

# DEVELOPMENT OF A SCHEME FOR THE INTEGRATED MANAGEMENT OF MUNICIPAL SOLID WASTE IN PYRGOS AND PANORMOS IN TINOS ISLAND

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## Abstract

The present paper deals with the development of an Integrated Solid Waste Management (ISWM) Plan for selected areas in Tinos Municipality, namely Pyrgos and Panormos communities with total population of about 400 inhabitants in order to ensure all prerequisites of the environmental legislative framework including those of the Waste Framework Directive. The paper presents the setting of specific objectives in regard to municipal solid waste (MSW) management and the organization of the ISWM plan in the examined areas. The organization of the plan includes all the necessary considerations for the effective implementation of MSW source separation and processing of the resulting materials.

## Keywords

biowaste; composting, integrated solid waste management; recyclables; separate collection; Waste Framework Directive

## INTRODUCTION

Planning is the first step in designing an Integrated Solid Waste Management (ISWM) system.



**Figure 1.** Planning process considerations of an ISWM system according to Environmental Protection Agency

Initially, the scope-framework of the ISWM plan is being set by defining (a) the type of waste considered in the plan and (b) the areas for which the plan will be developed. The ISWM plan is targeted for Municipal Solid Waste (MSW) and more specifically for household waste as well as commercial, industrial and institutional waste which resemble to household waste. Additionally, the areas that have been selected for the development and the implementation of the ISWM plan are Pyrgos and Panormos communities located at the northern part of Tinos Island in Greece.

The identification of the need for an ISWM plan is provided by presenting:

- the quantitative and qualitative objectives and measures that have been set at EU and national level in regard to MSW management &
- the currently conditions in relation to MSW management in Tinos Municipality and, thus, in Pyrgos and Panormos communities.

The development of a rational ISWM plan for the case of Pyrgos and Ormos Panormou communities is of major importance in order to contribute towards the EU and national mandatory targets for the effective and sustainable management of MSW, since neither treatment facilities nor safe disposal sites of MSW are currently in operation.

The long-term qualitative measures which are related to the integrated MSW management in Pyrgos and Panormos include the following:

- The continuous efforts to encourage prevention and reduction of MSW generation.
- The development and/or modernization of MSW collection and transportation network.
- The maximization of re-use and recovery of MSW waste and the minimization of MSW disposal.
- The closure and rehabilitation of uncontrolled landfills and dumpsites.

The quantitative targets are related to the following:

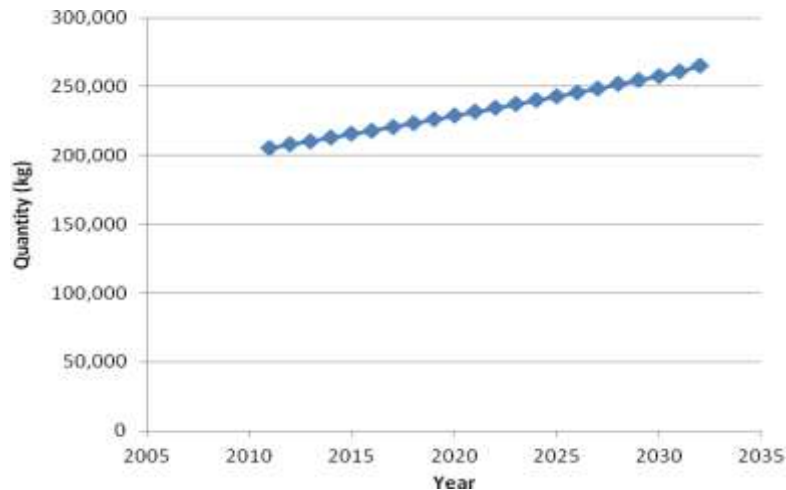
- Recycle 50% (w/w) of MSW by 2020
- By 2013 and 2020 the total amount of biodegradable waste produced in 1995 shall be reduced to 50 and 35% respectively
- Separately collect 5% and 10% (w/w) of biowaste by 2015 and 2020 respectively
- Recover or incinerate with energy recovery at least 60% (w/w) of packaging waste by no later 31 December 2011,
- Recycle 55 to 80% (w/w) of the totality of packaging waste by 31 December 2011 and attain the following targets for materials contained in packaging waste: 60 % by weight for glass; 60 % by weight for paper and paperboard; 50 % by weight for metals; 22.5 % by weight for plastics; 15 % by weight for wood.

## DEVELOPMENT OF THE ISWM PLAN

### Estimation of MSW quantities

The recording of the quantity of MSW of the selected communities is presented along with the estimations of the waste generation trends for the period 2012-2032.

**Figure 2.** Estimated MSW quantities for Pyrgos and Panormos



### Composition of MSW generated

The main fractions which characterize the composition analysis of MSW include biowaste (mainly food waste), paper – paperboard, metals, glass, plastics, Leather – Wood – Rubber, Textiles, Inert, & Others.

For the island of Tinos and especially for Pyrgos and Ormos Panormou communities there is no data on the qualitative composition of MSW. The most current and related data is provided by the Regional MSW management plan in 2008 which includes MSW composition analysis of areas located in South Aegean Prefecture namely the Municipalities of Rhodes and Naxos and the Municipality and communities of Kos. The estimated composition analysis for the area under examination is presented in Table 2 considering the aforementioned data along with the national MSW quality analysis provided by the Greek Ministry of Environment.

According to the estimated MSW composition analysis in Pyrgos and Ormos Panormou communities it can be observed that the organic fraction acquires the highest proportion of 41.75% w/w, followed by paper/paperboard at 20.98% w/w. Therefore, the biodegradable waste consisting of food and garden waste, paper/paperboard, as defined in the landfill Directive 1999/31/EC, amounts to 62.73% w/w of the total MSW generated. The fractions of plastic, glass and metal are found in smaller proportions ranging from 6.20 to 10.88% w/w, while the remaining fractions L-W-R-T and rest waste is estimated at 4.51 and 5.61% w/w respectively. It must be stated that the new consumption patterns and the requirements of modern marketing have led to higher packaging production rate (i.e. in EU level a total increase of 9.3 % has been reported from 1998 to 2008). In the case of Pyrgos and Ormos Panormou communities this is depicted by the increased shares of packaging waste which is estimate at 27.0% w/w.

**Table 2.** Estimated MSW composition in Pyrgos & Panormos communities based on related data

MSW Fraction	Average MSW composition (% w/w)							
	Organic	Paper – Paperboard	Metal	Glass	Plastic	L-W-R-T*	Rest	Total
Pyrgos & Ormos Panormou Communities	41.75	20.98	6.20	10.08	10.88	4.51	5.61	100.00

**Selection of the management practices**

The organization of the ISWM plan framework involves the planning of a source separation scheme of different MSW fractions and the effective processing of the segregated streams. The MSW fractions that will be source separated after suitable information campaign (WRAP 2009) include biowaste, paper, glass, plastic and metal. The selected grouping of MSW streams segregated for collection is listed in the following Table and it is based on the expected effectiveness of the separate collection and the subsequent processing efficiency of the materials.

**Table 3:** Grouping of MSW streams segregated for collection in Pyrgos & Ormos Panormou communities

Grouping of MSW streams	Colour
Separate collection of paper/paperboard	Yellow
Separate collection of glass	Orange
Joint collection of plastic & metal	Red
Separate collection of biowaste	Brown

Among the different source separation methods that are being commonly applied in EU, the curbside collection system was considered more appropriate for the areas under examination due to the specific characteristics of the selected communities. The curbside collection system that will be applied in Pyrgos and Panormos communities shall include the source separation of (a) biowaste, (b) paper & paperboard, (c) glass and (d) plastics & metals (joint collection) at household, commercial, institutional and industrial level using appropriate indoor bins and bags (i.e. caddies for sorted biowaste and reusable bags for dry recyclables). The participants shall discharge the segregated materials to corresponding outdoor collection bins of higher capacity (i.e. wheelie bins) which shall be appropriately positioned at public areas aiming to effectively cover the examined community in terms of MSW collection. At regulated frequency a waste collection vehicle shall collect and transport the segregated materials to designated areas for storage or processing.



**Figure 3.** Synopsis of the management plan for biowaste and dry recyclables

### **Determination of the type, number, capacity & location of the temporal storage equipment**

The temporal storage equipment for sorting MSW in Pyrgos and Panormos communities differentiates according to the type of segregated waste streams and the origin of the activity from which waste is generated namely household waste, commercial, industrial and institutional waste which resemble to household waste. Thus, the identification of the required equipment mainly involves the detection of the different types and quantities of waste generated from each activity. Therefore, the determination of the type, number, capacity and location of the temporal storage equipment for sorting MSW shall be performed on the basis of the different activities as well as on the basis of the different MSW streams that is being segregated.

#### ***Indoor equipment***

##### ***(a) Household waste***

**Biowaste:** The equipment that will be used for the collection of biowaste (i.e. food waste and small quantities of green waste) at household level shall include a small basket – caddie of about 10L, and biodegradable bags. Each biodegradable bag will be placed within the small bin in order to prevent potential leaching during sorting and deposition of the organic material. The caddies shall be placed near the kitchen. When the biodegradable bag is filled with biowaste, the householders shall deliver and deposit the bag to the nearest designated outdoor equipment.

**Dry Recyclables:** The dry recyclables namely (a) paper & paperboard, (b) glass and (c) plastics & metals will be separately collected by providing to the participants reusable bags. Therefore, three different bags will be given to the householders with distinct coloring according to the grouping of waste fractions segregated for collections. The characteristics of the bags are provided in

Table 1 in which the capacity of each bag is also presented depending on the quantity of each MSW fraction, the level of source separation (assuming 80% efficiency) and the market availability (i.e. production line of the available manufacturers).

**Table 1.** Suggested characteristics of the reusable bags for the collection of dry recyclables

<b>Grouping of source separated MSW fractions</b>	<b>Colour of the reusable bag</b>	<b>Capacity</b>
Paper & paperboard	Yellow	10L
Glass	Orange	10L
Metals & Plastics	Red	10L

The overall indoor equipment that is required for sorting MSW in Pyrgos and Ormos Panormou communities' households is the following:

- For sorting biowaste 100 pieces of 10L caddies and approximately 36,500 biodegradable bags shall be distributed considering that each of the 100 participating households will use one biodegradable bag per day throughout the primary annual duration of the ISWM plan.
- For sorting dry recyclables 300 pieces of reusable bags will be required, 100 pieces for each sorted material namely Paper/Paperboard, Glass and Plastic/Metal.

##### ***(b) Waste from commercial, industrial and institutional sector similar to household waste***

The equipment provided for the source separation of MSW from commercial, industrial and institutional activities is determined by the types and quantities of waste which resemble to household waste for each of the aforementioned activities identified in the examined area. The identification of these activities was performed by Tinos Municipality, while all the required information for the estimation of the type and capacity of the required temporal storage equipment was provided through appropriate questionnaire which was filled by the inhabitants. From the data provided it was concluded that there is a limited number of commercial, industrial and institutional

activities in the examined areas, while only several of them have specific waste generation ( $\text{kg cap}^{-1} \text{ day}^{-1}$ ) higher than that of households. Additionally, on the basis of feedback gained from various waste collection equipment manufacturers in the Greek market, it was pointed out that the production line of waste collection equipment is strongly related to the amount of the equipment that is procured. Considering the above facts it was concluded that the equipment that needs to be provided for sorting waste from commercial, industrial and institutional sector should be similar to that of households i.e. indoor caddie and reusable bags, while for the activities that acquire a specific waste generation higher than that of households a differentiation shall be made as presented in Table 6 depending on the expected amount of sorted MSW fractions.

**Biowaste:** The organic material generated in commercial, industrial and institutional activities in the area under examination will be collected by the inhabitants using either a small basket – caddie of about 10L (same as the equipment for householders) or 40L depending upon the quantities of biowaste generated. Along with the 10L or 40L caddies, appropriate biodegradable bags will be distributed acquiring the necessary specifications in order to be compatible with the bins. The equipment provided for each activity for the source separation of MSW is illustrated in **Error! Not a valid bookmark self-reference.**

**Dry Recyclables:** The recyclables generated in commercial, industrial and institutional activities in the area under examination shall depend on the quantity of each of the grouped waste fractions segregated for collections namely biowaste, paper/paperboard, glass and joint collection of plastic & metals. Therefore, the equipment provided for the source separation of MSW shall depend on the type of activity, i.e. commercial, industrial or institutional and thus to the corresponding waste fractions produced. The equipment that will be distributed is shown in Table 6 for each of the identified activities.

The overall indoor equipment that is required for sorting MSW from commercial, industrial and institutional sector in Pyrgos and Panormos are the following:

- For sorting biowaste 15 units of 10L caddies and 22 units of 40L bins shall be distributed. Additionally, approximately 5,500 and 8,000 biodegradable bags for the 10L and 40L bins respectively shall be purchased considering that the commercial, industrial and institutional activities which generate organic waste (similar to household waste) shall use one biodegradable bag per day throughout the primary annual duration of the ISWM plan.
- For sorting dry recyclables 283 pieces of reusable bags shall be distributed 81 pieces for each sorted material namely Paper/Paperboard, Glass and Plastic & Metal.

The overall equipment that will be required for the source separation of MSW in Pyrgos and Ormos Panormou communities is shown in **Error! Reference source not found.** considering also 10% additional units due to flexibility reasons and due to unforeseeable events (e.g. damage). The equipment that will be required for the implementation of the source separation scheme is shown in the following Table 6.

**Table 5.** Required equipment for the deployment of the source separation scheme in Pyrgos and Panormos

Equipment	Units (Households)	Units (Rest)	Total Units
Biodegradable bags (10L)	35,000	5,000	40,000
Biodegradable bags (40L)	-	8,000	8,000
Indoor caddies (10L)	100	15	115
Indoor bins (40L)	-	22	22
Outdoor bins (120L) for biowaste	30		30

Outdoor bins (240L) for paper/paperboard	30		30
Outdoor bins (240L) for glass	30		30
Outdoor bins (240L) for plastic & metal	35		35
Reusable bags	300	283	583

**Table 6.** Suggested equipment for sorting waste from commercial, industrial and institutional sector in Pyrgos and Panormos

Sector	Activity	Number of activities		Comments	Equipment				
		Pyrgos	Ormos Panormou		O Number and Type of caddies	P/P Number of reusable bags	G Number of reusable bags	P&M Number of reusable bags	
Institutional Activities	<b>Education</b>								
	Primary school	1		Double the equipment of hhs for dry recyclables + bin for biowaste	35-40L	1	2	2	2
	Kindergarten	1		Similar to households	10L	1	1	1	1
	<b>Religion</b>								
	Parish	2		Similar to households	10L	2	2	2	2
	Churches	10	5	Similar to households (no organic)	-	-	15	15	15
	<b>Local Governmental</b>								
	Citizens' Service Center	1		Similar to households	10L	1	1	1	1
	Local Affairs Office	1		Similar to households	10L	1	1	1	1
	<b>Sports – recreation</b>								
	Football field		1	Similar to households	10L	1	1	1	1
	Volleyball field		1	Similar to households	10L	1	1	1	1
	Basketball field		1	Similar to households	10L	1	1	1	1
	<b>Health</b>								
	Community clinic	1		Similar to households	10L	1	1	1	1
Pharmacy	1		Similar to households (no organic)	-	-	1	1	1	
Museum	1		Similar to households (no organic)	-	-	1	1	1	
Commercial Activities	Bakery	1		Similar to households	10L	1	1	1	1
	Butchery	1		Similar to households	10L	1	1	1	1
	Shopping stores	13	1	To be delivered directly to outdoor bins					
	Super Market	1		To be delivered directly to outdoor bins					
	Haberdasher	1		Similar to households (no organic)	10L	-	1	1	1
	Mini market		1	Similar to households	10L	1	1	1	1
	Tourist accommodation	3		Similar to households	10L	3	3	3	3
	Restaurants – Taverns	2	8	Double the equipment of hhs for dry recyclables + bin for biowaste	35-40L	10	20	20	20
Coffee shop	6	3	Double the equipment of hhs for dry recyclables + bin for biowaste	35-40L	9	18	18	18	
Industrial Activities	Marble manufacturers	5	1	Similar to households (no organic)	-	-	6	6	6
	Woodworks & Carpentry shop	1	1	Similar to hhs + bin for sawdust collection	35-40L	2	2	2	2
<b>TOTAL</b>		<b>53</b>	<b>23</b>		<b>10L Caddie: 15 pieces 35-40L Bin: 22 pieces</b>		<b>81</b>	<b>81</b>	<b>81</b>

hhs: households, O: Organic, P/P: Paper/Paperboard, G: Glass, P&M: Plastic & Metal



## Outdoor equipment

The segregated MSW resulting from households, commercial, industrial and/or institutional activities will be delivered by the participants, using the indoor equipment, to appropriately planned outdoor bins of higher capacity. Since waste deposition is strongly related to the existing situation in regard to the positioning of commingle MSW bins, it is suggested that the new bins should be placed alongside the existing grey bins which are currently used for the collection of mixed MSW. The estimations of the number and the capacity of the outdoor bins for the effective collection of MSW fractions consider the following: (a) the daily collected quantity (volume) of each MSW stream (b) the compatibility of the bins with the available waste collection vehicle (c) the existing sites/locations and capacity of the mixed MSW bins (percentile collection coverage of bin sites), and (d) the collection frequency. The methodology that has been developed is described below.

The collected quantity-volume of each individual material is estimated taking into account the total generation of each MSW stream and the assumption that the capture rate of the source separation scheme is 80% of the total quantity of each MSW fraction. The collection coverage of the sorted MSW fractions in each bin site/location is estimated based on the collection coverage of the existing commingle MSW bins in the examined areas considering their location, number and capacity.

- A thorough trial and error procedure was followed aiming to simultaneously satisfy the following conditions:
- According to the specifications of the available waste collection vehicle (EN840-1/5/6) the maximum lifting capacity is set at 240L.
- At each site where mixed MSW bins are located (30 sites/locations in total), at least one bin for each sorted material should be placed.
- At all times the capacity of the bins shall be sufficient for the collection of the source separated MSW fractions in each site/location where bins will be positioned (overflow prevention by setting maximum loading of the bins equal to 90% of their capacity).
- To regulate the waste collection frequency according to the differentiation of the loading level of the bin sites of each sorted material. Therefore a maximum of two different collections frequencies per sorted material is introduced in order to balance the need for waste collection between the different bin sites for each sorted material.
- The waste collection vehicle can transport only one type of waste per collection route. Additionally, the maximum daily number of collection routes per material is set equal to two (maximum capacity of the waste collection vehicle is 2.4 m<sup>3</sup>)
- For aesthetic reasons as well as for and social concession, no more than 5 recyclable bins in total should be placed in the same site/location.

The results from the above mentioned procedure show that outdoor wheelie bins of 240L should be deployed for the dry recyclable MSW streams while for biowaste outdoor wheelie bins of 120L is considered sufficient for the effective collection of the fermentable fraction of MSW. The number and the positioning of the outdoor bins for the sorting of biowaste, paper & paperboard, glass, plastic & metals (joint collection) is shown in **Error! Reference source not found.** and for the areas under examination.

## Planning the processing of sorted materials

The source separated materials collected by the vehicle namely (a) biowaste, (b) paper/paperboard, (c) glass and (d) plastic & metal (joint collection) will be transported to an appropriate area at the vicinity of Pyrgos and Panormos in order to be temporarily stored or treated, as summarized in Figure 3. The grouping of the MSW fractions in the source separation plan has been performed in order to achieve efficient sorting and effective processing of the resulting streams.



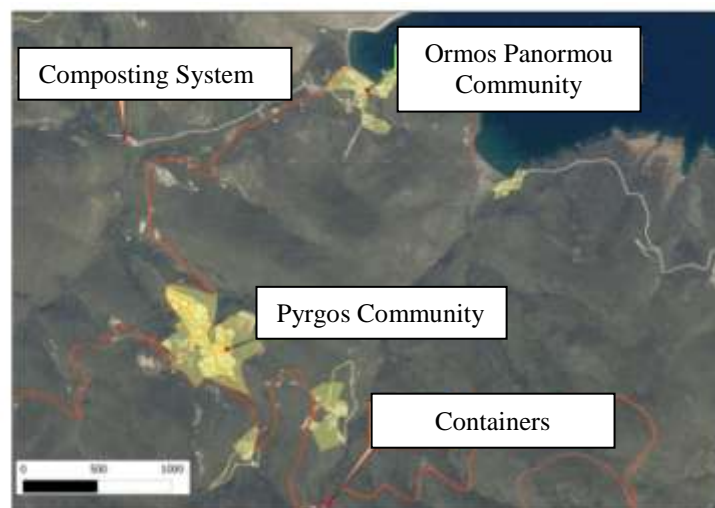
**Figure 4.** Network of waste collection points in Pyrgos & Panormos communities

### **Biowaste**

The source segregated biowaste will be transported and unloaded in an in-vessel composting system which will be installed near the wastewater treatment plant which is currently in operation in an approved area located near the settlements (ATHENS-BIOWASTE, 2012). The wastewater treatment facility acquires sufficient area for the installation and operation of the composting unit. The distance of the composting system is approximately 3.0 and 1.0 km from Pyrgos and Panormos communities respectively. The composting system, which has been designed, shall operate under controlled biooxidation conditions resulting in the production of high quality compost. Therefore, the organic fraction will be collected and treated on site, while the resulting product – compost will be thoroughly tested and characterized in order to certify its quality (e.g. heavy metal content, nutrients content). The tested compost will be then distributed to the participants in order to enhance the public perception in regard to MSW management and further promote the active involvement of the residents by depicting their responsibilities in relation to the effectiveness of the MSW management scheme.

### **Dry recyclables**

The collected source separated dry recyclables namely (a) paper/paperboard, (b) glass and (c) plastic & metal (joint collection) will be transported and mechanically unloaded to appropriately planned containers of specific capacity for each MSW stream in order to be temporarily stored. The site where the containers will be placed is shown in **Error! Reference source not found.** and it is in close distance from Pyrgos.



**Figure 5.** Location of the composting unit & containers for the storage of recyclables

The processing of the source segregated dry recyclables in the examined areas is depending upon various conditions the most profound of which are listed below.

- The absence of a mechanical separation facility in Tinos Island
- The absence of potential buyers of the resulting source separated dry recyclables in Tinos Island
- The differentiation on the material demand by potential buyers
- The experience of the participants on MSW source separation schemes
- The cost of the transportation of the collected materials i.e.the differentiation on the price of the recyclable materials which is mainly influence by the buyer, the type of the material, the purity level of the material, the quantity of the material, the subsidy level provided by the Hellenic Recovery Recycling Corporation (HE.R.R.Co), the characteristics of the examined area (insular or mainland).

Considering the above, the options for the recovery, re-use and recycling of the source segregated dry recyclables are given below:

- All the source segregated dry recyclables shall be transported to a Material Recovery Facility (MRF) for further processing.
- To realize sale contract/s with potential buyer/s for all or part of the source segregated dry recyclables (depending upon the demand). The remaining unsold materials will then be transferred to a MRF (mainland or insular) for further processing.

Due to the fact that (a) the participants and the competent authorities of Tinos Municipality do not have previous experience on MSW source separation schemes and (b) the realization of sale contract/s with potential buyer/s is a tedious and risky procedure, it is considered more appropriate in terms of the effectiveness of the scheme and the level of the associated implementation risk to initially operate the source separation program (at least for the pilot scale phase) by providing the segregated materials to a suitable Mechanical Recovery Facility (MRF) approved by He.R.R.Co. According to He.R.R.Co. it is suggested that the segregated MSW fractions will be transported to one of the recycling sorting centers located in Attica Region. The most prevailing option is the RSC located in Aspropyrgos Municipality. At this stage mechanical sorting and separation of the segregated MSW materials will be performed resulting in different material categories such as: packaging paper – paperboard, liquid cartons, print paper, plastic packaging (PET, HDPE), plastic film, other plastics (PP/PS), glass bottles and containers, aluminium and tinplate packaging items. These materials will be compacted (with the exception of glass), baled and forwarded to the corresponding industry sectors in order to be further recovered. It must be stated that He.R.R.Co. will be responsible for the operation of the selected RCS and for delivering the sorting materials to the respective industry.

For the monitoring and evaluation of the ISWM scheme in Pyrgos and Panormos communities appropriate set of indicators are envisaged in order to successfully implement the pilot scale demonstration scheme. These indicators are: (a) the specific waste generation rate, (b) the source separation ratio, (c) the ratios of materials in the residual MSW, (d) the ratio of impurities in sorted materials and (e) the participation rate.

**Table 7.** Determination of (a) the containers required for the temporal storage of source separated dry recyclables (b) the estimated transportation frequency of each container to the MRF

MSW fractions	Containers type	Container capacity (m <sup>3</sup> )	Level of compaction	MSW fraction volume <sup>1</sup> (m <sup>3</sup> day <sup>-1</sup> )	Transportation frequency	
					(days)	(yr <sup>-1</sup> )
Paper/Paperboard	Press container	20	1/3	0.24	Every 83	5
Glass	Open container	20	No	0.11	Every 184	2
Plastic & Metal	Open container	32	No	0.85	Every 32	10

<sup>1</sup> The daily volume of each fraction within the containers is estimated by assuming (a) 80% level of MSW source separation and (b) level of compaction, if any.

Finally, a public awareness plan accompanying the ISWM scheme is also foreseen aiming to engage the inhabitants at the early stage of the implementation phase and to encourage them to be actively involved throughout the duration of the demonstration.

### Conclusions

An effective ISWM plan has to be tailored to the needs of the application area in order to be successful and effective. The special characteristics (e.g. geographical, spatial, etc) have to be taken into serious consideration when deciding the planning parameters. Furthermore, the active participation of citizens is crucial in order to ensure high participation level and, therefore, the relevant planning should also take into account the opinions of the citizens, their habits and way of life. The citizen has to get convinced of why he has to act and separate the waste at source (the role of effective public awareness is obvious for that) and also to take advantage of the benefits that the Municipality will have, e.g. the produced compost should be distributed to the residents.

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