DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES NATURAL AND APPLIED SCIENCES

AN INVENTORY STUDY FOR MUNICIPAL SLUDGE PRODUCTION IN AEGEAN REGION-TURKEY

by
Adalet KAYA

February, 2012
İZMİR

AN INVENTORY STUDY FOR MUNICIPAL SLUDGE PRODUCTION IN AEGEAN REGION-TURKEY

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"AN INVENTORY STUDY FOR MUNICIPAL SLUDGE PRODUCTION IN AEGEAN REGION-TURKEY"** completed by **ADALET KAYA** under supervision of **ASSOC.PROF.DR. AZİZE AYOL** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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AN INVENTORY STUDY FOR MUNICIPAL SLUDGE PRODUCTION IN AEGEAN REGION-TURKEY

ABSTRACT

Recently, more disciplined studies are carried out in domestic waste water treatment in Turkey. To date, the chosen method that is applied to several projects was leading to problems during implementation because of the factors such as costs, climate conditions, operating problems. The modern plants built in parallel with developing technology and science, the applied projects have showed more successful results.

The vast amounts of sewage sludge have been produced at municipal wastewater treatment plants (WWTPs). The management of the sludges is a great challenge because produced sludge amounts to only a few percent by volume of the processed wastewater, but its handling accounts for up to fifty percent of total operating costs.

Although, many countries estimate their sludge production based on some criteria like wastewater characterization, wastewater collection systems, applied wastewater treatment technologies, etc., it is very limited to find a full inventory for the production, sludge processing and disposal during the municipal/domestic wastewater treatment. These kinds of inventory studies are required to be providing a sustainable sludge management.

In this thesis, the major municipal/domestic wastewater treatment plants were examined in the Aegean Region selected as pilot area, and the questionnaire in the Appendices of the thesis have been filled out by technical personnel, who are responsible for the plant operations, and the status of existing plants have been discussed according to the results of the inventory.

The wastewater treatment plants in Aegean region, which are located in the province of Muğla, have been mainly studied since the plants have changing flow-density depending on the touristic activities. The examined plants have been visited and compared with the other plants. The periodic observations of the municipal wastewater treatment plants have been done including summer and winter sessions.

In this thesis, the major municipal/domestic wastewater treatment plants in Aegean Region of Turkey, were examined based on an inventory study. The survey results have showed that although many practical applications are in progress for the sludge processing as well as the wastewater treatment, the information on the sludge production is very limited.

Keywords : Domestic wastewater, sludge, sludge management, sludge processing, sludge disposal methods, Aegean Region.

EGE BÖLGESİ'NDEKİ ARITMA ÇAMURU ÜRETİMİNE YÖNELİK ENVANTER ÇALIŞMASI

ÖZ

Evsel atıksu arıtma konusunda Türkiye'de geçmiş yıllara oranla, son zamanlarda daha disiplinli çalışmalar yürütülmektedir. Günümüze kadar uygulanan pek çok proje seçilen yöntem, maliyetler, iklim şartları, işletim problemleri gibi unsurlar nedeni ile uygulama esnasında sorunlara yol açmakta idi. Gelişen teknoloji ve bilime paralel yapılan modern tesisler, uygulamaya alınan projeler daha başarılı sonuçlar ortaya koymaktadır.

Evsel kentsel atıksu arıtma tesislerinde (AAT) önemli miktarlarda arıtma çamurları oluşmaktadır. Arıtılan atıksu miktarının hacim olarak küçük bir oranı arıtma çamuru olarak oluşmakla birlikte, bu çamurların arıtımı için gerekli yatırım ve işletim maliyeti toplam tesis maliyetinin yaklaşık yüzde ellisini oluşturmaktadır.

Pek çok ülkede arıtma çamurlarının miktarı, atıksu özellikleri, atıksu toplama sistemleri, uygulanan arıtma teknolojileri vb. göz önüne alınarak belirlenmesine rağmen, çamur miktarları, arıtımı ve bertaraf edilmesi konusunda tam envanter çalışmalarının oldukça sınırlı olduğu görülmektedir. Sürdürülebilir bir arıtma çamuru yönetiminin sağlanması için bu tür envanter araştırmalarına ihtiyaç duyulmaktadır.

Bu tezde pilot bölge seçilen Ege Bölgesindeki belli başlı evsel/kentsel atıksu arıtma tesisleri incelenmiş ve tezin ekler kısmında verilen anket, tesislerden sorumlu teknik personel tarafından doldurularak, mevcut tesislerin durumu envanter çalışması sonuçlarına göre tartışılmıştır.

Bu çalışmada turizm bölgesi olması nedeni ile değişen debilere hizmet veren tesislerin bulunduğu Muğla İline ait ilçe tesisleri yoğunluklu olarak incelenmiş ve inceleme yapılan tesislerin ziyaret edilmesi ile bu tesislerin diğer tesislerle kıyaslanarak değerlendirilmesi yapılmıştır. Belediyelere ait evsel atıksu arıtma tesislerinin yaz kış olmak üzere mevsimsel gözlemleri yapılmış ve arıtma tesislerinden kaynaklanan arıtma çamurlarının oluşumundan, bertarafına kadar geçen süreçte ne tür proseslere tabi tutulduğu ayrı ayrı incelenmiş ve tesislerden alınan bilgilere göre bu veriler kayıt altına alınmıştır.

Anahtar sözcükler: Evsel atıksu, arıtma çamuru, çamur yönetimi, çamur bertaraf etme yöntemleri, Ege Bölgesi.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

The vast amounts of sewage sludge have been produced at municipal wastewater treatment plants (WWTPs). The management of the sludges is a great challenge because produced sludge amounts to only a few percent by volume of the processed wastewater, but its handling accounts for up to 50% of total operating costs Although, many countries estimate their sludge production based on some criteria like wastewater characterization, wastewater collection systems, applied wastewater treatment technologies, etc., it is very limited to find a full inventory for the production, sludge processing and disposal during the municipal/domestic wastewater treatment. These kind of inventory studies are required to be provide a sustainable sludge management, which has become of greater concern, also because the conventional and more traditional recycling options, like utilization on land including agricultural usage purpose, are progressively restricted, and often banned, by legislation, thus requiring the development of innovative systems to maximize recovery of useful materials and/or energy (Spinosa et al., 2011). To solve the problem and establish a sustainable sludge management system, a full inventory study including wastewater and sludge information together is an important step.

This research study conducted in Department of Environmental Engineering at Dokuz Eylul University aimed to emphasize the importance of the sludge inventory studies to develop regional sludge management action plans for each region in Turkey within the upcoming years.

In this thesis, the inventory research has been done in the 13 municipal WWTPs. The study has been applied for the production of sewage sludge of the present WWTPs in major cities and towns of the Aegean Region of Turkey. The enclosed survey has been filled out with the technical staff working at the plants. The current status of the plants has been graphically interpreted according to the results of the survey. The applications in this region of Turkey have been compared with applications in the other regions in Turkey and some World countries.

1.2 Scope and Research Objectives of the Thesis

Inventory studies assemble the useful data in the field where research and control have been made. They have been also used as source for the planning and improvement studies. In the focus of the inventory studies, to induce the applicability of the current environmental legislation for the controlling of the environmental pollution and to determine the improvements needed for future planning are considered as important phenomena.

To solve the problems related to environmental pollution studies, practiced information from the existing plants should be determined at the end of inventory studies. However, it is commonly found that the inventory sources are insufficient.

It is obviously seen that such studies are also insufficient in Turkey when compared to researches made in the developed countries. Recently, within the framework of the transposing of European Union Directives on environmental legislation, although there are some improvements; however, they are very limited and insufficient information interims of data collection from the plants. Academic studies conducted in the universities and TUIK (Turkey Statistics Institute) data reveal the need for more studies and data collection for the environment database.

The aim of this thesis is to gather information with a survey based on the production of sewage sludge from WWTPs located in the western part of Turkey-Aegean Region, which was selected as pilot region. The research objectives of this thesis are therefore:

- to review the existing practical applications on wastewater and sludge treatment technologies in municipal WWTPs in the Aegean Region of Turkey,

- to analyze applications and processes in plants in terms of compliance with relevant legislation and the economic and technical dimensions,

- to investigate sludge productions produced at municipal WWTPs in the Aegean Region of Turkey.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter gives some information about the sludge processing and disposal methods and also sludge inventory studies.

2.2 Sludge Treatment/Disposal Methods

Throughout the wastewater treatment, depending on the applied wastewater treatment processes, different types of sludge have been produced. These are:

- **Primary sludge** – produced by settleable solids removed from raw wastewater in primary settling. This sludge has high putrescibility and good dewaterability when compared to biological sludge. Dried solids (DS) content in primary sludge vary between 2 and 7% (Turovskiy and Mathai, 2006);
- **Secondary sludge** (or *biological* sludge) – produced by biological processes such as activated sludge consisting of microorganisms, biodegradable matter (either soluble or particulate), endogenous residue, and inert solids. DS content in secondary sludge vary between 0.5 and1.5% (Turovskiy and Mathai, 2006);
- **Chemical sludge** – produced by precipitation of specific substances using some chemical like ferric salts or alum (i.e. phosphorus) or suspended solids.

In the sludge processing, a combination of any two or three of the above types can be introduced. Therefore, each unit of the sludge treatment processes has a unique function. Among the processes, thickening, conditioning-dewatering, and drying are the primarily methods used for removing water from sludge. Digestion, composting, and incineration are the methods used primarily for stabilization purpose to reduce the volatile solids and pathogenic microorganism contents of sludge (Metcalf & Eddy, 2003). Sludge treatment methods are summarized in Table 2.1. Possible options for sludge treatment and disposal in a municipal WWTP are given in Figure 2.1.

Table 2.1 Sludge processing and disposal methods (Metcalf & Eddy, 2003)

Unit operation/process/treatment method	**Function**
Pumping	Transport of sludge and liquid biosolids
Preliminary operations:	
Grinding	Particle size reduction
Screening	Removal of fibrous materials
Degritting	Grit removal
Blending	Homogenization of solids streams
Storage	Flow equalization
Thickening:	
Gravity thickening	Volume reduction
Flotation thickening	Volume reduction
Centrifugation	Volume reduction
Gravity – belt thickening	Volume reduction
Rotary – drum thickening	Volume reduction
Stabilization:	
Alkaline stabilization	Stabilization
Anaerobic digestion	Stabilization, mass reduction
Aerobic digestion	Stabilization, mass reduction
Autothermal aerobic digestion (ATAD)	Stabilization, mass reduction
Composting	Stabilization, product recovery
Conditioning:	
Chemical conditioning	Improve dewaterability
Other conditioning methods	Improve dewaterability
Dewatering:	
Centrifuge	Volume reduction
Belt – filter press	Volume reduction
Filter press	Volume reduction
Sludge drying beds	Volume reduction
Reed beds, Lagoons	Storage, volume reduction
Heat drying:	
Direct dryers	Weight and volume reduction
Indirect dryers	Weight and volume reduction
Incineration:	
Multiple – hearth incineration	Volume reduction, resource recovery
Fluidized – bed incineration	Volume reduction
Co-incineration with solid waste	Volume reduction
Application of biosolids to land:	
Land application	Benefical use, disposal
Dedicate land disposal	Disposal, land reclamation
Landfilling	Disposal
Conveyance and storage	Solids transport and storage

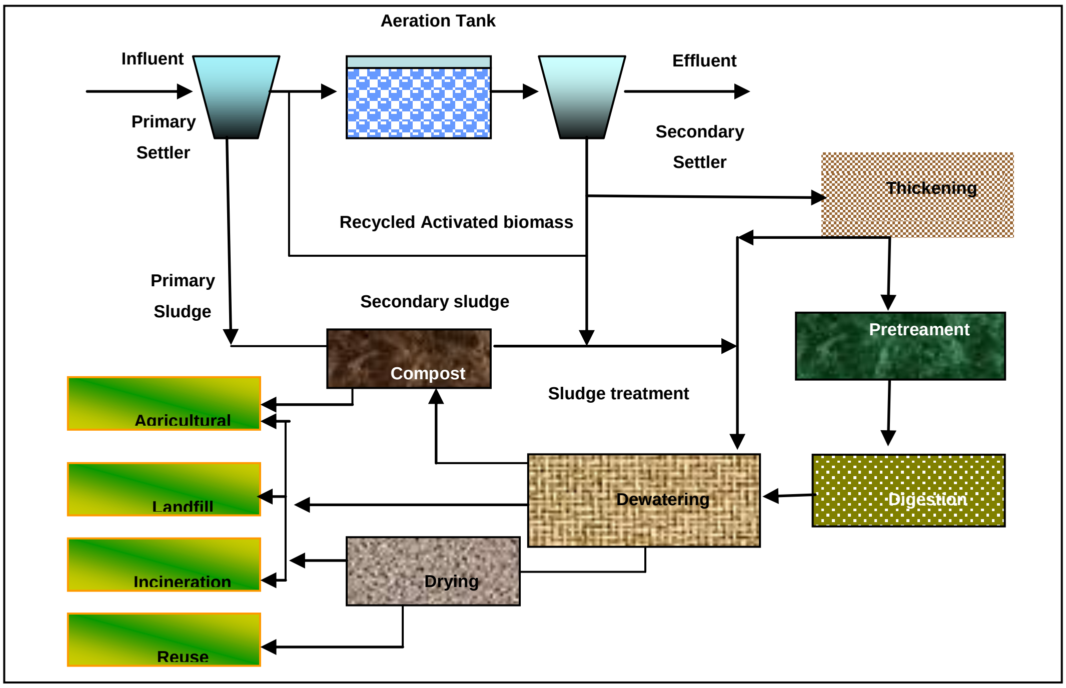


Figure 2.1 A typical sludge treatment network (Wang et al., 2004).

The cost for treatment + disposal of sludge in European countries has been estimated to reach, on average, approximately 500 € per ton of dry mass, depending on the applied treatment and disposal. Due to the increased sludge production, an increase in costs is expected. This situation led to promising the recovery of materials or energy from sludge, and also applications to reduce the amount of sludge produced. For this purpose, the current approach to sludge reduction addresses the two following aspects:

1) Reduction of volume of wet sludge;
2) Reduction of dry mass of sludge.

The increase of the solid content in sludge by dewatering significantly reduces the volume of wet sludge for disposal. The reduction of dry mass of sludge leads to the reduction of solid content and volume and this strategy should be favoured, because it allows the immediate reduction of sludge dry mass during its production in the biological treatment stage. Table 2.2 summarizes the methods (The book: Sludge Reduction Technologies in Wastewater Treatment Plants, IWA Publishing, 2010 http://www.iwapublishing.com/template.cfm?name=isbn9781843392781).

Table 2.2 The techniques integrated in sludge processing (Beddow, 2010)

MECHANISMS	**CELL LYSIS-CRYPTIC GROWTH**	**UNCOUPLED METABOLISM**	**ENDOGENOUS METABOLISM**	**MICROBIAL PREDATION**
TECHNIQUES INTEGRATED IN WASTEWATER SLUDGE HANDLING UNITS	- enzymatic hydrolysis - mechanical treatment - treatment with ultrasound - thermal treatment - chemical and thermo-chemical hydrolysis - oxidation with 03 or other oxidants -eletrical treatment - a combination of the above	- addition of chemical metabolic uncouplers -addition of a side-stream anaerobic reactor	-extended aeration processes, MBRs and granular sludge	- predation byprotozoa and metazoa

2.3 Sludge Characteristics

Depending on the sludge sources as mentioned above, the characteristics of the sludges vary according to the applied wastewater treatment techniques. However, sludge characterization is very important issue in sludge management since the characteristics strictly affect the selection and operation of the sludge processing units and also disposal/beneficial usage alternatives. The typical chemical composition and properties of untreated and digested sludge is given in Table 2.3 (Fytili and Zabaniotou, 2008; Metcalf&Eddy, 2003).

Table 2.3 The typical sludge characteristics (Metcalf&Eddy, 2003)

Item/sludge	**Untreated primary**		**Digested primary**		**Activated range**
	Range	**Typical**	**Range**	**Typical**	
Total dry solid (TS), %	2.0-8.0	5.0	6.0-12.0	10.0	0.83-1.16
Volalite solid (% of TS)	60-80	65	30-60	40	59-88
Grease and fats (% of TS)					
Ether soluble	6-30	----	5-20	18	----
Ether extract	7-35	----	----	----	5-12
Protein (% of TS)	20-30	25	15-20	18	32-41
Nitrogen (N, %of TS)	1.5-4	2.5	1.6-6.0	3.0	2.4-5.0
Phosphorous (P_2o_5,% of TS)	0.8-2.8	1.6	1.5-4.0	2.5	2.8-11.0
Potash (K_2O, % of TS)	0-1	0.4	0-3.0	1.0	0.5-0.7
Cellulose (% of TS)	8.0-15.0	10.0	8.0-15.0	10.0	----
Iron (not as sulfide)	2.0-4.0	2.5	3.0-8.0	4.0	----
Silica (SiO_2 % of TS)	15.0-20.0	----	10-20	----	----
Alkalinity (mg/l as $CaCO_3$)	500-1500	600	2500-3500	----	580-1500
Organic acid (mg/l as Hac)	200-2000	500	100-600	3000	1100-1700
Energy content	10,000-12,500	11,000	4000-6000	200	8000-10000
pH	5.0-8.0	6.0	6.5-7.5	7.0	6.5-80

Apart from the typical pollutants available in municipal sludges given above, heavy metals like Al, Cd, Co, Cu, Cr, Fe, Mn, Hg, Mo, Ni, Pb, Ti and Zn are available. The metals are principal elements restricting the use of sludge for land application (Alonso A ` lvarez et al., 2002). The more important and recent concern in the sludge chracterization is the presence of organic contaminants (OCs) (Fytili and Zabaniotou, 2008). The list of potential contaminants that have been detected in sludge includes: products of incomplete combustion (polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and dioxins), solvents (e.g. chlorinated paraffins), flame retardants (e.g. polybrominated diphenyl ethers), plasticisers (e.g. phthalates), agricultural chemicals (e.g. pesticides), detergent residues (e.g. linear alkyl sulphonates, nonylphenol ethoxylates), pharmaceuticals and personal care products (e.g. antibiotics, endogenous and synthetic hormones, triclosan) (Smith, 2008; Fytili and Zabaniotou, 2008).

While some countries have set limits for some OC groups, the others have no any limit fort hem. For example, UK, USA and Canada have not set any limit; Germany has set limits for PCBs and dioxins but not PAHs while France has limits for PAHs and PCBs but not dioxins. Denmark has set limits for a range of OCs including linear alkyl sulphonates, nonylphenol and nonylphenol ethoxylates and the phthalate, di(ethylhexyl)phthalate (DEHP) (Fytili and Zabaniotou, 2008).

Although there are many harmful pollutants in the sludge, the nutrient contents and calorific value of sludge led to diverse the disposal routes to beneficial usage alternatives of them. The nutrients found in sludge are considered as valuable elements for growing crops. Typically, wastewater sludge contains the following percentages of the major plant nutrients: 1-8 % nitrogen (N), 0.5-5 % phosphorus (P) as P_2O_5, and <1 % potassium (K) as K_2O (Global Atlas of Excreta, Wastewater Sludge, and Biosolids Management, 2008) The major nutrients in representative wastewater sludges and biosolids are given in Table 2.4

Table 2.4 Major nutrients in representative wastewater sludges and biosolids (Global Biosolid Atlas, 2008)

	N (%)	**P_2O_5 (%)**	**K_2O (%)**
The Benchmark solidge	3.5	3.5	0.2
Austrialia: Pert average biosolid (Gale, 2008)	7.4	1.8	0.97
Brazil average wastewater sludge (Andreoli et al. 2008)			
Canada: Greater Moncton Sewerage Commission avarage biosolids (LeBlanc and Richard, 2008)	2.1	0.5	0.1
Finnish average wastewater sludge (Rantanen, 2008)	3.4	2.4	No data provided
Italy :Sardinia average biosolid used in agriculture (Spinosa, 2008)			
Turkey: Izmir Guneybatı WWTP average wastewater sludge (Filibeli and Ayol, 2008)	1.68	0.68	0.49
USA:Milwaukee, WI Milorganite (Schlecht, 2008)	5.8	4.35	0.43

Data are given as percent dry weight and are from the individual reports in the Biosolid Atlas.

2.4 Sludge Quantity and Disposal Routes in EU Countries

About 10 million tons DS of sewage sludge were produced in the EU-27 countries. *This is probably underestimating the total quantities produced as not all of the Member States had provided up to date figures for the latest Commission survey (2003-2006) and figures from the previous survey (1999-2002) (EC, 2006) or from other sources were included in the Table 2.5* (Environmental, economic and social impacts of the use of sewage sludge on land Final Report, 2010). 37% of the produced sludge is recycled in agriculture.

Table 2.5 Recent sewage sludge production and quantities recycled to agriculture in the 27 EU Member States (Doujak 2007, EC, 2006, EC, personal communication, 2009, IRGT 2005)

Member state	**Year**	**Sludge production(t DS)**	**Agriculture(t DS)**	**(%)**
Austria(a)	2005	266,100	47,190	18
Belgium				
Flemish region	2006	76,254	1,981	3
Wallon region	2003	23,520	11,878	50
Brusseles region	2002	2,97	878	31
Denmark	2002	140,021	82,029	59
Finland	2005	140,000	4.200	3
France	2006	910,225	524,290	58
Germany	2006	2,059,351	613,476	30
Greece	2003	125,977	56,4	0
Ireland	2003	42,147	26,743	63
Italy	2006	1,070,080	189,554	18
Luxembourg	2003	7,750	3,300	43
Netherlands	2003	550,000	34	0<
Portugal	2002	408,710	189,758	46
Spain	2006	1,064,972	687,037	65
Sweden (e)	2006	210,000	30,000	14
United kingdom	2006	1,544,919	1,050,526	68
Sub-total EU 15		8,649,848	3,462,839	40

Table 2.5 Continued

Member state	**Year**	**Sludge production(t DS)**	**Agriculture(t DS)**	**(%)**
Bulgaria	2006	29,987	11,856	40
Cyprus	2006	7,586	3,116	41
Czech republic	2006	22,070	8,300-25,400	4-12
Estonia(d)	2005	Nd	3,316	?
Hungary	2006	128,380	32,813	26
Latvia	2006	23,942	8,936	37
Lithuania	2006	71,252	16,376	22
Malta				
Poland	2006	Nd	Nd	Nd
Romaina	2006	523,674	88,501	17
Slovakia	2006	137,145	0	0
Slovenia	2006	19,434	27	0<
Sub-total EU 12		1,216,880	190,3418(f)	17
TOTAL		9,866,728	3,653,180	37

Table 2.6 shows the disposal methods for sewage sludge in EU Member States. As can be seen from the table, incineration and landfilling are the main disposal methods to agricultural recycling for sludge management. It is reported that the amount of sludge to be incinerated significantly increases when recycling is discouraged or prohibited (Service contract No 070307/2008/517358/ETU/G4).

Table 2.6 Disposal methods for sewage sludge in EU Member States as percentage (AMF 2007, Doujak 2007, Eureau 2006 reported by Smith 2008, IRGT 2005, Leonard 2008, COM personal communication, 2009) (Service contract No 070307/2008/517358/ETU/G4 *Environmental, economic and social impacts of the use of sewage sludge on land*)

Member state	**Year of the data**	**Agriculture**	**Landfiil**	**Incineration**	**Other**
Austria	2005	18	1	47	34
Belguim					
Flemish region(b)	2005	9		76	14
Wallon region (c)	2005	32	6	62	
Brusseles region (d)	2002	32	2	66	
Denmark	2002	55	2	43	
Finland	2000	12	6		80(f)
France(g)	2002	62	16	20	3
Germany (h)	2003	30	3	38	29(i)
Greece (j)			>90%		
Ireland	2003	63	35		3
Italy		32	37	8	22(k)
Luxemborg	2004	47		20	33(I)
Netherlands(m)	2006	0	60	40	
Sweden		10-15		2	90-85(m)
UK	2004	64	1	19,5	15,5(o)
Bulgaria (p)	2006	40	60		
Czech republic (q)	2004	45	28		26
Hungary(r)	2006	26	74		
Poland (s)	2000	14	87		7
Romania (t)		0			
Slovenia	2006	>1	50		49
Slovakia	2006		17		83

2.5 EU Legislation on Sludge Management

The main directive on the sludge management in EU is the **Directive 86/278/EEC** “the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture”. It has article explaining the sewage sludge to be treated before it is used in agriculture. The other directives related with sludge management are given below.

Directive 91/271/EEC Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment related with the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. Under the Directive, Member States authorities must also publish the situation reports on the disposal of urban waste water and sludge in their areas.

Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. It concerns **the** reducing water pollution caused or induced by nitrates from agricultural sources and preventing such pollution. It also regards the spreading of sewage sludge.

Directive 99/31/EC Council Directive 99/31/EC pf 26 April 1999 on the landfill of waste (Landfill Directive). It encourages the recovery of value from waste products and to reduce the disposal of biodegradable wastes in landfill.

Directive 2000/76/EC of the European Parliament and the Council of 4 December 2000 on the incineration of waste. Dry sewage sludge can be incinerated to produce energy. Sewage sludge falls within the category of waste.

Directive 2000/60/EC of the European Parliament and the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive (WFD)). Cadmium, lead and mercury are designated Priority Hazardous Substances under the Water Framework Directive 2000/60/EC.

Directive 2008/105 on environmental quality standards in the field of water policy. This Directive lays down environmental quality standards (EQS) for priority substances and certain other pollutants with the aim of achieving good surface water chemical status. Member States might apply stricter measures to sewage sludge in order to respect these environmental quality standards.

Directive 2006/118/EC on the protection of groundwater against pollution and deterioration. Annex 1 of the Directive sets some groundwater quality standards; the spreading of sewage sludge will need to ensure that contaminants do not contaminate groundwater.

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

EC Regulation 1907/2006, concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Sludge producers are not directly affected by the REACH Regulation. However REACH will have an indirect impact on the sewage sludge composition, as it may lead to a reduction in the levels of chemicals contained.

Commission Regulation (EC) No 466/2001. This regulation sets maximum levels for certain contaminants in foodstuffs set limits for Cadmium in foodstuffs. The spreading of sewage sludge thus needs to respect these limits.

Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No2092/91. It is clear from the directive is that the application of material coming from non-organic production, including sewage sludge, is not allowed for organic production.

Decision 2006/799 establishing revised ecological criteria and the related assessment and verification requirements for the award of the Community eco-

label to soil improvers. Soil improvers containing sewage sludge shall not be awarded an eco-label.

Decision 2007/64 establishing revised ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to growing media.

2.6 Costs

The sludge processing units like thickening, stabilization, conditioning-dewatering, drying, and also disposal applications like landfilling, incineration, composting, etc. have capital and operating costs. Regarding the operating costs, energy consumption is the major component. A costing exercise for the European Commission was reported in ‗Disposal and recycling routes for sewage sludge (Sede and Andersen, 2002). This analysis results can be seen from Figure 2.2 including operating costs and annualized investment costs for capital items.

Figure 2.2 shows also any benefits from energy recovery but not the value of displaced as chemical fertilizer. The value of displaced chemical fertilizer plus additional crop yield for a range of sludge products is given in Figure 2.3. Estimated percentage of total wastewater costs required for wastewater sludge management for different countries is given in Table 2.7 (Global Bisolids Atlas, 2008).

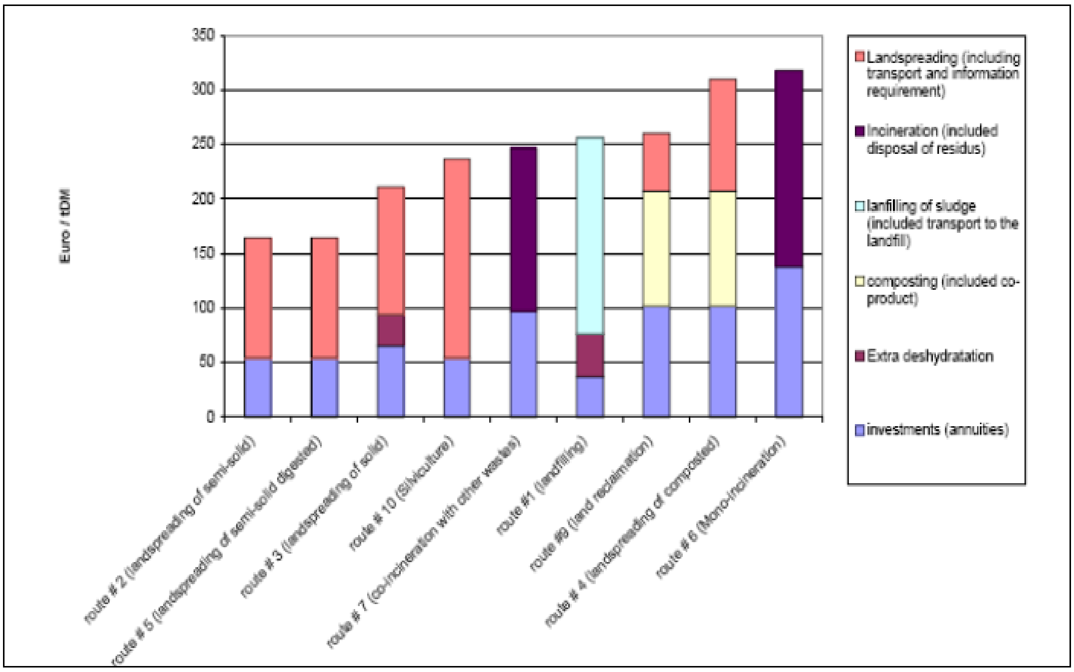


Figure 2.2 : Average internal costs of sludge disposal and recycling in Europe (Euro/ tonne dry matter) (From SEDE AND ARTHUR ANDERSEN (2002) *Disposal and Recycling Routes for Sewage Sludge*, European Commission, DG Environment – B2, 2002. Available at: http://ec.europa.eu/environment/waste/sludge/sludge_disposal.htm)

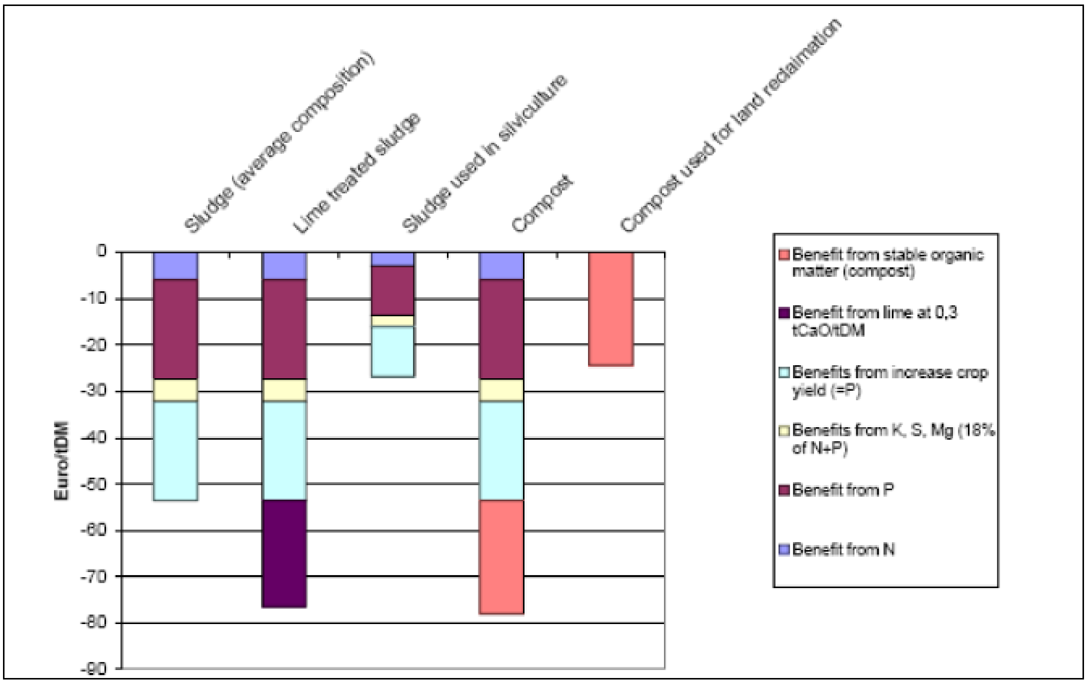


Figure 2.3 Internal benefits of sludge recycled to land (€/tDM) (From SEDE AND ARTHUR ANDERSEN (2002), at: http://ec.europa.eu/environment/waste/sludge/sludge_disposal.htm)

Table 2.7 Estimated percentage of total wastewater costs required for wastewater sludge management (Global Bisolids Atlas, 2008)

Country or City	Estimated percentage of total wastewater treatment costs attributable to wastewater sludge treatment and management
Austria	45 %
Bulgaria	20 %
Canada:Greator moncton	50 %
Canada:Ontario	50 %
Canada: Montreal Quebec	45 % (operations &maintenance only)
Canada: British Columbia	30 %
Canada: alberta	18 %
Czech republic	57 % (operations &maintenance only)
China	40 %
Columbia	3 %
England	18 %
Japan : Tokyo	36 %
Norway	50 % (20 % estimaned in 1996 Atlas)
Russian federation	24 %
Slovakia	40 %
Turkey	45 %
USA: Milwaukee ,WI	57 % (operations &maintenance only)

CHAPTER THREE
SLUDGE MANAGEMENT in TURKEY

3.1 Introduction

This chapter gives some information about the sludge processing and disposal practices in Turkey. It also reviews the Turkish environmental legislation on sludge management.

3.2 Current Situation on Sludge Management in Turkey

On the road of the accession of European Union, Turkey has transposed the environmental legislation from EU to the national legislation. Even, a priority list published in the Turkish National Programme for Adoption of the EU Acquis (Official Gazette No. 25178 of 24.07.2003) (Filibeli and Ayol, 2008).

Turkey has 16 greater municipalities, 3,225 municipalities, and more than 37,000 villages. The 70.5% of the total population of about 72 million lives in the cities. Because of the social-economical reasons, population distributions differ from region by region. While most of the population have settled in the big cities especially in the western part of Turkey, municipalities with a population less than 1,000,000 are located in the central part (Ayol and Filibeli, 2011; TUIK 2007).

Turkish Statistical Institute (TUIK) is the official institute, which is responsible for the data collection, evaluation and reporting in all sectors either public or private. TUIK also publishes energy and environmental statistics of Turkey and reports them to European Comission Statistcs (EuroStat). *Data OECD/EUROSTAT –The environmental data and indicators are compiled in accordance with data set within the framework of wastewater statistics. Municipalities are used as a source of data, a survey carried out within the scope of the work of the municipal wastewater Statistics amount of wastewater discharged to receiving environments in the* *municipalities, the percentage of population served by the sewer system, wastewater treatment plants type, capacity, and the amount of treated wastewater, wastewater treatment plants in the analysis results of input and output, applied to the compacting process and the amount of sewage sludge disposal have been compiled. Units in the municipalities responsible for wastewater services are compiled by surveys, and data is collected. The data within the scope of National basis have been compiled in accordance with the Turkish Statistics Law No. 5429 with date 10.11.2005. The principles of the Municipal Waste Statistics have been determined with Official Statistics Programme and improvements realized with update works to be done with the same program. The previous year's data are compiled through surveys. National Data release calendar is published on the specified period of time* (http://www.tuik.gov.tr/MetaVeri.do?tb_id=10&ust_id=3).

Depending on the TUIK database, based on the population served by the sewerage systems, the connection rate is almost 63%. The rates of population served by sewerage systems and wastewater treatment plants in total municipal population are 86% and 45%, respectively, by the year 2004. The rate of population served by wastewater treatment plants in total municipal population has been significantly increased up to 65% and 68% by the years 2008 and 2009, respectively. Based on 2004 Statistical Energy and Environmental Data of TUIK, the ratio of population served wastewater treatment plants to total population is considered as 37% and the assuming solids production as 60 g/c/d, the amount of municipal sludges can be estimated as 1,600 t/d (Filibeli and Ayol, 2007).

When the TUIK environmental database is reviewed, the indicators of waste water finally taking part in urban wastewater treatment plants statistical data for year 2008. The data published by TUIK (2010) based on the statistical evaluation of 2008 have shown that the total number of the WWTPs was 236, of which 29 have only physical treatment units, 158 biological treatment units, 32 advanced biological treatment units, including both phosphorus and nitrogen removals, while the rest are natural treatment systems, like wetland. The number of constructed municipal/domestic WWTPs was drastically enhanced. In Turkey, although small part of the sewerage systems are in operation as combined systems, most of them have been constructed as separate systems. The number of MWWTPs is announced as 298 based on the information published by the Ministry of Environment and Forestry in 2010 (Ayol and Filibeli, 2011). Figures 3.1 and 3.2 show the municipal WWTPs for the years 2001 and 2008, respectively. Analyzing data from TUIK for 2008, the amount of wastewater discharged to the sewer network is 3.6 billion m^3 and the treated wastewater amount is 2.25 billion m^3. The treated wastewaters has directly been discharged to receiving environments, 44.7% to seas, 43.1% to rivers, 3.5% to dams, 2.1% to lakes and ponds, 1.5% to land, and 5.1% to other receiving environments.

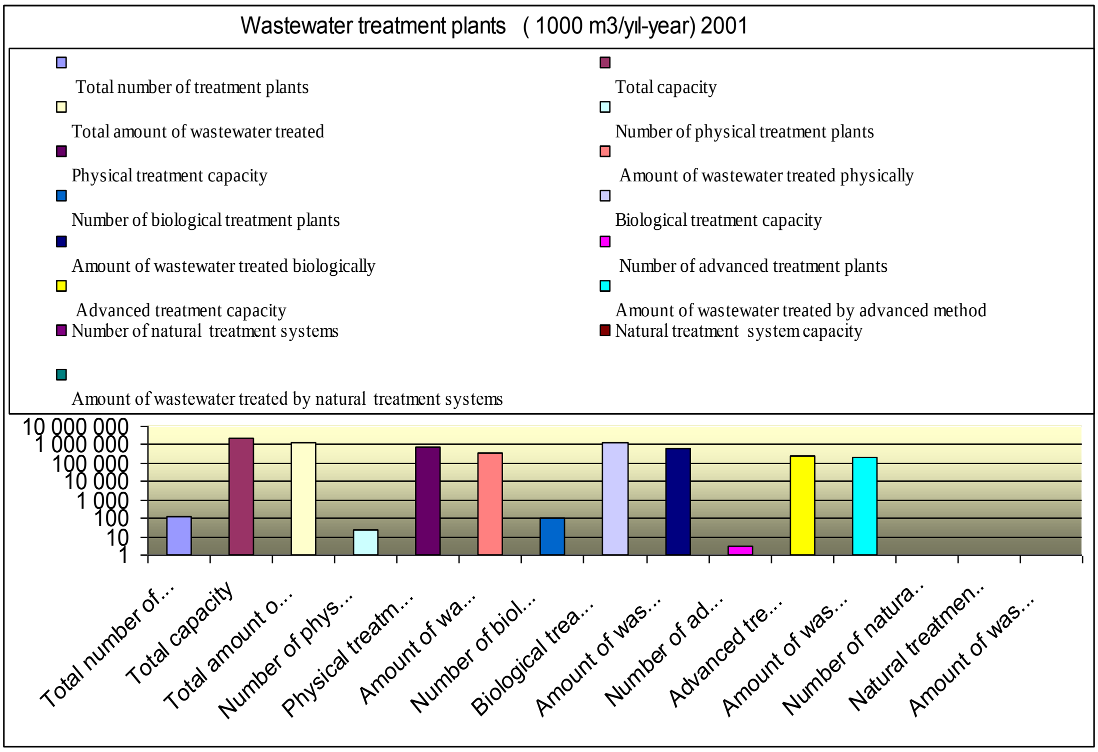


Figure 3.1 Municipal wastewater treatment plants of Turkey, 2001 (Source: TUIK, 2008)

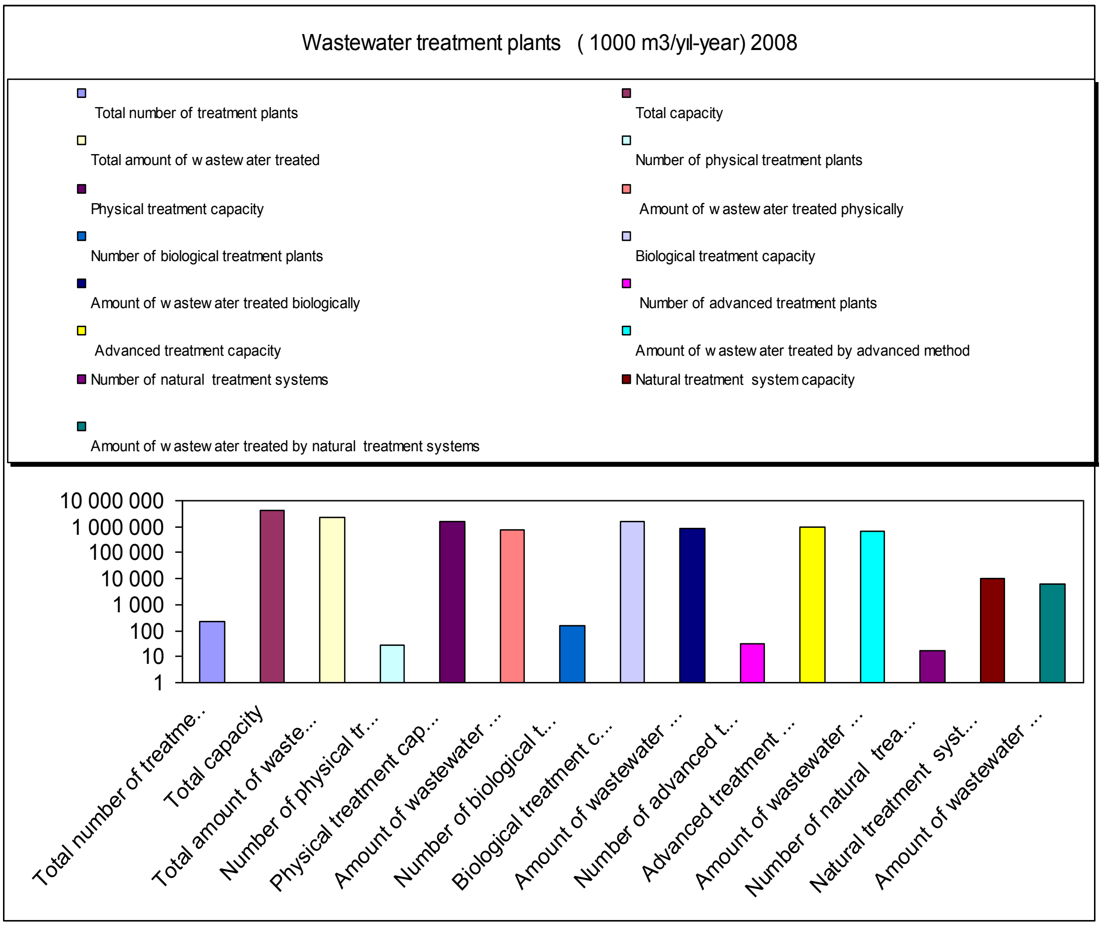


Figure 3.2 Municipal wastewater treatment plants of Turkey, 2008 (Source: TUIK, 2008)

Early wastewater/sludge treatment applications in Turkey include the trickling filters or conventional activated sludge systems as biological treatment units having sludge drying beds following by aerobically sludge stabilization. Sludge drying beds without aerobically stabilization had been used for extended aeration activated sludge units. Dried sludges have been landfilled or used for agricultural purposes. Regarding the strict limits for discharging effluents, population growth rates, environmental requirements, advanced treatment units for nutrient removals have been constructed for last decade (Ayol and Filibeli, 2011). The new plants also included advanced sludge handling processes like anaerobically stabilization units and mechanical dewatering equipments (Filibeli and Ayol, 2007). Even some wastewater treatment plants upgraded their mechanical dewatering units-changed belt-filter presses with centrifugation decanters to enhance the sludge dried solids content.

The selection of disposal methods varies from plant to plant regarding technical requirements detailed by legislation and local conditions in Turkey. The most applied alternative is landfilling for processed sludges either in special areas or in municipal solid waste disposal area. The second alternative is composting with organic fractions of municipal solid wastes or other wastes, like livestock. The technical requirements for compost quality are given in Turkish Solid Waste Control Regulation. The composted product is used for reclamation purposes in recreational areas if it has enough hygiene quality. Other alternatives of beneficial usage of sludge like energy recovery from sludges are still under research by universities, governmental institutions, and the administrations of the plants. Incineration as a final disposal method is not common in Turkey. Only one big plant namely IZAYDAS, established in 1997, for all hazardous wastes, industrial sludges, etc. is properly working in Izmit/Kocaeli, Marmara Region. A petrochemical complex namely Petkim located in Izmir has also an incineration plant accepting sludge and other hazardous wastes to be incinerated in Aegean region. Some cement producers have a license for beneficial uses of sludge as supplementary fuel in cement factories (Ayol and Filibeli, 2011).

3.3 Environmental Legislation on Sludge Management in Turkey

Turkey has made many progresses regarding the environmental legislation. The Ministry of Environment and Forestry (MoEF)-which was recently called as Ministry of Environment and City- has legitimized the importance of environment with regulations published in recent years and the applicable legislation, regulations with audit-based studies. As a milestone, the Law on Environment, nr. 2872, was established in 1983 and amended in 2006. All regulations and legislations including Water Pollution Control Regulation, Air Pollution Control Regulation, Solid Waste Control Regulation, Environmental Impact Assessment Regulation, Soil Pollution Control Regulation, Hazardous Waste Regulation, and Urban Wastewater Treatment Regulation, etc. have come into force under the LE, which is an umbrella act for environmental protection in Turkey (Ayol and Filibeli, 2011). Most of the regulations have amended and also new regulations from EU have been transposed.

MoEF also planned EU Water Framework Directive to be come into force by the year of 2011. in Turkey.

LE did not include any special regulation and technical legislation on the sludge management up to the year 2010. However, some special articles and limitations on sludge management had existed in the applied regulations like Water Pollution Control Regulation, Solid Waste Control Regulation, and Hazardous Waste Regulation. However, the regulations dealt with general applications on sludge management, but not enough for the special cases to solve the problems. MoEF has revised the *Soil Pollution Control Regulation* by dividing into two separate regulations: Soil pollution control and contaminated site with point sources regulation (8 June 2010) and Agricultural usage of domestic/municipal sludges (3 August 2010). The second regulation defines limits of heavy metals and organic micropollutants for stabilized sludge applications for the agricultural and/or land application purpose (Ayol and Filibeli, 2011).

Water Pollution Control Regulation (WPCR, 2004) - Sludge is considered as a pollutant for receiving area and discharging of sludge into a water reservoir or sea and shore is prohibited. To protect groundwater, all chemical tanks, sludge storage tanks, and special waste storage tanks should be constructed by using non-permeable material.

***Solid Waste Control Regulation (SWCR)* –** This regulation has many articles and restrictions on sludge management. SWCR covers limitations for transportation, landfilling (e.g. sludge with water content >65% cannot be stored in MSW landfill), incineration, composting of sludges produced either municipal or industrial wastewater facilities.

***Hazardous Waste Regulation (HWR, revised in 2006*) -** The fundamentals of handling and disposal of sludges containing hazardous materials, such as PCBs, cyanide, phenolic substances, etc., are regulated under HWR.

Soil Pollution Control Regulation (SPCR, 2005) - It covers technical aspects and restrictive on soil pollution prevention techniques, sludge disposal, and its agricultural usage. In addition to other regulations, the regulation gives limitations and general principles for raw sludge, treated-stabilized sludge, and compost material. SPCR is almost the same with European Directive 86/278/EEC on the agricultural use of sludge. SPCR was recently divided into two separate regulations as mentioned above.

Urban Wastewater Treatment Regulation (UWTR, 2006) - UWTR covers the use and restrictions of sewage sludge. It is forbidden to discharge of all kinds of solid wastes, sewage sludge, and septic sludges to receiving water media. In appropriate conditions, municipal sewage sludge can be reused. UWTR is almost the same of Directive 91/271/EEC.

Communiqué on Wastewater Treatment Plant Technical Procedures (Official Gazette Date: 20.04.2010 Official Gazette Issue: 27527) - This Communiqué has been prepared in order to organize basic technical procedures and practices to be used for disposal of sludge.

Waste Management Regulation (Official Gazette Issue: 26927, 05.07.2008) - Appendix 4 of the regulation classifies the sludges produced at municipal/domestic WWTPs as non-hazardous waste while industrial sludges are categorized as M (mirror) possibly hazardous waste.

Waste Landfilling Regulation (Official Gazette Issue: 27533, 26.03.2010) - It regulates the landfilling of the waste including treatment plant sludges.

Waste Incineration Regulation (Official Gazette Issue: 27721, 06.10.2010) –It regulates the requirements for the waste incineration plants. In addition, it also regulated the incineration of the sludges either in cement factories as a supplementary fuel or in other industrial applications.

Land Application of Stabilized Domestic/Municipal Sludges Regulation (Official Gazette Issue: 27661, 03.08.2010)- It regulates the limits of heavy metals and organic micropollutants for stabilized sludge applications for the agricultural and/or land application purpose.

Communiqué on Recycling of Some Non-Hazardous Wastes (Official Gazette Issue: 27967, 17.06.2011)- It regulates the collection, temporarily storage, and recycling of the non-hazardous wastes. In addition, the technical rules for the recycling of the sludges having non-hazardous property are regulated within this communiqué.

3.4 EUROSTAT

European Institute of Statistics has regularly collected data from the European countries. However, there is almost no data for Turkey until 2009 regarding the environment statistics. There is an increase in data records between the years 2009 - 2011. This shows that the inventory studies are done in recent years for data collection; however, it is not sufficient.

EUROSTAT-published the urban waste water treatment methods consisting of data from 37 countries in 2009. Total sludge production and disposal methods applied in the countries are given between the Figures 3.3 and 3.7. There is no data reported for Turkey from the Eurostat database.

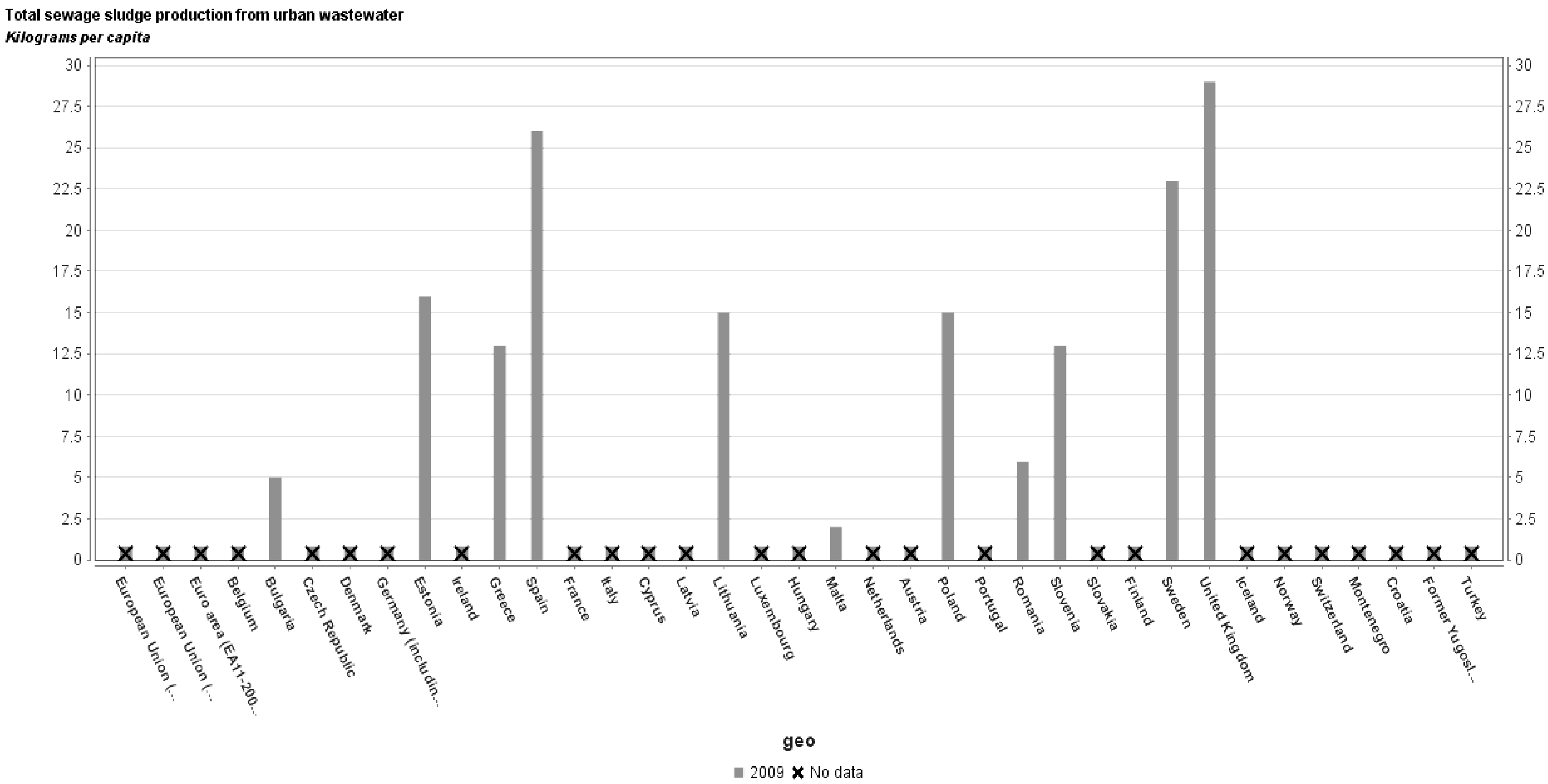


Figure 3.3 Total sewage sludge production from urban wastewater , EUROSTAT, 2009

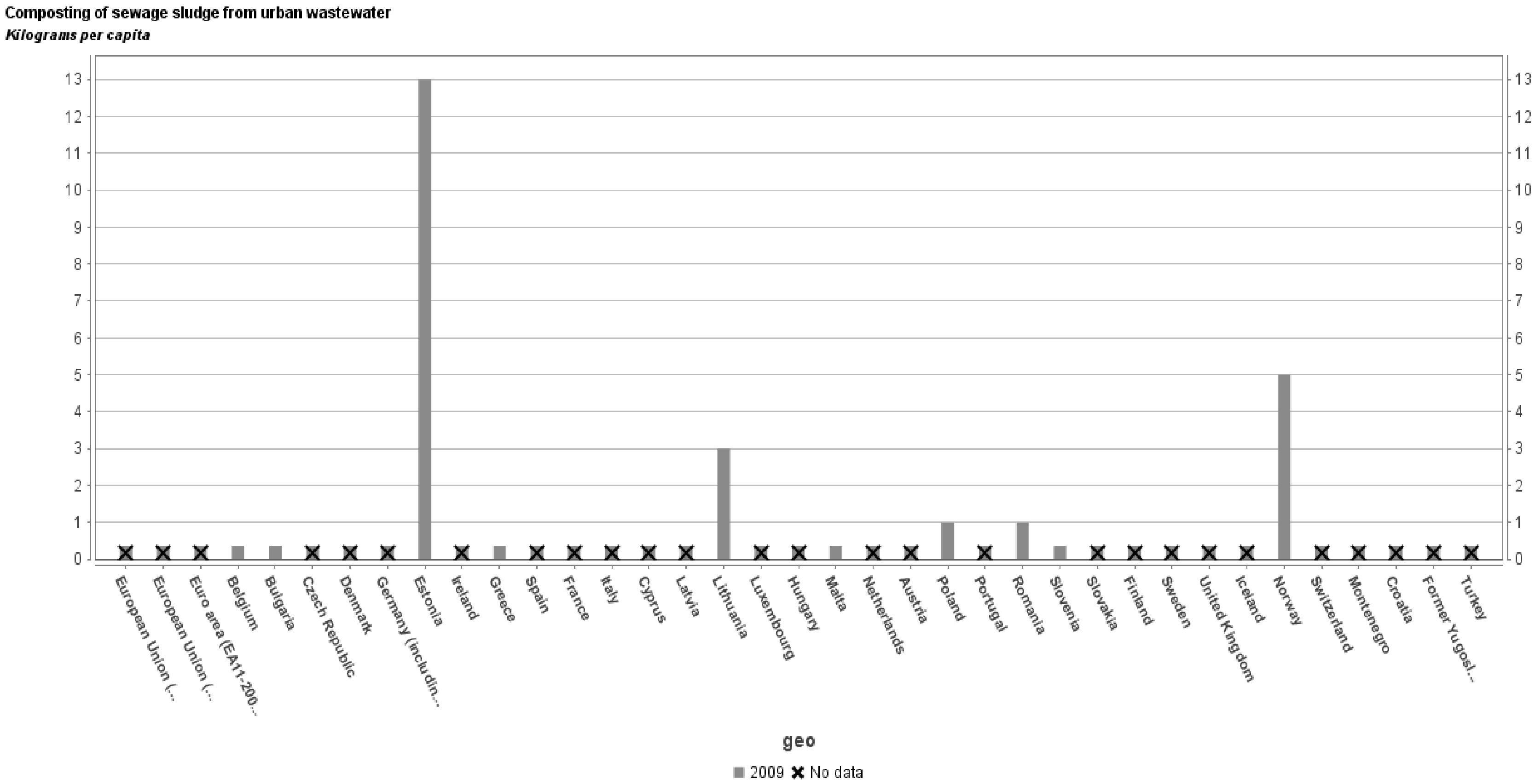


Figure 3.4 Composting of sewage sludge from urban wastewater, EUROSTAT,2009

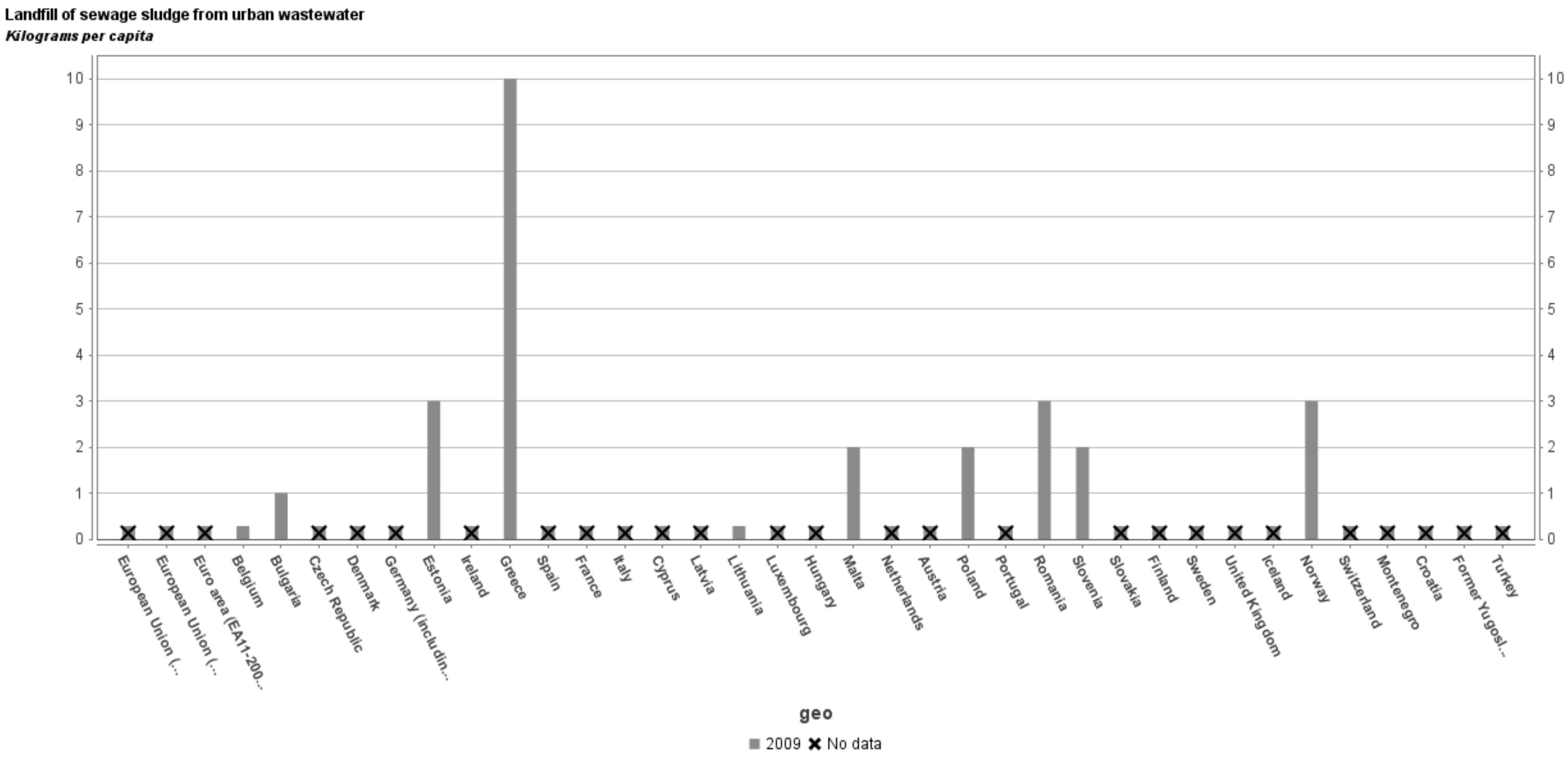


Figure 3.5 Landfill of sewage sludge from urban wastewater, EUROSTAT, 2009

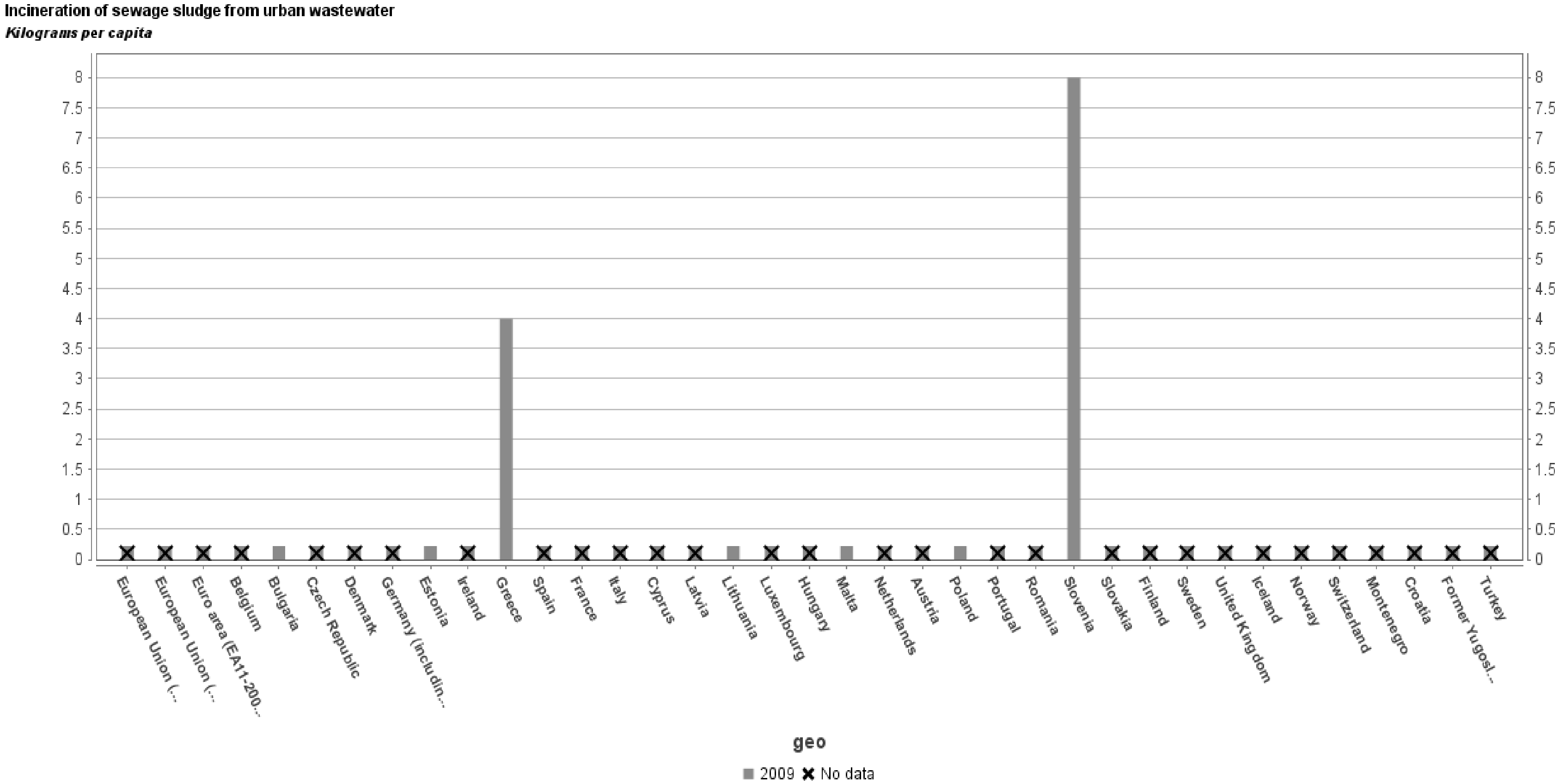


Figure 3.6 Incineration of sewage sludge from urban wastewater, EUROSTAT, 2009

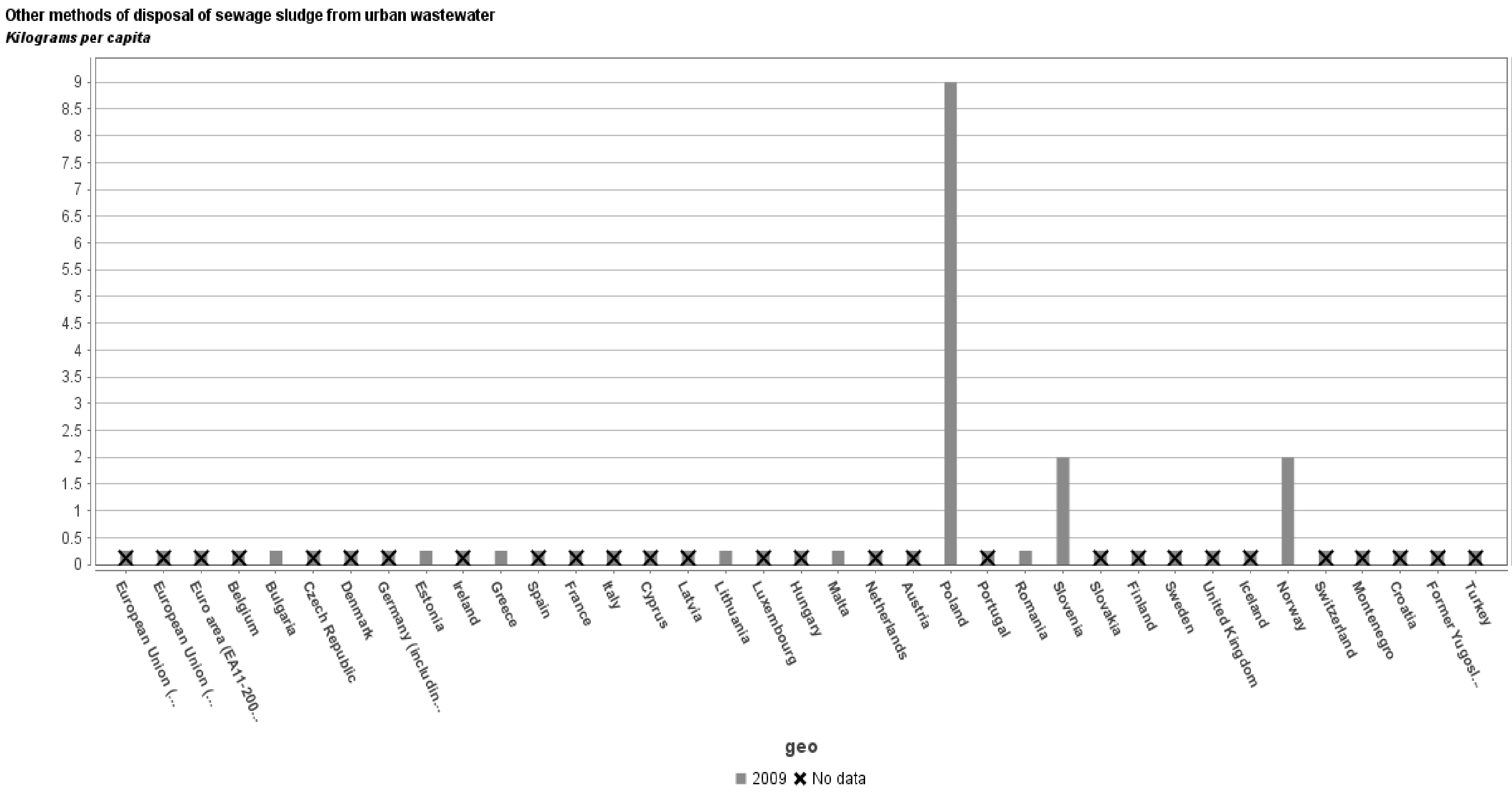


Figure 3.7 Other methods disposal of sewage sludge from urban wastewater, EUROSTAT, 2009

CHAPTER FOUR
INTRODUCTION of the WORKING AREA

4.1 Introduction

This chapter gives some information about Aegean Region where the inventory study was applied.

4.2 Aegean Region of Turkey

The Aegean region, which has the longest coastline of Turkey, is surrounded by Central Anatolia in the east, Marmara in the north, the Mediterranean in the south, and the Aegean sea in the west. This region has many industrial activities as well as agricultural applications. Fertile soils, climate and transportation conditions are favorable in the region and agriculture and tourism are often a source of livelihood of the population (wikipedia, September 2011).

This region has 8 provinces: Izmir, Denizli, Manisa, Muğla, Kütahya, Aydın, Uşak, and Afyonkarahisar. Among them, Izmir is the biggest city in terms of population -ranks third with 5.4% of Turkish total population (3,948,848 populations)-, industrial and other activities. There are Aliağa Oil Refinery, the automotive, metal product, chemical, ceramic, textile, cement, tobacco and olive oil industries in the İzmir, which is the region's most important city with industry, trade fair, and export port; weaving and olive oil industries in Denizli and Manisa; sugar, textile and leather industries in Uşak; sugar, cement, paper, and marble industries in Afyonkarahisar; carpet industries in Uşak; olive oil and figs processing plants in Aydın. Mugla is known as touristic city including many touristics settlements and also its some towns have industrial activities like Yatağan Coal Power Plant, marble mining sites and sand mining sites.

The Aegean Region is the second region of Turkey with the highest population density. Region's population of 62.2% percent lives in urban centers (Results of TUIK Address Based Population Registration System of the Year 2010). The population data of the Aegean region is given in Table 4.1. Figures 4.1 and 4.2 show the borders of the region and the working area.

Table 4.1 TUIK, Total population data by province. (31 December, 2010)

#	City	2009 Census	2010 Census
1	İzmir	3 868 308	3 948 848
2	Denizli	926 362	931 823
3	Manisa	736 884	740 643
4	Kütahya	571 804	590 496
5	Aydın	979 155	989 862
6	Uşak	335 860	338 019
7	Afyonkarahisar	701 326	697 559
8	Muğla	802 381	817 503

Turkey has made some progresses in the processing and disposal of sludge produced at municipal/domestic WWTPs. However, the progress is rather slow due to the economy and some insufficiency. In the Aegean Region, many important progresses were done regarding the wastewater treatment and sludge processing. Table 4.2 shows the municipalities served by the sewer network and treatment plants in the working area (TUİK, 2008).

Figure 4.1 Aegean region of Turkey (http://www.uyduharita.org/content/ege-haritasi-158/)

Figure 4.2 Working area in the Aegean Region (www.google.com).

The municipal wastewater treatment plants in Muğla, İzmir, Manisa and Aydın cities as 1000 m^3/year can be seen from the Figure 4.3 based on the TUIK data for the years 2001 and 2008. Total number of the plants and their treatment capacities are given in conjunction with the amount of treated wastewater, and water treatment method. Among these cities, there is no municipality having advanced treatment units in 2001. However, İzmir has 4 advanced treatment plants in 2008 and Aydın is in second place with 3 plants. There is no plant treating the municipal wastewater with advanced treatment method up to 2008 in Manisa. The information should be updated by inventory survey and field studies.

Table 4.2 Municipalities served by the sewer network and treatment plants and the populations, 2008-TUİK

Municipalities served by the sewer network and treatment plant and the population numbers, 2008								
Provinces	Total Number of Municipal	Total municipal population	The number of municipalities served by sewerage systems	Population served by municipal sewer network	The population served by municipal sewer network in the population rate (%)	The number of municipalities served by wastewater treatment plant	Population served by municipal wastewater treatment plant	Population served by municipal water treatment plant in the population rate (%)
TÜRKİYE	**3 225**	**58 581 515**	**2 421**	**51 673 078**	**88**	**442**	**32 518318**	**56**
Afyonkarahisar	107	550 886	95	501 202	91	6	191 251	35
Aydın	54	688 430	26	503 105	73	15	398 555	58
İzmir	89	3 467 834	79	3 259 380	94	23	2 999 454	86
Kütahya	75	447 610	74	441 904	99	2	231 662	52
Manisa	84	1 019 764	76	956 730	94	5	410 308	40
Muğla	61	515 436	29	288 555	56	21	194 472	38
Uşak	24	247 281	23	233 667	94	1	119 460	48
Denizli	100	736 379	79	656 146	89	15	248 086	34

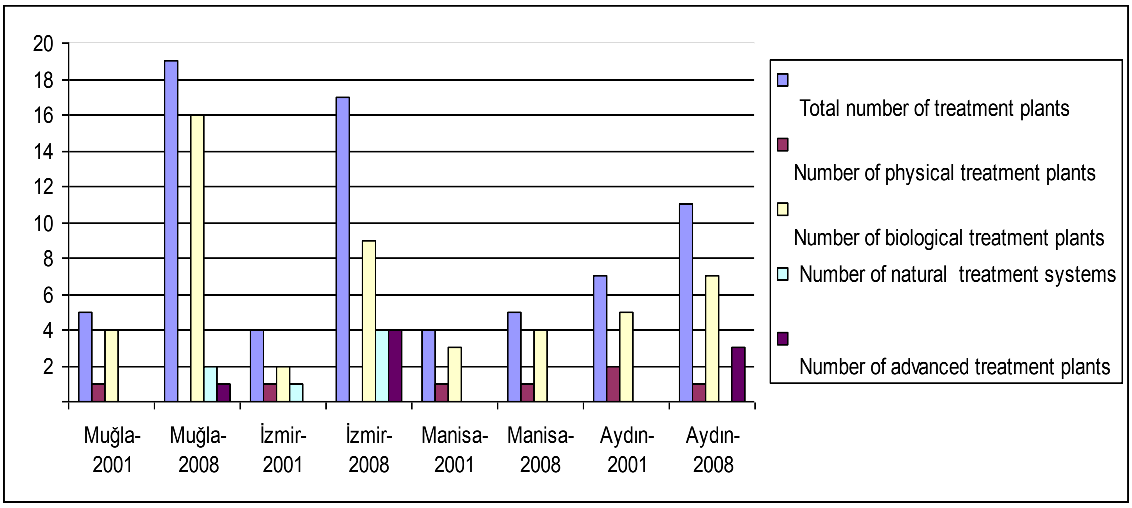


Figure 4.3 Total Number of wastewater treatment plants in Muğla, İzmir, Manisa, Aydın; 2001 to 2008 (TUIK, 2008)

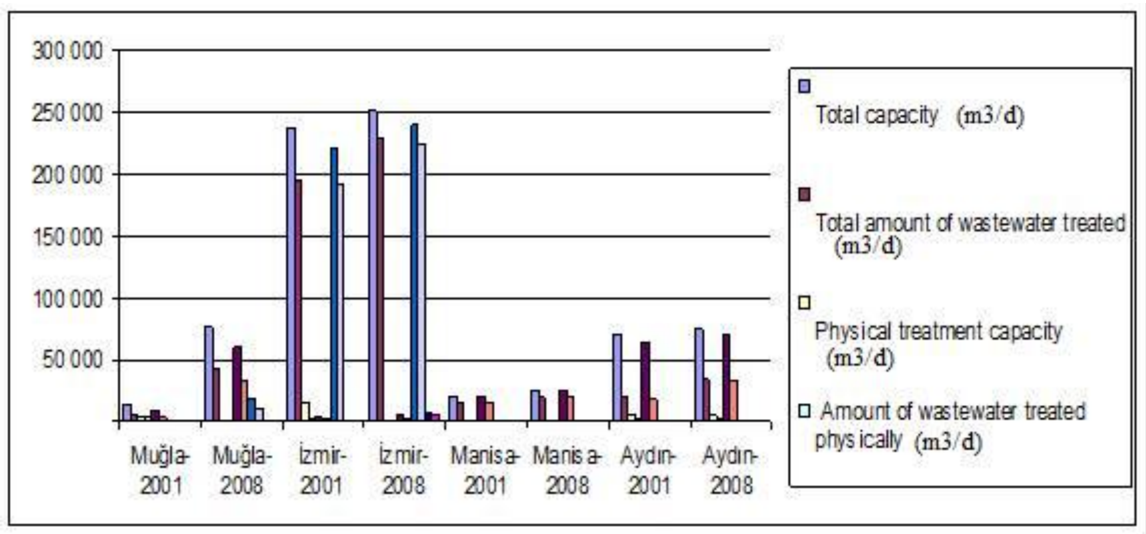


Figure 4.4 Total capacity of wastewater treated in Muğla, İzmir, Manisa, Aydın; 2001 to 2008 (TUIK, 2008)

CHAPTER FIVE
MATERIALS and METHODS

5.1 Introduction

This chapter introduces the survey prepared for the data collection on wastewater treatment and sludge processing in some selected municipal/domestic wastewater treatment plants. It also gives some information on the wastewater treatment plants worked within the context of the survey.

5.2 Materials

The survey to collect the information on wastewater treatment and sludge processing units was prepared as Microsoft Excel spreadsheet. The survey includes nine parts as general information, wastewater treatment plant, wastewater characterization, discharge information, sludge treatment processes, sludge analysis results, additional documents, and the cost information. The survey prepared for the inventory study is given in Appendices.

5.3 Methods

The surveys were filled out by the contact with technical staff either by field trip visits to the wastewater treatment plants or personal contact via email and phone. The list of the municipal/domestic wastewater treatment plants is given in Table 5.1. The completed surveys from 13 WWTPs were evaluated by using Microsoft Excel.

The graphics were shown the results according to the answers of the survey filled out by technical staff at wastewater treatment plant. Total treatment capacities of wastewater treatment facilities, in which process are used for wastewater treatment, and how the resulting sludge is disposed after wastewater treatment, and to which processes subjected have been compared with ratings given proportionate. At the end, the comparison between the studied plants has been given by topic as a separate graphics.

Table 5.1 Municipal/domestic wastewater treatment plants worked in this thesis

#	Wastewater Treatment Plant	Location	Type of the WWTP	Treatment Capacity (m^3/d)
1	Cigli Municipal WWTP	Izmir	Advanced biological treatment	605000
2	Guneybati Domestic WWTP	Izmir	Advanced biological treatment	21600
3	Manisa Municipal WWTP	Manisa	Trickling Filter	31000
4	Uşak Municipal WWTP	Uşak	A^2/O	20000
5	Fethiye Municipal WWTP	Fethiye	Advanced biological treatment	22394
6	Güllük Municipal WWTP	Güllük Muğla	Conventional activated sludge	5000
7	Türkbükü Municipal WWTP	Türkbükü Muğla	Extended aeration activated sludge	2000
8	Bitez Municipal WWTP	Bitez Muğla	Conventional activated sludge	3500
9	Mariç Municipal WWTP	Marmaris Muğla	Conventional activated sludge	50625
10	Nazilli Municipal WWTP	Nazilli Aydın	Conventional activated sludge	24000
11	Konacık Municipal WWTP	Konacık Muğla	MBR	1500
12	Bodrum Municipal WWTP	Bodrum Muğla	Activated sludge system	10000
13	Dalaman Municipal WWTP	Dalaman Muğla	Conventional activated sludge	12000

5.4 Information on the Wastewater Treatment Plants Studied

The current photos of the observed facilities have been taken in the extent of studies. As seen in photos of the facilities, the ones which have been built in the recent years are operated in more modern conditions when compared to the old facilities that this situation provides higher treatment efficiency and ease of operation. The photos, flow charts and general layout of the processes and units of facilities are given together with their summaries.

5.4.1 Cigli Wastewater Treatment Plant

Figure 5.1 The layout of Cigli wastewater treatment plant.

The units of Cigli WWTP shown in Figure 5.1 include a pre-treatment unit consisting of screen, grit chamber, Parshall weirs, and 12 primary settling tanks, biological treatment unit consisting of 6 bio-phosphorus tanks individually 8850 m^3, 12 units each of 24790 m^3 of aeration tank and 12 final settling tanks. Recycled activated sludge is transferred back to the bio phosphorus tanks with 4 pump units. Excess sludge is sent to the collection tank by using waste sludge pumps. Treated wastewater from the treatment plant is discharged into the sea by an open ferroconcrete channel.

At the plant, 2 tanks having 27 m-wide 5 m depth provide the sludge collection. The collecting tanks are mixed by 4 submersible mixers.

To ensure the separation of the liquid/solids fractions in the sludge, polyelectrolyte is dosed for sludge conditioning purpose. For the preparation of polyelectrolyte, 4 units with the 4000 l/h capacity are in operation. Following the sludge conditioning, sludge is sent to the centrifuge decanters for thickening and dewatering. The Centrifuge system consists of 7 decanters, and each decanter has a capacity of 120 m^3/ h dewatering and 150 m^3/ h thickening.

Dewatered sludge cakes are stabilized by using lime. The plant has 4 lime silos with 65-ton capacity. The stabilized sludge is sent to the special storage area. An average 600 tons of sludge has daily produced in the plant. Recently, the authority-IZSU, which is responsible to establish and operate the WWTPs in Izmir, has opened a tender for anaerobic sludge digesters and sludge drying units not only for the sludges produced in Cigli WWTP but also the other WWTPs in the vicinity of Izmir.

5.4.2 Güneybatı Wastewater Treatment Plant

Güneybatı Wastewater Treatment Plant (WWTP) shown in Figure 5.2 is the second wastewater treatment plant, which was built under Izmir Grand Canal Project. The plant with 21.600 m^3/day capacity has been commissioned in 2001 and is currently treated in dry weather, on average, 17.430 m^3/day wastewater. Biologically carbonaceous material, nitrogen, and phosphorus are treated in the plant by using A^2/O process (anaerobic/anoxic/aerobic). Güneybatı WWTP consists of coarse screen, pumping station, fine screen, aerated grit and oil chamber units as a pretreatment. Its biological units include anaerobic tank, anoxic tank, and aerobic tank, and final sedimentation tank. The treated wastewater is discharged to the sea at 25 m in depth in the middle gulf section of İzmir gulf with a sea discharge line with

600 m in length. The settled sludge from the settling tanks is transferred to the anaerobic tank by using sludge transfer pumps. The plant also includes the sludge mechanical dewatering units summarized in Table 5.2.

Figure 5.2 Güneybatı wastewater treatment plant, İzmir/Türkiye

Table 5.2 Sludge dewatering system of Güneybatı WWTP

Number of Thickener:	2 (1+1)
Input sludge dry matter content:	% 0.4
Belt press Number:	2 (1+1)
Output Sludge dry matter content:	%18-25
The amount of sludge cake:	18 ton/day

5.4.3 Mariç Wastewater Treatment Plant

The domestic WWTP is located in the area surrounded with Günnücek Park at the north and Karatas River at the east of Marmaris. It belongs to the Mariç-Marmaris Municipalites Association and its treating capacity is 50.625m^3/day. The plant has conventional activated sludge treatment system. It has pretreatment units including coarse and fine screens, grit chamber, primary sedimentation tank before the biological treatment. The picture of the plant is given in Figure 5.3.

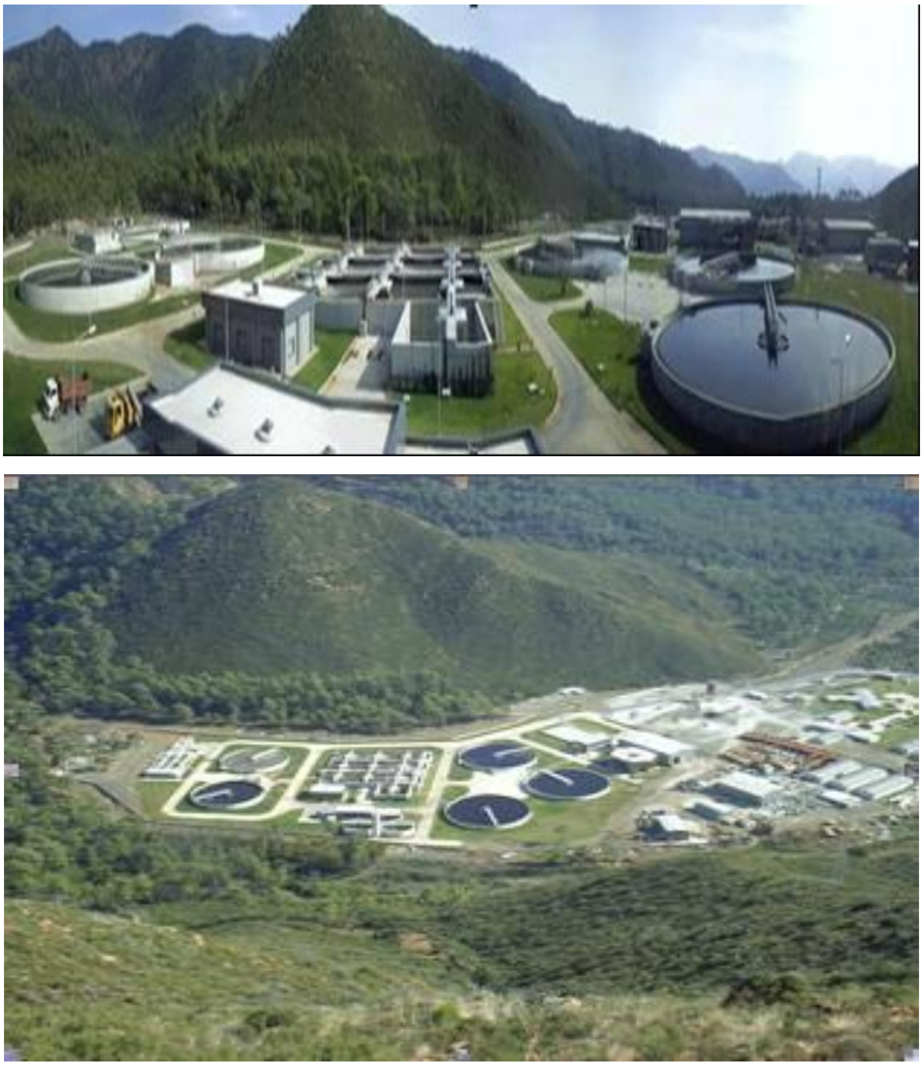
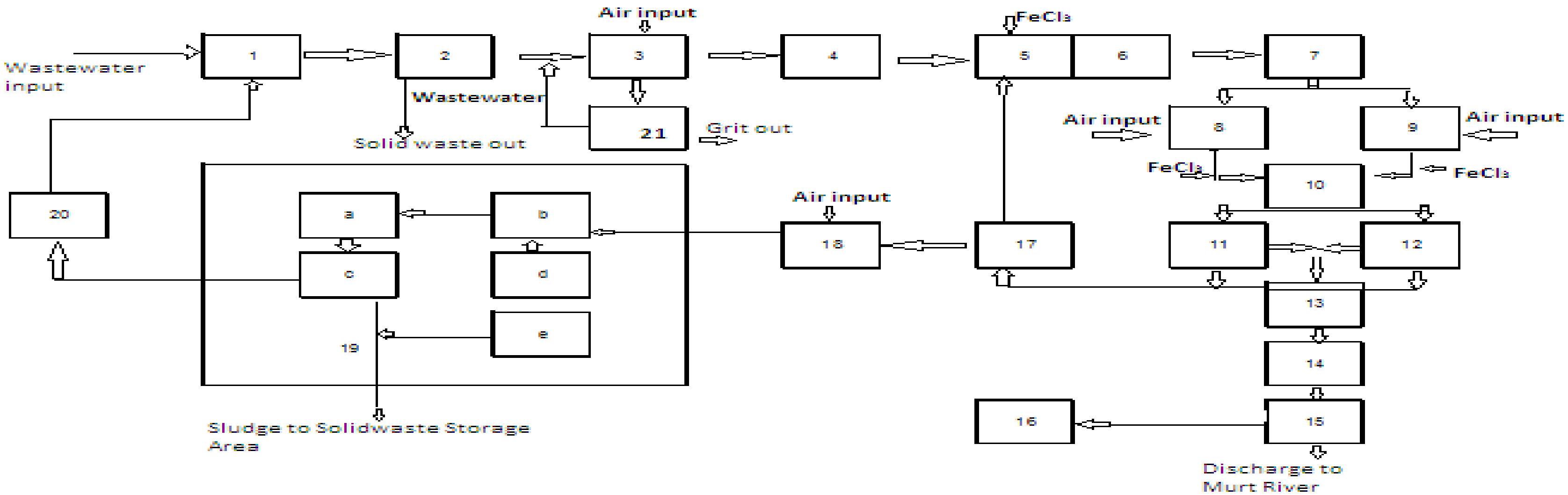


Figure 5.3 Pictures of Mariç wastewater treatment plant.

5.4.4 Fethiye Wastewater Treatment Plant

The domestic WWTP has A/O (anoxic/oxic) biological process for advanced nutrient removal. If necessary, $FeCl_3$ is dosed to the wastewater in the anoxic tank for enhanced phosphorus removal. The project capacity of the plant is 22394 m^3/day; however, the flowrate in winter session can increase up to 38000 m^3/day because of storm water and infiltration. The pictures of the plant are given in Figure 5.4 and the flowchart of it is shown in Figure 5.4.

Figure 5.4 Fethiye wastewater treatment plant, Muğla/Türkiye

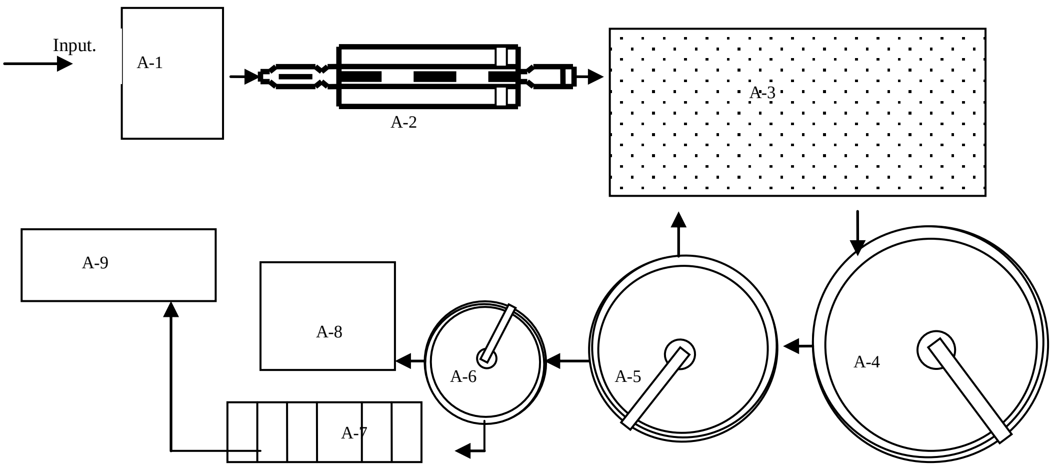


1. Input structure	8. Aeration tank-1	15. Output structure	a-Sludge Thickening
2. Fine screen	9. Aeration tank-2	16. Pressure Unit	b-Static Mixer
3. Ventilated oil and grit chamber	10. Distribution structure	17. Return unit	c-Belt Pres
4. Flow measuring flume	11. Final sedimentation tank-1	18. Sludge tank	d-Polyelectrolyte Tank
5. Selector tank	12. Final sedimentation tank-2	19. Sludge dewatering unit	e- Lime Silo
6. Biological phosphorus tank	13. Flow measuring flume	20. The filtrate tank	
7. Distribution structure	14. UV disinfection	21. Sand separator	

Figure 5.5: Systems Flowchart of Fethiye Wastewater Treatment Plant

5.4.5 Bodrum Wastewater Treatment Plant

There are 11 municipal/domestic WWTPs in Bodrum Peninsula. 3 of them namely İçmeler, Bitez, and Konacık are located in Bodrum Central District. The current statuses of WWTPs in the Bodrum District are given individually below. Regarding the 11 WWTPs, most of them are A/O, A2/O, and activated sludge systems as biological treatment with two exceptions: one biodisc and one MBR system. All WWTPs have sludge processing units. Icmeler WWTP has extended aeration activated sludge system. Sludge produced at the plant are first thickened by using a gravitational thickener and following the unit, it is dewatered by using a belt press dewatering unit. The flow diagram of the plant is given in Figure 5.6.



A	Input	A-1	Input Pumping Station	A-2 Physical Treatment
A-3	Aeration Tank	A-4/5	Sedimentation Units	A-6 Sludge Thickening Unit
A-7	Chlorination Plant	A-8	Belt Pres Unıt	A-9 Pumping Station

Figure 5.6 Flow chart of Bodrum wastewater treatment plant, İçmeler-Bodrum/Muğla

Some picture from the biological treatment units and sludge dewatering unit-belt press of the WWTP are given in Figure 5.7 and 5.8, respectively.

(a)

(b)

(c)

(a) Aeration tank, (b) Aeration tank during maintenance, (c) Sedimentation tank

Figure 5.7 Some picture from the Bodrum WWTP, İçmeler-Bodrum/Muğla,

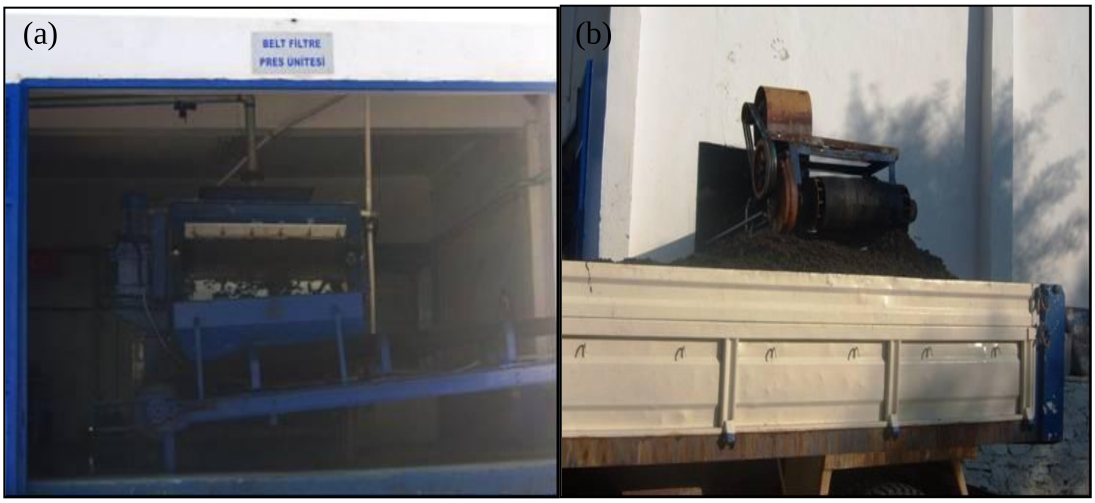


Figure 5.8: **(a)** Belt filter and (b) Sludge collection units of Bodrum WWTP, İçmeler-Bodrum/Muğla

5.4.6 Bitez Wastewater Treatment Plant

The conventional activated sludge system is applied at the facility that serves with the capacity of 3.500 m^3/day and to an equivalent population of 12.250. Annually, 1075 m^3 /year sludge producing at the facility and the dewatered sludge cakes are disposed at the landfill. A centrifuge decanter system is used for sludge dewatering purpose. Approximately 5 tonnes of the dewatered cakes are daily sent to the municipal landfill area. Some picture from the pretreatment unit, biological treatment units and sludge dewatering unit-centrifuge decanter of the WWTP are given in Figure 5.9.

5.4.7 Konacık Wastewater Treatment Plant

Konacik Municipal WWTP is the first plant designed as membrane bioreactor system-MBR for municipal wastewater in Turkey. The plant was established in 2009. The first stage of the plant is serving to 10,000 populations with a capacity of 1,500 m^3/day; however, the second stage project, which has 30,000 populations with the capacity of 3,000 m^3/day are under construction. Figure 5.10 shows some photos from the first stage of the plant and also Figure 5.11 schematize the flow diagram of the plant. The treatment units of the plant and the characteristics of the treated wastewater is given in Table 5.3.

(a) Pretreatment unit of Bitez WWTP (Grit chamber)

(b) Sedimentation tank and outlet structure units of Bitez WWTP

(c) Decanter centrifuge and sludge collecting systems of Bitez WWTP

Figure 5.9 (a), (b), (c) Some pictures of Bitez WWTP

(a) Front sight of Konacik Municipal Wastewater Treatment Plant

(b) Activated Sludge Tank with Submerged Membrane Unit

(c) Activated Sludge Tank with Submerged Membrane Unit

(d) MBR Cassette of Konacik Municipal WWTP

Figure 5.10 (a), (b), (c), (d) Some pictures from Konacik WWTP.

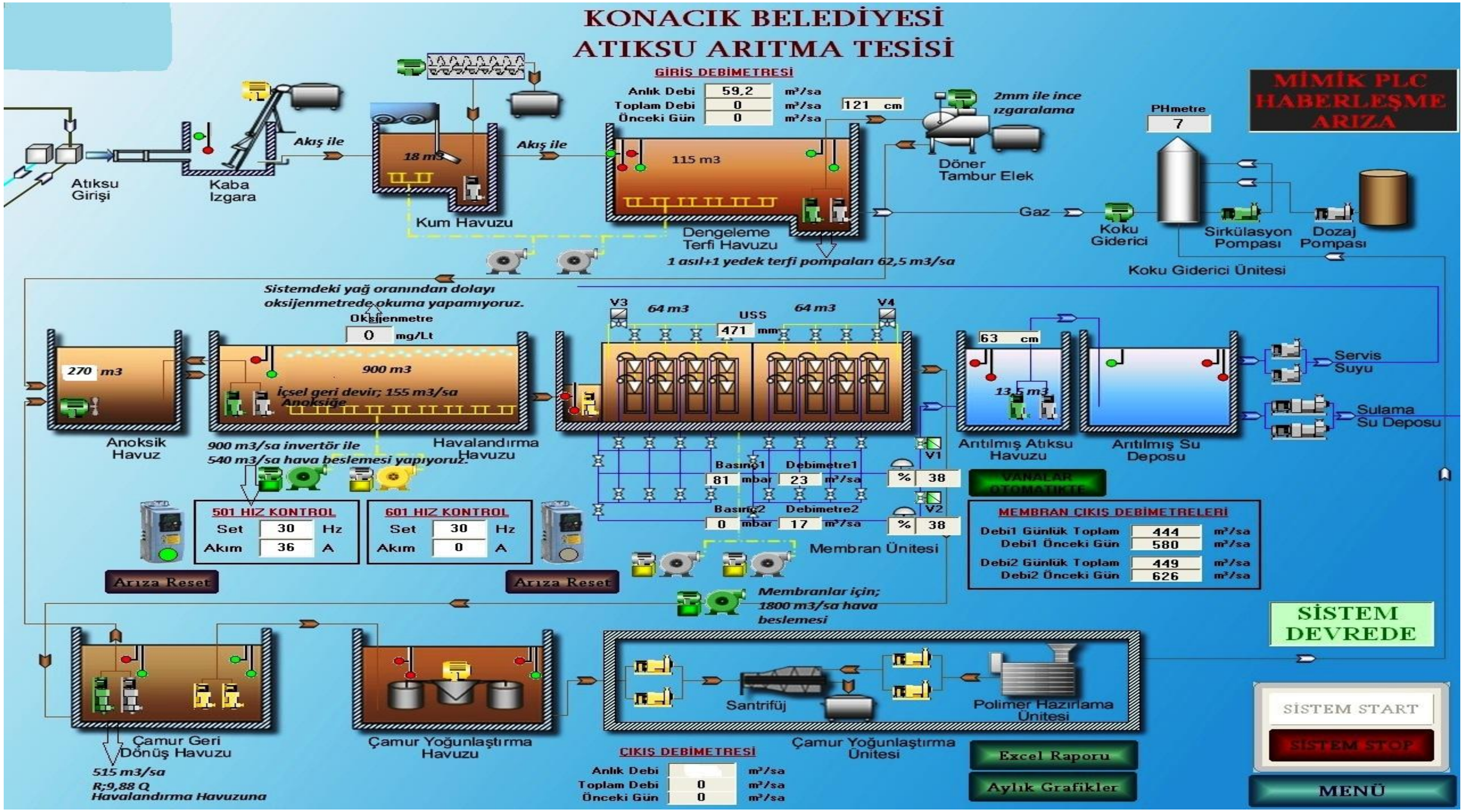


Figure 5.11 Flowchart of Konacik Municipal wastewater treatment plant.

Table 5.3 The treatment units of Konacik WWTP and the characteristics of treated wastewater

Konacik Municipal Wastewater Treatment Plant Units	**Characteristics of treated wastewater**
I. Balancing and Pump Unit	Organic Loading : 600 kg BOI_5 / day
II. Anoxic Unit	Wastewater flow : 1500 m^3/ day
III. Ventilation	BOI5 : <10 mg/l
IV. Membrane Bioreactor Unit	KOI : 25 mg/l
V. Sludge Unit	AKM : 10 mg/l
VI. Sludge Stabilization	AKM : <10 mg/l
VII. Sludge Dewatering (decanter centrifuge)	

5.4.8 Dalaman Wastewater Treatment Plant

The facility was designed to provide a serving to 56,000 population. The biological unit of the plant is conventional activated sludge process. The produced sludge is dewatered by using a belt-press dewatering equipment and the cakes are disposed at municipal landfill area. Some pictures showing the units of the plant and the belt-filter press dewatering unit are given in Figures 5.12 and 5.13, respectively.

(a) Screw pumps

(b) Sedimentation tank and sludge thickener

(c) Aeration tank (d) Sedimentation tank

Figure 5. 12 (a), (b), (c), (d) Dalaman domestic WWTP.

Figure 5.13 Belt-filter press of Dalaman domestic WWTP.

5.4.9 Güllük Municipal WWTP

Gulluk municipal WWTP has a conventional activated sludge process as a biological unit. Although the project flow-rate of the Gulluk municipal WWTP is 5000 m^3/day, the treatment flow-rate is currently about 1250 $m^{3/}$day. In addition, the flowrate is increased more than two times depending on the population equivalent served by the plant in summer time because of the touristic activities in this area. Plant provides service to approx. 11000 populations in summer session while it is about 4000 population in winter session.

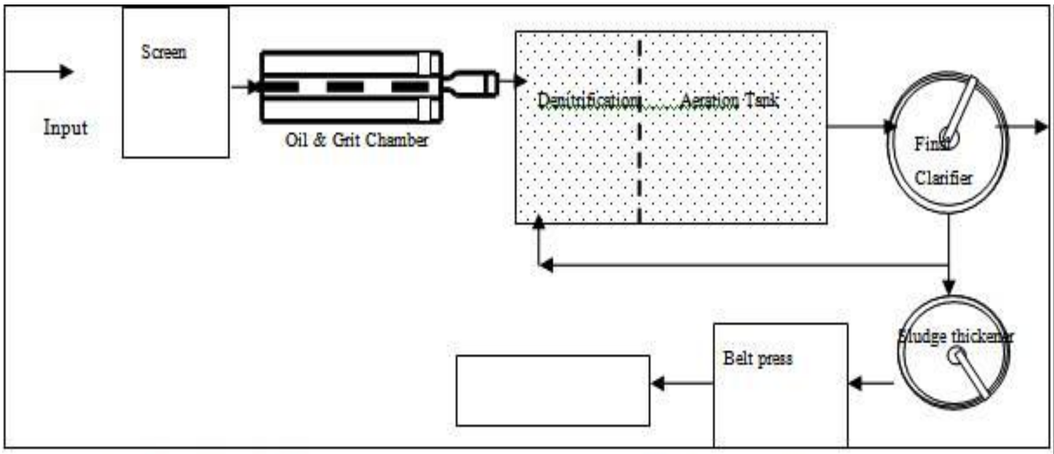
The seasonal fluctuation in the wastewater flow-rate also causes periodic changes in the amount of sludge. The personnel stated that the dewatered sludge cake is produced about 73 kg DS/day in winter session, while it increases up to 104 kgDS/day in summer time. This plant has a filter-press dewatering unit. The sludge produced at the plant is stored in a special storage area at the plant; however, the applications regarding the disposal of sludge to be produced in future years are planned. A photograph from the plant is shown in Figure 5.14.

Figure 5.14 Güllük Municipal WWTP.

5.4.10 Göltürkbükü Wastewater Treatment Plant

Golturkbuku Municipality has two WWTPs, which one of them was constructed in 1998 by Tourism Ministry. However, the plant did not suffice to treat the increased amounts of wastewaters produced in this area. Therefore, the municipality has opened a tender to build a new plant in 2008.

The new plant located in Golkoy, Golturkbuku has been in operation since 2009. This plant has advanced biological units: A/O process. The flow diagram and some photos from the plant are given in Figures 5.15 an 5.16, respectively.



Units of input structure	Treatment units
I. Screening	I. Denitrification Unit,
II. Oil&Grit Chamber	II. Nitrification Unit
III. Parshall weir	III. Final sedimentation
	IV. Chlorine contact tank and Discharge
	V. Sludge thickener, Dewatering unit (belt filter presses)
	VI. Sludge drying beds

Figure 5.15 Flowchart of Golturkbuku wastewater treatment plant.

Figure 5.16 (a) Denitrification unit, (b) Sedimentation tank of Göltürkbükü wastewater treatment plant.

5.4.11 Planned and Ongoing Construction Works in Mugla- WWTP

There is ongoing construction of Mugla Waste Water Treatment Plant containing active sludge process to be served to 100.000 populations. This plant also includes the anaerobic sludge digesters. In addition to this, the projects continue in many districts such as Ortaca, Bodrum Torba, Yerkesik, Ula, etc. A picture from the construction of Mugla WWTP is given in Figure 5.17.

Figure 5.17 The construction of the Mugla municipal wastewater treatment plant.

The second stage of the Konacik Municipality Wastewater Treatment Plant having MBR process is planned to be completed in September of 2012. The plant with 4500 m^3/day capacity has advanced disinfection system (UV) and reverse osmosis plant to recovery all treated wastewaters. This plant has advanced automation and online monitoring system, and Water-Wastewater-Microbiology laboratories.

5.4.12 Manisa Municipal WWTP

City of Manisa located in Gediz watershed area has a biological wastewater treatment plant built in 1993 with a capacity of 31000 m^3/day. The plant uses the trickling filter enabling to treat only carbonaceous material and a little bit nitrogen. However, the capacity is not enough to treat wastewaters produced in the city, which the population is around 300000 PE. The efforts to construct a new plant to meet standard limits including nitrogen and phosphorus parameters are still going on. Some images from the plant are given in Figure 5.18. This plant has aerobic sludge digestion unit and following the stabilization unit, sludge is taken to drying beds.

(a) Trickling filter

(a) Sedimentation Tank

(c) Sludge drying beds

Figure 5.18 (a), (b), (c) Manisa wastewater treatment plant.

5.4.13 Usak Municipal WWTP

City of Usak located in Gediz watershed area has a biological wastewater treatment plant built in 2006. The plant capacity is 20000 m^3/day. It has A2/O process as a biological unit. The sludge produced at the plant is first thickened by gravity thickener and then, dewatered by using a belt filter press. The photo from the plant is shown in Figure 5.19.

Figure 5.19 Usak wastewater treatment plant.

5.4.14 Nazilli Municipal WWTP

Nazilli city has a biological wastewater treatment plant built in 1987 with a treatment capacity of 24000 m^3/day. The plant has conventional activated sludge system. This plant has aerobic sludge digestion unit and then, sludge is taken to drying beds.

CHAPTER SIX
RESULTS AND DISCUSSION

6.1 Introduction

The results and evaluations of the inventory studies are given in this chapter.

6.2 Data Evaluation on Wastewater Treatment

Operational differences at the domestic/municipal wastewater treatment plants in Aegean Region of Turkey between the winter and summer sessions are noticed. These differences are considerably high especially, in touristic settlements.

The WWTPs in the touristic settlements are generally projected as two stages. Depending on the population density, both stages can be put into use. The changing population in summer and winter sessions also leads to the changes in wastewater characteristics. Some factors such as increases in usage of detergents and cosmetics products affect the wastewater characteristics and also the efficiencies of the treatment facilities having biological treatment units. Sometimes, operational problems like foaming can be observed. Similarly, the weather conditions - temperature and rainfall – also negatively affect the treatment efficiencies.

In this thesis, the major municipal/domestic wastewater treatment plants were examined in the Aegean Region. The inventory study based on wastewater treatment and sludge processing was done at the plants. The current statuses of the studied plants have been determined according to the results of the inventory.

Among the studied 13 WWTPs, four plants – Cigli, Manisa, Usak, Nazilli- are municipal WWTPs while rest of them are domestic WWTPs. The projected and annually treated wastewater flow-rates of the WWTPs are plotted in Figures 6.1 and 6.2, respectively. Depending on the flowrates, the numbers of the plants having the flow-rate up to 5000 m^3/day, between from 5000 to 20000 m^3/day, between from

20000 to 50000 m^3/day, and above 50000 m^3/day are 4 (30.8%), 2 (15.4%), 6 (46.1%), and 1 (7.7%), respectively. Cigli WWTP in Izmir has the biggest treatment capacity with 605000 m^3/day flow-rate, while Bodrum-Konacik WWTP in Mugla has the lowest capacity with 1500 m^3/day flow-rate. The population equivalents of the served facilities are depicted in Figure 6.3. According to the population that they provide service.

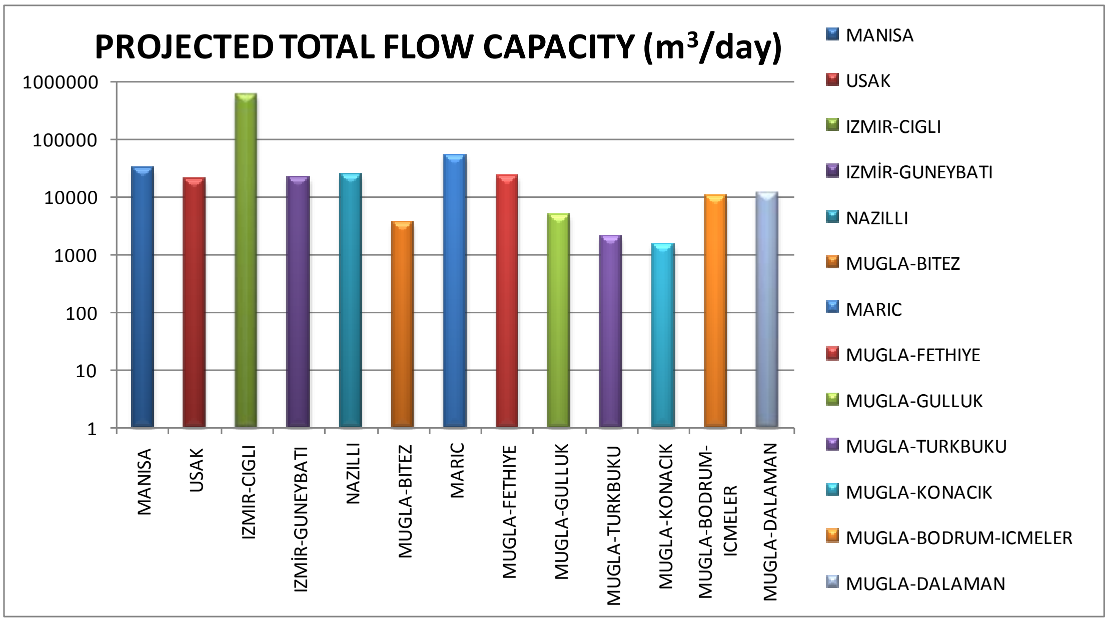


Figure 6.1 Projected total flow capacities of WWTPs (m^3/day)

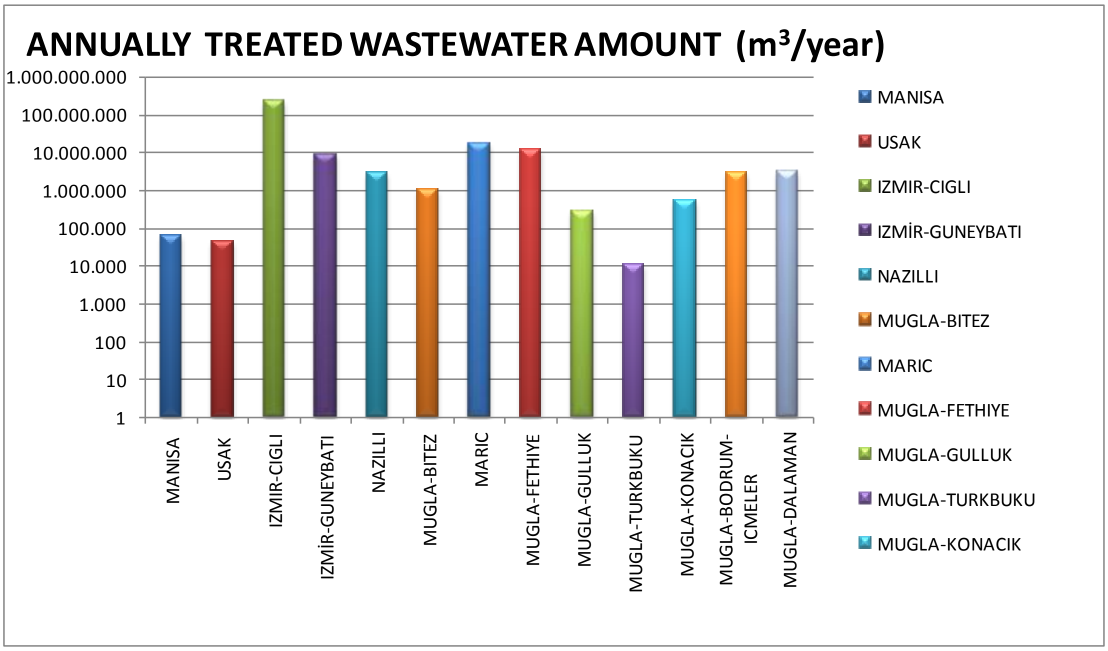


Figure 6.2 Annual amount of wastewater treated in the WWTPs (m^3/year).

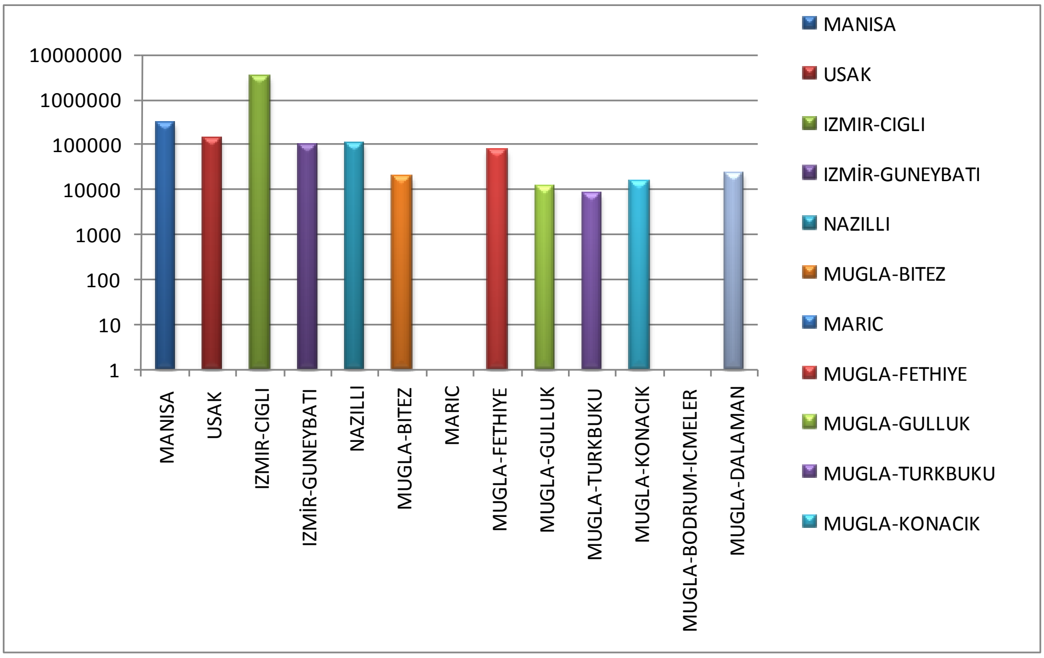


Figure 6.3 The population served by the WWTPs.

The seasonal fluctuations in flow-rates are observed. Some facilities serving to touristic settlements have a drastically increases in summer time flow-rates. The seasonal differences in the wastewater flows of these facilities are shown in the Figure 6.4. In the Bitez and Güllük treatment plants, the daily treated wastewater amount in summer time is more than in winter time due to the growth of population depending on tourism activities.

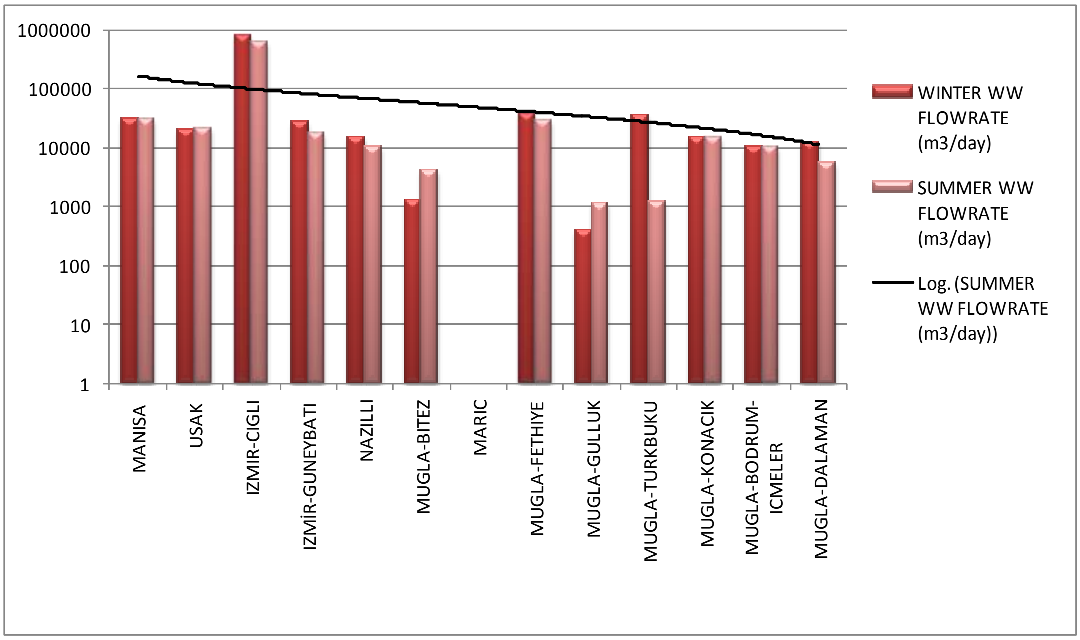


Figure 6.4 Winter and summer season wastewater flows in the WWTPs (m^3/day).

All WWTPs have biological treatment processes as explained in Chapter 5. In this region, most of the biological treatment processes are conventional activated sludge system (46.2%), while the others are as A^2/O process (23%), A/O process (15.4%), MBR (7.7%), and trickling filter (7.7%). Figure 6.5 shows the distribution of the biological processes used in the plants. The designing method of the activated sludge processes (12 WWTPs) are also given in Figure 6.6.

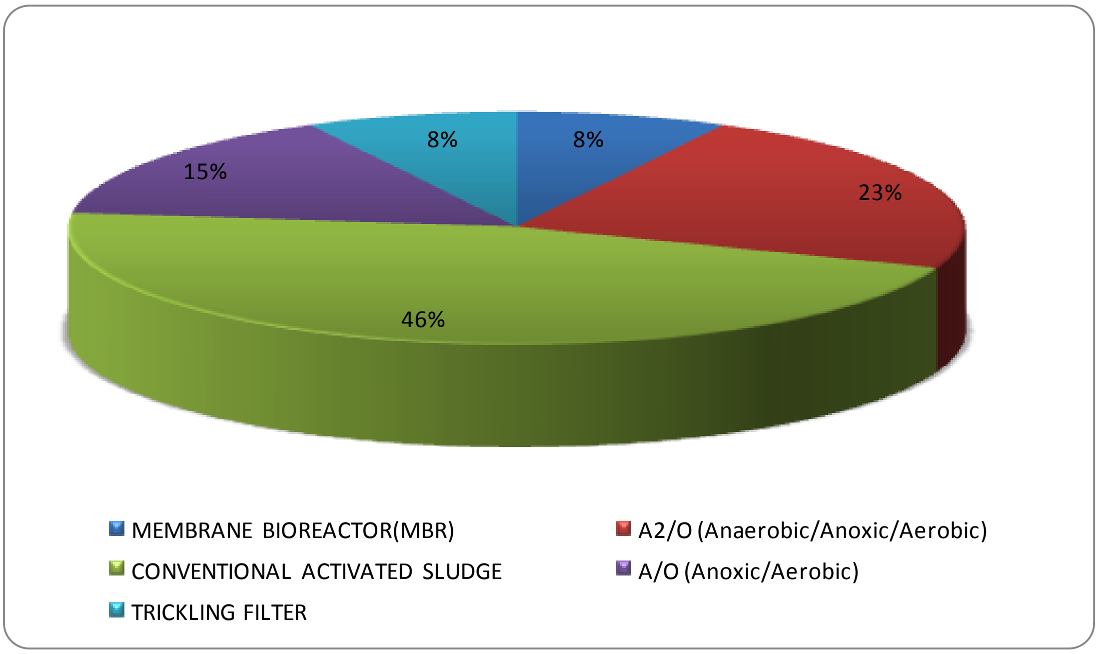


Figure 6.5 Type of biological process used in the studied WWTPs

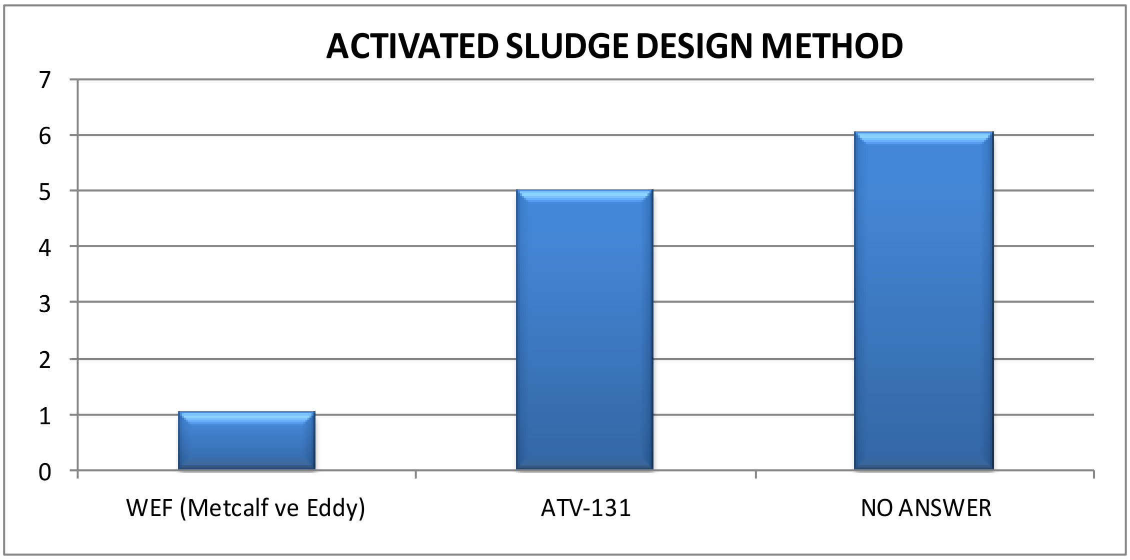


Figure 6.6 Activated sludge designing methods.

Among the WWTPs used activated sludge systems as a biological treatment, some of them use some chemicals assisted to the activated sludge process to enhance the phosphorus removal from the wastewaters. The number of the plants whether use some chemicals assisted to the biological process are shown in Figure 6.7.

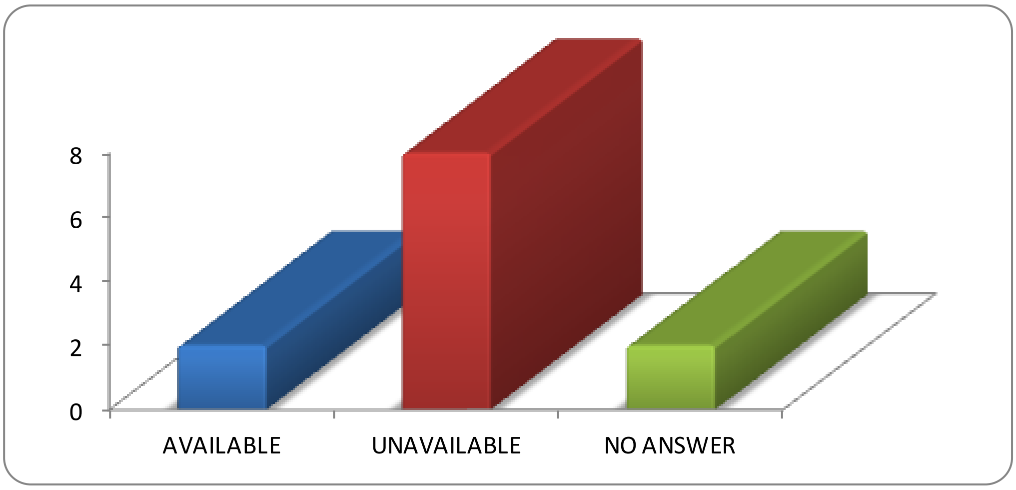


Figure 6.7 The number of chemical assisting activated sludge systems.

The sludge age, which is very important parameter affecting the produced sludge amounts in activated sludge systems, is answered by 6 WWTPs (50%) among the 12 WWTPs used activated sludge process. The results are given in Figure 6.8. Depending on the activated sludge process applied in WWTP, Konacik WWTP has the highest sludge age, since MBR process can be operated higher sludge ages and mixed liquor suspended solids-MLSS concentrations. The higher sludge ages show lower sludge productions in the plants.

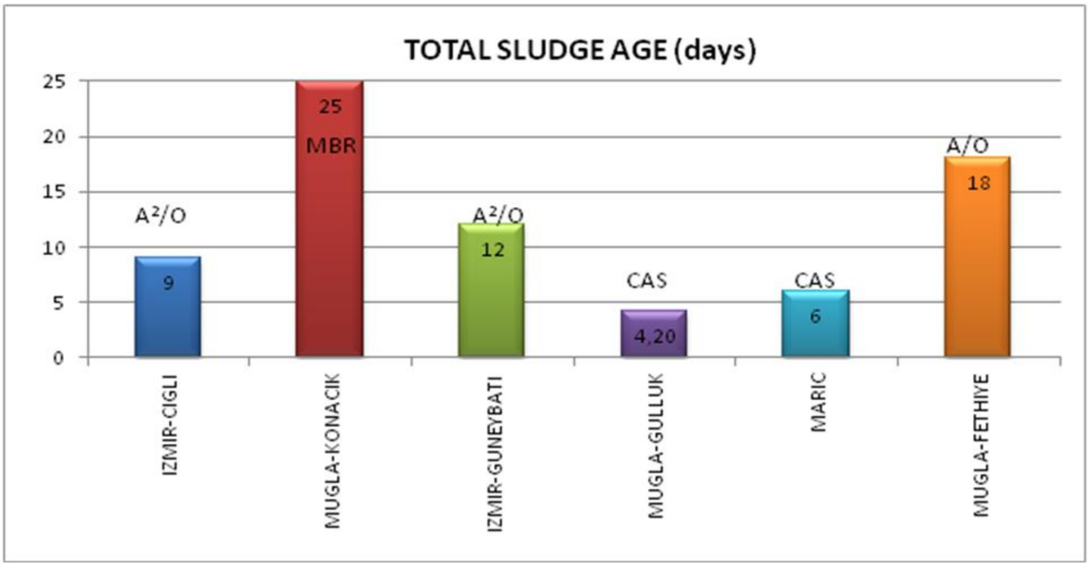


Figure 6.8 Total sludge age applied in the WWTPs (days)

The discharge type and the receiving media questions are answered by 11 WWTPs (85%). The results are shown in Figures 6.9 and 6.10, respectively.

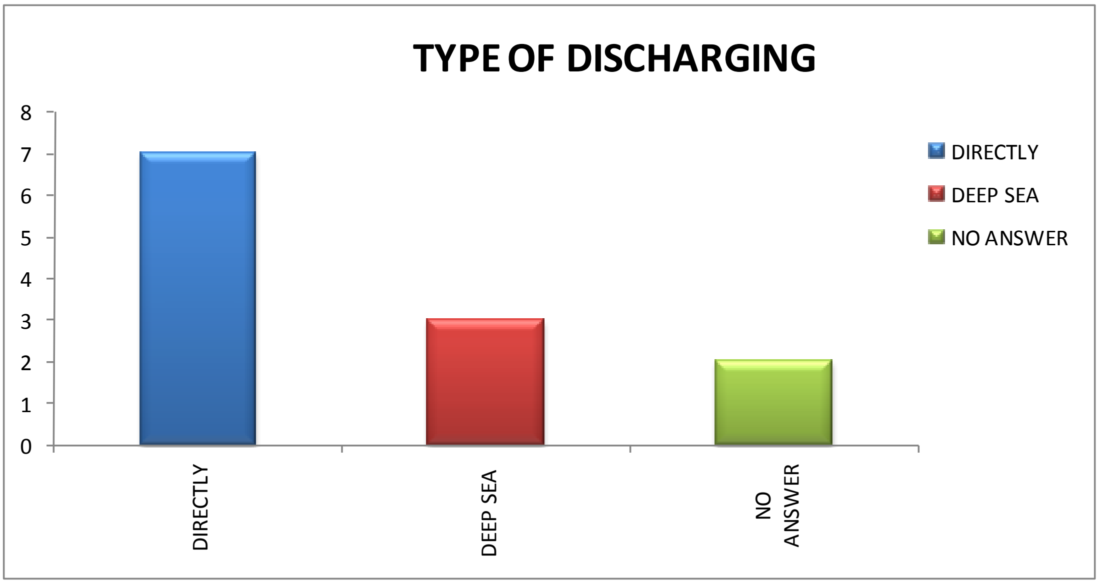


Figure 6.9 Type of treated wastewater discharges.

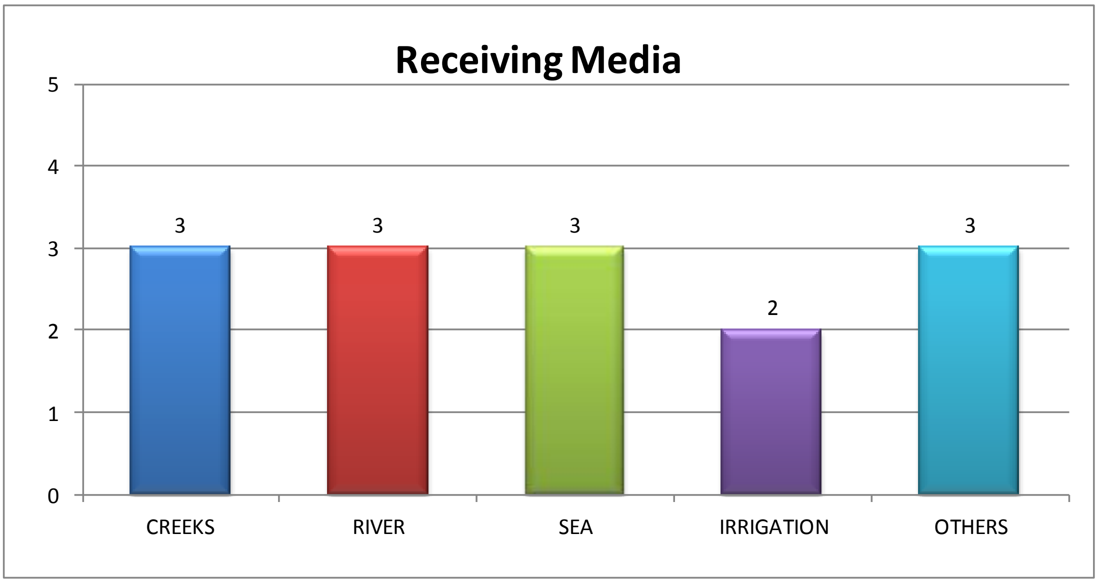


Figure 6.10 Receiving media for the treated effluents

Three WWTPs: Bodrum-Konacik, Bodrum-Golturkbuku (Golkoy), and Mugla-Gulluk apply advanced methods following the biological treatment for reuse purpose. Only 23% of these facilities reuse some of treated wastewaters as shown in Figure 6.11.

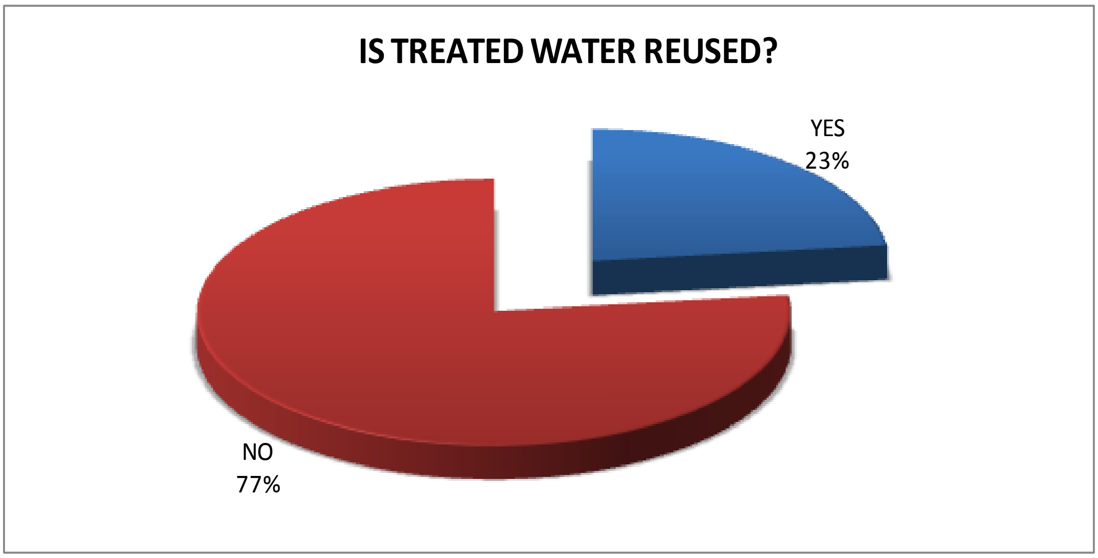


Figure 6.11 The ratio of reuse applied WWTPs.

10 WWTPs have automatically been operated using SCADA while the others have manually been operated as depicted in Figure 6.12. The process automation in different units of the WWTPs are shown in Figure 6.13. 45% of the WWPTs are used the process automation for only aeration purpose.

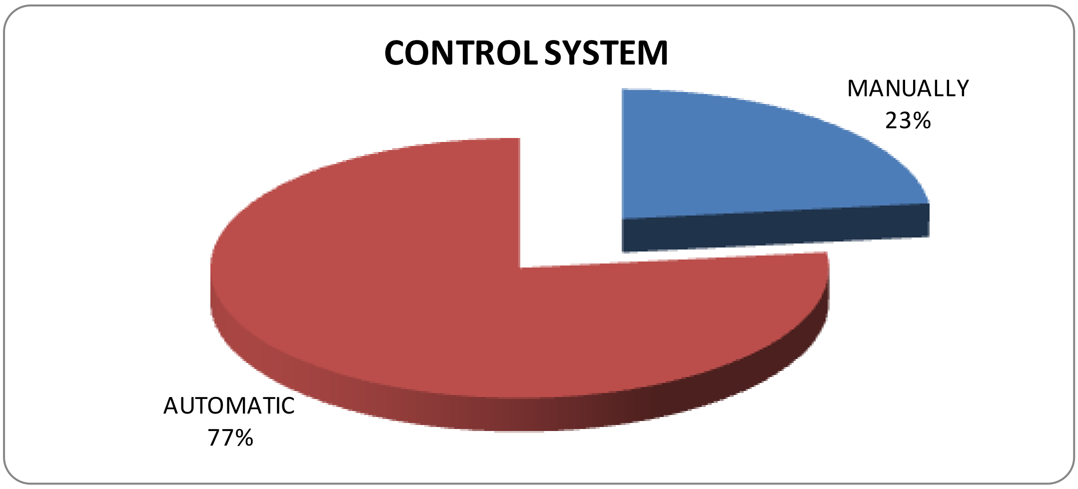


Figure 6.12 Control systems of the WWTPs.

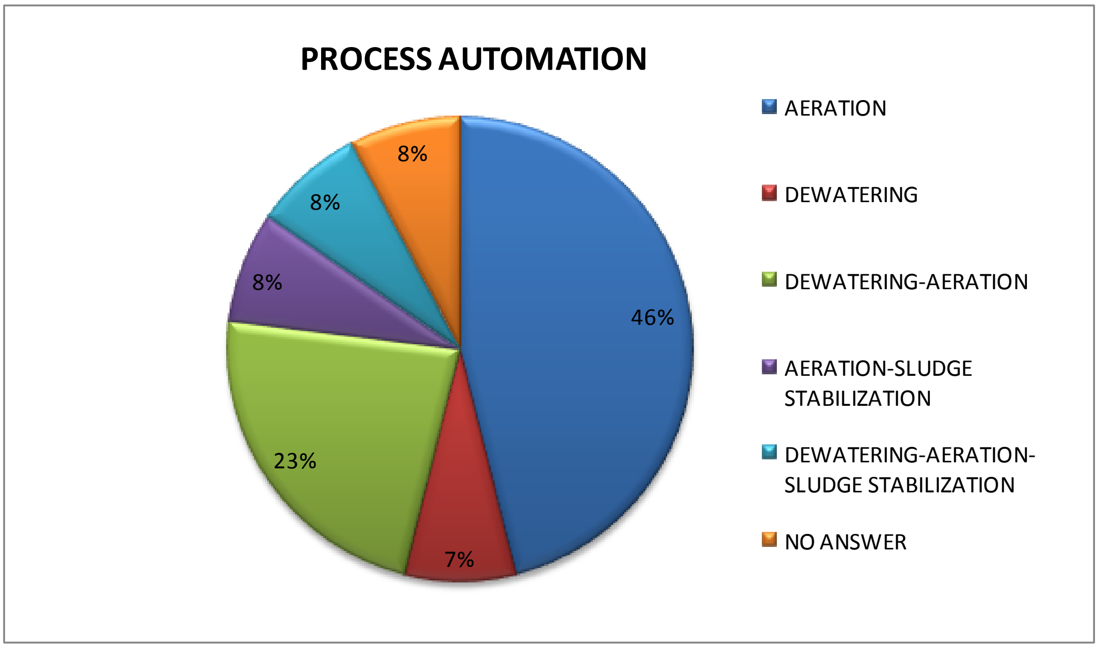


Figure 6.13 Process automation.

The surveyed plants have declared the type of sewerage network whether they are designed as separate or combined systems. The results are plotted in Figure 6.14.

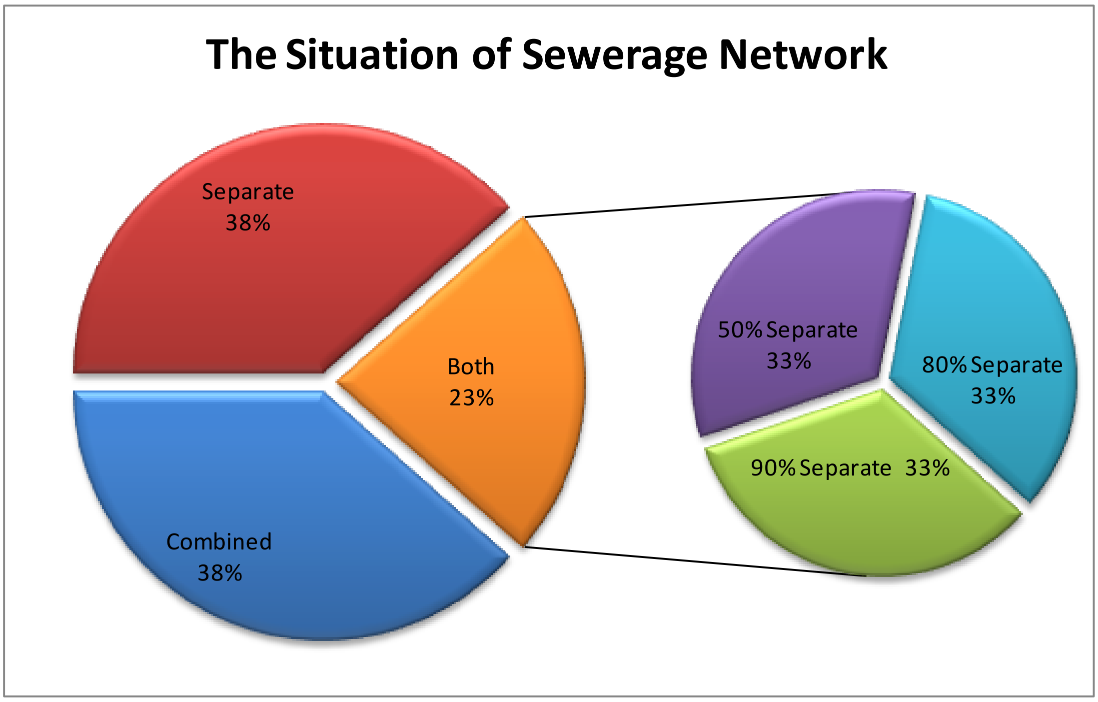


Figure 6.14 Situation of the sewerage network.

6.3 Data Evaluation on Sludge Processing and Disposal

Sludge processing and disposal applications of the studied WWTPs vary from plant to plant. Although some plants have well-equipped processing units, some of them have only auxiliary processing units depending on their sludge sources and the properties. The main sludge sources at the plants are primary sedimentation tanks and final clarifiers. Depending on the wastewater treatment processes, 54% of the studied WWTPs has primary sedimentation tank, while all plants have final clarifiers as shown in Figures 6.15 and 6.16.

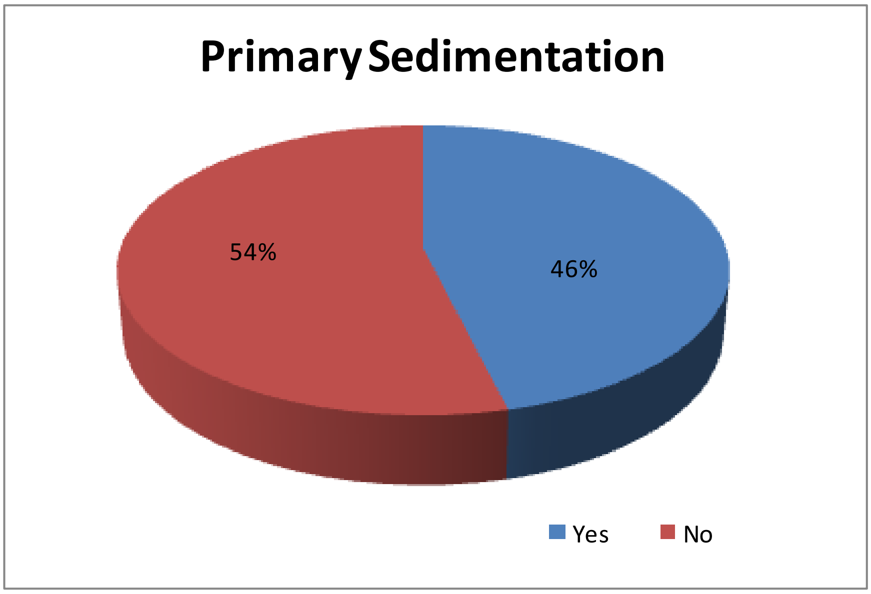


Figure 6.15 The percentages of the primary sedimentation at the WWTPs.

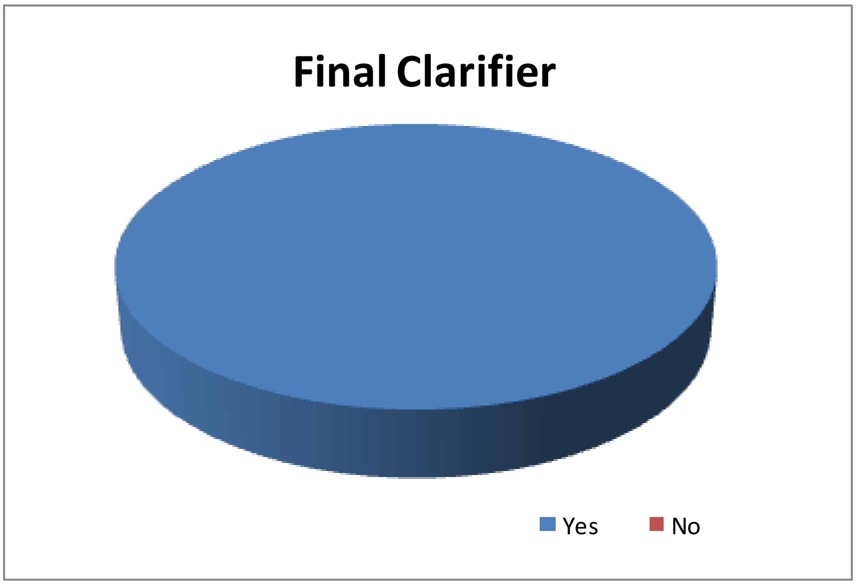


Figure 6.16 Final clarifier at the WWTPs.

One of the important processes reducing the sludge volume is thickening process enabling to increase sludge dried solids (DS) from 1-2% up to 10%. Regarding the survey results, 39% of the plants has applied the sludge thickening process. Among the thickeners at the plants, most of them is gravity type sludge thickener (60%) and one is flotation type thickener (20%) as shown in Figure 6.17.

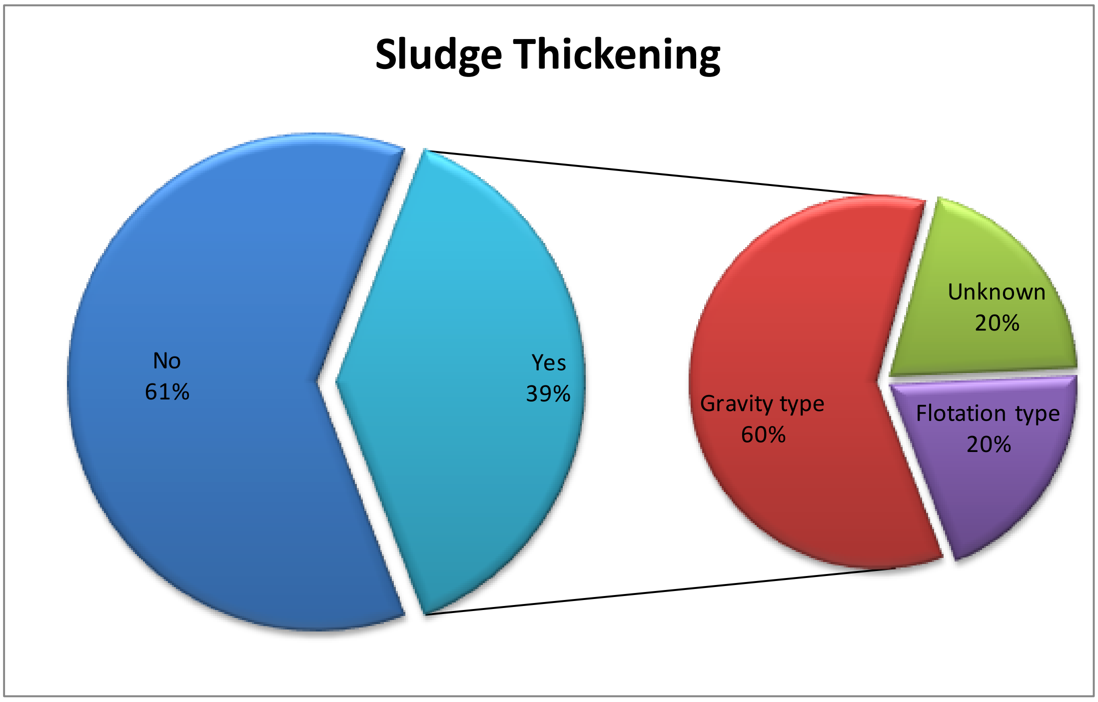


Figure 6.17 Sludge thickening process at the WWTPs.

Sludge stabilization process is invariably unique process in sludge treatment with many advantages including organic matter reduction, pathogen reduction, and lessening the odor potential in the plants. As in general in Turkey, sludge stabilization units are not common application with some exceptions. In this region, the ratio of the plants having stabilization units is 33%. Only two plants –Manisa WWTP and Nazilli WWTP- have aerobic sludge stabilization and one plant –Izmir-Cigli WWTP- uses alkali sludge stabilization method. The stabilization applications in the WWTP should be increased. Figure 6.18 shows the current situation on the sludge stabilization at the plants.

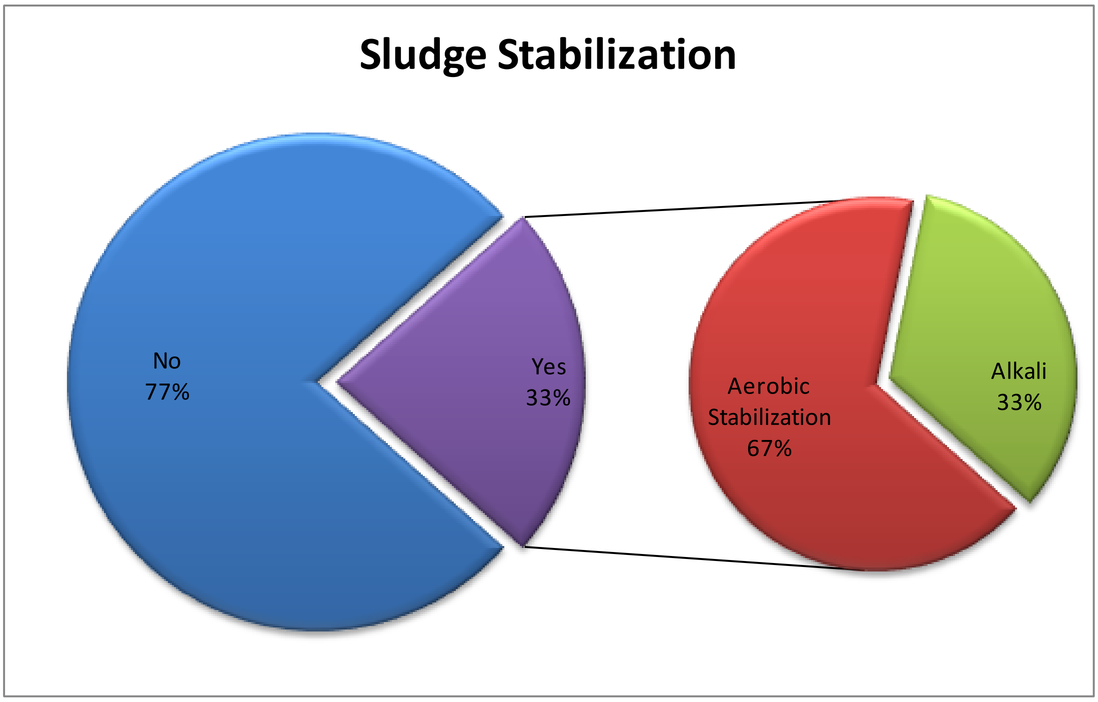


Figure 6.18 Sludge stabilization process at the WWTPs.

All WWTPs have sludge dewatering units. Most of them are mechanical dewatering systems with two exceptions using sludge drying beds. Figure 6.19 shows the types of sludge dewatering units used in these plants.

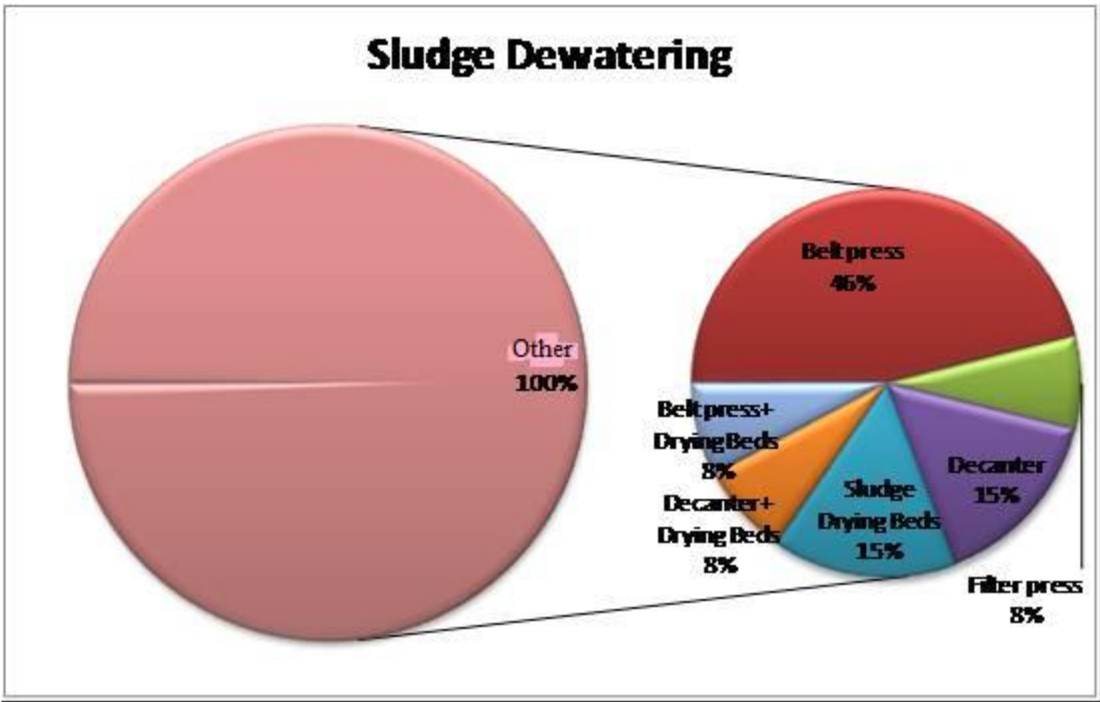


Figure 6.19 Sludge dewatering applications at the WWTPs.

Depending on the wastewater flowrates, applied wastewater treatment technologies, and also sludge processing units, the amounts of the produced sludges at the plants vary. Figure 6.20 shows the produced sludge amounts as tones/day. The Izmir-Cigli WWTP has the biggest value as 600 t/d depending on the plant capacity.

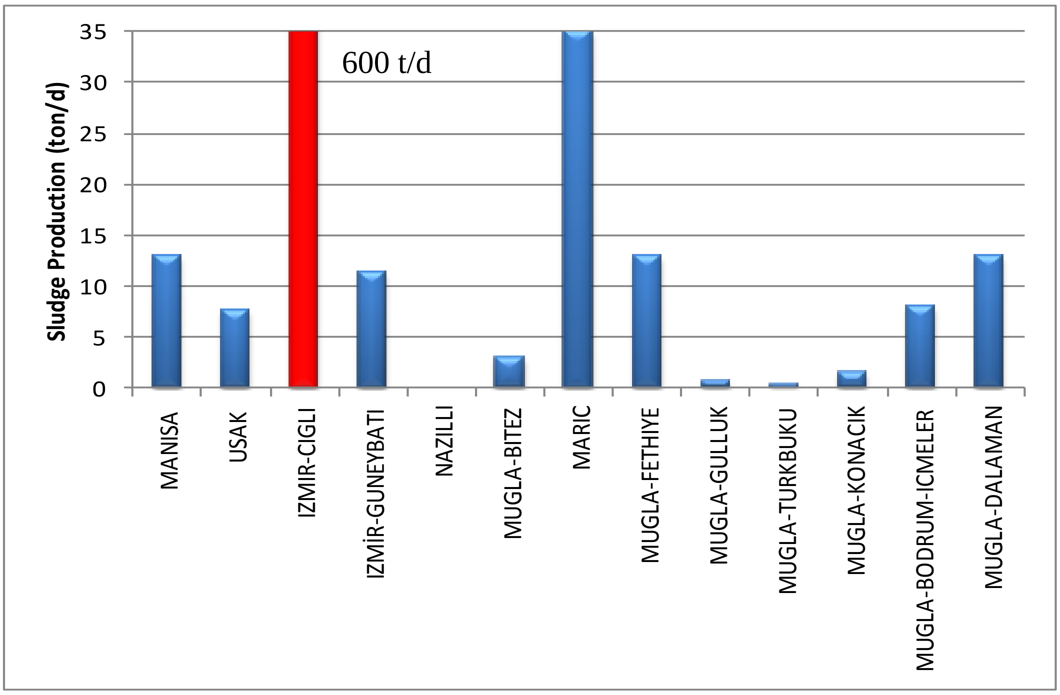


Figure 6.20 Sludge productions at the WWTPs.

Considering the applied dewatering technology, the DS contents of the dewatered sludge cakes differ from each other. As natural dewatering method, sludge drying beds led to the highest DS concentrations as 50% DS. However, regarding the mechanical dewatering systems, the plants having centrifuge decanters have the higher DS% around 25% than the other mechanical dewatering equipments. The DS contents of the dewatered sludge cakes from the plants are given in Figure 6.21. It can be said that DS contents of the all WWTPs are equal or higher than 20%.

As a final disposal method, all plants use "Land-filling". Only three WWTPs have special land-fill area. The other plants send their dewatered sludge cakes to municipal landfill areas. Only, Bodrum-Golturkbuku WWTP having 0.4 ton/day dry sludge gives the sludge to the surrounding olive groves. After using the sludge in the garden and agricultural areas, the excess sludge are sent to the municipal storage area. However, a regional sludge management action plan should be prepared regarding the dynamics of the regions and also focused on the beneficial usage alternatives of the sludge. Regarding the sludge characteristics, the beneficial alternatives change. The sludge produced at the plants are organic wastes and depending on the Land-filling Regulation come into force by Official Gazette 27533, 26.03.2010, the amounts of the organic wastes to be land-filled should be reduced. European Union Land-fill Directive has also similar articles.

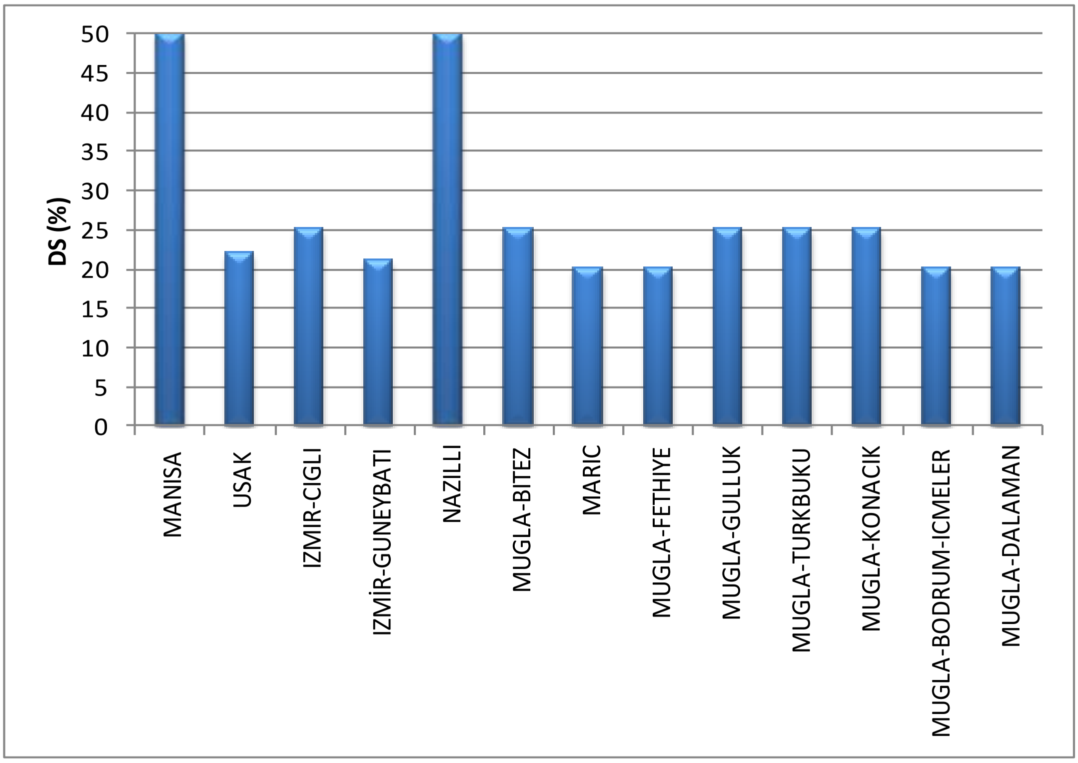


Figure 6.21 DS contents of the dewatered sludge cakes produced at the plants.

The costs of the sludge treatment and disposal are high and the cost can take 40-60% of the overall WWTP cost. Especially small-scaled municipalities don't keep up with new technologies because of their insufficient budget. It is required to develop beneficial recycling projects and economic planning in the fields to reduce the high costs including sludge treatment.

Figure 6.22 shows the operational costs of some WWTPs, which survey is applied. Bodrum-Konacik WWTP and Usak WWTP have the higher treatment costs. The costs of the wastewater treatment changed from 0.1 to 0.6 TL/m^3 of treated wastewater. Regarding the sludge treatment and disposal costs, the cost was changed from 5 to 35 TL/ton DS. These costs vary depending on many factors such as, the technology used, the disposal method, sludge transport, and sludge handling and storage practices. Figure 6.23 represents the average costs for sludge treatment of Maric- Belbir, Fethiye, Konacik, Cigli, and Guneybati WWTPs.

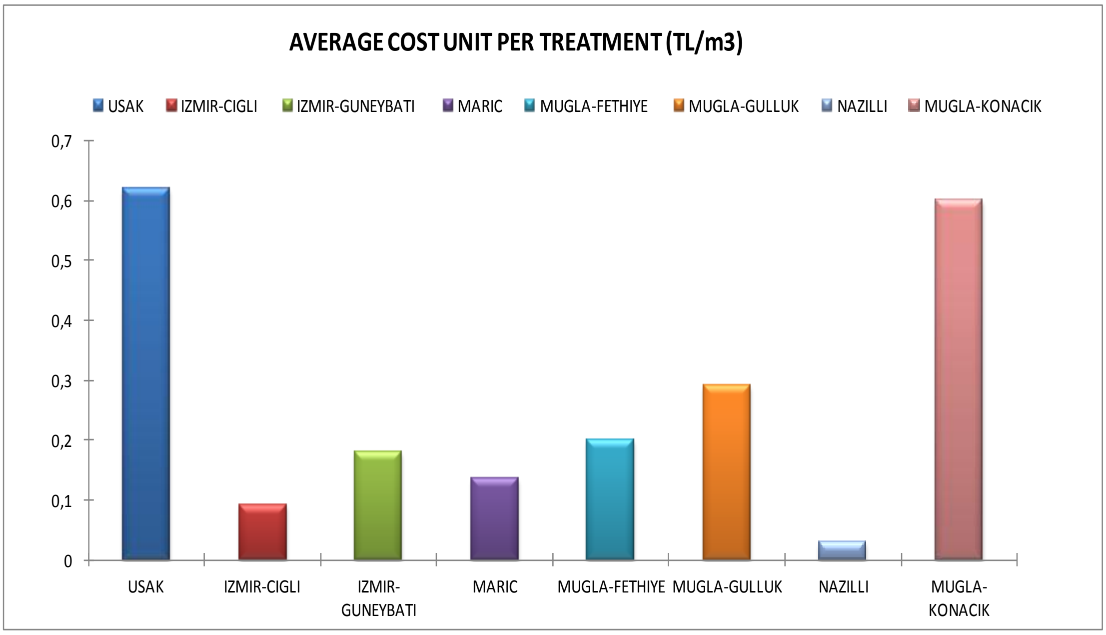


Figure 6.22 Average costs per treated wastewater amount (TL/m^3).

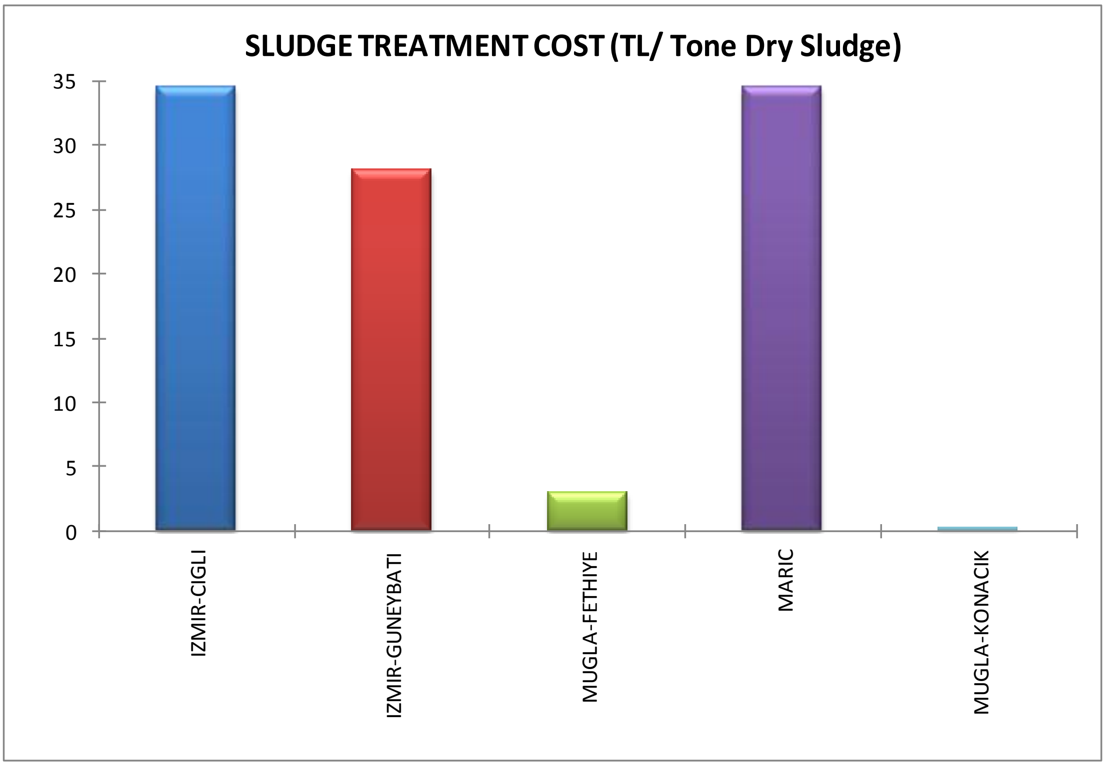


Figure 6.23 Sludge treatment cost (tl/ tone dry sludge).

CHAPTER SEVEN
CONCLUSIONS

Sludge has been produced in different forms at different treatment stages in wastewater treatment plants. As in all over the World, in Turkey, sludge management field should be applied in appropriate way. However, there are many technical and legislative progresses in the field. The first and significant step in the implementation of a suitable sludge management is to determine current situation including the number of plants, applied wastewater treatment technologies, flowrates, wastewater characteristics, sludge treatment process, the produced sludge amounts and their properties, and possible disposal alternatives, etc. To end this, inventory studies are very important studies as a tool.

In this thesis, the major municipal/domestic wastewater treatment plants were examined in the Aegean Region selected as pilot area. WWTPs in Aegean region, which are located in the province of Mugla, have been mainly studied since the plants have changing flow-density depending on the touristic activities. The inventory research has been done in the 13 municipal WWTPs. The study has been applied for the wastewater treatment processes and sludge processing units as well as disposal alternatives applied in the WWTPs. Depending on the applied survey in these WWTPs, the status of existing plants have been discussed according to the results of the inventory.

The concluding remarks from this thesis can be given as follows:

- Operational differences at the domestic/municipal wastewater treatment between the winter and summer sessions are noticed. This difference are considerably high especially, in touristic settlements depending on the factors such as increases in usage of detergents and cosmetics products in summer time.

- Among the studied 13 WWTPs, four plants – Cigli, Manisa, Usak, Nazilli- are municipal WWTPs while rest of them are domestic WWTPs. Depending on the flowrates, the numbers of the plants having the flow-rate up to 5000 m^3/day, between from 5000 to 20000 m^3/day, between from 20000 to 50000 m^3/day, and above 50000 m^3/day are 4 (30.8%), 2 (15.4%), 6 (46.1%), and 1 (7.7%), respectively.

- All WWTPs have biological treatment processes. In this region, most of the biological treatment processes are conventional activated sludge system (46.2%), while the others are as A^2/O process (23%), A/O process (15.4%), MBR (7.7%), and trickling filter (7.7%).

- The sludge age, which is very important parameter affecting the produced sludge amounts in activated sludge systems, is answered by 6 WWTPs (50%) among the 12 WWTPs used activated sludge process. Depending on the activated sludge process applied in WWTP, Konacik WWTP has the highest sludge age (25 days), since MBR process can be operated higher sludge ages and mixed liquor suspended solids-MLSS concentrations. The higher sludge ages show lower sludge productions in the plants.

- The discharge type and the receiving media questions are answered by 11 WWTPs (85%). Treated wastewaters are mainly discharged to the sea, creeks, and rivers.

- Three WWTPs: Bodrum-Konacik, Bodrum-Golturkbuku (Golkoy), and Mugla-Gulluk apply advanced methods following the biological treatment for reuse purpose. Only 23% of these facilities reuse some of treated wastewaters.

- 10 WWTPs have automatically been operated using SCADA while the others have manually been operated. 45% of the WWPTs are used the process automation for only aeration purpose.

- Sludge processing and disposal applications of the studied WWTPs vary from plant to plant. Although some plants have well-equipped processing units, some of them have only auxiliary processing units depending on their sludge sources and the properties.

- The main sludge sources at the plants are primary sedimentation tanks and final clarifiers. Depending on the wastewater treatment processes, 54% of the studied WWTPs has primary sedimentation tank, while all plants have final clarifiers.

- One of the important processes reducing the sludge volume is thickening process enabling to increase sludge dried solids (DS) from 1-2% up to 10%. Regarding the survey results, 39% of the plants has applied the sludge thickening process. Among the thickeners at the plants, most of them is gravity type sludge thickener (60%) and one is flotation type thickener (20%).

- Sludge stabilization process is invariably unique process in sludge treatment with many advantages including organic matter reduction, pathogen reduction, and lessening the odor potential in the plants. In this region, the ratio of the plants having stabilization units is 33%. Only two plants –Manisa WWTP and Nazilli WWTP- have aerobic sludge stabilization and one plant –Izmir-Cigli WWTP- uses alkali sludge stabilization method. The stabilization applications in the WWTP should be increased.

- All WWTPs have sludge dewatering units. Most of them are mechanical dewatering systems with two exceptions using sludge drying beds.

- As a final disposal method, all plants use “Land-filling”. Only three WWTPs have special land-fill area. The other plants send their dewatered sludge cakes to municipal landfill areas.

- The costs of the wastewater treatment changed from 0.1 to 0.6 TL/m^3 of treated wastewater. Regarding the sludge treatment and disposal costs, the cost was changed from 5 to 35 TL/ton DS. These costs vary depending on many factors such as, the technology used, the disposal method, sludge transport, and sludge handling and storage practices.

The survey results have showed that although many practical applications are in progress for the sludge processing as in the wastewater treatment, the information on the sludge production and processing is very limited. However, depending on the results, the sludge amounts to be disposed can be calculated based on the mass balances if the full wastewater characterization is achievable.

This survey study can be applied for all municipal/domestic WWTPs in Turkey to make possible the further studies.

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APPENDICES

Waste Water Treatment Plant Survey Form

The survey form consists of nine parts given below:

Part 1-2 General Information

Part 3 Wastewater Treatment Plant

Part 4 Wastewater Characterization

Part 5 Discharge Information

Part 6 Sludge Treatment Process

Part 7 Sludge Analysis

Part 8 Required Documents

Part 9 Costs

PART I- GENERAL INFORMATION		
NAME OF THE FACILTY	:	
PROVINCE/BOROUGH/MUNICIPALITY OF THE FACILTY	:	
COORDINATS (UCS)	:	LONGITUDE
STAGE YEARS AND BEGENNING DATE OF OPERATION	:	
THE SERVICE AREA	:	
REVISION DATE	:	
REVISION TYPE/CAPACITY CHANGE	:	
PROJECTING FIRM	:	
BULDING COMPANY /OPERATING FIRM	:	
BUSINESS MANAGER HIS/HER NAME-SURNAME TITLE	:	
NAME-SURNAME TITLE OF THE PERSON SURVEYED	:	
CONTACT TELEPHONE NUMBERS	:	
FAX NUMBER	:	
E-MAIL	:	

PART II- OPERATION INFORMATION RELATED TO THE PIRIFICATION FACILITY					
PROJECT TOTAL FLOW CAPACITY	:	m3/day			
ANNUAL DEMINERALISED AMOUNT OF WASTE	:	m3/year			
DAILY DEMINERALISED AMOUNT OF WASTE (DRY AIR FLOW)	:	m3/day			
MINIMUM HOURLY AMOUNT OF WASTE (DRY AIR FLOW)	:	m3/hour			
MAXIMUM HOURLY AMOUNT OF WASTE (DRY AIR FLOW)	:	m3/hour			
WINTER SEASON WASTEWATER FLOW and POPULATION	:	m3/day	person/head		
SUMMER SEASON WASTEWATER FLOW and POPULATION:	:	m3/day	person/head		
SERVICE FACILITIES TO THE POPULATION	:	person/head			
TOTAL NUMBER OF EMPLOYEES OF WASTEWATER TREATMENT FACILITY	:	person/head			
RECEIVING ENVIRONMENT OF THE DEMINERALISED WASTE DISCHARGE	:	Water course	LAKE		RIVER
		BROOK	DAM		SEA
DISCHARGE TYPE		DIRECT	DEEPVATER		
IS RECEIVING ENVIRONMENT WITHIN WATER BASIN?		YES	NO		
PLEASE SPECIFY THE WATER BASIN OF THE RECEIVING ENVIRONMENT					
IS DEMIRALISED WATER USED FOR GOOD PURPOSE?		YES	NO		
IF YES, PLEASE SPECIFY THE FLOW AND METOD		m3/day			
FLOW OF WASTE RECOVERY FACILITY		m3/day			
UNITS OF WASTE RECOVERY FACILITY					

PART II- OPERATION INFORMATION RELATED TO THE PIRIFICATION FACILITY – (2)						
THE WAY THEOPERATION OF PURIFICATION FACILITY IS DONE	WITH SCADA		YES NO			
IF IT IS ANOTHER SYSTEM, PLEACE SPECIFY:						
CONTROL SYSTEM OF THE PURIFICATION FACILITY (PANO)		MANUALLY		AUTOMATIC		
PROCESS AUTOMATION		VENTILATION		SLUDGE STABILIZATION		
		DEWATERING				
SITUATION OF THE SEWERAGE NETWORK		Combined system		Separated system		
			%	Separated system		
INDUSTRIAL WASTEWATER DISCHARGE HAS BEEN DONE TO FACILITY				YES NO		
IF ANY:	:					
		FOOD		BEVERAGE		PETROCHEMISTRY
PLEASE SPECIFY INDUSTRIAL SECTOR/ SECTORS AND FLOWS		TEXTILE		PAPER		AGRICULTURE
		METAL		CHEMISTRY		MEDICINE/COSMETIC
		LEATHER		HOTEL		WOODWORK
	OTHERS					
CONNECTION TO CANAL IS DIRECTLY DONE			YES		NO	INDUSTRIES
CONNECTION TO CANAL IS DONE BY MEANS OF PRE-PURIFICATION		YES		NO	INDUSTRIES	
CONNECTION TO CANAL IS DONE WITH FINE PURIFICATION		YES		NO	INDUSTRIES	
PART II- OPERATION INFORMATION RELATED TO THE PIRIFICATION FACILITY – (3)						
TYPE AND FLOW OF THE ORGANIZED INDUSTRIAL ZONE	:			m3/day		
TYPE OF THE PURIFICATION FACILITY	:		DIRECT		PRE	FINE PURIFICATION
SEEPAGE WATER AND FLOW OF LAND FILL	:			m3/day		
IS REVISION IN FACILITY CONSIDERED IN THE FUTURE?			YES		NO	
IS THE CANAL DISCHARGE STANDARTSWATER POPULATIONCONTROL REGULATION IS DIFFERENT FROM VALUES IN TABE 25, PLEASE SPECIFY						
TABLE 25 : WASTEWATER STANDARTS ENVİSAGED IN THE DISCHARGE OF THE WASTEWATER IN WASTEWATER INFRASTRUCTURE FACILITIES						
TABLE 2 : Dıscharge limits related to fine purification from urban wastewater purification facilities*						

PART-III PURIFICITION PROCESSES APPLIED IN PRESENT FACILITY		
PHYSICAL PURIFICITION		
COARSE GRID	PRESENT	ABSENT
FINE GRID	PRESENT	ABSENT
POMP STATION	PRESENT	ABSENT
SIEVE SYSTEM	PRESENT	ABSENT
SAND CATCHER	PRESENT	ABSENT
Ventilated Sand Catcher		
Parabolic Cross Sectioned Sand Catcher with Horizontal Flow		
Rectangular Cross Cectioned Sand Catcher with Horizontal Flow		
PRIMARY SEDIMENT POOL	PRESENT	ABSENT
Rectangular Cross Sectioned Sediment Pool		
Circular Sediment Pool		
Square Sediment Pool		
Sludge Collection System	STRIPPING	ABSORPTION

BIOLOGICAL PURICITION		
ACTIVATED SLUDGE SYSTEM		
Classical Activated Sludge System	PRESENT	ABSENT
Long Ventilated Activated Sludge System		
BNR Activated Sludge System Configuration		
A/O Process (Anaerobic/Aerobic)		
A/O Process (Anoxic/Aerobic)		
A/O Process (Anaerobic/ Anoxic /Aerobic)		
Bardenpho Process		
Phostrip Process		
University of Cape Town (UCT)		
Sequential Batch Reactor (SBR)		
Membrane Bioreactor (MBR)		
Others (Please Specifiy)		

ACTIVATED SLUDGE DESIGNING METHOD:			**ATV-131**							
			WEF (Metcalf and Eddy)							
			OTHERS (Please Specifiy)							
MINIMUM DESIGNING HEAT			^{o}C							
TOTAL SLUDGE AGE			day							
CHEMICAL FORTIFICATION AT ACTIVATED SLUDGE SYSTEM					PRESENT		ABSENT			
If present, the chemical used	Alum		FeCI3		FeSO4		OTHERS (Please Specifiy)			
TRICKLING FILTER	PRESENT		ABSENT							
BIODISK SYSTEM	PRESENT		ABSENT							
STABILIZATION POOL	PRESENT		ABSENT							
ARTIFICAL WETLAND AREA	PRESENT		ABSENT							
OTHERS (Please Specifiy)										
FINAL SEDIMENT POOL	PRESENT		ABSENT							
Rectangular Cross Cectioned Sediment Pool										
Circular Sediment Pool										
Square Sediment Pool										
Sludge Collection system			STRIPPING		ABSORPTION		DEPENTED ON GRAVITY			

DISINFECTION UNIT	PRESENT	ABSENT
Disinfection with Chlorine		
Disinfection with Ozone		
Disinfection with UV		
OTHERS (Please Specifiy)		
DEODIZER FACILITY	PRESENT	ABSENT
Please specify its type		
DISTANCE TO THE CITY	km	

PART-IV CHARACTERISTICS OF THE RAW WASTEWATER COMING TO THE FACILITY						
Is the wastewater analysis done in facility?		YES		NO		
PARAMETER	**UNIT**	**COMPOSITE FOR 2 HOUR**	**COMPOSITE CIRCADIAN**	**MINIMUM**	**ANNUAL AVERAGE**	**MAXIMUM**
BIOCHEMICAL OXYGEN DEMAND	(mg/L)					
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)					
SOLID (TKM) IN TOTAL	(mg/L)					
SUSPENTED SOLUD (AKM)	(mg/L)					
VOLITILE SUSPENSIVE SOLUD (AKM)	(mg/L)					
pH						
NITROGEN (TN) IN TOTAL						
KJELDAHL NITROGEN IN TOTAL (TN)						
PHOSHOR (TP) IN TOTAL						
CLORURE	(mg/L)					
SULPHATE	(mg/L)					
ALKALINITE	(mg/L,CaCO3)					
FAT-GREASE	(mg/L)					
COLIFORMS IN TOTAL	(NO/100 mL)					
OTHER PARAMETERS	**UNIT**	**MINIMUM**	**AVERAGE**	**MAXIMUM**		
Filtered KOİ	(mg/L)					
Precipiated KOİ	(mg/L)					
Volatile Fatty Acid	(mg/L)					
NH4-N	(mg/L)					
PO4-P	(mg/L)					

PART V- DISCHARGE FEATURES OF THE FACILITY and DISCHARGE CRITERIA WHICH SHOULD PROVIDE BYE THE FACILITY ACCORDING TO THE REGULATIONS

PURIFIED WASTEWATER FEATURES

PARAMETER	**UNIT**	**MINIMUM**	**AVERAGE**	**MAXIMUM**
BIOCHEMICAL OXYGEN DEMAND	(mg/L)			
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)			
SOLID IN TOTAL (TKM)	(mg/L)			
SUSPENTED SOLUD	(mg/L)			
pH	-			
NITROGEN IN TOTAL (TN)	(mg/L)			
PHOSHOR (TP)	(mg/L)			
CLORURE	(mg/L)			
SULPHATE	(mg/L)			
ALKALINITE	(mg/L, CaCO3)			
FAT-GREASE	(mg/L)			
COLIFORMS IN TOTAL	(100 mL)			
Other Parameters	**UNIT**	**MINIMUM**	**AVERAGE**	**MAXIMUM**
Filtered KOİ	(mg/L)			
AKM	(mg/L)			
UAKM	(mg/L)			
TKN	(mg/L)			
NH4-N	(mg/L)			
NO3-N	(mg/L)			
NO2-N	(mg/L)			
PO4-P	(mg/L)			

Table 21.1 Sector Domestic Qalified Wastewater (Class 1: As Pollution Load Raw BOI between 5-60 Population: 84-1000

PARAMETER	UNIT	COMPOSITE SAMPLE FOR 2 HOUR	COMPOSITE SAMPLE CIRCADIAN
BIOCHEMICAL OXYGEN DEMAND (BOI_5)	(mg/L)	50	45
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)	180	120
SUSPENTED SOLUD (AKM)	(mg/L)	70	45
pH	-	6-9	6-9

Table 21.2: Sector: Domestic Qalified Wastewater (Class 2: As Pollution Load Raw BOI Between 60-600 Kg/Day Popultion =1000-10000

PARAMETER	UNIT	COMPOSITE FOR 2 HOUR	COMPOSITE CIRCADIAN
BIOCHEMICAL OXYGEN DEMAND (BOI_5)	(mg/L)	50	45
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)	160	110
SUSPENTED SOLUD (AKM)	(mg/L)	60	30
pH	-	6-9	6-9

Table 21.3: Sector: Domestic Qalified Wastewater (Class 3: As Pollution Load Raw BOI bigger than 600-6000 Kg/Day Popultion =1000-10000

PARAMETER	UNIT	COMPOSITE FOR 2 HOUR	COMPOSITE CIRCADIAN
BIOCHEMICAL OXYGEN DEMAND (BOI_5)	(mg/L)	50	45
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)	140	100
SUSPENTED SOLUD (AKM)	(mg/L)	45	30
pH	-	6-9	6-9

Table 21.4: Sector: Domestic Qalified Wastewater (Class 4: As Pollution Load Raw BOI bigger than 600 Kg/Day Popultion >10000

PARAMETER	UNIT	COMPOSITE FOR 2 HOUR	COMPOSITE CIRCADIAN
BIOCHEMICAL OXYGEN DEMAND (BOI_5)	(mg/L)	40	35
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)	120	90
SUSPENTED SOLID (AKM)	(mg/L)	40	25
pH	-	6-9	6-9

Tablo 21.5: Sector: Domestic Qalified Wastewater (Natural Purification regardless of Equivalent Population) (Artifical Wetland) and for Urban Wastewater Purification Facilities that do Biological Purification with Pools System

PARAMETER	UNIT	COMPOSITE FOR 2 HOUR	COMPOSITE CIRCADIAN
BIOCHEMICAL OXYGEN DEMAND (BOI_5)	(mg/L)	75	50
CHEMICAL OXYGEN DEMAND (KOİ)	(mg/L)	150	100
SUSPENTED SOLUD (AKM)	(mg/L)	200	150
pH	-	6-9	6-9

Part VI- SLUDGE PURIFICATION/ PROCESSING PROCESS				
PRIMARY SEDIMENT PROCESS	PRESENT	ABSENT		
IF PRIMARY SEDIMENT PROCESS IS PRESENT:				
REMOVAL EFFICIENCY OF SUSPENDED SOLID	%			
PRIMARY SEDIMENTSLUDGE THICKENING		PRESENT	ABSENT	
Percentage of primary sediment solids	%			
	Amount (number)	Capacity (please specify its unit)	Percentage of Thick Sludge Solids (%)	EXPLANATION
GRAVITY THICKENER				
THICKENER OF FLOATATION TYPE				
THICKENER OF BELT TYPE				
DEWATERING BOARD				
THICKENER OF CENTRIFUGATION				
OTHERS (Please specify)				

FINAL SEDIMENT SLUDGE THICKENING	PRESENT	ABSENT				
Percentage of final sediment solids	%		Amount (number)	Capacity (please specify its unit)	Percentage of Thick Sludge Solids (%)	EXPLANATION
GRAVITY THICKENER						
THICKENER OF FLOATATION TYPE						
THICKENER OF BELT TYPE						
DEWATERING BOARD						
THICKENER OF CENTRIFUGATION						
OTHERS (Please specify)						
IS BIOLOGICAL SLUDGE MIXED WITH PRIMARY SEDIMENT?				YES		NO
IF THE ANSWER IS YES, PLEASE SPECIFY THE PROPORTIONS?						
IS CONDITIONER USED IN THICKENING?				YES		NO
IF YES, PLEASE SPECIFY THE TYPE AND AMOUNT?						

SLUDGE STABILIZATION	PRESENT	ABSENT			
		Amount (number)	Capacity (please specify its unit)	Sludge Solid Percentage of Post-Stabilization (%)	EXPLANATION
AEROBIC STABILIZATION					
ANAEROBIC STABILIZATION (DIGESTER)					
STABILIZATION WITH LIME					
COMPOSTING					
OTHERS (Pleace specify)					
DAILY BIOGAS AMOUNT OF ANAEROBIC DIGESTION				m3/day	
METHAN PERCENTAGE OF DAILY BIOGAS AMOUNT OF ANAEROBIC DIGESTION				%	
ENERGY SOURCE OF THE FACILITY	ELECTRICITY	KOGENERATION		OTHERS	
IS THERE ADDITION OF ORGANICAL SOLID WASTE IN ANAEROBIC SLUDGE STABILIZATION?					
			YES		NO
IF YES, THE TYPE AND AMOUNT?					
DETENTION PERIOD AND TEMPRATURE OF ANAEROBIC DIGESTER		:	DAY		oC

IS FINAL THICKENER USED?	PRESENT	ABSENT			
IF PRESENT, SPECIFY THE TYPE AND THE CONTENT OF THICK SLUDGE SOLIDS.					
IS CONDITIONER USED IN THICKENING PROCESS?				YES	
IF YES, PLEASE SPECIFY THE TYPE AND AMOUNT.					
SLUDGE DEWATERING	PRESENT	ABSENT			
Solıd percentage of dewatered sludge	%				
		Amount (number)	Capacity (please specify its unit)	Sludge Cake Solids Percentage (%)	EXPLANATION
BELT PRESS					
PLATE PRESS FILTER					
VAKUM FİLTRE VACUUM FİLTER					
DECANTER CENTRIFUGE					
ÇAMUR KURUTMA YATAKLARI SLUDGE DRYING BED					
SLUDGE LAGOONS					
SPREADING THE SLUDGE ON TERRAIN					
IS THERE ANY DRYING FACILITY?	PRESENT	ABSENT			
IF DRYING FACILITY IS PRESENT?					
OTHERS (Please specify.)					
IS SLUDGE STORAGE PROCESS CARRIED OUT IN FACILITY?				YES	
IF STORAGE PROCESS IS CARRIED OUT, ITS PERIOD					
DEWATERING OPERATION PERIOD/SHIFT				YES	
PLEASE SPECIFY THE SLUDGE CONDITIONING METHOD APPLIED IN DEWATERING.					
IF CHEMICAL CONDITIONING IS APPLIED, PLEASE SPECIFY THE CHEMICALS USED.					

THE AMOUNT OF THE CHEMICAL/POLYMER USED IN DEWATERING?					
SLUDGE REMOVING METHOD					
STORAGE AT SOLID WASTE STORAGE AREA OF THE MUNICIPALITY					
STORAGE AT PRIVATE STORAGE AREA					
APPLICATION AT AREA(*)					
BURNING					
GASIFICATION/PYROLYSIS					
BURNING AS ADDITIONAL FUEL CEMENT PLANT					
OTHERS (Please specify)					
* PLEASE SPECIFY FINAL USAGE OBJECTION IN CASE OF THE APPLICATION OF THE SLUDGE AT TERRAIN					
IF AGRICULTURAL APPLICATION OF SLUDGE IS PRESENT, PLEASE SPECIFY THE TYPE.					
Field					
Meadow-Pasture					
Vegetable					
Fodder plant					
Fruit growing					
Forest keeping – Forestry					
Others - please specify					
PLEASE SPECIFY THE PROBLEMS AROUSED AT FACILITY: (Example: sludge bulking and period, sediment problem etc.)					

<u>Part VII - PURIFICATION SLUDGE AMOUNT AND CHARACTERISTICS</u>			
AMOUNTS OF PURIFICATION SLUDGE			
	UNIT	**AMOUNT**	
ANNUAL AMOUNT OF PURIFICATION SLUDGE	**(ton/year)**		
DAILY AMOUNT OF PURIFICATION SLUDGE	**(ton/day)**		
PURIFICATION SLUGDE AMOUNT OF WINTER SEASON			
PURIFICATION SLUDGE AMOUNT OF SUMMER SEASON			
PARAMETERS	**UNIT**	**AMOUNT**	
TOTAL SOLID	(%)		
TOTAL ORGANIC SOLID	(%)		
TOTAL NITROGEN	(mg/kg KM)		
TOTAL PHOSPHOR	(mg/kg KM)		
CONDUCTIVITY	(dS/m)		
C/N			
POTASSIUM (K)	(%)		
CALCIUM (Ca)	(%)		
MAGNESIUM (Mg)	(%)		
SODIUM (Na)	(%)		
pH	-		

HEAVY METALS			
LEAD (Pb)	(mg/kg KM)		
CADMIUM (Cd)	(mg/kg KM)		
CHROM +3 (Cr^{+3})	(mg/kg KM)		
TOTAL CHROM (Cr)	(mg/kg KM)		
COPPER (Cu)	(mg/kg KM)		
NICKEL (Ni)	(mg/kg KM)		
PARAMETERS	**UNIT**	**AMOUNT**	
MERCURY (Hg)	(mg/kg KM)		
ZINC (Zn)	(mg/kg KM)		
IRON (Fe)	(mg/kg KM)		

MICROBIOLOGICAL ANALYSIS			
E. COLİ	(EMS/g)		
FEKAL KOLİFORM	(MPN/g)		
SALMONELLA	(#/g)		
Parameter	**Unit**	**Purification Sludge Analtsis**	**Analysis Methods**
AOX (Adsorbable organic halogens)	mg/kg KM		
LAS (Linear alkylbenzene sulphonete)	mg/kg KM		
DEHP (Diftalat(2-ethylhexyl))	mg/kg KM		
NPE (It includes nonyl phenol and the total of nonyl phenol ethoxyl that is 1 and 2 ethoxy group)	mg/kg KM		
PAH (The total of polycyclic polyaromatic hydracarbonsor polyarmonic hydracarbons)	mg/kg KM		
PCDD/F Polichlorinated dibenzodioxin/dibenzofurans	ng Toxic Equivalent.kg^{-1} KM		
PCB (The total of 28, 52, 101, 118, 138, 153, 180 numbered polichlorinated biphenyl compounds)	mg/kg KM		
Electricity conduvtivity	dS m^{-1}		
Moisture	%		
Please specify the place that Eluat Analysis ic carried out:			
Is purification sludge analysis carried out in the facility?	**YES**		**NO**
Does the facility have laboratuar?			
Please specify the parameters followed regularly.			

Regulation on the Control of Dangerous, APPENDIX-11 A, Storage criteria in sanitary storage facilities - I

		ELUAT ANALYSIS RESULTS	Wastes to be treated as inert waste (mg/L)	Wastes to be treated as riskless wastes (mg/L)	Wastes to be treated as dangerous waste (mg/L)
1	**Eluat Criteria**				
	L/S = 10 lt/kg				
1.01	As (Arsenic)		≤ 0.05	0,05–0,2	< 0,2–2,5
1.02	Ba (Barium)		≤ 2	2–10	< 10–30
1.03	Cd (Cadmium)		≤ 0,004	0,004 – 0,1	< 0,1–0,5
1.04	Cr total (Total chrome)		≤ 0,05	0,05–1	< 1 – 7
1.05	Cu (Copper)		≤ 0,2	0,2 – 5	< 5 – 10
1.06	Hg (Mercury)		≤ 0,001	0,001– 0,02	< 0,02– 0,2
1.07	Mo (molibden)		≤ 0,05	0,05 - 1	< 1 – 3
1.08	Ni (Nickel)		≤ 0,04	0,04 – 1	< 1 – 4
1.09	Pb(Lead)		≤ 0,05	0,05 – 1	< 1 – 5
1.10	Sb (Antimony)		≤ 0,006	0,006 -0,07	< 0,07 -0,5
1.11	Se(Selenium)		≤ 0,01	0,01 – 0,05	< 0,05 – 0,7
1.12	Zn (Zinc)		≤ 0,4	0,4 -5	< 5 -20
1.13	Chloride		≤ 80	80 - 1500	< 1500 – 500
1.14	Fluoride		≤ 1	Oca.15	< 15 -50
1.15	Sulfate		≤ 100	100 – 2000	< 2000- 5000

1.16	DOC (Dissolved organic carbon)[1]	≤ 50	50-80	<80-100
1.17	TDS (Total dissolved solid)	≤ 400	400-6000	<6000-10000
1.18	Phenol index	$\leq 0,1$		
2	Criteria on original wastes			
		(mg/kg)	(mg/kg)	(mg/kg)
Regulation on the Control of Dangerous, APPENDIX-11 A, Storage criteria in sanitary storage facilities -II				
2.1	TOC(total organic carbon)	$\leq$30000 (%3)	50000 (% 5)- pH $\geq$ 6 [2]	60000 (%6)
2.2	BTEX (benzene, toluene, ethylbenzene ve xylene)	6		
2.3	PCBs	1		
2.4	Mineral oil	500		
2.5	LOI (Loss of ignition)			10000 (%10)

Part VIII - ADDITINAL INFORMATION RELATED TO PURIFICATION FACILITY		
If any, please inform about the below written information related to the purification facility		
SCHEMA OF THE WASTEWATER PURIFICATION FACILITY		
FACILITY OPERATING DATA ON ANNUAL BASIS		
(Performance data, Wastewater Purification Costs, Sludge Purification and Removal Costs)		
1	P&I Diagramme	
2	Processing Report	
3	Mass Equilibrium of Purification Facility	
4	Daily Operating Leafs (Operating Sheets for 2008/2009/2010)	
5	Sludge analysis of waste Sludge	
6	General Settlement Plan	

Part IX. WASTEWATER PURIFICATION COSTS						
PURIFICATION COSTS PER AVERAGE UNIT FLOW		TL (Turkish Lira) / m3				
TOTAL ELECTRICITY SPENT PER UNIT FLOW		kWh / m3				
SLUDGE PURIFICATION COSTS		TL (Turkish Lira) Ton Dry Sludge				
SPECIFY THE FORM OF SLUDGEIFYING		Highway		Railway		Seaway
TRANSPORTATION DISTANCE AND COSTS OF SLUDGE			km		TL/km	