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A Feasibility Study of Plant for Composting Organic Waste in the City of Kragujevac

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Abstract: *Growing of waste quantity, its harmful influence on natural environments and world experiences has had so far impose the necessity for the analyses of techno-economic possibilities of the processes for treating the organic fraction of municipal solid waste stream, in our region. In this paper, problematic of treatment solid waste and composting process, which represents one of the most acceptable options for the processing of solid waste, are given. Composting involves the aerobic biological decomposition of organic materials to produce a stable humus-like product. Base of composting process, review of composting feedstock, use of compost, benefits of composting process and concrete proposal for composting process realization, with techno-economic analysis for the construction of composting plant on territory community Kragujevac, are given in this paper, too.*

Keywords: *Organic waste, Composting process, Compos*

1. INTRODUCTION

Due to an increasing demographic growth, industrialization, urbanization and economic wealth, are up and growing amounts of waste in developed countries and developing countries. Chemical composition of waste is complex, and more and more threatening human health and the environment.

There are four basic ways of waste management [1]:

- waste minimization and at source reduction,
- recycling and composting,
- incineration (with extract energy from waste),
- waste to landfill.

Municipal solid waste (MSW) is waste from households, residential buildings, offices, markets etc. and also waste from public areas (there is partly stable materials "green waste", plant garbage, cardboard etc.., and unstable material as waste of food). The most important characteristic is fast putrefaction especially over summer during high temperatures and high humidity. Odor emission is side effect of waste putrefaction. Other household waste contains combustible (paper, plastic, textile, rubber, leather, parts of furniture) and incombustible components.

Bigger part 40 ÷ 70%, is organic material. Some other potentially useful materials as garden waste, food residue, not recycled paper are usually being sent to landfill. Many of them could be efficiently recycled. Instead of dissolution in landfill, it can be used through composting process. Nevertheless, organic waste is also potential energy if we incinerate, or if obtain gas from gas installation on landfill.

2. REVIEW OF AVAILABLE OPTIONS FOR ORGANIC WASTE MANAGEMENT

Waste reduction at source – this aspect is focused on reduction of waste quantity as much as possible, especially industrial, because of its percentage, but also in our homes every person need to give own contribution .

Recycling - perhaps the best known and the best accepted of all the modalities of waste management. In this way, recyclable products can be used again in the same form.

Composting - or creating compost is controlled breakdown of organic matter in the warm, wet environment of the activities of bacteria, fungi and other microorganisms. This is a controlled biological process in which succession of microbial populations convert organic material into a biologically stable product. Composting can be used to produce compost, or composting can be implemented specifically as a waste treatment process. The real benefit of composting process, results when you do both.

Waste incineration - this technology converts heat energy into steam and/or electricity, providing heat and electricity for residential and industrial use. Just as coal, oil or natural gas is burned in boilers to generate electricity, pre-sorted MSW can be used as a fuel to generate power. This is a very attractive method for combustion reducing the volume to 90%, a weight of up to 70%. The rest originated in the combustion can be used as construction material (for the construction of roads or to improve the landfill).

Landfill gas collection – landfill gas is produced by the decomposition of organic wastes in a landfill site. Such gases normally contain around 55% methane and 40% carbon dioxide. They are collected through networks of pipes and wells. Since methane is a greenhouse gas, its recovery and use has the additional benefit of reducing global warming. Facility could be installed on sites where gas generation rates are high enough and the gas is used as a fuel to power the generation of electricity.

Waste disposal – disposing of waste in a landfill is the kind of waste management for which all have the need, because there is no way with present technology to reuse all waste. Waste disposing is a very complex and responsible process.

3. OPTIONS OF MUNICIPAL WASTE COMPOSTING

The creation of compost has become a more popular option of waste management as a way to draw the course of municipal solid waste and reduce pressure on landfill. Because of the importance of composting in order to achieve the objectives of waste management in the world, the number of facilities for the creation of compost significantly increased in the last 10 years [2]. As necessarily, regional composting plant need to be built. Reusing this materials will remarkable reduce final quantity of deposited waste. This is the main benefit, but compost is very useful product in agricultural business, that's why material retrieve validity.

Composting is mostly available for treatment of: garden waste, organic fraction of waste, partly treated and mixed waste and organic fraction of waste with residue from leachate. Potentially useful materials for composting are: garden waste (leaves, grass clippings, brush, and tree pruning), food scraps, scrap paper, and other decomposable organics, agricultural waste, waste from food factories [1].

Composting involves the aerobic decomposition of organic materials to produce a stable humus-like product. Biodegradation is a natural, biological process that is a common occurrence in both human-made and natural environments.

The technology used for composting involves the following three phases: (1) preparation of the feedstock (also known as "pre-processing"), (2) the compost process itself, and (3) the grading and upgrading of the final product (or "post-processing") [2]. The steps involved in the preparation of the feedstock generally include some type of size reduction and segregation of unwanted materials (i.e., contamination). Composting on the commercial scale occurs in three major phases. Initial processing includes size reduction to enhance microbial reactions. First, separation of inert materials (glass, plastic, metals, etc.) from the organic fraction is necessary. Size reduction and chemical or biological conditioning are extremely important at the outset if the finished product is to be used in agriculture. Next, microorganisms decompose the raw feedstock into simpler compounds, producing heat, as a result of their metabolic activities. The volume of the compost pile is reduced during this stage and the heat generated destroys many pathogens. In the final stage, the compost product is "cured." Microorganisms deplete the supply of available nutrients in the pile, which, in turn, slows down their activity. As a result, heat generation diminishes and the compost mass dries. When

curing is complete, the compost is considered "stabilized" or "mature."

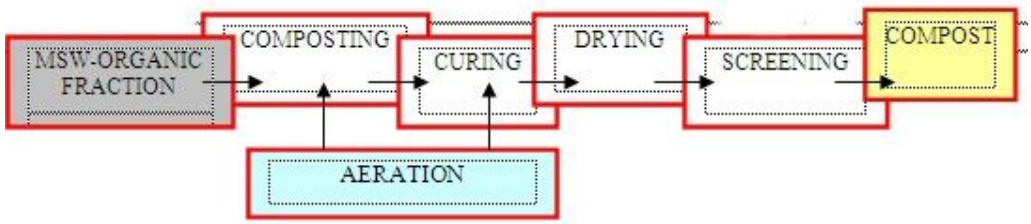

Figure 1. Flow chart showing the steps involved in the aerobic composting process

Any further microbial decomposition occurs only very slowly. Figure 1 provides the overall steps involved in the aerobic composting of the organic fraction of MSW.

Composting requires attention about factors that affect the process, to carbon and nitrogen ratios, moisture content, oxygen availability, maintenance of favorable temperatures. Altogether compost creating time is determined by composition of waste but primarily by type of applied process.

The actual compost process can be established in a number of environments, from simple outdoor piles to sophisticated reaction vessels with controlled temperature, airflow, and humidity [2].

Some popular composting methods are:

Open systems,

- Turned piles
- Turned windrows
- Static piles using air blowing or suction

Closed systems,

- Rotating drums
- Tanks
- Bunkers

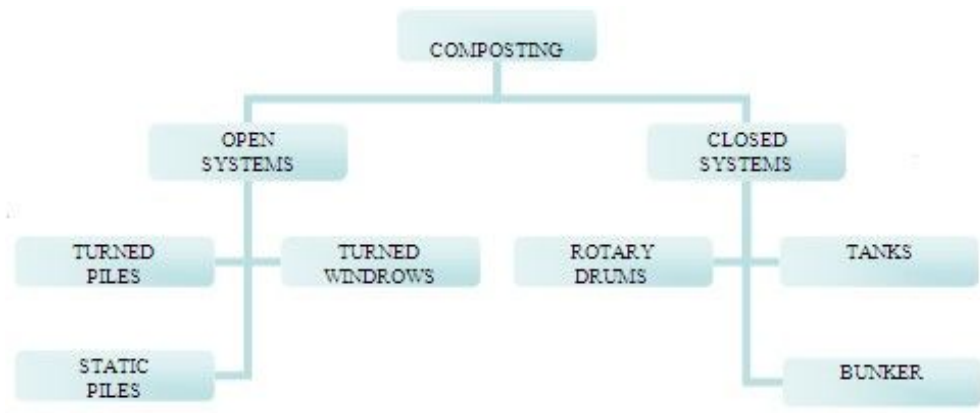

Figure 2. Composting methods

Turned piles are a widely used method for composting MSW due to their simplicity of operation. As the name implies, the feedstock is mixed periodically using a front-end loader or similar equipment. Turning of the feedstock maintains oxygen, moisture, and temperature at adequate levels for microbes.

Turned windrows are elongated compost piles that are turned frequently to maintain aerobic conditions. Forming windrows of the appropriate size helps in maintaining the desired temperature and oxygen levels.

Windrows operate most effectively at a height of 1.5 to 1.8 m. This height allows the feedstock to be insulated but prevents the buildup of excessive heat. Windrow heights vary, however, based on the feedstock.

Aerated static pile - In terms of operation, aerated static piles are relatively more complicated than turned piles. This approach is effective when space is limited and the composting process must be completed relatively rapidly. In this method, a series of perforated pipes is situated within or below a pile (or windrow). Air can be supplied via a negative pressure (suction) system or a positive pressure (blower) system. Fans or blowers force air through the pipes, which is then drawn through the feedstock materials (Figure 3.).

Rotating drums rely on a tumbling action to mix continuously feedstock materials. Figure 4. illustrates a rotating drum composter. The drums typically are long cylinders, approximately 3 m in diameter which are rotated slowly, usually at less than 10 r/min. Oxygen is forced into the drums through nozzles from air pumps.

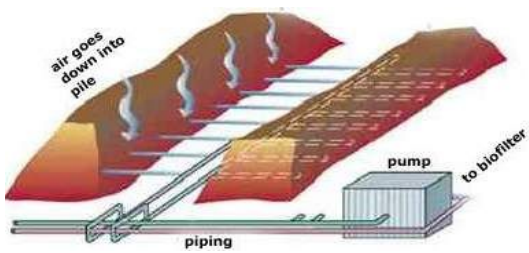

Figure 3. The aerated static pile

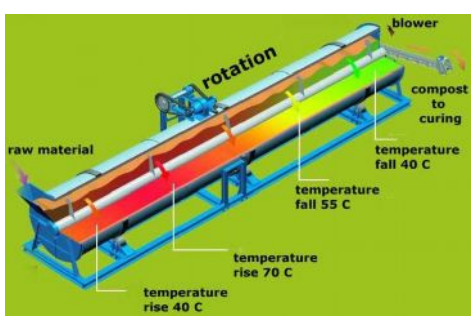

Figure 4. Rotary drum

Tank systems are available as horizontal or vertical types. These tanks are long vessels in which aeration is accomplished through the use of external pumps that force air through the perforated bottom of the tanks. Mixing is accomplished by mechanically passing a moving belt, paddle wheel, or flail covered drum through the feedstock. The agitation breaks up clumps and maintains porosity.

Bunker is a high concrete channel with a concrete surface which are embedded in the perforated pipes for ventilation air inlet to the mass. Air insufflations is achieved using the fan.

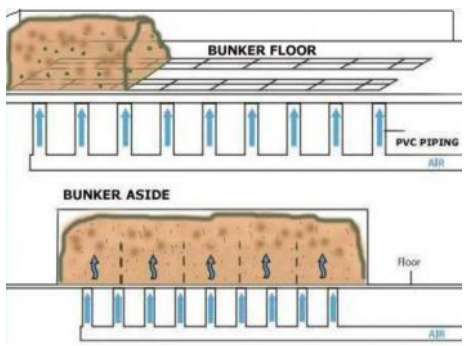

Figure 5. Bunker

Basic problems during composting process are: odor emission, toxins within the pile, pathogen control, leachate, generating noise, vectors (small animals and insects).

Most stages of the composting process can release odors. The feedstock itself will contain odorous compounds; odors can be produced during collection, transport, and storage of the feedstock. Improper composting procedures, for example, not providing adequate O_2 and allowing anaerobiosis will encourage the formation of malodorous compounds. Ammonia is released under anaerobic conditions and infrequently in some aerobic conditions

Concentrations of all herbicides, pesticides, and other biocides found in feedstock and compost samples were above the maximum allowable tolerance. It is extremely important to take care about this.

Municipal solid waste, sewage sludge, and other organic sludge may contain different kinds of pathogens that are infectious to several species of animals and plants, as well as to humans. Final product compost has not have

pathogens.

Leachate is produced in uncovered piles exposed to excessive quantities of precipitation. The leachate released from the pile can have elevated biochemical oxygen demand (BOD) and phenols, resulting from the natural decomposition of organic material. Leachate can also contain potentially toxic synthetic compounds.

Noise is generated by trucks entering and leaving the facility and by equipment used in composting operations. Hammer mills and other shredding machines are the noisiest of this equipment, generating about 90 dB at the source.

Vectors are small animals or insects that carry disease. Rodents can be attracted by the food and shelter available at composting facilities (particularly MSW composting operations) and can be difficult to eliminate. Flies can transmit food-borne diseases.

4. TECHNO-ECONOMIC ANALYSIS OF COMPOSTING PLANT IN CITY OF KRAGUJEVAC

Including the option of preserving and restoration of resources in the system of solid waste is a strategic task of local government. This is a complex economic and technical system with the social and political consequences, which require a complete techno-economic analysis before making any decision.

4.1 AVAILABLE AMOUNT OF WASTE FOR COMPOSTING

Of the total disposed solid waste in Kragujevac, 92% is municipal waste (daily disposal is app. 156 t of waste). Since it is more of the organic waste suitable for composting, an average of 67.1% (slightly higher percentage in the province and villages), so that the total deposited about 38,000 t of organic waste on an annual basis [3].

4.2 SELECTED COMPOSTING TECHNOLOGY

Market research and considering the available amount of organic waste, composting of existing technology, existing solutions for the composting plant in the world as well as their characteristics, selected facility that would meet the needs of the city. Selected solution for composting plant uses composting technology to the close space in the bunker, with forced ventilation material through the bottom of bunkers, and constant monitoring of the process with the appropriate equipment. This technology is suitable regarding management of the composting using the appropriate equipment. Continuous monitoring process, minimize the problems that occur in composting and get a quality compost.

Figure 6. Facility for composting

Microorganisms split material, temperature increases due to mass heat germ free operations, while the volume of mass decreases. Continuously tracked: humidity, temperature, pH value, oxygen content, the flow of air. After two weeks, decommissioning continues in the building, closed in the bunkers where the material is pressurized closed (in order to achieve the process temperature of 65 º C) and held at this temperature for 3 days, in order to destroy pathogens and seeds of plants. Due to high temperature there is a great mass of evaporation in this part of the process, and the steam is conducted through the bio-filter in the external atmosphere.

4.3 FINANCIAL ANALYSIS OF INVESTMENT IN THE COMPOSTING PLANT

Investment costs for the construction of the plant amounted to € 1.204.0000 [4], and include the cost of site, land, procurement of materials for the construction of necessary facilities, procurement of equipment and

machinery as well as the cost of management, planning,

Component	Weight proportion	Total per year (t)
Bio waste	**67,1 %**	**38.357,45**
Paper	5,4 %	3.086,89
Cardboard	5,9 %	3.372,71
Glass	3,7 %	2.115,09
Fe – metals	1,1 %	628,81
Ne – metals	1,1 %	628,81
Wood	1,5 %	857,47
Plast/comp.	2,7 %	1.543,44
PET	3,2 %	1.829,27
Foil	3,1 %	1.772,10
Textile	2,8 %	1.600,61
Inert materials	2 %	1.143,29
Hazardous waste	0,3 %	171,49
Total	**100%**	**57.107,43**

Table 1. The morphological composition of waste in the city landfill [3]

design, construction, transport, monitoring, documentation.

Sale of produced compost (16,000 t in the year), at a cost of 110 € / t, achieves an annual income of € 1,760,000.

Annual expenses include the cost of repayment of loans and the expected operational costs of the functioning of the plant.

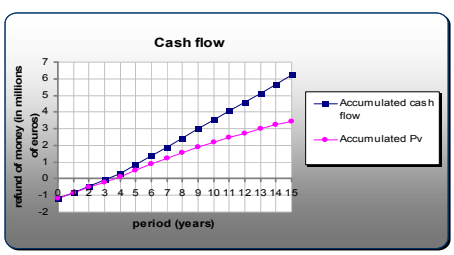

Figure 7. Cash flow diagram

The profit is income from the sale of compost and compost fertilizer sales less the cost of any repayment of loans and the expected operational costs of the functioning of the plant (the cost of primary and auxiliary materials, of labor, equipment, maintenance and insurance).

Assuming that the funds provided from its own sources (500,000 €) and a part of credit from a bank (704,000 €), in the form of loans to 4 years and the interest rate of 6%, a complete return on investment is possible for 4 years, provided that annually produced and sold 16,000 t of compost. Cash flow diagram in Figure 7.

5. CONCLUSION

Generation of waste monitors economic and technological development. As the main problem, there is limited space for accommodation of waste. Hence it is necessary that the new resources from the waste, whether through material recycling, composting or energy through a fuel obtained from waste.

Some EU members are still 80% of its waste stored at the landfill [5]. The 1999 EU Directive obliges member states to reduce the storage of organic waste in landfills, progressively in the next 15 years to 35%. Among other things are required, and actively increase and renewal of optimizing resources from waste, such as material and energy.

Decomposition of organic waste in the landfill gas, which usually consists of 55% methane and 40% carbon dioxide is good option.. Methane is a gas that affects the creation of greenhouse effect. Recycling of the material could be to solve the problem. The burning material is expensive and still not accepted by community, so that we remain composting as acceptable options. How to price of waste disposal increases, composting becomes financially tempting alternative as a source of earnings.

Application of technology is the origin of biological and ecological and human needs on the local level in order to release the dirt, garbage and waste, whether at the global level for reduction of carbon dioxide in the atmosphere, thus reducing global warming.

REFERENCES:

[1] Jovičić N., Solid waste management, in serbian, Textbook, in Serbian, Faculty of Mechanical Engineering, Kragujevcu, Serbia, 2006
[2] Pichtel J., Waste Management Practices: Municipal, Hazardous and Industrial, CRC Press, 2005
[3] Veljković V., Jovičić N., Babić M., Morphological analysis of municipal solid waste in City of Kragujevac, in serbian, Project report: Environmental information system of Kragujevac, Faculty of Mechanical Engineering, Kragujevcu, Serbia, 2007
[4] Petrovic D., Analysis of Municipal Composting Plant, Diploma Thesis, in serbian, University of Kragujevac, Faculty of Mechanical Engineering, Serbia, 2008
[5] www.assurre.org