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TM4. Waste management in Rural Communities

4.2. Biomass waste. Household waste

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Cuprins

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1. Introduction

Currently, we live in a world where technological progress is constantly developing, which greatly improves the quality of our life. In this continuous progress of the science, the main problems at the global level are the environmental pollution and the environment degradation, problems that are directly connected to the technological progress.

Environmental protection should represent a priority of the current generation, to ensure good living conditions for both, us and the future generations. There are plenty measures that can be applied to prevent, reduce and eliminate the environmental pollution. The first measure that can be applied is the selective collection of the household waste in own homes or at industrial level, in order to recycle and reuse this waste as secondary raw materials to obtain new products. Thus, by valorising the waste, we do not only protect of the planet, but also, we can obtain new, reusable products, or resources, such as energy and heat, if the waste are properly processed.

BIOMASS represents the biodegradable fraction of the products, waste and residues of biological origin from agriculture, forestry and related industries, including fishing and aquaculture, as well as the biodegradable fraction of industrial and municipal waste (Law 220/2008, republish in 2021)

The types of biomass are shown in Figure 1.

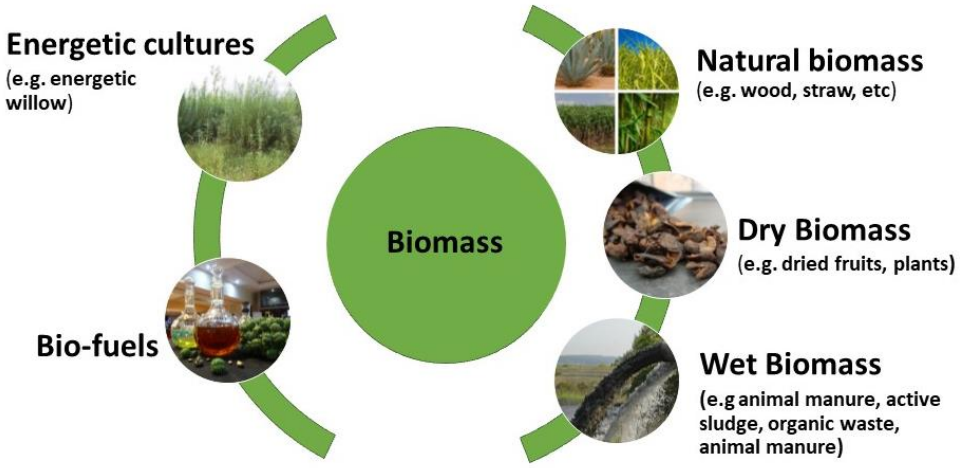

Figure 1. Types of biomass

Figure 2 shows the possibilities of the biomass valorisation into products, respectively the conversion of the biomass waste into heat and electricity.

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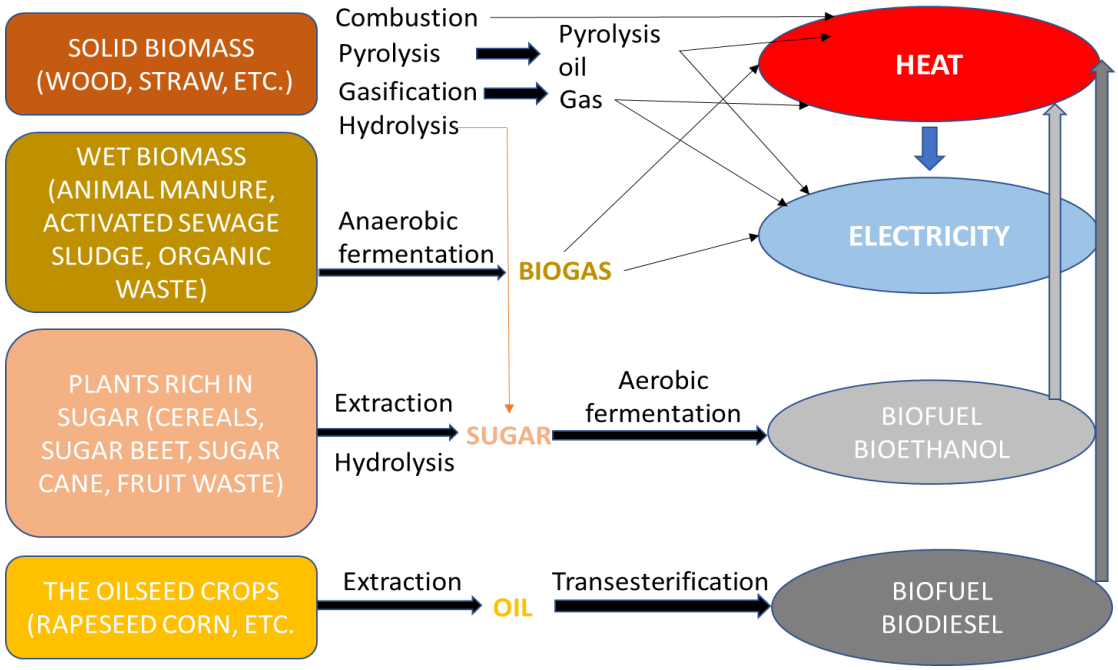

Figure 2. The possibilities for valorisation of the biomass and biomass waste in sustainable communities

The possibilities of the biomass valorisation by conversion into energy are presented in Figure 3.

1. Combustion	• To generate heat
2. Pyrolysis	• To generate Singas (CO and H_2) → heat
3. Anaerobic and aerobic fermentation	• To generate biogas (CH_4) → electricity • To generate bio-ethanol (C_2H_5OH) from vegetables residues rich in sugar (sugar beat, sugar cane, cereals)→ electricity • **To obtain bio-fertilizers by composting**
4.Transesterification of the vegetal oil	• To obtain bio-diesel (bio-fuels for compression ignition engines) and glycerin (used in cosmetics)

Figure 3. Biomass utilization for energy generation in sustainable communities

Although there are different methods for waste valorisation, in this work, we aim to describe a method to reduce, reuse and recycle the vegetables waste and the biodegradable packaging by using the process of aerobic composting.

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2. Household waste

2.1. Household waste

Household waste is a set of organic and mineral waste resulted from household, commercial or industrial activity. In the activity of preventing the environmental pollution and recycling the materials, household waste represents a valuable source for metals extraction and processing, for biodegradable organic materials, for plastics, glass and textiles.

Household waste affects the ecosystems and the human health. Some ecosystems can be seriously affected by the poor waste management or the improper waste disposal, as these may affect the growth of plants on the soil area affected by the waste (Gunoi menajer, 2022).

2.2. Selective collection of the waste

The household waste can be selectively collected, thus, the negative impact on the environment is significantly reduced. Figure 4 shows the types of containers that can be used for the selective collection of the waste.

Figure 4. Containers for the selective collection of the waste

https://www.adidobrogea.ro/reciclarea-deseurilor/despre-deseuri/

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2.3. Waste identification, sorting and storage

The types of household waste are schematically presented in Figure 5 together with the corresponding containers used in their collection. Biodegradable household waste, that can be recycled by composting, is stored in the brown container.

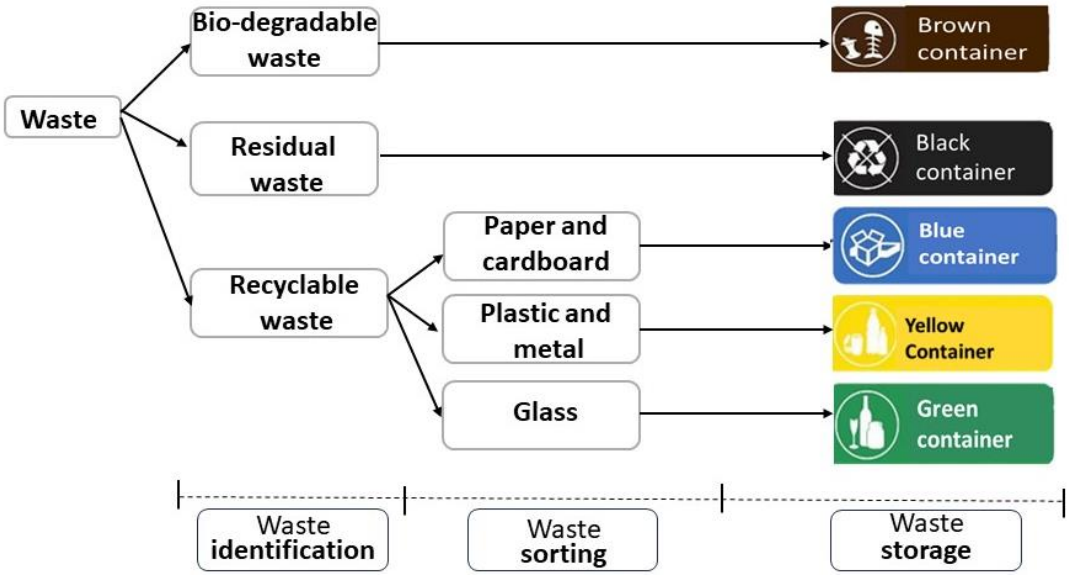

Figure 5. Types of containers used for household waste recycling

https://www.adidobrogea.ro/reciclarea-deseurilor/despre-deseuri/

The production of municipal organic waste constantly increases, thus the development of waste recycling technologies, as an alternative to their disposal or incineration are required. For example, the recycling of the biodegradable waste by composting represents a sustainable solution for the development of new ecological compost based-type substrates.

The biodegradable waste includes kitchen scraps and garden waste, that must be stored in the brown container. The following waste can be collected in this container: fruit and vegetable scraps, grass, flowers, leaves, tree branches, coffee grounds, tea bags. Food scraps, bones, spoiled food can also be stored in the same place. Unfortunately, when the recycling of this waste is done by composting, the latest mentioned waste negatively affects the quality of the compost.

The biodegradable waste represents the largest part of the municipal waste. Therefore, by treating them unproperly represents a high risk for the environment (Cecilia Girón-Rojas, 2020).

In order to handle this waste without a negative impact on the environment, the principle of the Integrated Waste Management Hierarchy created by Ad Lasnik in 1979 and introduced in 2008 in the Waste Framework Directive (2008/98/EC) should be applied. This defines the waste hierarchy as "the order of priority of the operations to be

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followed in waste management: reduction, reuse, recycling, other reuse operations, disposal" (Directive 2008/98/EC of the European Parliament and of the Council on waste, 2008).

Figure 6 schematically presents the Integrated Waste Management Hierarchy (adapted from https://www.google.ro/search?q=Ierarhia+managementului+integrat+al+de%C8%99eurilor&sxsrf=ALiCzsbKOnuqafN68gvSpudVhq03q-_kTA:1652780149981&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjT1eztneb3AhUuMuwKHXNMCRYQ_AUoAnoECAEQBA&biw=1280&bih=595&dpr=1.5#imgrc=sk3gopYQtl5zoM).

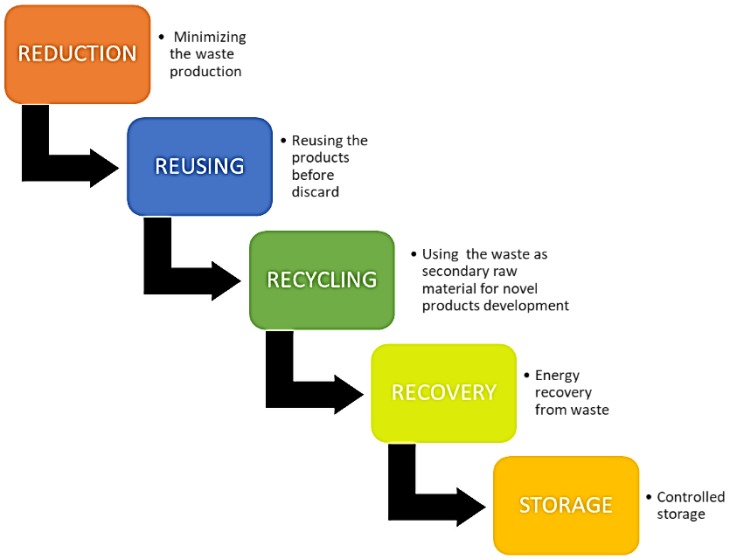

Figure 6. Integrated Waste Management Hierarchy to be used in a sustainable community

According to the National Waste Management Strategy: "The solutions for recovery, recycling and reduction of the biodegradable matter sent for final disposal" are the following:

- composting (aerobic degradation) with production of compost, that can be used as biofertilizer;
- anaerobic fermentation (digestion) with biogas production;
- heat treatment;
- mechanical-biological treatment (aerobic degradation) with the production of stabilized, storable waste" (Law - Decision no. 870/2013, 2022).

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3. Composting

Composting is the most recommended method of recycling the biodegradable waste, due to its economic advantages and from environmental impact perspective. Composting focuses on the 3Rs of the integrated waste management process: reduction, reuse, recycling. Therefore, composting reduces the amount of waste that ends up in the landfills, and offer the solution for recycling and reusing the organic waste instead of throwing it away (Jibril Dan Azimi Jibrila, 2012).

There is no a generally accepted definition for the composting process. The process can be described as the biological decomposition and transformation of the organic matter, under controlled aerobic conditions, into stable humus-like products (Epstein, 1997) or as the biological decomposition and stabilization of the organic substrates, in thermophilic temperature conditions as a result of the produced biological heat, to obtain a stable, pathogen-free final product that can be applied on the soil (Haugh, 2018).

Regarding the products obtained from the composting process: the microorganisms decompose organic matter and produce carbon dioxide, water, heat and humus (Hamouda, 2015).

Organic matter + O_2 → humus + CO_2 + H_2O + heat + mineral products

The main objectives of composting process (L. Dumitrescu, 2014) (Haugh, 2018), are:

- transformation of the waste into reusable products;
- destruction of pathogens from the waste composition, that are harmful to humans;
- reducing the odours of the biodegradable materials.

The following aspects concerning the importance of the composting process could be considered:

- it allows the biotransformation of the residual organic matter;
- eliminates of the unpleasant odours;
- improves the hygiene by destroying different pathogenic germs;
- annihilates of the germinating power of many weed seeds;
- improves the fertilizing value of the organic matter;
- activates the life in the soil;
- reduces the loss of nutrients;
- supports the environment protection.

The cycle of biodegradable waste is schematically presented in Figure 7.

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Figure 7. Life cycle of the compostable biodegradable waste

The composting process by aerobic fermentation is schematically represented in Figure 8.

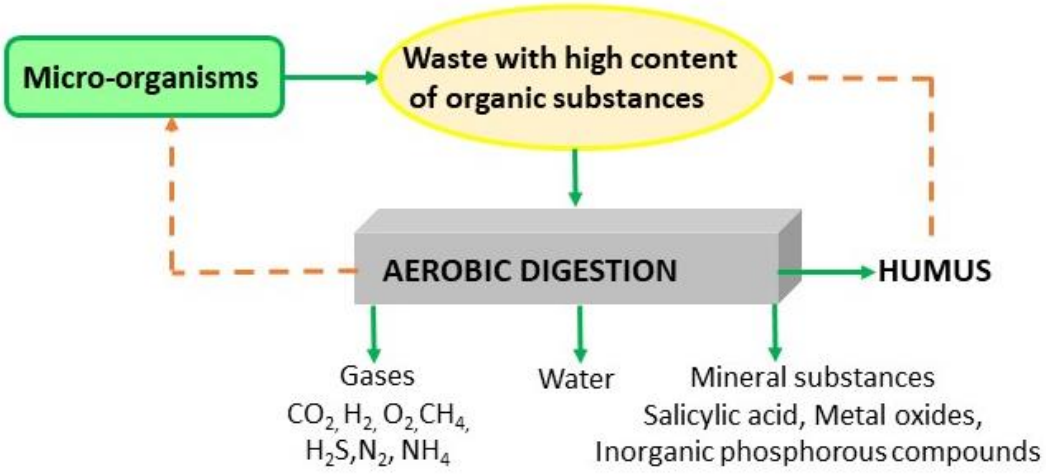

Figure 8. Schematic representation of the composting process

The waste recommended for composting are the following:

1. Vegetable food scraps;
2. Dried leaves, vegetation residues, yard trim and wilted plants;
3. Garden waste;

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4. Tea bags, plants used for tea preparation
5. Coffee grounds, paper coffee filters
6. Straw, cobs, dried grass
7. Animal waste (animal manure, animal litter)
8. Feathers
9. Eggshells, cardboard packing eggs
10. Very fine sawdust of untreated wood
11. Wood ash
12. Towels and paper bags
13. Biodegradable (through composting) packaging

The first 5 types (1-5) are rich in nitrogen in the compost, while the last 8 (6-13) are carbon rich waste.

Materials that should be avoided in the composting process are the following:

1. Cooked food and bread
2. Fats, sauces and oil
3. Meat and fish leftovers
4. Dog or cat excrement
5. Timber
6. Disposable diapers
7. Vacuum cleaner dust
8. Fly ash
9. Inorganic waste, plastic, glass
10. Paper printed with ink (newspaper, etc.), coloured or glossy paper

The phases of the composting process

The composting process has two stages: the decomposition stage and the humidification stage.

The decomposition stage occurs in 3 phases - the mesophilic phase, the thermophilic phase and the cooling phase. The humidification stage also corresponds to the ripening/curing stage.

The first phase of the decomposition stage is the mesophilic phase; it begins at the moment when the matter to be composted is stored, and end up at the point where the temperature increases so much that the mesophilic microorganisms can no longer function and are replaced by others, with higher resistance at high temperatures.

This phase occurs at a temperature of 25 - 40^{o} Celsius; the temperature gradually increases with the intensification of microbiological activity. A rapid degradation of the organic compounds, such as the carbohydrates and proteins, that are the major compounds in this phase, occurs.

The 2nd phase of the decomposition stage is the thermophilic phase.

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The temperature continues to increase, this phase taking place at temperatures of 40 - 65^{o} Celsius. Complex organic compounds such as cellulose or lignin are degraded to simple organic compounds and nitrogen is transformed into ammonia by the thermophilic bacteria, which replace the mesophilic bacteria active the first phase. Also, the high temperature favours the removal of various harmful pathogens, this phase being also known as a sanitization stage.

After the thermophilic phase, a 2nd mesophilic phase or cooling phase occurs.

In this phase, the temperature drops to 25 - 40^{o} Celsius, due to the significant decrease in the number of organic substances available for transformation, thus limiting the activity of the bacteria.

The thermophilic bacteria, that prefer a higher temperature, are replaced by the mesophilic bacteria; these mesophilic bacteria will degrade the complex organic compounds (predominantly cellulose) that were not degraded in the thermophilic phase.

The humidification stage consists of a single phase, the ripening or curing phase.

In this phase, the temperature drops until it reaches the ambient temperature; this phase occurs in the presence of mesophilic bacteria. The stabilization of the organic material and its transformation into humus is produced (Azim, Soudi, Boukhari, Perissol, & al., 2018).

The composting process is considered completed when all the nutrients have been consumed by the microorganisms active in the process, no temperature increases in the compost is recorded, and the oxygen consumption is low (André W.G. van der Wurff, 2016).

Composting is a complex process that requires investment of resources (time, money, human resources). However, there is no perfect process, thus advantages, but also some disadvantages of composting can be mentioned. (I. Manciulea, 2017).
The main advantages of the composting include:

- composting is an efficient recycling method of the biodegradable waste, avoiding their disposal or storage;
- a valuable product is obtained, that can be used for example as a natural biofertilizer;
- almost any organic material can be composted, that makes the composting process an economic alternative for recycling, considering the raw materials that enter in the process;
- a large number of composting methods are known, the process being very flexible, as the amount of waste, the available space for composting process and the applications of the compost can be adapted according to our needs;
- the compost promotes water retention in the soil;
- the use of the compost represents an ecological alternative for the use of synthetic fertilizers (I. Manciulea, 2017).

The main disadvantages of the composting are:

- is a long-term process, sometimes the compost reaches maturity even after a year;
- it can be an expensive process, depending on the composting method, as it requires the purchase of specific equipment;

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- the composting facilities need more space than those used in other waste recovery technologies
- unpleasant odours may be produced during the composting process;
- if the compost has not reached the maturity, it may affect the growth of the plants, as the microorganisms from the compost will consume the nitrogen, that is necessary for plants development, to complete the composting process;
- ammonia is released during the process, and may represent an atmospheric pollutant;
- to be sold on a large scale, the product (the compost) must be promoted on the market, and this involves additional costs (I. Manciulea, 2017), (Dreghiciu, 2017).

The main reasons for the compost to be applied to the soil are:

- it is a good soil improver, it supplies nutrients and organic matter, thus improving the quality of the soil.
- has a positive effect on soil physical, chemical and biological properties;
- it favours water absorption in the sandy soils;
- it favours the aeration of sticky soils, favouring their drying;
- the nutrients from the compost are gradually released into the soil, thus they are active for a long period of time;
- it helps maintaining a neutral pH in the soil, due to its high content of organic matter (Dreghiciu, 2017).

4. Conclusion

The recycling of the biodegradable household waste is an advantageous method of waste valorisation, as they can be considered as secondary raw materials to obtain new products.

In this chapter, different possibilities for valorisation of the biodegradable organic waste were presented, outlining the composting method as a sustainable method to obtain biofertilizers, which can be used in agriculture instead of the inorganic chemical fertilizers.

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