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Project

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

Activity 9

Planning of composting schemes for small for selected community in Greece

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1. Introduction

Aim of the present study is the planning of composting schemes in a selected area in Greece. Based on the previous research activity (market research on composting technologies Activity 2b), this study examines the large-scale implementation of composting schemes in a semi-rural area near Thessaloniki.

The selection of the community was based on specific criteria concerning the economic and demographical characteristics of the area, as well as solid waste production and composition. The suitable composting technology was selected, according to the available technologies implemented in Europe, existing infrastructure, as well as planning for the future solid waste management in the study area. The technical features of the method were analysed, the cost of the proposed technology was estimated and the expected quality of the produced compost was assessed. Moreover, the process of collection, transport and storage were also examined, whereas certain needs for additional adjustments were pointed out. Finally, the possibilities of commercial or any other use of the produced compost were also explored.

2. Selection of study area

The selected study area is the prefecture of Pieria, which belongs to the region of Central Macedonia and is located south from Thessaloniki (see figure 1). This prefecture is a semi-rural area with most of the population spread over small- and medium-sized rural communities. The specific area was selected, because of the prefecture’s agricultural activities and the production of large amounts of organic wastes. It was also taken into account that, in accordance with the prefecture’s solid waste management (SWM) planning, a composting plant has been proposed for this area. The need for soil fertilizers for the agricultural activities was also considered, as the compost market in the area could have very good perspectives.

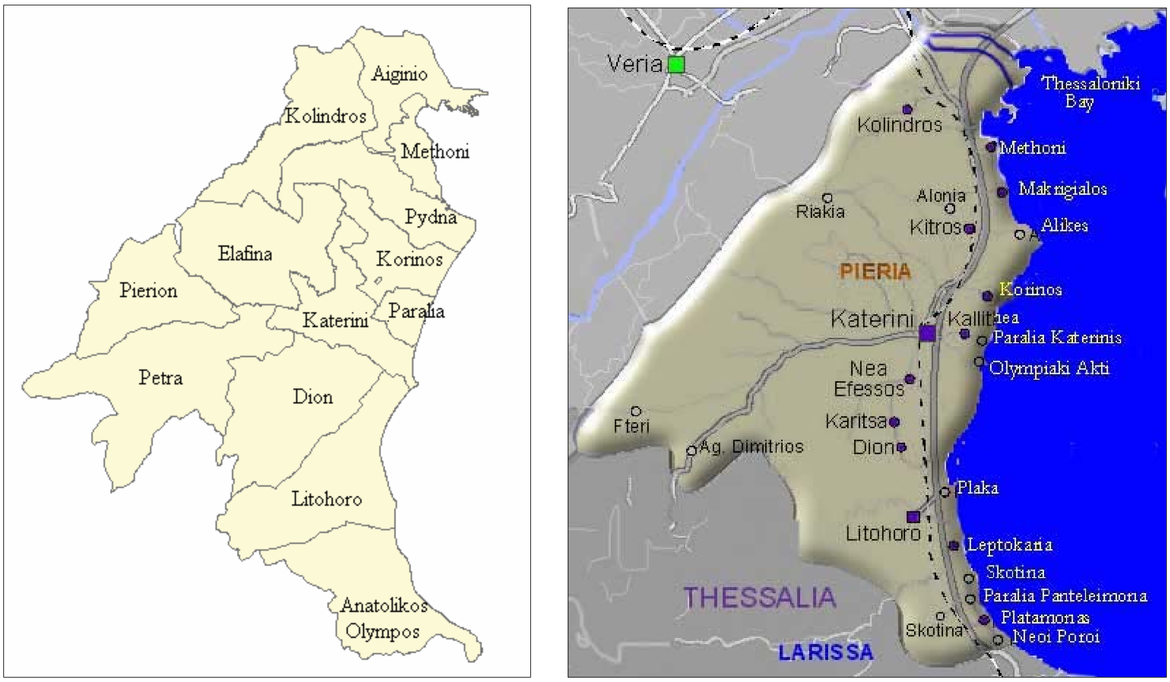
Figure 1. Region of Central Macedonia in North Greece and its 7 prefectures (1.Pieria, 2.Imathia, 3.Pella, 4.Kilkis, 5.Thessaloniki, 6.Chalkidiki and 7.Serres).

3. Main characteristics of Pieria Prefecture

3.1 Demographic characteristics

The prefecture of Pieria belongs in the region of central Macedonia, as figure 1 presents. Pieria shares borders in the north with the prefecture of Imathia and in the south with the prefecture of Larissa, while on the East it has shores on the Aegean Sea.

The prefecture has a population of 129.846 residents and is separated administratively in to 13 municipalities (see figure 2) [1]. The population of each municipality according to the 2001 national inventory is presented in Table 1. The existing communities per municipality are presented in Table 1.2. It must be emphasized that, during the summer period, the population of the prefecture is almost doubled because of touristic activities. These activities are spread uniformly along the prefecture's south coast and, specifically, in the municipalities of Paralia, East Olympus and Litohoro.



(a) (b)

Figure 2. Prefecture of Pieria and its Municipalities (a) and major population centers (b).

Table 1. Population Distribution per Municipality in Pieria Prefecture [1].

Municipality	Population	%	Municipality	Population	%
Katerini	56.434	43,5	Litohoro	7.011	5,3
Aiginio	5.264	4,1	Methoni	3.946	3,0
East Olympus	9.374	7,3	Paralia	6.449	4,9
Dion	11.252	8,7	Petra	6.246	4,8
Elafina	5.213	4,0	Pierion	2.811	2,2
Kolindros	5.223	4,0	Pydna	4.012	3,1
Korinos	6.611	5,1	**Total**	**129.846**	**100,0**

The city of Katerini is the capital of the Pieria Prefecture and also the municipality of Katerini, with a population of 56.434 residents [1]. The city is built next to the main national highway between Athens and Thessaloniki, whereas, generally, the economic activity of the prefecture is developed along this axis as well. Katerini is a typical Hellenic provincial city, with a developed touristic economy during the summer months and significant agricultural activities within small distance from its centre. It consists the major transit and export trade centre of its region.

Table 2. Communities per Municipality in Prefecture of Pieria

MUNICIPALITY	Number of communities	%
Katerini	12	13,3
Aiginio	3	3,3
East Olympus	11	12,2
Dion	7	7,8
Elafina	10	11,1
Kolindros	5	5,6
Korinos	6	6,7
Litohoro	5	5,6
Methoni	6	6,7
Paralia	3	3,3
Petra	13	14,4
Pierion	3	3,3
Pydna	6	6,7
Total	**90**	**100,0**

The rest of the prefecture can be categorized in two areas, the south and the north area.

The north area includes the municipalities of Pierion, Elafina, Korinos, Pydna, Methoni, Kolindros and Aiginio. In those municipalities roughly 25,5% of the total prefecture's population can be found. At this area the economic activity is mainly based on the agricultural production. The population is distributed in many small size communities and the morphology of the area is mainly flat, except from municipality of Elafina, where the morphology is clearly mountainous.

The south area of the prefecture includes the municipalities of Petra, Dion, Paralia, Litohoro and East Olympus where approximately 31% of the total population is found. In this area, the major touristic activity is observed mainly along the coastline and, as a result, the population is overdoubled. At the same time, there are also extensive agricultural and veterinary facilities mainly in the municipality of Dion and secondary in the municipality of Litohoro. The morphology is primarily flat with some mountainous areas [2].

The location of each community in the prefecture of Pieria is presented at Figure 3.

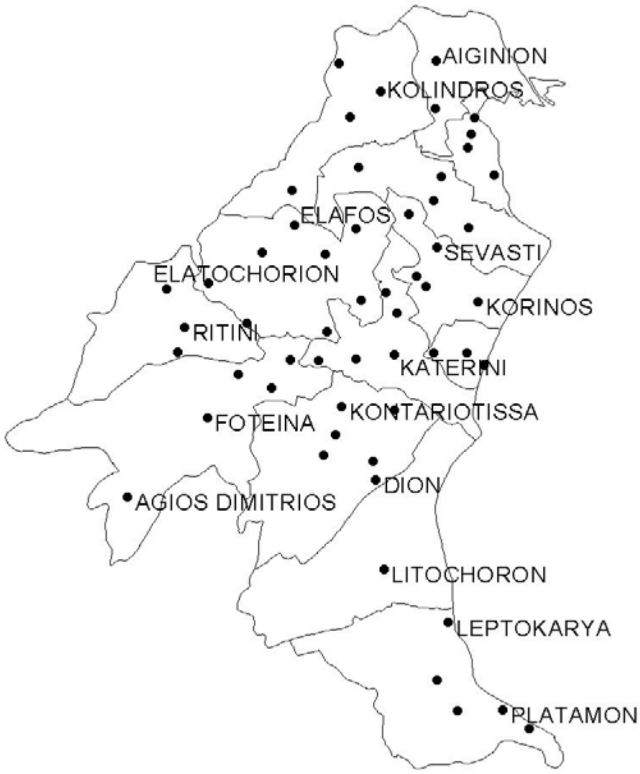


Figure 3. The Prefecture of Pieria and the location of each community.

<u>3.2 Climatic characteristics.</u>

The climate of Pieria in the flat regions is characterized by soft winters and hot summers. The presence of sea on the East side of the prefecture and of the Olympus and Pieria mountains on the West side, protect flat regions from intense meteorological phenomena. The mean annual temperature is 15,1^{o}C. The mean temperature during January and February is about 5^{o}C while during July and August is just above 25^{o}C.

The mean annual precipitation for years 1974-1994 was 826,5 mm. Most rainfall is observed during November (about 135 mm), while minimal precipitation is obtained during July and August (32mm).

Wind constitutes an essential factor for the dispersion and transport of pollutants and the characteristics of its flow depend on the morphology of the area. In the prefecture, the wind force seldom exceeds 2-3 Beaufort. The prevailing winds are E-NE and (during the summer) SE [3].

4. Solid Waste Management in Pieria Prefecture

4.1 Waste production and composition in Pieria Prefecture.

According to a study, carried out by the Technical Chamber of Greece on the region of Central Macedonia, the production of municipal solid waste (MSW) for the prefecture of Pieria is 0,994 kg per capita and day [4]. The total amount of solid waste generated in the prefecture is about 47.131 tones per year. This production is roughly 6,61 percent of the total waste production in the region of Central Macedonia [4]. The production of solid waste per municipality is presented in Figure 4. The southern municipalities of the prefecture along with capital city of Katerini show high MSW production, because of the touristic activity on the summer period in the south and the high population density in the capital city, respectively.

According to the CMD 14312/1302/00 the waste composition at the specific area shows 47% of organic waste, as presented in table 3. A laboratory analysis took place in the landfill located at Litohoro and the results on the waste's composition showed 60% organic wastes from the total waste quantity.

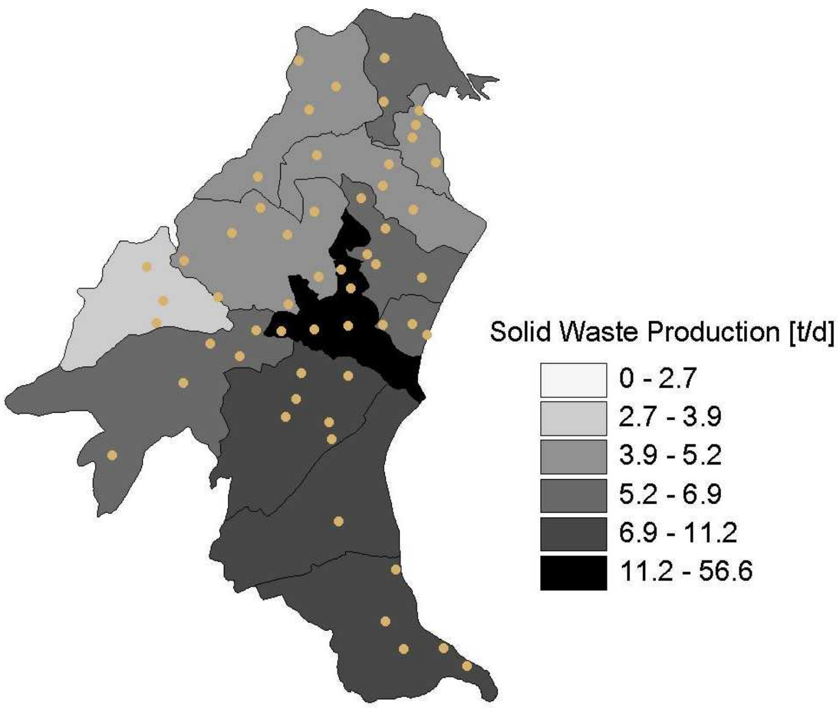


Figure 4. Production of solid waste per municipality for the prefecture of Pieria

Table 3. MSW composition of in Pieria Prefecture

Composites	CMD 14312/1302/00	Litohoro landfill
	%	%
Organics	47	60
Paper	20	17
Plastic	8,5	14,5
Metals	4,5	7
Glass	4,5	1
Other	15,5	0,5
Total	100	100

In parallel operation, with the sanitary landfill at Litohoro, are many uncontrolled dumpsites at the area. As a result, the organic waste composition from the national estimated composition (CMD14312/1302/00). "Other" wastes are usually disposed of in uncontrolled dumpsites within the area served by the landfill. It should be mentioned, that for the south area of Pieria, a variety on the MSW composition is present, which is caused by the high touristic activity during the summer period. Therefore, an increasing trend of the organic waste fraction is observed during the summer period.

4.2 Existing infrastructure

According to the planning for management of MSW, the prefecture is divided in three administrative areas (AA) as shown in Table 4 [5].

Table 4: Administrative Units of Pieria Prefecture

Administrative Area	**Municipalities**
1st	Aiginio, Kolindros, Methoni, Pydna
2nd	Katerini, Korinos, Paralia, Elafina
3rd	Litohoro, Dion, East Olympus, Pierion, Petra

In the capital city, Katerini, a sanitary landfill is already operating and MSW from the 2^{nd} administrative area are disposed of, while the Litohoro landfill is under construction and is expected to accept MSW from the 3^{rd} AA early in 2005. Katerini landfill is located outside the city of Katerini, while the Litohoro landfill is located between the municipality of Litohoro and the municipality of Dion. The two landfills will cover approximately 69,5% of the total prefecture population [4]. The municipalities not being served by these two sanitary landfills dispose their waste in 43 uncontrolled dumpsites some of which are located closely to populated areas [4]. Moreover, in Pieria there is already under operation a sewage treatment facility near the city of Katerini, whereas a second facility will be serving in the future the municipalities of Litohoro and East Olympus.

4.3 Future Planning

According to the planning for 1^{st} AA, a transfer station (TS) will be constructed in the Kolindros municipality. MSW from the 1^{st} AA will be collected, transferred, compressed and temporary stored to the TS and then transported by closed containers to the Katerini landfill. Moreover, the construction of a mechanical separation facility for MSW from the 1^{st} and the 2^{nd} AA, along with a composting plant next to the Katerini landfill, has been proposed. The facility will have the capability of co-processing sludge from the sewage treatment plant of Katerini. The proposed facility includes the recovery of recyclables through mechanical separation from mixed MSW and the control of the organic fraction in the composting plant. Produced compost can be used, in the first phase, as covering material for the daily cover of the existing sanitary landfill. Aim of this planning is the reduction of solid waste volume disposed of in landfills and uncontrolled dumpsites.

4.4. Selection of the appropriate composting technology

This part of the study was based on the previous research activity for the market research on composting technologies (Activity 2b). According to this study the following technologies have been implemented successfully in Europe:

- In-vessel composting
- Open windrow composting
- Vermicomposting

With a total MSW production of 47.131 tones, the annual amount of the organic waste is estimated at about 22.151 tones, based on data showing that the organic fraction constitutes 47% of the total waste quantity. This inflow is not very big, so we have to deal with an intermediate size of composting plant. This kind of waste does not justify the selection of sophisticated technology, which has higher cost of construction and operation.

The in-vessel technologies are excluded, as the cost of their installation and their operation is too high and they also require specialised personnel for operation. Moreover, the climatic conditions of Pieria with mild changes in temperature and humidity levels, does not create the necessity for the application of a technology that aims at the restriction of heat and humidity, like composting in closed containers.

Based on the facts presented above, the choice of windrow composting technology, is considered adequate for the specific area (see figure 5). The low operating cost of such a technology, together with the large available area near Katerini landfill and the absence of any populated area within a distance of 4 Km from the site, recommends the selection of this specific technology. The use of windrows in triangular forms is evaluated as the most suitable solution. The application of windrows takes place in a concrete plateau with the capability to install channels for aeration and grills for leachate collection under the pile.

The composting plateau must be constructed with a 2-3% inclination for better leachate flow. In this manner, pollution of underground water and excessive concentration of humidity in the interior of windrows is avoided, which could lead, locally, to conditions of anaerobic fermentation and undesirable odours with simultaneously negative consequences to the quality of the produced compost.

Figure 5. Windrow composting in triangular heaps

4. 5 Size of the selected unit.

The calculated quantity of 22.151 tones per year corresponds to a flow of roughly 60,5 tones per day. For a mean density of MSW in collection vehicles at about 300 kg/m^3 the composting plant will accept approximately 202 m^3 of input material per day [6]. Considering triangular windrows of 1,7 m height and 3 m wide, the estimated volume of material per metre is 2,55 m^3.

For the climatic conditions described above and the selected technology, the composting process will be completed in 7 weeks for the appropriate C/N ratio, proper mixing and particle size and proper moisture content of the composting material [7]. With this convention the installation will require for the composting phase roughly 3.881 m of windrows. Using 32 windrows of 121 m length each, the required area for the composting facility is estimated at about 17.250 m^2. Thus, size of 35000 m^2 is considered enough for the installation of the composting unit, the maturation plant, the waste reception area and the post-maturation treatment facility. It should be pointed out that the above calculation was based on the total MSW production of the prefecture.

The existing prefecture's planning assumes that only MSW from the 1st and 2nd AA will be led to the mechanical-biological treatment plant. This means that roughly 30t/d less MSW will be led in the facility. That is about 25% of total MSW production of the prefecture.

4.6 Required equipment

The basic equipment for the composting plant will be a self-propelled turner for the mixing of windrows as shown in Figure 6. It should be capable of turning the windrows in such a way that their height is increased by at least 33% after the turning. Moreover, the turner should be able to roll/unroll windrow covering material and have the ability to operate in low turns so that all of the CO_2 is ensured to escape from the pile.

The unit will use screens for the removal of undesirable over-sized material and a mixer for the addition of sewage sludge and green waste. Conveyors will be used for the movement of materials through the unit and bagging equipment will be used for exporting mature compost to the market. Moreover, the unit should be equipped with laboratory equipment for measuring the levels of CO_2, temperature and humidity in windrows.

Figure 6: Self-propelled compost turner

Concerning the infrastructure of the plant, an administration building will be constructed to accommodate the secretarial support, the lockers room and WC for the personnel. Moreover there will be space for the installation of a properly equipped laboratory for the analysis of MSW entering the installation as well as for determining the quality of the produced compost. Parking for the vehicles of the staff should also be foreseen .

4.7 Unit operation

The output material from the mechanical sorting facility will be led by conveyors into the composting plant. The material flow will be screened for over-sized particles (>100mm) and mixed, in order to achieve a homogenous texture. During this phase, green waste and/or sewage sludge could be added for achieving an optimal C/N ratio.

The composting field is to be covered for protection from rainfall. This will also help at the restriction of produced dust and protection of the underground water by minimizing the leachate flow. If the cost for such a cover's construction are too high, the windrows could be alternatively covered with a semi-permeable membrane, such as Gore-Tex [7].

Produced compost will be led with conveyor (after screening) to the maturation field, where it will be placed in triangular windrows having the same dimensions as those of composting. After the end of maturation, the product will be led to the refining facility, where it will be screened for the removal of uncomposted material and shredded down to the desired particle size. Finally, the ready product is either bagged for selling or used as it is for the daily cover of the landfill.

5. Planning of collection and transportation of solid waste.

The collection and transportation of MSW in Pieria prefecture takes place with closed-type collection vehicles. The basic types of vehicles are two: vehicles with a press and vehicles with a mill. The capacity of vehicles varies from 8 to $14m^3$ with mean density of waste at about $300kg/m^3$ [8]. The vehicles park in the landfill of their AA. The frequency of collection varies depending on the type of community and season of year. In mountainous areas like the municipalities of Petra, Elafina and Pierion the collection of waste happens twice a week during winter period (September-April), while this rate is increased to every second day during the summer months (May-August). In flat and coastal regions, where increased touristic activity is present, collection schedule is relatively "intense", three times per week during winter and in some cases every day during summer, as for example in the municipalities of Paralia, East Olympus, Katerini and Litohoro [8].

The cost of collection and transportation of solid waste is calculated in €/tn. For the calculation of this cost the mathematic types that are proposed in bibliography are used [9-11]. The covered distance between each community and the selected landfill was calculated with the help of ArcView 3.1 GIS software. The model was solved parametrically considering the minimum cost per minute as a parameter and comparing the output data with real cost figures. The cost curve is shown in Diagram 1. The model constants and mathematical types are presented below.

The operational cost of the mechanical-biological treatment plant is calculated as follows [12]:

$Y=2.857+313.959/d$ where

Y is the cost in €/t and

d is the input capability in t/day

The operational cost of the landfills is calculated [12]:

$Y=4.06-0.00676*d$ for the first and third scenario and

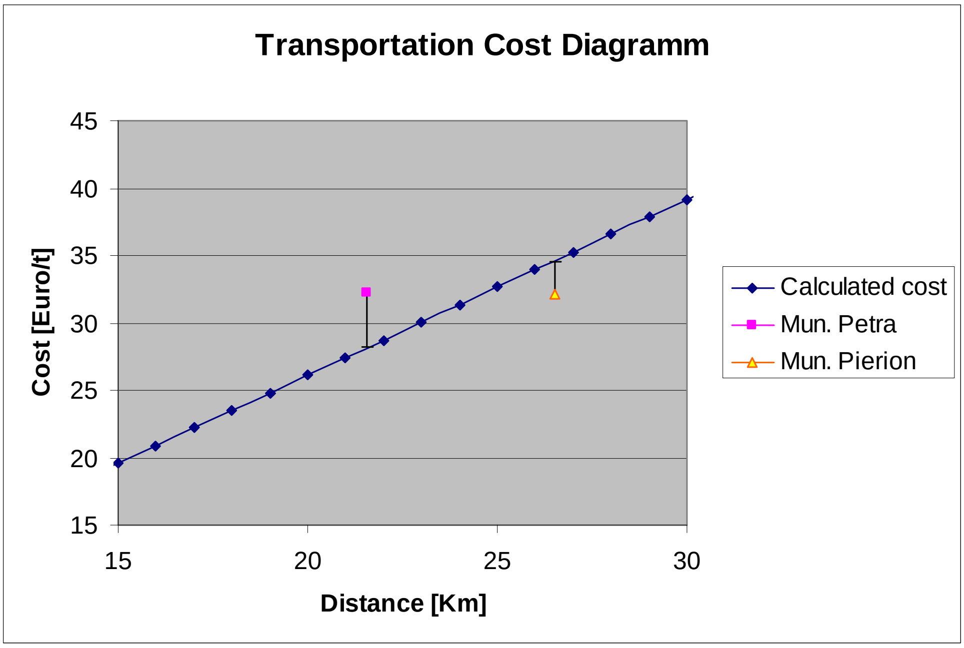
$Y=11.826-0.0508*d$ for all the other scenarios

Y is the cost in €/t and

d is the input capability in t/day

The operational cost for the transfer station is estimated by the cost presented from other same facilities of similar size in Greece.

Diagram 1: Transportation cost curve compared to real cost data.



The same model was also used for the calculation of the landfill operation cost, the transfer facility and the mechanical-biological treatment plant that were described above. The total cost of five different scenarios was calculated in this manner.

The six examined scenarios (based on the infrastructure used) are the following:

1. Only one landfill (in Katerini).
2. Two landfills (in Katerini and Litohoro) without any MSW pre-treatment facility available.
3. One landfill (in Katerini) with mechanical-biological treatment facility.
4. Two landfills (in Katerini and Litohoro) without any MBT facility installed.
5. The same as the second scenario with the addition of a transfer station in the 1st AA.
6. The complete scenario including all four facilities located as proposed above.

5.1 First scenario

According to this scenario the prefectural solid waste management is based on one sanitary landfill placed in Katerini as shown in Figure 7. Waste is transported to the landfill and deposited with no prior treatment.

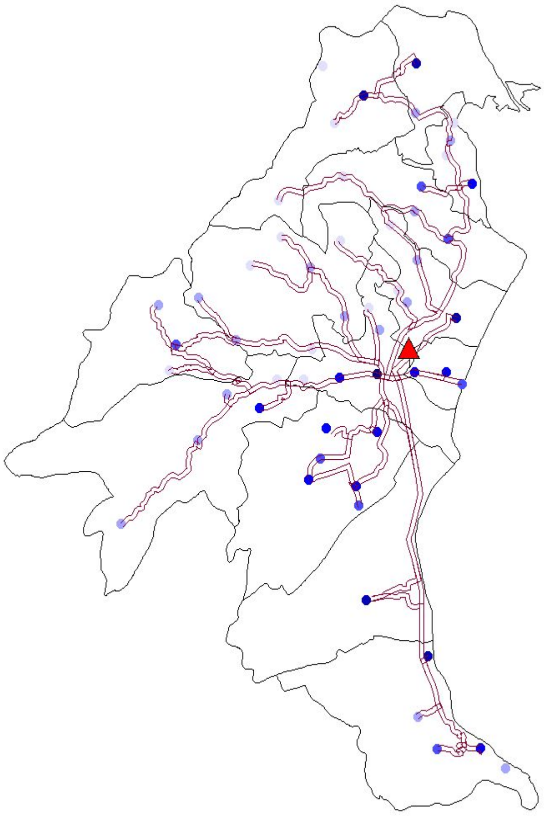


Figure 7: Planning of transportation scheme for the first scenario.

The total cost analysis of system operation appears in Table 5. It deserves mentioning that the maximum covered distance for the particular scenario is 42 Km and that in general the outer regions of the prefecture have minimum population density.

Table 5: Analysis of cost of first scenario

Transportation cost [€/d]	1932,6
Operation cost [€/d]	375,1
Total system cost [€/d]	2307,7

5.2 Second Scenario

According to this scenario the solid waste management for the prefecture is based on two landfills operating, one in Katerini and the other in Litohoro. No pre-treatment of waste occurs before disposal. The routing of waste flow for each landfill is presented in Figure 8.

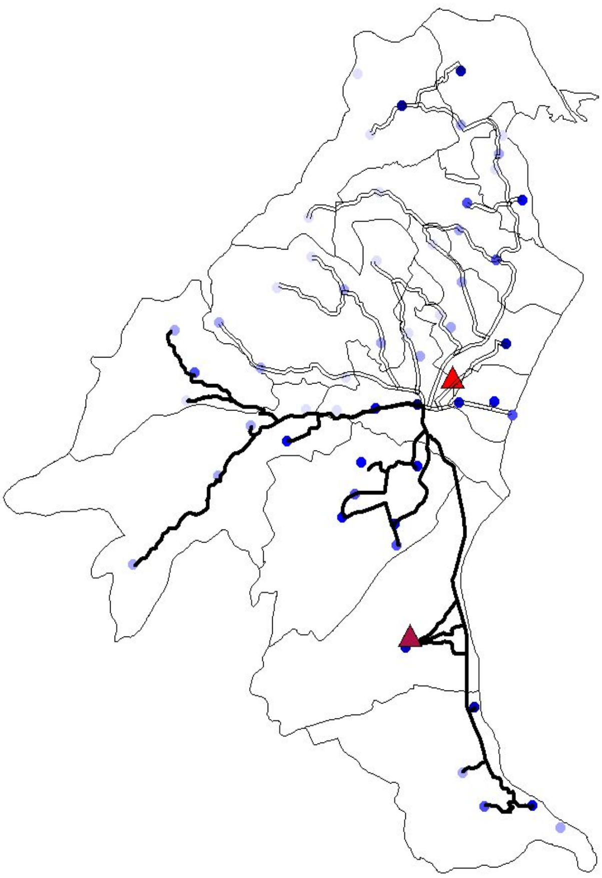


Figure 8: Planning of transportation scheme of second scenario assuming two landfills with no MBT of waste prior to disposal.

The total transportation and operating cost for this scenario is shown in Table 6. The cost is slightly increased compared to the previous scenario as the Litohoro landfill serves the municipalities of Petra and Pierion having as impact the increase of transportation cost.

Table 6: Total cost of second scenario

	Katerini landfill	Litohoro landfill	
transportation cost [€/d]	1036,2	754,2	
operation cost [€/t]	4,2	6,9	
total operation cost [€/d]	352,9	209,9	
total cost [€/d]	1389,1	964,1	
System cost [€/d]			2353,2

5.3 Third Scenario

This scenario assumes the operation of Katerini landfill as the only solid waste management facility in the prefecture combined with a mechanical-biological treatment (MBT) plant placed inside the landfill. The planning of waste collection and transportation to the landfill is the same as in the first examined scenario. The difference lies in the excess cost of MBT unit operation. There has been no consideration of the unit's profits from the produced compost and recoverable material possible marketing. Despite all these the total cost of the system is kept low as the operation cost of Katerini landfill is decreased dramatically due to the minimized input in the landfill. Cost assets for this scenario are presented in Table 7.

Table 7: Cost elements of third scenario.

	Mechanical-biological treatment	Landfill	
Operational cost [€/t]	5,61	7,02	
Total operational cost [€/d]	639,39	200,05	
Transportation cost [€/d]			1932,6
System cost [€/d]			2772,1

5.4 Fourth Scenario

The fourth scenario adds in the second scenario a station of mechanical-biological treatment in the Katerini landfill. The itineraries and the cost of waste transportation is the same as in the second scenario while no profit from compost selling is taken into consideration. The total waste management system cost in this scenario is shown in Table 8.

Table 8: Cost elements of fourth Scenario.

	Mechanical-biological treatment	Katerini landfill	Litohoro landfill	
Operational cost [€/t]	6,61	7,03	6,93	
Total operational cost [€/d]	552,92	200,05	209,88	
Transportation cost [€/d]		1099,24	754,17	
System cost [€/d]				2816,27

5.5 Fifth Scenario

In the fifth scenario a transfer station is added to cover the 1st A.A. and system operation without MSW treatment prior to disposal is examined. The map including the served municipalities per installation is presented in Figure 9.

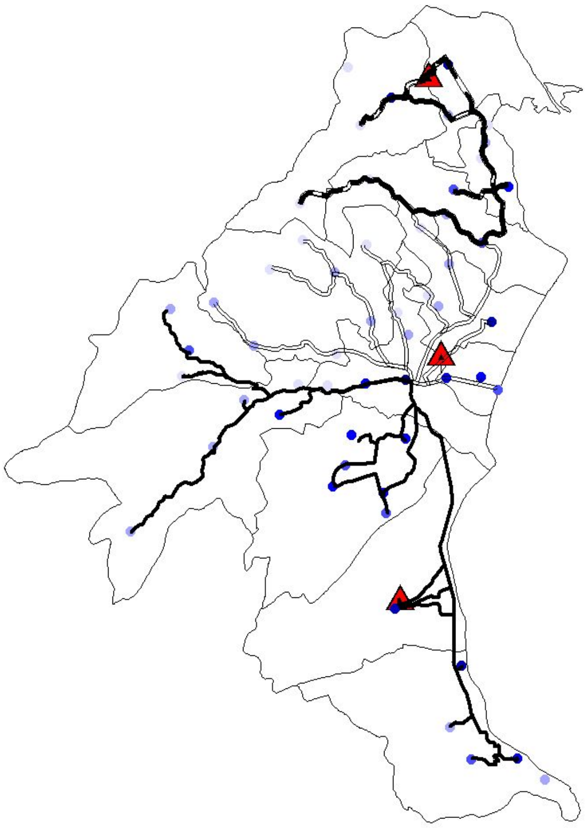


Figure 9: Planning of transportation scheme for the fifth scenario including two landfills and one transfer station

Table 9: Total cost of fifth scenario management system

	Katerini landfill	Litohoro landfill	Transfer station	
Input [t/d]	83,64	30,26	15,5	
operational cost [€/t]	4,21	6,93	203,4	
Total operational cost [€/d]	352,98	209,88	203,4	System cost [€/d]
transportation cost [€/d]	589,8	754,17	373,7	2483,99

5.6 Sixth Scenario

The last scenario represents the prefectoral solid waste management planning in its full extend. The waste flow from the 1st A.A. will be led through the transfer station to the mechanical-biological treatment plant placed in Katerini landfill where the flow from the 2nd A.A. will also be transported. As for the solid waste production of the 3rd A.A. it will be disposed untreated in Litohoro landfill. The collection-transportation scheme is the same as in the fifth scenario added the path from the transfer station to Katerini landfill as shown in Figure 10.

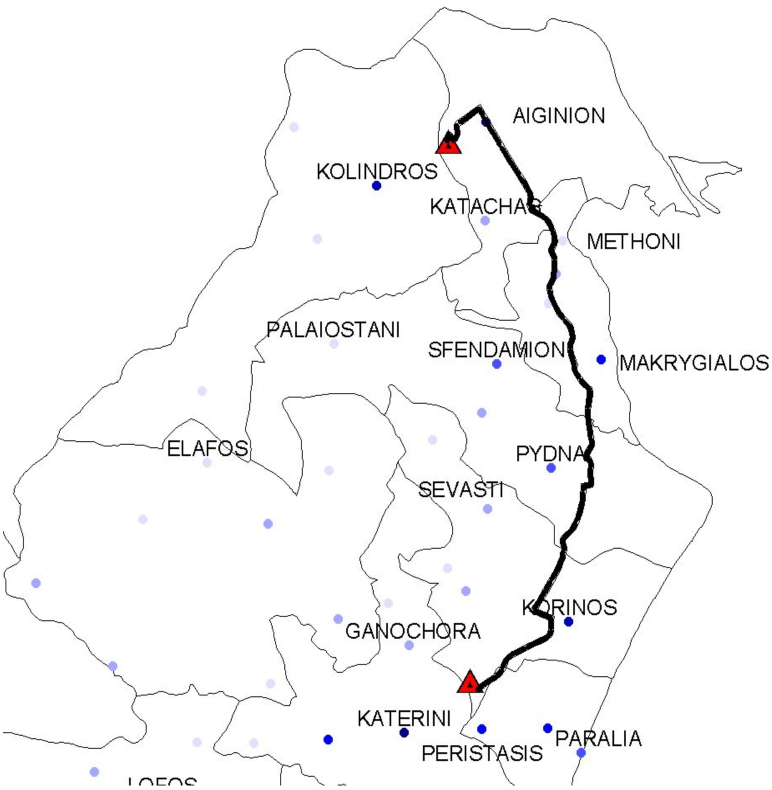


Figure 10: Transportation of waste between the transfer station and Katerini Landfill.

The collection-transportation and total operational cost of this scenario is presented in Table 10.

Table 10: Sixth scenario cost analysis

	Mechanical-Biological Treatment	Katerini landfill	Litohoro landfill	Transfer station	
Input [t/d]	83,64	28,47	30,26	15,57	
operational cost [€/t]	6,61	7,02	6,93	203,45	
total operational cost [€/d]	552,92	200,05	209,88	203,45	System cost [€/d]
transportation cost [€/d]		589,80	754,17	373,77	2884,06

6. Assessment of market/type of disposal

Due to the limitations set by national and EC legislation the use of MSW derived compost for agricultural uses is prohibited. As indicated in the bibliography [11] such compost product can be used:

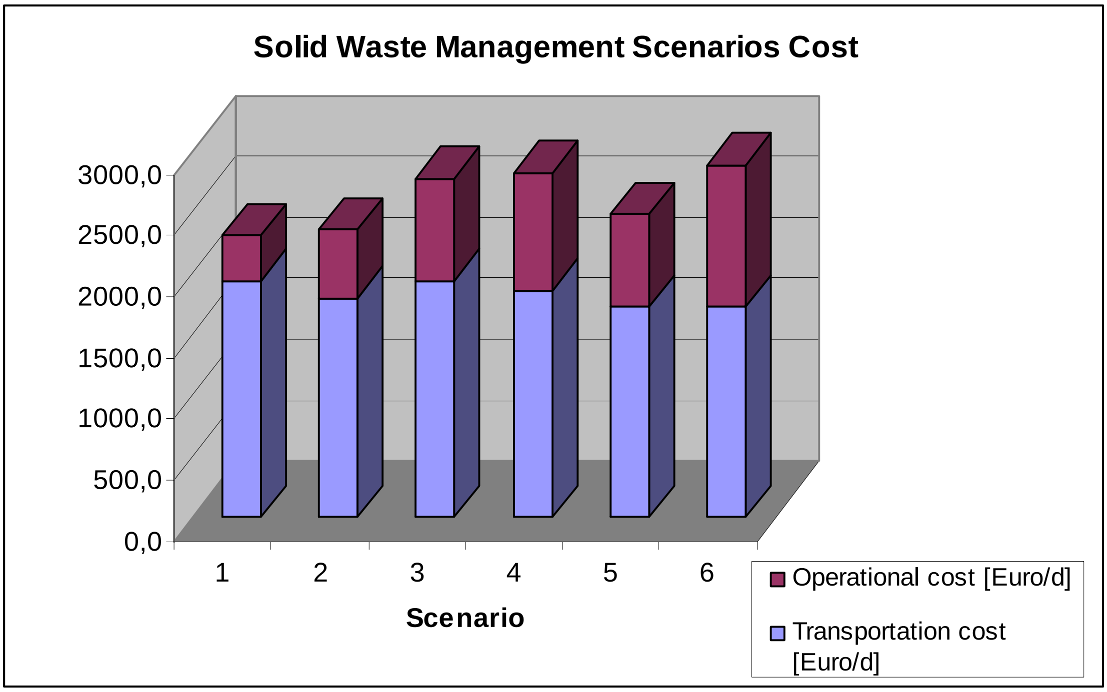
- In forestal nurseries
- For landscaping applications such as sports fields and parks
- For reforestations
- As biofilter material for odor control in sewage treatment facilities
- As soundproof material for populated areas near highways
- For the daily coverage of sanitary landfills and
- For abandoned quarry restorations

There hasn't been any prior experience for selling MSW derived compost in Greek market but the extended use of synthetic fertilizers in Pierias agricultural region assure a stable market. This provided that compost quality makes it safe for use in agriculture [13].

7. Conclusions

According to the numbers shown, the integration of a MBT facility in the prefecture's solid waste management system does not increase the total cost dramatically. Therefore, the cost calculated for the sixth scenario (two landfills, a transfer station and a MBT plant within Katerini landfill) is acceptable. The fact that no profit from the MBT facility is considered adds to the choice made. The total system cost for the six scenarios described above is presented in Diagram 2. Concluding, the integration of source separation schemes in the prefecture's solid waste management planning could lead to the production of high quality compost suitable for agricultural use. Such perspective could grant Pieria a viable and, in the long term, profitable solid waste management system.

Diagram 2: Total cost of Pieria's solid waste management scenarios



8. Bibliography

1. National Statistics Service of Greece, General Inventory, 2001
2. www.pieria.gr, Prefecture of Pieria website
3. www.emy.gr, National Weather Agency website
4. Technical Chamber of Greece, Report, Thessaloniki, 2003
5. Frantzis I., Complete Planning of Solid Waste Management for the 2nd DE of Pieria, Study for the Municipality Katerini, Athens, 2003
6. Mousiopoulos N., Karagiannidis Avr., Notes in the course of Solid Waste Management, AUTh., Thessalonica, 2004
7. Kanakopoulos D., Integrated Composting Installations - Equipment, Kompost-Net, Harokopio University, Athens, 2001
8. Prefecture of Pieria, Questionnaire of Situation of Solid Waste Management, Katerini, 2004
9. Katsameni M., Korakis P. Design of a Criteria Database for the Evaluation of Regional Solid Waste Management Scenarios, Diploma Thesis, AUTh, Thessaloniki, 1996
10. Caruso C., Paruccini M., A Regional Siting Study Of Urban Waste Disposal. The Decision Support Programme PURPLE, Commission of the European Community, Joint Research Centre, Ispra, 1989
11. Eleutheriadis X., The Unit of Mechanical Separation-Composting of Municipal Solid Waste in New Liosia Landfill, Kompost-Net, Harokopio University, Athens, 2001
12. Skordilis A., Katsogiannos E., Prokou D., Economic comparison of MSW Disposal Methods, Ministry of Environment and Social Works, Environment Administration, PERPA, Athens, 1985
13. Lasaridi K., Kouloubis P., Skoulaxinou S., Kanakopoulos D., Lolos G., Compost Quality Requirements and Marketing: Greek and International Experiences, EEDSA, 2002