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RESEARCHES ON CONSTRUCTED WETLAND SYSTEMS of TURKEY

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Abstract
Constructed wetland systems with their cheaper costs, easy design, construction, operation and maintenance and almost zero energy and labor requirement offer an alternative to high-cost quite complex conventional wastewater treatment systems. They are commonly used for treatment of domestic and industrial wastewater in specially designed basins with aquatic plants and can easily be used for small-to-medium sized communities. Despite old history in Europe and the USA, constructed wetland systems are quite a new technology in Turkey. The very first implementations were performed at the beginning of 2000s and the first one was built in 2004 without much considerations on optimum design parameters. Later on, researches mostly focused on appropriate design parameters, substrate materials and aquatic plants of these systems mostly to improve treatment performance of these systems. This study initially presents general information about the constructed wetlands, history and current status of constructed wetland systems of Turkey, then assess previous researches conducted especially for constructed wetlands systems of Turkey.

Keywords: constructed wetlands, natural treatment, Turkey, wastewater,

1. INTRODUCTION

Rapid depletion and pollution of water resources exert serious pressure on earth. Untreated wastewaters generate serious water and soil pollution when they were directly discharged into soil and water resources. Such polluted effluents also seep into ground and reach to groundwater, ultimately end up with groundwater pollution. Wastewater effluents into streams and rivers reach to seas and pollute river deltas and shorelines, too.

There are 1397 municipalities in Turkey and 1338 (about 95%) of them are served with a sewage system. With these sewage systems, annually 4.48 billion m^3 wastewater is collected. Of such a quantity, 40.2% is discharged into rivers, 49.1% into seas, 2.80% into dams, 1.80% into lakes and embankments, 0.40% into lands and finally 6.50% is discharged into other receiving bodies. Of 4.48 billion cubic meter wastewater, 3.84 billion cubic meters (86%) is treated. Of this treated amount, 37.9% is subjected to advanced treatment, 34.3% is subjected to biological treatment, 27.6% is subjected to physical treatment and 0.2% is subjected to natural treatment (Gokalp and Kanarya, 2018).

Together with rapidly developing technologies, new and expensive wastewater treatment methods have been developed in each day. However, municipalities responsible for treatment of domestic wastewaters generally have hard times to meet qualified labor, construction, operation, maintenance and monitoring needs of such advanced conventional wastewater treatment plants. Therefore, municipalities have tended to use low-cost environment-friendly natural treatment systems during the last three decades. Treated wastewaters are commonly used in agricultural and landscape

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irrigation, facility process water of various industries and in several processes of the municipalities. Water Pollution Control Regulations provide detailed information about the re-use of treated wastewater effluents (Anonymous, 1991).
The works of Konya Provincial Water and Sewage Administration (KOSKI) can be given as pilot implementation. KOSKİ passed treated effluents through sand filters, disinfected treated wastewater effluents with UV (ultraviolet) light and used in refuge landscape irrigations. This treated wastewater lines used in refuge irrigations was called as "Purple Lines". Similarly, Istanbul Water and Sewage Administration (ISKI) initiated works about potential use of treated effluents in irrigations (Anonymous, 2011).
In this study, initially a general information about the natural and constructed wetlands are provided. Then, history and current status of constructed wetland systems of Turkey were provided and previous researches conducted especially on constructed wetlands systems of Turkey were assessed.

2. NATURAL TREATMENT SYSTEMS

Natural treatment is a term defining wastewater treatment processes with the use of natural materials and methods. In natural treatment systems, soil, water, plants, microorganisms and atmosphere are in continuous interactions through physical, chemical and biological processes. Selection of a proper treatment system for a settlement with a population of between 500 – 2000 people is presented in Figure 1 (Kose and Yildiz, 2009). An underground seepage pond is illustrated in Figure 2. Natural wastewater treatment methods without a treatment facility can be classified as follows:

- Wastewater underground seepage basins (Figure 2)
- Wastewater evaporation basins
- Direct discharge of wastewater over sloping land (Figure 3)
- Stabilization ponds
- Constructed wetlands

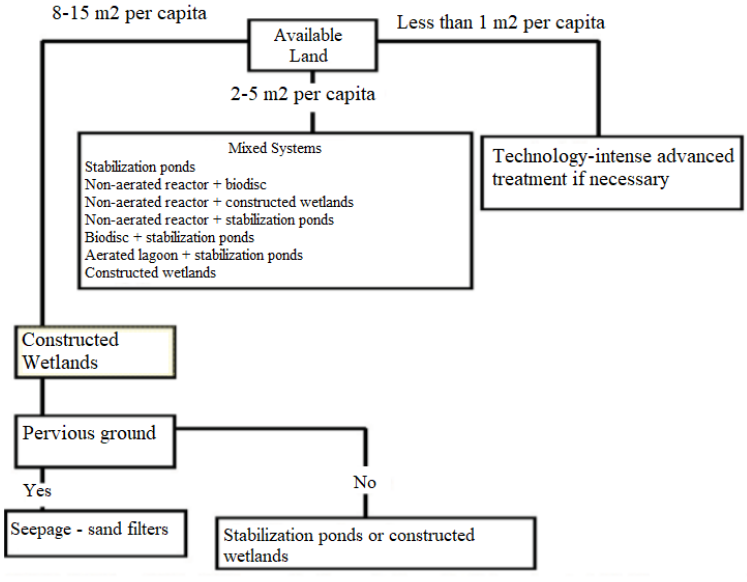

Figure 1. Wastewater treatment methods to be used for a settlement with a population of between 500 – 2000 people (Köse and Yıldız, 2009)

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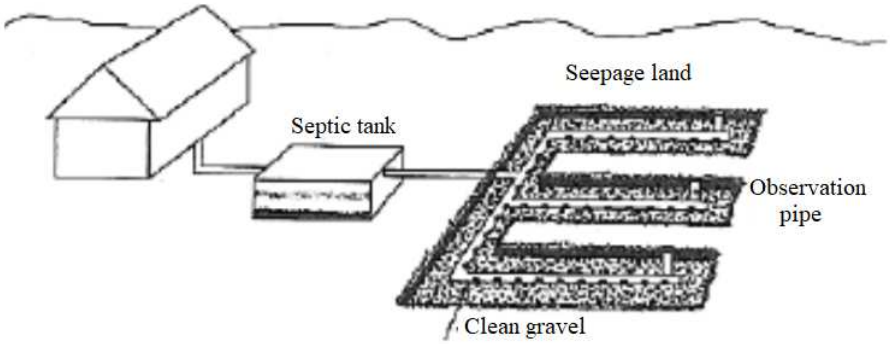

Figure 2. Underground seepage ponds (Balman and Balman, 2002; Bayhan, 2009

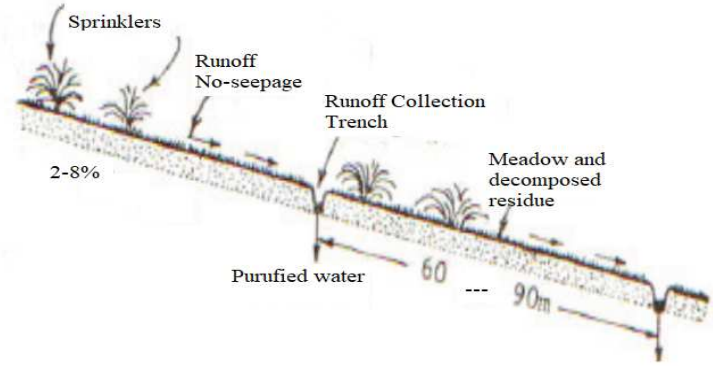

Figure 3. Discharge of wastewater effluent to sloped terrain (Balman and Balman, 2002; Bayhan, 2009)

3. CONSTRUCTED WETLANDS

Constructed wetlands have a capacity of using ambient solar energy and regenerate themselves. They also provide a habitat for several wildlife creatures. These systems depend on filtration of wastewater in a basin generated in a size needed and filled with naturally available materials and treatment of wastewater with the aquatic plants grown in them. They are small-scale imitations of the natural wetlands. With the treatment of wastewater in these systems fed with septic tank effluents, domestic wastewaters of rural settlement could reliably be treated and safely discharged into receiving bodies.

Constructed wetlands do not require complicated high-technology equipment, there is no need for qualified labor. Energy requirements are also almost zero since gravity flow is employed in these systems. A successful constructed wetland design should take the following general criteria into consideration (Gokalp and Kanarya, 2018):

- The design should be kept as simple as possible and complex technological approaches should be avoided to prevent possible failures.
- The design should be so performed as to require the least maintenance.
- The wastewater flow should be supplied through gravitational flow.
- Extreme weather and climate conditions should be considered in design.
- The design should comply with the natural landscape and topography.
- The systems should be allowed time to reach the desired performance values.

These systems are classified into two types: free water surface ones and subsurface flow ones. Free water surface constructed wetlands generally have odor and mosquito problems, thus they are

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preferred in practice and mostly subsurface flow ones are preferred. Subsurface flow constructed wetlands are also divided into two types based on flow regime generated in them: horizontal flow and vertical flow (Figure 4) (Ayaz et al., 2003).

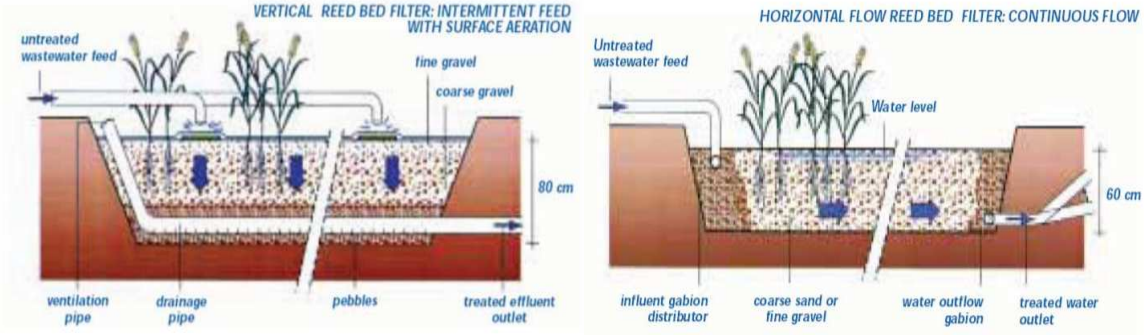

Figure 4. Subsurface flow constructed wetlands (Ayaz et al., 2003)

4. CONSTRUCTED WETLAND RESEARCH AND IMPLEMENTATIONS IN TURKEY

In Turkey, generally advanced wastewater treatment systems with long aerated sludge processes are used in wastewater treatment facilities of the municipalities. However, in places where sufficient lands for wastewater treatment facilities and with small populations, stabilization ponds or constructed wetlands (natural treatment systems) are also used. Direct seepage of untreated wastewater into underground, or discharge over the sloped surface or evaporation of wastewater are quite dangerous methods for human health. Since Turkey is trying to comply with EU Water Frame Directives, these methods are not used in Turkey (Anonymous, 2011).

Stabilization ponds are either natural or artificial water bodies in which wastewaters are kept until they get a stable and balanced structure before to discharge into waster bodies or lands. Stabilization ponds are the simplest type of wastewater treatment systems. They have several advantages over the other systems including no energy consumption, high reliability, easy operation and maintenance and environment-friendly nature. Cross-section of a stabilization pond is presented in Figure 5 (Ramadan and Ponce, 2019).

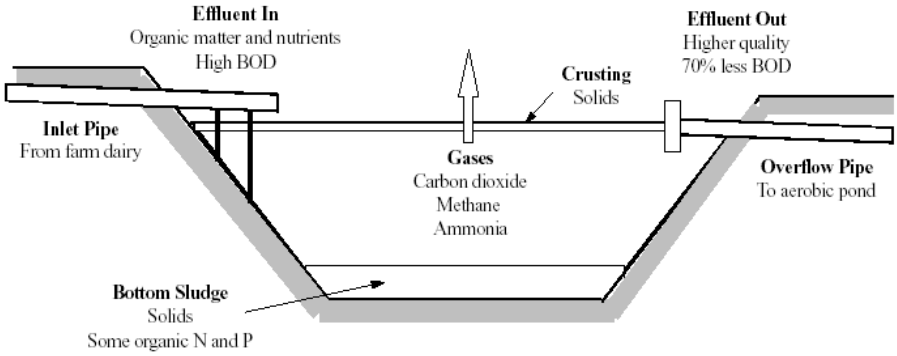

Figure 5. Cross-section of a stabilization pond (Ramadan and Ponce, 2019)

Natural treatment systems were first introduced by General Directorate of Rural Affairs in 43 villages of Turkey in 2004. The first constructed wetland system was applied in Dikilitaş village of Haymana town of Ankara. In that system, a constructed wetland project was designed to serve a

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population of 250 people. The second project was also implemented by General Directorate of Rural Affairs in Korucu village of Torbalı town of Izmir to serve for a population of 1095 people. This system was subsurface horizontal flow constructed wetland. The performance of this system is provided in Table 1 (Anonymous, 2011). Later on, natural treatment projects were implemented in Kapaklı village of Ilgın, Tuzlukcu village of Erdogdu and Camlı village of Aksehir. Another natural treatment system was constructed in Sakarkaya village of Akhisar town of Manisa province to serve for domestic wastewater treatment of 725 people living in 145 houses. This system was also subsurface horizontal flow constructed wetland. Performance parameters of that system are provided in Table 2 (Anonymous, 2011).

Table 1. Performance parameters for the constructed wetland of Torbalı town of Izmir

Parameter	Influent	Effluent	Regulation
COD (mg/l)	142	52	180
BOD_5 (mg/l)	50	15	50
TSS (mg/l)	89	11	70

Table 2. Performance parameters for the constructed wetland of Sakarkaya village of Manisa

Parameter	Influent	Effluent	Regulation
COD (mg/l)	842	685	180
BOD_5 (mg/l)	520	380	50
TSS (mg/l)	89	66	70
TN (mg/l)	64	56	
TP (mg/l)	2.02	1.17	
pH	6.88	6.74	6-9

Separate three constructed wetland systems were implemented at the effluent discharge of Istanbul Pasakoy conventional wastewater treatment system just to polish treated effluents. They were all subsurface flow constructed wetlands and there aren't any odor and mosquito problems. Water distribution is performed through the pipes, wetland basin was covered with a compacted clay layer, substrate materials included gravel and sand and plantation was performed with the use of aquatic cyperus species (Iskender et al., 2005). The other constructed wetland projects implemented in Turkey were listed as follows:

- Sultanhanı – Aksaray
- Viransehir – Sanlıurfa
- Salur - Kayseri (Figure 6)
- METU (Middle East Technical University) – Ankara

Almost of all the constructed wetland systems were subsurface horizontal flow type. Following the demolish of Rural Affairs, Special Provincial Administrations were responsible for the construction of natural treatment systems. Finally, Provincial Water and Sewage Administrations took the responsibility of design, construction, operation and maintenance of constructed wetlands (Gokalp and Tas, 2018a, b).

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Figure 6. Construction phases of a natural treatment system (Kanarya, 2018)

5. CONCLUSIONS

Present constructed wetlands of Turkey have various problems including site selection, filter medium clogging, leakages, plantation, operation and maintenance problems. In Turkey, almost none of the systems are monitored and assessed. The contractor constructs the system and transfer it to the village without any operation, maintenance, monitoring and assessment activities. The first thing to be done is to redesign the projects according to national and international standards. Instead of using pilot projects, site-specific project should be designed by taking the regional characteristics and wastewater characteristics into consideration. Natural treatment systems are state-supported and funded systems. Each year, millions are spent for the construction of these systems. If the relevant measures are not taken urgently, all these investments will turn into waste and dead investments.

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