, different loading steps were considered as follows:

2.3.1. First stage

Wastewater flow meter valves were used to control and monitor the flow rate of the raw influent wastewater (2.77 mL/s), HRT (2.9 h), and anaerobic retention time (1.1 h) during each operating phase of the reactor. After adapting the system to raw hospital wastewater, the samples were collected from the raw influent and effluent within 48 h.

2.3.2. Second stage

The influent wastewater was transferred from the storage tank to the reactor at a flow rate of 2.2 mL/s, with hydraulic and anaerobic retention times 3.6 and1. 4 h, respectively. After stabilizing the system, samples were subsequently collected.

2.3.3. Third stage

Although all operational systems were similar to those in the first and second stages, but the aerobic hydraulic retention time of 4 h, and anaerobic retention time of 1.5 h time were considered in this step with a volume of 2 mL/s. Accordingly, to formed adaptation, producing bio-film and achieving stable condition the time of a month was required moreover COD of less than the 100 mg / l in the effluent as a stability indicator of the system was measured.

Following each loading the reactor was continuously operated under new condition, consequently the COD level decreased to 100 mg/ l which revealed the stability form of the system at each step. It should be noted that the time between each loading step, respected at least 3 days.

2.4. Sampling

This study was descriptive – analytical. According to the three performing steps and the parameters that were to be examined in this study, a total of 450 samples was collected during a 6 month period, to evaluate the efficiency of the down flow anaerobic up flow oxic submerged bio-film reactor system in term of removing organic matter (BOD5 and COD), turbidity, suspended solids (TSS), nitrogen compounds (ammonia nitrogen, (TKN), nitrite and nitrate), phosphorus and pH with regard to the three retention time loading. Moreover, the aerobic and anaerobic retention times of 1.1, 2.9 h; 1.4, 3.6h; 1.5,4 h were selected in the first, secondary and third stages, respectively.

Thus, at every step of the process, 15 samples (5 samples of influent, 5 samples of effluent and 5 samples from the anaerobic zone) due to three times of process 45 samples were taken to measure 10 parameters of each sample.

2.5. Analyses

All sample analyses were carried out according to standard methods (5220-B, 2540-D,2130-B,4500-P,4500-NH_3,4500-NO_2 AND 4500-NO_3 (APHA, 2005). All chemical material used in this study was purchased from Merck (Germany). For data analysis, comparison the average removal of parameters at the three retention times was carried out by the Kruskal-Wallis test using the SPSS-Ver.16 software.

3. Results and discussion

The results obtained are presented in Tables 1 and 2, revealed the characteristics of influent and statistical analysis using Kruskal-Wallis regarding to three retention times, also the concentration of the investigated parameters in the effluent of anaerobic zone giving in tables 1and 2. The results indicated that the removal rate of COD, BOD_5, TSS, turbidity and phosphorus in the third step of the system (4 aerobic and 1.5 anaerobic) and ammonia nitrogen and TKN in the second stage (3.6 aerobic and 1.4 anaerobic) were excellent, respectively. Comparatively the average removal efficiency of the mentioned parameters (except COD and TSS) showed a significant difference within three retention times ($P <0.05$).

The results of this investigation demonstrated excellent performance regarding the removal of COD, BOD_5, TSS, turbidity and phosphorus from wastewater in the third stage of the process (4 h aerobic, 1.5 h anaerobic) and nitrogen ammonia, and TKN removal of the second point (3.6 h aerobic , 1.4 h anaerobic). Comparison of the average removal efficiency of parameters (except turbidity and BOD) showed no significant differences between three steps ($P>0. 05$). However, the reasons could be due to the long HRT and aeration time during this phase, rather than the other phases. Because, when there was a decline in the aeration time, there was also a decrease in the COD removal efficiency. The results obtained so far were similar to those in another study carried out by Hasani et al., (2009), who showed that the activated sludge attached growth used to treat wastewater with a high microbial contamination load, the optimal COD removal efficiency occurred at aeration times of 4.8 and 16 h. So, the best COD removal efficiency was 79.68 %, with an aeration time of 8 h. Significant BOD removal rates with increasing aeration time is a result of higher access by microorganisms to biodegradable organic matter (BOD), hence leading to better degradation of BOD contents.

On the other hand, COD contents in hospital wastewater consisting of more non-degradable compounds such as pharmaceutical and disinfectant material actually increases the limited retention time to 0.4 h, which doesn't have a significant impact on COD removal efficiency. Meanwhile, a large amount of turbidity is the result of suspended solids, the great extent of which can be removed by increasing the retention time (1.5 h).Consequently an even slight increase in retention time could affect the removal efficiency of the system.

Furthermore, other reasons that further affect the removal efficiency (at the third step) are the ambient temperature (temperature maintained by the surrounding plastic environment), thus enhancing the activity of microorganisms (Metcalf and Eddy, 2003).

Table 1. Average removal level of COD, BOD_5, TSS, turbidity, pH in influent and effluent wastewater according to different retention times

Retention time	***COD (mg/L)***			***BOD (mg/L)***			***TSS (mg/L)***			***Turbidity (NTU)***			***pH***		
	Inlet	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Anaerobic***
Aerobic (2.9 h) Anaerobic (1.1 h)	480± 8.2	94.7± 27	80± 6	240± 4.08	21.3± 1.9	91± 1	197.3± 5.5	6.8± 0.2	96.5± 1	26.3± 2.5	1.7± 0.6	94± 2.7	7.7± 0.2	7.8± 0.1	7.7± 0.05
Aerobic (3.6 h) Anaerobic (1.4 h)	464± 72.8	88.8± 8.6	81± 2	229.5± 17.3	16.5± 1.3	93± 1	300± 26.5	9.7± 2.1	96.7± 1	36± 9.8	1.5± 0.8	96± 1	7.8± 0.1	7.6± 0.1	7.7± 0.1
Aerobic (4 h) Anaerobic (1.4 h)	487.5± 26.3	95± 12.9	82± 2	228.8± 8.6	11.3± 7.5	95± 3	321± 18.5	4.9± 0.2	98.4± 0.1	31.8± 2.8	0.6± 0.1	98± 0	7.7± 0.2	7.6± 0.15	7.5± 0.1
P	0.995			0.05			0.08			0.043			-		

Table 2. Average concentrations of Ammonia Nitrogen, (TKN), Nitrite, Nitrate and Phosphorus in influent and effluent wastewater according to different retention times

Retention time	***Ammonia Nitrogen (mg/L)***			***TKN (mg/L)***			***Nitrite (mg/L)***			***Nitrate (mg/L)***			***TN (mg/L)***			***Phosphorus (mg/L)***		
	Inlet	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***	***Inlet***	***Outlet***	***Removal efficiency%***
Aerobic (2.9 h) Anaerobic (1.1 h)	38.36± 0.0	14.39± 0.74	62± 2	34.9± 3.3	95.64± 0.0	52.9± 2.7	45± 3	92± 3.3	0.98± 0.0	8.54± 2.07	1.04± 0.0	9.98± 1.04	96.16± 0.0	57.83± 3.59	39.86±3.6	12± 0.0	7.7± 0.6	36± 5
Aerobic (3.6 h) Anaerobic (1.4 h)	37..3± 10.8	0.98± 0.54	97± 2	32.2± 9.9	92.6± 26.9	3.5± 1.99	96± 3	87.7± 4.8	0.9± 0.34	7.76± 4.1	0.84± 0.52	10.7± 1.48	93.07± 27.15	8.33±3.62	91.04±3.88	14.3± 2.5	7.7± 1.2	45± 12
Aerobic (4 h) Anaerobic (1.4 h)	48.4± 3.36	9.5± 1.75	80± 3	44.6± 2.9	124.6± 0.0	37.4± 4.8	70± 4	118.2± 0.0	0.05± 0.01	9.98± 1.06	0.63± 0.03	8.5± 1.12	124.75±0.01	42.47±5.38	65.95±4.3	12± 0.0	5.7± 0.6	53± 5
P	0.007			0.007			-			-			0.006			0.035		

In addition, the results of this system indicated that the average amount of COD (unsuitable for disposal into surface water (> 60 mg/L)), BOD, TSS and turbidity were in agreement with the standard rate used for agricultural purposes and disposal into surface water. Therefore, to achieve appropriate COD removal, it might be better to extend aeration and anaeration retention times or decrease the organic load, and also control other parameters such as anionic surfactants that affect the COD removal efficiency. Which is consistent with studies of Leal et al., (2010), who showed that the COD removal efficiency declined by high concentrations of anionic surfactants (>43mg/L) in the anaerobic treatment systems and the combined aerobic-anaerobic systems.

The results of the present study is consistent with other studies as follows: A study by Shakerkhatibi et al., (2010) showed that the aerobic submerged fixed-film reactor (ASFFR), under optimal situation, with an organic load of 0.8-2.4 kg/m^{3}d, removed 95-99% of the COD and produced an effluent with a COD value less than 50 mg / l, which was lower than that of the Iran Environmental Protection Organization (EPO) standard for the effluent (COD <60 mg / l). However, increasing the organic load up to 2.7 kg/m^{3}d, a COD removal efficiency of 66% was achieved. Mousavi et al., (2005) showed that a combination of an aerobic-anaerobic fixed bed (UA / AFB) reactor with organic loads of 0.8, 2.3, 4.7 and 7.6 kg COD/m^{3}d, HRT of 9 h (5 h aerobic and 4 h anaerobic), and appropriate aeration times for the entire mentioned organic loads, led to a COD removal efficiency of > %95. So, 50-81% of the COD removal rate was achieved by using a doubled anaerobic filter with a sequencing bath reactor (SBR) aerobic system, at an OLR of 3.7-16.5 kg/m^{3}d and HRT of 16-72 h. In fact, the COD removal rate depends intensely on organic loads (Lopez et al., 2010). Though, Araujo et al., (2009) showed that 97% of the COD removal rate was achieved by an up flow fixed-bed combined anaerobic-aerobic reactor, with a hydraulic retention time of 35 h (21 h in the anaerobic zone and 14 h in the aerobic zone) and a recycling ratio (R) of 3.5. In addition, Kocadagistan et al., (2005) indicated that a combined up flow anaerobic fixed-bed (UAF-B) and a suspended aerobic activated sludge bioreactor (SAR) removed 94-98.7% of the COD.

Consequently, the significant difference was not observed between three phases in term of COD removal which might be due to no significant difference of retention time between these three phases.It can be noted that the retention time has a significant role in the removal of TSS.

According to results obtained in this study, the maximum removal rate of nitrogen ammonia and TKN takes place at the second step (3.6 h aerobic, 1.4 h anaerobic). Comparatively, the amounts of nitrogen ammonia and TKN at this step were less than those of the other stages. Founded on the hospital wastewater involves pharmaceutical compounds containing organic nitrogen, which made a major part of non-degradable TKN, therefore with increasing inlet nitrogen compound in this system the removal efficiency of nitrogen compounds will be decreased (Kermani et al., 2008). Thereby, the significance level in average removal efficiency of parameters above at three retention times indicated that the removal of nitrogen compounds is considerably affected by retention times at the aerobic and the anaerobic zone. Also, it is affected by the TKN concentration at the second stage, thus increasing aerobic and anaerobic time was not able to remove it at third stage rather than the second stage. Furthermore, more ammonia nitrogen and nitrogen are removed by nitrification and denitrification processes simultaneously, which is probably an acidic condition of the effluent at anaerobic zone and requiring nitrobacteria to low acidic condition (high alkalinity) decrease converting TKN to nitrite and nitrate (denitrification process). In contrast, increasing biodegradable organic matter in the aerobic zone cause increases the BOD / TKN ratio as a result, reducing nitrification (with increasing retention time in this area more organic acids produce similar with anaerobic zone). Therefore, presence more inorganic carbon could inhibit the oxidation of nitrogen compounds due to requiring the nitrobacteria to organic carbon. So a competition occurred between the heterotrophic bacteria and the nitrobacteria to achieve more oxygen, accordingly heterotrophic bacteria growing up rapidly and the population of nitrobacteria will be decreased in the bio-film of this system (Rusten et al., 1995). Whenever the oxygen concentration at the depth of fluke or bio-film of the attached growth system reaches about zero the denitrification take place. Thus, in this system both nitrification-denitrification processes are carried out at the same time, which has caused the removal of nitrogen compounds from wastewater (US EPA, 2009).

The results indicated that the levels of nitrite and nitrate of effluent were more than those of influent during the three operating form, which was probably due to nitrification in the aerobic zone. However, some of these compounds in the anaerobic system were reduced as a result of denitrification and because of the short aeration time the rate of it was less than the nitrification process (Metcalf and Eddy, 2003).

The outlet nitrite and nitrate levels in the three levels were within the range of the standard value (10 mg/L and 50mg/L, respectively) discharged into well and surface water. Thereby, the amount of nitrite at the second part was 10.7 mg/L, more than the standard value (10mg/L) discharged into the well. This could be due to a greater conversion of nitrite to nitrate. (Jayaraj and Latha, 2009) showed that the up flow Anaerobic/Aerobic Fixed Bed (UA/AFB) reactor at HRT of 7 simultaneously removed 90, 93 and 88% of COD, ammonia nitrogen (nitrification) and nitrogen (denitrification), respectively. The highest rates of NH3-N and N-NO3 removal occurred in the aerobic and anaerobic zones, respectively. Therefore, increasing HRT was resulted in decreasing denitrification rate; it can be according to the higher anaerobic biodegradable products for appropriate denitrifiers such as acetate in the short anaerobic HRT, which it is the most efficient substrate for denitrification. Khorsandi et al., (2011) revealed that an anaerobic/up flow sludge blanket filtration combined bioreactor USBF with the sludge age of 25 days, HRT of 24 h and optimum chemical oxygen demand/nitrogen/phosphorus (COD/N/P) ratio of 100/5/1 led to total nitrogen removal efficiency of 96.6 %.

The results showed that the highest rate of phosphorus removal occurred during the third step (4 h aerobic and 1.5 h anaerobic). This was in compliance with the standard rate of Iran EPO discharged into the permeable well and surface water. Thereby, the amount of phosphorus in the effluent of the first and secondary stages was 7.7 mg/L, which was more than the standard value of phosphorus (6 mg/L) disposed into the permeable well and surface water. The reason could be due to lower aerobic and anaerobic retention times at these two steps, and also the higher amounts of phosphorus in the second step. To meet the standard rate of Iran EPO effluent, the ratio of COD/P which is the important parameters in the removal of phosphorus is about >40.In this study despite the favorable ratio of COD/P sufficient situation for decomposition of organic matter was not provided due to low anaerobic retention time and at the second stage of process due to the low ratio of COD / P, phosphorus of effluent is not meeting the standard level. At the third step of working both the ratio of the COD / P and time of organic matter degradation was favorable therefore the phosphorus of effluent consistent with standard level. This was as a result of availability high amount of biodegradable organic matter for release phosphorus in anaerobic phase and the volatile fatty acid has been uptake and phosphorus will be released by the presence of adequate PAOs microorganisms in this area (US EPA, 2009).

However, with comparing the mean removal rate of the mentioned parameters at the three retention times, a significant difference was observed ($P<0.05$), which indicate that increasing retention time in aerobic and anaerobic zone is very effective. Dehghani et al., (2009) revealed that a bath reactor for biological removal of phosphorus led to phosphorus removal efficiency of 35.20 % in optimum form and with increasing sludge age up to 5 days, anaerobic 2 h, aerobic 18 h and anoxic 4 h removal efficiency of 60.91% was obtained. Kocadagistan et al., (2005) showed that the combined up flow anaerobic fixed bed bioreactor (UAF-B) and the suspended aerobic activated sludge bioreactor (SAR) removed 96-97.7% of the phosphorus. The results of this study showed that the phosphorus removal rate increased with increased anaerobic time.

4. Conclusions

Overall the results of this study revealed that the investigated down flow anaerobic up flow axis submerged bio-film system has a large capability of pollutant deduction in hospital wastewater such as

COD, BOD_5, TSS and turbidity up to about 81%, 93%, 96 % and 97%, respectively. According to no need returning activated sludge to aeration tank and decreasing the operational problems in this system, operation and maintenance costs decrease rather than the suspended growth systems.

Thereby, constructing a pilot plant of the system for treatment hospital wastewater is required to examine the processes regarding to the investigation of the different variables, including aerobic and anaerobic retention time, in order to achieve the best removal efficiency of the parameters and meet effluent discharge standards to obtain the best range of retention time and loading.

It should be stated that, the activated sludge treatment systems could be improved due to the results of this research in term of providing suitable condition to remove organic and inorganic material simultaneously.

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