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Performance evaluation of small treatment systems in Turkey

L. Akca* and A. Samsunlu*

*Department of Environmental Engineering, Istanbul Technical University, 80626 Maslak, Istanbul, Turkey

Abstract In accordance with the development of tourism, sea pollution has become the major problem of the coastal zones. In order to realize sustainable touristic activities in Turkey, it is very important to treat wastewater and preserve the environmental quality. It is roughly estimated that there are around 2000 small treatment plants in Turkey. However, it is necessary to construct 10,000 more wastewater treatment plants to solve the wastewater problems in small settlements. In this study, performances of small treatment systems were investigated. Two types of the treatment plants were of concern. The first one is a continuous system based on fixed bed activated sludge process, whereas the second system is based on batch activated sludge process. 96 treatment plants have been investigated in this study. The wastewater characteristic is determined as strong domestic wastewater. It has been observed that the effluent quality of the batch activated sludge and aerated biofilter systems meet the discharge requirements of Water Pollution Control Regulation in Turkey. Furthermore, they would be easily adapted to meet the stringent standards that are proposed for sensitive zones.

Keywords Aerated biofilter; batch activated sludge; performance evaluation; small treatment systems; touristic areas

Introduction

Turkey, surrounded by sea on three sides, is one of the most significant touristic centers of Europe. In accordance with the development of tourism, sea pollution has become the major problem of the coastal zones. In the coming years, this pollution will form a threat for the Marmara and Aegean Seas (Samsunlu *et al.*, 1995). Currently, Marmara Sea, Aegean Sea and the Mediterranean Sea are being polluted by both touristic facilities on the seashore and by the pollutants carried through the rivers from the inner cities (Samsunlu and Akça, 1999). In order to actualize sustainable touristic activities in Turkey, it is very important to preserve the environmental quality. For this reason, in many touristic facilities including holiday villages wastewater treatment plants have been built since 1980. There is a uniform standard, effective nationwide for effluent discharge in Turkey. According to the Water Pollution Control Regulation (WPCR) of 1988, wastewater discharge standards for places with population less than 10,000 are presented in Table 1. In addition to these standards that are in use, in some studies more stringent effluent standards have been proposed for sensitive zones in Turkey (Orhon *et al.*, 1998). According to this proposal, the effluents limit for BOD_5 is 25 mg/l, COD is 150 mg/l, TSS is 60 mg/l. Additionally full nitrification and at least 40% removal of total nitrogen, and 50% removal of total phosphorus are required. Although no legal enforcement exists, there are a few small wastewater treatment plants for nitrogen and phosphorus removal in Turkey. This is due to the need for reclamation of wastewater and to the sensitiveness of the area.

Table 1 Standards for discharge to receiving waters (PE less than 10,000) (WPCR, 1984)

Parameters	Unit	2 hours, composite	24 hours, composite
COD	mg/l	180	120
BOD_5	mg/l	50	45
SS	mg/l	70	45
pH	—	6–9	6–9

However, in this study, treatment systems for organic matter removal were investigated. It is roughly estimated that there are around 2000 small treatment plants in Turkey. It is observed that most of these plants are located in touristic areas and nearly all of them are packaged plants. However, it is necessary to construct 10,000 more wastewater treatment plants to solve the wastewater problems (Kinaci *et al.*, 1999).

The purpose of this study is to evaluate the performance of two different treatment technologies used especially in touristic areas in Turkey. It is assumed that, it will be possible to make use of these experiences in the design of other treatment plants in future. Furthermore, the results of the study will be a guiding source for the modification of existing plants if the discharge standards change for the sensitive zones. The treatment systems that have been studied are 2 package plants manufactured by Turkish companies. These companies use small treatment systems extensively and both are leaders in water and wastewater treatment technology. A total of nearly 1000 facilities have so far been built (for both these types) since 1981. Most of these facilities have been constructed in touristic areas and they are still in operation.

Treatment systems

In this study, two types of the treatment plants were investigated. The first one is a continuous system based on fixed bed activated sludge process. The system consists of screen, aeration tank filled with fixed bed, lamella settling tank, disinfection tank and sludge tank. This technology has been applied to the settlements with a population of 50–1500 people, in 16 different dimensions. The design parameters of the system are as follows:

Organic loading rate for biofilm (based on bed area)	:	6–10 g BOD_5/m^2 bed surface area.day
Organic loading rate	:	0.05 kg BOD_5/ kg MLVSS.day
MLVSS	:	4 kg / m^3
Overflow rate for secondary (lamella) settling tank	:	0.6 m^3/m^2.hour

The second system that has been studied is based on batch activated sludge process. It is composed of screen, aeration tank and chlorination unit. Settling and biological reactions occur within the same tank. The oxygen is provided by diffused aeration system. Settlements with population of 50–1000 people use this system in 11 different dimensions. The design parameters are shown below:

F/M ratio	:	0.1–0.15 kg BOD_5/kg MLVSS.day
Mean cell residence time (θ_x)	:	30 days
Sludge settling velocity	:	0.8 m /h

The operational problems of these facilities are typical problems of small treatment systems. In addition to this fact, the treatment plants of touristic places are operated on seasonal basis. One of the common problems of these facilities is the high peak value. For this reason, small treatment plants face highly fluctuating hydraulic and organic loadings. This situation affects the performance of the systems. On the other hand, the fullness and vacancy of touristic facilities directly affect the seasonal variations. The wastewater treatment plant is designed for full capacity of the place. It is not usually possible to achieve full capacity in many of the touristic places, or it is only reached for small periods of time throughout the year. It is expected that most of the treatment plants operate at 70% of design load in summer months (Akkaya, 1998).

Generally, there is a technician present at large wastewater treatment plants. Such personnel manage the plant in accordance with the rules set by the manufacturer. When a problem occurs within the plant, the company is notified for help. In smaller plants, workers have no technical education so simple management rules are taught. The sludge production is very low and the stabilization level of sludge is very high due to the extended aeration activated sludge systems that operate at lower loads. At most of these plants, excess sludge is removed within a period of 7–15 days. In some plants, there are sludge conditioning and dewatering units. However, in small plants, the excess sludge is carried to sludge treatment units of larger facilities by trucks. The law about disposal of treatment sludge is not detailed enough. Therefore, removal of this sludge is not handled properly.

The performance of treatment plants

In this study 96 treatment plants have been investigated. For most of these plants, the characteristics of influent wastewater have not been determined. The influent wastewater characteristics of 27 treatment plants are determined by analyses done only once. Although these plants are designed according to typical characteristics of domestic wastewater, the 50 and 90 percentile values of influent COD are 750 mg/l and 2000 mg/l respectively. Similarly, these values for BOD_5 are 400 mg/l and 1500 mg/l. It is clear that, in terms of carbonaceous organic matter content, wastewater entering the plants has strong domestic wastewater characteristics. With regard to TSS, a medium strength wastewater characteristic is observed. For TSS, median value is 220 mg/l.

Figure 1 shows the statistical evaluation of data from 60 treatment plants of the batch activated sludge system. Each of these data belongs to different plant. They are measured in wastewater samples taken after the plant reaches the steady state condition.

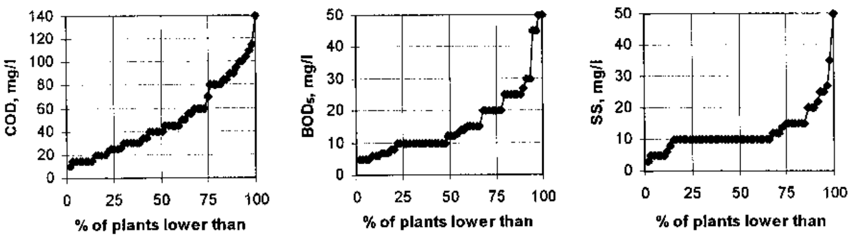

Figure 1 Statistical evaluation of batch system effluent characteristics

As presented in Figure 1, for COD, BOD_5 and TSS effluent water quality at 50 percentile has values of 40, 12 and 10 mg/l respectively. At 90 percentile these values are 95, 27 and 20 mg/l. These values belong to 2 hours composite samples. By comparing the standards, it is seen that both 50 percentile and 90 percentile values satisfy the standards. On the other hand, if the proposed standards for sensitive zones are applied, the following results will be achieved: COD value for 100% of sample is lower than the standard (150 mg/l). Similarly, at 88% of the plants BOD_5 is lower than the standard (25 mg/l) and all of the plants satisfy the 60 mg/l of limit. So, even if the standards are changed, most of these plants will be adapted to the new case with regard to conventional parameters (COD, BOD_5 and TSS). The nitrogen and phosphorus could be removed easily by reorganizing the operation modes under aerobic and anaerobic conditions.

Figure 2 shows the analysis of effluent characteristics of 36 aerated biofilter plants. Each of the values is from different plants belongs to 2 hour composite samples. As seen in Figure 2, the 50-percentile values of effluent for COD, BOD_5 and TSS are 50 mg/l, 15 mg/l and 8 mg/l, respectively. At 90 percentile, values for these parameters are 85 mg/l, 35 mg/l and 15 mg/l. Both 50 and 90 percentile meet the standards. When the evaluation is done with regard to sensitive zone conditions, the following results are reached: 98% of plants have 150 mg/l COD, 80% have 25 mg/l BOD_5 and 100% have 60 mg/l TSS. Therefore, if more

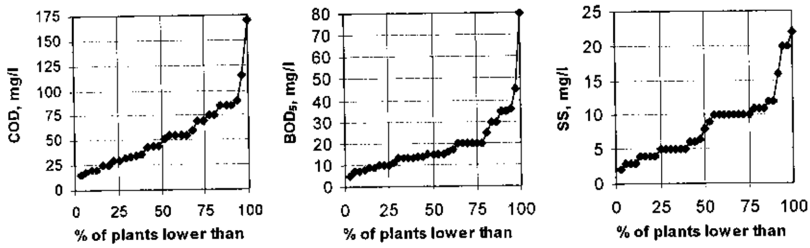

Figure 2 Statistical evaluation of fixed bed activated sludge effluent characteristics

stringent standards are applied for conventional parameters, all of the plants will easily be adapted to new standards. The design should be changed and new units should be added to the system for nitrogen and phosphorus removal.

Conclusions

Most of the plants referred to in this study are located in touristic places. The wastewater characteristics are determined as strong domestic wastewater. The effluent quality of the batch activated sludge system meet the discharge requirements of WPCR in Turkey. Furthermore they would be easily adapted to meet the stringent discharge standards that are proposed for sensitive zones. On the other hand, the results from the aerated biofilter system show that the effluents from this system also meet current standards. They are also capable of meeting sensitive zone standards for conventional parameters, but upgrading will be needed for nitrogen and phosphorus removal.

The effluent quality of batch system is higher than that of continuous system. This is interpreted as a result of good adaptation of batch system with regard to highly variable wastewater flow rate and quality. Furthermore, the batch system can adapt more easily when the removal of nitrogen and phosphorus is considered. On the other hand, for the batch system that works as completely suspended growth microorganisms, the required power is higher than that for the continuous system, which is based partially on suspended growth and partially on attached microorganisms.

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