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Composting as a Waste Management Method

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Abstract: Both the waste component, the rate of waste production and the amount of waste with increasing urbanization and industrialization day by day have increased. Disposal or evaluation of these wastes resulting from industrial, commercial, domestic, treatment plant and agricultural activities has become inevitable for municipal corporations. The amount of organic waste in solid wastes is about 40%, and the priority preferences of waste management include these wastes that have been chastened and recycled into environmentally compatible products. For this reason, compost production is becoming an alternative as an environmentally friendly biodegradation option that is becoming increasingly widespread. Biodegradable wastes which are described as garbage in public by compost are possible to convert into useful products. Therefore, compost can be made from a lot of waste as tree bark, animal faces, vegetable and fruit wastes, algae and other water plants, paper, newspapers to wastewater treatment muds. These produced composts can also be used in different fields from fruit to flower, from erosion control to odour elimination filter material. In Turkey, $33*10^6$ t/year of Urban Solid Waste (USW) was produced according to the data of the year 2013 and if compost production was made from these wastes, $6.6*10^6$ t/year compost could be produced. With the assumption that 5 t/ha compost can be used for agricultural land, the amount of land that can be applied to this manufacturable compost is seen $1.3*10^6$ ha/year. In the light of this information, compost raw materials, application areas of compost, compost technologies and preferential reasons and compost-related legislations in our country have been examined.

Keywords: *compost, technology, raw material, waste, management*

Introduction

After the industrial revolution, along with the rate of increase and rise in the world economy, economic priorities, welfare level, and technological expectations also increased. This has exceeded the absorption capacity of the environment for millions of years and has led to environmental extinctions that have adversely affected the processes of environmental transformation and are difficult to return.

Solid wastes, which are one of the environmental phenomena that destroy ecological cycles and cause environmental destruction, have become an important process, which nowadays is the worst of municipal corporations in our country and world and must be seriously planned (Yildiz *et al*., 2009). In this context, the recycling of organic wastes such as packaging wastes has become a necessity with the development of a friendly technology that is compatible with the public sociology, comfortable, non-irritating, with the environment, with the financial evaluations (Topal & Topal, 2013). The conversion of organic wastes, which have a proportion of about 40% in solid wastes, to environmentally compatible products and their reuse in the environment are among the primary objectives of integrated waste management (Topal & Topal, 2013).

Looking at waste management in terms of legislation, both national legislation and international directives are aiming at preventing, minimizing, reusing, recycling and recovering wastes (Topal & Topal, 2013). In this direction, wastes coming to regular solid waste storage facilities have been restricted and it has become imperative to carry out a pre-treatment without entering the wastes. For this reason, it is important to dispose of solid wastes in alternative ways other than the regular storage system. Composting processes, especially when compared to systems such as pyrolysis, incineration, and gasification, are being used effectively as a friendly technology for air, water and soil with various systems worldwide, especially considering biodegradable organic wastes (Topal & Topal, 2013).

When we look at the scale of local authorities in Turkey, it is seen that on average about 40% of

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the generated solid waste is a biodegradable waste. It is, therefore, a proof that composting is a very important and efficient method of waste management (Ozturk *et al.*, 2015). Compost is not just a reduction in the amount of waste going to landfills. Apart from this benefit, the compost product can be used as a soil conditioner, facilitating the processing of the land and reducing the cost by reducing the amount of fertilizer to be used in the land.

Composting

Composting; Is defined as biodegradable stabilized and mineralized humus transformation process by bacteria, micro- and higher-level organisms of decomposable organic constituents (agricultural, urban commercial etc. wastes) in solid wastes. Compost is not fertilizer but is used only for the structural improvement of the soil. However, it is possible to obtain fertilizer in superior quality by adding enough nitrogen, phosphorus, and potassium to the compost (Uygun, 2012).

Bacteria, actinomycetes, and fungi in the disintegration of organic substances use waste as first-hand and are called first-degree disintegrates. First-degree disintegrates are consumed by the protozoa, rotifer mite and various insects in the upper level. Third-degree disintegrates are also fed on the organisms in the first two degrees and control the populations at this degree. During composting, the organic matter is disintegrate down by microorganisms and forms carbon dioxide, water, energy and humus that are a highly stable end product (Avcioglu *et al.*, 2011).

Composting can be carried out in both aerobic and anaerobic conditions. Most of the composting systems are operated aerobically because less energy per unit weight of the organic matter separated by anaerobic conditions, the problem of odour due to interim products are exposed, the time required for compost formation is too long and the temperature of the composting organisms does not reach the required temperature values. In general, when it is called compost, aerobic composting first comes to mind (Tanugur, 2009).

Many factors play an active role in the composting process. Main factors; C/N ratio, moisture content, temperature, and can be listed as the percent volatile solids. By optimizing the operating conditions, nutrient loss during composting can be reduced to a minimum and composting time can be shortened (Avcioglu *et al.*, 2011).

Compost; increase the organic matter content of the applied soil, the water permeability of the soil with low permeability, the void ratio between soil particles and consequently the water holding capacity of the soil. It encourages root growth by facilitating the movement of plants' roots. It makes it easier to process the soil. Hummus prevents nitrogen from mixing into the groundwater by providing nitrogen retention. Hummus-rich soils make it possible for grown plants to be healthier, more resistant to diseases and harmful effects. Thus, the need for chemical and agricultural struggle is reduced. In addition, compost improves soil structure and increases water permeability. In particular, the water reaching the soil surface with rain by allowing it to be easily submerged into the ground instead of passing to the surface stream and reduces the water erosion (Avcioglu *et al.*, 2011; Basturk, 1979).

Raw Materials of Compost

It is the choice of the material to be composted one of the factors that have a verbatim influence on compost quality. The choice of product quality to be composted is of great importance in order to obtain high-quality products from organic wastes (Varank, 2006). The first step of obtaining compost material of considerable quality in compost production is the use of separated separately in the source and other wastes and uncontaminated organic wastes as raw material. For this purpose, rich and clean wastes in terms of organic wastes that come from marketplaces, parks and gardens, urban solid waste collection systems, etc. places should be used and processed (Yildiz *et al.*, 2009). Nitrogen percentage, C/N ratio, water content and densities of organic materials used in composting are given in Table-1.

Mixing different materials at right proportions is the most important step for composting. In order to be efficient in the composting process and to obtain high product quality, the mixture should be prepared as a composite of different substances, with the starting compost heap being C/N: 30/1 (CIWMB, 2007). Another thing in the compost raw material is hygiene. Hygiene is an important factor both in the use of the product and in the compost heap. To protect against viruses and pathogens, diseased plant materials and animal feces such as cats and dogs should not be added to the compost pile (Ozturk *et al*., 2015). Heavy metals should not be used. If used, heavy metals should be pretreated.

Table-1: Properties of some organic substances that can be used in composting (NRAES, 1999).

Organic Substances	%N (Dry weight)	C/N (weight/weight)	% Water content (Wet weight)	Density (kg/m^3)
Feces				
Chicken feces	1.6 – 3.9	13 – 30	22 – 46	470 – 640
cattle	1.5 – 4.2	11 – 30	67 – 87	820 – 1040
The dairy barn (tied bovine)	2.7	18	79	-
The dairy barn (free bovine)	3.7	13	83	-
Horse	1.4 – 2.3	22 – 50	59 – 79	760 – 1010
Racehorse□	0.8 – 1.7	29 – 59	52 – 67	-
Egg hen	4 – 10	3 – 10	62 – 75	860 – 1010
Sheep	1.3 – 3.9	13 – 20	60 – 75	<1080
Swine	1.9 – 4.3	5 – 19	65 – 91	<1010
Turkey feces	2.6	16	26	485
Stalk. dry grass. animal feed				
Corn	1.2 – 1.4	38 – 43	65 – 68	-
Dry Weed□	0.7 – 3.6	15 – 32	8 – 10	-
flowering Herbs	1.8 – 3.6	15 – 19	-	-
seedless herbs	0.7 – 2.5	-	-	-
Stalk	0.3 – 1.1	48 – 150	4 – 27	36 – 240
Oat stalk	0.6 – 1.1	48 – 98	-	-
Wheat stalk	0.3 – 0.5	100 – 150	-	-
Wood and paper				
Hardwood bark	0.1 – 0.41	116 – 436	-	-
Soft tree bark	0.04 – 0.39	131 – 1285	-	-
Corrugated cardboard	0.1	563	8	160
waste timber dough	0.13	170	-	-
Printed publication	0.06 – 0.14	398 – 852	3 – 8	120 – 150
Paper fibre sludge	-	250	66	710
Paper pulp sludge	0.56	54	81	-
Paper dough	0.59	90	82	870
Sawdust	0.06 – 0.8	100 – 750	19 – 65	220 – 280
Telephone directories	0.7	772	6	155
Wood crumb	-	40 – 100	-	276 - 385
Hardwood	0.06 – 0.11	451 – 819	-	-
Softwood	0.04 – 0.23	212 – 1313	-	-

Technologies of Composting

Composting; is a process in which organic matter is consumed, oxygen is consumed by microorganisms, water vapour is produced during active composting, heat and CO_2 are given to external atmosphere, and humus-converted compost is obtained. During the process, CO_2 and water losses are equal to about half of the weight of the primary materials. Composting thus reduces both their volume and weight as they transform raw materials into valuable soil conditioners (Rynk, 1992; Uygun, 2012). Composting takes place very quickly when appropriate conditions are maintained for the growth of microorganisms and when these conditions are maintained. The most important conditions for composting are;

- Mixing of organic materials to provide nutrients required for microbial activity and growth, including the appropriate carbon and nitrogen (C:N) ratio,
- Sufficient oxygen for aerobic microorganisms,
- Sufficient moisture content, which provides biological activity without inhibiting ventilation,
- Suitable temperatures provide strong microbial activity (Ozturk & Bildik, 2005).

The main purposes of composting are;

- To convert the separable organic material into the biologically desired suitable material,
- To destroy pathogens, insect eggs, other unwanted organisms and weed seeds that may be found in solid wastes,

- To produce a product that can be used as soil remediation,
- To obtain nitrogen, phosphorus, and potassium in the maximum amount available for use by plants (Tosun, 2003).

Composting can be carried out under aerobic and anaerobic conditions. Basic methods used in composting process can be listed as follows;

1. Composting in passive stack
2. Composting in transitional stack
   a. Composting in transducer stack using loader work machines to translate, mix and process
   b. Composting in transduced stack with special transfer machines
3. Composting in a ventilated static stack
4. Composting in closed reactors
5. Composting technologies used to reduce solid wastes at the source

The physical properties of organic materials, mixing ratios, and processing characteristics are influenced by the choice of composting method. In addition, distance, cost, compost process, and speed instead of settlement affect this choice (Tosun, 2003).

Aerobic composting

Aerobic composting is the process of decomposition in an oxygenated atmosphere. Composting starts when appropriate organic ingredients are combined. Raw materials are mixed first and the air is supplied in sufficient amount to start the process. The microorganisms rapidly disintegrate oxygen and the precipitated materials eject the air out of the pore spaces. Aerobic degradation slows down as the oxygen in the environment decreases and the process stops if oxygen is not provided. The aerobic composting accelerates the decomposition of matter and brings about a higher temperature increase than the temperature required to destroy the pathogens. At the same time, aerobic composting also reduces unwanted odours (Bayer, 2008).

Composting in passive stack

This method is mostly suitable for small and medium-sized settlements and has a very simple system. Organic materials are pelleted and waited until they are converted into a stable product without stirring. The stack height must be greater than 1-1.2 meters to ensure adequate air exchange and heat amplification. In the method, the compost pile is warmed due to biodegradation and the hot air ascends and separates from the pile. It draws clean and cold air from sides and base. A disadvantage of passive composting is that if the stack is uncontrolled (no heat output or inters pray space diminishes and squeezes), anaerobic conditions begin and odour problems arise (Ozturk *et al*., 2015; Ozturk & Bildik, 2005).

Composting in transitional stack

This method is one of the most commonly used composting methods. Waste stacks are mixed by turning to provide air entrainment, mix waste as a homogenous, facilitate heat movement, and increase the biologically active surface area. Too much mixing reduces the particle size excessively, thereby reducing the void ratio between the particles. This reduces the efficiency by preventing enough air from entering the stack (Isik, 2009).

In installations with capacities of 100-10000 m^3 per year, only the loader work machines may be sufficient for rotation. No extra equipment required. For higher capacities, special rotation equipment must be used for composting. It can be processed compost in between 400 - 4000 tons/hour by means of the rotation connected to the tractor and large transfer machines. in addition to this, it may be needed to additional equipment, such as a loader for additional workload, stack formation, maintenance and other work for operation and maintenance (Ozturk *et al*., 2015).

Heaps with small particle sizes and intensive such as fertilizer are raised like 0.9 m, the height of the stack, which is puffy such as leaves and the grain size is larger, is 3.6 m, widths vary from 3 to 6 m depending on the type of compost and the equipment selected. Stacks should be formed on a watertight ground as far as possible (Uygun, 2012). The temperature and the odour of the stacks determine when the mixing process should be done. The decrease in temperature (below 50 oC below average) and/or the increase in odour formation are Indicates that oxygen is needed and oxygen in the stack decreases. Also, the sudden drop in temperature is an indication that the batch must be mixed (for 4-5 days) (Uygun, 2012). It varies from 3 to 9 weeks Depending on the composition of the compound to be composted by the Composting in transitional stack method and the transfer frequency. The time for composting materials such as fertilizer is 8 weeks. If composting is desired to obtain at 3 weeks, the batch should be mixed 1 - 3 times in the first week and 3 - 5 days in the following weeks (Stofella & Kahn, 2001).

Composting in a ventilated static stack

Two types of stacks can be formed: passive and pressurized ventilation. In a passive ventilation system, perforated pipes that are one end open is buried in a stack. In the ventilated system with pressure, two topics are examined, positive and negative pressure. The pressurized ventilation system generally helps to keep the composting process in check, and it is possible to build larger stacks (Ozturk *et al.,* 2015).

Passive ventilation system

In the passive system, perforated pipes are placed in the stacks to provide air inflow into the stack. Ends of these pipes are open. Due to the chimney effect caused by the rise of the hot gas out of the sequential stack, the air moves to the pipes and then to the stack (Uygun, 2012). The height of the compost pile should be 0.9-1.2 m. The mixture should be laid on a floor made of straw, peat moss or finished compost to absorb the moisture, to prevent flies, to help retain smell and ammonia, and to isolate the sequenced stack. The ventilation pipes are placed on the ground covered with peat or compost. When composting is complete, the pipes are removed and the materials in the compartment are mixed with compost (Uygun, 2012).

It is a method used for composting animal feces that is came from the milk house with bovine and small cattle farms. When investigations are examined, it has been seen that in this method, composting has performed in the best way at the bulk temperature below 50 °C. Mixtures of seafood or peat moss are composted in 6-8 weeks, and animal stool mixtures are composted in 10-12 weeks (Ozturk & Bildik, 2005).

Compressed ventilation system

The pressurized ventilation system ensures that ventilation is maintained on a regular basis, reducing composting time and reducing odour when composting odoriferous substances such as sewage sludge (Stofella and Kahn, 2001). To keep the temperature and oxygen content in the Compost stacks within the desired range, perforated pipes are placed under the stacks at intervals as high as the height. One of the pipes is connected to the pressurized air supply and the other is closed (Ozturk *et al*., 2015). If the batch temperature is kept between 55 - 65 °C, composting is completed between 1-2 months. It is also held for 2 months for maturation (Anonymous, 2005).

The height of the pressurized vent stacks varies between 2-5 m. The width of the stacks is chosen to be twice the height. If the stack width is to be chosen more, ventilation pipes should be installed at intervals as high as the height (Diaz *et al.,* 2007). Stack length varies between 20-80 m. These values vary depending on the specifications of the stacking machines, the amount of compost area, the specifications of the compressed air supplier, and the weight of the material to be compacted (Stofella and Kahn, 2001). The organic materials that are pumped into the compressed air system are not rotated and must be thoroughly mixed before being pumped (Stofella and Kahn, 2001).

In the negative pressure system, air is drawn from the outside of the stack into the end of the pile by means of the pipe with the filter. The filter at the end of the pipe can prevent unpleasant odours from forming. In a positive pressure system, air exits to outside through into stack. For this reason, odour problems may occur. For this, a thicker composting layer should be used, so that the outer layer of the heap can show the filter feature (Uygun, 2012).

Anaerobic composting

Anaerobic composting is the biodegradation of organic substances in an anaerobic environment. The metabolic end products of anaerobic digestion are numerous intermediates such as methane, carbon dioxide, and low molecular weight organic acids. In the aerobic composting, hummus is found in the final product, while in the anaerobic composting it is in the form of mud. Composting rates of aerobic and anaerobic compost methods are 42% and 33%, respectively. In the anaerobic compost method, about 12% of the organic solid wastewater taken as reactant based on wet weight is converted into biogas containing 55-60% CH_4. 130-160 m^3 biogas per ton of organic solid waste can be produced (Ozturk, 1999).

Composting in closed reactors

Composting in an enclosed setting reactor is subject to decomposition of the compost raw materials in a closed building in a building, duct or any reactor. The reason for this the smell promotes and accelerates the process by reducing the problems and controlling the factors such as temperature, oxygen, humidity, microorganism and pH which are playing a role in the composting process. Despite the fact that the first investment cost is the highest, its use has increased in recent years due to the above-mentioned features and labour costs are low and land needs are low (Diaz *et al.*, 2007).
Organic materials taken into the reactor in the closed environment first undergo rapid fermentation (active composting) and afterwards they are removed from the reactor and left to slow fermentation by the transferring batch method. Active composting takes 1 to 2 weeks depending on the selected reactor type. Composting takes place between 4 and 12 weeks in total with the maturation period. A great majority of composting methods in the closed reactor have been developed for commercial purposes. There are different types of composting in the closed reactor. These;

- Piston stream vertical reactor,
- Piston flow horizontal reactor,
- Silo type reactor,
- Horizontal rotary drum reactor,
- Horizontal and open top rectangular tank,
- Mixing vertical reactor,
- Mixing rectangular bearings (Ozturk *et al.*, 2015).

Composting technologies used to reduce solid wastes at the source

Various and simple methods are used to compost the organic wastes produced in the garden and houses and reduce them in the source. For this, it is firstly necessary to correctly identify the produced waste. It should be decided how much time, energy and time will be spent for biodegradation after waste characterization. It should be determined which techniques should be used. Considering that the conventional composting method requires a lot of work due to stacking, compost balancing, final product discharge and paving, the following methods can be practically used.

- Pit composting,
- Canal composting,
- Composting in trash containers,
- Composting on the surface,
- surface made composting process to plant roots,
- Composting with worms,
- Bank and box type composting systems,
- Composting in houses (Dunne, 2001).

The Factors Affecting Composting

Oxygen, temperature, particle size, pH, moisture content, C / N ratio and microbial activities affect the composting process individually. Since all the parameters are interacting with each other, a change in one may cause the other parameters to change.

Oxygen

The composting process is an oxidation process in which oxygen is consumed in general and carbon dioxide is formed (Stofella and Kahn, 2001). Therefore, as a reliable indicator in the composting process, these two gases must be followed until the compost is formed. In aerobic conditions, higher temperatures are achieved than in anaerobic conditions and more pathogen removal is achieved. In addition, composting in aerobic conditions is completed in a shorter time and gives better product quality (Uygun, 2012).

Oxygenation to the compost pile varies depending on many factors such as the material's void ratio, moisture content, and composting technique. The minimum oxygen levels (percentage of oxygen in the total gas) of the compost stack should be as follows;

- In the fast fermentation phase, > 10% oxygen,
- At maturing stage, > 5% oxygen should be present (Ozturk *et al*., 2015).

Porosity and particle size

Porosity is a gap between particles. Particle size affects this void ratio. The free airspace is an important factor that facilitates the circulation of gases in the compost pile. Porosity assures the oxygen requirements of the microorganisms and helps out of the stack of gases that are released by and other results of biodegradation with carbon dioxide. There are three main issues to protect the free air space (Arikan, 2003; Ozturk *et al.*, 2015). These;

Optimum particle size

Smaller particles are trapped more quickly and may result in insufficient oxygen supply and therefore anaerobic conditions. Large particles facilitate gas exchange, slow compression and accelerate water loss. However, it is also difficult to control the heat in large particles and heat losses are experienced. Therefore, optimum particle sizes should be between 6 and 75 mm (Ozturk *et al*., 2015; Bayer, 2008)

Particle size distribution

Unequal, different particle size provides better porosity than an organic material mass having uniform particle size (Ozturk *et al*., 2015).

Regular mixing of compost stack

Porosity decreases over time due to biodegradation and deposition of particles in the pile over time. The compost stack is mixed at regular intervals to ensure adequate free air space and to avoid stacking (Ozturk *et al.*, 2015).

Microorganisms

Composting is a complicated process in which organic wastes are disintegrated and consumed by various types of microorganisms. In the composting process micro-organisms such as fungi, actinomycetes and bacteria play an active role. In some cases, it is also possible to encounter algae and protozoa in this process. Microorganism population changes during composting (Uygun, 2012). These changes, which are valid during the bulk composting with biological treatment sludge and wood chips, are given in Figure 1.

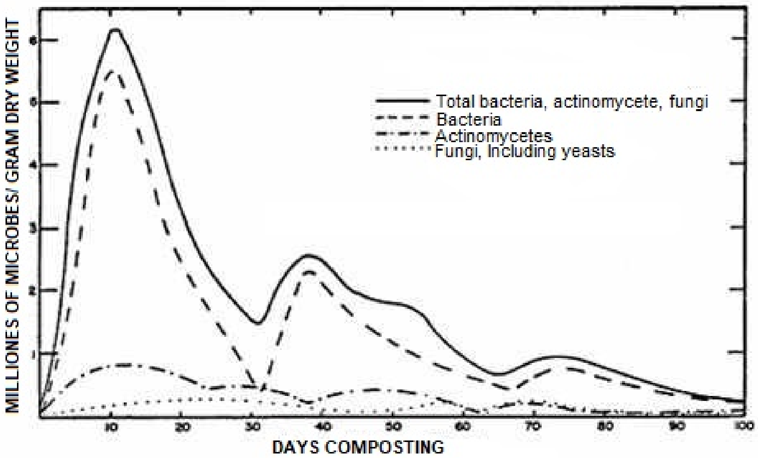

Figure 1. Variation in the composting process of the microbial population (Stofella & Kahn, 2001).

Bacteria, actinomycetes, and fungi use organic waste as an intermediary and are called first-stage disintegrants. First stage disintegrants are consumed by the protozoa, rotifer mite and various insects in the upper level. Third stage disintegrants are also fed on the organisms in the first two stages and control the populations at these stages. During composting, the organic matter is broken down by microorganisms and forms carbon dioxide, water, energy and hummus, a highly stable end product (Avcioglu *et al*., 2011).

Temperature

Biodegradation of organic matter results in heat in compost as a by-product. The amount of heat that will be generated depends on the outside temperature, the moisture content, the oversized of stack, the amount of top cover, the C / N ratio and the ventilation. It takes 3-5 days for a well-made compost process to reach 60-70 ºC temperature at the planning stage. In the composting process, the temperature is kept below 70 ºC. If the temperature of the stack increases excessively, ventilation and mixing are applied to reduce the high temperature (Topkaya, 2004).

If the temperature in the compost pile is low, biodegradation becomes slow. If the temperature is high (> 70 ºC), beneficial microorganisms decrease, leading to a decrease in microbial diversity (Ozturk *et al.,* 2015). The temperature and time for elimination of different types of pathogens are given in Table 2.

Table 2: Durations at different temperatures applied for pathogen removal (Paul & Geesing, 2009).

Organism	**Effect**	**Durations at different temperatures applied for pathogen removal (minute)**				
		50°C	**55°C**	**60°C**	**65°C**	**70°C**
Entamoeba histolytica cysts	Diarrhea, invasive liver abscess	5				
Ascaris lumbricoides eggs	tinea	60	7			
Brucella abortis	Brucellosis (cow/human)□		60		3	
Corynebacterium diphtheria□	Diphtheria		45			4
Salmonella typhi	Typhoid			30		4
Escherichia coli	Diarrhea			60		5
Staphylococcus aureus□	Skin, lung, etc. infections					20
Mycobacterium tuberculosis	Tuberculosis				40	20
Shigella ssp.	Shigellosis (diarrhea, fever)		60			
Necator americanus	Hookworm	50				
Taenia saginata	Tapeworm		30			5
Some viruses						25

Temperature is an important process parameter not only in terms of operation but also in obtaining high-quality products and compliance with the legislation (Genois, 1995). Exposure of the product to be composted to 50 ºC for 13 days with the pathogen removal resulting in leaving at 55 ºC for 3 days forms the same result. Weed and plant parasites, ovaries and cysts and most of the pathogens kill as 10 days 55 - 70 ºC to protect the temperature of the material. However, it permits the thermophilic ones from microorganisms. The end products of compost processes operated below the specified temperatures contain organisms that can pose a threat to human, animal and plant health (Ozturk *et al.*, 2015).

Carbon (C), nitrogen (N) and C/N ratio

The major components of organisms are examined in six parts. Carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P) and sulfur (S). All of the organic wastes contain these elements and need these elements as they are in all organisms in the microorganisms that provide the biodegradation. The C, N and C/N ratio for composting is important to create the optimum process. Carbon compounds are used as energy in autotrophic microorganisms. it is used nitrogen compounds as building blocks in protein synthesis. An ideal composting should also have a C/N ratio of 20 - 35 for raw material (Ozturk *et al.*, 2015).

The final product C/N ratio of a composting process with an initial C/N ratio of 30:1 reduces to 10-15:1. The reason for this, as convert 2/3 of the carbon to carbon dioxide is removed outside during the biodegradation of organic substances with microorganisms. The remaining 1/3 carbon is used in combination with nitrogen to build new microbial cells, which are released by the death of the cells (Topkaya, 2004).

Moisture

In the composting process, moisture has many important effects and has vital importance for many lifestyles including decomposing microorganisms. Moisture also has an important role in temperature control in composting (Erdener, 2010).

The ideal moisture content in the composting process ranges from 50 to 60%. Moisture content <30% inhibits microbial activity. If the moisture content is > 65%, the decomposition will slow down, cause anaerobic conditions, cause odors, and causes the nutrients to be separated by leaking water (Topkaya, 2004). One of the practice tests to measure the amount of moisture is a punch test. In this test, the material is squeezed into the palm of the hand and if the water comes out, the humidity is 70% or more. Raw materials with very low moisture content should be soaked in water. After the addition of water, the material should be mixed reach up to be homogeneous (Ozturk *et al*., 2015).

pH

The concentration of hydrogen ions influences the availability of nutrients, the solubility of toxic ions and microbial activity. The pH range for microorganisms in the composting process is 5,5 - 8. The preferred pH range for bacteria is 6.0 to 7.5. The fungi are in the range of pH 5.5 - 8 suitable for active work. An isolated compost is usually found at pH 6.0 to 8.0 (Ozturk *et al*., 2015).

Standards and Regulations of Compost

Standards related to compost product; it is Standards for process control, standards for hygiene requirements, standards for heavy metal content, standards for organic pollutants, and standards for the physical composition of composts. There are three main regulations on composting in Turkey. These;

- Regulation on the control of solid wastes (T.R. MEF, 1991).
- Regulation on the production of organic, organomineral fertilizers and soil conditioners used in agriculture and the production of microbial, enzyme-containing and organic products, biotechnology, exports and the market (T.R. MFAL, 2014).
- Regulation on the use of domestic and urban sewage sludge in the soil (T.R. MEF, 2010).

Regulation on the control of solid wastes (T.R. MEF, 1991)

The conditions stipulated in Article 33-34 of the regulation on the control of solid wastes regarding the compost application and the requirements for the facilities to be installed are as follows.

Use of Compost

Article 33. For the purpose of improving the compost soil structure obtained by the reduction of organic solid wastes in an oxygenated environment,

1. Composting of garden and kitchen waste in facilities established for this work,
2. In order to facilitate compost production, composting requires separate collection of suitable organic waste.

Required technical features in compost facilities

Article 34- In the compost facilities with an annual capacity greater than 200 tons;

1. If the composting plant is operated by ventilation, it should be given to the atmosphere after cleaning the absorbed air by filtration,
2. If the leaking water collected from the composting area is not used for composting, the receiving medium should be provided after the leachate has been treated, and in this respect the compliance of the Water Pollution Control Regulation to the receiving medium standards,
3. The front storage tank (bunker) serving as pre-storage and balancing for the solid wastes coming from the facility is closed,
4. The composting facilities are not built into the protection area of underground and surface water resources,
5. The closest distance to the residential areas should be 1000 meters.

Regulation on the production of organic, organomineral fertilizers and soil conditioners used in agriculture and the production of microbial, enzyme-containing and organic products, biotechnology, exports and the market *(T.R MFAL, 2014)*

"The purpose of this Regulation is to promote, define, and use the use of organic, organomineral fertilizers and soil conditioners and microbial, enzyme-containing and other products in order to improve the physical, chemical and biological structure of the soil, to increase the productivity in vegetative production, to protect human health and to prevent environmental pollution. Determine the methods of analysis and the procedures and principles to be complied with for the importation, exportation, production, registration with the market of these products and the sanctions to be applied if these procedures and principles are not observed" (T.R. MFAL, 2014). The amounts of heavy metals in products expressed in the regulation for human, animal and environmental health are given in Table 3 in mg/kg (ppm). Table 4 gives the conditions for the compost product to be provided between the organic soil conditioners.

Table 3: The highest permissible heavy metal concentration in organic fertilizers (T.R MFAL, 2014).

Heavy metal	Concentration (mg/kg)
Cadmium	3
Copper	450
Nickel	120
Lead	150
Zinc	1100
Mercury	5
Chromium	350
Tin	10

Table 4: Prescribed conditions for compost which is organic soil improver (T.R. MFAL, 2014).

Type name of the product.	Information on the way the organic product is obtained and its main components.	The raw material content of the product, its quantity, the content of the plant nutrient substance that should be present in its content and other criteria.	EC, pH and other required information of product	Mandatory content that must be declared on the label.
Compost	The product resulting from aerobic or anaerobic digestion of organic and/or industrial waste originating from organic sources. The sum of selectable materials such as glass, slag, metal, plastic, rubber leather cannot exceed 2% of the weight.	- Organic substance minimum: 35% - Maximum moisture: 30% - 10 mm of the product will exceed 90% of the product. - C/N: 10-30 **Pathogens** -Total Bacteria: $1x10^3$ kob/g or kob/ml - Enterobacteriaceae group bacteria:< 3cfu/ml - Mycobacterium spp.: None (25 g or ml) - Total yeast and mold: $1<10^4$ kob/gr-ml - Salmonella spp.: None (25 g or ml) - Staphylococcus aureus: None (25 g or ml) - Bacillus cereus: None (25 g or ml) - Bacillus anthracis: None (25 g or ml) - Clostridium spp: <2 kob/g or kob/ml - Clostridium perfiringens: None - Listeria spp: None - Staphylococcal Enterotoxin: None - E.coli: None - E.coli: O157H7 None - The size of the Plastic material or other possibly present non-recyclable material particles will not exceed 10 mm. - The source of the raw material used will be specified. - Arsenic in dry matter cannot exceed 20 mg/kg.	**pH** EC (dS/m) value max.: 10	-Toole organic matter - Maximum humidity - Total nitrogen (if exceeding 1%) - Total phosphorus pentoxide (P_2O_5) (after 1%) - soluble potassium oxide (K_2O) in the water (in excess of 1%) - C / N

Regulation on the use of domestic and urban sewage sludge in the soil (T.R. MEF, 2010)

"The purpose of this Regulation is; In accordance with the sustainable development objectives, the principles of taking the necessary precautions for the use of sewage sludge in the soil. This Regulation covers the technical and administrative bases for soil-controlled use of sewage sludge resulting from the treatment of domestic and municipal wastewater in such a way that it does not harm soil, plant, animal or human" (TR. MEF, 2010).

According to the directive, it is strictly forbidden to use raw untreated mud directly in the soil and the values are given in Annex I-B, Annex I-C and Annex I-D must not be exceeded in order to use stabilized mud to soil (Ozturk *et al.*, 2015).

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