CURRENT STATE CONCERNING THE CONSTRUCTION OF ORGANIC COMPOST EQUIPMENT. A REVIEW

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ABSTRACT

Globally, in recent years, attempts have been made to move towards organic farming by eliminating the use of synthetic fertilizers and pesticides. To increase soil fertility, more and more natural, biodegradable fertilizers are used. Composting is a naturally controlled process, in which beneficial microorganisms, bacteria, and fungi, turn waste into a finite, fertilizer and soil hardener, which can be considered the enemy of soil pathogens. By decomposing and stabilizing organic substances during fermentation under the action of microorganisms, by biological degradation, the organic material is transformed into a humus-like material. The main purpose of waste composting technologies is to reduce the amount of biodegradable waste, to store it in environmentally friendly conditions and, finally, to reintroduce the finished product, which is compost, into the economic circuit.
This paper aims to present the current state concerning the construction of organic compost equipment, but also the advantages and disadvantages of each equipment /machinery.

INTRODUCTION

As it is known, composting is the operation of recovering organic components from waste for their processing, and the finished product of the operation of composting organic waste is compost. Compost is a crushed and fertile mixture by total or partial decomposition of organic matter and is used to improve soil quality to increase its fertility.

The main purpose of waste composting technologies is to reduce the amount of biodegradable waste, to store it in environmentally friendly conditions and, finally, to reintroduce the finished product, which is compost, into the economic circuit. (Cristescu C.)

To date, countless researches have been carried out and various composting processes have been established, but the issue of composting is still current and continues to be studied, both independently and as part of the integrated waste management strategy.

Most of the equipment used to obtain a small volume of compost transforms the organic material in 24 hours, but this process can take several weeks for large amounts of organic material. During all this time the volume of material is reduced by 85-90%. These types of equipment generally consist of a compost tank, a humidity sensor, a heating system, mixing / homogenizing knives and an exhaust system.

The organic material is introduced into the equipment, at which point the humidity sensor sends the start command to the heating system. The tank starts to heat up and the shaft on which the knives are mounted rotates. The increase in temperature leads to the evaporation of water from the organic waste, and the exhaust system sends these vapors into the atmosphere.

Because the organic material is composed of 70-80% water, the largest reduction in volume occurs at this stage, the rest of the water evaporating under the action of bacteria and microorganisms. The process is simple and silent, which is based on the natural phenomena of decomposition of plant debris.

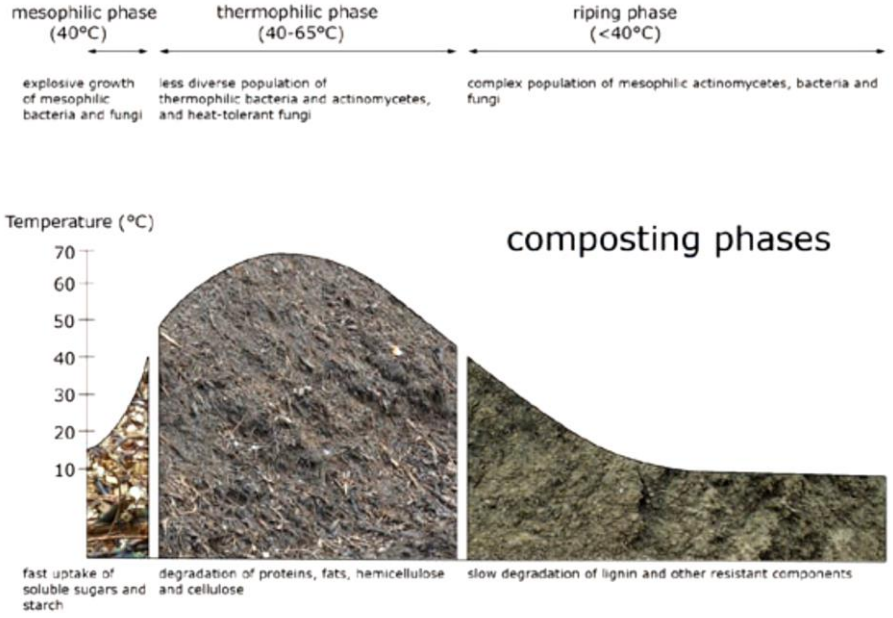

Figure 1. General overview of the three composting phases and the degradation processes taking place. The length of the different phases will differ, according to the composting method applied *(André WG et.al.,2016)*

By using compost from waste from agricultural and forestry areas, as well as from the wood processing industry, soil fertilization occurs. The use of organic plant compost also ensures the conservation, protection and improvement/rehabilitation of degraded or poorly productive land, by introducing natural organic materials into the soil, resulting in increasing or maintaining the quantity and quality of humus, following the principles of sustainable agriculture. *(Cristescu C.)*

MATERIAL AND METHOD

There are two common types of composting process that can be used, one of the types called "aerobic composting" that uses air in composting. In this process the bacteria is growing by high nitrogen waste, which also will make the bacteria create high temperature that makes organic waste breaks down quickly. We can say that aerobic composting is usually happens in nature. The microbes responsible for composting are naturally occurring and live in the moisture surrounding organic matter. Oxygen from the air diffused in to the moisture and is taken up by the microbes. As aerobic digestion takes place due by-products are heat, water and carbon dioxide (CO2). While CO2 can be classified as a greenhouse gas it's evolution from the composting process is not counted in emissions. Additionally, CO2 is only 1/20th as harmful to the environment as methane (the main by-product of anaerobic degradation) the heat produced in aerobic composting is sufficient to kill harmful bacteria and pathogens as these organisms are not adapted to these environmental conditions. It also helps support the growth of beneficial bacteria species including psychrophilic, mesophilic, and thermophilic bacteria which thrives at the higher temperature levels. This composting process takes 8-10 days. (*Mansi P., et.al., 2019)*

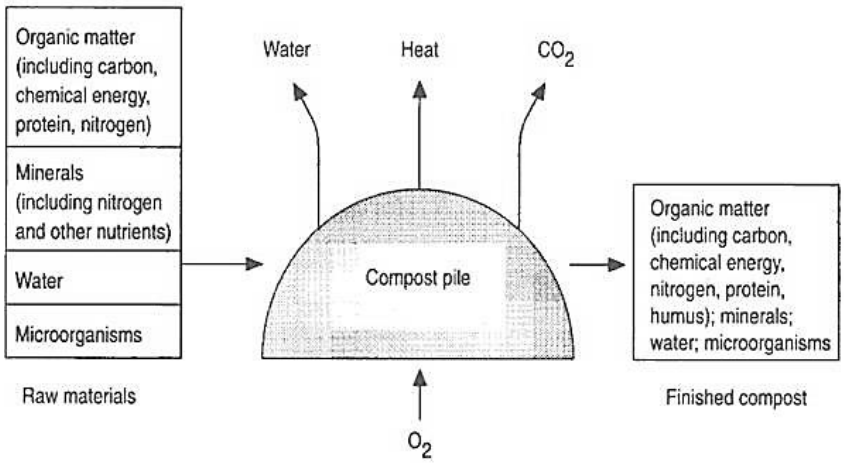

***Figure 2. The composing process**, (Source: https://content.ces.ncsu.edu/large-scale-organic-materials-composting)*

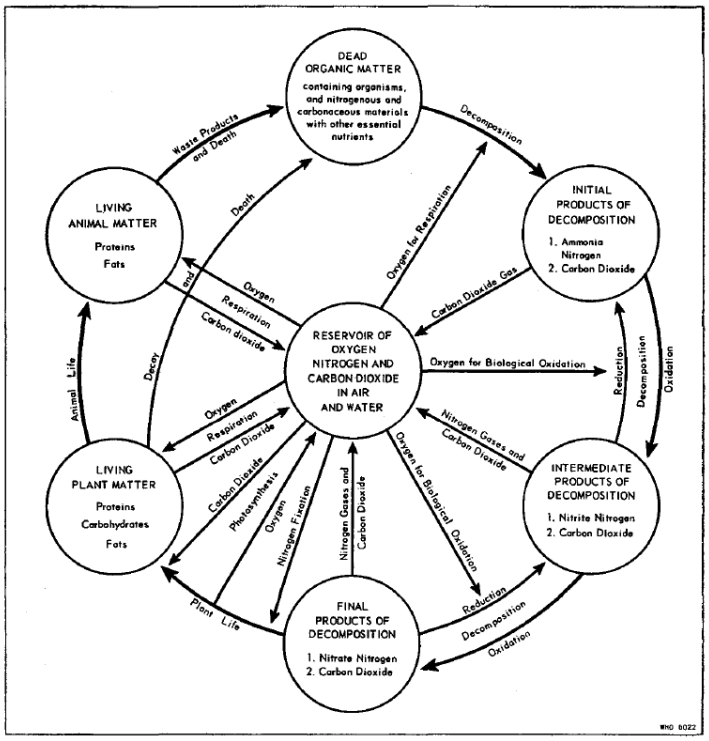

***Figure 3. Cycle of nitrogen and carbon in aerobic decomposition,** (Harold B. Gotaas, 1956)*

Anaerobic composting is decomposition that occurs using microorganisms that do not require oxygen to survive. In an anaerobic system the majority of the chemical energy contained within the starting material is released as methane. The process is characterized by very strong odors and only a small amount of heat is generated meaning decomposition takes much longer and doesn't reach sufficient temperatures to safely kill plant pathogens, weed and seeds. To overcome these limitations external (artificial) heat is normally added.

As the material is broken down by anaerobic digestion, it creates a sludge-like material that is even more difficult to break down. This material, digestate, typically requires aerobic composting to complete the stabilization process. *(Source:https://www.globalcomposting.solutions/aerobic-vs-anearobic-composting)*

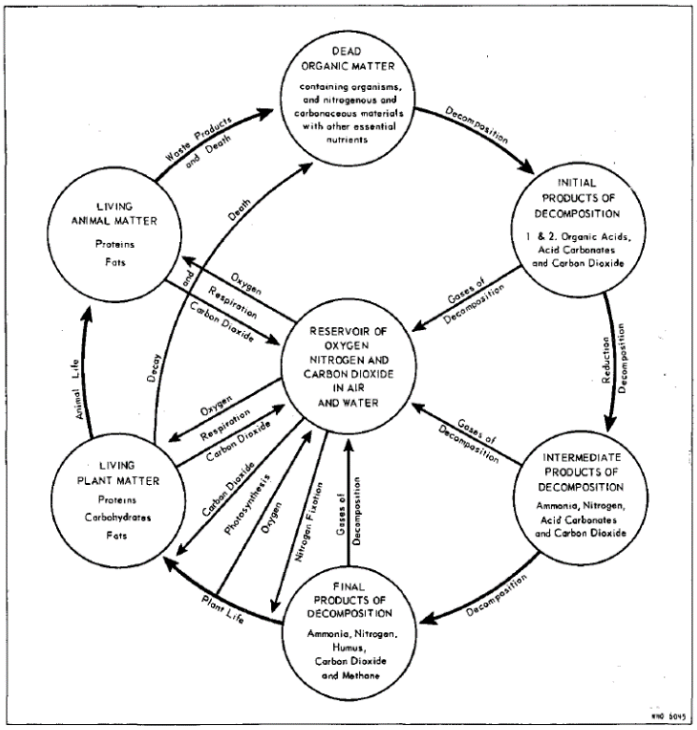

Figure 4. Cycle of nitrogen and carbon in anaerobic decomposition, *(Harold B. Gotaas, 1956)*

Table 1

Desired characteristics for the composting process *(Source: https://content.ces.ncsu.edu/large-scale-organic-materials-composting)*

Characteristic	***Reasonable range***	***Preferred range***
Carbon-to-nitrogen (C:N) ratio	20:1 – 40:1	25:1 – 35:1
Moisture content	40% – 65%	50% – 60%
Oxygen content	> 6%	~16% – 18.5%
pH	5.5 – 9.0	6.5 – 8.0
Bulk density	< 40 lbs per cubic foot	—
Temperature	113°F – 150°F	130°F – 140°F
Particle size	1/8 in – 2 in diameter	Varies*
***Depends on raw materials, pile size, and/or weather conditions.**		

RESULTS AND DISCUSSIONS

The following equipment represents the most important composting solutions available in the world.

Joraform offers two categories of composting solutions: a manual tumble cylinder for outdoor home use and an industrial, automatic composting machine for restaurants or big businesses.

***Figure 5. Jorakompost 125/270/400**, (Source: https://joraform.se/home/)*

The Jorakompost 125/270/400 are all part of the manual category and feature a cylinder split in half to create two chambers as shown in Fig. 5. One chamber can be used to add new food waste while the other can be allowed to mature without the addition of new food waste. The cylinder is propped up off the ground through its center axis so that it can be manually rotated to allow for easy mixing of food waste and other added materials. (*Mansi P., et.al., 2019)*

- This tumbling composter is constructed for ease and simplicity of rotation - it's simply turned by hand whenever waste is put in.
- The Jora Compost Tumbler is divided into two chambers. While one is being filled, the compost in the other chamber matures.
- The Jora Composter is positioned off the ground and the doors are secured with a latch so that there is no possibility of rodents or other pests gaining access to the waste in the machine.
- The JK270 has a volume of up to 70 gallons and capacity of 7-8 gallons a week.
- The JK 270 Compost tumbler is made from galvanized steel and the barrel is powder-coated to be more durable and longer lasting.

Earth Duo, a two chamber in-vessel batching composting machine. The first chamber is filled and then the second chamber. When the second chamber is full, the first chamber is ready to discharge. This chamber will then be filled and when full, the second chamber will be discharged. If data is supplied a dashboard measuring environmental impact of the use of this machine can be built for an additional service fee. *(Source: https://www.globalgiving.org/pfil/35967/projdoc.pdf)*

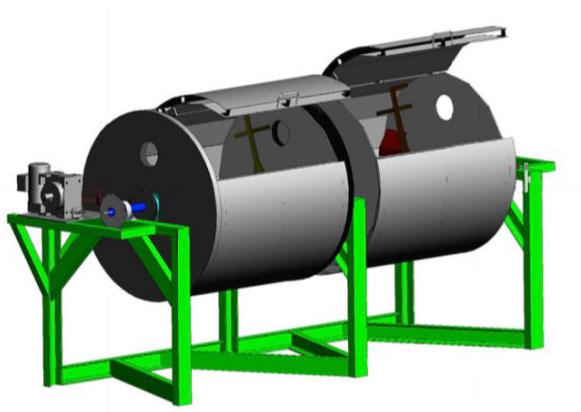

Figure 6. Earth Duo concept, (Source: https://www.globalgiving.org/pfil/35967/projdoc.pdf)

TG-CC-300 food waste recycling machine to organic fertilizer is a mechanical device that provides the necessary degradation environment for organic waste (food, garden, fruit, vegetable, etc) microbial treatment bacteria and rapidly degrades organic waste (kitchen, garden, fruit, and vegetable, etc). The device provides suitable temperature, humidity, oxygen content, and the like for the microbial treatment bacteria so that the organic waste can be rapidly degraded.

- Platinum catalyst deodorizing system
- Hot air-drying cycle system
- Device status and remote management

As the name goes, High-Quality Waste Composting Machine TG-CC-300 has a corrosion-proof body, Siemens touch-screen, and is equipped with the latest PLC technologies and automation control systems. In several steps the machine can decompose 300 to 350 kg of organic food waste, using in it the stage-in-craft indirect heating and dry composting technologies, in an expected time of 16-22 hrs. *(source: https://togohb.com/product/food-waste-recycling-machine/)*

Figure 7. TG-CC-300 food waste recycling machine, *(Source: https://togohb.com/product/food-waste-recycling-machine/)*

Ohio University became the university with the largest in-vessel compost facility in the United States with **The Wright Environmental Management, Inc. WEMI-4000** that was installed in 2009. WEMI-400 is a 2 ton in-vessel composting system. The tunnel inside the

system is controlled for air supply and temperature, a supply and exhaust fan and an air circulation shows that Composting material moves through a set of spinners that act to invert, homogenize, agitate and stack the material into the next zone. water will be added to the mix during material cross-mixing if needed to raise moisture levels to the desired levels Material remains in the second tone for an additional r of days equivalent to the retention time in zone (7 days in Zone l and 7 days in Zone 2 equals 14 retention days) while significant stabilization happens through control of air supply. Water and temperature the best temperature range for composting organic waste in this system is 50 degrees Celsius to 65 degrees Celsius. Any moisture that drains out of the composting material flows into the pl that run along the base of the tunnel and from the plenums to sump boxes through pipes located at the sides of the tunnel. Leach ate is pumped back on to the composting material from the sump box through pipe locate at sum box. (*Mansi P., et.al., 2019)*

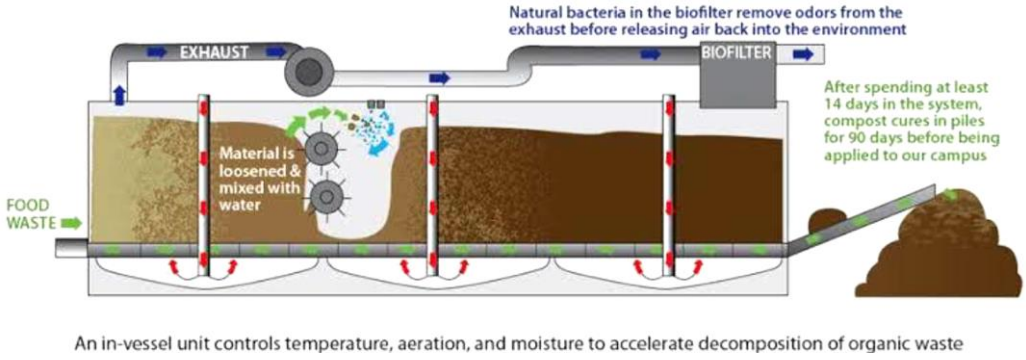

Figure 8. Ohio University's In-Vessel Composter, (*Mansi P., et.al., 2019)*

Ridan Composter uses natural ingredients and processes to create a warm environment in which food waste (nitrogen) and wood (carbon) can mix with air and water. Unlike other composters, all this happens without the need for electricity, making your Ridan cheap and easy to use Fig.8. shows that heat is created when micro-organisms, (including bacteria and fungi) break down the organic matter, bio food waste and wood. The heat attracts even more hyper active microbes. Which make the composting process quick and efficient. This creates the perfect composting condition. The food waste needs to stay inside the composter for a minimum of two weeks before it can be removed from the composter. Depending upon what sort of food is being composted it may be ready to spread straight onto the garden. However, it is usually best to mature the compost for 2-3 months. (*Mansi P., et.al., 2019)*

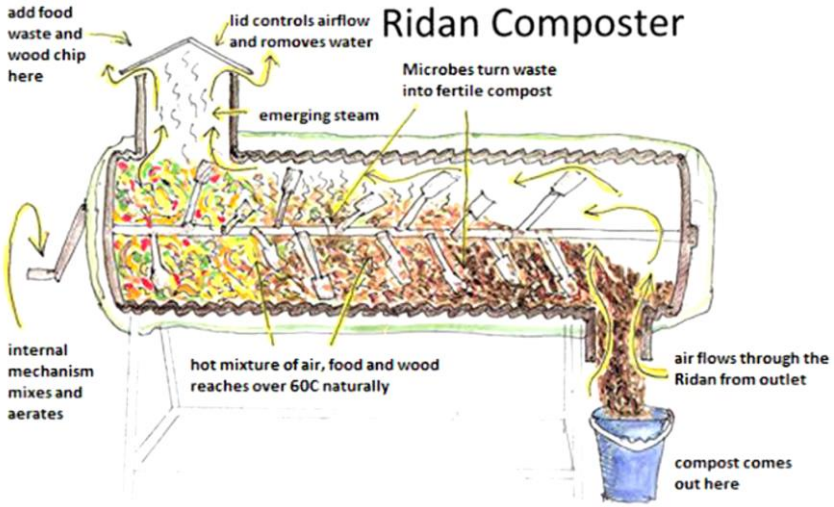

***Figure 9. Ridan Composter**, (Source:* http://www.ecovrs.com/en/products/in-vessel-composting/ridan-composter/)

IAB biohumus loosening equipment. The experimental model, IAB biohumus (vermicompost) loosening equipment, is intended for faster and better quality biohumus production. The installation will allow the operation in conditions of variable temperature and humidity, both in summer and in winter for the loosening-production of vermicompost. The IAB biohumus loosening plant can be seen in Fig.10.

Figure 10. IAB biohumus loosening equipment

Before starting work, the system is coupled to the tractor using the PTO shaft with the gear unit on the system. The speed received from the tractor is multiplied by the gear unit and transmitted to the knife drum. By positioning the equipment on the side of the tractor it covers the compost line better. By moving the tractor in front, the installation that loosens the compost line is also moved but also makes crushing of the compost components with the help of the knives on the drum. During the movement of the installation, it is brought to the transport position (along with the tractor).

Composting facilities are aerated or unaerated and covered or not covered. Composting methods include passive piles, windrow composting, static piles, and in-vessel composting (in bins, beds, silos, transportable containers, and rotating drums).

Passive piles are created by stacking materials in piles and allowing them to decompose over a long time with little management. This simple, inexpensive method also

has some disadvantages: the pile can overheat and spontaneously combust; it can become anaerobic and release odors; it sits there for years, taking up valuable space; and it can look like a dump and attract the dumping of unwanted materials. Passive piles can take a year or more to decompose, depending on the materials in the piles.

Windrow composting involves placing mixed materials in long, narrow piles and turning or agitating them regularly (Fig. 11). This is the most common method used for rapid composting of yard wastes. Windrows are typically 3 to 12 feet high, 10 to 12 feet wide, and hundreds of feet long. Windrows are formed using a front-end loader, and they are turned with this equipment or a specialized turning device. This method is more labor-intensive than aerated piles because some activity is performed on the site almost daily.

Determining how often to turn windrows depends on the rate of decomposition, moisture content and porosity of the materials, and the desired composting time. High-nitrogen or easily degradable materials may require daily turnings at the beginning of the process and weekly turning later. The active composting stage will last three to nine weeks, depending on the type of materials and frequency of turning. To produce compost in three weeks, turn windrows once or twice each day for the first week and every three to five days thereafter.

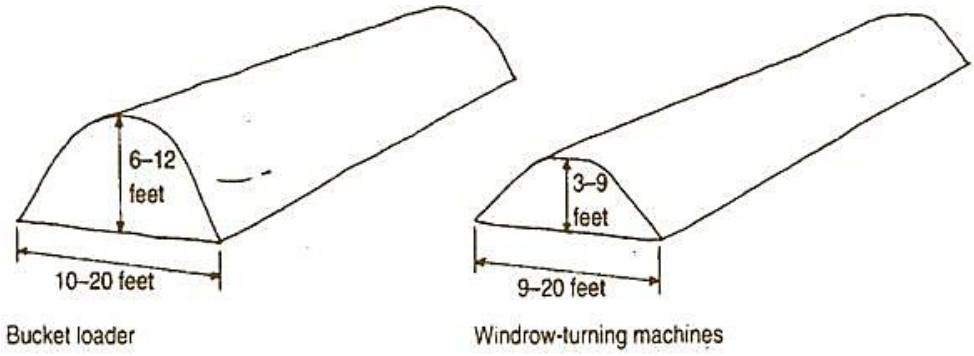

***Figure 11. Typical windrow shapes and dimensions**, (Source:* https://content.ces.ncsu.edu/large-scale-organic-materials-composting)

In summary, windrow and static pile systems are comparable in cost, labor, management, and speed of process. In-vessel composting is faster, but it has high capital costs with the exception of simple bin methods and some agitated bed systems.

The size of the site required for composting depends on the following factors: the anticipated volume of raw materials, the technology to be used (the higher the level, the less space required), the equipment to be used (which depends on the method and raw materials), and the projections for growth. Some factors that should be considered when choosing a site are: accessibility (roads suitable for traffic and convenient to feedstocks, or raw materials), population density (no houses within half a mile), and type of neighbors (some industries require a clean atmosphere and no flies). Desirable site characteristics include (1) slightly sloped land (for drainage), (2) a firm soil type that packs well, (3) not located in a flood plain, (4) convenient utilities, and (5) a rectangular or square site, which is more efficient than a circular or irregularly shaped site. Fig.12 shows a generic site layout for a composting facility*. (Source:https://content.ces.ncsu.edu/large-scale-organic-materials-composting)*

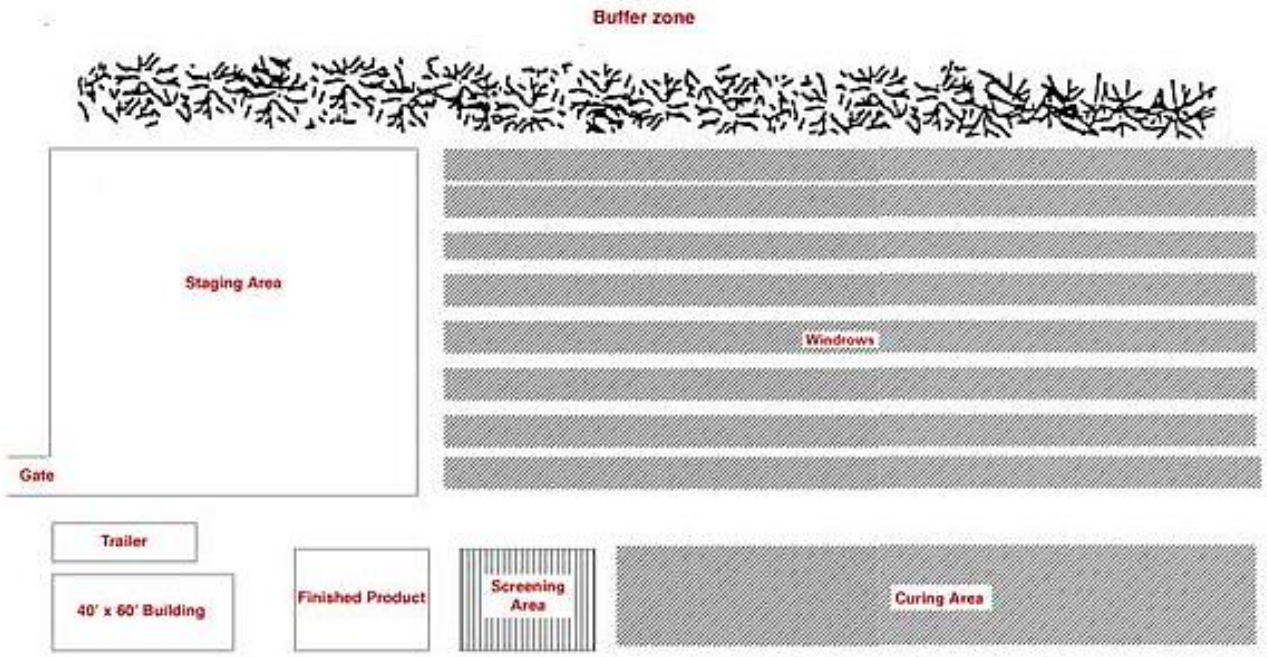

Figure 12. Generic compost site layout, *(Source:* https://content.ces.ncsu.edu/large-scale-organic-materials-composting)

CONCLUSIONS

The continuous growth of the human population determines the increase of production, implicitly the effective increase of the consumption of resources, generating a significant impact on the environment. Over time, man has developed new techniques, various sophisticated technologies, to meet their primary needs but not only, but following the idea of increasing comfort, economic development.

The manufacture of the product involves the generation of certain pressures on the environment, from the consumption of natural resources to the disposal of those parts that can no longer be used. The interdependence between economic growth and the impact of activities on natural capital, the cause of resource consumption and implicitly the generation of waste raises problems globally.

Aerobic composting is the principle at work in aboveground composting environments — whether it takes place in a freestanding pile or in a container that provides air circulation, such as a bin with open sides or a tumbler with aeration holes.

Anaerobic organisms work without oxygen, so most anaerobic takes place underground in pits or trenches. Basically farmers dig a hole, fill it with organic matter, and seal it with a layer of soil. Anaerobic decomposers get right to work, with no need for fresh O_2.

Anaerobic organisms work at slower rates than their aerobic counterparts, and it's near impossible to monitor their progress. Anaerobic organisms exude smelly gas as a byproduct of their exertions. And because of the colder conditions, weed seeds and plant pathogens aren't destroyed.

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