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EUROPEAN UNION

Waste Free Rivers For A Clean Black Sea
GEORGIA MOLDOVA ROMANIA

Black Sea
CROSS BORDER
COOPERATION

MANUAL ON THE PRODUCTION OF COMPOST OUT OF BIODEGRADABILE WASTE

Project funded by EUROPEAN UNION

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1 DEFINITIONS

Waste – Any substance or object that the owner disposes of, has the intention or obligation to dispose of;

Mixed municipal waste - domestic and commercial waste, industrial and institutional waste, which, due to its nature and composition, is similar to household waste, but excluding the fractions indicated in annex no. 2 to the Government Decision no. 856/2002 on waste management records and on the approval of the list of waste, including hazardous waste, under no. 20 01, which are collected separately at the source and excluding other types of waste indicated under number 20 02 of the respective Annex.

Commercial waste assimilable to household waste - waste resulting from commercial activities, shops, public and industrial service activities, etc., provided it can be stored together or in the same way as household waste according to its type and quantity.

Parks and gardens waste - plant waste coming from gardening surfaces, public parks, cemeteries and lawns located along the streets.

Bio-waste – is the biodegradable solid waste. The biowaste is the household waste containing food waste, green or domestic waste or garden waste, paper and cardboard waste. The selective collection of biowaste (in the "U-U" or "AP" system allows the production of compostable material and the production of a quality material (compost). Other types of waste can be collected and composted, eg. cantines, restaurants and shopping units. By expansion, also the sludge out if the sludge stations that meet certain established quality criteria can be assimilated as "biowaste" and be harvested after composting.

Composting

- a process of decomposition and transformation of solid organic substances by microorganisms (mainly bacteria and fungi) into a stable material that can be exploited in agriculture. The process is controlled in terms of speeding up decomposition, optimizing efficiency and minimizing the environmental and population impacts, can be applied to green waste and municipal solid waste and takes place in two phases: a) Mechanical treatment; b) decomposition (fermentation).

- microbiological degradation process, under aerobic / anaerobic conditions of organic materials, with the formation of CO2, water and humic substances.

Hazardous waste - any waste that has one or more of the hazardous properties listed in annex no. 4 to Law no. 211/2011 on waste regime.

Recyclable waste - waste from or associated with household waste. It includes paper, cardboard, packaging waste, plastic or metal waste.

Pre-collection - is the activity that takes place before collection. It takes place outside the waste collection site by the collection service. The pre-collection regroups all the operations necessary to household waste removal to the place where the picking-up operation takes place by the collection services.

Collection – the waste collection, including the preliminary sortage and storage of the waste with view to its transportation to a treatment plant. (Law 211/2011)

Urban waste collection - is a set of operations consisting of removing waste and sending it to a transfer station, a composting center, a treatment center or a warehouse.

Selective Collection - is a municipal waste management process whereby domestic (household) materials with recycling potential (paper, cardboard, glass, plastic and metal) are recovered and directed to the recycling channels.

This process requires a "source"- composting, a separate collection of secondary materials and their treatment in a recovery center.

"Door-to-door" collection (U-U) - is a way of organizing selective collection where the number of persons producing waste is easily identifiable and the waste storage container is located in the immediate vicinity of the manufacturer's home or place of production waste.

Voluntary collection (AP) - is a way of collecting waste where the waste storage container does not belong to a producer group. One or more containers are located so that all persons who voluntarily deposit their previously sorted waste may have free access to.

Containers are made available to residents either on public roads, or in voluntary collection centers or as well as within large car parks. The most common containers are those for glass collection, paper collection and grid surfaces for collecting plastic.

Operator - any natural or legal person who exploits or controls the installation or has been delegated the economic decision-making power for the technical operation of the installation.

Flow – at the selective collection level, that is at the entrence in the composting centre.

Fraction – at the level of composting process, that is inside the composting centre.

Composting plant – an installation that allows the composting and biological conditioning of the waste.

Emission - direct or indirect release of substances, vibrations, heat out of the installation or of noise from individual or diffuse sources in air, water or soil.

Emission limit values – the mass expressed in terms of specific parameters, concentration and / or emission level, which can not be exceeded during one or more periods of time.

Compost refusal - waste that has been not recovered from the composting operation. Some types of composting refusal may be subject to subsequent treatment.

Reuse - any operation whereby products or components that have not become waste are used again for the same purpose for which they have been designed;

Recycling - any recovery operation by which the waste is reprocessed into products, materials or substances in order to carry out its original or other purposes. This includes the reprocessing of organic materials, but it does not include energy recovery and reprocessing for the use of materials as fuel or for soil backfilling operations;

Treatment - recovery or disposal operations, including pre-treatment for recovery or disposal;

Recovery - reuse - any operation that results in the fact that the waste serves to an useful purpose by replacing other materials that would have been used for a particular purpose or the fact that the waste is prepared to serve the respective purpose in companies or in economy general.

2 BACKGROUND

Composting is the recovery operation of the organic compond in the waste with the purpose of their processing.

Compost is the final product of an organic waste composting operation and it consists of a comminuted and fertile mixture obtained by the total or partial decomposition of organic materials and which can be used to improve soil quality in order to increase its fertility.

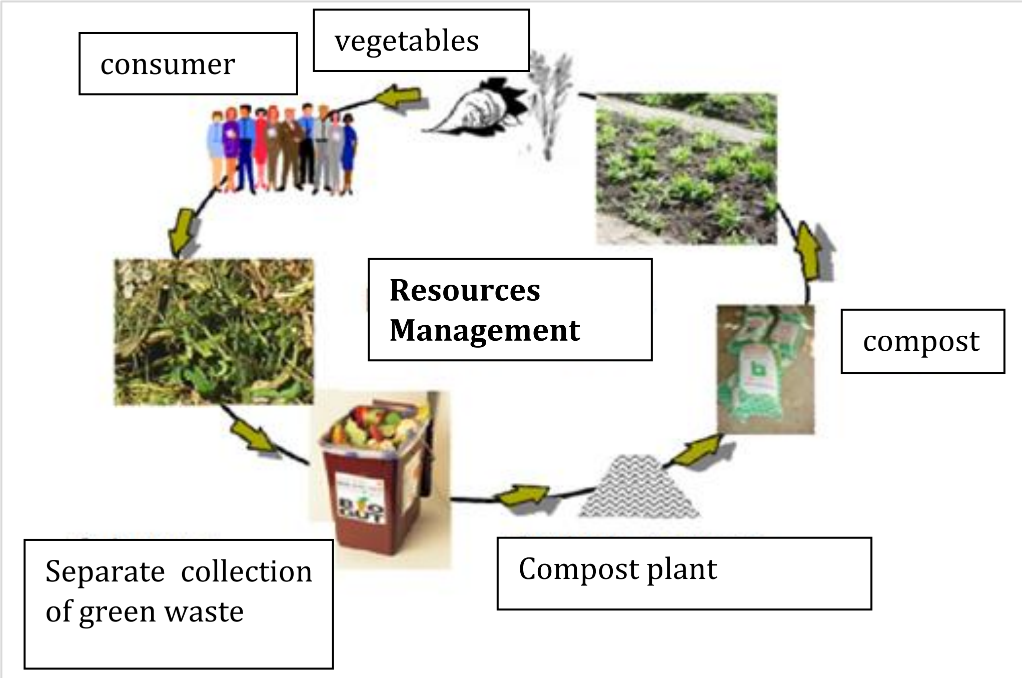
The procedure for the composting of vegetable waste consists of a process of decomposition and transformation of plant waste by microorganisms (mainly bacteria and fungi) into a stable material, which can be used in horticulture and agriculture. The process is controlled in terms of speeding up decomposition, optimizing efficiency and minimizing environmental and population impacts, and it is carried out in two phases: mechanical treatment and decomposition (fermentation) – a microbiological degradation process in aerobic / anaerobic conditions of organic materials, with CO2, water and humic substances formation.

The purpose of composting vegetable waste is:

- compliance with the laws in the field of of recicling and recovery;
- reduction of waste streams to storage;
- obtaining a marketable material, depending on the characteristics, in agriculture or land improvement works (soil improvement);

When mineral fertilizers are not available or they are too expensive, compost is the most important source to provide plant nutrients and adjust soil condition. Today many people appreciate compost as a natural source of nutrients and humus.

Turning materials into compost involves the conclusion of the natural circle of life.



Picture 2-1: Resource management

Waste suitable for composting:

- kitchen waste, public food resulted waste;
- green waste (coming from gardens, parks, vegetation, leaves, branches);
- waste obtained in the timber waste processing industry;
- animal manure;
- agri-food markets waste;
- sludge resulted from cleaning stations of urban waste water.

Composting systems can be simple and unsophisticated in early development countries and mechanized and sophisticated in those countries with a relatively advanced technological development. In emerging countries, this treatment of biodegradable waste has many advantages: low equipment and operating costs fully environment-frindly and at the end of the process, a useful product is obtained.

The decomposition of biological substances is a natural process. The production of compost as a way of using biodegradable waste is a very old process and it has been practiced by the Chinese long before Christ. To adjust the curing process, it is necessary to understand the basic principles of the composting process.

Monitoring of the composting process is very important to provide the optimum conditions in the pile and to obtain a good and useful final product, the compost.

3 HOW TO COLLECT COMPOSTABLE WASTE

Waste that can be biologically treated (compost) is mainly the following:

- the biodegradable fraction of the household and assimilable waste;
- waste coming from gardens and parks;
- waste resulted from markets and food complexes;
- biodegradable residues from the food industry;
- sludge from urban waste water cleaning plants.

Waste mechanical and biological treatment (composting) is conditioned by the type of waste and the collection manner.

Selective collection is a municipal waste management process whereby domestic (household) materials with recycling potential (paper, cardboard, glass, plastic and metal) are recovered and directed to the recycling channels.

This process requires a "source" composting, a separate collection of secondary materials and their treatment in a recovery center.

The biodegradable fraction of the household and assimilable waste

Stages:

a) collection, transport, reception, storage;
b) mechanical sorting for material composting to be recovered in a composting station (plastic, paper and cardboard and metals);
c) special treatment for composting – crushing, grinding, separation;
d) biologica treatment – composting and finishing – by controlling the temperature, oxigen and humidity;
e) final prepation of compost – grinding, sieving, packing.

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Waste resulted from gardens, parks, markets, biodegradable scraps from the food industry

Stages:

a) collection, transport, reception, storage;

b) manual sorting (removal of metals) and crushing (optional);

c) biological treatment - composting and finishing - only with moisture control;

d) final preparation of the compost - grinding, sieving (optional), packaging

In the case of compost obtained from such types of waste, the degree of safety can be easily verified by introducing the compost into a plastic bag, sealing and opening after 48 hours. If after 48 hours the compost smells unpleasant, it means that the finishing stage is not finished.

Benefits

- contributing to material and organic recycling
- reducing the flow of mixed collection for treatment

Restrictive factors (setbacks)

- the effort required of private waste producers, therefore, motivation is an essential factor for a successful selective collection;
- a rigurous management of the selective collection system organization.

***Wastes** that is subject to selective collection*

There are two main types of selective collection:

- selective collection of "clean and dry" waste (glass, paper, cardboard, newspapers – magazines, plastic, aluminum);
- *selective collection of biodegradable household waste or "bio-waste".*

Selective collection of waste depends on:

- ⇒ local context: type of habitat, population density and so on;
- ⇒ nature and number of the flow that needs treating (the recyclable part of the household packaging, newspapers, fermentable fraction of the household waste, etc);
- ⇒ collection methods:
    - door to door;
    - voluntary contribution;

  - regrouped collection or mixed collection, etc.

⇒ organization of collection (frequency of collection, loading equipment, types of recipients of collection vehicles, etc.

4 COMPOSTING TECHNIQUES

4.1. The purpose of composting

The purpose of composting lies in:

- compliance with the legislation in the field of recycling – recovery;
- reduction of waste flows to landfills;
- obtaining a profitable material, depending on the characteristics, in agriculture or land improvement works (soi improvement);

Basically, composting implies two stages, namely:

- mechanical treatment;
- biological treatment (fermentation).

Fermentation

a. *The main factors favouring aerobic fermentation.*

Oxygen in the air. Theoretically, the quantity of air ensuring the necessary oxygen for fermenting mechanically treated household waste is 4,5 - 5 liters of air per kilogram of dry matter (45% moist waste) / hour. Where possible, it is preferable that the amount of air should be increased.

Aeration may be done by various systems, according to the adopted composting process, as follows:

- simple aeration, by overturning the compost piles when composting on otdoor platforms;
- introducing air through perforated conduits in case of composting in piles;
- introducing cold or hot air in the fermentation chambers;
- by a slight depression in the fermentation chamber;
- by continuous mixing with special machines.

These systems may be combined.

Water. Depending on the amount of organic matter present in the waste, the optimum moisture content for fermentation should be as follows:

- when the organic material content of the residues is <50%, moisture must be about 45%;
- when the content of organic matter> 50%, moisture should be about 50 - 55%.

In order to control the fermentation process, the composting material should be protected from rain because too much humidity can lead to anaerobic fermentation phenomena.

Waste composition. This is one of the most important factors in triggering the fermentation process. If the waste has a high content of fermentable matters and the ambient temperature is high, the composting process is triggered rapidly and may be carried out properly. The condition is that the process should be managed by way of introducing the required amount of air. On the contrary, if the waste is low in organic matter, especially during winter, the fermentation is delayed and the introduction of additional air oily damages the fermentation process (leading to the development of unpleasant odours).

b. *Auxiliary factors favouring the aerobic fermentation.*

In addition to the main factors mentioned above, aerobic fermentation is also influenced by a number of auxiliary factors, including:

- homogeneity of the mixture;
- granulation of the waste undergoing fermentation;
- the manner of settling the ground waste in piles or in fermentation tanks;
- slowing the temperature rise rate.

c. *The stages of aerobic fermentation process.*

Compost can only be used in agriculture in a finished (matured) state. Freshly ground waste is very active and can sometimes be used as a warm bed for winter or spring crops.

Prefermented waste may be hygienically satisfactory, but its immediate use is restricted by the above considerations.

Waste converted to mature compost is hygienic and can only be used in agriculture without any health hazards. A compost can be considered mature when the activity of the microorganisms is minimized.

Determination of maturity is done by determining the consumption of O2 (or the CO2 production) by plant tests, by analyzing the physical structure, etc.

The composting process aims at obtaining a high temperature for the destruction of pathogens and the production of colloidal materials of a thermal nature. These two processes are due to the action of microorganisms on organic matter from waste in the optimal conditions of the temperature, air, water environment.

The main phases that occur in the waste fermentation process are as follows:

- ***the latent phase***: corresponds to the time period required for the colonization of microorganisms in the new environment created; this phase starts practically from the storage period in pre-collection and collection containers and lasts until the temperature increases;
- ***the growth phase*** corresponds to the increase in temperature and depends on the waste composition, moisture and air;
- ***the thermophilic phase***: represents the period corresponding to the highest temperature; this phase may last longer or shorter periods, as the environment is acted upon by air or water, depending on the amount of fermentable organic substances and the degree of thermal isolation achieved. During the thermophilic phase, a more efficient action is possible on fermentation.
- ***the maturation or growth phase***: it corresponds to a secondary, slow, moist favourable fermentation, respectively to transforming organic compounds into humus under the action of microorganisms.

Compost is good to be used in agriculture at the end of the thermophilic phase when the product is richer in organic coumpounds. Excessive maturation in the storage leads to extensive mineralization, which makes it lose its soil-friendly effects. This is why, generally, compost should be no more than 3 months in the storage.

During fermentation, organic coumpounds in waste facilitate two simultaneous and antagonistic actions that carbon and nitrogen enter, leading to the mineralization of biodegradable substances, generating on the one hand, the production of carbon dioxide and ammonia and, on the other hand, to the formation of humus, whose role is very important for maintaining the physical, chemical and biological properties of the soil.

d. *The average composition of a compost sample*

Determining the composition of compost, consisting in establishing the physico-chemical properties is made in oder to know the possibilities of their usage in agriculture.

The carbon / nitrogen ratio is a factor that reflects the stage of waste fermentation evolution. The compost obtained may be considered proper for agriculture if it has, on average, the following characteristics:

- granulometry: 90% of the compost should be sifted through 35 mm sieves;
- the carbon percentage should be > 5% of the dry matter;
- nitrogen percentage > 0,3% of the dry matter;
- the carbon / nitrogen ratio between 20 - 30 in the initial waste may lead to a 10 – 15 ratio after composting.

The composting techniques must ensure the elimination of the process alteration risk by:

- speeding up processes by optimizing the altering conditions;
- directing the aerobic process;
- emission verification.

Techniques are based on two basic procedures:

- the static process (composting in piles, composting in cells);
- the dynamic process (composting with altering tumblers, composting in altering towers).

Composting operations and equipment depend on the type of waste to be composted:

- the biodegradable fraction in the household and assimilable waste;

- waste resulted from gardens, parks, markets, biodegradable residues from food industry.

THE CONCEPT OF COMPOST

4.2. Basic knowledge

Biodegradable waste is a major component of household, trade and institutional waste. Biodegradable waste includes, for instance, kitchen scrap, garden waste, paper, cardboard, natural fabrics and wood. The presence of iodegradable waste in landfills, which is inevitable due to their permanent presence in the household waste, is in fact, undesirable considering that it causes gass emissions (it contains methane, strong greenhouse gas which is explosive and dangerous) and instability in the waste landfills.

Most of the time, plant debris is either thrown into landfills or burned. These processes are environmentally polluting, issuing carbon dioxide, polluting air, soil and groundwater.

In addition to recycling paper, glass, plastic and metal waste, it is also useful to recycle household waste, kitchen and garden waste for fertilizer / compost production. The benefits of these methods lie in reducing the amount of waste stored, preserving natural resources and reducing the amount of biodegradable waste stored, which is responsible for generating methane gas, a greenhouse gas.

One of the large groups of methods used to neutralize household waste is commonly known as (biothermic) composting.

Composting is the recovery operation of organic waste components with view to their processing.

Compost is the final product of the organic waste composting operation. It is a comminuted and fertile mixture obtained by the total or partial decomposition of organic materials and which can be used to improve the soil quality in order to increase its fertility.

The composting procedure of vegetable waste consists of a process of decomposition and transformation of plant waste by microorganisms (mainly bacteria and fungi) into a stable material, which can be used in horticulture and agriculture. The process is controlled in terms of speeding up decomposition, optimizing efficiency and minimizing environmental and population impacts, being carried out in two phases: mechanical treatment and decomposition (fermentation) - microbiological degradation process in aerobic / anaerobic conditions of organic materials, involving CO2, water and humic substances formation.

5.2. Pros and Cons for composting

The main **advantages** of composting consist of the following aspects:

- compost is the best mulch and **natural amendment** to the soil and it can be used instead of commercial fertilizers;
- the use of compost leads to **improved soil structure**, improved excessive textures, increasing aeration and water storage capacity, it increases soil fertility and stimulates the development of a healthy plant root stem;
- the organic matter applied by compost provides **food for microorganisms**, that preserve the soil in healthy conditions;
- **diminishes pollution** from landfills;
- helps **neutralizing pH** in the soil;
- nitrogen, potassium and phosphorus will be naturally produced by feeding the micro-organisms, so there will be no need to apply soil amendments or at least fewer of them;
- composting **converts the nitrogen content of manure** into more stable organic forms; even if this involves some nitrogen losses, what remains is less susceptible to washing and loss in the form of ammonia;
- the garbage with a thick bedding (as it is happening today in livestock farms) has a high C:N ratio, which when applied in the field causes nitrogen demand (excess carbon in the garbage leads to the consumption of nitrogen assimilable reserves in the soil by micro-organisms, which becomes not accessible to crop plants); the process of composting these garbage mixtures with a high C: N ratio leads to a reduction of the C: N ratio to an acceptable level so that it can be applied on the ground without producing nitrogen demand;
- **heat generation** during the composting process reduces the number of weed seeds in the manure;
- the use of compost leads to the **reduction of diffuse pollution** from agriculture;

- exclusively compost-fertilized soils offer a surplus of plant nutrients during May-September and a shortage for the rest of the year, which calls for mineral fertilizers' application in parallel;
- in an increasing number of livestock farms, garbage is more of a burden than a valuable thing; garbage deposits are causing important issues especially to farms that buy a large part of the food, or where the number of animals is uncorrelated with the surface available for garbage storage or in densely populated areas; many worries are caused by landfill runoffs from frozen ground and nitrate contamination of well waters; composting has the potential to reduce these shortcomings; composting converts nutrients into forms that are more difficult to leach into the groundwater or are less likely to be spilled by surface leakages;
- ensures the environment protection near zootechnical units and throughout the areas where it is applied;
- it is an efficient recycling method for crop residues;
- replacing a bulky, high in moisture, difficult to transport product, around a small area around the livestock complex with a concentrated, easily transportable, odourless, pathogen free product capable of controlling the development of diseases and pests from soil, which is also easy to store, does not generate flies or weeds issues and can be applied on land at the most convenient time;
- preserves nutrients in the trash; the compost contains a more stable organic form of nitrogen, which is less washable into the groundwater;
- the final product yields more difficultly the nutrients available to plants and can be applied on the field for a longer period;
- a valuable fertilizer is obtained for agriculture, especially for the vegetable and floricultural sectors, which can substitute large quantities of chemical fertilizers;
- obtaining a product capable of reducing the organic matter and microelements deficit in agricultural soils, improving the physical, chemical and biological characteristics of soils and increasing the indices of utilization of nutrients from applied mineral fertilizers;
- it can substitute bedding;
- **the release of residues is combined with soil improvement** in a "natural" manner that does not require very high energy consumption, but requires good management, etc. Composting does not just mean stacking waste products and then wait to have compost in a few weeks;
- it is a method of removing excess nutrients from farms and reducing the area occupied by residue deposits;
- compost is spread evenly on the agricultural land with the existing equipment of units;

- compost is an excellent soil conditioner, it improves the soil structure, has an important contribution to organic matter and reduces the potential for soil erosion; it is the ideal fertilizer for the garden and it is especially recommended for seedlings, as it has an antifungal potential;
- the existence of a compost market makes it a very attractive product; the main buyers are gardeners, vegetable growers, landscape farmers, ornamental plant growers, golfers, etc.;
- compost can be used as biofilter material;
- extending the use of landfills by reducing the volume of waste that is subject to final disposal;
- composting offers the possibility of re-using nutrients and organic fraction coming of farm residues and leads to a new, marketable product demanded on the market, able to increase the quantity and quality of agricultural production.

As it is the case with any other activity, there may be a series of **disadvantages** in composting, consisting of:

- composting requires time and money, **equipment, work and management**; if only farm equipment was used, it would increase the labour volume. It is therefore necessary for medium and large farms to purchase special composting equipment whose cost varies from at least EUR 10,000 to over EUR 100,000 in order to start composting operations;
- it **requires a field** for activities; the necessary surfaces for the storage of the raw materials, the finished compost and for the composting process can be very extensive;
- **odours may occur**, at least in the first phase of the process, products subject to composting often release unpleasant smells, especially if stored for a while before the process starts, some places may require odour reduction measures; odours can also be generated by way of an inappropriate management;
- **weather can affect or prolong composting**; cold and humid weather may prolong the composting process by reducing the temperature in the compost pile and increasing the humidity; heavy and long-term snow may even block the composting process;
- a marketing study and its deployment is needed; which implies an inventory of potential buyers, advertising, transport to points of sale, equipment management and product quality maintenance;
- manure and vegetal remains are removed from agricultural production and given other direction;
- **potential nitrogen losses from manure** are possible; often the compost contains less than half of the nitrogen present in the fresh manure;

- compost **yields slowly nutrients** to plants;
- there is a risk that the business should be treated as a commercial enterprise.

6 FACTORS INFLUENCING THE PROCESS

Microorganisms degrade the material introduced into piles and the decomposition products of the previous population serve as an underlayer in the next phase of the decomposition process. This process depends on various factors. These factors and the relations among them influence the speed of the decomposition process, the decomposition phase and the activity of the microorganisms.

These factors that influence the process are useful in monitoring and controlling the composting process.

Optimal descriptions of all factors that influence the composting process are presented below.

6.1. Quality of the Decomposing Matter

As provided in the definition of "composting", the substrate must be biodegradable. By using a particular material or mixture of different materials entering the process, many properties of the process can be influenced, such as: volume of interstices, moisture or particle size of the material introduced into the pile, but also the quality of the compost. Therefore, the mixture of input materials (the substratum used) is the most important step in producing quality compost.

Easily decomposing matter create the potential for the development of a very intensive microbiological activity and consequently rapid decomposition and intensive heat release. The decomposition of hardly decomposing matter (like: lignins, resin, wax, animal origin-keratin) is slow. It is very difficult to decompose the following: plastic material in general (such as: foils, bottles, containers, sponge and others that are present in household waste to an increasing extent).

Organic substances containing poisonous matters (eg. paints, phenol, tanners, etc.) are frequently discharged from industrial units. They can easily get into the mud extracted from the sewerage networks and industrial wastewater tanks. Also, the final decanters of sewer networks in the cities may contain such materials in a fairly large quantities (eg phenol, detergents, etc.). Compounds containing highly poisons substances cannot be composted locally, or possibly after a very long time and their mixture with easily compostable materials, prevents this process. They have an unfavorable action that can hinder the activity of microorganisms. Strong acid or basic materials have a similar action.

6.2. Granulation and homogeneity of the matter

Small granulation materials provide for microorganisms a much larger attack surface than big size granulation ones (the decomposition process may have a faster rhythm), due to which, during the composting technology, before the start of the process, the material is crumbled quite frequently. This may be beneficial in some cases due to the fact that the constructive elements of the materials which decompose by a difficult microbiological breakdown are tackled, therefore this way it is possible to simultaneously favour the access of the microorganisms to the easily decomposing parts.

An important factor is also the homogeneity and the uniform distribution in the compost mass of the various components with different physical, chemical and biological characteristics and properties. Taking as a whole the entire compost mass of C / N ratios may be favourable, but it may be unfavourable if the components with different C / N ratios are at a great distance from one another and therefore do not complement one another.

The situation is similar when components with a higher or lower moisture content or the dier are unevenly distributed. These unfavourable influences can be eliminated by shredding and mixing the comport, that is its homogenization. The shredding results in a much higher degree of compaction and consequently the decomposition is may move into the unfavourable direction (i.e. the anaerobic decomposition).

6.3. Temperature

Similar to pH values, the temperature appears partly as a result of the formation of decomposition processes and on the other hand as a reaction that causes and modifies the decomposition process. The temperature variation that occurs in the decomposition process favours various groups of microorganisms (mesophilic, thermophiles). Microbes adapted to different temperature ranges, break down various components of matter and produce various intermediate materials. Temperature has its well-established role in purely physical or chemical changes (for example, in the case of high and long temperatures, the construction of fabrics is weakening, endothermic chemical changes are accelerating, exothermic changes are decreasing and material absorption properties are getting altered, etc.).

The systematic measurement of temperature is one of the main conditions for the regulation of composting processes. This way, we have the opportunity to enter the composting processes, as the evolution of temperature expresses very clearly the total action of the factors taking part in the process. Besides the main factors for determining the temperature evolution presented above (the quality of the material subject to composting, the composting process itself and the storage form).

The heat exchange between the decomposition matter and the environment is all the more intense as the temperature difference between the two media is higher. Relative to the mass of matter, the heat exchange is the more intensive, the larger the contact surface of the decomposing matter is with the environment. The heat losses are are higher if the mass of the material is low or if it is stored in large surface shapes (for instance in long, narrow prisms). In case the surface area of the material is relatively small (eg. storing in piles) the gas-air exchange of the material is significantly reduced and thus, the decomposing process may become anaerobic. In such cases, artificial ventilation systems may be required or the material should be flipped quite frequently.

The main purpose of composting is the destruction of human, animal and vegetal pathogens that are found in residues. This can only be done by composting at high temperature (pasteurization). Therefore, it is conditional that the entire mass of the material subjected to composting should be maintained at a temperature above 50 ° C for several days (if the average temperature is higher, the time may decrease, nevertheless, the temperature must not exceed 70 ° C).

Temperature checking

Temperature is a very important indicator in the process of obtaining compost. Measure the temperature in the center, at least in 3 spots of the pile.

External temperature is also important in order to determine the growth and decrease over a week.

The testing procedure:

- Divide the mound into (minimum) three sections to measure temperature in the same spot every day.
- Place the thermometer in the heap and wait for five minutes if you are using a normal thermometer without electronic display. Then, remove the thermometer from the heap and immediately check the temperature.

6.4. Humidity

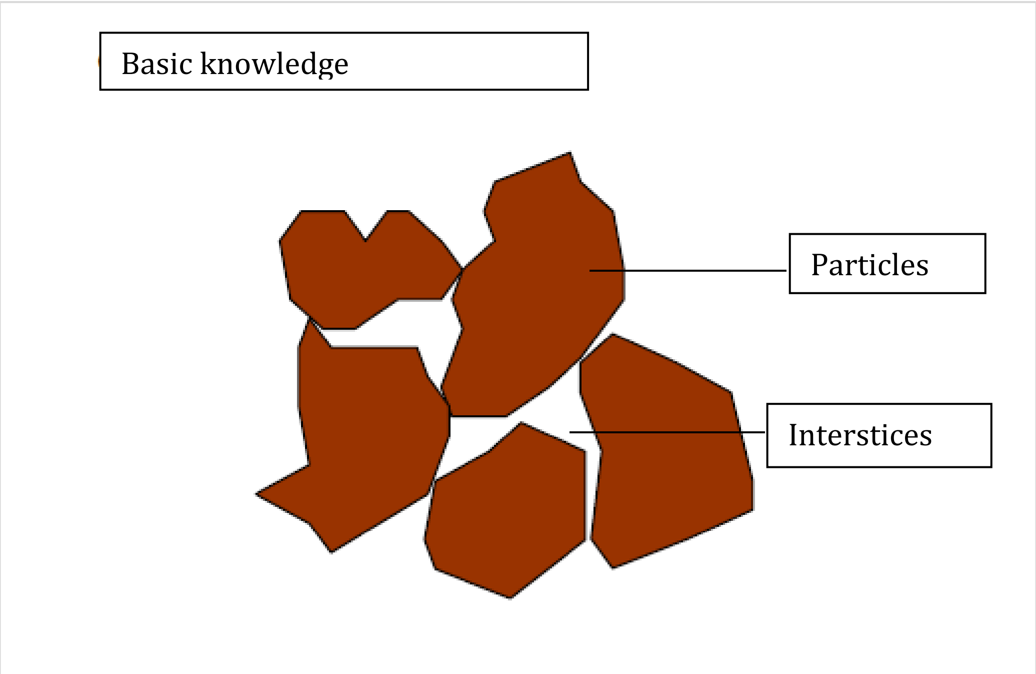
Excessive drying of the matter subject to composting greatly hinders the activity of micro-organisms and, on the other hand, too much moisture content is not favourable as it will lead to anaerobic decomposition ratios.

Free water, closed in particle cells, subject to composting, as well as waters bound to different forces to the particles surface should be considered. Likewise, it should be taken into account that the decomposing process is accompanied by the release of important water quantities. Generally, humidity is considered favourable when the decomposing material is squeezed in the hand and leaves no water.

In composting certain materials (for example cannery waste, vegetable and fruit, melon residues, etc.) after the cell wall decomposition, large amounts of water are released and, as a result, the entire material mass becomes moist, very often almost fluid.

Due to water from rainfalls, excessive moisture of materials to be composted should not be taken into account. However, in case of improper placed waste deposits or in case of inadequate landscaping, accumulated precipitation water, as well as the groundwater may highly moisten the materials subject to composting.

The problem is the very close relationship between water and ventilation. They both nedd inter-particle interstices which can be filled by “free” water and air. The amount, the size and distribution of interstices depend on the input material used.



Picture 6-1: Magnified image of the particles and interstices

Due to this relationship, monitoring of humidity is very important.

Humidity checking

The fist test

It is very easy and fast to measure the moisture content of a compost pile. Record your results (wet, dry, good) in your data collection sheet on "temperature, the fist test and the water sprinkling necessity".

Testing procedure:

- Remove the first layer in the compost mound and take a sample.

- Tighten your fist and press the sample in your hand.
- If there is water coming out of your fist, the material is too wet.
- If the material breaks down or crumbles when you open your fist, then it is too dry.

- When you open your fist, the material should remain cohesive and moist.

6.5. Aeration

Depending on the air saturation, two types of decomposition may be distinguished: anaerobic and aerobic. Knowledge of these two types is very important considering that it is on these two types that the following elements depend to a great extent: the rate of decomposition, the kind of intermediary products formed, the health effect the composting will have and the value of the final product from the point of view of its use in agriculture.

Microorganisms performing anaerobic decomposition can live and grow without the oxygen in the air. They get the oxygen necessary for their development processes out of the decomposed materials, respectively of their products.

In the anaerobic decomposition process, called rotting, a badly odorous odor is produced and very bad odorous materials (ammonia, hydrogen sulfide, indole, skatole, putrescine, cadaverine, various acids, butyric acid, acetic acid, propionic acid, etc.) which attract flies, favoring the deposit of millions of eggs. In the environment of rotting materials, rodents also multiply. The rotten material has a dark color, often greasy, mucilaginous; under it, the earth gets a dark blue hue. The temperature in the decomposition process does not rise above 30-35 °. The decomposition rate is much slower than the aerobic process. In the case of insufficient calcium and magnesium, the material is acidified.

Aerobic decomposition microorganisms mainly use the oxygen in the air for the energy they need for life and growth. In the process of aerobic decomposition, also called rotting, there is no bad odor, we do not have to do with the multiplication of flies and rodents. The mass of matter is very high in mushrooms content, mold, actinomyce, due to which the matter often gets a white color. Because of the rapid decomposition of the produced acids, we do not have to do with a more important acidification. The temperature rises very quickly to 60-75°, especially if the content of decomposing elements is great and the other factors of decomposition influence are also favorable. The decomposition process is much faster than in anaerobic conditions.

There are opinions according to which aerobic decomposition would also produce a series of plant stimulation compounds (hormones, auxins, etc.) due to the intensive activity of the mold mushrooms and actinomycetes. Hence, it has been discovered that on soils fertized by such a compost, plants have been healthier, more resistant to various diseases, as some of the nutrients were already present in this product, therefore their nutritional action was greater.

The process of pasteurization, which takes place due to the high temperature for a long time, in aerobic decomposition (probably under the action of antibiotics resulting from decomposition) destroys human, animal and plant pathogens in a much safer way than in the case of anaerobic decomposition.

Throughout the decomposition process or only in certain phases, one of the two types of decomposition becomes dominant, but at the same time, the decomposition of the other type occurs. Thus, under sufficient air conditions, decay is dominant and characteristic, and the process takes place on the macrosurfaces of the matter particles. Pore decomposition inside the lumps and crumbs is anaerobic. The greater share of anaerobic decomposition can be caused by a too dense compaction of the matter and the fact that in the mass of waste deposited in relatively loose layers, a large number of gaseous products is stored in the existing pores as a result of intensive decomposition. In the mass of the composting material, even in the case of intensive aeration, the carbon dioxide concentration in the internal voids may exceed 1500 times its concentration in the open air and the oxygen content can be reduced to ¼ from its concentration from the outside.

It is more beneficial from all points of view if aerobic decomposition predominates in the composting process, but it is not necessarily exclusive. The processes of the two types of decomposition complement each other.

6.6. The level of pH

The pH value decisively determines the activity of any living microorganism. It may favor, prevent or render this activity impossible. Due to this, the evolution of pH values is one of the important factors, even determinant on the composting process.

The pH range of the microorganisms involved in the composting process is approximately between the limits 4 and 9. In case of acid conditions, mushrooms have a more intense activity, whereas in the case of alkaline ratios – it is bacteria that thrive.

The evolution of pH ratios is mainly determined by the quality of the matter to be decomposed (for example, a low $CaCO_3$ and $MgCO_3$ content matter has insufficient buffer capacity and consequently tends to acidify) as well as by the aerobic-anaerobic ratios. In the case of anaerobic conditions, acidification is favoured, especially where the predominantly vegetable matter (green matter) has preponderance in the matter undergoing composting. In these cases, instead of composting, a silo process (butyric fermentation, propionic acid) will take place.

In countries with limestone and magnesium depleted soils, in order to avoid acidification, it is often necessary to lime-treat the composting matter, as particles of soil and minerals that usually accompany organic residues, are poor in limestone and magnesium.

The multicomponent composition of the material subjected to composting can reduce the risk of acidification.

In order to prevent unfavorable pH ratios, the following main aspects should be considered:

- industrial residues of a purely acidic or basic nature should not get into the matter undergoing composting:
- the possibility of predominantly anaerobic decomposition should be excluded
- the compost should be a mixture of several types of components as much as possible;
- compost mixing should be as intensive as possible.

6.7. The C/N ratio

The proportion of carbon and nitrogen atoms in the bulk material is in a close relationship with the rate of the decomposition process. The optimal carbon ratio (C): nitrogen (N) should be between 20: 1 and 35: 1.

If the proportion is below 10: 1, growth is inhibited by the absence of carbon and if the proportion exceeds 40: 1, too little nitrogen is available. Outside these limits (1:10 up to 1:40), the population of micro-organisms cannot grow.

Actually, the activity of microorganisms is the same, but in the absence of a growing population, the necessary time for the decomposition process to take place, increases as well.

Very important for the C/N ratio are not the results of the chemical analysis, but the ration of the carbon and nitrogen atoms that are available as a consequence of biological recirculation (on a short-term).

Materials that are rich in carbon are, usually, dry materials, such as sawdust, cardboard, dry leaves, branches and other slow decaying wood or fibrous materials.


Materials that are rich is nitrogen are, usually, moist, water-rich materials, such as green grass, fruit and vegetable scraps, various animal dung, manure, leaf-rich plants that rot very *fast*.


In the table below, there are shown average carbon – nitrogen ratios for some of the most common materials used for compost:

High nitrogen content materials	
Horse manure 30: 1	City sludge 6-16: 1
Swine manure 30: 1	Food scraps 15-20: 1
Cattle manure 19: 1	Vegetable residues 12: 1

Bird guano 10-16: 1	Cut grass 19: 1
Vegetable garden waste 30: 1	Green timber 25: 1
Fish 7: 1	Coffee ground 20: 1
Carbon high content materials	
Newspaper 398-852: 1	Paper pulp 90: 1
Corrugated cardboard 563: 1	Leaves 40-80: 1
Sawdust, wood chips 442: 1	Fruit residues 35: 1
Tree bark 100-130: 1	Coniferous needles 80: 1
Corn stalks 75: 1	Straw 75: 1
Nut shells 35: 1	Ashes 25: 1

7 PREPARATION OF MATERIAL

a. Directives on the selection and the use of materials.

The quantitative and qualitative ratios of the materials used for composting and their modification must be determined in advance by appropriate analysis.

It is generally recommended that the compost be produced from a variety of materials, considering that in the composting process they are physically, chemically and biologically complementary to each other, thereby ensuring the increase in the value of the compost.

It is desirable that solid and liquid matters should be **processed jointly** (first of all, human droppings cesspools in the areas lacking communal sewage, the domestic sludge from the individual settling basins or from the communal wastewater treatment plants). The joint processing is also very advantageous from a health point of view, because this method can solve the very difficult issue regarding neutralization of liquid household waste. These two sorts of materials complement each other very well. This mixture should not include – to the greatest extent possible – matters with a water content higher than 90-92%. If this can not be done, or if the amount of solid matter, without becoming too diluted, liquid matter must be concentrated beforehand, absorbing the moisture by adding peat.

It is recommended that poisons or hard decomposing or decomposition materials (eg salted leather waste, resinous wood bark, etc.), **generally industrial residues, should be sorted and composted, possibly separatedly**. These materials hinder or render the decomposition difficult, making it virtually impossible to use compost.

On the other hand, it is advisable to improve the quality of the compost by adding fillings, thus increasing its value of use.

For those basic materials where the mineral content of the soil is low, it is advisable to **add clay, bentonite**, etc.

By this, the formation of useful clay-humus complexes in the decomposition process, respectively in the composting process is favoured. The amount of added matter is about 5-15%.

Of the chemical fertilizers, we are primarily interested in the nitrogenous ones. Those containing phosphorus are not so important, chemical fertilizers containing potassium or other elements are not needed as an addition to composting. The use of these chemical fertilizers is indicated in those cases where the nitrogen and phosphorus content of the materials to be processed is not sufficient and consequently, the composting processes will have a low pace. By supplementing with chemical fertilizers, the value of the use of compost is also increased. The amount of fertilizer added is about 1-2%.

The use of limestone fillers is necessary when the materials subject to composting are poor in limestone. The required amount of addition is about 1-2% (calculated on $CaCO3$). The addition materials should be mixed consistently with the base materials prior to sthe composting process start.

The use of enrichment materials is aimed at sensitively increasing the qualitative characteristics of compost to make it usable for a particular purpose. The aim pursued may also be to eliminate some qualitative features or unfavorable properties. These fertilizers obtained by using the enrichment materials are called enriched composts (e.g., compost enriched with phosphorus fertilizer, lime-enriched compost, etc.).

The degree of enrichment is generally determined by the needs of the compost buyer.

The proper application of enrichment materials should be done not at the start of the composting processes, but after their completion, respectively before the compost valorization. Some enrichment materials dosed at the beginning of the composting may prevent or complicate the composting process (e.g., high lime admixture).

If the organic substances content or the humus content is wanted to be increased, such as enrichment material, the use of lignite dust, peat or mud soil is customary. The maximum amounts (the maximum weight percentage) usable from these enrichment matters are prescribed on the compost standards. The maximum amounts (maximum weight percentage) usable in these enrichment environments are prescribed by composting rules. The purpose of these prescriptions is to prevent the release for free circulation of composting of materials in which preponderance is not compost, but some enrichment matter (eg muddy soil).

The mixing of enrichment matters should be made with great care.

b. Processing, storage and handing over of raw materials. The large amount of residue arriving daily must be weighed with the appropriate tilting scale. Determining quantities will make it easier to track inventory and settle them. This purpose also corresponds to the usual weighting machines used in practice, but in large composting installations it is necessary to install automatic scales, coupled to accounting machines in which the necessary data are recorded in an electronic system.

The scales are also used to determine the quantity of final product dispatched from the plant and the quantity of other materials (residues, slag, etc.). The scales must be located on the entrance-exit ways of the composting plant site.

Longer storage and stocking of raw materials should be avoided as much as possible. These materials spontaneously decompose, the process being accompanied by an unpleasant smell and the multiplication of flies. The capacity of the plant and the sizing of the storage tanks has to be so that the materials arriving on a daily basis be continually processed. For sizing, the time when the composting unit receives the highest amount of residue must be considered.

The previous storage bunkers area must be fitted with doors that open and close automatically. Dust suction installations must also be installed to prevent dust and odor from spreading out of the transport vehicles.

Waste storage bunkers must be in accordance with the conveying systems coupled downstream on the technological flow.

In smaller and medium-sized installations, bunkers are coupled with underlying transport installations where downloaded materials are transported continuously. In these bunkers, the materials are often piled up causing disruptions in continuous transport. To prevent these interruptions, the walls of the bunkers are either vertical or cone-tipped downwards. The residues are transported by conveyor belts having a 1-2 m width, whose capacity can be changed by changing the transportation speed. The height of the layer is most often 30-40 cm. Bunkers perform a dual function. On the one hand, they store the waste, and on the other hand, they dose it for further processing.

The storage capacity of bunkers equipped with belt conveyors is often insufficient as they are limited by the width of the walls. In larger installations, besides bunkers equipped with conveyors, deep storage bunkers are built, which are periodically emptied by grab cranes. These are also used for the transport of large-scale waste, sieve leftovers from combustion furnaces, as well as for the destruction of vaults formed as a result of the accumulation of residues.

In large installations, it is recommended to separate storage and dosing operations, consequently, to separate deep hopper construction from dosing facilities. The dosing installation, located at the required height above the deep hopper represents a smaller hopper, usually with a capacity of 10m3, equipped with a belt conveyor.

The most suitable means of transporting the residues are the multiple claws grab cranes. This kind of equipment, as opposed to the two semishells, have the advantage that they can pick up the bigger residue. In the latest types of installations, automated programmable grab cranes are used so that a single operator, as required, can simultaneously drive multiple cranes.

In addition to the above-mentioned dosing plants, special facilities are used to mix the prepared and shredded along with the sludge from the domestic waste water treatment plants, dosing the two types of matter, either by weight or by volume. The sewage sludge from domestic waste water treatment plants is dosed with screw dispensers, adjusting the quantity by either advancing the screw or by varying the speed of rotation.

For a continuous, uninterrupted handling of the materials in the composting plant, various means of transport, installations and equipment are used. Their correct choice, the proper design and delivery of the transport flow, are of particular importance as they can at some point become narrow, bottleneck areas in the processing capacity of the plant.

For the transport of materials inside the installation, the most suitable are the textile insertion rubber belt conveyors or – for specific purposes, plastic belt conveyors which are usually used for the transport of the raw waste. This type of transport has the advantage, besides its relatively small weight, of having a fairly high transport capacity, it is resilient and durable. The disadvantage lies in that they operate at a tilt angle of up to 20°, especially when transporting fresh waste. The tilt angle can not be increased by vulcanized rubber wedges on the belts and, on the other hand, wedges can make it difficult to clean the belts. The bandwidth of these conveyors must be at least 800-1000 mm.

Horizontal or low-slope conveyor belts are also used for sorting operations (for example, when sorting large quantities of waste materials that can be directly used as raw materials).

For short distances and high levels, simple conveyor belts can not be used; for this purpose, multi-fold conveyor belts are used. Chute conveyor belts are used for transportation at a steep tilting angle. In these types, the corrugated side plates, together with the pieces transversely attached to the strip, form a box-shaped space. This installation can operate up to a 35 ° tilt angle.

For vertical transport, bucket elevators, rack sluice gate conveyor belts or casing conveyor belts are used. Bucket elevators have the disadvantage that when transporting waste, the waste gets stuck inside the walls of the well and the buckets, causing the installation to stop. The drive chains also wear out quickly. In terms of sustainability, the rack conveyor belts are the most advantageous.

For these special types of conveyors, during transportation, the material does not move, neither is it moved. Compared to these, in the chute and chain conveyors cases, the waste is conveyed by way of sliding, by pushing devices, fixed to an endless chain, mounted on the bottom of a fixed gutter.

The advantage of this device is that the chain can be moved inside a horizontally, vertically or tilt directed item and the place of waste loading and unloading can be freely chosen.

The chain chute conveyor has been initially used in the composting installations in Switzerland for the transport of minced and prepared waste. When using this type of conveyor for transporting fresh waste, there have been quite frequent bottlenecks.

In the case of short transport distances, vibratory conveyors as well as coil conveyor systems are used in composting plants. Vibrating conveyors (by waste slipping into the chutes) have the advantage of having a high resistance to mechanical action, and during transport, they develop an aeration and homogenization effect. Screw conveyors are used for horizontal transport of small quantities. Their disadvantage is that the friction developed during transport requires a significant drive effort and due to intense wear, gutters and coils wear out quickly. Screw conveyors are not suitable for the transport of raw waste and sive scraps, as textiles are winding around the spindle shaft and block its movement.

c. Preparation of raw materials for maturation

The preparation is aimed at accelerating the biochemical reactions ocurring in the decomposition process. In the preparation process, prior separation of the non-decaying materials and those which can be directly used as raw materials and the balancing of the granulation, physical and chemical composition of the waste must be ensured. For microorganisms to decompose intensively organic substances, it is necessary to mix the materials as homogeneously as possible.

One of the most important operations in the preparatory phase is sieving, with the purpose of sorting the materials to be processed after granulation.

The screens are basic facilities for composting units that generally perform the following operations:

1) Separation of the fine particle size materials;

2) Subsequent sieving of the shredded waste with the purpose of separating the ungroundable parts;

3) Subsequent sieving of the previously mechanically cured waste with the purpose of separating the non-decaying or hardly decomposing materials;

4) Sieving the final compost with the purpose of obtaing a better-quality compost;

In order to accomplish these operations, several types of screens are used in other industrial fields. Rotary drum screens are simpler and more reliable, but they require a high construction height. However, oscillating screens clog faster.

For streamlining the technological flow, it is necessary to ensure the operation of the screens without clogging. Although the screens ensure self-cleaning during operation, it is still necessary to install simple cleaning devices. The danger of clogging is caused by textiles, plant debris, some plastics, and large glass and ceramic shards. For some types of sieves, a longer sifting length must be ensured, ensuring thus a longer sifting time.

For the pre-screening operation, any type of sieve is suitable, provided that they have a 8-20 mm aperture size. This phase generally does not require the complete separation of waste. Fine fractions, obtained by prior sieving, are subsequently mixed with compost materials. Separation of fine fractions will also facilitate preparation operations (eg. manual sorting, magnetic separation, pre-crushing, etc.). For the subsequent screening of the crushed waste, a rotary drum or a vibrating sieve with 25-40 mm openings, are also used.

The sieving of premature materials is an operation harder to achieve, especially when the waste is processed in the mix with sluge from urban waste water cleaning stations. If after subsequent screening, a crushing is made, then the screens with 15-30 mm hole diameter are enough.

The wet material sticks to the sieve and forms a film. In such cases, vibrating sieves are more appropriate as the action of the acceleration force produced is much better emphasized. To prevent clogging with fibrous matter above the vibrating sieves, chains are moved slowly back and forth. This is also the goal of the cone-shaped rotating drum, inside which a device always cleans the surface of the sieve.

Attempts have also been made to prevent clogging by way of heating the sieve surface. In this regard, the problem of obtaining a drying effect of the compost has been raised, the subsequent sieving having to follow immediately after drying. If further crushing is required after further sieving, it is not necessary to use a fine screen.

For the extraction of ferrous material in composting units, different types of magnetic separators are used. The most common solution is to mount the magnets in the upper drive drum of the belt conveyor. However, the extraction capacity of this system is limited by the small diameter of the drive drum. The yield and withdrawal capacity of separately mounted magnetic rolls is higher. They are mounted in the majority of cases in the way of the falling material from the strip, so that during transport, the ferrous materials stick to the drum and the non-magnetic ones will fall immediately. After rotating the roll at 180 °, when reaching the non-magnetic area, the extracted ferrous material will also fall.

Magnetic strips are also used to extract the iron scrap. They are actually a short belt conveyor mounted above the main waste conveyor, strong magnetic magnets being mounted in the middle of the magnetic strip. The magnetic strip pulls the iron out of the trash carried beneath it and throws it in the process of rotation in the non-magnetic area.

Iron cannot be extracted entirely from the mass of waste with the help of magnetic separators, Some iron residues such as cans, shaving blades, needles, etc. are embedded in the litter and in most cases, practically they cannot be extracted. Organic decomposing substances may remain in cans, which, on further processing of the iron, may cause certain drawbacks. The best separation of iron can be done with rotating magnets when the residues are in a vibrating chute, using several series-mounted separators, one after the other.

With view to reducing volumes, in many composting units, iron is pressed into bundles and recovered.

Hard materials (eg. stones, bottles, ceramics, non-ferrous metals, etc.), even in the broken form, worsen the quality of the compost. Only those with relatively large size can be removed by being sifted from the other materials. Due to this, it was necessary to introduce other installations to extract the lesser fractions of these hard, undesirable materials.

Thus, various types of such installations have been built, operating according to different principles.

Such an installation used is the separation hopper, where the crushed material first arrives in a drum, out of which, a high-speed steel rotatable bar throws it out through an orifice. According to the ballistics laws, residues with different weights and shapes are thrown at different distances, falling into different bunker compartments. The hardest materials with the greatest specific weight reach the furthest compartments whereas the lighest materials (probably organic substances) get into the closed compartments.

A simpler installation is the thrower separator where the material thrown from the high-speed belt strikes against a slightly tilted plate. The hard materials are deflected from the plate at a greater distance and thus on the shield of a roll properly mounted beneath the plate, they will roll in a hopper, opposite the lighter materials.

Lately, a sloping strip separator has been developed. The materials fall off the conveyor on another sloping separation strip under it and then moves slowly upswing. Specific heavier materials roll down on the tilted strip in the opposite direction to its movement, until the lightest ones are carried further. The speed and the angle of inclination of the strip can be modified as needed.

For the separation of the hard materials, besides the installations presented, which are used in other industrial fields, composting units have been built into other special types. So far, no complete separation of the hard materials has been achieved by any kind of installation.

A blowing or suction device is used to extract other light waste, whose share is constantly increasing (for instance: plastic material, foil, etc.).

The aim of the crushing is to facilitate and favor the activity of microorganisms by increasing the attacking surfaces and a more homogeneous mixing of the materials. In general, household waste before maturation should not be crushed, as the maturing process is carried out in continuous motion and ventilation, and the necessary shredding occurs on its own. However, practical experience has shown that the breakdown capacity can be increased by prior crushing.

For the crushing, various crushing machines (mills) are also used in other industrial fields, but special facilities have been built for waste shredding.

Some of the first installations used are the drum screen (Egsetor) built decades ago. The installation is a twin concentric rotating sieve with a distance of 100-110 mm between the bars of the inner drum. The diameter of the holes on the outer screning drum is 15 mm. The rotation speed is 15 rpm. In the matter subject to a rotational movement, due to the friction forces, there is a crushing effect, which is quite insignificant. Due to this fcat, the installation can be considered a sieve, and the remaining half must be removed. The fine material obtained from the vast majority of units is used to cover the waste deposited in the enclosure.

The crushing screen (Siebraspel) is a special installation, specifically designed for waste processing for composting. The installation is a large diameter (5.5 m) double metal tray. The upper tray is a metal plate consisting of partial segments with holes of 22-25 mm in diameter and partly with fixed embedded shredding blades. Above the top tray, several arms, fixed on a shaft mounted in the center of the trays, rotate at a 8-10 rpm speed. The waste loaded on the top of the tray is always pushed forward and rotated. During rotation, the soft components break easily and, along with the fractions smaller than the diameter of the holes, they fall on the lower plate. Hard or non-crushing materials will remain on the top plate where the rotating arms remove them 2-4 times / 8 hours by opening a lateral hole. The share of the noncrushed scrap (Raspeltest), generally composed of hard and textile materials, is about 8-20% of the initial mass of raw waste, depending on their properties and the size of the holes. The materials gathered on the bottom plate are removed through a discharge port by means of cleaning arms also fixed to the central shaft, rotating over the lower tray.

The crunching effect of the crushing screen is much higher than that of the drum screen; nevertheless, the amount of material remaining on the screen is still quite large and it contains significant quantities of materials which can be used in compost.

The use of the Dorr-Oliver crushing screen is quite extensive, being used in small and large composting plants in many cities in Europe.

Picture 7-1: Dorr-Oliver crushing screen

The reduction of the amount of material remaining after the crushing screens, thus ensuring the maximum utilization of the raw materials for composting, can also be accomplished by the pre-crushing of the residues in hammer crushers. Hammer crushers of many types are used in the composting technique and various production capacities.

In hammer crushers, hard materials in the waste can be ground to a very fine grain. The raw materials thus obtained are more rich in mineral substances and ballast than those obtained from other crushing installations (eg. crushing screen).

The disadvantage of the hammer crusher is that it requires a lot of energy for its operation, as well as the fact that it wears out very quickly. Hence, depending on the composition and the grain size of the waste, after the processing of 800-1200 tons of waste, the hammers must be replaced, the hammer replacement takes about 1.5-3 hours.

The wear degree of the crusher elements can be reduced by the pre-screening of the residues , using for this purpose an 8-10 mm sieve, of the types previously described, respectively by prior separation of fine fractions of mineral materials, which give a grinding effect in the crusher.

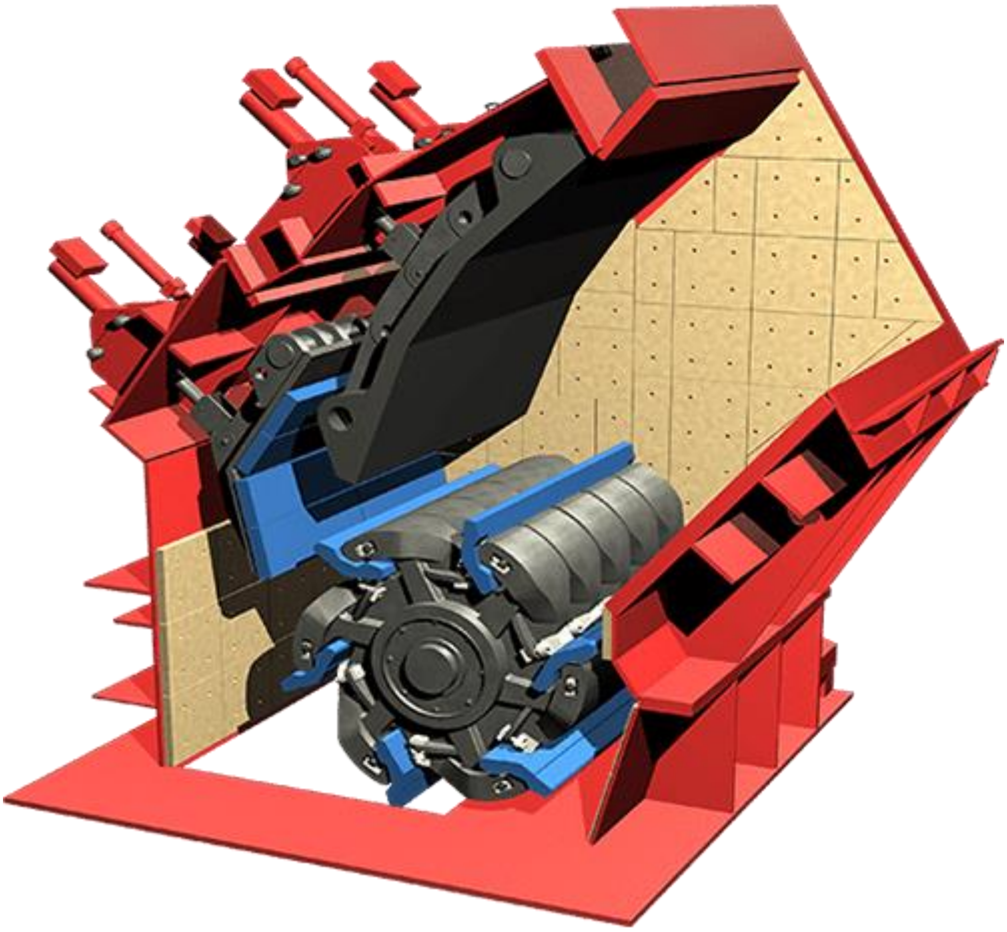
Hammer crusher installations (Büttner type, Germany). The crushing is done with two rotors with the same rotation direction. The installation is generally used for fine crushing. The capacity of the plant is 10-20 t / hour.

It is also convenient that, prior to the starting the crushing operations, that the raw materials usable directly be **hand-sorted** and that the iron content be extracted with magnetic separators.

The dust produced during the operation of crushers and especially those provided with hammers, is released into the atmosphere and pollutes the environment, even in the case of their indoor operation. When installing the plant, this aspect must be considered and the aspiration of the released dust should be ensured.

In case of using different materials and, above all, in case of additions to the waste, it is necessary that proper dosage and mixing of the materials should be ensured. The mixing should be as smooth as possible and the dosage should be made as such as the additive material does not prevent the decomposition processes (the moist content, the C/N ratio).

Hammer crusher (HAZEMAG type, Germany). It is used for pre-crushing. The energy consumption needed to shred a ton of waste is much lower than that for the hammer crushers. Filling hole dimensions are 800x1100mm or 1800x3000mm. Components: drive shaft, grinding wheel, prismatic striking-grinding bodies, gutter for waste loading.



Picture 7-2: HAZEMAG Hammer crusher

Waste mixers

The choice of the mixing installation type is determined in all cases by the quality of the sludge. The most appropriate type is the two-axis mixer, which ensures very good mixing of the rubbish and the sludge from the waste water treatment plants. In these cases, after mixing, it is necessary to loosen the material to prevent compaction.

For mixing the sludge from domestic sewage water treatment plants, coil stirrers are used in some rare cases. Both the two-axis and the coil mixers have a continuous flow, in some cases also concrete mixers, the type used in the construction industry, are used. In these mixers, the mixing is done on the principle of free fall; in the concrete mixers, the sludge from the liquid or dry water treatment plants can best be mixed.

For some of the mixing installations, dispensing mechanisms are attached to, regulating the quantity of the materials to be mixed.

In the case of a too dry matter, a certain amount of water should be added in some cases for mixing. The simplest and most effective method for wetting is spraying with water sprinklers that can be mounted on top of a belt conveyor.

8 THE QUALITY OF COMPOST

The quality of the compost depends on the type of waste treated.

Green waste is of superior quality to the **biodegradable fraction of household and assimilable waste** and is, therefore, superior in quality.

Composting process control

The control of the composting process can be carried out within the composting installation by measuring mainly two process indicators: pH and temperature. The following tables show the optimal average range of variations for the sizing of buildings and installations.

pH indicator control – average values

Week	1	2	3	4	5	6	7	8
pH value	6,5	7,2	8,5	8,0	7,4	7,2	7,1	7,1

Temperature control

Number of days	1 - 7	8 – 15	16 – 20	Over 16
Temperature maximum value (°C)	70	50	20	< 20

Obviously, during operation, for each composting installation, specific indicators, which should be followed, may result (oxygen concentration, the maximum allowable value of hydrogen sulphide which does not represent the transition to anaerobic fermentation, etc.) in order to ensure a good composting quality.

Even theoretical values presented in the above tables can be modified in operation, according to the quality required to compost.

9 SPECIFIC ELEMENTS OF ENVIRONMENTAL PROTECTION

If not controlled, the composting process may create many environmental issues, such as water, soil and air pollution, discomfort in inhabited areas due to noise, vibrations and unpleasant odours, fires, etc.

Many of these problems can be minimized from the design stage or the correct operation of the constructions and installations.

Water Quality

Water pollution in the area of composting stations may be due to the leachate in the rainwater.

The Leachate

The leachate resulting from the green waste composting plants can have a high load on organic substances (expressed in CCO-Cr), phenols and nitrates, a concentration resulting from the fermentation process itself.

Producerea de levigat poate fi redusă sau prevenită prin monitorizarea și corectarea nivelului de umiditate în compost și prin folosirea de spatii de compostare acoperite.

The production of leachate can be reduced or prevented by monitoring and correcting the moisture levels in compost and by using covered composting areas.

In the case of uncovered composting areas, there may be organised collection channels, storage and pumping into compost of the leachate as required (ensuring the optimum moisture content of the compost).

The excess leachate can be introduced into the sewage system, stored and pumped into the city's sewerage network or in the drainage basin.

Discharging into the city sewarage network (directy or by cesspit emptier) must be done based on laboratory tests so as to establish compliance with legal requirements.

To reduce the risk of groundwater pollution, the following measures are necessary:

- designing a special network for leacheate collection;
- collection of leachate in the treatment areas and post-treatment and controlled discharge from the premises;

- the use of waterproofing systems for potential contaminated surfaces (clay, synthetic materials).

Discharged water from the premises

The discharged water from enclosures is defined as:

a) pluvial waters, polluted by substances collected inside the station premises;
b) water used in the production processes and which are polluted with pollutants specific to production processes (eg. water that is used for washing means of transportation, production bays, etc.).

Discharged water from premises that has been in contact with the received waste, partially treated waste, non-cured waste, washing water and rain water, collected on certain surfaces cannot be discharged from the premises without pre-treatment.

The system used is for collection, passing through a separator and discharge into the city sewerage network or a drainable basin.

The discharge into the city sewerage network (directly or by cesspool emptiers) should be made based on laboratory analysis to establish compliance with the legal requirements.

Odours

Unpleasant smells may occur during collection, transport, storage and composting, especially if anaerobic composting phenomena occur.

Anaerobic composting can lead to the generation of odorous compounds such as organic acids, mercaptans, hydrogen sulfide, ammonia, etc.

Noise

The noise is generated by the cars entering and coming out of the station and the work equipment.

The work equipment (mills, crushers, sieves, tumblers, etc.) may generate a noise level of over 90 dB.

The measures to reduce the noise level in the neighboring areas fall into:

- the proper construction and exploitation of the buffer zone;
- the inclusion of technical specifications for the production equipment (provision with noise reduction systems);
- a proper maintenance of work equipment;
- establishing a schedule to limit traffic inside and outside the premises (hours and days).

Infectious germ carriers

They are defined as “small animals or insects that carry diseases”.

Rats, mice, flies, mosquitoes, etc are "potential” visitors of a composting station.

The necessary measures to be taken are keeping the enclosures and bays clean, maintaining aerobic processes and appropriate temperatures in the composting and curing areas, etc.

Fires

If the compost gets dry and it becomes too hot, there is a danger of spontaneous combustion. Organic compounds in the compost can instantly catch fire even unde conditions of 25-45% humidity.

The necessary means to be taken are as follows:

- ensuring a height of 3 m for the piles of compostable material during composting;
- maintaining a compost temperature of maximum 60 ° C.

  In addition to these measures, specific to the composting process, the enclosure must be designed with a supply system and a fire reserve tank and a fast access road for intervention vehicles.

An additional and very important measure is to ensure that, during the operation, the station will not become, even on the short term, a depot of waste oils, dust accumulated in the vicinity of composting and conditioning equipment and other flammable materials.

Wind-driven residues

Wind-driven residues in a composting station may become a source of pollution and discomfort for the neighboring areas. They are mainly plastic and paper bags that certain waste has been brought into and small parts of these are to be found after pretreatment in the compostable material. These residues can be controlled by way of:

- transporting wastes in covered means of transportation;
- reception, processing and packing recyclable materials in enclosed spaces;
  collecting them in the premises after each operation taking place in open spaces.

Volatile Organic Compounds (VOC)

Volatile organic compunds (eg. benzene, chloroform, trichloretilene) pose a potential risk for the composting stations. These subtances may occur in the composting station if certain types of timber waste has been admitted to composting even if they contain solvents and paints.

The combination of forced aeration, waste mixing and a high temperature can release VOCs in workspaces and / or in the atmosphere.

This process takes place during composting and VOCs are discharged into the atmosphere either directly (composting in open spaces) or through ventilation systems (composting in enclosed spaces).

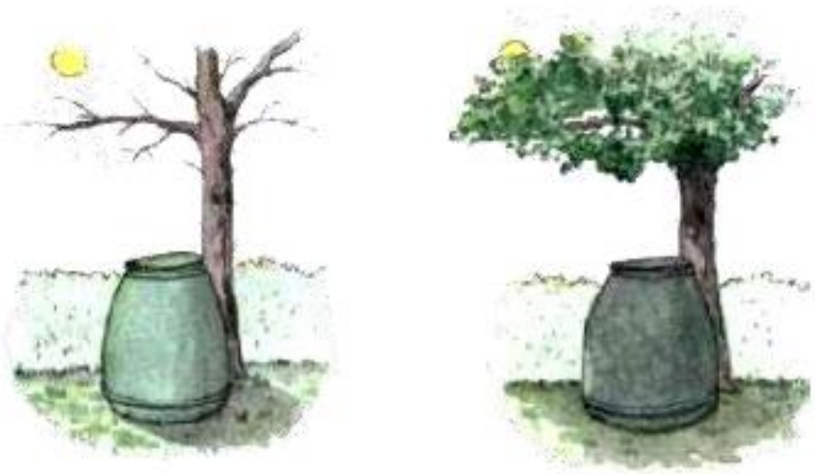
Elimination techniques are very expensive and it is preferable to use measures to limit the occurrence consisting of a very careful examination of waste reception and non-acceptance of waste that can generate the appearance of VOC by treatment.

10 INDIVIDUAL COMPOSTING

10.1 Compost size and location

The compost should be about 1 cubic meter. Larger and smaller particle sizes result in slowing down the composting process. la încetinirea procesului de compostare.

The compost is to be placed in a shady place, the sun ray leading to the oxidation of organic matter.



Picture 110-1: Advantageous placement of the individual composting unit

The compost must be placed directly on the ground to facilitate de access of the soil organisms to the compost pile. It has to be positioned close to the areas where vegetal remains are produced. It should be located close to a source of water, without stale water, in a sheltered place without strong winds that can slow down the processes.

Picture 110-2: The optimal placement of the compost pile

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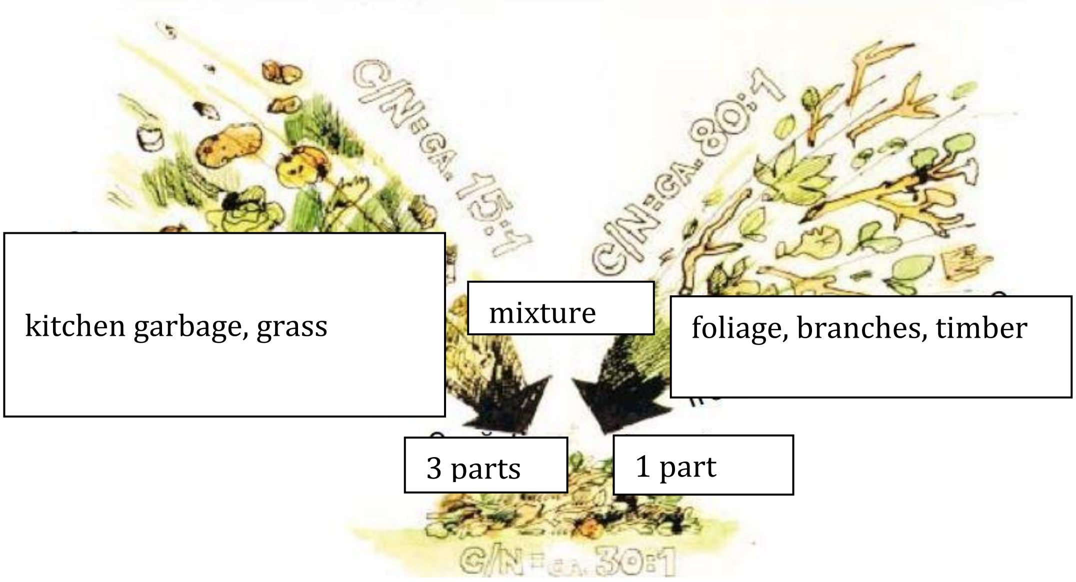
10.2 Compost materials



Picture 110-3: Optimal ratio of the materials to be composted

What materials should be introduced in the compost

In order to easily calculate the C:N ratio, we are offering a simpler, easiler to apply rule: 2 parts green matter, 1 part brown matter. The result will be the one expected and, even if problems occur, they can be solved either by adding green matter or by adding brown matter.

What should the compost contain:

- Vegetable kitchen scraps;
- Cardboard and paper;
- Hay and staw;
- Leaves;
- Coffee ground;
- Egg shells;
- Feathers;
- Seedless weed;
- Cut grass;

- Hair.

What should not be added to compost:

- Ash;
- Citrus;
- Meat;
- Cheese;
- Oil;
- Bones;
- Sick plants;
- Cat and dog feces;
- Treated wood;
- Plants or turf that have been treated with pesticides.
- Non-bio-degradable materials such as: metal, glass, plastics.

10.3 Composting methods

Composting methods are diverse and the materials used have a wide range. You can find here several container models for composting.

Composting in a pit or a ditch

Composting in a pit or a ditch is very simple and at hand for everyone. Actually, the method involves digging a pit or a 40-50 cm deep groove where it is desired to start a garden or expand one, fill it with vegetal remains and cover it with previously dug earth.

This composting system has two advantages: reduced need for watering and no need to overturn vegetal remains.

Picture 110-4: Example for composting in a pit or a ditch

Composting steps:

The compost will be located near the area where vegetal remains are produced.

30-50 cm depth pitches or trenches are to be dug here. In case planting of fruit trees is desired, composting in a pit is recommended. This has to be approximatively 50/50/50 cm, and in case you should want to make a garden bed for your future garden, dig a 50-80 cm wide ditch (depending on the breadth of the bed) and 30-50 cm depth.

The removed soil is placed on the edge of the pit so it can be used to cover the pit later.

The pit id filled with vegetable scraps, following the instructions regarding what to compost or not.

The pile may be covered in earth at the end of the process or during the intermediate stages. The soil initially dislodged for covering may be used, so you will get a semi-elevated layer. For 5-6 months, microorganisms will decompose the scraps and you will get a fertile soil.

This method of composting is recommended to be done in early autumn and compost can be used late spring or early spring to sow and plant it with vegetables or trees.

A variation of this composting theme is the digging of a simple hole (at least 30 cm deep) among the plants already in the garden. The pit will provide support for the plants around it, and later on it will merge with the rest of the garden.

Container composting

Composting in containers can be done in 2 types of containers: stationary and rotary. For both types of containers, it is necessary to periodically overturn vegetal remains to provide oxygen to the compost heap.

Stationary containers can be made with walls of wire fence, wooden boxes or pallets.

Rotary containers can be built from a support and a barrel with a door to feed the organic matter.

This way, the container is easy to rotate, and composting can be done more often, thus speeding up the composting process.

In the case of the stationary container, direct contact with the soil allows the benefic organisms to consume the vegetal remains, thus helping to transform them more quickly into compost.

Composting installations made of wood	Composting installations made of plastic	Household-made composting piles

Picture 110-5: Examples for container composting

Stages of stationary container composting:

An approximatively 1m^3 container is purchased, depending on the quantity of vegetable waste.

A 10-15 cm layer of thin branches or straws is lain in order to achieve the drainage and initial aearation of the pile, the composting matter is added in 5-10 cm layers. A layer of nitrogen rich matter (N) is placed, followed by a carbon (C) rich layer; the process is repeated up to the height of about 1 meter.

After each layer addition, water will be sprinkled so as to ensure an appropriate moisturization.

Manure can be added over a thicker layer of carbon-rich matter (C) and then cover it with another layer of carbon rich matter. The manure contains a high amount of nitrogen (N) and it will help speed up the composting process.

The compost hull will be covered with tarpaulin or plastic foil. When you overturn the heap, you can add more items to be composted. If the pile was built in the spring, compost could be used no sooner than 5-6 months later, whereas if it was made in autumn, the composting process takes 8-9 months. In the case of a rotary container, it is important to consider that the C: N ratio should be balanced, that it has a suitable moisture and that the aeration container is rotated.

Composting in a 3-container system

Composting in a 3-container system is very effective. For this method, 3 stationary containers are built next to one another, each of $1m^3$.

Picture 110-6: Exemplifying composting in a 3-container system

Composting steps:

A wooden 3 meter length and 1 meter width container, with 2 sheets of wood of 1 meter width, every one meter, is required, so as to obtain 3 compartments, every one being $1m^3$. A roof to cover the containers should be built. There can be only one, covering all compartments or one for each container.

On the first overturn, the compost will be transferred into the middle container, and for the next one, it will be placed back into the first container, repeating the process until the first container is completely filled.

After filling the container, no further operation is to be made so that the composting process is completed.

After the first container is filled, the composting is started in the next container.

As the amount of compost and temperature increase, the vegetable matter returns to the 3rd container, the returns are repeated from the container 3 regularly to the second container, until it is filled. The final place should be the 3rd container.

After the 3rd container is filled, no further operation is to be made so that the composting process is completed.

The compost in the first container can be used and the filling of the 2nd container is made. The finished compost in the first container must be used until the compost in the second will be overturned so that the heap from the 2nd container may be overturned.

In this system, it is important to always have an empty container available to be able to overturn the pile of the others.

This is a composting system very easy to be used in any garden.

Quick composting

Usually, the composting process lasts between 5 and 9 months, here is a a way to get compost within a month.

This composting system can be built anytime from spring to autumn in urgent situations when you need compost.

The composting method involves the elimination of pathogens and weed seeds by temperatures up to 70 ° C.

This method is called the Berkley method since it was developed at the University of California at Berkeley.

The procedural difference between this method to the others is that plant debris must be prepared in time, thus having the biomass necessary to get it fully activated.

Picture 110-7: Exemplification for a quick composting

Steps in composting:

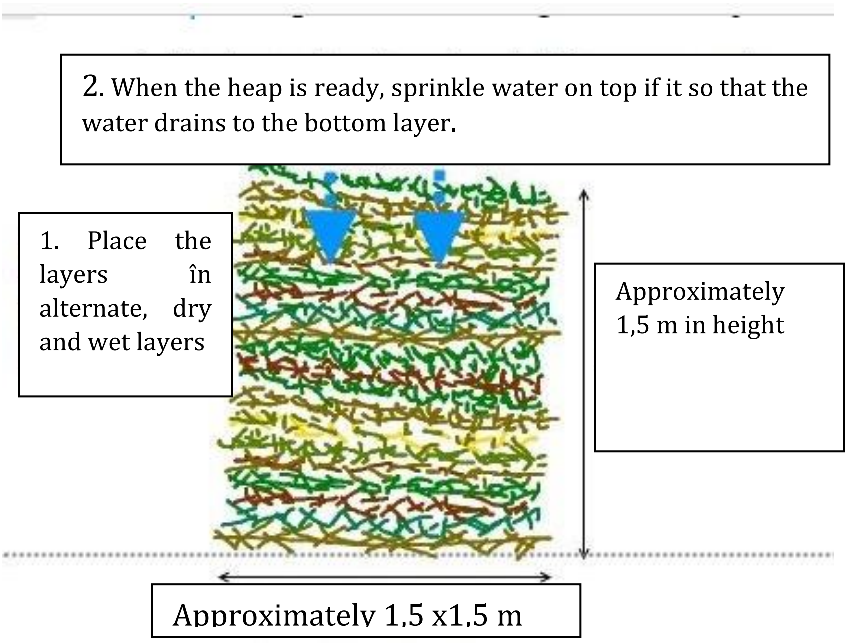
A compost pile of 1,5/1,5/1,5 m is to be built in open field. As it is built in a container, it would be harder to handle. The pile can be built in equal layers of matter, rich in carbon and nitrogen.

In this method, the volume will be higher, requiring a larger biomass to enable faster activation and to obtain a high temperature.

After each layer, water should be sprinkled eavenly.

In the middle of the layers, add an activating layer that can consist in nettle, comfrey, yarrow or a matured compost layer.

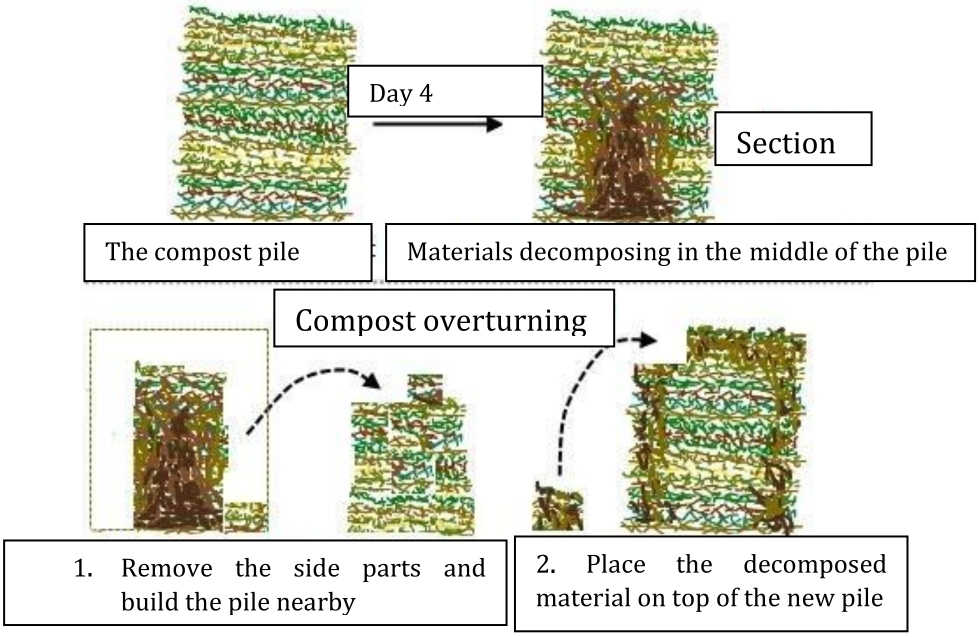
Humidity is checked daily, kept within normal limits to avoid slowing the composting process.



Picture 110-8: Composting stages

Four days later since the pile formation, the compost should be overturned so that, the material on the edges, that has not yet begun to transform into compost, should get in the middle of the pile, whereas what was inside the heap, already decomposing, should get on the outside.

Five or six day after the compost pile formation, the temperature inside reaches 70°C, which leads to the occurrence of a white mould, which is in fact, a thermophilic bacterium that helps accelerating the decomposition process.



Picture 110-9: Composting stages

The pile is overturned every two days. After 18-22 days, the pilereaches a final form, it gets cooled and the compost is good to be used.

In case of a rainy or cold wheather, the pile is covered with a waterproof material so that the composting process is not slowed down.

10.4 Composting mistakes

The composting process is a simple one, but errors can occur, leading to the irreversible destruction of the plant material.

Among the errors made in case an unpleasant smell comes from compost pile:

- **the C:N ratio is wrong,** if there is too much N loaded matter. For correction it is to be completed with fine sawdust (or any other material rich in C) in the area where the odor comes from or when the heap is overturned.
- if the pile is **too damp and nonaerated**, anaerobic decomposition begins. In this case, place a heap of branches on the compost perimeter right next to it and overturn the pile over these branches. It will act as a drainage system that will not allow water to stagnate around the compost and will help at the same time to ventilate the pile. Add straws at pile overturn when needed.

- if the pile does not get composted, it means that **it does not contain enough water**.
- if the pile **does not get enough warmth**, it means that the compost l**acks nitrogen**. In this case, add freshly cut grass or kitchen waste.
- it is **contraindicated adding animal products** in the compost, eggs, cheese, meat. They release a very umpleasant smell in the decomposing process.
- avoid adding **seed weed**, as they will spring in the area.
- Do **not add diseased plants** or plants that have been attacked by pathogenic fungi or bacteria. They risk infesting the result compost, with the risk of transmitting diseases further to the plants in the garden where compost is administered.
- do not add **cat or dog droppings** as they can contain pathogen agents, that are harmful to humans.

Comparison between cold and hot composting

Cold composting

Advantages:

- accesible method to those less experienced in gardening;
- a small space for composting is necessary;
- low water and labor consumption;
- low nitrogen losses.

Disadvantages:

- slow and sometimes incomplete decomposition of the organic matter;
- only a part of the weed seeds and pathogens is destroyed;
- limited control of decomposition;
- a lower compost production.

Hot composting:

Advantages:

- rapid and complete decomposition of the organic matter;
- almost total distruction of weed seeds and pethogenic germs;
- total control over decomposition processes.

Disadvantages:

- high water and labour consumption;
- large space alloted to the composting ramp;
- high nitrogen losses.

Biological features of the compost

Compost can contain pathogens from the products subject to composting.

To reduce the risk of disease, compost will comply with certain rules. Where compost does not contain raw materials known to have a high load of human pathogens, the following criteria shall be considered:

- for the composting method in the container, solid residues will be kept at 55 ° C or above for 3 days;
- under the circumstances of platform composting, solid residues will be maintained at 55°C temperature or higher for at least 15 days during the composting period;
- the pile will be overturned at least 5 times during periods with high temperature;
- for the composting method in aerated static piles, solid residues will be maintained at 55°C ot higher, for three days. It is advisable to cover the pile with a layer of insulated material, such as mature compost or wood chips, to ensure that the entire surface subjected to composting is exposed to teh required temperature.

Compost quality

The compost is of a good quality if it shows the following characteristics:

- it is a homogenous product of a dark bown or black colour;
- the smell is earthy;
- the size of the particles is less than 1,2 cm;
- it is a stable product, that may be stored easily and does not lose its qualities;
- it does not contain viable weed seeds;
- it does not contain phytotoxins or visible contaminants;
- its pH ranges between 6,0 – 7,8.

11 METHODS OF COMPOSTING AT INDUSTRIAL LEVEL

Composting methods are mainly distinguished by:

- overturning technique applied to the material to be composted;
- running the biological process;
- the aeration technique for the fermentation process;
- duration of the intensive fermentation process;
- the degree of maturation of the finite material.

Composting processes:

- composting in open or covered piles;

- composting in tunnels or in rows;
- composting in the fermentation chambers;
- composting in cells;
- composting in tumblers;
- composting in towers;
- rebound composting.

Depending on the capacity, the composting stations are classified into:

- small capacity composting stations: 1.000÷3.000 t/year;
- medium capacity composting stations: 3.000÷10.000 t/year;
- large capacity composting stations: >10.000t/year.

The general trend in composting units is accelerating the decomposition processes. This can be achieved by the proper preparation of the raw waste and by the addition of air (oxygen) in necessary quantities for the organic substances' decomposition.

On purchasing equipment and installations, one should take into account not only their purchasing price, the labour or the energy spent to operate them, but the cost of spare parts, maintenance as well as the downtime losses.

From a technical point of view, in establishing the types of installations, means and machinery, the basic requirements are as follows:

- simple and massive (reliable) construction
- a large enough section to allow the rapid flow of matter without bottlenecking embedded cross-sectional features;
- as few rotating parts as possible, easy to be maintained and replaced;
- closed (covered) drives;
- as little directional changes as possible in the material routing stream; as much as possible resistance to corrosive action and to mechanical wear.

The technology required for composting developed in different types of plant, even for similar operations, the number of installations used, their location and sequence may differ a lot.

The classification of composting units is grouped into 4 categories, namely:

• composting without crushing;

• composting after crushing

• prematuration composting without crushing;

• prematuration composting after crushing.

Composting is grouped into 3 main categories, namely:

1) Open composting system (the entire composting process takes place on open open ground;
2) Closed composting system (the entire composting process and all work operations take place indoors);
3) Partially closed composting system (part of the process - for example, pre-maturation on a longer or shorter time - is spent in enclosed spaces, and then composting is done on open ground).

Open systems can be classified into two groups, depending on whether or not a pre-treatment of the waste is done.

Closed systems can be classified according to whether during the period of waste maturation, it is in continuous motion (static), respectively, if it is moving, but only periodic (transient).

11.1 Open composting system

11.1.1 Open system without pre-treatment of the material - Van Maanen

Residues transported to the composting unit are unloaded and stacked on the composting land in prismatic heaps of 6 meters height. The unloading and stacking operations are carried out with the use of rotating grab cranes, deployable by rail or by truck grab crane. Maturing in heaps takes 6-8 months.

Maturation in dumps takes 6 to 8 months. Large-scale waste (metal boxes, cardboard boxes, wooden crates, other packaging means, etc.) left in the waste heap, forms large voids within it, accumulating the air needed for decomposition. Matured material is sieved without crushing. The iron is extracted with magnets and the foreign ballast bodies are separated by ballistic separators out of the sieved materials. The materials remaining after sifting, are stored and used to fill various pits.

The process allows composting relatively large waste quantities by way of reduced mechanical means. Investment and exploitation costs are quite low. The maturing time is very long. The amount of residual material is high and the quality of the final compost is often a poor one. Due to the long composting time, the required land area is very large and because of the atmospheric pollution phenomena, it must be placed as compared to the inhabited areas, at a distance of at least 500 m. These types of plants / composting units are in operation in the Netherlands.

11.1.2 Open material preparation system – Brno

This process is a large composting unit, similar to the Van Maanen system, which operates on open ground with maturation in 4 to 6 meters high and 8 to 10 meters wide, processing multiple types of waste (household waste, sludge from sugar and alcohol factories, other industrial waste, lignite dust, etc).

Waste is pre-crushed and sieved. Liquid sludge from domestic sewage treatment plants is transported to the composting plant by way of pumping, or transported in tanks. The mixing of sludge with waste is done by spreading with a special installation. The material is mixed by grab cranes, twice.

Aeration during maturation is not appropriate due to the fact that decomposition processes can become anaerobic. As a result, these types of composting units can be located in remote areas. Such a facility was built in the Czech Republic near the Modřice locality, 15 km away from the city of Brno.

Likewise, a composting unit of similar character works at a distance of 15 km from Prague, near Jeneč, with the exception that the residues are not crushed beforehand. To this composting facility / composting plant, only fine grain waste is brought from waste incineration plants in Prague and instead of the sludge from domestic wastewater treatment plants, a mixture of 15% of human faeces and an important amount of peat (31% of the weight) is used.

The composting plant near Prague produces annually 40,000 tons of compost, while the one near Brno, an amount of 100,000 tons.

11.1.3 Open system involving material preparation – Baden-Baden procedure

In this composting unit, the means of transport download the collected waste into storage tanks built of reinforced concrete. From these basins, the waste is loaded with grapple cranes onto a belt conveyor and transported to a closed building where they are screened. Fine fractions are partially conveyed to open-air composting, where they are used to cover prisms. From the coarse fraction, the large size waste is manually sorted, and the iron extracted with magnets and pressed into bales. The compostable materials are mixed in a mixing drum with sludges from the domestic wastewater treatment plants, that are fermented and dried on drying beds. The mixture is transported by vehicles on the composting ground and stored in 3, 5 meters high and 8 meters long stacks. Maturation lasts 8 months without the material upheaval. The temperature in the stacks reaches 65 to 30°C. For ventilation, a series of perforated concrete pipes are mounted in the longitudinal direction. The gases released during the decomposition process are aspirated through the above mentioned tubes, fitted with fans and placed in a 25 meters high chimney or under the grid of the combustion furnaces of the cogeneration plant, if any. Stacks are covered with mobile roofs

After maturation, the materials in the composting ground are milled with a hammer crusher and screened. Residues left after sieving are burned in the combustion furnaces of the plant or used for fillings.

Due to the long composting time, the process requires a relatively large area of land. Insufficient ventilation occasionally causes a series of disturbances in the decomposing processes (decomposition processes slow-down, odor, etc.). When the prevailing wind direction is not favorable, the smell released in the decomposition process is also felt in the city. As a result, it is recommended that these types of installations be located in remote locations (at least 500 m).

The first unit of this type was built in the town of Baden-Baden (Germany) where the process name comes from. The unit was built next to the centralized sewage treatment plant. It works periodically (during winter, it is not operational).

11.1.4 Open system including material preparation – Dorr-Oliver

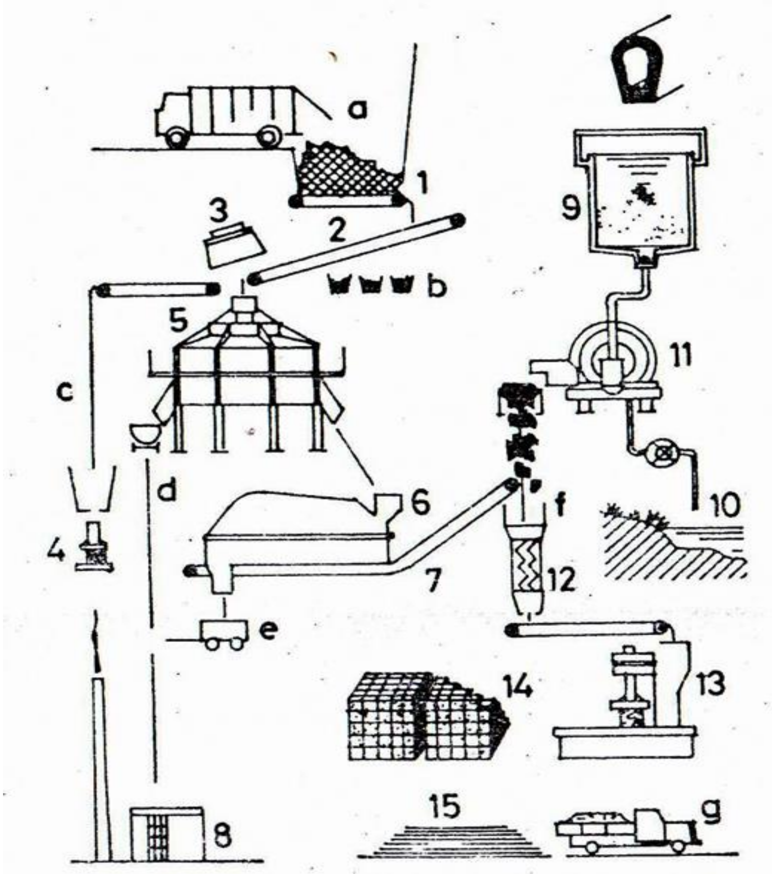
The essence of this process is the special crushing screen made by the Dutch company Dorr, based on which, the raw material before maturation is not only sifted but also crushed.

During maturation, as a result of insufficient ventilation, it may happen that the process becomes anaerobic. In such cases, the material should be overturned, or aerated by way of punching venting holes. The amount of residue remaining after sieving is very high. The area required for this process is relatively large, and also requires considerable manual work. The technology is quite simple.

11.2 Partially closed composting system

11.2.1 Brikollare (Caspari-Meyer) - static system

Based on this process, the crushed waste by the crushing sieve (Raspelel) or in hammer crushers, is not matured (composted) in a loose storage condition in the open air, but are pressed in the form of bricks (briquettes) with a content of water of about 50% after having previously been mixed with sludge from household wastewater treatment plants, dehydrated by filtration. The pressed bricks are stored in sheds covered, not too high. The pellets thus stored for 10 days molde very hard, undergoing a very intensive anaerobic decomposition process. The temperature in the matter reaches over 60 ° C, due to which fact it dries very quickly. As a result, about two weeks later, the decomposition processes slows down, practically the material is preserved. Approximately three weeks after pressing, the stored material is loose (the moisture content dropping to about 20% during this time). If necessary, the briquettes are crushed and stored outdoors in prisms with a height of 3m. By moistening and after a three-month storage, a mature compost can be obtained.



Picture 11-1: The technology process of Brikollare system: a-fresh waste; b-sorted materials; c-iron; d-sifted materials; f-dehydrated domestic sludge; g-compost.

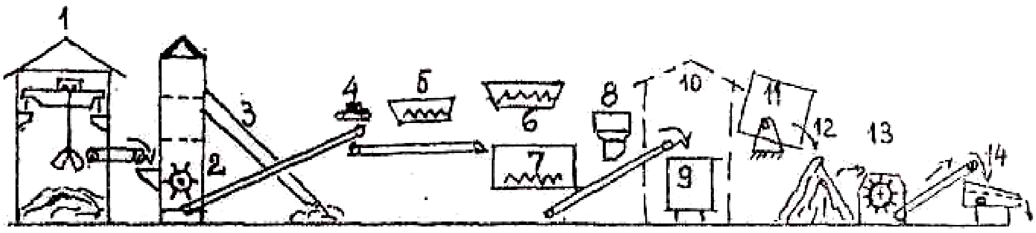
With this process, the raw material is treated in closed spaces and stabilized by preservation, not by maturation. As a result of the short maturation time, the process requires a relatively small area and the sludge treatment resulted from cleaning stations is also an advantage. On the other hand, the multitude of operations leads to the significant increase in the operation and maintenance expenditures.

11.2.2 Prat Sofraine - static system

Based on this process, developed in France, raw residues are composted in large maturing cells (60-100 m3), placed in closed halls.

The cells designed by Prat-Sofraine are actually wire mesh stalls, where the raw material is top loaded without any prior treatment. The raw material is stored in these stands for 5 days and the temperature of the decomposition process is measured by a thermometer; the waste height in these cells is 3m.

The cells are sized so that the amount of daily waste should fit into a single cell or possibly into several. The circulation of air in cells is ensured with bars funnel-shaped stacks and at certain time intervals, the mass of waste is pierced with sharp-pointed steel bars. For the ease of handling, wheel-moving cells have been proposed and built.



Picture 11-2: **Prat-Sofraine procedure**. 1-bunker; 2- hammer crusher; 3- infrared separator; 4- magnetic separator; 5- compost dispenser; 6- domestic sludge dispenser; 7- mixer; 8- chemical reagents basin; 9- maturation cells; 10- cell storage bay; 11- cell discharge system by tilting; 12- posterior maturation prism; 13- grinding installation; 14- screen rotating drum.

The temperature of the waste in the cells reaches 650C. The products are harvested either for fresh compost or are stored in large prisms for further composting with no overturning.

The premature process time is limited, the residues are practically completely processed. Investment costs are relatively low.

The process was generally applied in France in some small towns (Toulouse, Narbonne, Tarbes).

11.2.3 Biotanc SGEA - static system

Based on this process, the pre-crushed raw material is deposited in 5m high tent - shaped enclosures (biotanks), moving on rails in these enclosed spaces (biotank), waste is prematured for 2-3 weeks.

Waste is introduced into the tent through the top by means of a rotating belt conveyor. The sockets placed sideways and below the tent provide air blowing to the freshly loaded waste.

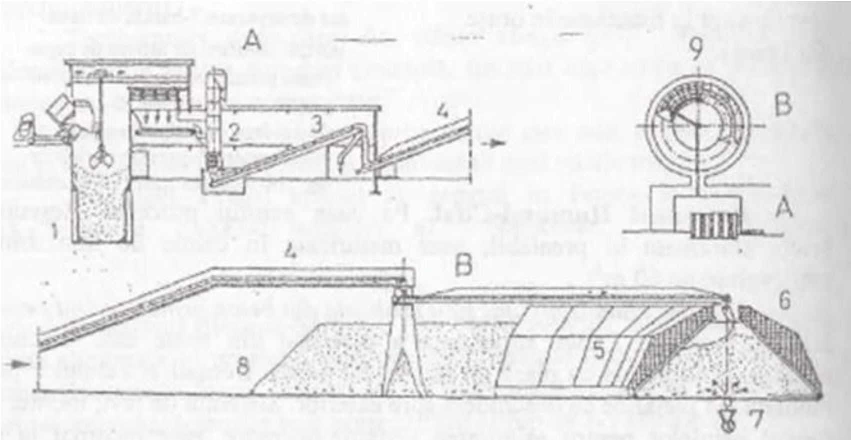


Figura 11-3: Biotanc-Sgea procedure 1-bunker; 2- crusher; 3- magnetic separator; 4- belt conveyor;5- maturation biotank (tent); 6- moistening installation; 7- air discharge; 8- subsequent maturation.

After maturation, the biotank is shifted and, without opening or mixing the content, the waste is still matured for 2-3 months, in prisms. The prism has a ring shape and the biotank comes back to the starting point after approximatively 8 months.

The Gondard plant combined with the separation of raw materials is used for crushing.

The feature of the process is that, after premature crushing in the movable biowaste tank, the maturing is continued outdoors without the movement of the material.

Advantages: a relatively small unit, the waste material is low, facilities of this type are in operation in cities in France.

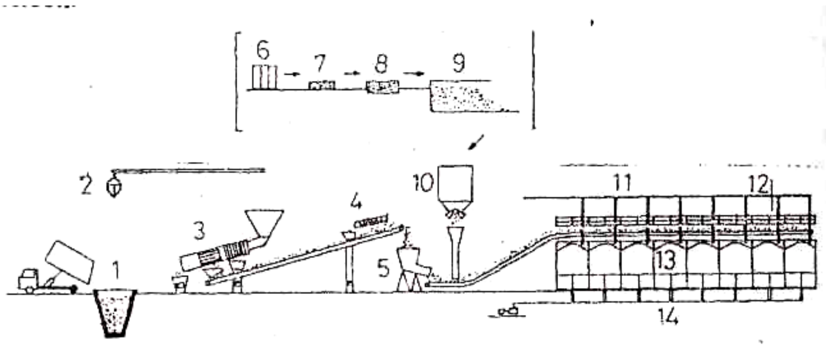
11.2.4 Humusol Cifal - static system

Based on this process, the raw crushed waste is matured in large cells (60 m3 volume).

The Humusol-Cifal cells are made of reinforced concrete with the side walls closed. The upper part of the rear wall is open, the hole being closed with a wire mesh. On the front walls of the cells, metal doors, opening outwardly, are mounted.

The pipe system, mounted on the bottom of the cells to provide the necessary ventilation, is connected to an external air distributor. Loading waste into cells is done with a chain conveyor in a gutter.

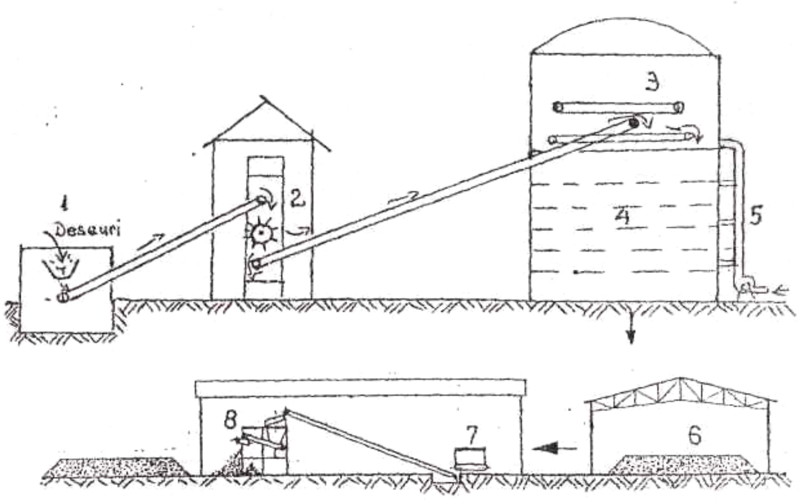
The raw material is previously crushed (screened) and mixed with a special product containing bacteria. One week after the cells are loaded, the metal doors open and the material is removed using mobile grapple cranes, then it is further stored in prisms to continue the maturing process. The actual process is similar to the system for process continuing, with the exception that the material is downloaded from cells with mobile grapple cranes, which at the same time ensures mixing.



Picture 11-4: The technological scheme of the Humusol-Cifal procedure:
1-bunker; 2- grapple crane; 3- rotating drum screen; 4- magnetic separator; 5-hammer crusher; 6-waste waster sludge dispenser; 7-mixer; 8-mixer; 9-seeding material storage cell; 10-dispenser; 11, 14-water installation; 12-movement area; 13-maturation cells.

11.2.5 Thompson - transient system

The raw material prepared is matured in tower-shaped cells in which 5-6 cells are placed, one after another. The bottom plates of the cells are perforated and can be opened by being folded downwards. Pre-crushed waste is loaded with a conveyor belt in the upper cell. The waste is stored in each cell for one day, then by opening the bottom, it will successively fall into the cell immediately below. Thus, once-a-day moved waste is stored in the tower for about a week, during which time the premature process will take place. After this time, the premature waste is deposited for further composting in outdoor sheds.



Picture 11-5: Thompson (Carel-Fouché) procedure technological scheme:
1-storage hopper; 2-hammer crushing installation (Gondard); 3-distribution strip; 4-maturation tower; 5-venting installation; 6-subsequent maturation; 3-dosing tank; 8-subsequent screening.

11.2.6 Dano biostabilization - transient system

The principle developed by the Danish company Dano consists in maturing the waste without crushing it into a large diameter (3.5 m diameter) revolving cylinder, mounted with a slight slope, having a relatively small rotation speed and continuously forced ventilated by air blowing and, in the vast majority of cases, waste is mixed with the addition of rotting domestic sludge.

The length of the cylinder is chosen according to the machining capacity required. The longest cylinder to date is 28 m. The cylinder is generally mounted out in the open, but there are also cylinders that are located in closed halls.

The uncrushed waste is intruduced at the top end of the cylinder by way of a sliding through conveyor. The cycle time lasts 3-5-3 days, when the components of waste that easily disintegrate, decompose to some extent (gets stabilized). During the cylinder rotation, the waste is mixed and a certain grinding effect occurs. The fresh air to favour decomposition is produced by fans and introduced in the inner space of the rotary drum by the piping system mounted on the outside. Appropriate venting inside the drum is required only when it is loaded with uncrushed waste. The air saturated with gas and vapors resulting from the decomposition process is discharged through a soil filter. The goal is to filter off the foul odor.

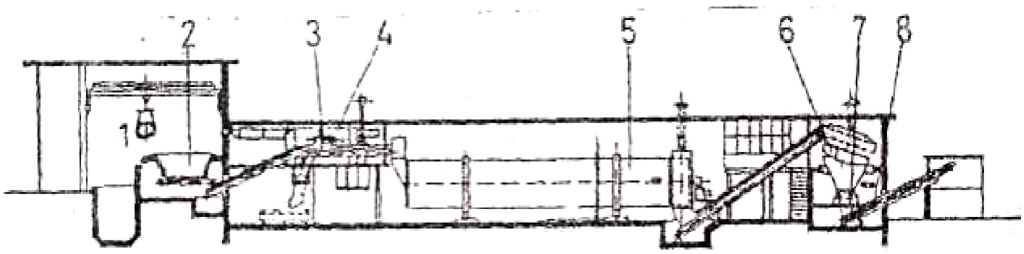


Figura 11-6: The technological scheme of Dano biostabilization procedure: 1-storage hopper and grapple crane; 2-dispenser; 3- magnetic separator; 4-manual sorting strip; 5- maturation drum (biostabilizer); 6-vibrating screen; 3- hammer crushing installation; 8- belt conveyor for discharging the screen scraps.

The material discharged from the rotating cylinder is sifted, crushed with hammer crushers, further matured outdoors and stored in prism molds.

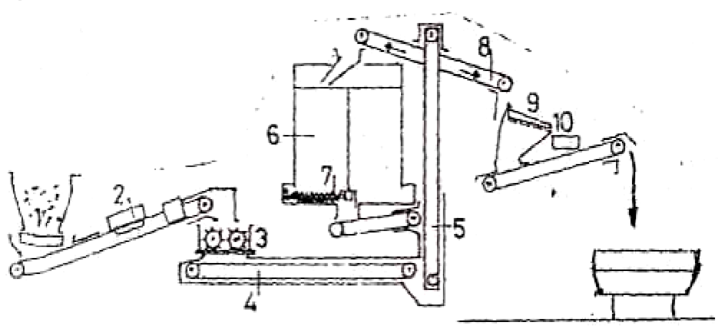
This type of installation requires a relatively small area, there is no danger of bad odors or insect propagation, and as a result, it can be achieved even in the perimeter of the localities. As a result of grinding and screening, the degree of raw material use is very high and the amount of the waste matter is reduced. Due to the high cost of the maturing drum, the investment costs are quite high.

Such types of units are currently made in all parts of the world, in over 100 cities, in the form of small, large and medium sized units. The major larger installations known in Europe are in Edinbourgh, Leicester, Rome.

11.2.7 Humboldt - dynamic system

Crushed and loaded waste at the top of the tower is carried by a motion-driven plate by an endless screw, mounted at the bottom of the tower. There are ventilated ducts in the tower, which penetrate to the its bottom. From the experience so far, it is better if the waste is crumbly broken, because it is already provided with an appropriate series. Ventilation would have been favored even more if hard materials had been removed before maturation.

The decomposition of the continuously moving residues in the maturing tower is not satisfactory, as the raw materials are deposited at 10 m height, a high pressure is produced and the phenomenon of self-compacting is produced, the air being propelled d only in certain ventilation ducts.



PIcture 11-7: The technological scheme of the process:
1-storage hopper; 2-magnetic strip separator; 3-hammer crushing installation; 4-(vibrating) belt conveyor; 5-elevator; 6-4 chamber maturizer (hygienizer); 7-screw dispenser; 8-belt conveyor; 9-screen; 10- magnetic separator.

In the city of Landau (Germany), there is a similar composting unit operating under the name of the Herbold-Diefenbacher process. This process is distinguished by the fact that the maturing towers have a trapezoidal section. In this process, before maturation, a two-stage screening is performed besides crushing. The residues are roughly crushed, after which a new sieving and crushing is done. After the second sieving, the middle fraction of the waste is recycled, and the rest of the raw materials are burned. Mixed sludge from domestic sewage treatment plants is also mixed in the fine, crushed material. In this system, no further sieving is practised. In order to provide a better ventilation, the fan preheated air is inserted into the towers.

11.2.8 Thomas Maturation tower - dynamic system

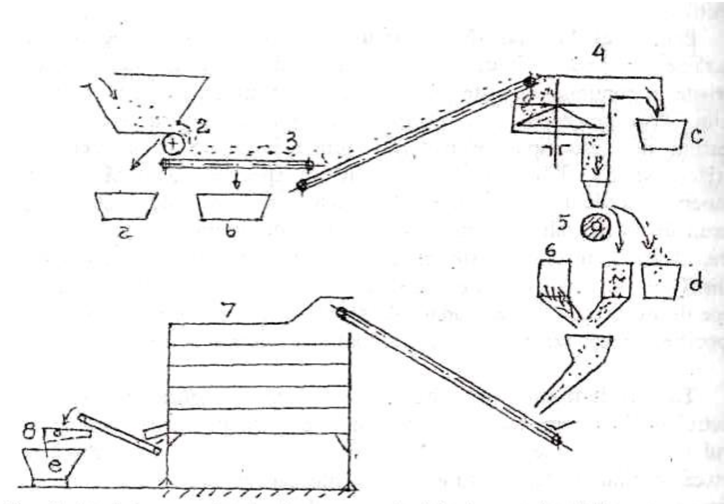
It is a single-story building with a diameter of 3 - 5,5 meters, the number of floors is 3 to 10. On a spindle, mounted in the center of the tower, four rotating arms are fixed to each floor, which continuously move and mix the raw materials on the storey floorings.

The arm-mounted pallets are plow-shaped and by their proper positioning, the raw materials are moved to each floor, alternately from the outside to the inside and vice versa. Through existing floor openings, on each floor, the raw materials fall from the upper floor into the lower one.

The raw materials loaded on the uppermost floor, are moving continuously and blending to the lowest level in 24 hours. Two pipe systems are connected to bring the fresh air and the exhaust gases to the side wall of the tower. Fresh air is provided either by natural drafting or by forced ventilation.

The advantage of the process consists in the fact that the continuous movement and mixing of the loaded raw materials, as well as the embedded ventilation system, ensure the intensive and rapid decomposition of the residues. In these ripening towers, a fresh compost can be obtained after 24 hours. The closed and storeyed construction of the whole system favors the placement of the composting unit on a relatively small field, being easier to achieve.

In these types of towers, only the use of fine waste is allowed, as the long and fibrous one, by clogging the holes or being wound on rotating arms, can cause operating disturbances, and will greatly increase the force required to rotate the arms. The most important disadvantage of this process lies precisely in the disturbances stated. Installations of this type known in Europe are in Italy, Switzerland and Greece.

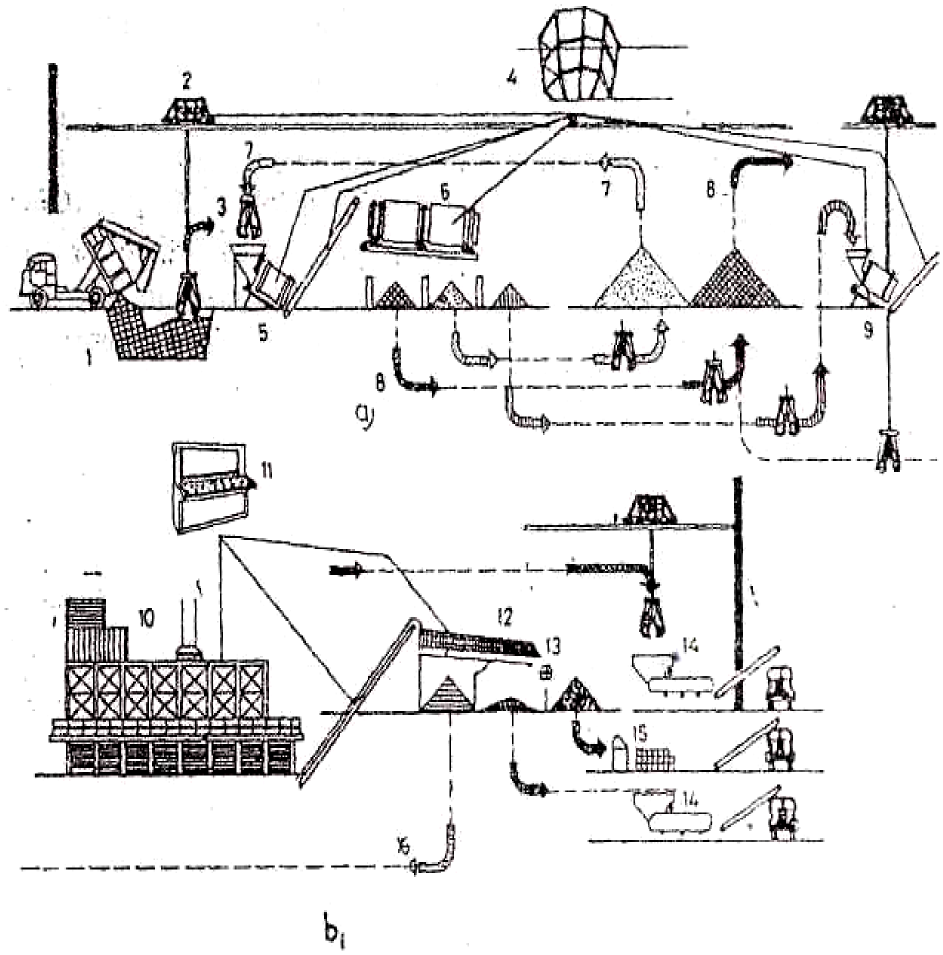


Picture 11-8: The technological scheme of Thomas procedure (Multibacto):
a-iron; b-glass, rubber; c-plastics, fabrics; d-hard foreign matters;
e-stone, glass;1-sorting hopper; 2- magnetic separator; 3-sorting strip;
4-crushing screen (Raspel); 5-hard material separator; 6-waste water settling tank with mixer; 3-maturation tower;
8-subsequent screen.

11.3 Closed composting system

11.3.1 Tecnitalia - system

The principles of this installation, built by the Italian company Tecnitalia: each operation (preparation of the raw materials, composting, burning of residual materials, and all operations related to this process) is carried out in closed bays. All waste handling operations are carried out with a grab crane, rquipped with a 1 m³ bucket. The crane is mounted on a metal construction above the technological line and is operated by a single operator in a hermetically sealed enclosure.



PIcture 09: The technological flow of Tecnitalia process:
a-pretreatment and maturation; b-treatment of residual matters; 1-storage tank;2-displaceable crane; 3-grab crane; 4-control room for the grab crane; 5-mixer; 6-rotary screen; 3-recirculation of material; 8-fine materials; 9- crushing installation; 10-burning boilers; 11-control; 12-slag sorting installation; 13-magnetic separator; 14-crushing installation; 15-iron pressing; 16-fine ash.

Residues brough by vehicles are unloaded into a reinforced concrete storage silo, closed with a photocell inlet. From the storage silo, the residues are loaded with a grapple crane into the pre-crushing plant. After crushing, a three-part sorting is made using a drum screen, namely: fine parts (under 15mm grain), medium parts (15-50mm grain) and coarse (over 50mm grain).

The fine fraction is deposited in heaps on the floor of a closed hall, a few meters high and matured for 3 days, and is then harvested as fresh compost.

The middle fraction is also stored in piles and matured for 30-40 days, after which it is returned to the crushing plant. Thus, the residues in this fraction are recirculated several times.

The coarse fraction is crushed in the second crushing plant and dried in a rotating drum, after which it is burnt in combustion furnaces. The combustion gas is used to dry this fraction. After burning, the iron is extracted with magnets out of the slag and ash and it is pressed in 30kg bales. Slag and ash are sifted. The fine ash is mixed with the fine fraction, and the remaining slag is used for fillings.

The advantage of this process is that all operations are performed in closed spaces and the materials are recirculated. This ensures very good mixing and ventilation, and consequently, the intensity of decomposition increases. All the work is done mechanically, completely automatedly and the number of operating personnel is very small. The composting unit can be built on a small area and near the localities. It is very beneficial to neutralize coarse fractions by burning. Combustion furnaces are also used to burn industrial waste. The maturation time of fine fractions is short, lasting up to 3 days. The construction of the plant requires relatively large investment funds.

Installations of this type have been built in many cities in Italy (Lucca, Vicenza, Lecce, Sassari, Rovigo, Cagliari). Among these, the biggest unit is the one in Lucca, located at 4 kilometers distance drom the city. All the work is carrie out by 4 workers.

CONCLUSIONS

A quality compost is the product complying with the following terms:

- At screening, 90% of the material should pass through the sieve with a mesh size of 35 mm;
- The equivalent carbon percentage should be more than 5% in the dry matter amount;
- The equivalent nitrogen percentage should be more than 0,3% in the dry matter amount;
- The C/N ratio should range between 10 and 20.

For the use in agriculture, users must comply with the following terms:

- Compost streading should be made on the soil surface;
- If the waste is fresh and more than 10 t/ha is used, it has be be left after being spread until sowing (1 to 1,5 months) so that fermentation is completed and maturation takes place;
- Coarse compost is to be used on clay soil and a fine compost on dry sandy soils;
- Compost with a content higher than 5% calcium will be used preferably on acid soils;
- Compost may be used on a land with poor humus soil;
- The recommended doses vary between 20 – 100 t/ha depending on the quality of the soil and the nature of the crop to be sown and it can lead to an increase in the yield by 15 %/year on average.