гр. Кула – 3 800, ул. “Възраждане” № 38. Тел: кмет: 0938/3-20-20, зам. кмет: 0938/3-22-24, e-mail : obshtinakula@abv.bg
Town of Kula – 3800, “Vazrazhdane” str. 38. Tel: mayor: 0938/3-20-20, deputy-mayor: 0938/3-22-24, e-mail: obshtinakula@abv.bg

TRAINING MATERIAL FOR SCHOOL CAMPAIGN

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Content

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INTRODUCTION

This training material was created with the purpose of preparing lectures for pupils who are attending higher grades of primary school. The goal of the lecture is to familiarize students with the problems of household waste management, especially with the possibilities and needs of its exploitation and treatment. Due to its increasing quantity and negative impact on the environment, waste is considered one of the most significant ecological problems of the modern society. Man is, through his activities, the primary factor of change and pollution of the environment. All these activities are related to fulfilling life necessities. Many of those necessities are artificial and it makes one question whether we need so many different products which will become waste after use. Our civilization produces more and more waste and nothing indicates a change in this way of doing. Nevertheless, by virtue of technological advancement and the development of environmental awareness, the struggle with waste is becoming more successful.

In recent decades, the laws of developed countries include the intensive development of the concept of integrated waste management. These regulations contain a modern approach to waste management with the focus on avoidance, utilization and treatment of waste with the purpose of disposing of as small quantities as possible and with as fewer harmful particles as possible. European Union legislation contains various directives, decisions, regulations and recommendations. Directives related to waste and waste disposal resolutions lay down the basics of waste management and Member States are required to avoid waste generation, reduce waste production, recycle, as well as to commit themselves to building plants with the best available technologies, to develop waste management plans and apply the "polluter pays" principle to cover waste management costs.

Bearing in mind that the countries of the Western Balkans are trying to adapt to the requirements and standards of the European Union as much as possible, we wish to use these training materials and lectures to bring the students closer to the problem of waste management, how to solve it, and to familiarize them with the processes that are necessary for achieving the goal of proper waste management. The quality of the environment does not only depend on the decisions of the government and ministries, the work of utility companies, but it also depends on the conduct of the citizens themselves. Responsible attitude towards waste and the development of a general approach to proper waste management is the basis for creating a healthy environment and a basis for a healthy life.

A list of basic ecological terms

Wrapping material waste

Any wrapping or wrapping material that cannot be used for original purposes, other than being residue from the production process.

Landfill

Waste disposal site where waste is disposed on the surface or below the surface of the soil.

Ecology
Ecology is a science that studies the relation between living beings and the environment. The word ecology was derived from the word: oikos = house, home, habitat and logos = word, speech, knowledge.

Ecosystem
A complete system of relations between plant and animal species and the habitat.

EU Directives
EU legal directives that connect all member states and that must be implemented through the legislation of the member states within the prescribed deadlines.

Herbicides
Chemicals used to destroy weeds.

Inert waste
Waste that is not subject to any physical, chemical or biological changes.

Insecticides
Chemicals used to destroy insects.

Incineration (burning) of waste
Thermal treatment of waste in a stationary or mobile plant with or without the use of energy produced by combustion.

Composting
Process of decomposition and conversion of organic waste into compost (humus).

Municipal waste
Waste from households, or any other waste which due to its nature and composition is similar to household waste.

Fee for garbage collection
Amount to be paid for the removal of household waste to a landfill.

Non-renewable sources
Natural sources that are the result of geological processes for millions of years. For example: ores, minerals, fossil fuels (oil, gas, coal, etc.)

Non-hazardous waste
Waste that does not have hazardous waste characteristics.

Renewable sources
Natural sources that are renewed in a natural way. They can be of vegetable and animal origin.

Hazardous waste
Waste which containing components that may cause immediate or permanent adverse health effects.

Organic waste
Waste of organic origin: fallen leaves, grass residues, food leftovers, etc.

Waste
Dumped material that is no longer used, i.e. unusable in its original form

Pesticides
Chemicals used to destroy pests and weeds.

Reuse
Use of products that can be used more than once, for example a wrapping that can reused more than once.

Recycling
Processing of waste materials in the production process for the original or other purpose, other than energy purposes.

Waste collection
The activity of systematically collecting waste, sorting and / or mixing waste for transport for further treatment or disposal.

Waste storage
Temporary storage of waste at the location of the producer or the owner of the waste, as well as the activity of the operator in the plant equipped and registered for temporary storage of waste.

Transport of waste
Transport of waste outside of the plant, which includes loading, transport (as well as reloading) and unloading of waste.

Treatment of waste
It includes physical, thermal, chemical or biological processes including waste sorting, which modify waste characteristics to reduce the volume of waste or hazardous characteristics, facilitate waste control, or encourage recycling which involves reuse and recycling of waste.

Dump
An open, unregulated landfill with very harmful consequences for the environment and human health.

Waste management
Implementation of the prescribed waste management measures within the collection, transport, storage, treatment and disposal of waste, including the supervision of such activities and the maintenance of waste management facilities after closure.

Environment
Natural environment (air, soil, water, climate, flora and fauna and man), as well as the environment created by man (cities, villages and total material goods)

1.0. The formation of solid waste

Waste is formed as the result of the economic activity of each individual, family, work environment, and all other waste generating subjects. This process depends on the standard of living, the way of life, the social circumstances and other parameters characteristic of the wider community. The amount of waste generated by people is not constant, but can differ significantly between subjects - generators, as well as within an organizational unit (local self-government, institutions, business, etc.).

In accordance with the Law on Waste Management and Waste Management Strategies, which are in accordance with the EU Directives, the following types of waste are defined:

- municipal waste (household waste);
- commercial waste and
- industrial waste.

Waste, depending on the hazardous characteristics that affect human health and the environment, can be:

- inert;
- non-hazardous;
- hazardous

2.0. Characterization of waste

Characterization of waste represents an important activity in the planning of the treatment of waste materials and secondary materials, and it can be visual and instrumental. The information on the waste material and secondary material should contain:

- name of waste,

- place of formation and origin,
- place of delivery and disposal.

Visual characterization of waste provides basic information on the type of waste, its appearance, condition, where all information is exclusively descriptive.

Instrumental methods of characterization of waste materials and secondary materials include the preparation and determination of:

- physical characteristics,
- technical analysis,
- chemical analysis and
- elemental analysis,

3.0. Collection of municipal waste

The basic precondition for efficient recycling of municipal and industrial waste, as well as the safe disposal of waste remains is the efficient collection and transport of waste to the recycling plant or to the landfill. In the process of collecting and managing of waste, it is necessary to try to minimize pollution, in order to make the most efficient and rational utilization of useful components.

3.1. Waste collection systems

There are three systems for the collection and utilization of useful components from waste:

1. A system for collecting a mixture of waste with subsequent sorting,
2. A system for collecting a mixture of useful waste components with subsequent sorting
3. Separated system for collecting useful components and residual waste.

The first system of collection and utilization of waste, i.e. collection of a mixture of municipal waste with subsequent sorting. With this system, the collected waste is transported to the plant where it is sorted, in which the useful components for further use are sorted (e.g. glass, paper, metals, plastics, etc.). The rest of the waste is processed (for example, for composting, combustion in power generation plants (thermal and electrical) or disposed of at landfill sites). The main disadvantages of this collection and utilization system of useful waste components are:

- high level of contamination, i.e. pollution of the mixture of waste and
- insufficient cleanliness of sorted useful components for efficient use.

An alternative to this system of collecting and using useful components from waste is that waste producers separate useful components from waste, that is, pre-sorting at the source itself (for example, in households, stores, public institutions, etc.). This waste collection system requires first of all:

- adoption of legislation that obligates individuals and institutions to this way of collecting
- high motivation of the population and
- high level of informing of the population.

With the separated system of collecting useful components from waste, it is necessary to take into account the appropriate costs, as well as the costs of the plant for the subsequent processing of these useful components.

The system of transporting of the components and the rest of the waste to a certain place is a systems where citizens from households, shops, public institutions, etc., bring separately collected components from the waste and the rest of the waste (garbage) to a particular collection site (e.g., yard used for recycling, etc.) and dispose them in a container for each component separately, or several useful components are deposited in one of the containers, and the rest of the waste (garbage) is deposited in the other container.

The system for getting to the useful components and the rest of the waste is a system of collecting and separating of useful components from municipal waste and the waste residue (garbage) and it is done at the place of its creation, i.e. in households, industrial plants, hotels, public institutions, etc., from where the separated components from municipal waste and the rest of the waste (garbage) are directly disposed of to the final destination (sorting facilities, waste dumps, etc.). Disposal of these waste components can be done directly from the yards of the households, institutions and similar facilities, or by collecting on the street at a precisely determined time. For the transport of separated useful components and the rest of the waste (garbage) it is most often necessary to place an additional container (container or bin) at a specified collection site. For the transport of separated useful components mostly the same containers (containers or bins) are used as well as for the rest of the waste. Containers for the separation system of separately collected useful components are labeled separately or are made in special colors. Vehicles that are used to dispose of the rest of the waste can be used to dispose of these useful components, but they have a modified device for receiving and compacting these components in the bunker of the vehicle. The main advantage of the discharge system in relation to the waste component delivery system is a higher percentage of collection with slightly higher costs and a slightly lower quality of useful components. None of these systems can achieve a percentage of the collection of 100% useful components that are found in municipal waste. In the system of getting to the useful components and the rest of the waste, it is practiced to separately collect the waste residue and bio-waste, while in both systems, separate collection of useful components is practiced.

The system of collecting municipal waste in a particular environment should satisfy the basic conditions:

- accepted by residents of a particular environment,
- security of possible negative consequences for the inhabitant and surroundings of a particular environment,
- hygienic and aesthetic requirements,

- economic criteria, etc.

Containers, garbage bins or bags for waste collection should be regularly disposed of in order to avoid the formation of unpleasant odors from the biodegradation of organic waste components and to avoid adverse environmental impacts.

3.2. Types of waste containers

Various types of containers may be suitable for the storage of waste, but in some cases, the choice of containers depends on the method or place of collection. Depending on the method or collection site, any of the following containers may be suitable for keeping waste from households and commercial waste:

- Plastic bags,
- Metal or plastic rigid containers,
- Containers on wheels (large plastic containers on wheels),
- Large metal or plastic bins, as shown in the illustration.

Containers for waste storage

PLASTIC BAGS

Plastic bags are suitable for holding waste within the place where waste is generated, but outside they should be used only if the place where waste is collected is at the door. Plastic bags placed outside the building attracted cats, birds and other pests, which is one of the main causes of waste scattering around the tiles and curbs of the streets.

METAL OR PLASTIC RIGID CONTAINERS

Only rigid plastic or metal containers that have been manufactured for waste disposal and have lids that can be tightly closed should be used if waste is collected outside of the building. In some situations, conventional plastic or metal bins with lids that can be tightly closed are suitable, with a capacity between 100 and 150 liters.

CONTAINERS ON WEELS

A container on wheels is a specially designed plastic container that can be pushed on wheels from the point of storage to the pickup vehicle and then mechanically discharged. Containers on wheels are made in dimensions between 120 and 480 liters and are very suitable for storing waste from several residential buildings or commercial firms.

WASTE BINS

The only operational and environmentally friendly type of waste containers to be used for central waste collection is a plastic or metal “waste bin”, sometimes referred to as a "trash can", which can be mechanically (hydraulically) lifted and discharged into waste collection vehicle. The capacity of the waste bin usually ranges from 1 to 6 cubic meters.

3.3. Frequency of waste collection

The final strategic decision to be taken is how often household waste and commercial waste should be collected. In this decision on the appropriate frequency of waste collection, the needs for storage capacity and the available storage space must be considered, as well as the standard design

criteria. The frequency of collection for different circumstances should also be considered, depending on local conditions and payment capacity:

- once a week
- twice a week
- daily
- other

4.0. Sorting of municipal waste

Manual sorting represents the oldest type of separation. Today's hand sorting systems involve the movement of materials on conveyor belts, where magnets are used to extract the iron-based components.

In order to achieve more rational processing and greater waste utilization it is necessary to increase the price of finished materials (via tax system) or to introduce mechanization and process automation to reduce the costs of processing.

In addition to sorting at source, a viable collection and processing process is a central sorting procedure. City utility services organize the collection of the residue and transport it to a central processing station, within which the system for sorting (from manual to fully automated) is installed.

5.0. Transport of municipal waste

For the collection and transport of municipal waste, there are several different designs of collecting bunkers that are mounted on vehicles. The bunkers consist of a loading compartment with various waste compaction devices, with the aim of maximizing the vehicle's load capacity. The common feature of these vehicles is that they have a loading chamber, the so-called loading area, which is separated and isolated from the bunker for collecting waste, thus eliminating the negative impact of unpleasant odors and dust on the environment. For various types of bunkers for the collection of municipal waste, several types loading areas can be mounted on one vehicle.

A common feature for all collection systems is that the bins, waste containers and other types of containers must be transported to the loading compartment on the vehicle. The lifting and removal of waste from the bins and containers is carried out by using hydraulic systems, while bags are manually inserted into the loading chamber. Vehicles with a loading receiving bunker are mostly used for collecting and transporting waste, in which waste is compacted by:

- horizontal rotary drum and
- mobile hydraulic device in the loading chamber.

When transporting waste, it is necessary to meet the following requirements:

- waste must be transported with minimum costs;
- waste must be contained during transport;
- vehicles for the transport of waste must be such that they can navigate modern roads;
- The capacity of waste must not be contrary to the permissible vehicle load and
- The procedures used for loading and unloading must be simple and safe

6.0. Waste treatment

A large number of waste treatment plants in the world that have already been constructed, and the way in which new ones are being planned, show that the waste removal process, after the separation of quality materials, is acceptable from the point of view of environmental protection and from an economic point of view, and as such should be applied in our environments.

6.1. Waste recycling

Recycling of municipal waste means the reuse of some of its components, which as secondary raw materials have a usable value in the same or other technological processes - production. The first strategic decision is to identify the material that will be included in the recycling program. Not all materials that can be recycled, produced by residents and commercial firms, can be easily or successfully integrated into a conventional recycling system. Depending on the analysis of waste composition, the list of recyclable materials generally contains the following:

- Paper (newspapers, cardboard, paperboard, paper for writing, envelopes, magazines, etc.)
- Plastics (bottles and plastic products),
- Glass (old glass-glass residue),
- Metal,
- Wood,
- Rubber,
- Textiles,
- Garden waste,

- Organic waste,
- Hazardous waste.

The advantages of recycling as a waste treatment are:

- Possibility of separating useful components as secondary raw materials for production;
- Reduction of the quantity of the municipal waste to be disposed of at the landfill;
- Economic gain is achieved (direct sales or participation in production);
- Reducing the need for imports;
- Reduction of the use of natural resources;
- Energy is saved in industrial production;
- Reducing the costs of production and processing of raw materials;
- Improvement of the environmental protection system.

RECYCLING PAPER

Paper and cardboard represent the most common component of municipal waste, especially in developed countries. Paper that is recycled includes: old newspapers, packaging cardboard, quality writing and computer paper, mixed paper. Packaging cardboard is recycled the most, which is mainly used for making new packaging, corrugated cardboard. Better types of paper, with or without pre-processing (color removing, bleaching and washing), are used to produce new quality paper. Paper with lower quality, after obligatory processing, is used for the production of paper rolls, toilet paper, paper handkerchiefs and cardboard for boxes. Mixed paper is used without color removal for the production of various packaging boxes, egg packaging and various pressed products used in construction.

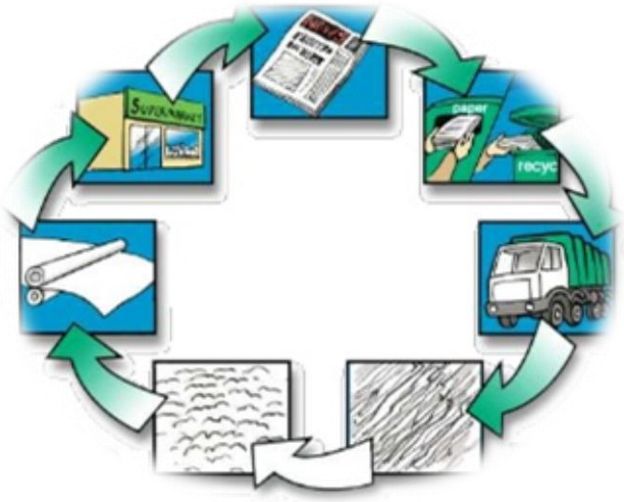
The basic advantages of using old paper and cardboard as a secondary raw material in the paper industry are:

- For the production of new paper and cardboard products, old paper and cardboard are used in the amount of 13 to 98%, which depends on the type of these products (Table 3).

- The use of old paper and cardboard significantly reduces the exploitation of forests. One ton of sorted paper waste of medium quality replaces an average of 3.3 to 5.3 m^3 of cellulosic wood.
- Old paper and cardboard can be used up to 7 times for the production of new paper and cardboard products. This limitation is related to fiber shortening, which occurs in every use. After a complete usage, the old paper and cardboard is most often used as secondary energy fuel.
- The recycling of old paper and paperboard reduces the amount of utility waste, i.e. improves the general state of environmental protection and improves the utilization of waste dumps.
- In the process of producing paper and cardboard, by using old paper and cardboard significant savings in energy consumption and fresh technological water are achieved, while reducing the impact on the basic elements of the environment, especially underground and surface waters.

Table 3. Percentage of old paper and cardboard in the production of new paper and cardboard products

Product type	**Old paper, %**	**Primary fiber, %**
Cardboard,cardboard boxes	95,6	4,4
Hygienic paper	83,4	16,6
Newspaper paper	67,3	32,7
Cardboard and pack paper	62,9	37.1
Writing paper	13,6	82,4
Average	43,1	56,9



PLASTICS RECYCLING

Plastic is a material obtained from oil. Usage of oil and its processing into plastic results in consumption of one of the non-renewable natural resources. At the current rate of consumption, it is estimated that world oil reserves will be exhausted in 35 years. In addition to oil, raw materials used for making plastic are gas or coal.

Plastic represents an organic polymer consisting of monomer groups containing carbon and hydrogen. Natural polymers have been used since the creation of the world while synthetic polymers are significantly younger.

In the last decades, plastic has achieved its popularity due to the retention of its mechanical properties after molding, crushing, threading and recycling after use.

Plastic masses are processed by rolling in foil, injection, pressurized pressure, etc. Due to its mechanical and chemical properties and design possibilities, plastic materials have suppressed many other materials. Plastic materials have been used for years to produce packaging, although they present a problem from the aspect of environmental protection. The reasons for the increasing use are, among others, the low prices of raw materials, low weight and various processing capabilities. The specific energy consumption in the production of plastic materials, used for packaging production, is much lower than in the production of packaging of, for example, glass or aluminum.

Synthetic materials obtained from recycling plastics can be used for the production of garments, foils, new packaging (bottles, bins, barrels...) and other products. For some types of plastics, the packaging industry is the main market. The rest is used in other industries. The European plastics industry has chosen to maximize the use of waste plastics as a resource and minimize the disposal of waste plastics to landfills. This involves the utilization of plastics through mechanical or chemical recycling or as an energy raw material, along the path of integrated waste management. Increased use of plastic materials also increased the amount of plastic waste, especially of plastic packaging as it occupies a large area in landfills.

The problem with plastic is that it does not disintegrate in the soil and is permanently retained in the environment that it afterwards pollutes. It is also possible to destroy it by burning process, but then we pollute the air.

Types and characteristics of plastic

The division and labeling of plastic products is of utmost importance for the process of plastic recycling, especially for the sorting process, and then for further treatment.

Although several labeling systems are used according to certain standards, it can be said that they are all generally based on ISO 1043-1 standard and exist (with little modification) as shown in Figure 6. American Society of Plastic Industry ASPI distinguishes seven categories of polymer from the process of recycling.

Figure 6. Symbols for labeling plastics

Recycled plastics are classified into categories according to the basic chemical composition:

1. PET -polyethylene terephthalate,
2. HDPE -high density polyethylene,
3. PVC -polyvinyl chloride,
4. LDPE -Low density polyethylene,
5. PP -polypropylene
6. PS -polystyrene
7. Other -rest.

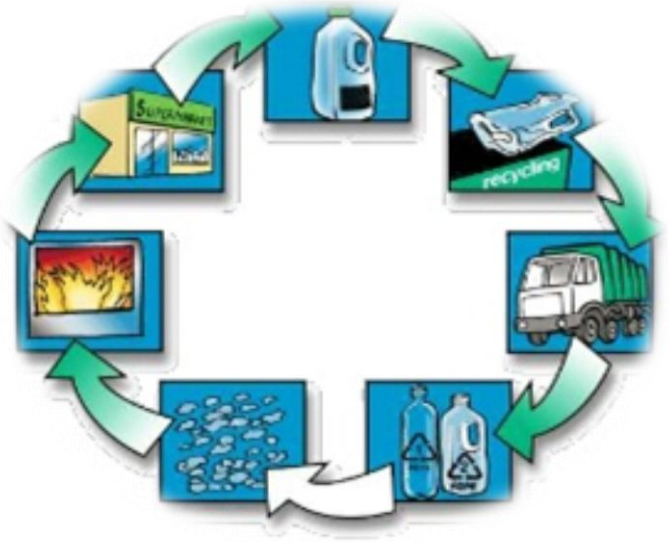
Symbols have a dual role. They indicate to the consumers that the packaging can be recycled, and to those associated with recycling the symbols also indicate the type of plastics applied.

Procedures for processing plastic waste

Used plastics products can be reused or processed through different methods, depending on the goal, and all due to the reduction in the amount of waste to be disposed of.

Technologies for the recycling of plastics can be divided into four basic categories:

- Primary: Re-extrusion, or the re-usage of plastics of the same characteristics into the production process itself,
- Secondary: Mechanical, developed for the purpose of recycling of various plastic products by physical processes,
- Tertiary: Chemical, intended to produce raw materials for the chemical industry,
- Quaternary: Obtaining energy, that is, complete or partial oxidation of plastic waste materials for the production of heat, and / or gas fuels, oils, and / or materials that are deposited (for example, ash).



RECYCLING GLASS

The basic raw materials for the production of simple glass packaging are: quartz sand (about 60%), soda (about 18%), dolomite or limestone (about 15%), feldspat (about 6-7%) and additions for coloring, removal of color, and accelerating the melting process. Glass is a material used in everyday life through various products: bottles, glasses, jars, windows, mirrors, etc. It can be of different colors, which are added to it in production.

Glass is an important material from a recycling point of view. Glass exists in large quantities, and in the process of manufacturing packaging glass it is obligatory to use the so-called glass debris, to

improve the melting process. For recycling, it is essential that the glass is separated by color. By color it is divided into colorless, green and brown glass, and depending on the color of the glass it has a different value of use. Hence, in the recycling process, it is very important that the glass is separated by color. It is followed by grinding, then mixing with primary raw materials (in the appropriate proportion) and melting, resulting in a glass mass.

In the beginning, glass recycling aimed to reduce the amount of glass waste in municipal waste. However, today glass recycling is much more than is required by the environmental protection measures. Glass waste from municipal waste represents a very competitive secondary raw material in the glass industry compared to primary raw materials, especially taking into account energy savings.

When collecting glass debris for processing or for the production of glass packaging, the following must be taken into account:

- Only glass bottles, glass containers for fruit and vegetable packaging, and glass containers for the packaging of certain cosmetics and medicinal products of a particular color that is indicated on that container are allowed to be disposed of into a particular container.
- Glass vases, glassware and similar glass products are not allowed to be disposed of into these containers since these products have different chemical composition, create certain problems in melting, or make the recycling process of glass debris more difficult.

Thus, the separated glass debris is transported to the glass factory, where its preparation is carried out before proceeding to the technological process of the production of glass products.

Recycled glass has multiple usages for:

- re-manufacture of glassware;
- asphalt glass, asphalt made with the addition of glass for asphalt roads;
- production of building and construction materials, such as clay bricks and elements, masonry blocks, glass-concrete, lightened aggregate in concrete and plastic, for insulating foams and panels;
- reflex color for road markings;
- insulating glass wool;
- drainage and dehumidification of the terrain;
- decorative sand in restaurants;
- glass fibers;
- abrasive;
- many other construction materials in the textile industry.

Compared to the production of new quantities, recycling saves energy and reduces pollution. In the production of new glass, the raw materials are heated to 1400 degrees Celsius, and during recycling the glass breaks into smaller pieces, melting at lower, appropriate temperatures. Recycling reduces energy consumption by 40%, air pollution by 20% and water use by 50%. With every ton of recycled glass

it saves more than a ton of raw materials needed to produce new glass. Recycling only one glass bottle saves enough energy to light a 100 watt light for four hours.

6.2. Biological treatment of waste

The goal of bio-ecological waste treatment is to imitate natural processes as much as possible and to keep the system as close as possible. This reduces the risk of adverse effects on the environment such as overloading or spreading pollutants.

The products of biological decomposition obtained from solid waste include compost, methane, various proteins and alcohols and several other organic compounds.

COMPOSTING

Bio-waste or organic waste is biodegradable waste that can be processed with biological treatment into quality compost. Compost is a material similar to humus, and is created as a result of biological degradation of organic substances.

The preparation of bio-waste for composting begins with separate collection in households and other industrial, commercial and catering facilities. Bio-waste that is suitable for composting includes the following types of waste:

- Household and similar waste of organic origin: waste from vegetables, fruit and southern fruits, egg shells, coffee and tea filters, food leftovers - only vegetable leftovers (not meat, fish, bones, etc.), paper (napkins , bags, handkerchiefs, individual newspapers),
- Herbal waste in small quantities: from flats and houses (balcony plants with soil, withered flowers), from gardens and parks (leaves, wild plants, branches of trees and shrubs, mowed grass, etc.).

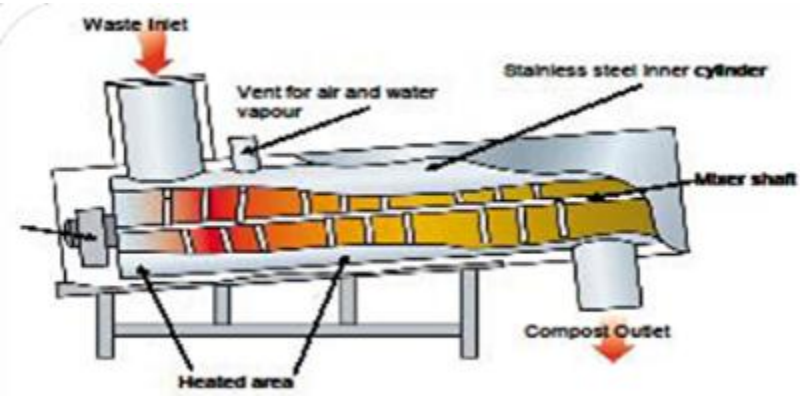
In order to obtain a good structure and quality of composting materials throughout the year, that is, in all seasons of the year, the collection and processing of bio-waste from households should be carried out together with herbal waste and green waste. If the bio-waste is collected together with the

residues of the old paper, this can be an advantage in the process of collection and transportation, as the paper has the ability to absorb moisture and dirt, which affects the reduction of unpleasant odors. However, such a method of collecting can lead to a reduction in the quality of compost, e.g. when the paper contains harmful substances (paints, etc.).

Composting requires the following conditions:

- Oxygen from 15% to 18%. If the concentration of oxygen drops below 10%, the process becomes anaerobic;
- Humidity between 25% and 70%. If the humidity is less than 20%, the process will stop, and if it is greater than 70%, water will fill the space between the particles and reduce the percentage of oxygen which results in the transition to anaerobic process;
- Nutrients such as carbon, nitrogen, phosphorus, potassium. Particularly important is the ratio of carbon and nitrogen (C: N);
- Temperature – inside the composting area: the temperature reaches up to 700^{0} C. High temperatures have a disinfecting effect;
- The pH value - optimum values are from 6.0 to 9.0. Also, the pH value has a disinfecting effect and is subject to change.

Shredding and spreading of waste is done to improve the composting process. Composting of biodegradable waste can be a static and dynamic process. In the case of a static process, the air supply system is built into the middle of the composting area, and in the dynamic process, the waste is mixed in a rotary drum. These methods are used only in the case of there being more than 33% of compostable biodegradable waste in the waste.



6.3. Thermal waste treatment

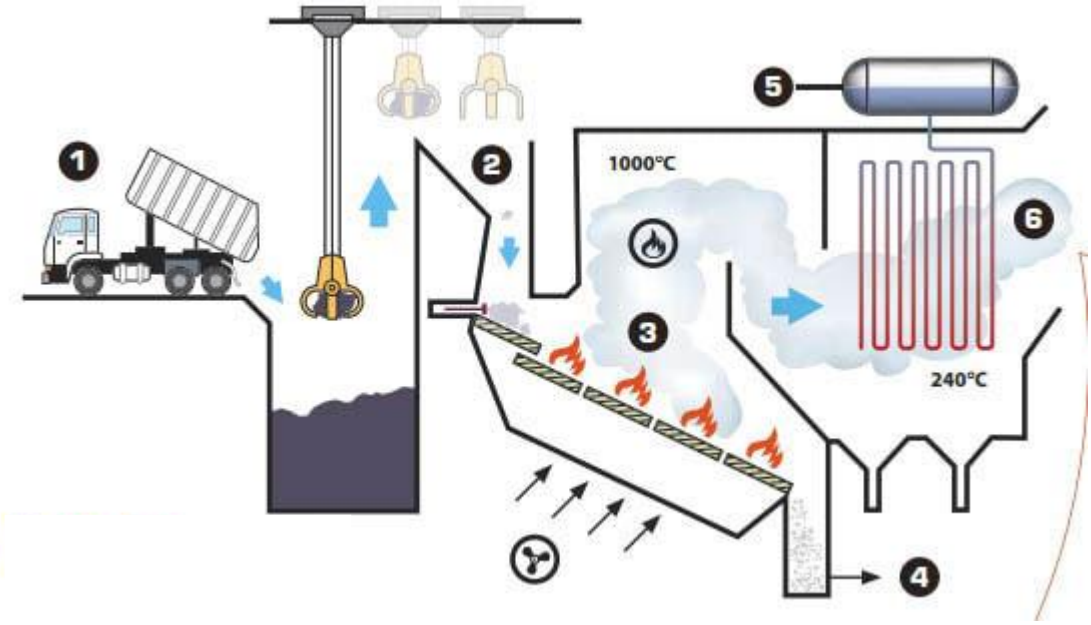
In contrast to biochemical long-term degradation processes, combustible organic waste components can be processed by thermal processes. In the thermal treatment of waste, chemical reactions take place in which energy is released (exothermic reactions), or energy should be provided for their maintenance (endothermic reactions). The most common thermal processing of waste is the incineration of waste.

Burning (incineration) - is a process of controlled combustion of municipal solid waste, in order to reduce the volume and to obtain heat energy. Combustion results in thermo-chemical conversion with the release of chemical energy of fuel and thermal energy. It is applicable to fuels with limited moisture quantity and higher thermal power. Incineration is carried out under oxidation conditions at a temperature interval of 300 to 1200°C. Under these conditions, the waste material is degraded by oxidation with the formation of gaseous, liquid or solid products of a simpler chemical composition. In the meantime, the weight and volume of the solid part is significantly reduced. It should be noted, however, that the solid products of combustion such as slag and ash are in many cases more dangerous than the waste material, because they can concentrate the most dangerous elements of waste. Smoke gases, which result from combustion, can also contain harmful gaseous compounds and solid particles.

Waste incineration, as thermal treatment, is permitted in plants that have been designed and constructed, or equipped for waste treatment and which operate in such a way that the emission limit values are below the legally prescribed values. Waste incineration is carried out with the use of energy generated by combustion only if it is economically justified and if no additional energy is used for the incineration of waste, except for initial ignition, or if waste is used as a fuel or additional fuel for co-incineration.

Waste incineration has been used for thousands of years, in order to reduce waste quantity and utilize the resulting heat for heating and preparing food. In many years, waste from households, production, and especially from agriculture, has been burnt down. As the industry developed, this method has been perfected and has started to apply to waste that belongs to the class of hazardous waste materials. The first incineration furnaces, which simultaneously used the energy obtained, appeared in the second half of the 19th century. It is considered that waste incineration can get up to 10% of the energy from waste from the total energy required by a country. By burning waste, the energy obtained is most often used to heat water and to drain hot water or steam to the user.

The main advantage of burning over the other conventional methods of waste treatment is a large reduction in volume that needs to be disposed of and lesser restrictions in terms of ash disposal from the incineration plant in relation to the disposal of untreated solid waste. Under some circumstances, the heat generated by the combustion of waste can be usefully used or converted into another form of energy for industrial or communal usage.



6.4. Disposal of municipal waste

Disposal of municipal waste is the oldest way of its removal in our country and in the EU countries. In the EU countries, the disposal of waste into regulated landfills began in the mid-1960s, when legislation for the disposal of municipal waste was introduced for the first time. Unlike EU countries, waste is deposited most often in unregulated landfills in our country. Unregulated waste dumps have a major impact on pollution of water, land, air, and especially human health.

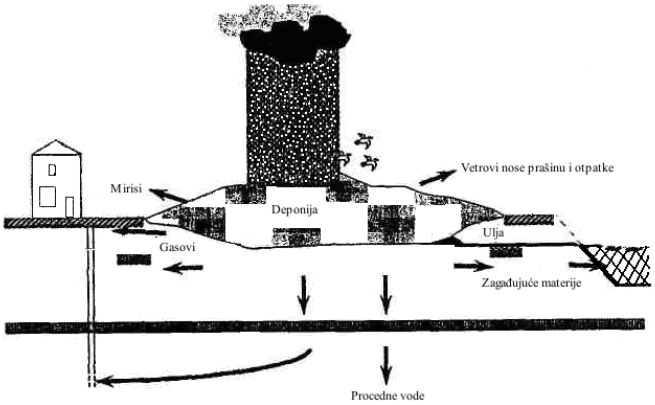


Figure. Schematic representation of negative impacts of incorrect solid waste disposal on the environment

Today, in practice, there are several ways to remove (deposit) waste, which are considered to be the most widespread, but least desirable ways of waste management. In some ways, it can be freely stated that they are used exclusively to remove waste from our vicinity and thus do not differ much from the original way of removing waste. All of these ways of disposing of waste, which are more or less used, can be classified into several groups:

- disposal to landfills,
- disposal into the sea and the oceans and
- disposal into old mines.

Depending on the type of waste landfills can be: landfills for hazardous waste, landfills for inert waste and landfills for non-hazardous and inert waste. In addition to this, depending on the environment from which the waste is sent to landfills, they can be divided into industrial and municipal landfills. However, in practice so far, regardless of legal limitations, there are landfills where waste was deposited both from households and industrial facilities, regardless of the type and quality of waste.

An extremely important process that takes place in each landfill is the decomposition of waste in the presence of water, air and microorganisms, creating new organic or inorganic substances. With all landfills where waste was not selectively disposed of, there are three basic problems:

- the formation and contamination of leachate contained in the waste water, the water generated by the decomposition processes in the disposed waste and the water passing through the deposited waste (rain, snow). Leachate contains debris, dispersed and soluble matter from the waste (high content of ammonia, nitrite, heavy metals, various organic compounds, often including toxic organic compounds).
- the formation of landfill gas (methane, sulfur dioxide, hydrogen). These products of anaerobic fermentation of organic matter carry with them toxicity, fire and explosion hazard and a global ecological threat due to the emission of gaseous gases.
- A special problem with municipal landfills is the large population of various birds and rodents (mice and rats) living in them, which are potential carriers of many infectious diseases.

In order to avoid the detrimental effects of landfills on environmental pollution, when planning, designing, exploiting and controlling the process of decomposition of waste, absolute consideration must be given to preventing the discharge of landfill gas and other very harmful substances from the landfill into the biosphere and the hydrosphere. Special attention must be paid to the protection of surface and ground waters, air and mechanical stability of deposited waste.