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PERFORMANCE ASSESSMENT FOR CONSTRUCTED WETLANDS OF KAYSERI PROVINCE OF TURKEY

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Abstract

Constructed wetlands are commonly used for domestic waste water treatment in rural parts of Turkey. However, routine monitoring and assessments of these systems are not performed. The present research was conducted to assess the treatment performance of two constructed wetlands in Kayseri province of Turkey. Influent and effluent waste water samples were taken at the beginning of each month for 5 months of the year 2016. Samples were taken in accordance with the principles specified in Water Pollution Control Regulation. Wastewater samples were then subjected to biological oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), pH, electrical conductivity (EC), total nitrogen (TN) and total phosphorus (TP) analyses. Effluent BOD5 concentrations varied between 40-420 mg/L; COD concentrations between 63-134 mg/L; pH values between 7.18-8.04; EC values 1571-2870 µS/cm and TSS values between 64-84 mg/L. While pH, EC, TSS and total phosphorus values were meeting the discharge criteria, BOD_5 and COD values were not meeting the relevant discharge criteria. Considering the parameters not able to meet the discharge criteria, it was concluded that these systems should be either repaired or rehabilitated to eliminate the deficiencies experienced in practice.

Keywords: Constructed wetlands, Domestic wastewater, Effluent, Pollution, Water treatment.

1. INTRODUCTION

World population is continuously increasing and reached to almost 8 billion. Parallel to rapid increase in world population and food demands of this increasing population, water demands are also rapidly increasing to produce food to feed this huge population. Despite increasing demands, fresh water resources are continuously depleting worldwide. Basic water-user sectors (agricultural, domestic and industrial) are in ever-aggravating competition for limited water resources. Continuously polluted waters, decreasing fresh water resources because of climate change and resultant global warming, increasing labor and energy costs all brought the water and treatment technologies into the first place in the agendas of the world countries. To solve water-related problems, initially water losses in agricultural, domestic and industrial uses should be prevented, efficient water use should be provided in agricultural practices and possible use of wastewater and treated water should be investigated.

Untreated wastewaters are usually discharged into seas, rivers and other receiving water bodies because of high treatment costs in Turkey. According to the results of Municipal Wastewater Statistics Survey, which was applied to all municipalities, 1 338 out of 1 397 municipalities were served by sewage systems in 2016 in Turkey. Out of 4.5 billion m^3 of wastewater discharged via sewage system, 3.8 billion m^3 was treated in wastewater treatment plants. The rate of advanced

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treatment was 44.5%, while the rate of biological treatment was 31.6%, the rate of physical treatment was 23.6% and the rate of natural treatment was 0.3% (Anonymous, 2016).

2. MATERIALS AND METHODS

Natural treatment systems constructed in Kayseri province of Turkey between the years 2015-2016 were visited onsite (63 of them were visited) and one of them was selected for performance assessment. Most of them were either not operating or already out of order. Therefore, only one of them was able to be selected since they were already operating and available for water sampling from influent and effluent discharge sections. Location of the selected system (Salur village) is presented in Figure 1, the constructed images of them are presented in Figure 2 and design projects are presented in Figure 3.

Influent and effluent water samples were taken at the beginning of each month for 5 months (May, June, July, August and September) in accordance with Water Pollution Control Guidelines issued by Ministry of Environment of Turkey (Anonymous, 2004). Then, water samples were subjected to pH, electrical conductivity (EC), biological oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total kjeldahl nitrogen (TKN) and total phosphorus (TP) analyses.

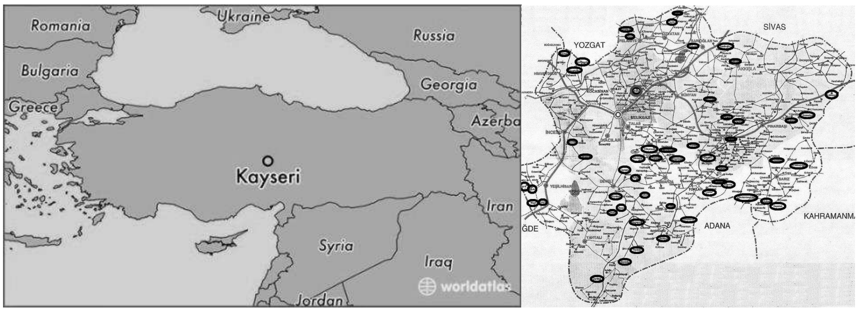

Figure 1. Location of natural treatment systems

Figure 2. Natural treatment system

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Water samples were transported to laboratory immediately and subjected to pH and EC analyses with a pH (Hanna Instruments, pH 211 model) and EC (Hanna 98107 model) meter. BOD analyses were performed with BOD measurement apparatus (WTW- Oxitop). COD analyses were performed with a COD measurement set (WTW CR2200 model thermo reactor). TSS suspended solids were determined with a vacuumed filtration apparatus. Kjeldahl method was used to determine total kjeldahl nitrogen content of water samples. ICP-MS device (model 7700 Agilent Inc., Tokyo, Japan) was used to determine total phosphorus content of water samples.

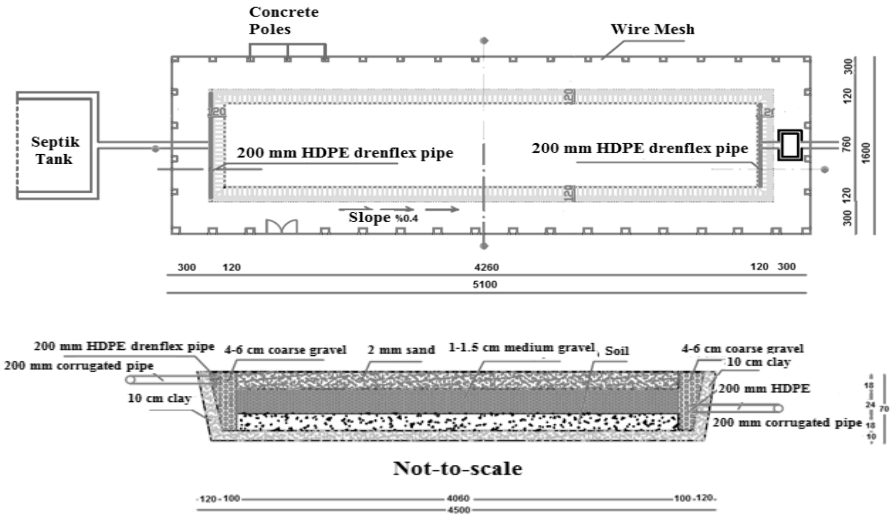

Figure 3. Design project of natural treatment system

3. RESULTS AND DISCUSSIONS

Biological oxygen demand (BOD_5), chemical oxygen demand (COD), pH, electrical conductivity (EC), total suspended solids (TSS), total kjeldahl nitrogen (TKN) and total phosphorus content of influent and effluent water samples are provided in Table 1. Influent BOD values varied between 33-123 mg/L and effluent BOD values varied between 26-110 mg/L. The monthly variations in BOD values are presented in Figure 4a. According to effluent discharge standards set by the Ministry of Environment (Anonymous, 2004), effluent BOD value should be maximum 50 mg/L. The natural treatment systems considered in this study were quite far from meeting the effluent discharge standards.

Influent chemical oxygen demand (COD) values varied between 16-125 mg/L and effluent COD values varied between 5-97 mg/L (Table 1). Monthly variations in COD values are presented in Figure 4b. Influent and effluent COD values exhibited irregular changes. The effluent discharge criterion was set as 100 mg/L in relevant standards (Anonymous, 2004). Thus, system was not able to meet the discharge criteria. COD is not a design parameter, but a pollution parameter. Contrary to BOD values, COD may include some substances not biologically degraded, therefore, COD values of wastewaters usually higher than BOD values of the same samples (Anonymous, 2017b). The primary reason for failure in COD removal performance was again improper design of the systems since the natural treatment systems of the present study were design without taking wastewater influent characteristics into consideration and only the previously prepared pilot projects were used. Demirors (Demirors, 2006) quite low effluent COD values (24 mg/L) and high COD removal efficiencies (71%). Since the natural treatment systems of that study were designed especially for BOD removal, researchers were able to achieve high removal efficiencies for COD. The average

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COD removal efficiency of the present study was calculated as around 20%. However, Kotti et al., (Kotti etal. 2010) reported an average COD removal efficiency of 67.9%.

Table 1. Physico-chemical wastewater characteristics

	Months				
	May	June	July	August	September
			BOD (mg/L)		
Influent	36	33	106	123	110
Effluent	33	26	70	110	86
			COD (mg/L)		
Influent	29	16	71	100	125
Effluent	5	11	36	18	97
			pH		
Influent	8.78	8.77	8.63	7.47	7.50
Effluent	8.78	8.44	8.49	7.42	7.45
			EC (µS/cm)		
Influent	1550	1545	1327	1441	1289
Effluent	1548	1544	1265	1455	1275
			TSS (mg/L)		
Influent	94	70	220	70	190
Effluent	60	50	70	40	60
			TKN (mg/L)		
Influent	37	40	44	111	87
Effluent	32	34	43	100	81
			TP (mg/L)		
Influent	4.606	5.439	8.518	8.469	8.545
Effluent	4.226	3.469	6.575	7.182	8.166

Influent pH values varied between 7.47-8.78 and effluent pH values varied between 7.42-8.78 (Table 1). Monthly variations in influent and effluent pH values are presented in Figure 4c. The pH values also exhibited irregular variations in months. The discharge standard was set as to be between 6-9 for domestic wastewater effluents from natural treatment systems (Anonymous, 2004). So, the effluent pH values of treatment system was meeting the discharge criteria. While influent EC values varied between 1289-1550 µS/cm, effluent EC values varied between 1265-1548 µS/cm. The monthly variations in EC values are presented in Figure 4d. Again the trend was irregular in EC values. The discharge criteria were set as to be between 750-2000 µS/cm in relevant standards (Anonymous, 2004). So, the effluent pH values of treatment system was meeting the discharge criteria. In similar previous studies, effluent pH values were reported as between 6.5-7.9 (Demirors, B., 2006) and 6.5-8.5 (Koottatep et al., 2001). Current effluent pH values weren't well comply with these earlier findings.

Influent total suspended solid (TSS) values varied between 70-220 mg/L and effluent TSS values varied between 40-70 mg/L. The variations in TSS values with months are presented in Figure 4e. The discharge limit value was set as 150 mg/L, so system was meeting the discharge criteriaon 4 months. Since septic tanks were used in front of the inlet sections, TSS values were quite lower than expectations. Septic tanks provided a pre-settlement for suspended solids before they get into to treatment system as influent. Demirors (2006) was not able to achieve TSS removal standards. The average TSS removal performance of the present systems was calculated as 14% and both systems were well meeting the discharge standards set for effluent TSS values of natural treatment systems.

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Therefore, low TSS values were an expected case in these systems with pre-treatment septic tanks (Gokalp et al., 2014).

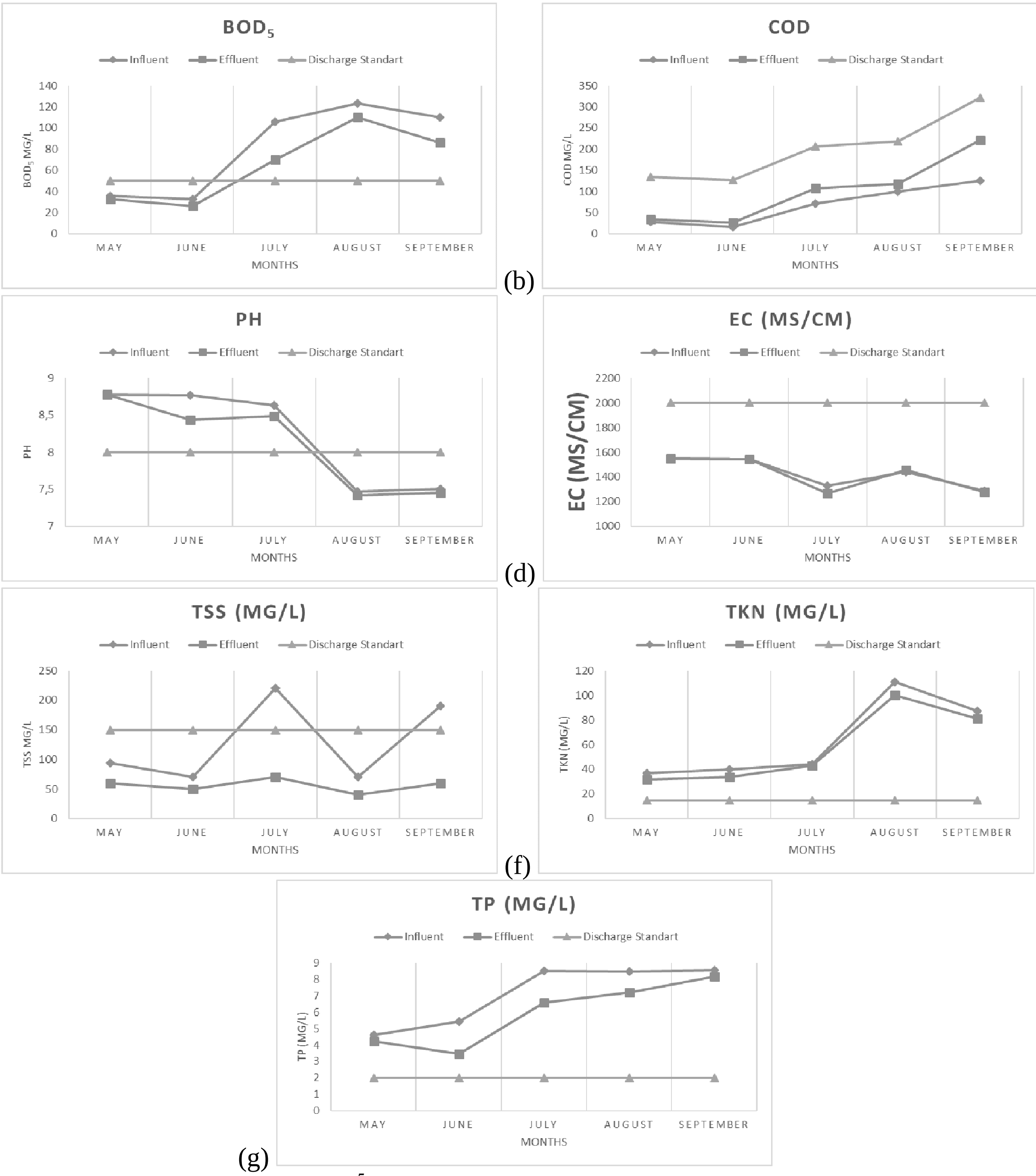

Figure 4. Monthly variations in (a) BOD^5, (b) COD, (c) pH, (d) EC, (e) TSS, (f) TKN and (g) TP values of influent and effluent wastewater samples

Influent total kjeldahl nitrogen (TKN) values varied between 37-111 mg/L and effluent TKN values varied between 32-100 mg/L. Monthly variations in TKN values are presented in Figure 4f. The

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discharge criteria set for effluent TKN is 15 mg/L (Anonymous, 2004). Current effluent TKN values weren’t well comply with these earlier findings. Organic nitrogen is used in photosynthesis process of the plants (Anonymous, 2017a). Nitrogen removal performance of natural treatments systems are greatly influenced by hydraulic loading rates and hydraulic retention times, so each system may have different removal performances (Kadlec and Knight, 1996). The average nitrogen removal performance of the present systems was calculated as about 44%. Influent nitrogen concentrations were quite high in this study because wastewaters of livestock facilities are also entered into the treatment systems. While influent total phosphorus (TP) values varied between 6-11 mg/L, effluent TP values varied between 4-8 mg/L (Table 1). The variations in TP values with months are presented in Figure 4g. Both systems were not able to meet the discharge criteria set for total phosphorus concentration of domestic wastewater effluents (2 mg/L). Detergents in domestic wastewaters may increase influent phosphorus concentrations. The phosphorus removal performance of the present systems was calculated as 22.8%. Since phosphorus removal usually occurred through absorption and plant use, it is quite usual to have low phosphorus removal performance for natural treatment systems (EPA, 1999; Ugurlu et al., 2006; Vlyssides et al., 2004).

4. CONCLUSIONS

Considering the current impacts of climate change and resultant global warming of fresh water resources, re-use of treated wastewaters play a significant role in sustainable and efficient use of water resources. Discharge of untreated wastewaters creates significant threats on both environment and human health. Wastewaters should be treated before to discharge them into receiving bodies or before to re-use them. Natural treatment systems are preferred for domestic wastewater treatment especially in rural sections, in villages of Turkey. These systems were also indicated as the primary issue in Rural Development Strategy Document of State Planning Organization of Turkey. Usually pilot projects are used in construction of natural treatment systems. Influent wastewater characteristics, local climate conditions and relevant discharge standards have not been taken into consideration. Therefore, majority of already constructed ones either not operating or are not able meet effluent discharge criteria. Current performance assessments also revealed that the natural treatment systems of the present study were also far away from meeting the effluent discharge criteria specified in relevant standards. The natural treatment systems should be rehabilitated urgently to get the desired performance outcomes from them. The new ones to be constructed should be designed by taking specific design criteria and local conditions into consideration.

5. ACKNOWLEDGEMENTS

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