STATE-OF-THE ART OF WASTEWATER AND SLUDGE TREATMENT IN TURKEY

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Abstract. As a candidate country for the EU membership, proper wastewater treatment and disposal is one of the crucial challenges in Turkey, which should be fulfilled during the next 15 years. More than 3,000 treatment plants are necessary in order to comply with the EU legislation. Huge investments are required for the rehabilitation and new construction of sewage networks as well as for the wastewater treatment plants. Protection of the environment and the need of treated water during the long and dry summer months make the wastewater and sludge treatment process more important than ever.

Keywords: wastewater, sludge treatment, nutrients removal, treatment facility.

1. Introduction

Wastewater treatment has always been one of the main environmental and infrastructural problems which as an EU candidate Turkey is facing. Parallel with the population increase (1.5–1.9% per year) wastewater related problems shows increasing tendency. Due to lack of financial sources, rate of sewage network and treatment plant construction lies far behind the urbanization rate. The dimension of wastewater and sludge management is considerably high, as wastewater produced by over 70 million residents has to be managed.

In the framework of EU accession process of Turkey, harmonization of the EU legislation is ongoing. The relevant EU legislation has already been transferred into Turkish legislation. In the report of National Environmental Strategy (2003–2023) [1], certain time limits are set for the implementation of the wastewater related EU directives such as Water Framework Directive, Urban Wastewater Directive, etc. It is planned to fulfill the requirements of the directives until year 2023. For this purpose significant amount of investments are necessary: It is foreseen that the initial investment and rehabilitation costs of the wastewater treatment plants and networks between years 2007–2023 will be 18 billion Euro. One of the

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main reasons that lead to this huge amount of investments is the uneven distribution of the population within the 3,225 municipalities and 140,00 villages. According to the statistical data (2006), 78% of the population is living in the municipalities (urban population) and the remaining in villages (rural population) [1]. However, official statistics covers only the “urban” population. As seen from Fig. 1.1, 96% of the municipalities have population less than 50,000, which are classified as small-medium sized municipalities. On the other hand, 58% of the urban population lives in only 135 centers. Unfortunately, only 11.2% of the municipalities, in which 42% of the urban population lives, are served by wastewater treatment plants; whereas in the remaining municipalities, the produced wastewater is discharged untreated, mainly to water bodies as the receiving environment.

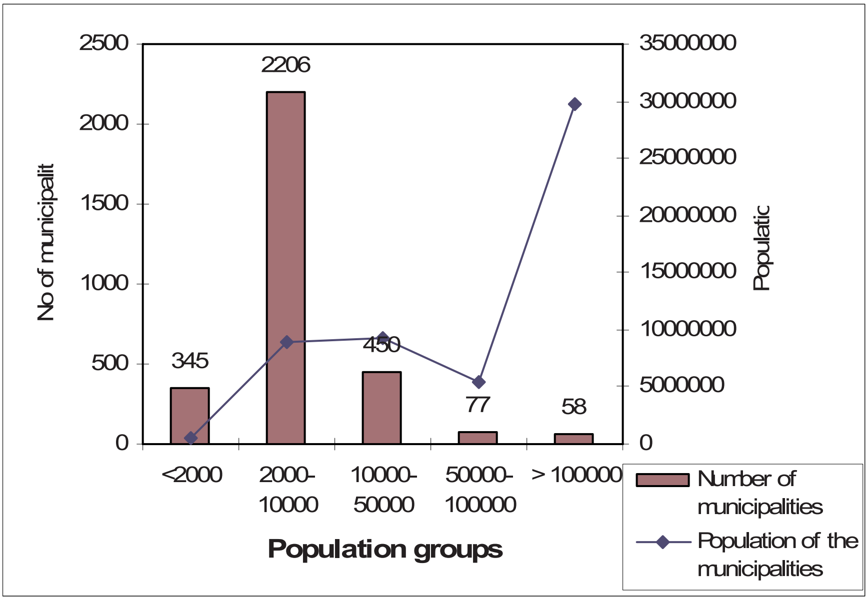


Fig. 1.1. Distribution of the number of municipalities and population according to population groups.

In addition to the necessity of the protection of the receiving environments, water plays a very crucial role in Turkey, especially during the long lasting summer months: The overall climatic condition in Turkey is classified as arid-semiarid. In order to satisfy the irrigation water demand of agriculture, as well as to supply the residents and touristic facilities with potable and drink water, considerable amount of good quality water is needed. Due to climatic conditions summer months usually do not have contribution on the water budget of the country. Therefore, treated wastewater is a very important source of water.

In this study, the current stand of the wastewater and sludge treatment in Turkey is analyzed and proposals for sustainable wastewater management are introduced.

2. Wastewater treatment

In 2,321 of the 3,225 municipalities 3.4 million m^3 wastewater is collected through sewage systems (Table 2.1). This corresponds to 87% of the total population [2].

On the other hand, the stand of wastewater treatment is not well developed to this extend and in addition to this it is not evenly widespread throughout the country. Only 184 wastewater treatment plants are currently under operation, in which secondary and advanced treatment are applied [2]. 2.1 million m^3 municipal wastewater produced in 362 municipalities is treated in one of these WWTPs. It means that only 42% of the total population is served with a wastewater treatment plant. The secondary treatment plants are initially constructed to remove the organic matter content of the wastewater. Parallel with the increasing sensitivity and awareness regarding the receiving water environments, other parameters than only BOD_5 and COD are also taken into consideration. As a result Nitrogen and Phosphorus are removed in wastewater treatment plants especially located along the touristic coastal areas. From Table 2.1, it is evident that 62% of the produced wastewater receives biological and advanced treatment. As it will be discussed more in detail below, advanced treatment comprises from advanced biological treatment facilities, in which nutrients such as nitrogen and phosphorus are removed besides organic matter.

Table 2.1. Main wastewater indicators of municipalities 2006 [2].

Number of municipalities served by sewerage system	2,321
Rate of population served by sewerage system in total population (%)	72
Rate of population served by sewerage system in municipal population (%)	87
Amount of wastewater discharged (million m^3/year)	3,367
Number of wastewater treatment plants	184
Physical	22
Biological	135
Advanced	23
Total capacity of wastewater treatment plants (million m^3/year)	3,648
Physical	1,329
Biological	1,511
Advanced	808
Amount of wastewater treated by treatment plants (million m^3/year)	2,140
Physical	714
Biological	927
Advanced	500
Number of municipalities served by wastewater treatment plants	362
Rate of population served by wastewater treatment plants in total population (%)	42

An evaluation of the distribution of the treatment systems in comparison to the number of treatment plants and with respect to the volume treated in these plants indicates some discrepancy. Number of conventional activated sludge plants is not much but they are mostly large treatment facilities (Fig. 2.1a). As a matter of fact, approximately 70% of the treated wastewater is processed by conventional and nutrient removing activated sludge systems (Table 2.2).

Especially during the last 10 years, in order to avoid sludge treatment, extended aeration systems (EAS) are constructed (Fig. 2.1b). These plants are the modifications of CAS, with longer sludge retention time (15–30 d), longer hydraulic retention time (12–36 h) and lower F/M ratio (0.05–0.15 mg BOD_5/mg ML SS·d). The main advantage of these systems is the fact that the primary sedimentation and external sludge treatment units can be avoided that helps to reduce the construction costs.

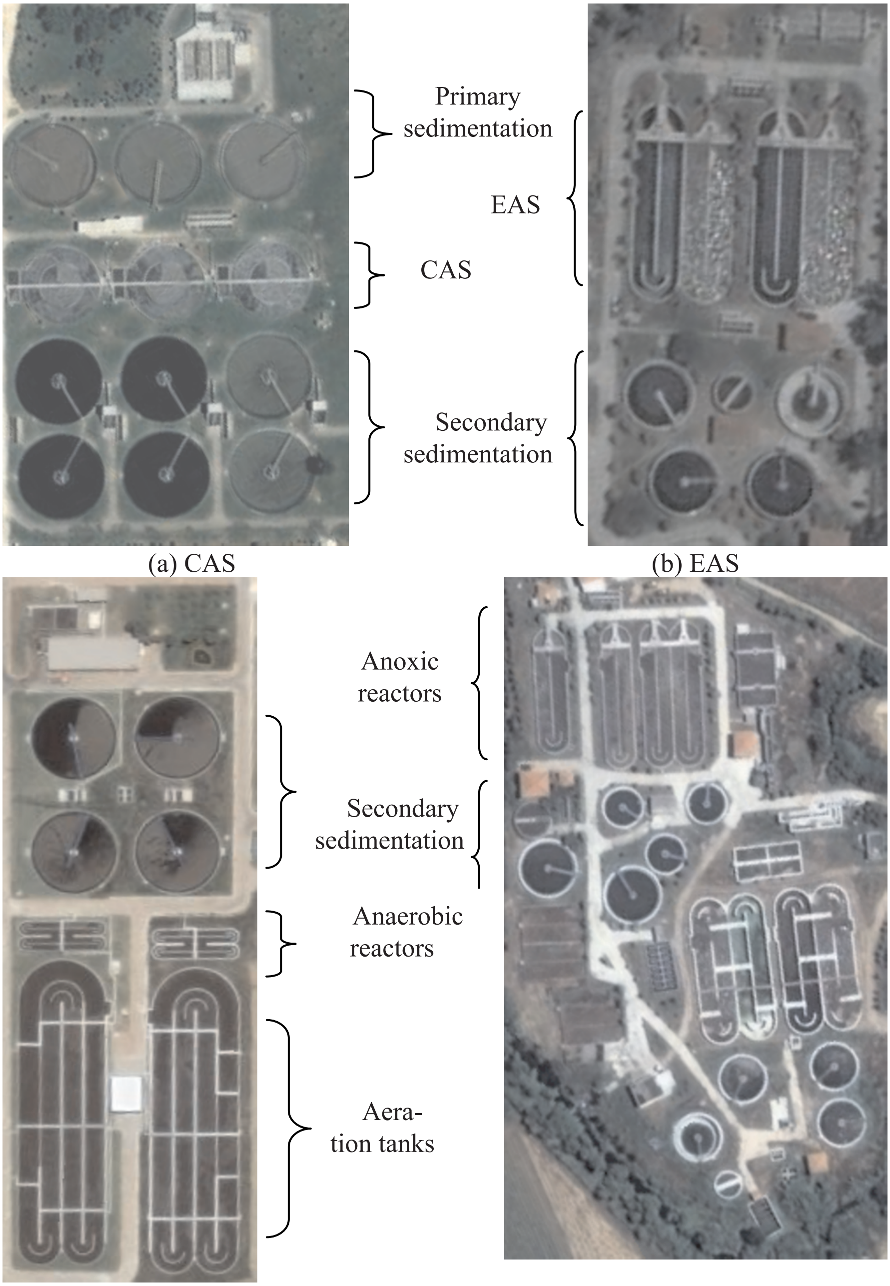
Table 2.2. Distribution of the applied treatment systems based on the number of plants and volume of treated wastewater [3].

System	Based on the number of treatment plants (%)	Based on the amount of treated waste water (%)
Conventional Activated Sludge (CAS)	20	47
CAS + Nutrient Removal (BNR)	5	23
Extended Aeration Systems (EAS)	61	25
EAS + Nitrogen Removal	3	3
Biological filters + N-removal	11	2

By taking into consideration the increasing sensitivity of the receiving water body several new constructed plants are designed as biological nutrient removal (BNR) plants. Typical example to this is the main wastewater treatment plant of Antalya City (500,000 PE) shown in Fig.2.1c. In this plant, wastewater, which passes through screens, grit and scum removal units, are directly derived into the anaerobic tank in which phosphorus removal is encouraged. The following aeration tank is operated in extended aeration mode. Secondary settling tank is followed by deep marine discharge units. The phosphorus concentration of the discharged water is low (<1mg/l) and the other parameters fulfill the requirements of discharge criteria.

Along the costal zone of Antalya, three existing treatment plants, which are considered as oxidation ditches were upgraded with anoxic tanks for removal of nitrogen (Fig. 2.1d).

In addition to the problems of insufficient treatment capacity, there are several problems that the existing plant operators have to face with. Dilution of the incoming wastewater due to infiltration of ground water along the coastal regions is very common. Treatment plants, which are designed for municipal wastewater, have to deal with industrial influents also. In addition to overloading of the central plants located in touristic regions during summer months, which lead to sludge bulking and low dissolved oxygen levels in the aeration tanks, is very common.



(c) BNR (d) EAS + Nitrogen removal

Fig. 2.1. Views of the existing wastewater treatment plants.

In order to fulfill the requirements of Urban Wastewater Treatment Directive, approximately 2,942 new treatment plants with various capacities are required to be established for residential units with a population more than 2,000 inhabitants. In the small municipalities and villages with population less than 2,000, appropriate treatment and disposal methods will be used. As investment costs are the main concern two scenarios are developed:

- Highest Cost Scenario

All waters of the country are classified as sensitive areas and advanced treatment was recommended for all wastewater collection areas of more than 10,000 PE

- Lowest Cost Scenario

Marmara, Aegean and Mediterranean coastal zones are classified as sensitive. Other areas, Bosporus and Black Sea are considered as less sensitive for discharges.

As the highest cost scenario can be a significant financial burden, lowest cost scenario was chosen for the implementation of the Urban WWT Directive. The goal set in the Environmental Approximation Strategy [1] is to install sewage systems and treatment plants until the year 2020, so that the population that will benefit from the treatment plants in the provinces, which have more than 50,000 inhabitants. By deciding on the technology of the treatment plant the criteria of sensitive and less sensitive areas will be considered.

2.1. Economics of waste water treatment

The evaluation of the initial and operational costs of the existing treatment plants show dependency on the degree of treatment and the source of financing [3]. The high variability in the per capita investments is partly related to the financing sources. In cases where investments were made through international loans, costs are usually high. On the other hand, the lower is the investment costs when national financial sources are used.

From Table 2.1.1 it is obvious that,

- The highest costs are those for nutrient removing EAS systems, and the lowest are for conventional activated sludge.
- Activated sludge units are operated at the lowest cost.
- The EAS and nitrogen removing EAS plants appear to have the highest operational costs.

The BNR plants operate at a lower cost than nitrogen removing EAS systems. This is possibly due to the difference in the sizes of treatment plants. The selected nutrient removing activated sludge plants are larger facilities while nitrogen removing EAS are smaller units.

Table 2.1.1. Costs of the applied treatment technology [3].

Treatment technology	Initial cost (€/capita)	Unit operational cost (€/m^3)
Conventional Activated Sludge (CAS)	13.76–46.67	0.0146–0.0903
Nutrient Removing Activated Sludge (BNR)	32.30–266.2	0.0473–0.0553
Extended Aeration Activated Sludge (EAS)	29.00–49.85	0.0320–0.1260
Nitrogen Removing EAS (EAS-NR)	12.72–83.47	0.0528–0.1534

3. Sludge treatment

Proper sludge disposal is the weak point of sludge management in Turkey. Due to lack of financial sources sludge treatment units are designed thrifty. In treatment plants with large capacity, anaerobic sludge treatment is applied. With the application of extended aeration systems it is planned to omit the primary sedimentation tanks, at the same time as sludge stabilization in the aeration tanks is achieved, external sludge treatment units were also omitted. In the majority of the plants constructed during the last years, thickening is the first stage of sludge treatment followed by dewatering units (belt press or centrifuges) to 25% DM. This conversion of the sludge to a solid 'cake' form is followed by disposal in landfills. As the landfill operators are increasingly against landfilling of sludge and as WWTP sludge traditionally has a very limited usage as fertilizer in the agriculture, it is common practice that produced and dewatered sludge are deposited in unsanitary landfills which in turn causes serious environmental problems.

Anaerobic digestion is applied in a limited number of plants. In order to manage the increasing amount of sludge, usage of treatment plant sludge as fuel in cement factories is allowed and several cement factories have license to incinerate sludge. In 2008, the first sludge drying system has become operational in Antalya.

It is expected that the quantities of sludge requiring disposal would continuously increase with the implementation of the EU Directive. The production of municipal sludge is estimated to increase up to more than 1 million tons DM/a in 2020. The new Environmental Approximation Strategy [1] foresees the treatment and controlled usage in the soil and final disposal of the sludge from treatment plants through appropriate technologies.

4. Conclusions

In order to comply with the relevant EU Directives high investments are required. These investments are needed for the renovation of the networks, construction of new networks, renovation of the existing wastewater treatment plants, for the construction of more than 2,900 new WWTP's and for proper sludge handling, which should be realized till 2020. Due to high costs it is envisaged to maintain treatment services only in residential centers >50,000 population. Strengthening institutional capacity plays also a considerable role. It is estimated that approximately 10,000 additional technical personnel are required. As the applied wastewater treatment technology affects the quality of the sludge, in the newly constructed plants water and sludge treatment units should be planned as a whole. Life cycle assessment methodology can help to decide on the most appropriate method in taking environmental and economic conditions into consideration.

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