SANITATION SYSTEMS AND ENVIRONMENTAL PROTECTION ACTIVITIES OF ISTANBUL METROPOLITAN AREA AND THE BOSPHORUS

Abstract

This study reports the local and regional sea pollution investigations in the Bosphorus and Marmara Coastral lines due to the Metropolitan Muncipality wastewater discharges. The necessary precautions for locally generated pollutants being taken since 1995 by spending and investigating 100 millions US dollars each year for the improvement of the existing sanitation systems and wastewater treatment plants. Accumulated effects of these investments since 1995 have resulted in major improvements of the sea water quality in the Bosphorus and the Golden Horn as well as Marmara Sea coastral lines.

The status of the existing and planned wastewater disposal, treatment and sea outfalls of Istanbul City are represented.

Introduction

Istanbul City with its 12 million population is the most populous city of Turkey with its historical, economic and cultural significance. A population census started during the 1950s when the city was the major industrial and commercial center of modern Turkey. As a result, the city has become attractive for those living in other cities and major migrations have started to take place leading to unprecedented population increase. The population was about 1.5 million in 1960, increased 2.1 in 1970 and 2.7 in 1980. The population jumped to 6.6 million in 1990. Today one person out of six in the country lives in Istanbul. Consequently, 40% of the Turkish industry is located in this city and almost half of the taxes are collected from Istanbul. Fast growing population and rapid urban development arising from socio-economic and political policies have created infrastructural problems such as water suply and sanitation services.

Sewer projects are not well documented as the water projects to have complete historical developments starting from the early times of Istanbul City. Actually, due to relatively less importance and emphasis given to the sewer projects, most of the works were carried out during the last 150 years. The concept of wastewater collection, treatment and disposal exhibited significant changes following the changes in technology and awareness of the public. Although, the changing concept caused some elements of the early systems to become redundant, thus they were demolished or could not have the intended function. But major parts of the earlier projects were integrated to following projects and they become a part of the follow up systems.

The geographical location and topography of the city is quite unique. Istanbul is situated at the confluence of two continents: Asia and Europe divided by Bosphorus Strait. The Sea Sea of Marmara is an enclosed sea, connected to Black Sea and Aegean Sea by the Bosphorus and Dardanelles. Therefore there is a very strong and permanent stratification in the Sea of Marmara throughout of the year, lower layers carring Mediterranean and upper layers carrying Black Sea water. This unique coastal structure of Istanbul necessitated a detailed study to determine the level of wastewater treatment and the location and depth of marine outfalls.

Key figures about Istanbul Water and Wastewater Administartion (ISKI)

In order to give an idea about the size of the facilities and the services the following key figures are given:

- Population served: 12 million
- Total area served: 6.504 km^2
- Total number of customers (connections):3.6 million
- Total length of water distribution pipes: 12.650 km
- Total length of sewers: 9.720 km
- Annual yield of water resources : 1.170 million m^3
- Average daily water supply: 2.000.000 m^3/day
- Current unaccounted for water: 27%
- Current water tariff (including sewer charges): House: 1.12 $/$m^3$ Commercial: 2.24 $/$m^3$
- Budget (2005): 1.2 Billion USD
- Investment budget: 709 Million USD
- Number of staff:6.191

Environmental Protection Activities

Wastewater collection, treatment and discharge duties have accelerated during 1980's. The prepared projects started to be applied. The first of these projects was the "Southern Golden Horn Collector, Yenikapi Pre-treatment Plant and Ahirkapi Sea Discharge Project". The wastewater are collected, pre-treated and discharged to sea. It is the first marine discharge application. The collected wastewater passed through a preliminary treatment plant consisting of screens and grit chamber and the marine discharge system consisted of piping of 1100 m. length and depth 60 m given from Ahirkapi where two layers flow was detected. The system was completed in 1988.

An improvement in the sea water quality especially in Golden Horn is observed after 1998 since discharge of the raw wastewater diminished after completion of the intercepting sewers along the creeks discharging into Golden Horn Estuary by the end of 1997. Following the interception of the wastewaters from the banks of the Golden Horn and after dredging of 5 million m^3 of sludge from the bottom, the water quality has improved much and 27 species of fish have returned back. Golden Horn in the past was one of the best recreational area of Istanbul. As a result of the implementation of the environmental protection and rehabilitation projects, the Golden Horn is regaining its historical recreational value. Picture 1 and 2 shows before and after the rehabilitation works of the Golden Horn from 1996 to 2003.

Picture 1 The Golden Horn in 1996

Picture 1 The Golden Horn in 2003

A comprehensive three dimensional water quality modelling study has been concluded that tertiary treatent including nitrojen and phosphorus is required for the effluent discharges into the Marmara Sea. However, enhanced primary or even primary treatment has been found satisfactory for discharges into the lower layers the Bosphorus and Black Sea. Provisions for upgrading to secondary treatment were recommended. All treatment plants are located at or close to the coast except Pasakoy WWTP which is in the catchment area of Omerli Reservoir, the major source of drinking water for Istanbul City.

Measurements have indicated that the major flux of disolved organic material trough the Bosphorus – and into the Marmara Sea- was the flow of Black Sea water. The soluable organic material from Yenikapi discharge was never observed to exceed 10% of the total concentration in the lower layer of Mediterranean water. The increase in the concentration of dissolved organic matter in the Bosphorus and flowing into the Sea of Marmara during the periods of blockage was the order of about 10%. The effluents are discharged into the lower layers of the Bosphorus. The tracer studies sponcered by ISKI and conducted by the Institute of Marine Science of METU (Ozsoy, 1995) have verified the assumptions made in the design of wastewater disposal system.

Fecal coliforms were the most direct assesment of the pollution which could be attributed to the discharges. It has been observed that the fecal koliforms orijinating from Yenikapi could survive up to the Black Sea end of the Bosphorus through the lower layer of Bosphorus flow, most probably due to the inability of solar radiation to penetrate into to the lower layers.

Water quality modelling studies resulted in that tertiary level of treatment is needed for effluent discharges into the Sea of Marmara and primary treatment for discharges into the Black Sea and low layers of Bosphorus by deep sea outfalls. The following projects were the application of preliminary treatment followed by marine discharge system as the best available technology to be applied to the Sea of Marmara. In future it is determined to apply biological treatment to these systems especially in regions where the currents are less significant and where the sea depth is limited.

Existing and Planned Treatment and Disposal Facilities

The existing and planned wastewater facilities, treatment plants and marine outfalls are illustrated in Figure 1 and are summarized in Table 1, 2 and 3. Table 2 and 3 indicates that significant amount of the municipal wastewater treated before discharge. Within the past years, the preliminary treatment and marine disposal systems of Uskudar, Baltalimani, Adalar, Kadikoy, Kucuksu have been completed. The biological treatment plants of Tuzla, Pasakoy, Terkos and Buyuk Cekmece have started operation. Thus, within the previous 11 years, the treated wastewater percentage increased from 9% to 95%.

Table 1 Existing Wastewater facilities.

Investment	Total
Pre-Treatment Plant	**7**
Biological Treatment Plant	**6**
Pumping Stations	**27**
Tunnel	**54 km**
Collector	**363 km**
Main Collectors	**363 km**
Pipe – Jacking	**22 km**

Land Pipeline	**16 km**
Sea Outfall	**16 km**
Wastewater Network	**9650 km**

Figure 1 Location of Wastewater Treatment Plants and Marine Outfalls in Istanbul Metropolitan Area

Table 2 Existing WastewaterTreatment Plants.

No	Name of Facility	Year Commissioned	Capacity (m3/day)	Average Amount of Treated Wastewater per day (m3)
1	Yenikapı Pre-Treatment Plant	1988	873,000	514.918
2	Uskudar Pre-Treatment Plant	1992	108,173	25.151
3	Atakoy Biological Treatment	1996	7,650	6.143
4	Baltalimani Pre-Treatment Plant	1997	625,000	420.790
5	Tuzla Biological Treatment	1998	150,000	259.693
6	B.Cekmece Pre-Treatment Plant	1998	155,120	34.542
7	Pasakoy Advanced Biological	2000	125,000	58.247
8	Terkos Advanced Biological	2000	1,730	1.040
9	K.Cekmece Pre-Treatment Plant	2003	354,000	116.205
10	Kadıkoy Pre-Treatment Plant	2003	833,000	363.701
11	Kucuksu Pre-Treatment Plant	2004	654,000	131.299
12	Bahcesehir Biological Treatment	2004	7,400	7.306
13	Canta Biological Treatment	2005	1,600	1.483
	Total		3.894.073	1.940.518

Table 3 Existing Marine Outfalls.

No	Adı	Year Commissioned	Length (m)	Diameter (mm)	Depth (m)
1	Yenikapı	1988	2.360	2 x Ø1600	- 60
2	Uskudar	1992	275	Ø1200	- 47
3	Baltalimani	1997	700	2 x Ø1727	- 70
4	Tuzla	1998	2.203	Ø2200	- 46
5	B.Cekmece	1998	1.803	Ø1600	-40
6	K.Cekmece	2003	1.057	Ø1600	-27
7	Kadikoy	2003	2.308	Ø2200	-52
8	Kucuksu	2004	363	Ø2172	-67
9	Buyukada	1989	2.200	Ø600	-62
10	Burgazada P2	1988	890	Ø315	-30
11	Kinaliada	1997	1.100	Ø315	-52
12	Heybeliada	1999	1.020	Ø450	-62
13	Anadolu Kavagi	1991	120	Ø315	- 32

Figure 2 indicates that a significant fraction of the wastewater is treated before discharge. The percentage of the treated wastewater in line with the above mentioned discharge strategy is presented in Figure 2. As it is evident from this diagram that there was little increase in percent treated wastewater, 9% in 1989 to 16% in 1996 due to allocation of the budget to water projects in these years to eliminate the water shortage. Following the relief of this problem the funds were diverted to the wastewater projects and consequently sharp rises were achieved in the percent of the wastewater treated.

The start of the operation of Baltalimani, B.Cekmece, Tuzla, Kadikoy, Kucuksu WWTP in 1998 increased the percentage of treated wastewater to %63. With Kadikoy and Kucuksu put into operation in 2004, the percentage of the treated wastewater has risen up to 95%.

Figure 2. The increase of the percent treated wastewater with time

Conclusions

Wrong planning, wrong selection of the priorities and also corruptive practices have delayed the construction of the needed facilities, consequently the citizens of the Istanbul has bitterly witnessed pollution of coatsral waters due to municipal discharges with the sign of 'forbidden to swim'.

The Bosphorus and Marmara Sea coasts are polluted as a result of the city municipal outfalls. Istanbul Water and Sewerage Administration took the neccesary measures for the offshore marine outfalls to control the environmental effects of municipal pollution sources. Short and long term strategies for the treatment and disposal of wastewaters based on the water quality modelling studies where the effluents are given to the bottom layer which conveys them into the Black Sea basin.

The future population of Istanbul city is estimated as about 20 million in 2032 considering the population increase rate during the last 35 years. The required levels of treatment were given as primary treatment for discharges into Bosphorus and Black Sea and tertiary treatment achieving nutrient removal for discharges into the Sea of Marmara. In both case discharges of the effluents into the lower layers was required.

Following the implementation of the wastewater collection, treatment and disposal projects, significant improvements are obtained in coastal water quality. Since 1995 coastal water quality is continuously monitored at about 50 stations. Improvement in bacteriological water quality is obvious. The percentage of the treated wastewater has risen from 10% in 1994 to 95% in 2005.

The implementation programme together with cost estimates on water, wastewater and stormwater projects up to the year 2032 is estimated about 10 billion US dollars. The share of the wastewater projects in this total is increasing with time. The cost covering not only the treatment facilities, but also the associated collection and interception infrastructure and the marine outfalls required a massive investment of $2128 million in the early years of the program before 2010 in order to commission the identified facilities. A summary of the capital expenditure in each phase of the investment programme is defined in the Master Plan.

REFERENCES

[1] IMC (1995). Sewage Effluent Disposal, Istanbul Master Plan Study Task Report TR 7.

[2] ISKI (2004), Annual Report For 2004, Istanbul Metropolitan Municipality, Istanbul Water and Sewerage Administration.

[3] ISKI (2003), Annual Report For 2003, Istanbul Metropolitan Municipality, Istanbul Water and Sewerage Administration.

[4] ISKI (2002), Annual Report For 2002, Istanbul Metropolitan Municipality, Istanbul Water and Sewerage Administration.

[5] ISKI (12001), Annual Report For 2001, Istanbul Metropolitan Municipality, Istanbul Water and Sewerage Administration.

[6]Institute of Marine Sciences and Management University of Istanbul Research Education Foundation (2001), Water Quality Monitoring Final Progress Report, Istanbul Metropolitan Municipality, Istanbul Water and Sewerage Administration.

[7] Eroglu, V, Sarikaya, H.Z. and Okus, E. (2002). Improvements Achieved in Beach and Coastal Water Quality in Istanbul, The Wolrkshop on Beach Management and Sustainable Development in Europe, Constanta, Romania.

[8] Eroglu, V., Sarikaya, H.Z. and Aydin, A.F. (2001). Planning of wastewater treatment and disposal systems of Istanbul metropolitan area, Water Science & Technology, 44(2-3), 31-38.

[9]Ozturk, I., Yuksel, E. and Tanik, A. (1999). Wastewater Management Strategies for the Black Sea Coast of Turkey, Water Sci. & Tech. Vol.39(8), pp 169-176.