

# METHODS AND TECHNOLOGY OF SOLID WASTE MANAGEMENT IN MUNICIPALITY OF KRATOVO, R. MACEDONIA

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***Abstract:** The municipality of Kratovo is situated in the northeast part of R. Macedonia, between the towns of Kriva Palanka, Probishtip, Sveti Nikole, Kumanovo and Kochani. Kratovo is one of the oldest towns in the country. It is located in the crater of an extinguished volcano on the Osogovo Mountains, between the banks of three small rivers. The structure of the terrain varies from low to high areas, which on the other hand, affects the way of life. With its 10800 citizens and spreading over 376 km<sup>2</sup>, it is amongst the smallest towns in R. Macedonia. An investigation of land use pattern has shown that the land in Kratovo can be categorized as forestry land, pastures and arable land. Only 1% of the land in Kratovo is registered as non-arable land. About half of the forests and pastures are in private ownership. This makes difficulties in effectuation of the solid waste management plan, which could not be well accepted by the owners of the land. Therefore an integrated approach to solid waste management has been taken. It is based on well-established economic and ecological goals requiring separation of the individually created waste in the processes of collection, processing, renewal and removal. The present practices of solid waste management in Kratovo are based on mixing of a number of types of waste resulting in health and ecological risks aggravating the renewal of resources. The different types of waste have been classified depending on amount, composition and physical properties of each type of waste. The author of this report presents all kinds of solid waste management to be applied for improvement of the human environment.*

***Keywords:** hazardous waste, human environment, landfilling, incineration, recycling, waste management, waste types*

## 1. INTRODUCTION

Kratovo is one of the oldest towns in the Balkan dating back to the 4<sup>th</sup> century BC. It is located in an area of an extinct volcano crater from which the name of the town was derived.

With its unique characteristics, Kratovo itself is more like a museum, being rich in natural, historical and cultural monuments.

During their first visit to Kratovo, visitors come across rarities that cannot be seen in the other parts of the country and they always want to come back. Knowing these qualities of Kratovo, it is considered a known tourist place that has lately been visited by many tourists. People talk about and want to see the five stone bridges with vaults, the well-known Rada's bridge (which is said to have inside its structure the body of a young girl named Rada in order that it could exist). The bridge used to lose its stability since it is built over a small river flowing through the Kratovo gorge. There are also several stone towers out of which one was referred to as the clock tower since it once had a clock. The architecture of all houses is associated with old Turkish houses with large timber windows ending with arches in their upper parts, large open porches, tile roofs and gable walls. The streets are narrow and made of paving stone. Most of them are not suitable for motion of trucks.



Fig. 1. A typical street in Kratovo



Fig. 2. A stone tower in the center of Kratovo

Therefore, through the municipality, there was established a programme on the mode of collection of waste from the town and its dislocation to a landfill. The landfill is situated at a distance of 3 km from the city and does not represent a sanitary landfill but a large hole. It is not covered and contains different types of waste representing a big threat for the human environment.

The Association of Engineers without Borders from the University of Florida (EWB-UF) along with the authors of this paper – Dr. Biserka Dimiskovska and Tomislav Petrovski, grad. civil eng. have elaborated this Integrated Plan for Solid Waste Management for the needs of the municipality of Kratovo, R. Macedonia in accordance with the conditions and the legislation prescribed by EU. The study presents the methods by which Kratovo can improve the present system of solid waste management. It will show the way in which the following goals will be achieved:

- Communication between the members and the mentors from EUB-Uf and their Macedonian colleagues;
- Development of an integrated strategy for solid waste management;
- Development and maintenance of interactive Geographical Information System (GIS) tool for mapping of the municipality of Kratovo;
- Design and manufacturing of dustbins for collection of plastic bottles for recycling;
- Optimization of locations in which the dustbins for recycling material will be placed;
- Development of partnerships between public institutions and private sector;
- Development and effectuation of ecological educative programme;
- Development of education and strategy at state level for the purpose of providing information aimed at decreasing of the waste at places where it is created, its reuse and recycling.
- Definition of phases of progress made towards the goals and the effectuation of the plan, and
- Definition of resources necessary for further construction of a recycling facility.

## **2. PROJECTIONS AND AMOUNT OF WASTE**

The integrated approaches to solid waste management based on well established economic and ecological goals often require that the individually created waste be separated in the processes of collection, processing, renewal and elimination. The present practices of solid waste management in Kratovo are based on mixing of several types of waste in the management cycle resulting in health and ecological risks and aggravation of reuse and renewal of resources. These are the following types of waste:

1. Solid communal waste;
2. Solid technological waste;
3. Hazardous waste;
4. Agricultural waste;
5. Construction waste;
6. Special waste.

## 2.1. Description of the Planned Territory

Fig.3. shows the location of Kratovo in R. Macedonia. The demographic and the physical characteristics of the city have had a key role in establishment of the plan for solid waste management including the activities for reduction and recycling. The land ownership structure and the relations among neighbours, the topography and the geographic factors have also had an influence upon the Plan.

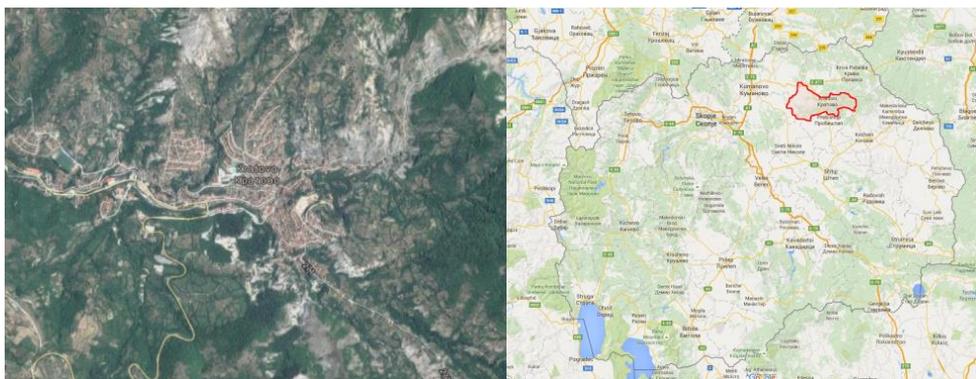


Fig. 3. Kratovo and the region

The air shot of the town is given in Fig.4. showing the present locations for waste collection and the ways of waste creation by use of ArcGIS©.

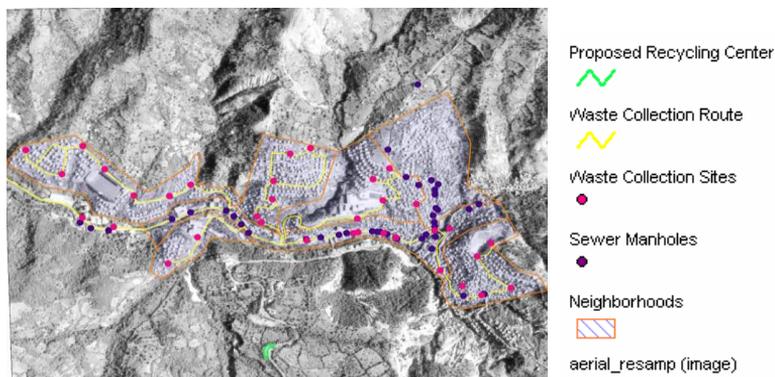


Fig. 4. Satellite shot of Kratovo presented with the solid waste management system

In conditions of solid waste management, the local ways of waste creation affect the mode of collection and transportation of the solid waste since some of the streets are too narrow and steep for larger vehicles. The trailers for waste collection are drawn by tractors that can drive along the steeper and narrower streets.

### ***2.1.1. Communal Solid Waste***

The communal solid waste is the waste created from the everyday activities of the people, households, courtyards, business and other types of buildings and areas including different kinds of waste like food from households, waste from gardens, agricultural waste, paper, cardboard, wood, metal, glass, porcelain, leather, plastic, rubber and other. In the densely populated areas, the communal solid waste is mainly composed of paper, cardboard, plastic, metal, glass, other materials used for packing, organic kitchen waste. In the houses with their own gardens, the created waste mainly includes organic and inorganic garden waste., table 1.

Table1. Content of the communal solid waste in Kratovo

<b>Waste content</b>	<b>Sample 1 in kg</b>	<b>Sample 2 (in kg)</b>	<b>Total (in kg)</b>	<b>%, per mass</b>
<b>Vegetation</b>	76.0	259.7	335.7	80.8
<b>Food waste</b>	14.6	17.3	31.9	7.6
<b>Crushed cardboard</b>	8.8	0.6	9.4	2.5
<b>Other types of paper</b>	0.0	2.5	2.5	0.6
<b>Textile</b>	1.5	1.7	3.3	0.8
<b>PET bottles</b>	3.6	2.2	5.9	1.4
<b>Other types of plastic</b>	11.1	0.9	12.0	3.2
<b>Glass</b>	2.9	3.4	6.3	1.8
<b>Non-coloured and metals</b>	0.6	0.0	0.6	0.1
<b>Construction materials</b>	3.0	0.0	3.0	0.8
<b>Other inorganic materials</b>	1.5	0.0	1.5	0.4
<b>TOTAL</b>	123.7	288.3	412.0	100

### ***2.1.2 Solid Technological Waste***

Technological waste includes waste from production processes carried out in industry, institutions, services, etc. This kind of waste is different from the communal solid waste regarding its content and characteristics. The only successful industry in Kratovo is the local textile factory located in the industrial part of the town and managed by Sileks.

### ***2.1.3 Hazardous Waste***

The hazardous waste contains substances that have one of the following properties: these can explode, react with other substances, burn, burst forth, be toxic, contagious, with cancerogen and mutagen effects, ecotoxic or can emit toxic gases through chemical reactions or can be biologically degradable.

### ***2.1.4 Agricultural Waste***

A considerable percentage of agricultural waste in R. Macedonia is re-used or recycled. For example. A considerable grape waste is composted and again used as a fertilizer. The Kratovo landfill is known for its considerable amount of agricultural waste that is increased with each day including the waste from clipping of vineyards and orchards.

### ***2.1.5 Construction Waste***

In accordance with Article 11 of the Law on Maintenance of Sanitation, Collection and Transportation of Communal and Technological Waste, construction waste is created in the process of performance of construction, industrial and handicraft activities. This kind of waste includes: construction waste materials, earth, mica, mud (inert or non-hazardous), stones, waste containing pieces of tiles, sanitary fittings.

### ***2.1.6 Special Waste***

Special waste is defined as waste created in health care institutions (sanatoria, hospitals, polyclinics and outpatient departments), scientific-research and development institutions, laboratories as well as material obtained as a product from resources used in the course of curing patients, their examinations and control.

## **2.2. Predictions Regarding Creation of Solid Waste and Models for Its Collection**

Successful planning of solid waste management requires methods for approximate computation of the amounts of all kinds of created waste. As mentioned before, the level of creation of solid communal waste depends on several factors including the population, the number of households, number of employees, type of trading activities and the level of education of the population, table 2.

Table 2. Projections on waste creation in Kratovo

	2000	2005	2010	2015	2020	2025	Assumptions	
<b>Creation of solid waste in the municipality (tons)</b>	1,080	1,068	1,057	1,045	1,034	1,023	1,012	Permanent rate of creation of waste
<b>Creation of solid waste in the municipality (tons)</b>	1,080	1,229	1,376	1,518	1,658	1,795	1,928	Rate of creation of waste is annually increased for 1.5%
<b>Increase of the rate of creation of waste in the rural areas</b>	0.099	0.114	0.129	0.144	0.159	0.174	0.189	/

### 3. SYSTEM OF SOLID WASTE MANAGEMENT

The solid waste management system involves the citizens, the private firms and the local self-government. The system is composed of the following elements: collection, removal and recycling. The municipality programme for solid waste management presents the needs of Kratovo for a better quality of environment, efficient public services and economic vitality of the municipality.

#### 3.1 Collection

The municipality of Kratovo does not manage the six categories of solid waste separately. There is one system of collection and transfer of almost the entire solid waste to the local landfill. There is a plan for collection and elimination of medical waste, but it has its flaws so that the medical waste is mixed with the communal solid waste and is eliminated to the local landfill.

##### *3.1.1. Solid Communal Waste*

Kratovo has a solid waste management system based on relatively new metal containers and a waste collection vehicle. In the town, which is divided into zones, the waste is collected systematically from 15 to 18 containers per zone. In the central part of the town, the waste is collected each day (from Monday until Saturday), whereas in the residential zones, it is collected each Monday and Thursday.



Figure 5. Dustbins for solid waste



Figure 6. Vehicle for solid waste collection

The vehicle for collection of waste (Figure 6.) is produced in 1991, type MAN F0617192. It represents a donation by the Norwegian embassy to the municipality of Kratovo. The donation was made on 21st October 2004.

### ***3.1.2. Technological Solid Waste***

There are no special programmes or measures for collection of the technological solid waste.

### ***3.1.3. Hazardous Waste***

There are no special programmes or measures for collection of hazardous waste.

### ***3.1.4. Agricultural Waste***

There are no special programmes or measures for collection of agricultural waste.

### ***3.1.5. Construction Waste***

There are no special programmes or measures for collection of construction waste.

## **3.2. Elimination of Waste**

The solid waste which is collected by the special vehicle in Kratovo is transferred to a landfill at a distance of about fifteen kilometres (Figure 7.). The landfill is reached in about 15 minutes, while the waste is normally landfilled through two to three rounds daily.

The place where the waste is landfilled does not fulfill the criteria for a sanitary landfill and there have been observed several problems from safety and ecological viewpoint. The greatest risk is perhaps associated with the drivers of the vehicle because of the possibility for sliding of the formed pile of solid waste.



Figure 7. The landfill in Kratovo



Figure 8. Elimination of waste from an unlicensed Landfill

### 3.3 Unlicensed Landfills

One of the greatest problems presented in this project proposal is the existence of unlicensed landfills, i.e., different places of disposed waste in the town (Figure 6.).

### 3.4 Recycling

In Kratovo, there is neither facility nor any activities for recycling of waste material. The EWB-UF team will collaborate with Mr. Stojan Nacevski – founder of the non-governmental organization “Soncev rid” – organization that collects and packs PET bottles and transports them to Veles, R. Macedonia.

## 4. HIERARCHY IN SOLID WASTE MANAGEMENT

The integrated plan for solid waste management involves six levels that are part of the waste management hierarchy. IMPUCO must provide a strategy that will include all the elements of hierarchical organization of the main operations of waste management as are the creation, the collection, the transportation, the processing and the final elimination of the waste. The hierarchical organization of waste management is as follows:

Decrease of amounts of waste at places of its creation; Reuse; Recycling; Processing of waste; Incineration; Landfilling.

### 4.1. Decrease of Amounts of Waste at Places of Its Creation

The decrease of amount of waste at places of its creation involves actions aimed at decreasing the amounts or the toxicity of the solid waste that is to be managed. These actions take place prior to involvement of the waste

in the communal solid waste management system, i.e., at the place of its creation or earlier. An example of decrease of quantities of waste at places of its creation is the decrease of the amount of packages for transport of different products. Each individual can contribute to the decrease of waste creation at the very source by carrying own bags for the new procurements instead of obtaining new bags. Also, the garden waste from own gardens could be composted. Another example of reduction of amounts of waste in companies, institutions and households is copying on two sides by which saving of paper to about 50% can be achieved.

#### **4.2. Reuse**

Reusing is a technique of waste management by which the product is used again for the same purpose but with a new quality without its physical change. For example, construction materials eliminated during renovation or tearing down of some buildings, as are the fittings for example could be used for another structure. Until now, the municipality of Kratovo has still not identified nor it has monitored the trends of reuse by the citizens and other organizations that are working in the territory of the municipality.

#### **4.3. Recycling**

Recycling is a process in which used parts from the waste, which is to be eliminated, are separated to obtain new products. Recycling, first of all, refers to materials as are iron, aluminum other non-ferrous metals, glass, plastic and paper. These materials should, first of all, be collected, separated, cleaned and be in sufficient industrial quantity in order to be used for production of new products. Recycling decreases the excavation and processing of natural materials, as is, for example, the iron ore whereby the negative effects upon the environment are decreased. Some local economic gains from some materials could be realized as well, enabling adequate market compensation for the labour involved. Most of the recycling processes are energy saving compared to the use of natural materials.

#### **4.4. Treatment of Waste at the Place of Its Creation (Waste Turned Into Energy)**

The incineration of solid communal waste will decrease its volume by a factor of ten and will decrease its weight for up to 75%. The incineration of waste in facilities produces energy that is turned into vapour. Such vapour can directly be used for heating or can be conducted into turbines for production of

electricity. The obtaining of energy from the burning of gas decreases its volume and consequently the amount and the cost of control over emissions.

#### **4.5. Incineration**

The solid communal waste can be incinerated without energy production. Incineration is not in wide use because other technologies have almost completely supplanted this process.

#### **4.6. Landfill**

A sanitary landfill for solid communal waste is the recommended option by all the experts in solid waste management worldwide. The sanitary landfill represents an engineering structure intended for permanent elimination of waste and designed to minimize its adverse effect upon the environment including surface waters, underground waters and air pollution. The design of such structures treats landfill filtrate and gas (methane), daily covering material for prevention of smell and prevention of development of pathogenic microorganisms as well as a finishing covering material to prevent penetration of water into the landfill body. In the integrated waste management systems, only the waste that is not previously recycled, processed or incinerated is disposed in a landfill.

### **5. CONCLUSION**

The main purpose of the Plan for Solid Waste Management is to improve the existing practices of solid waste management in Kratovo and make them comply with the standards prescribed by EU, i.e., the directives for waste 2006/12/EC.

1. Establishment of a sustainable programme for recycling in Kratovo, R. Macedonia.
  - Waste collection plan;
  - Establishment of a sustainable recycling system;
  - Possible installation of a facility for processing of recycled materials;
2. Campaigns for education of the population and raising of the public awareness about the environment.
3. Decrease of the number of unlicensed landfills by placement of dustbins for waste for recycling.
4. Development of a national strategy for management of all kinds of solid waste from all sources of waste creation.
5. Development of a detailed action plan that will ensure the fulfillment of the set goals.

6. Preparation of laws, by-laws and standards necessary for the effectuation of the new strategy by taking into account all the sources of waste and all kinds of waste.

Waste management in Kratovo is not at the same level as waste management in the capital of Macedonia - Skopje. With the realization of the IPUCO objectives, the municipality of Kratovo will fulfill the requirements pertaining to the European Regulations for Solid Communal Waste Management. This municipality will be an example of good waste management for the other municipalities in Republic of Macedonia.

## References

- Handbook of Risk Management, Editors: Carter, R.L., Crockford, G.N., and Doherty, N.A., Kluwer Handbooks, London, Kluwer Publishing, 1974-85.
- Lees, F.P., Loss Prevention in the Process Industries, Vol. 1 and Vol. 2, Butterworth&Co Ltd, 1980.
- Human Reliability Associates, Practical Techniques for Assessing and Reducing Human Error in Industry, Course Notes, Manchester, England, 1988.
- Human Reliability Associates, Practical Techniques for Assessing and Reducing Human Error in Industry, Course Notes, Manchester, England, 1988.
- Nomenclature for Hazard and Risk Assessment in the Process Industries, Prepared by a Working Party of the Engineering Practice Committee of the Institution of Chemical Engineers, England, 1985.

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