



Review paper

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COMPOSTING IN SERBIA – POSSIBILITIES AND LIMITATIONS

Mirčeta Vemić ^{*1}, *Gordana Komazec* ^{**}, *Zorica Žujović* ^{**}

* Geographical Institute “Jovan Cvijić” SASA, Belgrade, Serbia

** Faculty of Engineering Management, Belgrade, Serbia

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Abstract: The concept of sustainable development of the planet Earth, which includes environmental, economic, social and institutional harmony of normal life of the people in it, is applicable to both the global and the regional and local level. This concept was promoted by the United Nations (UN) at the end of the last century, and one of the solutions has been offered in this direction: *Vision 2050: The new agenda for business*, published by the *World Business Council for Sustainable Development* (WBCSD). In accordance with the above document, Serbia in 2008 adopted a National Strategy for Sustainable Development, in which it set out its vision and anticipated a number of measures for its realization. Within the projection of sustainable development, composting can take an important place as a process of natural decomposition of organic waste, by which, its quantity is reduced and harmful impact on the environment can be removed on the one hand, while on the other hand a cost-effective material used for soil conditioning or as fertilizer can be obtained. Surveys carried out in Serbia show that there are respectable agricultural and forest resources which generate substantial amounts of organic waste. In this paper, in the specific examples of regions of Belgrade, Novi Sad and Niš, the possible range of biodegradable waste suitable for composting is established, which is now in Serbia at the beginning of the application.

Key words: sustainable development, composting, Serbia, social responsibility, education

Introduction

The aim of the paper is to stress the importance of composting which is in Serbia at its beginning of the application but with the recognisable opportunities for its development. In many countries, with a more developed awareness of the need for environmental protection, composting is widespread. Thus, for example, in the U.S. there is the U.S. Composting Council with the mission of improving and promoting the use of compost to improve the soil and to provide economic and environmental benefits to society. Special attention is paid to the composting in households. For example, Cornell Waste Management Institute provides detailed information on composting of kitchen and garden waste (Schwarc & Bonhotal, 2011). In addition to the role of the state, socially

¹ m.vemic@gi.sanu.ac.rs

responsible companies play an important role. They promote a culture of environmental protection, health and safety (Karanović, 2012). For example, socially responsible company Tetrapak encourages composting of their products. Cardboard packaging used for beverage can serve as raw material for composting with other organic household waste – even 75 to 85% of the composition of the packaging is cellulose and wood fibres. An important aspect of composting is the health and safety of workers (Brown, 2012).

Composting is the natural process of decomposition of the biodegradable organic matter, especially waste, and its conversion into the final product, which is called compost. Compost is a material which is similar to humus, which has no foul odour and can be used for soil conditioning or as fertilizer, resulting in the circulation of matter in nature. Composting is related to the concept of sustainable development, which means a kind of projection of the development of life on Earth, with the rational use of natural resources, protection of the environment and assurance of the normal life of people, at all geographic levels: global, regional and local.

In the last decades of the last century, the issue of sustainable development began to attach greater importance, starting with the United Nations (UN), especially the “Vision² 2050”, through national programs of certain countries to local communities. The Republic of Serbia has adopted a strategy of sustainable development and a number of significant regulations related to it, including regulations on waste that is noticeable in the whole territory of Serbia and has a negative impact on the environment. A significant percentage of that waste is organic waste that can be viewed as a material for composting.

Since the origin of organic waste, in addition to feeding of population, is mostly related to agriculture and forestry, where Serbia has significant resources and where significant quantities of organic waste are produced, there is a need, in both the environmental and the economic and social terms, to find possibilities

² This paper presents a platform for dialogue and a call for collective action. The five most important changes are identified in the Vision, which are required to achieve a sustainable future:

- Acceptance of limits and possibilities according to which a good life is allowed for 9 billion people within the existing limits of the Earth;
- Redefining the concept of success and progress at the national, corporate and individual level;
- The gradual abandonment of the existing capacity of the planet through an increase of bio-productivity;
- Develop opportunities with low environmental impact in countries with a high standard and a high degree of capacity utilization of the Earth, and
- Improve the quality of life in underdeveloped countries without increasing the environmental impact over the allowed limit.

to increase the volume of composting. In addition to addressing the broader assumptions of conditions and ways of composting and use of natural resources in agriculture and forestry, in this paper, the features of the three largest cities in Serbia are emphasized as an example: Belgrade, Novi Sad and Niš, as the three most important sites, regional centres, in terms of collecting and treating organic waste suitable for composting.

The Importance of Composting

The Government of the Republic of Serbia adopted the “National Strategy for Sustainable Development” (RS Government, 2008) for the period 2008–2017, in which it presented its own 1) vision³ of sustainable development of the country, 2) national priorities, 3) the principles of strategy, 4) an analysis of the strengths and weaknesses of the environment and natural resources, sustainable economy based on knowledge and social conditions and prospects of development, 5) institutional framework, 6) financing of the strategy, 7) indicators of monitoring the situation and 8) action plan (National Strategy, 2008). Composting is one of the possibilities of the realisation of the concept of sustainable development.

Composting increases cyclicality, that is, circular flow of production, which is one of the goals of sustainable production. Sustainable production tends to shift from the linear systems (raw material is used for the products, by-products and waste) to the circular systems (waste is re-used as energy or raw material for another product or process). Given that composting depends on the eating habits of the population, the standard and style of living in a specific geographic region, the authors believe that the knowledge of the specifics of geographical indications is a condition without which it cannot be entered into the process of composting. The authors also believe that this is yet another confirmation that the contemporary problems can be solved only by trans-disciplinary approach. If these assumptions are correct, then in Serbia an interdisciplinary team could be formed to develop composting, by which a new, small step towards a sustainable future for Serbia would be made.

Composting helps reduce waste. Serbia, as well as other countries of Europe and the world, is trying to systematically solve the problem of waste (Komazec,

³ “The Republic of Serbia is in 2017 institutionally and economically developed country with adequate infrastructure, compliant with the EU standards, the knowledge-based economy, efficiently used natural and man-made resources, greater efficiency and productivity, rich in educated people, with a preserved environment, historical and cultural heritage, a country in which there is a partnership of public, private and civil sectors and providing equal opportunities for all citizens” (National Strategy, 2008).

Kicošev & Puzić, 2011). According to the Regulation on waste disposal in landfills of the Republic of Serbia, in the period from 2012 to 2016, in order to establish a system of control of disposal of biodegradable waste to landfill, the rate of decrease of disposal for 25% of the total amount is determined, by weight of biodegradable waste, while up to 2026 the rate of reduction of 65% of the total amount of deposited biodegradable waste is determined (Waste Regulation, 2010). This also indicates the actuality of the subject of this paper.

Circular, closed flows are one of the requirements of sustainable production. Support for the development of such systems is in the industrial ecology that attempts to provide a new conceptual framework for understanding the impacts of industrial systems on the environment. Industrial ecology (Garner & Keoleian, 1995) is the study of the physical, chemical and biological interactions and interrelations within and between industrial systems and environments. In addition, some scientists believe that industrial ecology defines and implements strategies of industrial systems for better, harmonious and sustainable imitation of natural ecosystems. Simplified, industrial ecology can be seen as the science of sustainability. This is a young but rapidly growing multidisciplinary field of research that combines aspects of engineering, economics, sociology, toxicology and natural sciences. It is a kind of powerful prism through which the impact of industry and technology is examined, as well as associated changes in society and the economy to environmental biophysics, that is, it provides an understanding of the functioning of industrial systems, their regulation, interaction with the biosphere, and then based on the knowledge of the ecosystems it finds options for restructuring that is compatible with the functioning of natural ecosystems.

Composting is a good way to solve the problem of organic biodegradable waste. It is usually defined as rapid dissolution of wet, solid biodegradable organic substance: food waste, garden waste, paper, cardboard, using aerobic microorganisms under controlled conditions. Compost production is the process of biological treatment of waste which is in Serbia determined by the *Waste Management Law*, Article 40. It is defined as the utilization of valuable components of waste in material and energy purposes, and its treatment before final disposal (Waste Act 2009, 2010). The overall objectives of composting are:

- Transformation of the biodegradable organic material into biologically stable material and that the volume and weight of the waste reduce during the process;
- Decomposition of the pathogenic microorganisms, eggs of insects and other undesirable organisms which may be present in solid communal waste;

- Retention of the basic nutrients such as sodium (N), phosphorus (P) and potassium (K) in quantities as larger as possible;
- Obtaining the product which can be used for growing plants.

Controlled composting which is applied to the treatment of biodegradable organic fraction of communal solid waste is different from that which occurs in nature only by conditions, and the process of composting comprises the following reactions: [the proteins, amino acids, lipids, carbohydrates, cellulose, lignin, ash] + O₂ + nutrients + microorganisms = compost + new cells + CO₂ + H₂O + NO₃ + SO₄ + heat.

The newly formed cells become part of the active biomass involved in the conversion of organic substance, while the dead ones become part of the compost. The speed of the composting process is dependent on several factors, and by the end of the process the volume reduces for 20–60%, and weight up to 50%. Moisture content is reduced by 40%, the pH is about 7, the ratio of carbon and nitrogen (C/N) should be less than 20:1. Unpleasant odours that occur at the beginning of the process disappear. The process is the most influenced by the characteristics of the starting material, the conditions under which the composting takes place and the degree of decomposition.

Finally, the compost can be used for 1) the bioremediation and prevention of pollution, restoration of contaminated soil, control of odour or degradation of volatile organic compounds, 2) erosion control and nutrients outflow, as well as the compaction of soil, 3) growth promotion, the control of plant diseases and the control of plant pests, thereby increasing the yield in agriculture, 4) reforestation, wetlands restoration, rehabilitation of habitats, etc. Moreover, the compost “can be used in agriculture, but only under the condition that all sanitary rules are perceived and the control of compost is made in terms of the existence of pathogenic microorganisms and harmful chemicals in it” (Lješević, 2009).

Morphology of Waste for Composting

There are six basic types of source materials or raw materials for composting (Williams, 2005):

- The remains of food processing: material for composting formed after processing of fruits, vegetables, grains and meat.
- Manure and agricultural by-products formed in the farrowing pens, feedlots, incubators, farms, glass-houses, plastic covered greenhouses, etc.

- Residues from forestry and wood industry including bark, sawdust and fibrous residues from the manufacture of paper.
- Waste mud or organic waste created by biological waste mud treatment in the wastewater treatment plants.
- Leaves, shrubs, twigs and other plant remains, as well as waste from the yards, house gardens and gardens.
- Organic waste containing sorted composting fractions of communal waste.

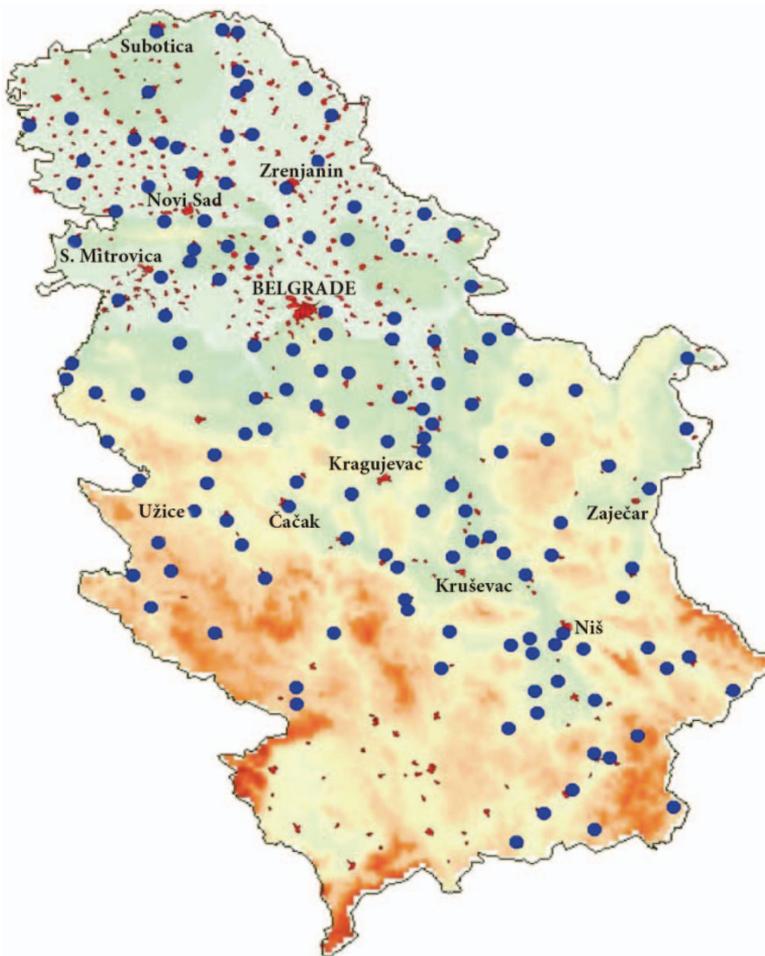


Figure 1. Disposition of landfills in Serbia (Waste Statistics, 2012)

Which of the source materials will be used and in what proportions depend on the geographic region, economic structure, standards, lifestyle and dietary habits of the population. The most important natural resources of the Republic of Serbia belong to agricultural land and then forests and forest land on which organic matter is mainly produced, and a great organic biodegradable waste remains behind it. According to the data given in the Survey of the Republic of Serbia (2010), agricultural land covers about 68% and wooded 29.1% of the territory. Within agricultural land, “arable land accounts for about 64% of agricultural land or about 3,300 thousand hectares, orchards – 5% or 240 thousand hectares, vineyards – about 1% or about 58 thousand hectares. The remaining 30% of the area consists of meadows (12%) and grasslands (18%).” (Kovačević, 2010)

In this regard, as many analyses show, one of the biggest environmental problems in Serbia is waste and improper conduct with it. In current practice, the waste is usually disposed in disorderly landfills and there are a huge number of illegal landfills that have occurred due to negligent treatment of the population whose households are not covered by organized waste collection. On the territory of the Republic of Serbia there are 164 local landfills, which are the only way to manage waste. However, they often do not meet even basic sanitary and technical conditions for waste disposal. Most of them are not properly located⁴ and many are practically completed. The largest landfills are located in Belgrade, Niš and Novi Sad.

In the Republic of Serbia, only in the last few years it has been started with the gathering of data on generating, manner of disposal and quantities of all kinds of waste: 1) communal-household, 2) commercial and 3) industrial, which is divided according to the impact it has on people’s health and environment into 1) hazardous and 2) non hazardous waste (Waste Statistics, 2012).

Options of Composting in Serbia

The first results were obtained by measuring the waste in characteristic municipalities and waste assessment in other municipalities in relation to the

⁴ In Loznica for example, “in addition to being located in the alluvial plain of the Drina, the landfill is set normal to the direction of dominant wind blowing, which significantly affects the dispersal of smoke and odours from the landfill” (Božović, 2010). In Serbia, only in recent years data have begun to be collected on generating, method of disposal and quantities of waste of: 1) communal – home, 2) commercial and 3) industrial waste, which, according to the impact on human health and the environment, is divided into: 1) hazardous and 2) non-hazardous waste (Waste Statistics, 2012).

population. In this way, “by adding the data it has been obtained that in the Republic of Serbia 2,226,427 tons are generated during the summer period, 1,857,589 tons during the winter and 2,086,212 tons of waste during the spring period” (Waste Statistics, 2012). There is also a projection of the morphological composition of the waste in the whole of the Republic of Serbia (Figure 3) for the period 2008–2010 (Waste Statistics, 2012).

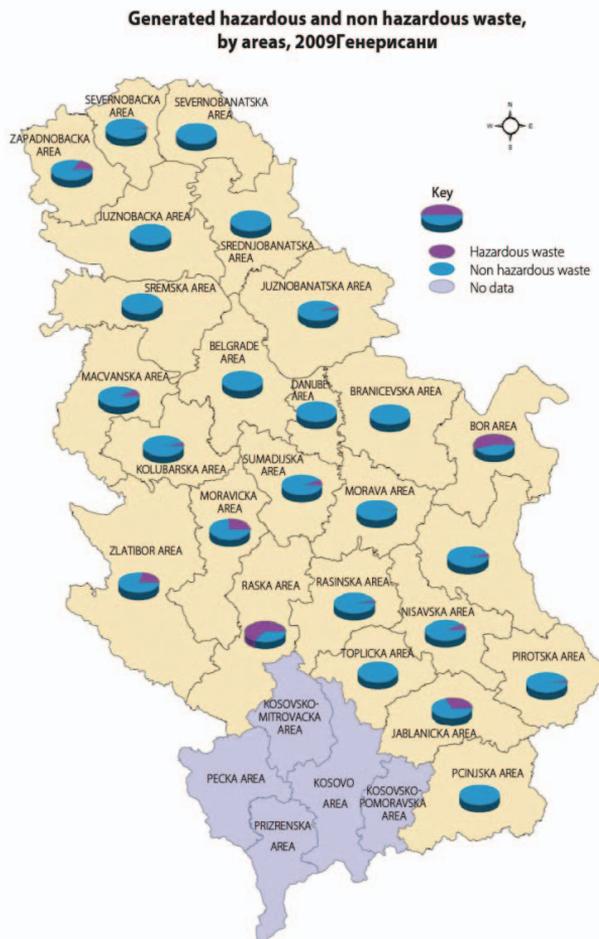


Figure 2. Waste generated in Serbia, by areas, 2009 (Waste Statistics, 2012)

The Faculty of Technical Sciences in Novi Sad, Department of Environmental Engineering, did a project entitled: “Determining the Composition of the waste and the Amount Assessments in order to Define the Strategy of Managing Secondary Raw Materials as Part of the Sustainable Development of the

Republic of Serbia” in 2009. Results of the project indicate that the organic waste (garden waste, “other biodegradable waste” and paper) makes about 50% of the morphological composition of the waste in the Republic of Serbia. In the total weight of the waste, the so-called “other biodegradable waste” is represented by 31.0% (37.62% – this figure does not correspond to the official data, as well as the arithmetic mean of the data below, which amounts to 31.14%), and there are about three times more of it than garden waste. The “other biodegradable waste” includes the remains of food (all kinds of bread, meat, vegetables), dead chickens and animal organs.

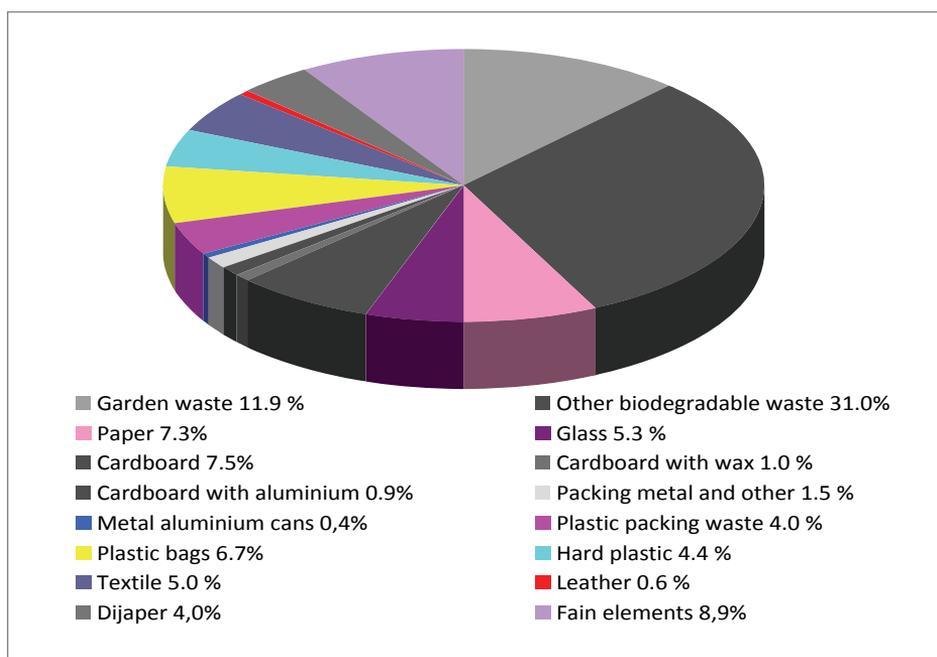


Figure 3. Morphological composition of communal waste in the Republic of Serbia (Waste Statistics, 2012)

The Table 1 shows the basic data about the selected cities, regional centres. Belgrade occupies 71.36% of the total area of the three cities and has 73.38% of the total population, indicating a slightly higher density compared to Novi Sad and Niš. All three cities have significant agricultural area, which indicates a large amount of organic waste.

In every city there is a public company which is engaged in the collection, separation and disposal of waste, but in none of the cities the separation of organic waste is performed. Recyclable materials are collected such as paper,

plastic and metal. Based on the research conducted in Novi Sad in 2004 and 2005 (Komazec, Kicošev & Puzić, 2011), it can be concluded that under 10% of the total waste is singled out as a raw material and in average every citizen creates about 0.5 tons of waste per year, which is in line with the European average. The collection of garden waste has been carried out in Novi Sad since May 2004.

Table 1. The basic geographic parameters of the selected cities, regional centres

Parameters	Belgrade	Novi Sad	Niš
Area	3,227 km ²	699 km ²	596 km ²
Agricultural land	69.1%	73.2%	61.7%
Population	1,659,440	341,625	260,237

Source of data: The Republic Statistical Office: Census of population, households and apartments in the Republic of Serbia in 2011.

According to the results of the Faculty of Technical Sciences in Novi Sad, the morphological composition of waste in three selected cities is shown in the Table 2. If we accept the results of research of Komazec, Kicošev and Puzić (2011) that averagely 339 tonnes of waste were collected per day in 2004, and 528 tons per day in 2005, then on an annual basis can be collected 124, that is, 193 thousand tons of waste. In the total weight of waste, the material which can be composted in Novi Sad comprises from 30.73% to 49.9%, which means that in the same structure of the waste in 2004 there would be about 38 to 62 thousand tons of waste that could be composted. In 2005 it would be 59 to 96 tons. These derived data are intended to indicate the extent of waste, not to provide precise information about the waste that can be composted. In Serbia, there is no institute that professionally deals with the problem of waste, especially of composting, there are no official statistics, and these data are the result of scientific research of the faculty and researchers who are working on a case-by-case basis. There is no continuing research in this area.

If the results of composting are applied on the obtained data by which the volume of waste is reduced by 20–60%, and a weight of up to 50%, then it can be concluded that in 2004 composting could reduce waste by at least 19 thousand tons, that is, up to 31 thousand tons and by 29.5 thousand tons in 2005, that is, up to 48 thousand tons. The data itself show enough what would be the advantage of the city of Novi Sad if it managed to organize and effectively perform the composting process. Not only that fewer landfills would be needed, but significant savings would be made in fuel consumption for trucks that collect and distribute waste, exhaust gases would be much less, in order to improve air quality, etc. and the saved money could be directed to the purchase of equipment for composting.

Table 2. Morphological composition of the waste in selected cities, regional centres

Belgrade			
Category of waste	Mass share in %		
	Summer analysis	Winter analysis	Spring analysis
Garden waste	5.75	7.5	6.79
Other biodegradable waste	41.16	27.47	24.15
Total	46.91	34.97	30.94
Novi Sad			
Category of waste	Mass share in %		
	Summer analysis	Winter analysis	Spring analysis
Garden waste	9.17	4.62	7.17
Other biodegradable waste	40.73	26.11	28.95
Total	49.9	30.73	36.12
Niš			
Category of waste	Mass share in %		
	Summer analysis	Winter analysis	Spring analysis
Garden waste	9.07	5.19	15.75
Other biodegradable waste	35.46	31.32	24.90
Total	44.53	36.51	40.65

Source of data: University of Novi Sad, Faculty of Technical Sciences, Department of Environmental Engineering: Project – Determining the Composition of the Waste and the Amount Assessments in order to Define the Strategy of Managing Secondary Raw Materials as Part of the Sustainable Development of the Republic of Serbia, Novi Sad, 2009.

However, the separation of waste is necessary to be carried out at the source of waste. In order to separate the waste at the source, a different attitude of residents toward the protection of the environment is required. Novi Sad tried to make the separation of communal waste. The various containers were obtained in which residents should dispose sorted waste, but after a while they gave up because there were no positive results. Overall, the authors believe that new technologies should bring a new way of thinking, which cannot be reached without the joint action of all actors of society, especially without a different education and culture (Komazec, Vuksan-Delic, 2013).

Conclusion

Composting, as a form of natural decomposition and recycling of organic biodegradable waste that is at the beginning of application in Serbia has all the environmental, economic and social implications as significant activity in the concept of sustainable development of the planet Earth. Considering the large number of local and lots of illegal dumps, as well as a mass of various garbage, scattered throughout the territory of Serbia, its collection, recycling, processing and disposal is increasingly becoming a priority environmental requirement. As waste is a huge loss of resources in the form of materials and energy and has

serious consequences on the environment, its reuse or processing, which include composting, in retroactive terms represents an economic very profitable activity.

Serbia has substantial agricultural resources (68%) and forest land (29.1%), where in addition to economic products large amounts of waste are generated. It is estimated that in Serbia annually 6,170,228 tons of waste are generated, of which close to 50% can be subjected to the process of composting. That would, in addition to reducing the area under waste and air and water pollution, brought significant benefits in the form of materials for soil conditioning or fertilizer. More detailed research of the quantities and morphological composition of generated waste are carried out in several cities in Serbia, and in this paper data were presented for the largest cities, as the largest environmental regional centres, Belgrade, Novi Sad and Niš, which have the greatest amounts of waste. These examples show the full ecological expediency, economic viability and social feasibility of composting for sustainable development of Serbia, which runs the circulation of matter in nature and reaches the goals of the normal life of the people with preserved nature.

To apply composting in Serbia, in accordance with capabilities, it is essential that the government takes further actions. One of the possibilities is to support the establishment of the institutes or similar organizations that would have the primary task of spreading the culture of environmental protection, promotion of composting and education of the population. Joint efforts of government agencies, local communities, enterprises, academic institutions and the population could in the next period start the process of composting in households and enterprises. This period is certainly not several years, but decades. Education can play a significant role, from primary to high, in the shortening of the time period. It must develop the ability of process thinking of participants in order to understand the circular flow of the nature. It is also necessary that the schools and the university are turned more toward educational component and develop a sense of social responsibility of the participants. Socially responsible enterprises can also affect the development of composting. On the one hand they can apply eco-design of their products, and on the other hand they can invest in the education of residents about composting.

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