

# Innovative Waste Management Practices in Remote Areas

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**Abstract**—Municipal waste consist of a variety of items that are everyday discarded by the population. They are usually collected by municipalities and include waste generated by households, commercial activities (local shops) and public buildings. The composition of municipal waste varies greatly from place to place, being mostly related to levels and patterns of consumption, rates of urbanization, lifestyles, and local or national waste management practices. Each year, a huge amount of resources is consumed in the EU, and according to that, also a huge amount of waste is produced. The environmental problems derived from the management and processing of these waste streams are well known, and include impacts on land, water and air. The situation in remote areas is even worst. Difficult access when climatic conditions are adverse, remoteness of centralized municipal treatment systems or dispersion of the population, are all factors that make remote areas a real municipal waste treatment challenge. Furthermore, the scope of the problem increases significantly because the total lack of awareness of the existing risks in this area together with the poor implementation of advanced culture on waste minimization and recycling responsibly. The aim of this work is to analyze the existing situation in remote areas in reference to the production of municipal waste and evaluate the efficiency of different management alternatives. Ideas for improving waste management in remote areas include, for example: the implementation of self-management systems for the organic fraction; establish door-to-door collection models; promote small-scale treatment facilities or adjust the rates of waste generation thereof.

**Keywords**—Door to door collection, islands, isolated areas, municipal waste, remote areas, rural communities.

## I. INTRODUCTION

WASTE is an inevitable product of human settlements. Waste management practices were initially developed to avoid the adverse effects on public health that were being caused by the increasing amounts of solid waste discarded without appropriate collection or disposal, common practice until not long ago.

Although municipal waste represents only around 10% of total waste generated in the EU [1], [2], it is probed that countries that have developed efficient municipal waste management systems generally perform better in overall waste management [3]. This is why managing municipal waste more effectively is today a need that society has to address.

In dealing with the waste there are two fundamental requirements: less waste, and then, an effective system for managing the waste still produced.

Total municipal waste generation in EU countries declined

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by 3% in absolute terms and average generation per person by 7% from 2004 to 2014; however, there has been no uniform trend, with an increase in municipal waste generation per person in some countries and a decrease in others [4].

Degree of industrialization, economic development, public behaviour, and local climate are all factors that clearly influence generation of municipal waste. Generally, when the economic development and rate of urbanization are high, the production of municipal waste increases.

The urban population produces about twice as much waste as rural residents [5]; however, waste management in rural areas, mainly in those considered remote, is a big challenge nowadays due to the difficulties associated to its collection, the lack of infrastructure or lack of accessibility to treatment centers.

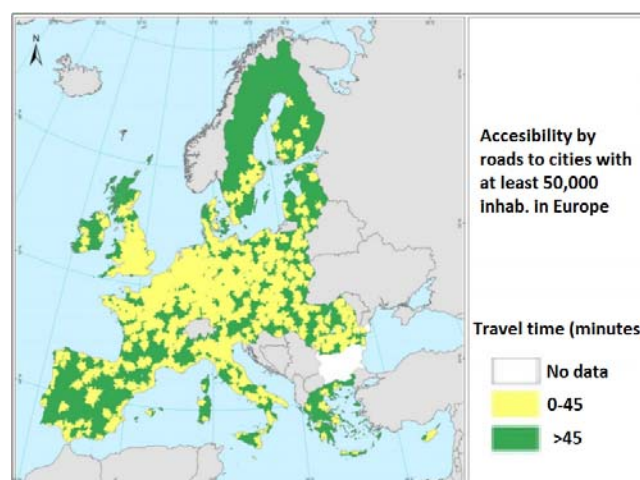


Fig. 1 Accessibility by roads to cities with at least 50,000 inhabitants in Europe [6]

Considering the European Union as a whole, approximately 28.4% of the EU-28 is classified as remote at more than 45 minutes from the nearest urban centers with at least 50,000 inhabitants, 49.1% of the EU-28 territory is located in remote areas and 12.4% of the EU-28 population is living in remote areas. The remote areas account thus for almost half of the European territory (Fig. 1), but only for one-eighth of the European population [6].

Special attention has to be paid to islands, since they also fit in the category of remote areas. Waste generation in the islands has grown significantly in the last years because of touristic activity. The restrictive characteristics of the territory greatly impede, in these cases, the execution of works related to waste collection, transportation, storage, treatment and

disposal activities and entail high management costs, due to the need to transfer waste to the continent [7].

The population distribution associated to remote areas (including islands and isolated rural communities in the definition) further complicates municipal waste management. Traditional waste management models have not the same results than when applied in continental big cities and authorities are aware of this reality. The collection coverage is a key indicator that allows to evaluate whether the infrastructure for waste collection in a specific location is adequate [8].

Different alternatives for the management of municipal waste generated in remote areas will be identified and analyzed in this paper. Also, the extent to which the targets proposed by current law are met in each case will be assessed.

## II. MUNICIPAL WASTE MANAGEMENT MODELS

The process of waste management planning considers the evaluation of impacts on existing and future waste streams are vital and essential aspects [9].

Generation of waste and planning are commonly influenced by different factors impacted by socio demographics, including the amount of waste generated and personnel required, what is directly dependent on the population density, and the cost of operations [10].

Shifting the focus to how the municipal waste is managed in Europe, there is clear evidence of a shift up the waste hierarchy. Landfilling of municipal waste in EU-27 decreased by almost 48 million tonnes in the period 2005-2015, whereas incineration, recycling and composting increased by 16, 12 and 11 million tonnes, respectively [11].

However, some countries do not cover their whole territory with a collection scheme, reporting more waste generated than treated (Table I). This particularly concerns remote areas which are not provided with such services. If waste is not collected properly, and no 100% collection coverage is reached, the consequence is clear: such waste will most likely be disposed of without environmental controls, illegally buried, dumped, burned or stored. Deficits in collection result in uncontrolled abandoning of waste, unused resources and severe impacts on the environment.

Countries using some economic incentives for households to recycle their waste (for example 'pay-as-you-throw schemes', requiring the payment of fees based on the weight of the residual (not separately collected) waste, the size of the residual waste bin or the frequency of collection) have mostly performed better than countries where waste collection fees are just based on the property value, size of the property, household size or similar [12].

According to Zorpas et al. [13], municipal solid waste management models are becoming more and more complex, especially in rural and insular communities. The move from landfill-based to resource recovery-based solutions is a trend nowadays, following the recommendations of international and national normative. To divert waste from landfills and to increase recycling and recovery rates is a common objective of waste administrations.

TABLE I  
 MUNICIPAL WASTE GENERATION AND TREATMENT IN EUROPEAN COUNTRIES  
 IN KG PER CAPITA, 2015 [11]

Country	Generation	Treatment	Not covered by a collection scheme
EU (28 countries)	477 <sup>s</sup>	463 <sup>s</sup>	14
EU (27 countries)	477 <sup>s</sup>	464 <sup>s</sup>	13
Belgium	419	409	10
Bulgaria	419	412	7
Czech Republic	316	316	0
Denmark	789	789	0
Germany	625 <sup>e</sup>	610 <sup>e</sup>	15
Estonia	359	313	46
Ireland	587 <sup>1</sup>	532 <sup>1</sup>	55
Greece	506 <sup>1</sup>	506 <sup>1</sup>	0
Spain	434 <sup>e</sup>	434 <sup>e</sup>	0
France	502 <sup>e</sup>	502 <sup>e</sup>	0
Croatia	393	384	9
Italy	486	432	54
Cyprus	638 <sup>e</sup>	590 <sup>e</sup>	48
Latvia	433	366	67
Lithuania	448	442	6
Luxembourg	625 <sup>e</sup>	625 <sup>e</sup>	0
Hungary	377	377	0
Malta	624	599	25
Netherlands	523	523	0
Austria	560	542	18
Poland	286 <sup>e</sup>	286	0
Portugal	453 <sup>3</sup>	453 <sup>3</sup>	0
Romania	243 <sup>3</sup>	218 <sup>3</sup>	31
Slovenia	449	421	28
Slovakia	329	310	19
Finland	500	500	0
Sweden	447	447	0
United Kingdom	485	472	13
Iceland	533 <sup>3</sup>	533 <sup>3</sup>	0
Norway	421	415	6
Switzerland	725	725	0
Montenegro	533	518	15
Former Yugosl. Rep.	370 <sup>3</sup>	370 <sup>3</sup>	0
Serbia	259	194	65
Turkey	400 <sup>e</sup>	352	48
Bosnia and Herzeg.	311 <sup>2</sup>	233 <sup>2</sup>	78
Kosovo	178	-	-

- : not available; s: Eurostat estimate (phased out); e: estimated data from <sup>1</sup>2012; <sup>2</sup>2013; <sup>3</sup>2014

The provision of urban waste services can be organized under different modalities. Home municipalities can offer direct management as a public service or by means of public entities, through the modality of subcontracting or license service. On the other hand, private agents operating under a public contract (public bidding) system with the municipality can offer indirect management. In this case the municipality is responsible only for the regulatory aspects. Fig. 2 shows the most frequent legal modalities established in waste management [14].

It is a common practice that each municipality decides the form of management modality of its waste services. The councils or municipalities usually have decision capacity when deciding rules and procedures. Municipalities may even be

sometimes be grouped in order to optimize the management of the waste services.

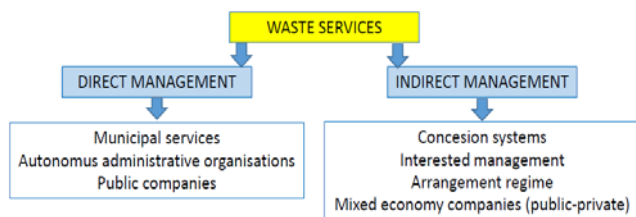


Fig. 2 Forms of waste management organizations (adapted from [14])

The design of collection systems for solid household waste varies largely in different parts of the world, but also between different regions within a country. Recyclables can either be source-sorted by households and collected separately or disposed commingled by households for later post-sorting. The latter system is less common in the EU, but feasibility studies show that systems for this exist and could function also in a European context [15].

### III. WASTE MANAGEMENT IN ISLANDS

Waste management in island communities is often complicated by their isolated geographies and the fact that their economy is dominated by the services sector. This results in even greater challenges for ensuring sustainable solid waste management. Waste production in small insular countries like Cyprus and Malta and other islands like Sicily, Crete, Balearic, Canary, Cyclades etc., is continually increasing as those destinations are the main tourist resorts in the European tourist industry. Also, they present similarities as they have urban, mountainous, rural and purely tourist regions. Cyprus, Malta, Sicily and Greek islands, among others, landfill more than three quarters of their municipal waste [16]. Sicily for example landfills 93% of its generated municipal waste [17] while Cyprus up to 60% until now [18].

Touristic activity can generate nearly twice waste than the local population [19]. Excessive waste generation is one dimension of the problem, but not the only one, since insular destinations have very limited capabilities for managing wastes. According to Santamarta et al. [20] significant weaknesses of the waste management system in insular communities are based on infrastructure and lack of local recycling programs.

Although in most of the insular cases the waste generation is sufficient, for example, for the development of a central waste to energy plant, due to the absence of specific strategic policy, wastes are proceeded for landfill [13].

Isolation of insular territories drives to serious difficulties to achieve economies of scale for the treatment of these residual streams. This is perhaps one of the main problems of the islands in the field of waste management. The result is usually that authorities have not another option than transfer them to another place, which implies high associated transport costs [21].

### IV. WASTE MANAGEMENT IN RURAL COMMUNITIES

Most waste plans do not address the specificities of waste management activity in remote rural areas or provide concrete solutions for them.

According to Ciuta et al. [22], the differences between the rural and urban areas in municipal waste composition are evident. The plastic fraction, for example, is significantly higher in urban areas, almost six-times higher generation by inhabitant annually than in rural areas. This aspect is crucial when considering valorization options. The greater amount of plastics generated in urban versus rural areas considerably increases the calorific value of waste and, as a consequence, the possibility of valorization for energy recovery.

The biodegradable fraction is used in many cases as feed for farm animals in rural areas. The rural population habits make organic waste selective collection, anaerobic digestion or centralized composting less common options. Jofra et al. [23] proposed household and community composting as the main actions to improve waste management models in isolated rural areas.

Paper, cardboard and wood does not require separate collection in rural areas, since they are frequently reused in the households for individual heating.

The remoteness of the facilities for selection of the remaining fraction makes difficult the fulfillment of legal objectives on waste. This, together with the low rates of selective collection and the scarcity (or even absence) of waste recycling plants in these areas, means that most of the remaining fraction is discharged without prior selection.

To improve the management of waste generated in isolated rural areas, a key option is the introduction of door-to-door collection systems, which have been shown to achieve in rural communities better results in terms of selective collection than container-based models [23].

The current cost of providing waste management services in rural municipalities is not necessarily higher (per capita) than in large municipalities, probably because rural services render less often complete services. However, it is desirable to promote the provision of services at the supra-municipal level to optimize waste management costs.

Economic instruments are a powerful tool to encourage waste reduction and selective collection. These include the potential of taxes on the discharge of municipal waste, which are currently not applied, and the rates of payment for waste generation. The correct implementation of sanctions by the authorized bodies is another tool to be considered when other methods fail.

Better results for efficient selective collection systems could be achieved by supporting all of the above with education campaigns especially aimed at the rural population.

### V. INNOVATIVE WASTE RECYCLING SCHEMES FOR REMOTE AREAS: THE PAVETHEWAYSTE PROJECT

Nowadays, there are numerous initiatives that seek to improve municipal waste management, but only a few of them are focused on the specific problematic of remote areas. In this

sense, of particular note is the called PAVEtheWAYSTE [24], a pilot project that aims to put into practice, test, evaluate and disseminate a new recycling strategy in remote locations. The main goal of this project is to encourage the local and regional authorities, being the key players in waste management, to implement the provisions of the Waste Framework Directive

2008/98/EC. This will be achieved through the development and implementation of an Integrated Solid Waste Management (ISWM) scheme (Fig. 3), including the demonstration of innovative systems used for the fine separation and treatment of municipal waste at source.

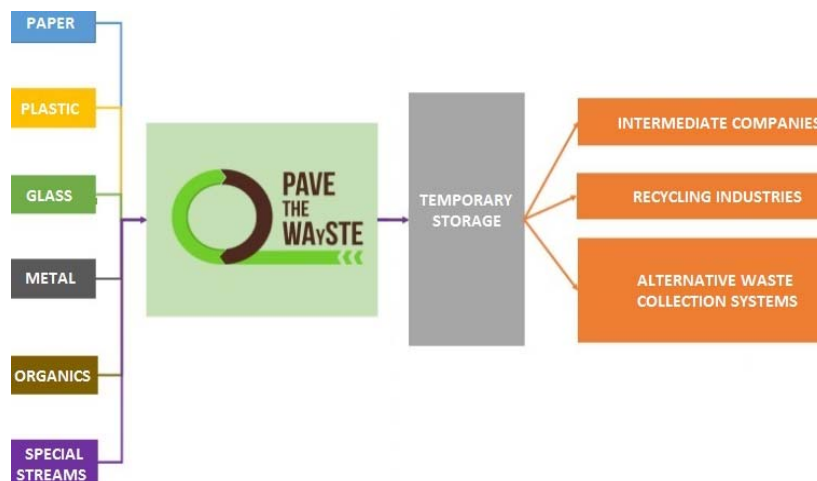


Fig. 3 Proposed ISWM scheme for remote areas

The main objectives of this on-going initiative are:

- To establish an integrated, replicable system of innovative character for source separation and treatment of municipal waste for remote areas;
- To treat municipal waste at source avoiding waste collection, transportation and treatment in central recovery facilities;
- To recover the maximum possible resources generating more than five streams of clean materials, while contributing to diversion of waste from landfill;
- To evaluate the quality and the commercialization of the end products in correlation with the specifications of the local/regional market and the specific norms of the industry;
- To make waste recycling an economically attractive option for remote areas, where transportation costs predominate (50% reduction in waste management costs);
- To eliminate landfilling practices and, in particular, illegal waste management practices, such as uncontrolled landfill, currently in use in some remote areas;
- To inform and train citizens on how to sort different types of recyclable material through the set up of innovative prototype systems.

The project is currently being implemented in two Greek remote areas, the Municipality of Naxos and Small Cyclades Islands and the Municipality of Ancient Olympia. In addition, and in order to extend the demonstration character of the project, replication and transfer of the developed ISWM system and its findings will be provided not only in other remote municipalities of Greece (Patmos, Nisyros and Agathonisi islands), but also in follower municipalities of Spain with similar characteristics (Lanzarote island and

remote rural locations of Valladolid province).

The pilot project envisages to facilitate the selected remote municipalities to significantly improve municipal waste recycling rates and, thus, “pave the way” to high resource efficiency.

## VI. CONCLUSION

For many regions in Europe, especially for those “remote” or “isolated” the optimization of urban waste management becomes a big challenge. Appropriate infrastructure and local-tailored minimization, recycling and reuse programs could be the key to improve the current situation.

## ACKNOWLEDGMENT

The authors gratefully acknowledge support of this work by the LIFE Program under the responsibility of the Directorate General for the Environment of the European Commission (project LIFE 14 ENV/GR/000722-LIFE PAVEtheWAYSTE).

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