Two different purification systems at Istanbul-Tuzla and Adana-Kozan, their characterizations

Abdullah Yinanç

ABSTRACT

In most developed countries, wastewater treatment plants are presently utilizing efficient purification technology meeting the sufficiency requirements of quality and quantity. However, in developing countries, the number of wastewater treatment plants is limited. As a result, the establishment of a connection between the wastewater collection system and wastewater purification plants is increasingly becoming a top priority for researchers. The aim of this article is to analyze wastewater collection and purification systems and establish the links between these two processes. In the present study, the efficiency of the present purification system at the Istanbul-Tuzla and Adana-Kozan plants was investigated with the aim of enhancing their performance. The findings pertaining to the model sewage system revealed a decrease in NH_3-N by 20–70%, total nitrogen (T-N) by 25–75%, biological oxygen demand (BOD_5) by 50–60%, chemical oxygen demand (COD) by 35–55% and suspended solids (SS) by 55–85%. As a result of studies performed in the Tuzla sewage treatment system, we can confirm that T-N decreased by 50–75%, suspended solid particles by 24–57%, and BOD_5 by 34–57%, while 35–55% of COD was removed. Similarly, in the canal exit at Kozan, BOD_5 decreased by 40–55%, COD by 30–50%, SS by 25–45% and T-N by 5–40%.

Key words | canals, efficiency, purification systems, wastewater collection

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ABBREVIATION LIST

BOD_5	Biological oxygen demand
BUR	Benthic oxygen uptake rate
COD	Chemical oxygen demand
CH_4	Methane
CO_2	Carbon dioxide
GHGs	Greenhouse gases
NH_3-N	Ammonia-nitrogen
N_2O	Nitrous oxide
k-NN	k-nearest neighbor
SS	Suspended solids
T	Value
T-N	Total nitrogen
T-P	Total phosphorus
TS	Total solids
TVS	Total volatile solids
TSS	Total suspended solids
Q	Deby

INTRODUCTION

Wastewater is transported to collectors through canals, which can have large diameters and extend over several kilometers before reaching purifier systems. Sewage transfer is an important issue that is addressed differently in each country (Robert 2011). In conventional activated sludge systems, the flow of water can take 4–6 hours to pass through the aeration phase. Over such a long period of time, wastewater undergoes physical, chemical and biological changes that affect the quality and quantity of pollutants (Yinanc 2009). The removal of heavy metal ions from industrial wastewater is particularly important because of their harmful effects on the environment (Hoseinian *et al.* 2015).

In many cases, this requires redesign of the existing treatment systems, taking into account the extent of the aforementioned changes occurring in canals and collectors, as well as activation of treatment technologies in canals. In addition, removal of degradable materials from wastewater increases the efficiency of wastewater treatment plants.

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The long-term goal of this initiative is improvement in the economic parameters characterizing the environment and the operating system. Disposal of untreated industrial wastewater containing chemical nutrients, especially compounds containing nitrogen and phosphorus, can have significant adverse environmental effects that undermine the recycling processes of the entire bio-system (Umamaheswari & Shanthakumar 2016).

In the present study, the design of wastewater treatment facilities was examined along with the construction and operational factors that play an important role in the treatment processes that occur naturally in long canals and collectors of large diameter. Existing wastewater treatment systems are analyzed in order to propose wastewater treatment solutions that can be adopted as a means of increasing the efficiency of existing systems.

Economic indicators of the wastewater treatment facilities are analyzed by examining the effect of adding microorganisms between the operation and collector phase, as well as by measuring quality parameters in the wastewater output by the collector systems in treatment facilities. Depending on the quality of the sewer system, considering the evidence yielded by existing scientific studies on self-treatment of wastewater in sewer systems and collectors performed in several countries, the time required for aggregation, and for a biological curtain to be formed on the inner surface of canals and collectors, can be assessed, along with the effect of ventilation and speed of flow on the treatment effectiveness. Granata *et al.* (2015) discussed the air transport phenomenon and the effects of the absence of ventilation in drop manholes. Based on their findings, the authors modeled the influence of the main hydraulic and geometric parameters on the drop manhole system for sewer systems.

In the work presented here, water volume, type of suspended solids (SS) particles, changes in the levels of protein and carbohydrate concentrations in aerobic and anaerobic sections, as well as the rate of deviation in nitrogen and sulfate combination were determined. Moreover, the biological curtain through the sewer system was observed and results were analyzed.

METHODS

The laboratory model consists of 20 m PVC pipes of 100 mm diameter and pumps with a fixed wastewater pumping capacity (0–25 L/s). In addition, in order to observe the feeding and sample tanks, and control the amount of water circulating in the system, water meters are used.

The collector slope is designed with 0.015 gradient, thus ensuring that the system is fed with residential wastewater at a high flow rate, while preventing industrial wastewater from entering the system. The data for analyses were collected throughout the summer (24 h/day). During the data collection performed on hot summer days, air was introduced into the water circulating in the system. The water flow rate in the system was maintained at 0.7 m/s, while the collector fill rate was set at 50% (Akça 2003).

The canal system structure was fed with wastewater and the quality parameters at entry and discharge were recorded in order to establish the polluting substance levels. In the structured model of the system, part of the water discharged from the reactor is fed back into the system, as this allows examination of the difference in SS substances, flow rate and fill rate. The effect of the canal slope on the flow rate and fill rate, as well as feeding volume regulation and changes in flow times, served as model parameters. The resulting model may be used in future research and practical wastewater treatment projects.

RESULTS AND DISCUSSION

Irregular formation of solid suspended particles and volatile substances within canals were identified. Empirical evidence shows that these formations have a negative effect on the aerobic productivity rate. Moreover, the productivity level of newly formed biological curtains is governed by the concentration of degradable substances.

Old biological curtains contain aerobic active degradable substances. In the system studied as a part of this investigation, the influence of bacterial treatment substances (metagenics, as well as sulfate clearance and treatment) is observed. Through the biological curtain, hydrolysis can occur continuously in wastewater, as the biological curtain can release the easily degradable substrate into the wastewater. Escobar-Jimenez *et al.* (2012) presented the most notable effluent characteristics, including high turbidity and tartrazine, which are deemed responsible for the occurrence of several green water curtains. They also noted the presence of salts and chemical organic matter values considered high for the reuse of water.

The speed of the denitrification process depends on the level of oxygen and the nitrate concentration in wastewater. Thus, in this work, the biological curtain characteristics, volume and effectiveness, as well as formation on the circular section and through the canal length, are analyzed and the findings are shown in Figure 1.

Biological curtain is also sensitive to small changes in the hydrodynamic parameters characterizing the wastewater flow. Fraction of volatile substances in the biological volume and oxygen's effective depth of influence on an unworn biological curtain are also shown in Figure 2. As can be seen, oxygen's effective depth of influence on an unworn biological curtain is much smaller than the overall curtain depth. This fraction of volatile substances has anaerobic biomass. Three parameters are deemed to play the main role in the formation of a circular biological curtain (Hruschka 1980). Firstly, maximum speed in the centre of the flow and minimum speed on the water surface result in a minimum cutting power affecting biological curtain formation on the inner canal walls. Secondly, solid substances and activated sludge present in wastewater have an ability to penetrate biological curtains. Thirdly, since the fat in wastewater rises to the surface, it is deposited on the inner walls of the system.

The thickness of the biological curtain on the sewer system walls can reach 1 mm, which exceeds the depth of effectiveness of oxygen carried by the anaerobic biomass. Moreover, as some parts of substances travel through the system, they can cause thinning of the biological curtain on the system walls. The extensive measurements related to BOD_5 changes in our studied system indicate that 0.7 g of biological oxygen demand (BOD_5) can be removed for each gram of O_2. According to Kuhn (1978), in summer months, when temperatures reach 20–24 °C, 1.4 g of

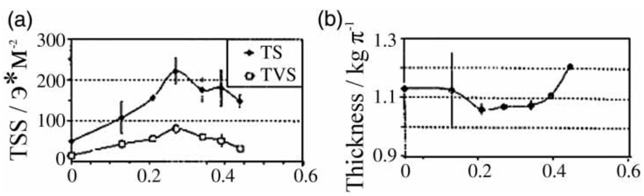

Figure 1 | The formation of the circular biological curtain within the canal, (a) Total solid (TS) and total volatile solid (TVS), (b) The thickness of the biological curtain

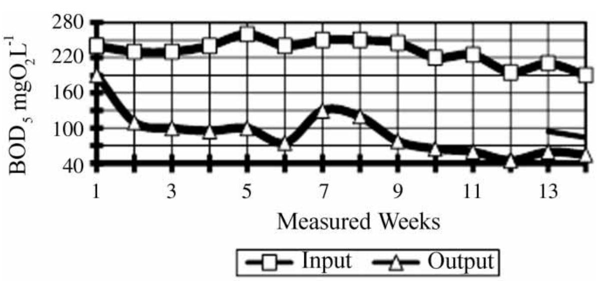

Figure 2 | The change in BOD_5 in wastewater within the canal under investigation.

BOD_5 can be removed for each gram of O_2. In this study, two sections were thoroughly investigated, whereby the data were analyzed in the laboratory in Istanbul-Tuzla and in Adana-Kozan, respectively. This system was used to increase the efficiency of the plant. In this study, the Istanbul-Tuzla and Adana-Kozan plants were comparatively investigated for their efficiency. Physicochemical parameters such as chemical oxygen demand (COD), NH-N, total nitrogen (T-N), SS and BOD_5 were correlated in detail with efficiency, which changed from 35% to 70% in the system. In Turkey, wastewater treatment discharge standards change as the following parameters: pH: 6–9, BOD_5: 45 mg/L, COD: 100 mg/L, SS: 60 mg/L, total phosphorus (T-P): 3 mg/L, T-N: 20 mg/L. These standards are only obtained by the addition of a treatment process in front of a classical active sludge system at the canal. In a classical active sludge system, it is impossible to obtain the standard values in the Tuzla plant, because, there is industrial wastewater entering into the system.

Studies performed in Istanbul-Tuzla

The wastewater pumped into the system is called 'entering water,' while wastewater that has passed through the system is referred to as a 'discharge water' sample. Discharge water analyses were performed in Istanbul Water Sewerage Administration laboratories using standard methods. Measured parameters and analysis procedures are summarized in Table 1.

Some countries in the Middle East are already 100% dependent on desalinated water for their fresh water sources (Ghaffour *et al.* 2013; Aryapratama *et al.* 2016). Water pollution poses a particularly significant problem in developing countries such as China. According to Zhang *et al.* (2016), who assessed the current status of urban wastewater treatment plants in China in 2012, the total national wastewater discharge in China was 68.5 billion tons, which represented a 3.7% increase relative to the previous year. The authors further note that, in 2013, 23.5 and 2.5 million tons of COD and ammonia-nitrogen (NH_3-N), respectively, were discharged.

The rate of oxygen input into the wastewater line was maintained at 2 mg/L. In the 14 weeks of the study (June-September), the system was modeled under laboratory conditions and the results are presented in Table 2. The aim was to establish the BOD_5 difference in the canal, as depicted in Figure 2. In their recent work, Mischopoulou *et al.* (2016) studied ozonation and sonication processes, which were applied to baker's yeast wastewater with high molasses

Table 1 | Measured parameters and methods of analysis

Name of the analysis	Measured method	Used device
Ability of electrical conductivity	SM-2510 B Laboratory device	
pH	SM-4500-H B Electrometric	Metroohm 632
Temperature	SM-4500-O G Membrane electrode	Metroohm 632
Dissolved oxygen	SM-4500-O G Membrane electrode	OHI-196 632
AM	SM-2540 D Gravimetry	Oven, Sensitive balance
BOD_5	SM-5210 B 5 per day	
COD	SM-5220 B Open reflux	Spectrophotometry
TOK	JİS-K-0102 AMA method at high temperature	Shimadzu, APHA TOC-500
T-P	SM-4500 P D Stannus chloride	Dioneh 4000İ ion chromatography
PO_4-P	SM-4500 P D Stannus chloride	
TKN NH_4-N	SM-4500HH$_3$ B.C Distillation + flicker and Nessler ASTM standards, D 1426–93,1993	Kjeldahl device, Gerhardt Vapodest 3S, Distillation aparat
NO_3-N	Dr.LANGE-CAD AS200 analysis method	Dioneh 4000İ ion chromatography

Table 2 | The results yielded by analyzing parameters (COD, NH_3-N, T-N, SS, BOD_5, and pH), obtained in the laboratory

	COD		NH_3-N		T-N		SS		BOD_5		pH	
Date/week	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output
1	380	160	22.0	19.0	22.0	20.0	325	65	240	190	6.80	7.80
2	365	151	21.0	15.0	19.0	17.0	330	150	230	110	6.80	7.80
3	372	145	22.0	9.0	19.0	11.0	300	90	230	100	6.80	7.60
4	396	133	23.0	4.0	18.0	9.5	330	90	240	95	6.88	7.50
5	440	135	21.0	1.5	16.0	5.0	315	130	260	100	6.85	7.70
6	355	128	21.0	1.0	17.5	5.0	325	95	240	75	6.80	7.95
7	370	120	21.0	1.5	21.0	4.5	300	65	250	130	6.80	6.25
8	382	200	22.0	3.0	17.0	3.0	350	143	250	120	6.80	7.00
9	396	279	20.0	9.5	16.0	13.0	340	95	245	78	7.50	7.00
10	345	170	22.0	7.0	14.0	7.0	295	45	220	65	7.50	8.00
11	326	160	17.8	3.0	18.0	3.5	320	36	225	60	8.50	6.70
12	404	155	19.5	2.0	19.0	2.5	355	90	195	45	6.29	7.80
13	444	170	21.0	1.5	18.0	5.0	325	69	210	60	6.39	7.00
14	298	165	22.0	1.0	15.5	3.0	270	39	190	55	6.20	7.10

content, under various operational conditions. The main objective was to understand their effect on COD removal and methane enhancement. The authors reported a significant reduction in the COD content, as a reaction time of 5 h resulted in COD removal of up to 38%.

While the BOD_5 level varied from 190 to 260 mg O_2/L at the entry, 45–190 mg O_2/L was measured at the canal exit. However, in the first week of study, when the temperatures were highest, the level declined below 100 mg O_2/L. In the first 8 weeks, the pH values of the input are less than 7 (acidic medium) but in output, it is pH > 7 (basic medium). In addition, between 9 and 11 weeks, due to the different amount of water entrance of the system in input, pH > 7, but in output it is pH < 7. The acidity or basicity of solution changes directly affect the other parameters (COD, BOD_5, T-N, NH-N, and SS). Especially, after the eighth week, the pH value in the output is higher than output values, which increases the efficiency of the system.

At the canal entry, while the nitrogen level was stable (19.5–22 mg/L), its concentration at discharge varied significantly (1–19 mg/L). In the first 2 weeks of the study, the maximum level of nitrogen in the treated water initially declined. On the other hand, the NH_3-N level in discharge water reduced in the last 4 weeks, reaching the minimum in weeks 5–7 (1–1.5 mg/L). Starting from week 7, the nitrogen level increased again and reached its peak in week 9. Between weeks 9 and 14, a decrease in the nitrogen level was observed (Figure 3).

Changes in the number of suspended particles in wastewater during the flow were also investigated. During the study, the quantity of SS particles in the water that was added to the canal ranged from 270 to 350 mg/L. However, while the quantity of SS particles in the added water was relatively stable, the changes registered at discharge were more significant (Figure 4). During the three summer months, when the temperature was high in general, it was not possible to reduce the number of SS particles at discharge below 90 mg/L.

In existing studies in this field, the k-nearest neighbor (k-NN) method is typically used to predict the influent flow

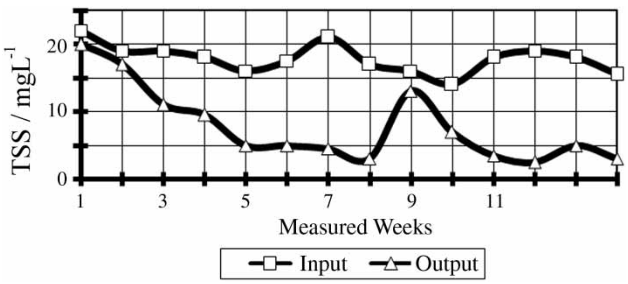

Figure 3 | Changes in the total suspended solids (TSS) in wastewater in the canal under study.

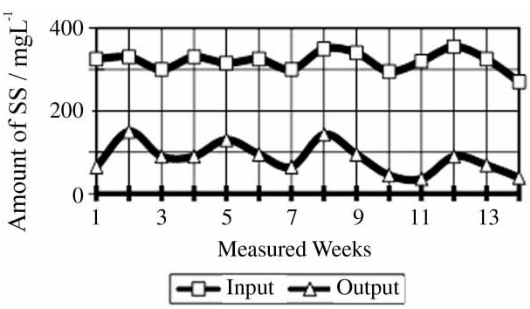

Figure 4 | Changes in the amount of SS substances in wastewater.

rate and four water qualities, namely COD, SS, T-N and T-P at a wastewater treatment plant (Kim *et al.* 2016). Oxygen supply has a positive effect on the homogeneity of volatile substances treatment and the biological curtain thickness. In the present study, when this approach was adopted, at the discharge from the canal, the ammonia levels decreased to 20–70%, T-N concentration to 25–75%, SS to 50–78%, COD to 50–60% and BOD_5 to 50–60%. The results of the laboratory studies confirmed that such systems are essential parts of treatment facilities, and further system development can help increase the overall productivity of facilities.

Studies aimed at observing self-treatment processes in canals were conducted in an active Istanbul-Tuzla line. The collector that served as the study site is of 1,200 mm diameter and 14 km length. Thus, the wastewater remains in the collector for about 7–8 hours. The process adopted by the treatment facility relies on the formation of a biological curtain in contact with wastewater flowing through the canal, along with the use of feeding substances entering the canal system, known as collector type reactor, by biological curtain.

Biological curtain collects and uses the volatile substances found in wastewater. The present study was performed in two cities characterized by different temperatures. The investigation was conducted in three stages: (1) transporting feeding materials from wastewater to existing biological curtain; (2) molecular diffusion of nutritional substances in biological curtain; (3) assessing metabolic reactions in biological curtain.

The study findings revealed that the level of suspended particles in wastewater decreased to 24–57% (SS), 35–55% (COD), 34–57% (BOD_5), and 50–75% (T-N), while no unpleasant odor was noted in the surrounding environment. The number of bacteria added to the canal during the study period was 100–300 mg/L mixed liquor suspended solids (MLSS). Hickey (1988) measured *in situ* benthic oxygen uptake rates (BUR) for sewage fungus biofilms in river using a chamber. El-Fadel & Massoud (2001) noted that the anthropogenic emissions of greenhouse gases (GHGs) have led to an increase in the concentrations of these gases in the atmosphere over the past 100 years. The GHGs, such as methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O), are emitted from wastewater treatment processes (Kampschreur *et al.* 2009; Duan *et al.* 2015).

Studies performed in Adana-Kozan

The study performed at the Adana-Kozan sewage line revealed that the wastewater remains in the line for

4 hours in order to achieve the required treatment effects. The surface of the bacterial layer in the canal reached 8.000–10.000 m^2. In this part of the investigation, useful SS bacteria were used. This was the first attempt to utilize SS bacteria in wastewater treatment in canal systems in Turkey.

In this study, wastewater treatment facility facultative pools with a surface area of 100.000 m^2 were used. As an addition to the existing canal system, duckweed was added to the first and second facultative stabilization pools. Aerobic and anaerobic treatment systems were positioned at the entry into the pools before bacteria were added. The system in Kozan is aerobic and a minimum temperature in the canals of ~30 °C was recorded for a period of 6–7 months. Therefore, the requirement of reaching the average temperature of 20 °C for an entire calendar year was fulfilled.

Research findings confirmed that the dissolved oxygen level in wastewater exceeded 2 mg/L in April–June, as a result of the bacteria (active microorganisms) application to the collector line. The solution was prepared in the 1/10,000–1/15,000 ratio, and was added at the 10 m^3/week rate to the canal entry.

In addition, aerobic decomposition was observed only when the level of dissolved oxygen in water was adequate, otherwise anaerobic decomposition prevailed. In order to prevent the unpleasant odors from developing in the canals, active organisms were used with good results. A biological curtain formed at the inner canal surface and activated sludge added to the wastewater played an important role in the process. For degradable substance decomposition, heterotrophic microorganisms are of great importance. Breaks on the surface of the biological curtain forming on the inner wall of the canal can stop the transportation of oxygen from wastewater to the curtain.

The processes taking place in the canal are generally a combination of biological and physical processes. Thus, they are studied alongside the decomposition of degradable substances, function of bacteria, oxygen supply from the air, and oxygen requirements of activated sludge. During the 16-week study period, dissolved oxygen, COD, BOD_5, SS and T-N levels were measured. At the canal exit, wastewater activity, reactions and differences were also studied and the results are presented in Table 4 (Yuceyurt & Yinanc 2005).

As can be seen from the reported findings, adding active microorganisms to the wastewater yielded positive results. In this work, when active microorganisms were used, the ventilation rate decreased (an oxygen gain was noted) and the process productivity level increased. Since the decomposition level of degradable substances increases, the amount of oxygen needed for the oxidization of all degradable substances decreases. In order to avoid the negative effect of changing the microorganism composition in canals and stabilization pools, dissolution of 1–2 mg/L of oxygen in a biological reactor is deemed sufficient. Active microorganisms play an instrumental role in the performance of activated sludge and the removal of organic substances. Our findings indicate that they cause a 25–50% increase in the settling velocity in anaerobic and facultative pools, as well as a 10–20% decrease in the amount of sludge formed. Since assessing the air quality with respect to the amount of H_2S and ammonia released is important, this issue was especially taken in consideration in the data analyses. According to our findings, the amount of released hydrogen-sulfate and ammonia from the collector and treatment facility decreased by 80–90%, thus resulting in no unpleasant odors. In the sewage line, decreases in BOD_5 by 40–55%, COD by 30–50%, SS by 25–45% and T-N by 5–40% were noted. After passing through the stabilization pools, the system productivity increased to 90%. Finally, for systems in which only pre-treatment is performed, this added work increases the wastewater treatment effectiveness to 70%. The biodegradability of the water samples (BOD_5/COD) are obtained in Tables 2–4. COD is higher than that of BOD_5; maximum of up to 4 times in medium

Table 3 | The transported extra pollution burden at Tuzla sublimation plant

	COD, kg/day			BOD_5, kg/day			SS, kg/day			T–N, kg/day		
Months	**First**	**Last**	**Waste, %**	**First**	**Last**	**Waste, %**	**First**	**Last**	**Waste, %**	**First**	**Last**	**Waste, %**
I	17,223	9,125	47.0	8,050	5,340	33.7	14,860	6,795	54.3	1,676	815	51.4
IV	14,730	9,345	36.5	7,550	3,500	53.6	8,707	6,650	23.6	8,160	2,261	72.3
VI	21,675	9,800	54.8	10,325	4,690	54.6	14,050	6,020	57.2	3,213	805	74.9
VII	18,850	10,675	43.4	9,145	5,005	45.3	12,740	6,825	46.4	3,064	1,540	49.7
VIII	20,650	9,240	55.3	10,340	4,410	57.4	11,468	5,775	49.6	2,929	1,085	63

Table 4 | The quality performances of Turkish standards at different points in Kozan plant

		Earned O_2, mg/L		Parameters, mg/L								
				COD		BOD_5		SS		T-N		
Weeks	T, °C	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output	pH Output
1	16.7	3.1	2.2	360	260	225	148	230	175	22	21	7.11
2	16.2	3.0	2.3	384	250	240	145	265	171	21	19	7.13
3	17.4	3.5	2.1	392	250	245	140	290	160	22	19	7.10
4	17.6	3.4	1.95	380	230	234	135	265	155	20	17	7.30
5	18.8	3.0	2.05	420	240	258	130	290	160	18	16	6.95
6	20.1	2.6	1.85	380	230	240	132	245	148	20	14	7.30
7	20.6	2.7	1.9	350	210	220	130	245	152	17	13	7.20
8	20.9	2.7	1.7	325	190	210	120	230	150	20	14	7.05
9	23.2	2.9	1.6	360	195	230	128	255	143	19	13	7.20
10	22.6	2.8	1.6	455	210	266	123	290	175	21	14	7.40
11	23.4	2.9	1.5	420	215	255	122	250	170	21	13	7.20
12	22.9	2.8	1.8	390	210	240	125	275	165	22	13	7.15
13	24.3	2.7	0.6	440	160	245	45	290	120	23	11	6.90
14	24.6	2.8	0.45	430	145	235	40	275	120	24	11	6.50
15	25.1	2.6	0.4	445	140	255	38	285	110	23	9	6.88
16	25.1	2.7	0.35	450	142	245	35	280	110	22	9	6.90

scale industries; but it varies based on the industrial process and nature of the raw materials used. Some literature sources give such information: when the ratio of BOD_5/COD is greater than 0.5 it is easily biodegradable; 0.2–0.4 is slowly biodegradable and <0.2 is not biodegradable. COD/BOD_5 >2 is not easily biodegradable. Table 2 shows COD/BOD_5 <2, which is easily biodegradable. In Table 3, COD/BOD_5 is higher than 2, so it is not easily biodegradable. In Table 4, the COD/BOD_5 ratio is less than 2 so it is easily biodegradable.

CONCLUSIONS

The present study investigated a self-treatment process in the operation of wastewater transport canals of large diameter and length, in order to obtain technical information that can be used for improving system efficiency. This is the first applied study performed in Turkey in which the wastewater treatment system, and specifically the processes occurring in the canals, was investigated. The aerobic effectiveness of the biological curtain formed inside the canal as a result of SS particles and volatile substances, and its effect on the productivity and aerobic productivity of this biological curtain, were analyzed. The findings indicate that the productivity depends on the pollutant levels in the wastewater. A hydrolysis process also occurs within the wastewater, outside the biological curtain. The biological curtain can easily transfer the substrate to wastewater. Moreover, the biological outer layer can accept the substrate, which is easily removed from wastewater. The denitrification process is not affected by the oxygen and nitrate concentration in wastewater. In order to prevent the change in microorganism composition in canals and stabilization pools, and thus avoid the negative effects of such changes, there should be 1–2 mg/L of dissolved oxygen in the canal water.

The Adana-Kozan canal treatment method is suitable for collector lines built outside residential areas, where the line diameter does not exceed 1,000 mm and the wastewater flow time is within the 5–6 hour range. Applying such natural and efficient methods can increase the productivity of wastewater treatment systems by 90%. The amount of the activated sludge added to the entry of the channel should be 100–300 mg/L. At this dosage, water can be treated with 60–80% effectiveness. After treatment in the canals, when natural plants are used in systems, a further four-fold increase in treatment productivity can be achieved.

The proposed method for wastewater treatment was examined with technical and economical criteria in Turkey. Natural treatment methods were compared to the classical treatment systems via energy consumption, rehabilitation and planned with additions. These comparisons were given with the example of Kozan by the following formulas.

General value of project (\$):	$T = 2565.9Q^{0.6702}$
Operating cost (\$/city):	$T = 62.455Q^{0.5482}$
Treated water cost value (\$/m^3):	$T = 0.56Q^{-0.3767}$
Necessary area cost (\$/m^2):	$T = 1276.8Q^{0.6743}$

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