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Investigating the effect of canal treatment on the wastewater refining facilities

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ABSTRACT

In this study, all wastewater transport and treatment systems in Istanbul are discussed in detail. "Collector Collecting (Storage) Capacity" of the large wastewater canalization systems was investigated by considering the length and diameter of the collectors. The active capacity of the large-scale collectors that feed the whole refining facility was defined. The facilities and the feeding lines whose active capacity rates are more than 45% (active capacity/project capacity rate) are evaluated. Standby duration usage capacity of collectors for time-based situations when the standby exceeds 70% was subjected to the correlation. The collector lines and regions whose standby duration is over 5 h were determined. The gradient, gas generating status and current land status of the collectors that feed the facility were determined by considering the residential areas, and the "Biological Wastewater Treatment Facilities" on the collector lines and the collectors with appropriate ventilation systems (chimney, etc.) were taken into evaluation. In particular, one of the branches of Tuzla collector was used in our research and practice. The process of the impacts of the current flow conditions of the canal line on Tuzla wastewater treatment facility was examined. The results of the canal treatment on the wastewater in Istanbul were discussed in more detail.

Keywords: Wastewater treatment; Pumping; Water aqueduct; Tuzla

1. Introduction

It has been predicted that in this century, a third of the population in developing countries will be living in regions that will experience severe water scarcity [1]. Istanbul is a big but convenient city for the wastewater to be picked up and removed from the city. However, rapid population growth and unplanned construction in the area has not left enough areas for the treatment facilities [2]. During the collection of wastewater, it is important to prevent contamination of drinking water collected from the basin. This is why the treatment technologies applied to the basin must be advanced. Wastewaters besides the drinking water basin is discharged into Black Sea, Marmara, or into the Bosphorus after the treatment according to DAMOC Master Plan prepared by the Consortium in 1966–1972 years. The water supply and sewerage project for Istanbul is convenient for the wastewater to be discharged into the sea after passing through the pre-treatment [3]. According to the Master Plan prepared by Istanbul Master Plan Consortium in 1992–1999, the wastewater passing into the Marmara Sea and drinking water basins must be discharged after an advanced biological treatment is applied, and wastewater that is discharged into the Black Sea and Bosphorus is considered to pass from treatment of the first phase of the pre-treatment and an advanced biological treatment [4]. Treatment Plant and Marine Outfall, built in accordance with the Master Plan DAMOC, has begun to be transformed into biological treatment systems since 1995, and Istanbul is still the focus of large wastewater and infrastructure investments [5,6]. For this reason, the field where treatment facilities will be set up costs much. This aims to use of the existing space more efficiently and aims to support active treatment facilities with appropriate structures and practices. Therefore, it requires almost importance to investigate and implement new technologies.

In many of the industrial facilities in Istanbul, biological and chemical treatment facilities are available. If appropriate conditions are provided in the collector lines, active sludge and biological films that are released from water treatment system will be an alternative treatment [7]. Through this work, it is determined that the treatment process in the canal is a partial treatment system with specific bacteria substituted or unsubstituted, and that it can be classified as a supplementary treatment method for the current biological treatment facilities.

2. Materials and methods

2.1. Analysis of collector lines transmitting wastewater to wastewater treatment facilities

In Turkey, 600 million m^3 of wastewater in a year is treated by municipalities and 500,000 tons of dry matter originates from sludge [8]. Istanbul's wastewater is taken as basin based. Each basin's canalization network, pumping stations and carrying collector lines are completely independent from each other [2]. Currently, in Istanbul only five of the basins have a biological treatment plant. In other basins, mechanical (pre-treatment) facilities with the capacity to eliminate only 2%–5% of pollution are available. Large-capacity wastewater treatment plants in Istanbul are given in Table 1.

A total of nine wastewater treatment plants were investigated in Istanbul. The actual total refining capacity of nine plants is 1.9276 million m^3/d. In this study, the data of the parameters sent to the receiving environment of the plants between the years 2005–2006 and the total amounts of pollutants is given in Table 2 [2]. When the table is analyzed, it can be seen that supplementation of new parts to the plants that exist in Istanbul or improvements are necessary. Arslan-Alaton et al. [9] have stated Istanbul Water Canalization Management (ISKI) has started to initiate not only secondary but also advanced biological treatment units to the already existing plants for 20 years. ISKI has to supply high quality drinking water to the inhabitants of the city and is responsible for the treatment of the urban wastewater. The collector wait time and the related pollutant parameters (suspended solids [SS], biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and discharge embodiment's pollutants) are examined in Tables 1 and 2. There is no linear relationship with Pearson correlation matrix (Tables 1 and 2).

Table 1
Utilization analysis of treatment plants and collectors

Facility name	The date of entry services	Project capacity (m^3/d)	Actual capacity (m^3/d)	Use status (%)	Transmiting collector's			
					Diameter (cm)	Length (m)	Gathering volume (m^3)	The collector wait time (h)
Tuzla (BT)	1998	150,000	260,000	173	100–450	60,244	238,000	22
Pasakoy (BT)	2000	125,000	58,200	47	70–220	29,457	30,000	12
Kucuksu (PT)	2004	640,000	131,000	21	70–220	12,270	12,270	2.3
Kadikoy (PT)	2003	622,000	364,000	44	70–400	69,456	143,000	9.5
Baltalimani (PT)	1997	625,000	421,000	67	100–360	50,884	243,000	14
Yenikapi (PT)	1988	864,000	515,000	60	120–280	56,696	124,400	6
K. Cekmece (PT)	2003	130,000	116,000	89	100–200	9,527	22,000	4.5
B. Cekmece (PT)	1988	155,120	34,500	22	50–120	24,580	15,000	10.6
Uskudar (PT)	1992	77,760	27,900	36	100–150	3,639	4,460	3.8

Note: BT – biological treatment plant and PT – pre(mechanical) treatment plant.

Table 2
In the current business terms, the amount of pollutants

Facility name	Actual capacity (m^3/d)	Year	SS (tons/year)	BOD_5 (tons/year)	COD (tons/year)	Total (tons/year)	Discharge embodiments pollutants (tons/year)
Tuzla	260,000	2005	59,597	33,025	63,773	156,395	36,000
Pasakoy	58,200	2005	6,755	4,249	10,112	21,116	2,000
Kucuksu	131,000	2005	13,245	9,228	17,405	39,878	39,250
Kadikoy	364,000	2005	31,887	27,502	65,600	124,989	119,200
Baltalimani	421,000	2005	30,733	29,811	33,960	94,504	91,500
Yenikapi	515,000	2005	69,363	34,775	84,401	188,539	165,000
K. Cekmece	116,000	2005	9,442	9,273	20,958	39,673	36,670
B. Cekmece	34,500	2005	2,456	1,914	4,785	9,155	8,800
Uskudar	27,896	2005	2,851	3,554	5,977	12,382	11,200
Other facilities	15,600 (for 4 plants)		2,680	1,700	3,300	7,680	6,300
			227,909	155,031	310,271	693,211	507,920

2.2. Pollution assessment and systematic study of existing facility

While assessing pollution and creating a system for the study, evaluations were made entirely to enable practice. Instead of theory, results based on practice were concluded. The calculated results were discussed in the framework of pilot and lab work was put into practice. Assessments are as follows:

- 17%–18% of the existing wastewater treatment plants in Istanbul are biological treatment plants and they have an average removal efficiency of 75%–85%, and an average efficiency factor of 0.7–0.85.
- Pre-treatment plants consists of a sand keeping system where particles with a high diameter or density are kept via a coarse and a fine screen. The pollution prevention rate of this type of system is 2%–3%. After treatment of wastewater at the plants, cleaned wastewater is transmitted to "Marmara, the Bosphorus and the Black Sea". The rate is 80%–85% on average for Istanbul at the time and this shows that a very high amount of wastewater is discharged into the sea without enough treatment (Table 2).
- Most of the facilities do not have enough places available for biological treatment. Because of this, implementation of "Treatment Canals" is important.
- The amount of pollution from industrial plants is continuously increasing. Total pollution load may be reduced from 80%–85% to 35%–60% range through control and supervision of the facilities.

2.3. Analysis of collector system

Parameters analyzed at nine wastewater treatment plants that were inspected are taken as the basic criterion. These are as follows:

- In the study, the lines with a canal whose diameter is 700 mm or more were taken into evaluation.
- The main collector channels in the basin feeding of the treatment plant were evaluated.
- Collector length and diameter of the movement system "Collector Depositing Volume" was calculated.
- Facilities with a ratio of actual capacity/project capacity more than 0.45, namely whose actual capacity is higher than 45% and the lines that feed them were taken into evaluation.
- For the situations when the standby time at the collector is higher than 70%, they were correlated, and collected areas with 5 h or more were determined.
- Collector lines on "Biological Wastewater Treatment Plant" and those with appropriate ventilation system of collectors (chimney, etc.) were taken into the evaluation.
- The collectors supplying the system were evaluated by considering the conditions of gradient, gas production, and whether it is the current site of the facility, and all these evaluations are presented in Table 3.

Wastewater treatment in Turkey should be equated to EU standards. Therefore, in addition to the lower cost, systems that can fulfil future expectations and that are permanent should be built.

As a result of the preliminary investigation of the facilities:

- Tuzla, Pasakoy, Kadikoy, Baltalimani and Yenikapi are determined to be eligible for collector lines of treatment at the channel.
- The utilization of these five wastewater collectors for the treatment of wastewater at the channel was determined.
- As a result of the study and practice, implementation of primary sedimentation pools to the pre-treatment plants and their effect on total treatment were examined in detail.

There are two different processes used in the wastewater treatment, such as aerobic treatment, anaerobic treatment and membrane systems [10]. Treatment of domestic wastewater by various processes has worked in different scientists [11–13]. In addition, domestic wastewater treatment was studied coupled with conventional or individual aerobic–anaerobic membrane bioreactors or direct membrane filtration [14–16].

2.4. Studies conducting in the channels of the area of study

The total flow of the collector lines in the related area is around 25,000–35,000 m^3. Three separate arms feeding the system in the operation area and these arms' total pollution impacts on Tuzla treatment plant were examined. The decomposition formed at channel because of reactions and removal of materials are given in Table 4. COD, BOD_5, the amount of change in these basic parameters, such as SS are given via Table 4 and Figs. 1–3, and also the results were analyzed.

Table 3
Analysis of collectors and treatment basins appropriate for refining at channel

Plant name	Capacity utilization factor (CUF) (actual/project)	Standby time in the collector (h)	Treatment plant status on collector line	Considered operating system of the collector
		Existent		
Tuzla	1.73	22	Biological plant available	Anaerobic
Pasakoy	0.47	12	Facility not available	Aerobic
Kadikoy	0.44	9.5	Partly facilities available	Anaerobic
Baltalimani	0.67	14	Biological plant available	Aerobic
Yenikapi	0.60	6	Partly facilities available	Aerobic

Table 4
Pollution load values (2005–2006) log in Tuzla biological treatment plant arising from leather line

Parameter	Study points	April	June	July	August
COD (mg/L)	Head of leather line	14,730	21,675	18,850	20,650
	End of leather line	9,345	9,800	10,657	9,240
	Troubleshoot in the channel	37%	55%	56%	45%
BOD_5 (mg/L)	Head of leather line	7,550	10,325	9,145	10,340
	End of leather line	3,500	4,690	5,005	4,410
	Troubleshoot in the channel	46%	45%	55%	44%
SS (mg/L)	Head of leather line	6,202	14,050	12,740	11,468
	End of leather line	2,261	6,020	6,825	5,775
	Troubleshoot in the channel	37%	43%	54%	51%
Temperature (°C)	Average	17.2	19.88	23.54	24.16

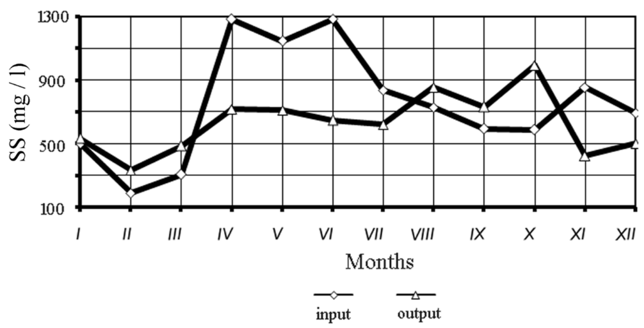

Fig. 1. Suspended solids (SS) concentration graph of the annual change.

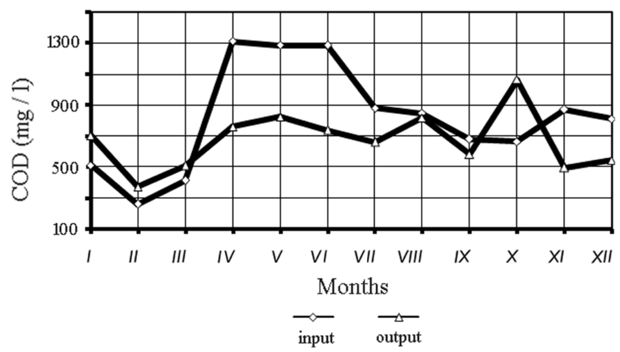

Fig. 2. Chemical oxygen demand (COD) concentration of the annual change.

In some regions output SS concentrations are higher than input SS concentrations due to the rain flowing on the months of February and March (Fig. 1). The reason for the higher amounts of COD and SS concentration on February and March is the solid substances that come from rain flow and discharging of compositing water (Fig. 2).

3. Results and discussion

Of all the 13 wastewater treatment plants in Istanbul only 5 of them are suitable for treatment in the channel. Of these, we had measurements in leathermakers line feeding the wastewater treatment plant in Tuzla, in the months when the temperature is around 20°C in the head and end of the line. The amount of wastewater in the system is around 25,000 m^3 in the summer. It is 10% of the wastewater flowing to Tuzla treatment plant in total. The treatment plant (as of the date of the research) has been working with more than 173% of the available capacity. The duration time of wastewater in the channel exceeds 22 h. The system works as anaerobic and pressurized. Dissolved oxygen concentration in the channel is less than 0.2 mg/L. BOD_5, COD and SS in the 14 km long canal system, an improvement of 37%–55% was observed between output and input.

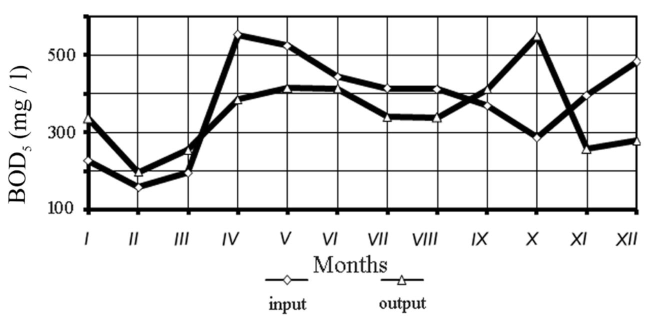

Fig. 3. Biological oxygen demand (BOD_5) concentration of the annual change.

As a result of this study:

- Primary sedimentation efficiency in the wastewater treatment plant in SS is also around 70%–80%. The favorable situation in the channel is partly because of the natural treatment.
- Segregation in the system is mainly concentrated in the summer months. In order to make it harmless to the environment, running channels aerobically or gas disposal systems absorbing the gas in the collector and filtering it via active carbon should be added to the system at intervals between 500 and 700 m.
- Protruding material in the channel during the rainy months in order to reduce the risk of clogging channel system should be operated as an absolute compound.
- Although the system continuously produces bacteria, it is negligible with the contribution of refinement process and film formation at the wall of system.

If five of treatment plants in Istanbul are supported by the channel whose cost is very low, 20%–25% benefits in investment and 10%–15% in business will be available. Places where wastewater quality is domestic and the concentration of the release is linear, and channel temperature is more than 15°C, and channel slope appropriate, significant gains will be achieved in the treatment channel through evaluating odor and other environmental factors. In this research, it is seen that the canal treatment system is not an alternative or new system, but a method to be applied in order to increase the efficiency of development or existing treatment systems. Mechanism and kinetics of the system are completely the same anaerobic and aerobic biological process systems. In the system, in order to provide treatment, the amount of bacteria can be increased in a controlled manner either adding active and intense bacteria artificially to the collector, or through the release of bacteria like the situations in small facilities like Tuzla treatment facility.

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