CHAPTER 9

REUSE OF WASTEWATER IN AGRICULTURE IN TÜRKİYE

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Introduction

Increased competition for limited land and water resources requires the development, monitoring and evaluation of these resources (Tanriverdi et al., 2011). Water is an indispensable source for living beings to survive and water is expected to become a vital topic both nationally and internationally (Khairy at al., 2001). Preservation of existing water resources is crucial for the continuation of the world's existence and productivity. Global warming and increasing world population reveal the necessity of using the existing water more accurately. Water scarcity and climate change have been among the most important issues in recent years. The increasing use of industrial and domestic water necessitates effectively use of water in agriculture (Degirmenci et al., 2016). For the more efficient use of water resources reuse of water is one of the measures taken in various areas (agricultural, industrial, urban). 97.5% of the world's water is composed of salty water in the ocean and the remaining 2.5% of the fresh water is composed of glaciers, groundwater, surface waters, atmospheric waters and frozensoil layer. 0.4% of freshwater is surface and atmospheric water, which is present as lakes, rivers, wetlands, atmosphere, soil moisture and biological water (Anonymous, 2009; Kara et al., 2013; Atalık, 2007). In the world, it is observed that distribution by water sector is 69% for agricultural use, 19% for industrial use and 12% for urban use. This distribution differs according to the continent, but in other regions outside of Europe, agricultural use comes first (Anonymous, 2007). Many countries in the world (as Saudi Arabia, Libya, Israel, Algeria, Kuwait, Singapore,

Bulgaria, Malta) face water shortage, a limited number of countries (as Romania, Canada, Norway, Finland, Russia, Australia, etc.) do not suffer water problems for now. However, this does not mean that countries without water stresses in the current situation will not suffer water shortages in the years to come. Turkey, with an amount of 1600 m^3 water per capita, is country that neither have water excedent nor is suffering from water scarcity (Bilen, 2008; Şahin, 2016). In order to avoid a potential water problem in the near future, it is necessary to use the water resources more efficiently, to treat the used water. When it is considered that the difficulty of stopping global warming and population growth despite no increase in water resources, the reuse of water has become a very valuable research topic in the world at the currently. According to the amount of water per capita, countries are classified by a number of indicators. One of these is Falkenmark, beeingthe most commonly used. Accordingly, the 'Water Stress Index' of the countries is determined and shown in Figure 1. This index is defined as the ratio of the annual total water consumption for human consumption to the total renewable fresh water resources (Raso, 2013; Duman, 2017; Köle, 2017).

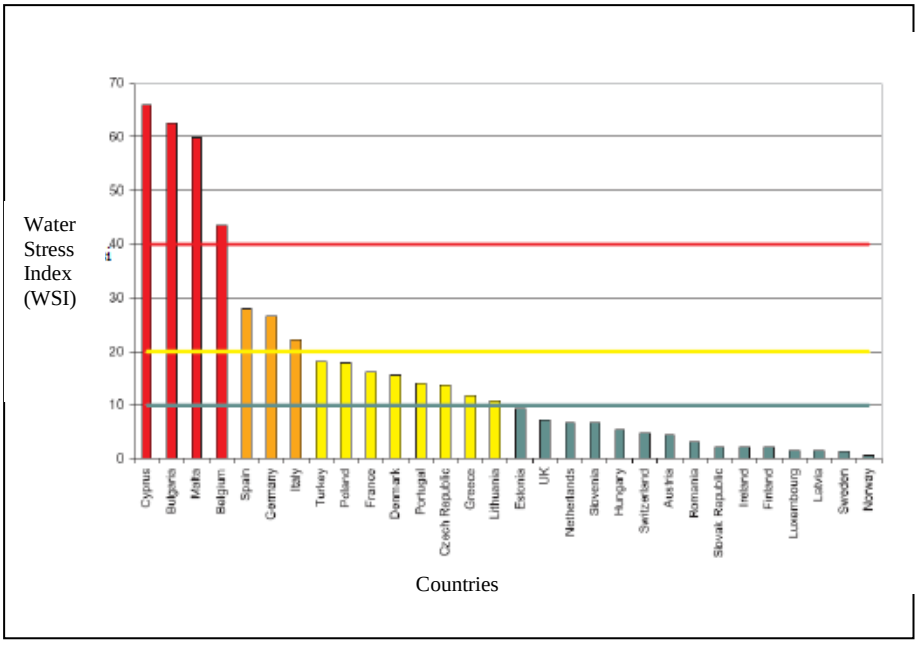

Figure 1. Water stress index for european countries cccording to the water

Stress Index (WSI), if the ratio is below 10%, it is low, between 10% and 20% is medium, between 20% and 40% is high and if it is more than 40%, it is considered seriously. In this case, Turkey water stress index is in the range of 10-20% when confronted with water stress, countries like Romania, Norway, Norway, Slovenia are among the countries with lowest WSI. Cyprus, Bulgaria, Malta and Belgium seem to be countries with serious water stress.

Inadequate water resources and the deterioration of the quality of these resources are anxious in many countries around the world, and are clearly stated in international forums that this will be one of the major problems in the future (Polat, 2013). Alcamo et al. (2017), estimated an increase in water consumption by the contribution of climate change for the 2070 European countries in a study they

conducted. France, Spain, Italy, Greece, Ukraina, Turkey is also including in this study especially striking results emerged for Turkey. In these six countries discussed in the research, Turkey was determined to be the most affected country mostly in terms of water use from climate change. More than water consumed in our country today, it is predicted that in 2070, to be consumed only for climate change reasons (Alcamo et al., 2017)

Irrigation water consumption has a very high proportion of total water consumption. This rate varies between 30% and 92% and from country to country. Since the amount of water used for agricultural irrigation is so high, it becomes important that irrigation wastewater is used for irrigation in agriculture after its treatment. New strategies for sustainable water management need to be developed. For this reason, the use of wastewater considered as alternative water resources has emerged (Karakaya, 2015). The reuse of wastewater, which is considered to be a new water resource, is a continuous alternative of water resources conservation, prevention of coastal pollution, water and fertilizer acquisition in agriculture, savings in clean water use and wastewater treatment costs (Cepra and Scicolone, 2006). In most countries, waste water treatment and reuse efforts have been initiated to meet supply to water resources, including countries that do not have water constraints. This area is dominated by USA, Israel, Western Europe and Australia (Miller, 2006).

Refining and reusing water must be compatible with each other quality of waste water and necessary properties according to the usage

area. Secondary (biological) and tertiary (advanced) treatment technologies are used to irrigate with wastewater in agriculture. In places where salt water such as seawater should be used, quaternary purification systems including microfiltration, reverse osmosis, nanofiltration processes are used.

The aim of this study is to show status of the re-use of wastewater in agriculture in Turkey, the amount of the existing wastewater treatment plan, necessity of using waste water and the advantages of using waste water.

2. Water potential and waste water treatment plants in Turkey

Consumable groundwater and surface water potential is of 112 billion m^3 per year, although the 44 billion m^3 is used in Turkey (Anonymous, 2015). 32 billion m^3 of this water is used for irrigation. In this case, approximately 73% of Turkey's water resources' is used for irrigation. Along with this, with increasing population and developing industry, water demand is increasing. In 2023, it was determined that domestic water use would be 16% and water use for industry would be 20% in Turkey Environmental Status Report (Anonymous, 2011).

The development of water resources schemes is expected to be completed in 2030, in Turkey. In the final case, it is planned that 65% of the water potential of 110 billion m^3 per year will be used in irrigation, 23% will be used for drinking-use purposes and 12% will be used for industrial use. Currently, while amount of water used for

agriculture is %73 of total consumed water, it is believed that these value will be %65 in 2030 (Anonymous, 2017).

In Turkey, because majority of the water resources is used in agriculture sector, it is necessary to reuse the wastewater as an alternative source.

Table 1. Turkey municipal wastewater statistics (Anonymous, 2018).

Years	Total number of municipal ities	Number of wastewater treatment plants	Amount of wastewater discharged from municipal sewerage to receiving bodies (thousand m^3/year)	Total capacity of wastewater treatment plants (thousand m^3/year)	Amount of wastewater treated by total wastewater (thousand m^3/year)
1994	2740	41	1 509 651	586 877	150 061
1995	2801	46	1 632 534	606 736	169 287
1996	2827	55	1 679 239	690 441	201 902
1997	2835	68	1 920 322	1 245 719	365 719
1998	2834	80	2 096 714	1 559 087	589 515
2001	3227	125	2 301 152	2 287 918	1 193 975
2002	3227	145	2 497 657	2 358 507	1 312 379
2003	3227	156	2 860 980	2 805 164	1 586 550
2004	3225	172	2 922 783	3 410 352	1 901 040
2006	3225	184	3 366 894	3 648 198	2 140 494
2008	3225	236	3 261 455	4 143 140	2 251 581
2010	2950	326	3 582 131	5 293 204	2 719 151
2012	2950	460	4 072 563	5 562 075	3 256 980
2014	1396	604	4 296 851	5 940 579	3 483 787
2016	1397	881	4 484 075	5 941 049	3 842 350

According to data of TÜİK in 2018, there is declining numbers of municipalities, an increase in the amount of wastewater treatment plant, discharged wastewater, total capacity of wastewater treatment plants, and treated wastewater due to municipal data compared to years (Anonymous, 2018). In particular, the amount of wastewater treated after the beginning of 2000 has reached more than double value of wastewater obtained in 1998. Aware of Turkey's water scarcity can be understood with increse in wastewater treatment.

According to data of TÜİK in 2016 (Anonymous, 2016), with a total capacity of about 6 billion m^3 having 881 wastewater treatment plants in Turkey, only according to the Municipal data there is 4.5 billion m^3 of waste water discharged from the sewer network. Amount of treated water reused in agriculture was determined as 0.4% of discharged 4.5 billion m^3 wastewater. The rest is discharged to the sea, streams, reservoirs, lakes and ponds and other receiving environment. This study reveals unused 4.32 billion m^3 of water purification and maybe today we need less, but in later years the advantages of taking the necessary measures without delay with an emphasis on the importance of the necessity to use again in Turkey.

The total number of municipalities is 1397 in Turkey. The total number of wastewater plant based on municipalities is only 881. Of the 881 treatment plants, 55 are physically, 492 are biological, 135 are advanced and 199 are natural treatment plants. While the physical treatment plant capacity is 1,802 billion m^3, the amount of treated wastewater is 906 million m^3. While the biological treatment plant

capacity is 1,748 billion m^3, the amount of treated wastewater is 1,216 billion m^3, the capacity of the advanced treatment plant is 2,365 billion m^3, the amount of wastewater treated is 1,708 billion m^3, the capacity of natural treatment plant is 24,9 million m^3 and the amount of treated wastewater is 12,8 million m^3. In total of these data, only 3.64 billion m^3 of water with a capacity of 5.941 billion m^3, ie 64.64% of the total capacity, is being treated. If only 0.4% of this treated water is used in agriculture, 16 million m^3 of treated water is used in agriculture. This amount is quite insufficient compared to the 32 billion m^3 used in the irrigation in Turkey. If the untreated 4.32 billion m^3 of water is also treated not discharged to lake, pond, stream, sea; the ratio of water to irrigation drops from 73% to 62.7%. In this case, thanks to the water from the wastewater in our water resources are protected. Israel is the first worlwide to treat wastewater (75 %) and use it again in agriculture, while Spain is second with 12% in 2013 (Anonymous, 2016).

In Spain (Valencia region) 419 million m^3 of waste water was refined in 2015 and 34.73% (145.52 million m^3) of 419 million m^3 of treated wastewater was reused. 145.52 million m^3 was 91.87% T 133.69 million m^3 was used for irrigation purposes (Mudgal et a., 2015; Arahuetes, 2016). According to 2015 data in Israel, 400 million m^3 of 508 million m^3 of water has been used for irrigation (Tarchitzky, 2015)While the rate of water purification from wastewater treatment plant is 92-95% in Israel, this rate is 64.64% in Turkey. The amount of reuse treated wastewater in Arab countries is determined as 1.200 million m^3/year (with Syria, Saudi Arabia and Egypt being the most

predominant in this regard (Duman, 2017). The amount of treated wastewater in Jordan, Morocco and Algeria is 2.6-6 billion m^3 / year, most of which is used for agricultural purposes (Tanık et al., 2015). Use of waste water in Agriculture Turkey compared to European countries and North Africa countries, it is seen that Turkey is at quite a low level.

3. Treatment processes

Treatment plants are classified as physical, biological, advanced and natural treatment plants. Accordingly, it is necessary to pass these processes in order to remove the pollutants contained in the water. In the wastewater treatment plants the steps are:

3.1. Physical treatment: is a treatment process in which insoluble pollutants are removed from wastewater by settling or floating. Most common physical treatment units are screens, grit chambers, equalization basins, sedimentation tanks, flotation units, etc.

3.2. Biological treatment: is a treatment process in which dissolved organic substances that cannot be removed to the required extent by phsical and/or chemical methods are oxidized by microorganisms. Most common biological treatment operations are trickling filter, activated sludge and stabilization (oxidation) ponds.

3.3. Advanced treatment: indicates treatment processes that are employed following biological and/or chemical treatment processes in order to improve the water quality and remove pollutants that cannot be removed by other methods (nitrogen, phosphorus, heavy metals,

toxic organic substances, etc.):nitrification, denitrification, activated carbon adsorption, ion exchange, etc. are the most common advanced treatment techniques.

3.4. Natural treatment: settlement of pollutants in wastewater via artificial wetlands and treatment of wastewater by the plantation living in this environment.

4. Conclusions

In this study it was examined the use of wastewater in agriculture in Turkey and were compared with the results of some other countries. According to the results, the use of wastewater in agriculture is lower than Morocco, Tunisia, Algeria, Spain, Israel but higher than many Arab countries. In addition to global warming and population growth located in the arid and semi-arid regions in Turkey, in order to use more efficient water and water resources use of waste water in agriculture must to be widespread . In Turkey between 1998 and 2016, based on the municipal waste water treatment plant, the amount of discharged wastewater, the total amount of capacity wastewater plants, amount of treated wastewater are increasing.

In Turkey currently 32 billion m^3 water is used for the irrigation and 16 million m^3 of this water are treated water.This amount meets only a small portion of the water allocated to irrigation in Turkey and unfortunately it is insufficient. Countries with the largest share of wastewater use like Israel and Spain can treat 400-430 m^3 of water. While waste water treatment rate is %92-95 in Israel's wastewater treatment plant, this rate is % 64.64 in Turkey. If Turkey can

increase water treatment rate from %64.64 to %90-95 such as Israel, 16 million m^3 treated water value can remove 400 milyon m^3 or more. If reuse of water does not spread and the amount of treated water is not increased, it is inevitable that we will face a much bigger water hazard in the future. In the current situation, water shortage is estimated to be closer to the poverty line, which will change in the next 10 years due to water pollution factors. In order to avoid a possible water shortage and to use the water more efficiently, necessary precautions should be taken, the necessary infrastructure for the facilities should be provided, incentive systems should be developed and the subject matter of the project should be explained.

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