Setup, monitoring and evaluation of MSW management scheme in Pyrgos & Panormos communities in Tinos Island, Greece

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Abstract

The present paper acquaints with the set up procedures followed regarding an Integrated Solid Waste Management (ISWM) scheme applied in selected areas of the Municipality of Tinos (Greece) and encompasses the methodology ensued for its implementation as well as the monitoring and evaluation outcomes achieved during the first eight months of the ISWM scheme operation. The scope of the ISWM scheme implementation was to put into practice a viable and environmentally sustainable solid waste management system by setting distinct, target MSW streams and combining waste collection, treatment and subsequent safe disposal methods with the aim of acquiring environmental and economic benefits, as well as social acceptance.

Keywords

integrated solid waste management; separation at source; curbside collection; dry recyclables; recycling; biowaste; composting; Waste Framework Directive; Landfill Directive

1. Overview of the developed ISWM scheme in Tinos island

The target area is the Municipality of Tinos in Tinos Island of Greece. The ISWM scheme was implemented based on a developed plan tailored to the needs of the selected region of Tinos island, after taking into account important planning aspects, such as the specific contextual and geographical features of the area, the existing legal framework and current applied techniques for Municipal Solid Waste (MSW) management.

The developed ISWM plan envisages the separation at source of distinct MSW streams in accordance with: a) the provisions and targets of the EU and national legislative framework towards a recycling and resource efficient society which constitutes the principal European goal and b) the legislative measures and objectives which have been set regarding packaging waste, biodegradable waste and biowaste (European Commission, 2010; Landfill Directive 1999/31/EC; Waste Framework Directive 2008/98/EC).

More specifically, the developed ISWM scheme includes the separation at source and collection of dry recyclables (paper, glass, metal & plastic) as well as the separate collection of biowaste (i.e. food waste & green waste) and their subsequent aerobic treatment (composting) in a prototype composting unit which is foreseen to be installed on the island, close to the area under examination. The implementation of the pilot ISWM scheme began in

June 2013 and is in line with the European Waste Framework Directive 2008/98/EC which encourages the separate collection, the reuse and recycling of waste, a practice which has been widely employed by almost all European countries.

The target area is consisted of two selected communities (Pyrgos and Ormos Panormou) of Tinos island, covering a population of 400 people (i.e. 100 households & facilities). A curbside collection system is employed, including a 30+ waste collection points' network, located in pre-defined public sites, at the periphery of the communities. The ISWM scheme foresees that the participating population should separate their waste at source (i.e. household, shop, restaurant, public building etc.) using specific indoor equipment (reusable bags, kitchen caddies and biodegradable starch-based bags) and subsequently dispose them to corresponding outdoor wheelie bins of greater capacity. The grouping of the target waste streams (Table 1), according to the ISWM plan, has been based on the expected effectiveness of the source separation and the subsequent processing efficiency of the materials.

Table 1 Target MSW streams of ISWM scheme

ISWM scheme phase	Grouping of MSW streams on ISWM plan	Colour
1st	Separate collection of paper/paperboard	Yellow
	Separate collection of glass	Orange
	Commingle collection of plastic & metal	Red
2nd	Separate collection of biowaste	Brown

Collection and transport of waste is performed by a satellite vehicle, which operates at regulated frequency in order to transfer the pre-sorted materials to designated areas for storage or processing. In particular, given the absence of a mechanical separation facility in Tinos island, the fraction of MSW of dry recyclables is temporarily stored in special containers, placed at a Waste Transfer Site and provided by the Hellenic Recovery Recycling Corporation (HeRRCo). The segregated dry recyclables are transferred, upon communication, to a Recycling Sorting Centre (RSC) of Koropi Municipality, in Attica region so as to be appropriately processed and effectively recovered by the corresponding industry sectors (first phase of the ISWM scheme), in Greece and abroad. The pilot ISWM system will be fully operating with the completion of construction and installation of the prototype composting unit on the island and the integration of separate collection of biowaste in the scheme, with the aim of producing high quality compost (second phase of the ISWM scheme).

2. Overall objective of work

The overall scope of the present work is to demonstrate the setup stages and the ensued monitoring procedures, as they have been suggested in the ISWM plan and consequently present the outcomes resulting from the implementation phase of the ISWM scheme in the Municipality of Tinos, Greece.

3. Methodology applied for the setup & monitoring of the ISWM scheme

With the aim of putting into practice the ISWM scheme to the target area, the following preparatory activities were accomplished so as to encourage the participation of the target population, provide special training to the responsible local authorities' staff and consequently, facilitate the continuous monitoring and evaluation of the scheme performance.

3.1 Purchase and preparation of the source separation indoor and outdoor equipment

Intensive market research took place in order to choose the appropriate type of equipment for the source separation scheme. As listed in Table 2, the indoor equipment is consisted of:

(a) Reusable Bags of 10 – liter (L) capacity for collection at source of the different streams of recyclables. The participants are able to transfer the collected waste to the collection points by using these bags. The bags have a different colour per waste stream–: a yellow bag for paper/paperboard separate collection, an orange bag for glass separate collection and a red bag for plastic & metal separate collection. In total, three (3) different bags have been provided for each household.

(b) Biodegradable Bags and **Baskets (Caddies)** of 10 or 40 – liter (L) capacity for collection at source of biowaste, i.e. in households or facilities, respectively. The biodegradable bag is placed in the basket. The participants will be able to transfer the biowaste by using the basket and emptying it to the collection points. In total, one (1) basket and adequate sets of starch-based, compostable bags will be provided to each participating household, when the separate collection of biowaste will be initiated, following the completion of construction & installation of the prototype composting unit in Tinos island.

The outdoor equipment chosen for the ISWM scheme includes:

(c) Bins of 120 (for biowaste) or 240 (for dry recyclables) – liter (L) capacity for massive collection of different waste streams. The ISWM TINOS bins which have been distributed in more than 30 collection points of the pilot area have a different colour per targeted waste stream. In total, four (4) different bins is envisaged to be placed in each collection point. Moreover, at least one bin per collection point is already placed for the collection of rest waste, according to the existing waste collection system. It is noted that for the time being (June 2013 to June 2014), the first (1st) phase of the implementation of the ISWM plan is into action, concerning the separation at source of dry recyclables. Therefore, only three (3) bins (yellow, orange, red) out of 4 have been placed to the points determined by the waste collection points' network.

Table 2 Overview of equipment for the deployment of the ISWM scheme in Pyrgos & Ormos Panormou communities

EQUIPMENT		Capacity (L)	Units Purchased	Colour	Waste Type
INDOOR	Caddies	10 or 40	113 22	**Brown**	Biowaste
	Biodegradable bags	10 or 40	38,000 7,200	**White**	Biowaste
	Reusable bags	10	640	**Yellow**	Paper/paper-board
				Red	Plastic & Metal
				Orange	Glass
OUTDOOR	Wheelie Bins	120	30	**Brown**	Biowaste
		240	100	**Yellow**	Paper/paper-board
				Red	Plastic & Metal

				Orange	Glass

According to the developed ISMW plan, the overall equipment that was estimated to be required for the source separation of MSW in Pyrgos and Ormos Panormou communities is also shown in Table 2, considering also additional units due to flexibility reasons and due to unforeseeable events (e.g. damage). The required items were purchased in accordance with the tendering procedure as it is foreseen by the national laws. Figures 1- and 2 present photos taken during the delivery of the indoor and outdoor equipment to the premises of the Municipality of Tinos.

Figure 1 Delivery of outdoor equipment at Tinos Municipality premises

Figure 2 Indoor equipment for the separate collection of dry recyclable materials and biowaste

Prior to the setting of the ISWM bins to their final positions in the periphery of the target area, certain preliminary procedures were accomplished in order to assist the regular monitoring and evaluation of the scheme operation.

Taking into account that no calibrated weighbridge is available in the implementation region of the ISWM scheme, a simplified technique of recording the volume of the collected materials was developed. The inner surface of each ISWM bin was marked by dividing it into eighths so as to allow the operators of the ISWM scheme to keep data records easily and directly (Figure 3). Furthermore, the ISWM bins were also codified in order to ensure quick and easy recording of waste quantities. Each code provides with a unique identity the specific ISWM bin, revealing the location and type of material collected. This information is documented in a specially designed sheet by the waste collection vehicle operator every time prior to collection. For this reason, a notebook with specially designed sheets was prepared to facilitate the accurate data gathering of separated waste streams and the recording of arising problems in every waste collection point. The exact information noted is: the date of collection, the code of the bin (five digits), the volume of the sorted materials, operator's comments. Finally, the ISWM bins were labeled with stickers indicating the material-target i.e. "Paper/Paperboard", "Glass", "Plastic & Metal" and "Biowaste", making the sorting of waste a more user-friendly process. Figure 4 shows an example of a set of codified and labeled ISWM bins.

Figure 3 Details from the inner side of a calibrated ISWM bin

Figure 4 Codification and labelling of a set of ISWM bins for the collection of dry recyclables

The curbside collection system which was chosen to serve the participating population was formulated by a network of waste collection points in view of a number of important parameters, namely: a) the collection coverage of the separated waste materials in each bin location which was considered based on the existing location, number and capacity of the commingle MSW bins of the selected target areas , b) the collected quantity-volume of each distinct waste stream which was based on the total generation data for each MSW stream and the assumption that the capture rate of the source separation scheme equals to 80% of the total quantity of each MSW fraction, c) the compatibility of the ISWM bins comparing to the capacity of the available waste collection vehicle and d) the collection frequency. The final locations of the ISWM bins were mapped using digital means, as shown in Figures 5 to 8. Figure 8 illustrates additional waste collection points in four communities adjacent to the target area, which were equipped by using ISWM stock bins, upon strong demand of the inhabitants. The Gas station of the area has been also provided with an ISWM outdoor bin, since it's a source of paper/paperboard generation.

Furthermore, a time schedule was suggested, including:

- Paper/paperboard collection: every 4 days
- Glass collection: every 25 days
- Plastic & metals collection: every 4 days

The waste collection frequency was designed with flexibility and, consequently it might be subjected to alteration and optimization during the implementation phase of the source separation scheme, as indicated by the recorded waste data i.e. specific capture rates, participation rate etc. To this end, in certain waste collection locations, the collection frequency may be reduced in order to achieve higher loads and reduce the transport of the vehicle while at the same time coincide with the collection day of the respective material-target.

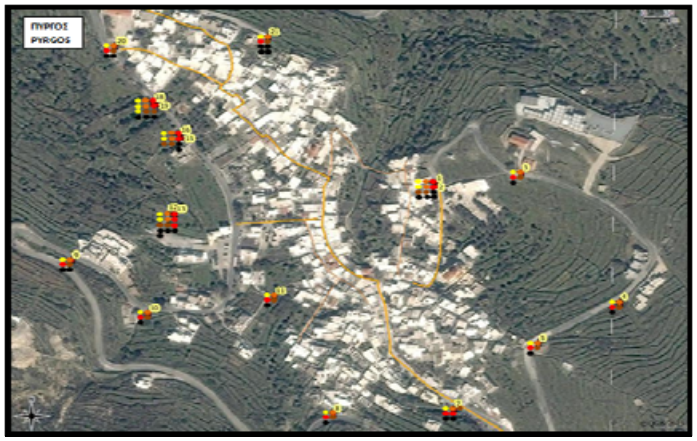

Figure 5 Distribution of waste collection points in Pyrgos community

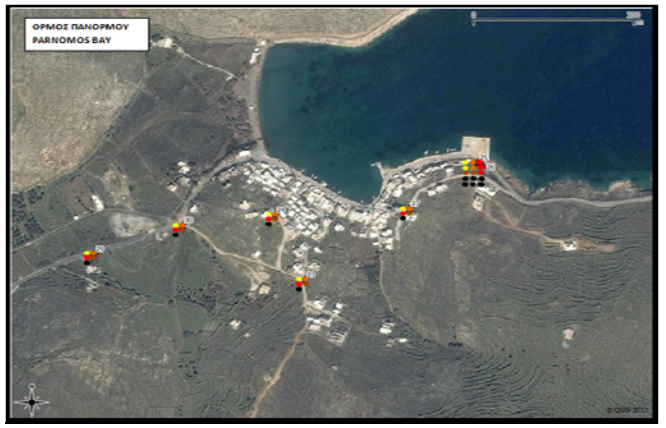

Figure 6 Distribution of waste collection points in Ormos Panormou community

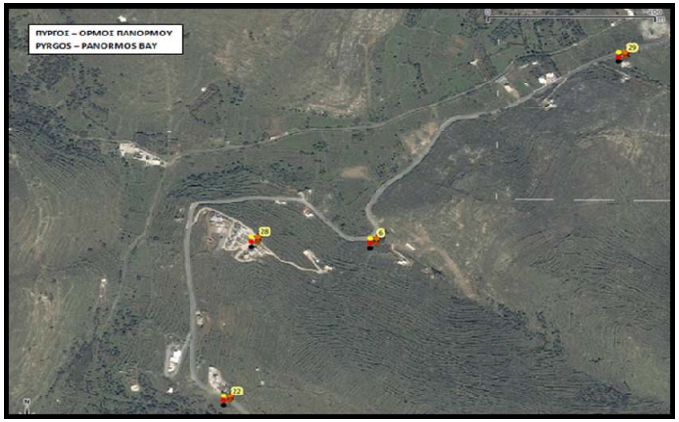

Figure 7 Distribution of waste collection points between Pyrgos & Panormos Bay communities

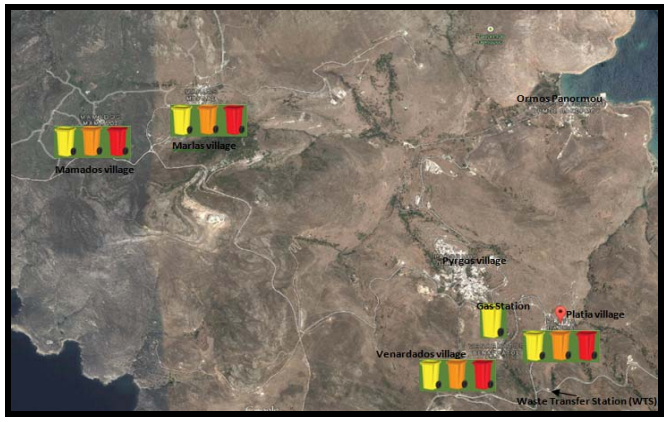

Figure 8 Additional waste collection points in Plateia, Venardados, Marlas & Mamados communities and location of the Waste Transfer Station

Figure 9 Waste collection vehicle, provided by the Municipality of Tinos

Apart from the developed waste collection points' network and the relevant time schedule, the transportation routes of the satellite vehicle were accordingly designed, so as to assist the work of the vehicle operator. Figure 9 depicts the waste collection vehicle employed for the source separation scheme in Pyrgos and Ormos Panormou communities. The small-sized vehicle has an open system with a capacity of 2.4 m^3, can perform manual and mechanical discharge of the materials and has a hydraulic lifting system to discharge the bins' content.

3.2 Training of the involved Local authorities and the participating public

In the framework of the developed ISWM plan, two (2) training sessions were organized, aiming to the activation of different target groups.

- The **first (1st) training session** was addressed to the responsible members of the Municipality staff with the aim of providing knowledge and improving the motivation of those engaged to the operation of the ISWM scheme. Thus, the appropriate sorting of waste and the subsequent effective processing and recycling of the materials could be ensured. The involved Municipality staff are the operator of the waste collection vehicle and the operator of the telephone helpline which was activated at the Community of Pyrgos.

  For the accomplishment of the first session and the training of the operator of the waste collection vehicle, the following useful "tools" were employed:
  - the developed waste collection points' network
  - the pre-determined, indicative, time schedule for waste collection
  - the specially designed data recording sheets
  - preparation of codes and labels, defining the identity of each ISWM bin, as mentioned above and
  - an on-site demonstration session following a complete collection route from a specific collection point to the designated Waste Transfer Site (WTS), so as to check the loading – unloading process and any potential problems of access or manoeuvrability of the vehicle.

  Regarding the training of the telephone helpline operator and the subsequent completion of the first type of training session, a 'Frequently Asked Questions' (FAQ) document was prepared incorporating basic questions focused on clear service information. During the training session, appropriate guidelines were given to the operator of the helpline. Thus, a link was created between the experts of the ISWM project working team and the participating public. The telephone number of the helpline has been added to all the informative documents (i.e. leaflets, brochures, educative cards) distributed during the dissemination activities of the project.

- The **second (2nd) training session** was addressed to the participating households of the target area, according to the ISWM plan. The objectives set for the 2nd type of training activities has been the following:

- the launching of an innovative, integrated waste management service which introduces the method of source separation of MSW
- the successful change of behavior towards enhanced environmental awareness
- the motivation and participation of the target population in the ISWM scheme over time (WRAP, 2009).

For this purpose, a wide variety of high quality informative documents was prepared so as to raise public awareness on the initiation of the ISWM scheme, namely brochures, educative cards, press releases, posters, signboards, web announcements etc. for adults, as well as their special editions for students. Consequently, a raising awareness event was implemented in order to signify the launching of the scheme. During the raising awareness event, the participating households and local facilities were clearly informed on how to participate in the project, what their service rules are, what happens to the recyclable materials after the separate collection and what are the expected results of its implementation.

3.3 Distribution of the indoor & outdoor source separation equipment and launching of the scheme

Each participating household was provided with the following indoor equipment and informative material:

- For paper/paperboard separate collection: one (1) yellow reusable bag
- For glass separate collection: one (1) orange reusable bag
- For plastic & metal separate collection: one (1) red reusable bag
- Two (2) brochures for adults and students, describing the applied ISWM scheme
- Two (2) sets of illustrative cards for adults and students, indicating recyclable and non-recyclable materials regarding each target waste stream

3.4 Collection and transportation of the source separated MSW (dry recyclables – 1st phase of ISWM scheme)

The pre-sorted waste materials are collected from the outdoor bins on regulated frequency and subsequently are transported by the satellite vehicle to the WTS where they are temporarily stored in high capacity, open top containers. Subsequently, the fully loaded containers are transferred to an RSC in Attica region, as appointed by HeRRCo, the competent company for the management and transportation of the segregated recyclables. Figure 10 encompasses an illustrative diagram of the collection and transportation stages of the sorted materials from the source of generation to the RSC.

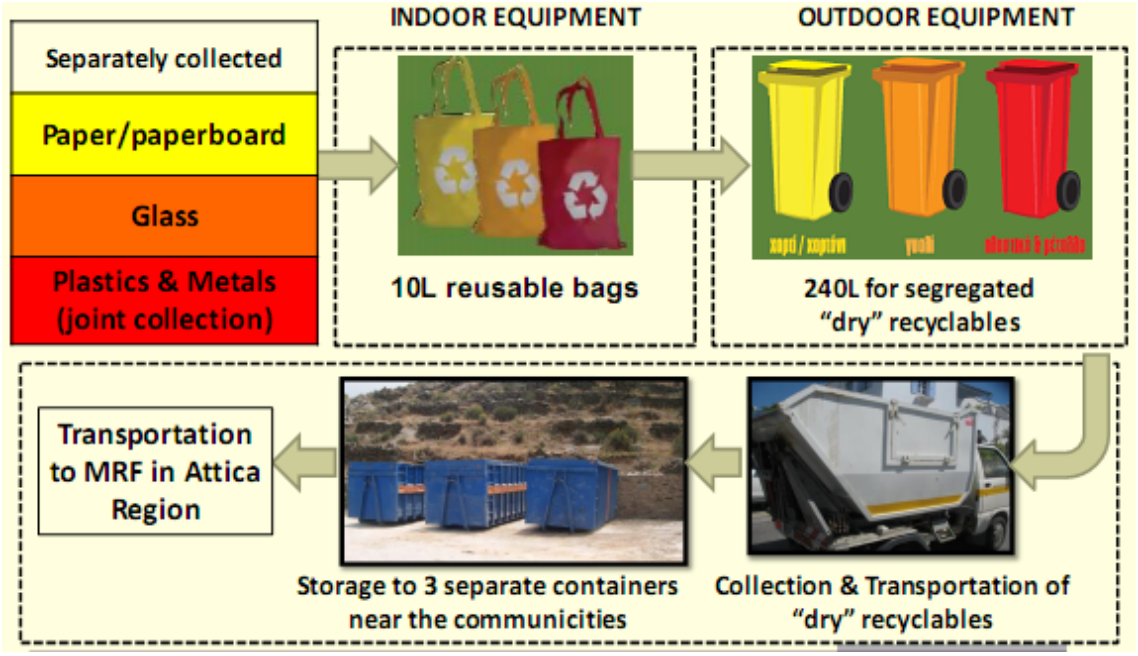

Figure 10 Consecutive stages of ISWM scheme for dry recyclables

3.5 Processing of sorted materials

In order to achieve the effective and efficient operation of the ISWM scheme and keep the level of the associated implementation risk to a minimum, it was considered more suitable to run, at first, the source separation scheme -at least for the pilot implementation period- on the condition that the segregated materials are provided to an appropriate RSC, approved by HeRRCo due to two important parameters: (a) the participants and the competent Local authorities of the Municipality of Tinos are not experienced with MSW source separation schemes and (b) the realization of sale contract/s with potential buyer/s is considered a tedious and risky procedure.

Given the absence of a mechanical separation facility in Tinos Island, a Waste Transfer Site (WTS) for the temporary storage of the pre-sorted dry recyclables [paper/paperboard, glass, metal & plastic (joint waste stream)] was chosen to serve the target area, after inspecting alternative sites. The site which was finally selected is located at the vicinity of Pyrgos and Panormos communities, about 2.8 and 5.5 km away, respectively and was prepared, considering all the relevant issues of safety and convenience. An agreement made between the Municipality of Tinos and HeRRCo which appointed WATT S.A. as the responsible company for: (a) delivering the necessary containers to the WTS, (b) the transportation of the filled containers from the WTS to the RSC located in Koropi municipality in Attica Region and (c) the processing and recycling of the segregated material to the market. Table 3 presents the selected equipment for the temporal storage of source separated dry recyclables, as well as the actual transportation frequencies as have been reported by the Municipality of Tinos and the RSC staff in Attica region. The determination of the type of containers was based on the following significant aspects:

(a) The compaction capability of the collected dry recyclables, since the need for compaction is relevant to elongated periods of storage due the volume reduction of the segregated materials and consequently to lower transportation frequency.
(b) The transportation frequency of the containers and the related cost.
(c) The type and capacity of the container that can be provided by HeRRCo.
(d) The available surface area where the containers will be set-out.

Table 3 Type, capacity and transportation frequency data for the selected containers

MSW fractions	Containers		
	Type	capacity (m^3)	Transportation frequency (annual average) (yr^{-1})
Paper/Paperboard	Open container	20	3
Glass	Open container	20	2
Plastic & Metal	Open container	20	4.5

At the RSC of Koropi Municipality, the mechanical sorting of the segregated MSW materials is accomplished, resulting in different material categories such as: packaging paper – cardboard, liquid cartons, print paper, plastic packaging (PET, HDPE), plastic film, other plastics (PP/PS), glass bottles and containers, aluminium and tinplate packaging items. Then, the waste materials are compacted (with the exception of glass), baled and forwarded to the corresponding industry sectors in order to be further recovered. Figures 11 to 13 include photos of the RSC at Koropi and specific categories of the segregated materials.

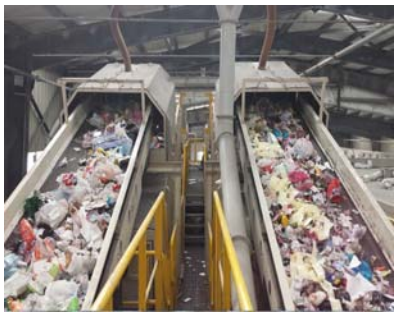

Figure 11 Mechanical sorting process

Figure 12 Aluminium balls

Figure 13 Mixed paper balls

3.6 Monitoring Indicators of the ISWM scheme

The successful implementation and performance of the developed ISWM scheme in the selected communities of Pyrgos and Panormos, in Tinos Municipality is done by means of appropriate monitoring and evaluation actions throughout the pilot scale demonstration of the scheme. Therefore, relevant gathering and measuring information processes have been set towards this direction, according to the ISWM plan, which are linked with the practice of source separation of MSW and the subsequent processing of the recyclable materials.

It is considered that concurrent and consistent data related to characterisation and quantification of the actual waste flows are of vital importance when examining and evaluating the performance of an ISWM scheme. These data are collected in order to determine and quantify a specific set of indicators, namely 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 and facilitate comparisons of other collection systems in an easy and comprehensive way (Dahlén & Lagerkvist, 2010). According to literature and various published studies, the selected indicators have been commonly applied for the assessment of the performance of source sorting schemes and it is best to be examined together so as to understand the correlation with each other (Dahlén et al., 2007).

The aforementioned chosen indicators are defined as follows:

- **Specific Waste Generation Rate** (kg capita^{-1}·yr^{-1}). The specific waste generation rate is the most fundamental indicator in the process of monitoring and evaluations of the scheme. It is commonly used in order to describe the amount and the type of MSW generated per person per year. The specific waste generation rate indicator is applied at both aggregated (commingled) and separated waste, that is: the total MSW generation rate, the generation rate of individual source separated materials, the residual MSW generation rate and the amount of specific materials found in the residual MSW. It is noted that potential changes on the specific waste generation rate could be appointed to differentiation on the source separation behavior of the participants and/or changes on the purchasing - consuming habits of products.

- **Source Separation Ratio** (% w/w). The source separation ratio reveals the extent to which participants separate their waste and it is formed by the ratio of the total weight of the collected source separated materials over the total amount/weight of MSW generated as shown by the following equation (Eq. 1).

$$\text{Source Separation Ratio}_{\text{total}} = \frac{\text{weight of source separated MSW}}{\text{Sum of weights of sorted \& unsorted waste materials collected}} (Eq.1)$$

This indicator can be also at individual sorted materials with regard to the potential amount of the material as indicated by the following equation (Eq. 2) with the aim of describing the extent to which participants sort the specific MSW fraction.

$$\text{Source Separation Ratio}_{\text{individual}} = \frac{\text{weight of a source separated MSW fraction}}{\text{Sum of the potential weights of the MSW fraction}} (Eq.2)$$

In practical, the indicator 'source separation ratio' displays whether an increase in the amount of source separated waste per capita is caused by an overall increase in MSW generation or because of an improvement on the sorting effectiveness by the participating population

In another study (Berg, 1993) the term 'recycling rate' is used instead of source-sorting ratio. However, this encompasses the assumption that all the quantities of the sorted waste are recycled after being collected, something which is not necessary and cannot

be ensured. Therefore, the indicator source-separation ratio is considered more correct.

- **Ratios of Materials in the Residual MSW** (% w/w) – The particular indicator reflects the percentage of different types of waste fractions in the remaining MSW which have not been sorted (Eq. 3). These ratios can provide useful information on the potential recovery rate for the recyclable materials. Therefore they can offer an insight for the optimization of the source sorting scheme and for the organization of educative campaigns in order to increase the awareness and thus, the diverted amounts. Based on the developed ISWM scheme, these different types of waste fractions in the remaining MSW can be classified as follows: (a) biowaste (b) paper/paperboard (c) plastic and metal and (d) glass.

$$\text{Ratios of Materials in the Residual MSW} = \frac{\text{weight of a MSW fraction in residual MSW}}{\text{weight of residual MSW}} \quad (Eq.3)$$

- **Impurities ratio of sorted materials** (% w/w) – This indicator presents the purity level of the source separated materials termed as the ratio of the total weight of mis-sorted materials in the recyclables over the amount of collected source separated materials, as shown by the following equation (Eq. 4).

$$\text{Impurities ratio of sorted material} = \frac{\text{weight of mis-sorted materials in a MSW fraction}}{\text{weight of the MSW fraction}} \quad (Eq.4)$$

The significance of the specific indicator is linked to the fact that increased levels of impurities in sorted materials can be misleading in regard to the effectiveness of the source separation scheme. In addition, this ratio can offer valuable information when preparing informative campaigns or dissemination documents i.e. instructions for source separation.

- **Participation rate (%)** - This indicator presents the percentage of the population where the scheme is implemented that actually participates in the source separation process as described by the following equation (Eq. 5).

$$\text{Participation rate}(\%) = \frac{\text{population that participates in the source separation activities}}{\text{total population of the area where the scheme is applied}} \quad (Eq.5)$$

The participation rate provides an insight on the distribution of the source-sorting activities in the areas where the scheme is applied. However, measuring the participating population is a hard task considering that the implemented ISWM scheme does not include a door to door collection system where the participation rate can be recorded as a set-out rate. In order to measure the participation rate for the case of Pyrgos and Panormos communities, instructions has been given to the participants in regard to which bin sites they shall discharge their waste. The main criterion of the bin sites selection was the distance between the participants' location and the location of the ISWM bins.

Furthermore, the monitoring and evaluation of the pre-sorted materials processing have been envisaged to be accomplished in two (2) stages: (a) per individual processing type, i.e. mechanical sorting for dry recyclables in the corresponding RSC and composting concerning biowaste, as well as (b) the overall processing of the source sorted materials. Therefore, the chosen indicators for this purpose are the following:

- The **Sorted dry recyclables - processing** in an RSC will be evaluated using the following equation (Eq. 6):

$$\text{RecyclingRate}_{\text{RSC}} = \frac{\text{Weight of RSC input materials} - \text{Weight of materials not recycled in the RSC}}{\text{Weight of RSC input materials}} (Eq.6)$$

- The **Sorted Biowaste - processing** in an in-vessel composting unit will be evaluated using the following equation (Eq. 7):

$$\text{RecyclingRate}_{\text{composting}} = \frac{\text{Weight of sorted biowaste} - \text{Weight of impurities in sorted biowaste}}{\text{Weight of sorted biowaste}} (Eq.7)$$

- The **Overall evaluation** and monitoring will be evaluated using the following equation (Eq. 8):

$$\text{RecyclingRate}_{\text{TOTAL}} = \frac{\text{Weight of effectively processed materials (composting + RSC)}}{\text{Weight of source separated materials}} (Eq.8)$$

It is reiterated that the ISWM pilot system has not been fully operating yet, as only the first phase regarding the separation at source of dry recyclables has been put in place. When the composting unit will be constructed and installed at the designated area, the second implementation phase of the system which is related to the separate collection and aerobic treatment of biowaste using a prototype composting system will be incorporated. Therefore, the indicators corresponding to Equations 7 & 8 have not been quantified.

3.7 Sources of data acquisition

For the effective monitoring of the applied ISWM scheme, certain steps have been designed to be followed related to three (3) different sources of data acquiring.

- **Data source 1**: is the waste quantities recorded in a specially designed notebook, prior to collection of each bin by the Municipality staff (waste collection vehicle operator). Telephone communications, emails and fax messages are employed to acquire this type of information on a regular basis.
- **Data source 2:** is the waste quantities and material types recorded by the staff of the RSC located at the Municipality of Koropi. Similarly, telephone communications and emails are

employed to acquire this type of information every time a fully loaded container arrives at the facilities of East Attica region.

- **Data source 3**: is the waste quantities recorded by the conduction of waste sampling and compositional analysis, following a specific protocol, which was formed for the case of the ISWM scheme. This protocol encompasses a step-by-step methodology which describes how the generated MSW quantities could be estimated by a selected number of volunteer-households and what are the (% w/w) percentages of the main MSW fractions (i.e. paper/paperboard, glass, plastics & metals, biowaste, residual or rest waste). The implementation of waste sampling events is described as fieldwork studies and comprises a means of direct observation and primary data acquisition.

4. Results of the ISWM scheme performance

4.1 Data source 1 outcomes

The volumes of the sorted materials and the collection frequencies from each recycling bin have been continuously examined and recorded by the waste collection vehicle operator, using the specially designed data record sheets, since the launching of the ISWM scheme (i.e. June 2013). The information gathered was further processed in order to make conclusive remarks as regards to the effectiveness of the collection and transportation stages of the segregated dry recyclables.

The average volume per month of the collected packaging waste (i.e. plastic & metal, paper/paperboard and glass) from each bin is displayed as a function of the collection frequency to the Figures 14 – 16. In addition, Figure 17 gives an overview of the average volume of collected packaging waste from each bin as a function of the collection frequency for the whole period under examination, which lasted from June 2013 to December 2013. What can be concluded from the graphs is that the overall collection process of metal & plastic and paper/paperboard packaging waste is efficient given that the great majority of bins are collected when they record an average monthly capacity higher than 150L. For a few bins, it was shown that the monthly average volume of collected material is higher than the capacity of the bin. This is an indication that a higher collection frequency is required at that specific collection point so as to cover the quantity of materials sorted by households. To this end, communication with the waste collection service was made in order to give guidelines and resolve the issue. A general remark is that plastic & metals (red bin) and paper/paperboard (yellow bin) show much higher collection frequency and volume of materials compared to glass packaging which is anticipated due to the lower percentile composition of glass in MSW. Another observation was that the collection frequency and average volume of all packaging waste are significantly increasing, during the summer period, presenting the peak values in August. Despite the demanding collection & transportation services during the summer period, which results from the increased number of tourists and visitors in the target areas, the collection of sorted materials is very efficient in terms of quantity and collection frequency.

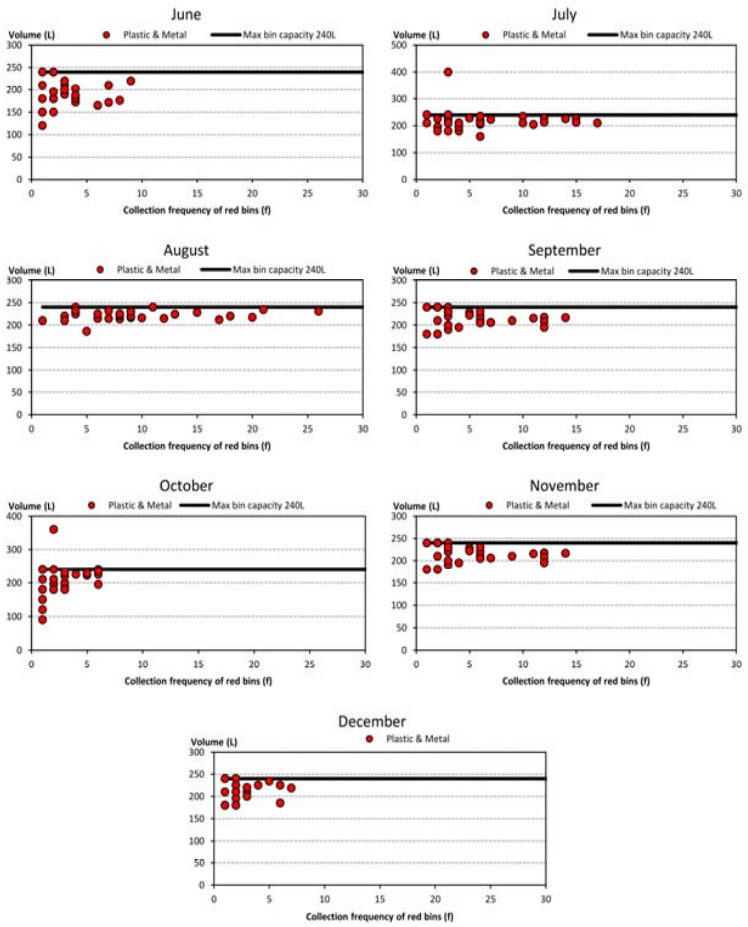

Figure 14 Monthly average collection frequency in relation to the level of plastic & metal packaging waste collected in each bin (examination period: June 2013 to December 2013)

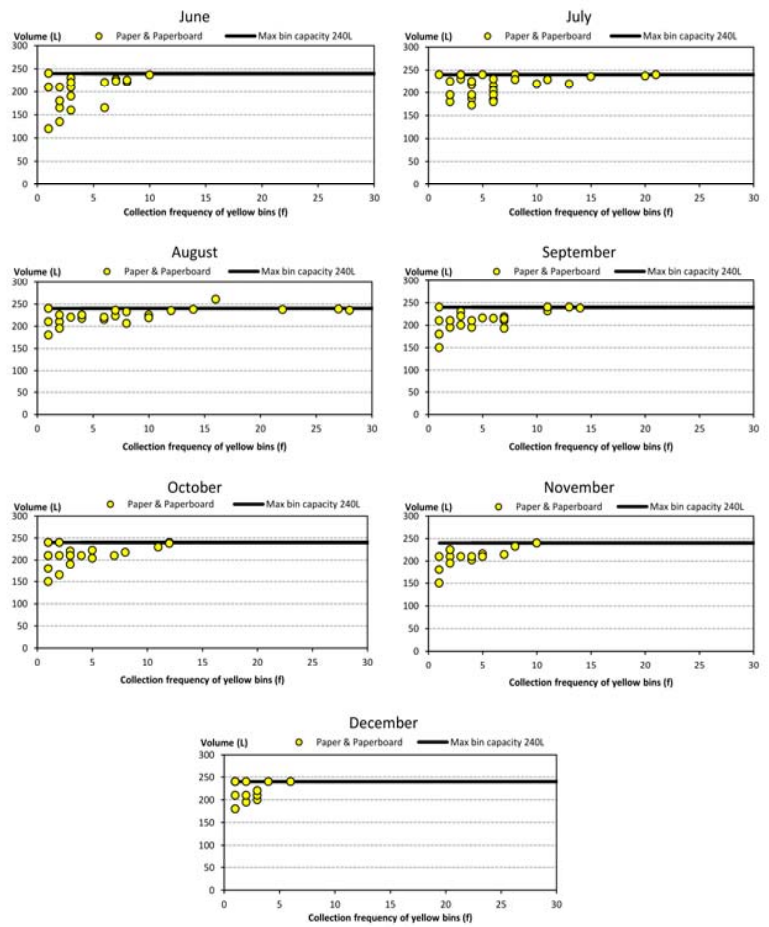

Figure 15 Monthly average collection frequency in relation to the level of paper/paperboard packaging waste collected in each bin (examination period: June 2013 to December 2013)

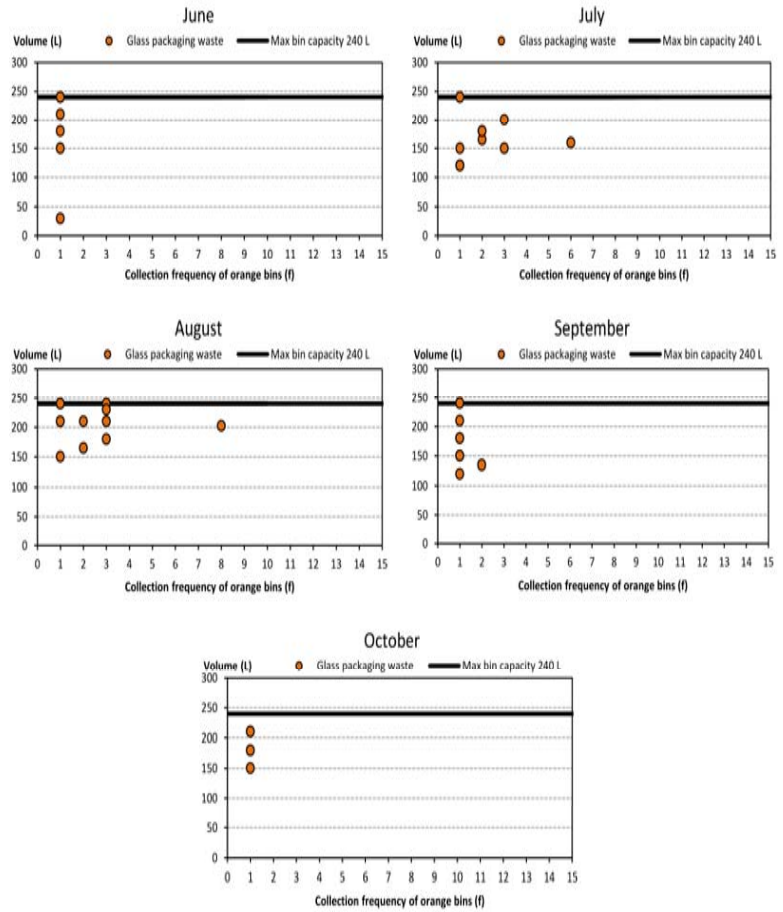

Figure 16 Monthly average collection frequency in relation to the level of glass packaging waste collected in each bin (examination period: June 2013 to October 2013)

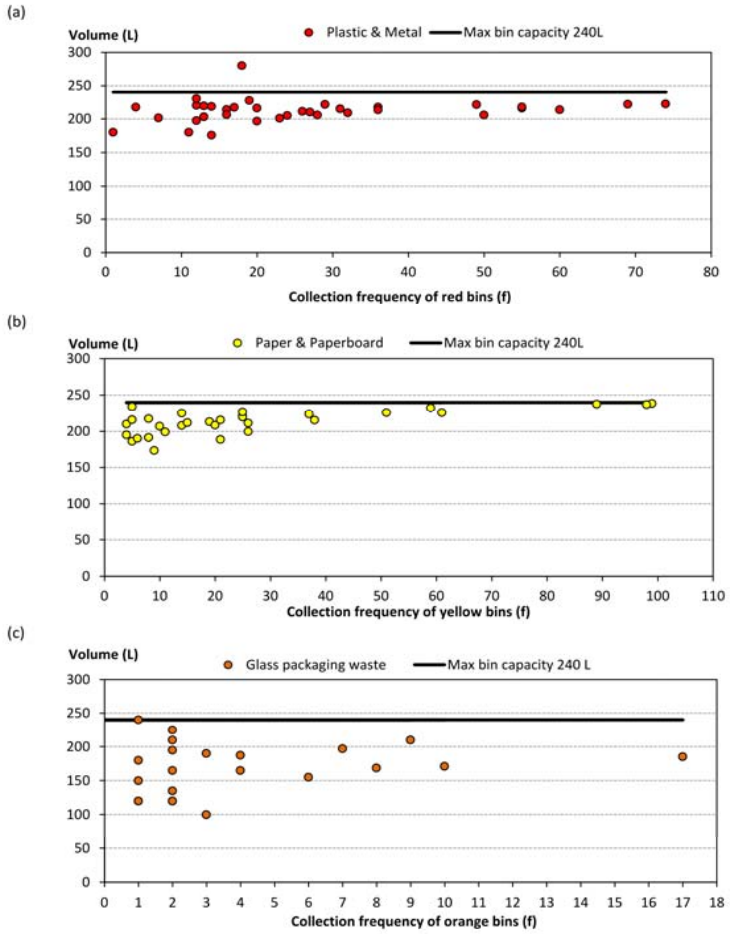

Figure 17 Overall average collection frequency in relation to the level of (a) plastic & metal packaging waste, (b) paper/paperboard packaging waste and (c) glass packaging waste collected in each bin (examination period: June 2013 to December 2013)

4.2 Data source 2 outcomes

In total, during the first 8-month operation of the ISWM scheme (i.e. June 2013 to February 2014), six (6) loads of containers with pre-sorted waste materials have been transferred to, the appointed by HeRRCo, Recycling Sorting Center of Koropi Municipality (East Attica). The following quantities per transportation have been recorded via communication with the RSC staff.

- **1st transportation of containers**: one (1) with paper/paperboard (P/P) of 3,840 kg and one (1) with plastics & metals (P&M) of 2,920 kg, covering the period from 10.06.2013 to 05.08.2013
- **2nd transportation of container**: one (1) with plastics & metals (P&M) of 2,140 kg, covering the period from 05.08.2013 to 10.09.2013
- **3rd transportation of container**: one (1) with plastics & metals (P&M) of 2,865 kg, covering the period from 10.09.2013 to 10.02.2014
- **4th transportation of container**: one (1) with paper/paperboard (P/~~)~~P) of 7,049 kg, covering the period from 10.09.2013 to 14.02.2014
- **5th transportation of container**: one (1) with Glass (G) of 3,291 kg, covering the period from 10.06.2013 to 14.02.2014

Table 4 summarizes the total quantities of the segregated packaging waste materials, along with the characteristics and relevant information provided regarding purity levels when treated in the RSC premises.

4.3 Data source 3 outcomes

The third supplementary source for data acquisition regarding the generation rates of MSW and the compositional fractions of MSW has been determined to be the on-site visits and sampling analyses (data source 3). For this purpose, a relevant protocol was formulated, encompassing a step-by-step methodology which should be followed in order to conduct MSW sampling and compositional analysis of the targeted waste streams. The principal scope of the fieldwork studies has been the filling of the knowledge gap concerning the absence of accurate waste generation data for the selected communities. The existing information is based rather on estimations and not on actual figures, since the island of Tinos does not have a weighbridge. Therefore, by conducting fieldwork studies, direct and reliable data can be collected. The resulting observations and measurements which are employed in conjunction with the aforementioned data sources 1 & 2 are useful in obtaining a more spherical and accurate view of the actual waste flows within the area under examination. The analyses were carried out with the collection of primary data from a sample of preselected households (# 20) for a specific period, in order to identify and measure the following requested information:

Quantitative data: The quantities produced for each waste stream, as defined in the ISWM scheme applied to the target area [(i) paper / cardboard , (ii) glass , (iii) plastic & metal , (iv) biowaste (food waste and green waste in particular)], the quantity of mixed / residual waste, the total amount of MSW, volume and bulk density for each waste stream - target

Qualitative data: the qualitative composition of biowaste, the qualitative composition of mixed/residual waste

Table 4 Summarized quantities and characteristics of the ISWM scheme during the examination period 10.06.2013 to 14.02.2014.

	Period	Days	Quantity received to the RSC (Kg)	Total packaging waste (including mis-sorted packaging) (kg)	Total packaging waste (without mis-sorted packaging) (kg)
1st container Plastic & Metal	10.06.2013 - 05.08.2013	56	2920.00	2366.51	2304.43
2nd container Plastic & Metal	05.08.2013 - 10.09.2013	36	2140.00	1691.74	1641.44
3rd container Plastic & Metal	10.09.2013 - 10.02.2014	153	2865.10	2190.18	2118.23
Total Plastic & Metal	10.06.2013 - 10.02.2014	245	**7925.10**	**6248.43 kg** **25.50 kg cap^{-1} yr^{-1}**	**6064.10 kg** **24.75 kg cap^{-1} yr^{-1}**
1st container Paper/Paperboard	10.06.2013 - 05.08.2013	56	3840.00	3593.44	3593.44
2nd container Paper/Paperboard	05.08.2013 - 14.02.2014	193	7049.10	7005.76	6570.39
Total Paper/Paperboard	10.06.2013 - 14.02.2014	249	**10889.10**	**10599.20 kg** **36.30 kg cap^{-1} yr^{-1}**	**10163.83 kg** **34.81 kg cap^{-1} yr^{-1}**
1st container Glass	10.06.2013 - 07.02.2014	242	3291.19	3225.37	3225.37
Total Glass	10.06.2013 - 07.02.2014	242	**3291.19**	**3225.37 kg** **11.37 kg cap^{-1} yr^{-1}**	**3225.37 kg** **11.37 kg cap^{-1} yr^{-1}**
Total source separated (kg)			22105.39	20625.18	20314.09
Total source separated (kg cap^{-1} yr^{-1})*			76.48	69.42	67.28
Total purity level (% w/w)			-	90.81%	88.00%

(*Considering a total population of 428 inhabitants within the implementation area of the ISWM scheme)

The completion of the waste sampling analyses resulted in the following acquired data and subsequent outcomes:

4.3.1 Municipal Solid Waste

The primary data gathered during the sampling visits were focused on the quantity and the determination of different fractions of MSW generated by the target population of the implementation area of the ISWM scheme. Table 5 shows that paper/paperboard (P/P) fraction constitutes 13.25% of total MSW, while glass waste constitutes 3.52% and Plastic&Metal (P&M) waste constitute 11.76%. Thus, the packaging waste materials represent the 28.54% (i.e. 124.290 kg cap^{-1} yr^{-1}) of total MSW. Moreover, the fraction of biowaste (food waste & green waste) constitutes 52.45%, whereas residual waste account for 18.97% of total MSW. The specific MSW generation rate (kg cap^{-1} yr^{-1}) has been calculated equal to 1.193. Consequently, this quantity reveals that the total waste generation rate for the population – target of the communities of Pyrgos & Ormos Panormou (428 inhabitants) should be approximately 186 tonnes per year.

Table 5 Generated MSW quantities and mean weight percentage (%) of MSW composition in the selected communities of Pyrgos & Ormos Panormou

Waste Sampling Data	MSW	P/P	GLASS	P&M	BIOWASTE	REST WASTE
kg cap^{-1} day^{-1}	1.193	0.158	0.042	0.140	0.626	0.226
kg cap^{-1} $month^{-1}$	35.795	4.744	1.260	4.211	18.773	6.790
kg cap^{-1} yr^{-1}	435.503	57.719	15.335	51.236	228.402	82.607
Percentage of MSW (%)	100.00	13.25	3.52	11.76	52.45	18.97
Total MSW kg of target - population*	186,395.46	24,703.59	6,563.32	21,929.12	97,756.23	35,355.71

*Considering 428 inhabitants in the examined areas in Tinos Island

In addition, it should be noted that the value appointed to the specific generation rate concerning the fraction of Rest Waste of MSW (i.e. 82.61 kg cap^{-1} yr^{-1}) has been defined in view of the results of the waste sampling analyses. The value of 82.61 kg cap^{-1} yr^{-1} 'Rest waste' which are contained in the total quantity of generated MSW has been derived from an initial value of 97.15 kg cap^{-1} yr^{-1} Rest waste (i.e. 0.266 kg cap^{-1} yr^{-1}) which included quantities of packaging waste and biowaste, according to fieldwork sampling. By excluding these quantities and transferring them to the corresponding categories of packaging waste and biowaste, the actual value for Rest waste declines to 82.61 kg cap^{-1} yr^{-1} and the following determined value for Rest waste generation rate is formed into 0.226 kg cap^{-1} yr^{-1}. It is also reminded that the Rest waste category encompasses all the materials which are not included in the groups of paper/paperboard, glass, plastic, metal or biowaste (i.e. non recyclable materials), as for example the used toilet paper.

4.3.2 Biowaste (food & green waste) compositional analysis

Table 6 Categories of biowaste for compositional analysis

Category Name of biowaste
1. Vegetables & Salads
2. Fruit
3. Bread & bakery products
4. Meals (homemade & pre-prepared)
5. Meat & Fish (bones)
6. Dairy products & Eggs
7. Cakes, pastries & snacks
8. Beverages (coffee filters & tea bags)
9. Pasta/Rice/Flour/Cereal
10. Paper
11. Leaves (green waste)
12. Plastic bags
13. Residual waste
14. Impurities

During the sampling analyses, the generated quantity of biowaste was weighed and categorized into fourteen (14) different categories (Table 6) every day, so as to ensure the freshness of the source separated food waste and green waste. This condition is considered as a substantial requirement due to the fact that the high volatility of bio-degradability affects their characteristics and inhibits the conduction of qualitative compositional analysis. The categorization of biowaste into the 14 distinct groups of materials was chosen by taking into account the durability of the results and the possibility of comparing them with those of other regions and countries (Heaven S. et al, 2010). The analysis of biowaste resulted in the formation of **Error! Reference source not found.**~~**Error! Reference source not found.**~~Table ~~7~~ and the respective stacked columned-graph in Figure 18. It is mentioned that the term 'Rest biowaste' is defined as organic materials which do not fit into another category because (a) it is not possible to be integrated in a category and / or (b) have a size less than 3mm.

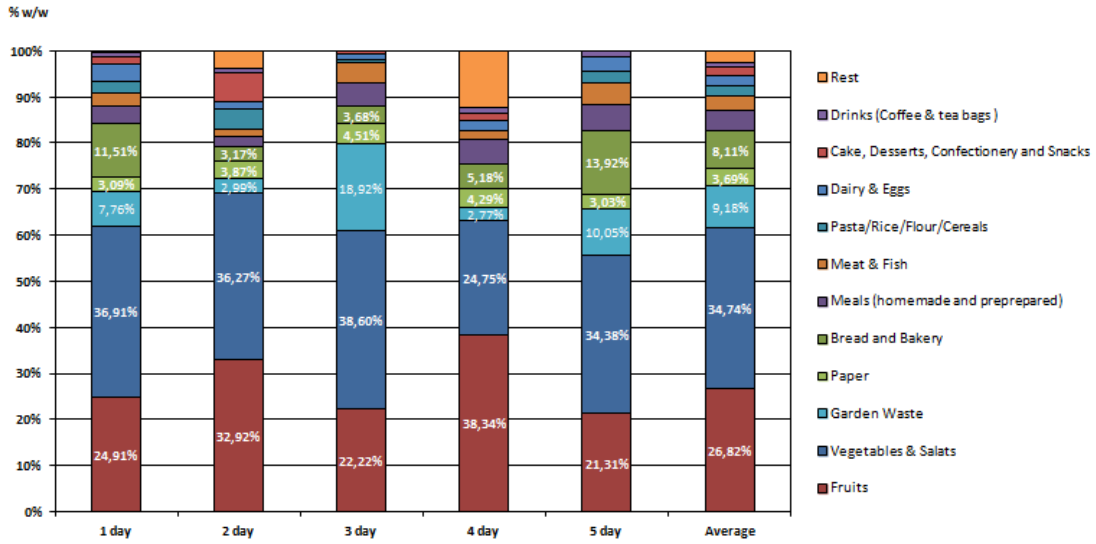

Figure 18 Compositional analysis of biowaste per day of sampling and average values, in the selected communities of Tinos island

Table 7 Waste compositional analysis for sorted biowaste in the communities of Pyrgos & Ormos Panormou, Tinos island

Tinos Biowaste Composition												
Biowaste categories	**Mass (kg)**						**Composition (%)**					
	1 day	2 day	3 day	4 day	5 day	Total	1 day	2 day	3 day	4 day	5 day	Average
Vegetables & Salats	6,77	4,12	6,08	2,77	5,68	25,42	36,91%	36,27%	38,60%	24,75%	34,38%	34,74%
Fruits	4,57	3,74	3,5	4,29	3,52	19,62	24,91%	32,92%	22,22%	38,34%	21,31%	26,82%
Bread and Bakery	2,11	0,36	0,58	0,58	2,3	5,93	11,51%	3,17%	3,68%	5,18%	13,92%	8,11%
Meals (homemade and preprepared)	0,70	0,26	0,8	0,62	0,92	3,30	3,82%	2,29%	5,08%	5,54%	5,57%	4,51%
Meat & Fish	0,55	0,16	0,68	0,21	0,8	2,40	2,99%	1,41%	4,32%	1,88%	4,84%	3,28%
Dairy & Eggs	0,66	0,18	0,2	0,22	0,54	1,80	3,61%	1,58%	1,27%	1,97%	3,27%	2,46%
Cake, Desserts, Confectionery and Snacks	0,30	0,72	0,12	0,18	0	1,32	1,63%	6,34%	0,76%	1,61%	0,00%	1,80%
Drinks (Coffee & tea bags)	0,18	0,12	0	0,14	0,2	0,64	1,00%	1,06%	0,00%	1,25%	1,21%	0,88%
Pasta/Rice/Flour/Cereals	0,44	0,5	0,1	0	0,4	1,44	2,41%	4,40%	0,63%	0,00%	2,42%	1,97%
Paper	0,57	0,44	0,71	0,48	0,5	2,70	3,09%	3,87%	4,51%	4,29%	3,03%	3,69%
Garden Waste	1,42	0,34	2,98	0,31	1,66	6,71	7,76%	2,99%	18,92%	2,77%	10,05%	9,18%
Rest	0,07	0,42	0	1,39	0	1,88	0,37%	3,70%	0,00%	12,42%	0,00%	2,57%
Total	18,33	11,36	15,75	11,19	16,52	73,15	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

The identification of the specific categories of biowaste is considered a task of great importance and provides valuable information, since it is widely known that the physicochemical parameters of biowaste which comprise the input material for a composting system, define to a great extent the progress of the process and are strongly related to the quality of the final product (compost). The determined impurities level is also important so as to take necessary corrective measures and ensure the production of high quality compost. The acquisition of accurate and regular information on compositional analysis facilitates the design and optimization of effective and sustainable waste management schemes.

4.4 Evaluation of the overall ISWM scheme performance

As has been stated above, the evaluation process of the ISWM scheme performance is based on the set of selected indicators related to the effectiveness of the source sorting scheme and to the processing of sorted materials as described in paragraph 3.6. In order to quantify the chosen indicators, particular procedures were followed for the acquisition of the appropriate primary data and the subsequent interpretation of the collected information, as presented under paragraph 3.7. Therefore, the present section is dedicated to portray the aforementioned indicators of the ISWM scheme progress to the selected implementation area of Tinos island, for the examination period of 10.06.2013 (launching of the scheme) to 14.02.2014. Additional information is presented concerning the effectiveness of the scheme compared to EU and national quantitative targets in terms of MSW management. The evaluation has been performed separately for each target packaging waste material (i.e. paper/paperboard, plastic, metal and glass), according to the ISWM plan, while an overall evaluation of the source separation practice is also provided. It should be stressed that during the examined period only the source sorting of dry recyclables (plastics, metals, paper/paperboard and glass) has been set up, while the initiation of the source separation and composting of biowaste is expected to take place on a later phase.

4.4.1 Specific Waste Generation Rate of MSW

According to the monitoring procedures followed, for the examined areas of Tinos island, it has been defined that the MSW Specific Waste Generation Rate equals to 435 kg capita^{-1}·yr^{-1}, which is lower than the average MSW production of 503 kg capita^{-1}·yr^{-1} in Greece for 2012 (EU-27 average value: 492 kg capita^{-1}·yr^{-1} in 2012). This variation is probably due to the different living standards of the inhabitants of Tinos Island, in respect of urban centers, where the majority of the population is established. An additional reason may possibly be the on-going Greek economic recession.

4.4.2 Specific generation rate of packaging materials

For the period 2005 and 2011, in the EU-27, the packaging materials generation rate remains almost constant at approximately 150 kg cap^{-1} yr^{-1}. For Greece, the respective average rate equals to 65.3 kg cap^{-1} yr^{-1}, whereas for the case of ISWM scheme the specific generation rate of packaging materials (excluding wood packaging) has been found equal to 124.29 kg cap^{-1} yr^{-1}. This difference is related to the high composition of packaging waste in MSW in touristic areas, such as Tinos island (i.e. 28.54 % w/w of MSW).

4.4.3 Glass packaging waste

Regarding the case study of Tinos Island, the glass packaging waste fraction comprise the 3.52% w/w of MSW, whereas the corresponding indicator of specific generation of glass packaging waste was found equal to 15.33 kg cap^{-1} yr^{-1} which is higher than the national generation rate of 10 kg cap^{-1} yr^{-1} in 2011. Greece along with Bulgaria (9.4 kg cap^{-1} yr^{-1}) and Romania (6.5 kg cap^{-1} yr^{-1}) possess the smallest amounts regarding glass packaging generation. In contrast, the top consumer is 72 kg cap^{-1} yr^{-1} in Luxembourg and 44 kg cap^{-1} yr^{-1} in France, as well as in UK. It should be mentioned that the quantity of the recycled glass packaging is considerably different from the amount of glass waste generated. The highest quantity of glass recycled is shown by Luxembourg, while other European countries with a high recycling rate are Belgium (35 kg cap^{-1} yr^{-1}), France (31 kg cap^{-1} yr^{-1}), Germany (29 kg cap^{-1} yr^{-1}), the UK (28 kg cap^{-1} yr^{-1}), Austria and Ireland (27 kg cap^{-1} yr^{-1}). For the case of Greece, the small amount of recycled glass packaging waste equals to 3.8 kg cap^{-1} yr^{-1}. This value corresponds to about 38% w/w

recycling rate. Even though Greece is the only EU-27 Member State that has not fulfilled the 60% glass recycling 2008-target, it is notable that the glass packaging waste which is recycled in the pilot ISWM scheme, in Tinos island accounts for 11.37 kg cap^{-1} yr^{-1} which is well above the Greek average value. In addition, the percentile recycling (i.e. source separation ratio) of glass packaging waste is 74.12% w/w which is much higher than the mandatory EU and national 2001 and 2008 targets (15 and 60% w/w respectively) and well above the national achieved recycling level. It is also worth mentioning that the ratio of glass packaging waste in the residual MSW was found low, equal to 1.1 % w/w (i.e. 4.0 kg cap^{-1} yr^{-1}). Consequently, it is obvious that the potential in further increasing the recovery rate from residual waste and subsequently the diversion from landfill is low for the specific type of recyclable material. In addition, the impurities level of source sorted glass packaging waste is 2.00 (% w/w) revealing that the participating householders segregate the glass packaging waste in a proper way.

4.4.4 Paper/paperboard packaging waste

In the pilot case study of Tinos Island, paper/paperboard waste fraction has been determined at 13.25% w/w of total MSW. The specific generation rate of paper/paperboard waste is 57.72 kg cap^{-1} yr^{-1} while the in Greece it is about 33 kg cap^{-1} yr^{-1}. The respective average production of paper/paperboard waste in the EU-27 for 2011 equals to 63 kg cap^{-1} yr^{-1}, encompassing a wide range varying from Germany with 90 kg per capita to Romania with 14 kg per capita.

At this point, it is noted that the practice of recycling of 'Paper/paperboard' has been in operation since the 1980s, in many Member States. Consequently, the recycling of 'paper and board' packaging was already high before the packaging legislation came into force (Packaging Directive 94/62/EC). It should be mentioned that the recycling 2001 and 2008-targets of 15 and 60% respectively, have been successfully achieved by all Member States (except Poland). In view of that, the applied ISWM plan in the selected areas in Tinos Island achieves satisfactory recycling rate of 60.31% w/w achieving the established targets and further contributing to the already high national source separation ratio. In addition to the latter, the 6.22% ratio of paper/paperboard in the residual MSW shows that measures can be taken to further increase the diversion of this fraction from rest waste. For this purpose, the forthcoming dissemination activities will aim, apart from other, to improve the sorting of paper/paperboard packaging waste (e.g. by enhancing participation rate, by repeating sorting instructions and reminding the types of waste included in the paper/paperboard packaging fraction of MSW). Concerning the quality of sorted paper/paperboard packaging waste, the impurities level which was found equal to 7.53% w/w indicates that the participating householders segregate effectively paper/paperboard.

4.4.5 Metal & plastic packaging waste

The metal packaging waste consists of steel and aluminum, whereas plastic packaging waste is composed mainly of PET, FILM PE (LDPE), HDPE and PP/PS. Due to the fact that plastic & metal packaging waste comprise a joint collection, in the applied ISMW scheme, an estimation of the quantity of each material should be made so as to quantify the necessary performance indicators. It has been found that the specific generation rate of plastic and metals equals to 45.21 and 6.03 kg cap^{-1} yr^{-1} respectively (aggregate amount 51.24 kg cap^{-1} yr^{-1} of plastic & metal). Plastics packaging material is the packaging material with the highest growth rate over the 7-year period 2005-2011 in EU. It is noted that in most EU Member States the amount of plastic packaging waste generated lies between 20 to 35 kg cap^{-1} yr^{-1} in 2011. The increased level of plastic waste in the selected communities of Tinos island and the differentiation compared to the average Greek value (i.e. about 18 kg cap^{-1} yr^{-1} in 2011) is most probably related to the touristic activities which result in greater

quantities of plastic packaging waste than householders. In contast, the metallic packaging waste generation in the areas under examination is almost half the amount of EU-27 average (i.e. 9 kg cap^{-1} yr^{-1}), while the average value equals to 10.5 kg per capita in Greece.

Compared to other packaging materials the recycling of plastics is more difficult and costly leading to lower recycling rates in EU Member States. Consequently, in most EU countries the recycling rates range between 20 to 35%. –Despite the aforementioned difficulties in plastics packaging waste recycling, the source separation ratio in the pilot case of Tinos island, is as high as 46.47 %, well above the 2008-target of 22.5 %. This fact is obviously associated with the technology employed in the RSC facility which effectively separates the different plastic packaging waste categories (e.g. PET, FILM PE, HDPE and PP/PS), with the use of appropriate equipment (i.e. optical sorting systems)

The source separation ratio of metallic packaging waste during the implementation of the ISWM plan was recorded at 1.69% w/w. The low level of metal packaging waste indicates that an awareness raising activities should be performed with the aim of increasing the recycling rates of metal packaging waste to levels which conform to the national 2008-target of 50% w/w. However, it must be stated that in absolute numbers the quantity of metallic packaging materials that need to diverted in order to achieve the aforementioned target is relatively low, taking into account the fact that this fraction of MSW represents only 1.4% w/w of MSW. Furthermore, it is noted that all Member States obliged to comply with the 2008-target of 50% w/w, have achieved their goal expect Greece (i.e. about 42.5% w/w).

As mentioned above, the specific generation of plastic & metal (joint collection) equals to 51.24 kg cap^{-1} yr^{-1}, whereas the source separation ratio is 41.20% w/w regarding the 8-month implementation of the ISWM scheme. Consequently, it is evident that there is a potential of improvement for the segregation of plastic & metal packaging waste which is also confirmed by the increased ratios of materials in the Residual waste which amount to 8.19 % of rest waste. Additionally, the impurities level of sorted plastics & metals was found equal to 23.48% w/w which is higher than the contamination level of other target materials (i.e. paper/paperboard and glass packaging waste.

Based on the indicators presented above, it is concluded that the project shall intensify its efforts in increasing the diversion rate of plastic & metal packaging waste from residual waste and decrease the contamination level of sorted materials. Therefore, the forthcoming awareness campaigns should focus on the aforementioned issues by encouraging and informing the participants of the target areas in Tinos Island.

4.4.6 Overall evaluation

The total source separation ratio depicts the extent to which participants sort their waste and it is given by the ratio of the total weight of the collected source separated materials over the total amount/weight of MSW generated. The total source separation ratio of packaging waste during the examined period is equal to 15.45% which is considered satisfactory given the fact that 67.29 kg cap^{-1} yr^{-1} of the produced dry recyclables (i.e. packaging waste) is being effectively sorted.

The 67.01 kg cap^{-1} yr^{-1} of segregated packaging waste in Tinos pilot scale scheme corresponds to an overall recycling rate of 54.14 % of generated packaging materials, which is lower than the EU-27 average of 62.5 % in 2011 and very close to the 2008-target of 55 % w/w. For the reference year

2011, most of the EU Member States subject to meeting the 2008-target of 55 % recycling rate, achieve the goal marginally.

Concerning the impurities level of the source separated materials, it is given by the level of mis-sorted materials in the recyclables. During the implementation period of the ISWM source separation scheme, from 10.06.2013 to 14.02.2014, the packaging waste demonstrate an overall contamination rate equal to 12.00% w/w. This shows a satisfactory purity level regarding the effective treatment and recycling of waste materials.

Furthermore, the participation rate was estimated at about 55% which indicates that the ISWM scheme working teams shall further encourage people to participate actively in the recycling program by continuously supporting the people that contribute to the implementation of the ISWM scheme and engaging the ones that are not currently involved in separating their waste. It is expected that the participation level will increase since after the set up of the bio-waste segregation scheme followed by appropriate training and awareness sessions, aiming to promote the updated scheme and to enhance the inclusion of more households to the existing recycling system.

Considering the project's progress (i.e. only packaging waste recycling scheme in place) on the whole, the overall Recycling Rate is determined by the effectiveness of the source separation scheme of packaging waste in the examined areas and the efficiency of the Recycling Sorting Center, located in Attika Region in Koropi Municipality, to treat the segregated MSW fractions. The overall amount of packaging waste that has been delivered to the RSC amounts to 22.1 tn, 2.0 tn of which is non recyclable impurities, while 0.6 tn is packaging material which has been mis-sorted (e.g. paperboard waste that was misplaced in the glass or plastic & metal packaging waste collection bin). Since the Recycling Sorting Center is able to treat commingled packaging waste, the overall Recycling Rate equals to 90.81% w/w, instead of 88.00 % w/w, indicative of the increased performance of the ISWM scheme in terms of packaging waste recycling.

Therefore, it can be concluded that the ISWM scheme is progressing effectively taking also into consideration that the recycling rate in existing Greek source separating schemes for packaging waste applied in various municipalities is between 50 to 60 % w/w (According to personal communication with HeRRCo and site visit to the RSC in Koropi, Attica region, Greece).

5. Conclusions

Considering the setting up procedures of the curbside collection system for the separation at source of the four (4) target waste streams, namely paper/paperboard, glass, metal & plastic (joint collection) and biowaste, they have been accomplished successfully, as listed below:

- Extensive market research, purchase and placement to pre-defined waste collection points of the outdoor ISWM equipment (i.e. wheelie bins)
- Inspection, selection and preparation of a designated area to serve as a Waste Transfer Station, complying with rules of convenience and safety and in accordance with the capacity characteristics of the available waste collection vehicle provided by the Municipality of Tinos
- Development of useful ‘tools’ for the implementation of the ISWM scheme and the effective monitoring of its performance, such as: network of waste collection points, waste collection schedule, specially designed sheets for data recording, telephone helpline activation, ‘FAQ’

document on the operation and services provided by the ISWM system, high quality educative/informative materials (brochures, cards, posters, e-newletters etc)
- Training sessions addressed to the involved Municipality staff (driver of the waste collection vehicle, telephone helpline operator), as well as of participating households
- Implementation of the raising awareness event to the target communities.

For the time being, the monitoring and evaluation of the ISWM pilot system performance concerning dry recyclables, is carried out during the demonstration phase of the project, using the set indicators determined according to the ISWM plan. For the collection of the required information and the subsequent quantification of the set indicators, all the available data sources have been considered, such as feedback from the staff of the Municipality (data source 1) concerned with the implementation of the ISWM scheme, as well as the RSC staff (data source 2). Additional information is gathered by on-site visits and sampling analyses (data source 3), regarding the generation rates of MSW and the compositional fractions of MSW.

Regarding the overall evaluation of the ISWM scheme performance for the first 8 months of its operation, it has been found that the source separation ratio of packaging in the served area of Tinos Island equals to 15.45% w/w of MSW and 54.14 % w/w of packaging waste materials. It has been shown that the recycling target of 55% of packaging waste has not been achieved yet and further efforts should be made in order to enhance the diversion of packaging from residual waste. More specifically, priority should be given to the plastic & metals fraction considering the low source separation ratio of 41.20%, its increased ratio in the residual MSW of 8.19% w/w and its moderate purity level (23.48% contamination level). Additionally, efforts should be made to increase the source separation ratio of the paper/paperboard fraction. Despite the fact that the recycling rate of paper/paperboard packaging equals to 60.30%, which marginally achieves the 2008-target of 60%, the ratio of paper/paperboard in the residual MSW is high (i.e. 8.19% of residual MSW) showing the potential of increasing the recycling of paper/paperboard. Moreover, during the examination period, it was shown that glass and paper/paperboard packaging is effectively separated considering the low level of contaminants (only 2% and impurities), whereas glass packaging has a low potential for recovery from residual waste, since it consists only 1.1 % of rest MSW.

Overall, the contamination rate of packaging material equals to 12.00% w/w, while the Recycling Rate at the RSC facility amounts to 90.81% w/w. Both of these figures denote the increased efficiency of the ISWM recycling scheme. However, the participation ratio has been estimated to be about 55 % indicating that the project working team needs to further promote active involvement and engagement of people towards sorting their waste.

It is also expected that the total source separation ratio will be significantly increased since after the initiation of the bio-waste source separation considering the fact that bio-waste constitutes the single biggest fraction of MSW accounting 52.45% w/w of the total MSW production as has been determined by on-site composition analysis of MSW in the target areas. Additionally, the international experience on MSW source separation has proved that the effective diversion of bio-waste at household level enhances the segregation effectiveness of dry recyclables. Therefore, the aforementioned conditions in conjunction to the recycling awareness activities that will take place in the served area are expected to contribute to the increase of the total source separation ratio to levels equal or higher than 50% w/w of MSW generated.

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