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Waste Free Rivers For A Clean Black Sea
GEORGIA MOLDOVA ROMANIA

Black Sea CROSS BORDER COOPERATION

INITIATION COURSE IN THE COMPOST PREPARATION PROCESS

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

Compost is the finished product of the organic waste components composting operation, which is a ground and fertile mixture, obtained by total or partial decomposition of organic materials and which may be used to improve soil quality in order to increase its fertility.

The procedure for the composting of vegetable waste consists of a decomposition process and transformation of vegetable waste by microorganisms (mainly bacteria and fungi) into a stable material, which can be utilized in horticulture and agriculture. The process is controlled in terms of speeding up decomposition, optimizing efficiency and minimizing the impact on environment and population and is to be carried out in two stages: mechanical treatment and decomposition (fermentation) – a microbiological degradation process in aerobic / anaerobic conditions of organic materials, involving the generation of CO2, water and humic substances.

1.1 Basic Principles

Biodegradable waste is a major component of household, commercial and institutional waste. Biodegradable waste consists of kitchen waste, garden waste, paper, cardboard, natural textiles and wood. The presence of biodegradable waste in landfills, inevitable due to their permanent presence in household waste, is in fact undesirable considering that it causes gas emissions (containing methane, strong greenhouse gas which is explosive and hazardous) and instability in landfill waste.

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

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

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

Composting is the recovery operation of organic compounds contained in waste with view to their reclaiming.

Compost is the finished product of the organic waste components composting operation which is a ground and fertile mixture, obtained by total or partial decomposition of organic materials and which may be used to improve soil quality in order to increase its fertility.

1.2 Composting: Pros and Cons

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;
- compost-fertilized only 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 depositing 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 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.

2 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.

2.1 The 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.

2.2 Granulation and Homogeneity of the Matter

Small granulation materials provide for microorganisms a much larger attack surface than big size granulation (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 mass of the compost 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.

2.3 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).

The systematic measurement of temperature is one of the main conditions for the regulation of composting processes.

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).

2.4 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 bonds.

In general, humidity is considered favourable when the decomposing material is squeezed in the hand and leaves no water. The problem is the very close relationship between water and aeration. Both need inter-particle interstices and these interstices may be filled with free water or air.

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

2.5 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 depend to a great extent the following elements: the rate of decomposition, what kind of intermediary products are formed, what health effect will the composting have and the value of the final product from the point of view of its use in agriculture.

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.

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.

2.6 The pH Level

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 CaCO3 and MgCO3 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 silage process (butyric fermentation, propionic acid) will take place.

2.7 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 of 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 also.

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

Compost Quality

Compost is of good quality if it has the following characteristics:

- it is a homogenous product of a dark brown or black color;
- it smells 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.

The purpose of composting lies in:

- compliance with recycling / recovery laws;
- reduction of waste flows to landfills;
- obtaining a recovery material, depending on the characteristics, in agriculture or land improvement works (soil improvement);

Basically, composting involves two main phases, namely:

- mechanical treatment;
- biological treatment (fermentation).

Fermentation

a. *Main factors favouring aerobic fermentation.*

The Oxygen in the Air. Theoretically, the amount of air that provides the oxygen required for the fermentation of mechanically treated household waste is 4.5-5 litres of air per kilogram of dry matter (45% humidity) per hour. Where possible, it is preferable to increase this amount of air.

Aeration can be done by several systems, according to the adapted composting process, as follows:

- simple aeration by overturning compost piles when composting on outdoor platforms;
- introducing cold or hot air into the fermentation chambers;
- by making a slight depression in the fermentation chamber;
- by continuous mixing with special machines.

These systems can be combined.

The 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 matter content of the residues is <50% the humidity 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 material to be composted should be protected from rain because too much humidity can lead to anaerobic fermentation phenomena.

Waste composition. It is one of the important factors in triggering the fermentation process. If the waste is highly loaded with fermentable matter and the ambient temperature is high, the composting process is triggered rapidly and can be carried out properly if it is well conducted by introducing the required amount of air. On the contrary, if the waste is low in organic substances load, especially during winter,

fermentation is delayed and the introduction of additional air only damages the fermentation process (appearance and development of unpleasant odours).

b. *Auxiliary factors favouring aerobic fermentation.*

Besides the main factors mentioned above, aerobic fermentation is also influenced by a series of auxiliary factors, among which:

- homogeneity of the mixture;
- granulation of the waste subjected to fermentation;
- the ground disposal settlement in piles or fermentation tanks;
- slowing down the rate of temperature increase.

c. *Stages of aerobic fermentation process.*

Compost can only be used in agriculture in a finished (cured) state. Freshly ground wastes are very active and can sometimes be used as warm beds for winter or spring crops.

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

Waste converted into compost is hygienic and only can be used in agriculture without any inconvenience in term of health. A compost can be considered mature when the activity of microorganisms is minimized. Determination of maturity is done by establishing the consumption of O2 (or CO2 production) by plant testing, by analysing the physical structure, etc.

During the composting process, a high temperature for the destruction of pathogens and the production of colloidal materials of a thermal nature is aimed at. These two processes are due to the action of microorganisms on organic matter from waste under optimal conditions of the environment as regards temperature, air, water.

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

- ***the latent stage***: corresponds to the time period required to colonize microorganisms in the new environment created; this phase starts practically from the storage period in pre-collection and collection tanks and lasts until the temperature rise begins;
- ***the growth stage***: consists in rising the temperature and it depends on the waste composition, moisture, air, and so on;
- ***the thermophilic stage***: represents the period corresponding to the highest temperature; this phase may take longer or shorter periods, depending on the action taken on air or water environment, on the amount of fermentable organic substances and the degree of thermal insulation achieved. During the thermophilic phase, a more efficient action can be taken on fermentation.

- ***the curing or growing stage:*** corresponds to a slow, secondary fermentation, which is favouring moisture, respectively transforming certain organic compounds in humus under the action of microorganisms.

It is recommended that compost should be used in agriculture at the end of the thermophilic phase when the product is richer in organic matter. Excessive maturation in the landfills leads to excessive mineralization, which makes it lose its soil-friendly effects. That is why it is generally allowed for 3 months period at the most to maintain compost in the landfill.

During fermentation, organic waste material facilitates two simultaneous and antagonistic actions in which carbon and nitrogen enter the soil and leads to the mineralization of biodegradable substances, leading to 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*

Determination of the compost composition, consisting in establishing the physio-chemical properties, is made for the knowledge of possibilities of their use in agriculture.

The carbon / nitrogen ratio is a factor reflecting the stage of waste fermentation evolution. The compost obtained can be considered good for agriculture if it shows, on average, the following characteristics:

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

Composting techniques should ensure the elimination of the process alteration risk by way of:

- speeding up processes based on optimizing the alteration conditions;
- targeting the aerobic process;
- emission checking.

The techniques are based on two basic procedures:

- the static process (composting in stacks, 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;
- the waste resulting from gardening, parks, markets, biodegradable scrap from food industry.

3 ELEMENTS SPECIFIC TO 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 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 reintroduction (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.

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

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.

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 (COV)

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.

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:

Benefits:

- 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.

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.

Composting methods at industrial level

Composting methods are mainly distinguished by:

- overturning (winnowing) 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.