ARISTOTLE UNIVERSITY THESSALONIKI
DEPARTMENT OF MECHANICAL ENGINEERING
LABORATORY OF HEAT TRANSFER AND
ENVIRONMENTAL ENGINEERING
HEAD: PROF. DR.-ING. HABIL N. MOUSSIOPOULOS

Project

"Integration of Solid waste management Tools into specific settings of European and Asian Communities"

Activity 2

a) Literature review on waste generation and composition in Greece

Prepared by: M. Theodoseli, A. Karagiannidis

Thessaloniki, March 2004

Table of Contents

1. Literature review on Waste Generation and Composition in Greece

1.1 Solid Waste Generation in Greece

Greece has a population of 10.2 million with a population density of 79 inhabitants/km^2, half of the EU average. The urban population accounts for 59% of the total, while nearly 50% lives in the two largest cities, Athens and Thessaloniki. The numerous populated islands (>100) and the large mountainous areas (>43% of the land) contribute to the beauty and the tourist attraction of the country but increase the challenges for cost-efficient, sustainable waste management [1].

Local Authorities have a central role in solid waste management (collection, recycling and disposal) and there is also a rather large informal recycling sector. More specifically, municipalities and communities are mainly responsible for the waste collection and disposal, but also some aspects of planning. In many cases, waste disposal comes under the competence of associations of local authorities, the most important being the Association of Attica and the association of Greater Thessaloniki.

At a national level, the Ministry for the Environment, Physical Planning and Public Works is responsible for policy making, national planning, technical matters, funding and licensing of large waste treatment and disposal facilities. In most cases, solid waste management issues also fall under the province of other Ministries such as the Ministries of Interior, of Health and Public Security and of Development [1].

The total amount of waste generation in Greece, based on data from European Environment Agency (EEA), was estimated in 15.612.000 and 20.805.000 tones in 1992 and 1995, respectively [2].

The data, however, show that waste quantities are increasing. This may be explained by a close link between economic growth and waste generation. The Waste Generation by sector in Greece for the year 1992, based on data from EEA is presented in table 1.

All amounts refer to 1992 except “Municipal” (1991) and “Mining” (1995). The figure for manufacturing is a partial total according to the Hellenic Ministry for the Environment, Physical Planning and Public Works to the EEA.

Table 1. Waste generation in tones by sector and country 1995 [3].

Sector	Waste Quantity (t)
Construction & Demolition	3.400.000
Energy Gas	7.000.000
Manufacturing	2.905.000
Mining	3.900.000
Other	
Municipal Waste	3.600.000
Total	20.805.000

Municipal Solid Waste generated in Greece in 1997 increased and reached the amount of 3.900.000 tones [4].

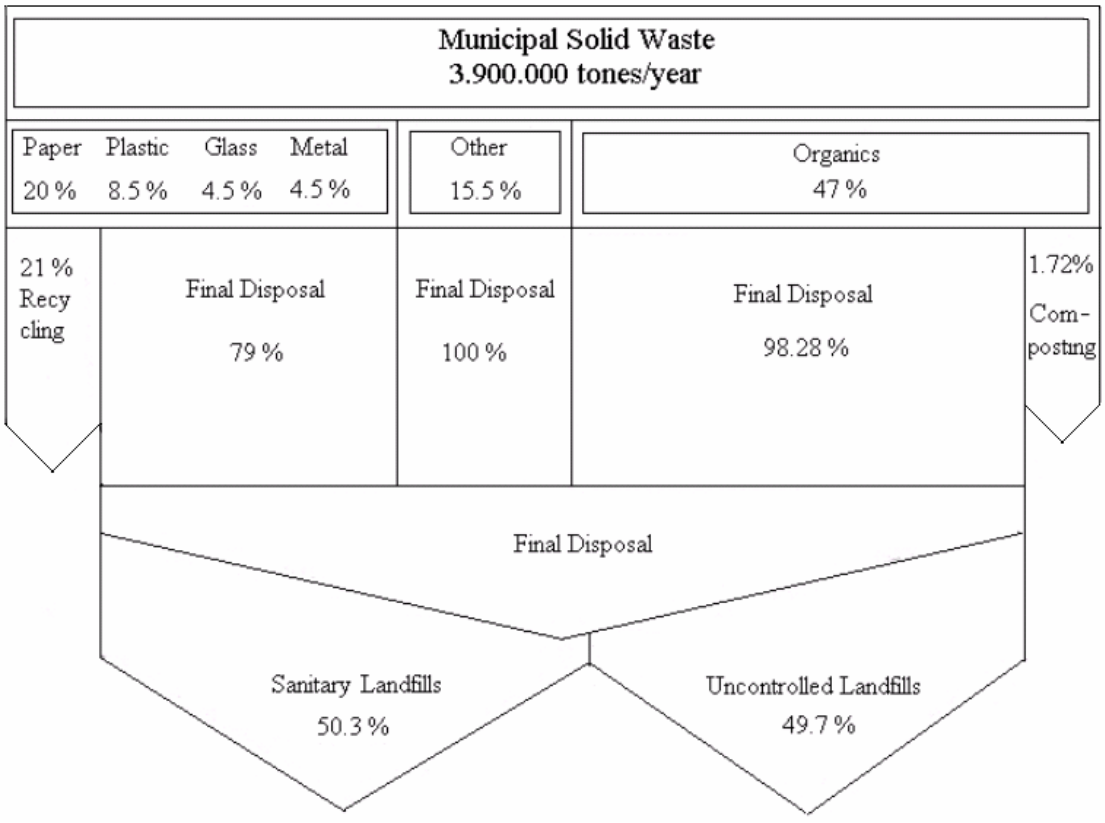

Figure 1. Flow chart of Solid Waste generation and composition in Greece [4].

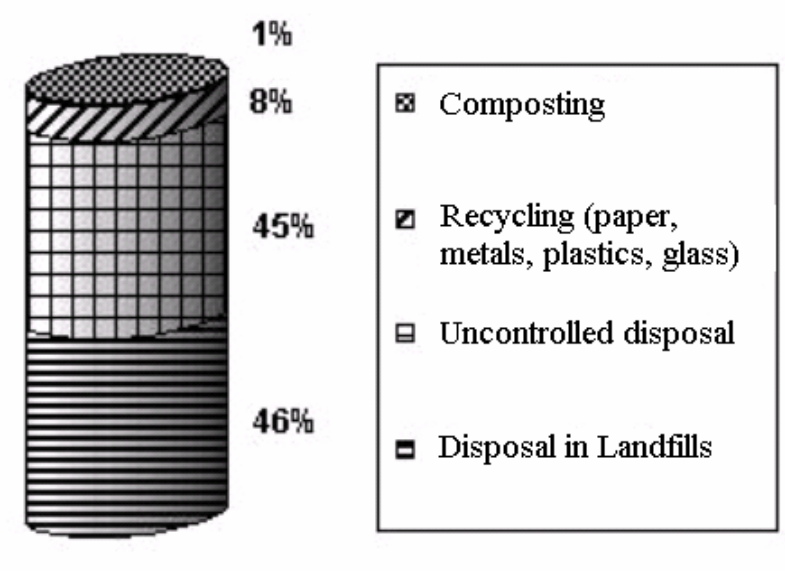

Figure 2. Composites (% per weight) of the SW production in 1997 [4].

Figure 3 shows annual and daily waste production data from the year 1991, in comparison with data from year 1997[4].

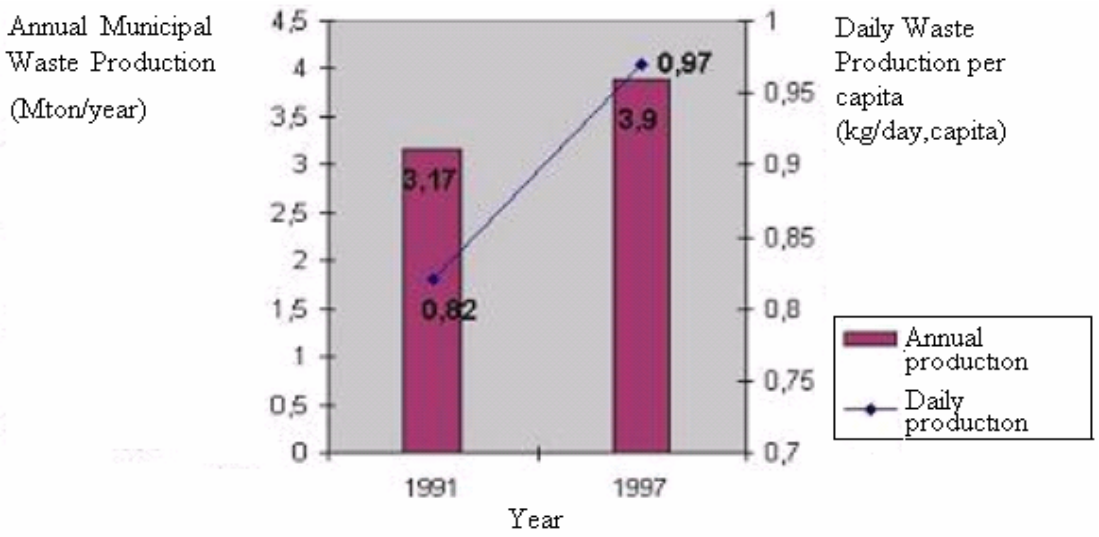

Figure 3. Annual and daily municipal waste data from 1991 to 1997 [4].

Internationally, but also in Greece a significant increase is observed of the waste quantity, which is daily produced per capita. This increase is mainly due to the change **of consumer patterns because of the rising living standards of residents**. This increase of unit waste production is expected to be continued in the future but with smaller annual rates of increase, because of the wide effort by the European Community for the reduction of waste production.

Table 2. Waste Production per capita in Greece [5].

Population	Average municipal waste production (kg/day per capita)
< 2.000	0.6 – 0.8
2.000 – 100.000	0.8 – 1.2
> 100.000	1.2 – 1.4

Waste generation from household and commercial activities in Greece for the year 1996 was 328 kg/capita, that is 28 kg/capita more than the EU level for 1998 of 300 kg/capita by the year 2000 [6].

The waste amount is continuously increasing as the population is increasing, while landfill spaces are being saturated. As an example, in 2001, the production of MSW in Greece was 4.559.000 tones, while in 1997 it was 3.900.000 tones (Fig. 4).

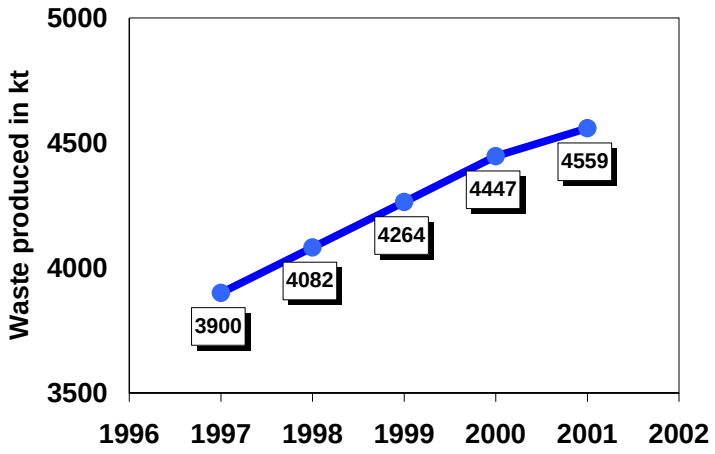

Figure 4. Trends in MSW generation in Greece 1997-2001 [7].

1.2 Solid Waste Composition in Greece

According to the results of the analysis set that had been carried out in 1995 from Ministry of the Environment, Physical Planning and Public Works, the municipal waste composition in Greece was estimated and presented in table 3.

Table 3. Typical Waste Composition in Greece [8]

Composites	**Percentage (%)**
Organics	49,0
Paper	20,0
Plastic	8,5
Leather – Wood – Textile	5,0
Glass	4,5
Metal	4,5
Inert	3,0
Other	5,5
Total	**100**

Recently data showed that the waste consists mainly of organics (47%) and paper (20%), as that is illustrated in Figure 5.

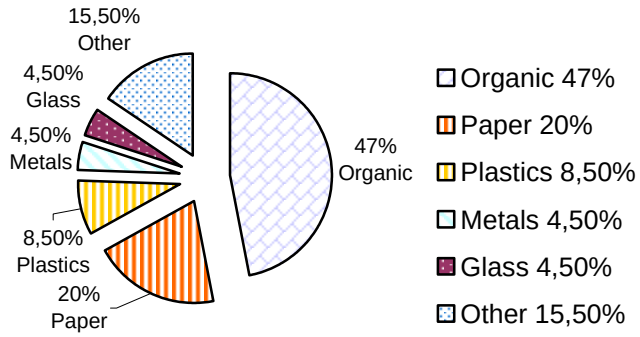

Figure 5. Waste fractions of 4.559.000 tones in year 2001 in Greece [7].

The municipal solid waste management in Greece presents different features compared to that of most EU countries. The quantity of waste continues to be somehow lower than in other European countries, reflecting a less intense consumption pattern. Their composition is also different, having as principal characteristics the high content in fermentative materials and the relatively low content in packaging materials. These positive characteristics are counter-balanced by certain delays in the waste management sector. The high number of open dumping sites (reduced to 1,260 today) constitutes the most negative element, while the percentages of useful material recovery are also low. With regard to the final disposal

data, 40% of the disposed waste is dumped in non-engineered sites, whereas 51% is disposed in sanitary landfills.

A research study took place in Thessaloniki's Greater area during 1999 concerning the MSW Composition. This study was realised under the supervision of the Prefecture Authority of Thessaloniki. The municipalities of the Thessaloniki Prefecture were classified in accordance with their main way of life and the economic features [9]. The classification included Urban, Semi-Urban, Agricultural and Touristic municipalities and the waste composition for each type is presented in table 4.

Table 4. Municipal Waste Composition in the Prefecture of Thessaloniki, 1999 [9].

Composites % κ.β.	**Urban**	**Semi-urban**	**Agricultural**	**Touristic**
Organics	43,1	40,7	48,7	39,5
Paper	22,8	23,5	18,5	24,5
Plastic	13,9	14,7	10,5	11
Metal	3,6	3,9	3,5	4,5
Glass	3,3	3,2	2,5	9,5
Remaining combustibles	4,3	5,8	5	3,5
Inert	2,2	2	4	4,5
Other	6,8	6,2	7,3	3

Three laboratory analyses took place in Thessaloniki for the determination of the waste composition in the Greater Thessaloniki area. The results of the analyses as measured in:

a. 1987 and 1998 at the entry of the central landfill of Tagarades and
b. 1997 from the waste bins in Pylea municipality,

are presented to table 5 [9].

Table 5. Waste composition in Greater Thessaloniki area, as measured in 1987, 1997 and 1998.

Year Composites %	1987	1997 (official results)	1998
Organics	51.70	43.00	26.66
Paper	17.70	22.70	29.21
Plastic	7.20	13.60	17.90
Metal	5.90	3.70	4.43
Glass	4.10	3.50	3.61
Leather – Wood – Textile - Others	9.40	4.50	9.13
Inert material	4.00	2.40	4.00
Other	0.00	6.60	5.06

In spite of the past efforts and the guidelines of the recently adopted Technical Regulations Framework on Solid Waste Management, there is no standardised mechanism for the collection of waste related data, especially regarding waste composition. As a result, policy making or even facility design, are often based on 'informed' estimations. Current management practices are illustrated in Table 6 [1].

Table 6. Municipal Solid Waste Management Practices in Greece [8]

Method	Greater Athens area 1.3 million tones pa 400kg/year/capita	Greece 3.3 million tones pa 320 kg/year/capita
Landfilling	85 per cent	50 per cent
Incineration	-	-
Open dumping	10 per cent	45 per cent
Recycling	5 per cent	5 per cent

Based on the previous results and on other different studies that have been carried out in Greece, for the estimation of the Waste Composition, it is obvious that the percentage of the organics is high. Hellenic Solid Wastes appear high amounts of compostables as table 7 shows.

Table 7. Qualitative composition of wastes derived from several regions of the Hellenic dominion

Region (Municipality or Communities)	Attica					Thessaloniki	Patra	Iraclio	Mun. of Rhodos	Mun. of Kos	Communities of Kos	Chania	Mun. of Naxos	Komotini	Xanthi	Kalamata
Period	1969	1970	1971	1972	6/83-6/84	4/86-3/87	1990	1987	9/87-8/88	1989	1990	1990	1994	92-93	92-93	1992
Population	3,5 millions.					1 million.		115.000	45.000	15.000	12.000					60.000
Organics (% by.w.)	55,3	57,2	57,5	60,9	59,8	51,7		52,5	41,6	37,3	39,8	55,2	48,3	67,1	61,2	47
Paper (% by w.)	24,4	23,2	23,3	22,0	19,5	17,7	21,9	17,2	13,6	25,0	23,5	19,1	21,6	9,1	15,1	25,0
Printing paper										4,8	4,9	5,7	4,5			3,1
Cardboard										2,9	2,0	2,5	3,7			8,7
Packaging paper										2,6	2,9	1,5	2,1			1,7
Other papers										14,7	13,7	9,4	11,3			11,5
Metals (% b.w.)	4,6	4,4	4,2	3,9	3,8	5,9		2,8	10,5	5,4	5,3	3,7	3,4	2,8	3,2	3,5
Ferrous										3,2	3,1	2,8	2,1			2,8
Aluminum							0,5			2	2	0,9	1,1			0,6
Batteries										0,2	0,1		0,1			0,1
Glass (% b.w.)	3,8	3,8	2,6	2,2	2,6	4,1	1,3	1,4	12,6	12,3	9,6	4	5,8	1,7	2,1	2,6
Plastics (%b.w.)	7,4	8,0	10,0	9,3	7	7,2		14,3	11,7	10,9	11,4	8,3	9,4	6,1	7,1	7,4
PE-sheet										4,8	4,9	5,6	4,4			5,1
PVC										1,4	2	0,1	0,6			0,1
PET										1,2	1,2	0,2	1,5			0,3
Others										3,5	3,3	2,4	2,9			1,9
Others (% b.w.)					8,2	13,4	11,7		10,0	9,3	9,8	9,7	9,8	12,9	11,3	14,4
Incombustibles					4,7	4	11,7		5,8	4,7	4,9	5,9	7,0			8
Inerts					0,7	4			2,6	3,2	2,6	1,9	3,2			5
Others					4	0			3,2	1,5	2,3	4	3,8			3
Combustibles	4,5	3,4	2,4	1,7	3,5	9,4			4,2	4,6	4,9	3,8	2,8			6,4
Fabric										1,9	2,1	1,7	1,8			2,1
Leather, Rubber										0,7	0,8	0,4	0,8			0,6
Wood										2	2	1,7	2			3,7

Region (Municipality or Communities)	Attica					Thessaloniki	Patra	Iraclio	Mun. of Rhodos	Mun. of Kos	Communities of Kos	Chania	Mun. of Naxos	Komotini	Xanthi	Kalamata
Spec. weight (kg/m^3)					167,2				119,8	113	113,1	137,9	121,9			80,7
Δh_l (kJ/kg)	6.884	6.132	6.324	6.675	7.315	4.381			4.844	7.289	7.089	7.071	7.678			7.327
Fuels (% b.w.)					28,7				34,5	45,3		45,9				48,1
Moisture (% b.w.)					37,5				30,2	31,4		40,8				37,5
Ashes (% b.w.)					33,8				35,3	23,3		13,3				14,4
>120 mm (% b.w.)					31,2				38,3							
40-120 mm (%b.w.)					34,1				45,7							
<40 mm (% b.w.)					34,7				16,0							
Ratio C/N (-)						22,5			18,5							

2. Acronyms

EEA	European Environment Agency
EU	European Union
MSW	Municipal Solid Waste

3. References

1. Lasaridi K. (1999) Solid Waste Management in Greece: a phase of change, Athens Municipality Development Agency, Athens, April.
2. European Environment Agency (2001) Indicator Fact Sheet Signals 2001 – Chapter Waste, Total Waste Generation.
3. OECD Environmental Data Compendium 1997, OECD 1997: National Accounts 1983-1995, OECD/Eurostat (provisional 1998-questionnaire) and Letter from Hellenic NRC concerning Construction and Demolition waste in Greece.
4. Hellenic Ministry for the Environment, Physical Planning and Public Works (1998) National planning for solid waste management (in Hellenic), August.
5. Alexakis M. and Agapitidis I. (1995) Solid Waste Management in Greece, Athens.
6. European Environment Agency (2001) Indicator Fact Sheet Signals 2001 – Chapter Waste, Generation of Waste from Households.
7. Common Ministerial Decision, Measurements and terms for solid waste management, National planning for solid waste management (in Hellenic), Government Paper 1909, CMD 50910/2727, 2003.
8. Hellenic Ministry for the Environment, Physical Planning and Public Works (1995), Hellas Ecological and Cultural Reserve, Athens, July.
9. Anatoliki S. A., 1999. Study of Thessaloniki's Prefectural Framework for Integrated Solid Waste Management. Anatoliki S.A. Development Agency of Eastern Thessaloniki, Funded by the Prefecture of Thessaloniki, according to the new European legislation 91/156, 94/62 (in Hellenic).