Production Of Compost With Bovine Manure. Reduction Of Environmental Impact

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Abstract

The amount of manure generated by livestock production can cause negative environmental impacts, if its storage, transport, or use are not controlled, due to the emission of polluting gases into the atmosphere and the accumulation of micro and macronutrients in soils and in surface water bodies. In this research, a review of the strategy that may be feasible and viable to implement to reduce the environmental impact generated by greenhouse gases is made, from manure, the methodology used was *desk research* and the inductive method, the research aimed to evaluate the greenhouse gas emissions caused in the production of compost produced by cattle manure. Through the review, it was concluded that the production of compost is a viable alternative for reducing the environmental impact generated by greenhouse gases (GHG) globally, which emit 44% methane (CH_4), 29% nitrous oxide (N_2O) and 27% carbon dioxide (CO_2) to the atmosphere.

Keywords: Compost, fermentation, greenhouse gases, manure, cattle

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Introduction

Climate change is caused by the accumulation of greenhouse gases in the atmosphere, which causes an increase in temperature on the planet since approximately the 1950s, this variation has been evident; the observed changes are unprecedented in decades and even millennia. The atmosphere and oceans are warming, polar ice and glaciers are shrinking, sea level is rising, as well as ocean acidification (IPPC, 2014).

One of the residues with the greatest impact from livestock activity is manure, which is an important source of nutrients, but if it is not treated properly, it can contaminate the groundwater table and the soil (Beltrán et al., 2016). However, its abundance in pastures has led to proposing the production of compost as an alternative to recycle biodegradable organic solid waste, transform it into fertilizers for agriculture and avoid its inappropriate disposal in landfills, in search of solutions to reduce emissions. of greenhouse gases (GHG) and the filtration of liquids from this residue that contaminate aquifers (Da Costa Ferreira et al., 2018).

Compost is a biological process in which organic matter is transformed into humus under the activity of microorganisms in such a way that the necessary conditions for the aerobic fermentation of these materials are guaranteed (Soto, 2003). It is considered a food for the trophic chain of the soil because it promotes the biological activity of microorganisms, a substrate with disease control properties of cultivated plants. In summary, compost is an excellent productive factor in agroecosystems and can be an excellent element in the protection and maintenance of the soil (Fernández et al., 2004).

The application of compost on agricultural land increases the organic matter of the soil, improves properties such as structure, water retention capacity, oxygen content; it also reduces soil erosion, nutrient leaching, and increases nitrogen and phosphorus content, which ultimately increases crop yields (Iglesias, 2014).

The quality of the final compost depends on various parameters that intervene during the fermentation and maturation process, the most relevant being temperature, humidity, carbon-nitrogen ratio, presence of oxygen and pH (Soto & Meléndez, 2003). Based on the, compost is considered a valuable resource that leads to completing the nutrient cycle, allowing a large part of the nitrogen to return to the soil, making it one of the most viable alternatives to reduce environmental impact. due to excess manure in the different sectors of the livestock industry (Cairo & Álvarez, 2017).

In the different production systems, a well-structured and adequate management plan should be considered for the waste produced, to generate sources of income instead of environmental contamination, thus allowing it to be considered as an economic alternative for the efficient use of compost (Estrada, 2005).

Compost quality is not an absolute term but depends on its intended use. In this sense, it is the concept of "the capacity or adequacy of the compost to the needs of the plants with a minimum impact on the environment and without endangering public health" (Ansorena et al., 2011).

The concept of quality is difficult to define because it must consider several aspects and it can always be very subjective. The effectiveness of the compost must always be based on the properties that result from ecologically sustainable processing, in accordance with acceptable waste management, and whose purpose is to produce a product intended to be used in the soil or as a substrate (Soliva & López, 2004).

The quality of the compost for a specific use is usually determined in two different ways; The first is field trials, where the response of the plant is measured under real growing conditions with different doses of compost for biomass production, root growth, number of leaves or flowers, the second, measuring a set of properties. , some of which, for example, organoleptic properties (smell, color, particle size, presence of unsuitable elements such as plastic, glass) can be sensorially evaluated (Ansorena et al., 2014), while the physical, chemical and biological properties (density, porosity, aeration, pH, electrical conductivity, nutrient content, heavy metals and bacterial contamination), are usually determined in the laboratory.

In the composting process, two separate and successive phases are distinguished: the composting phase itself, where the activity of microorganisms is maximum because they have access to a large number of easily biodegradable compounds, and the maturation or stabilization phase, where the activity of microorganisms decreases when the supply of biodegradable material is depleted. The first stage is dominated by the mineralization of the organic fraction, while the second is dominated by the polymerization and condensation of the compounds contained in it. Both phases are controlled by temperature, humidity, and ventilation, which distinguishes composting from uncontrolled natural processes that can lead to anaerobiosis. The duration of each stage is very different depending on the material to be composted and the process conditions and can vary from a few weeks to several months (Abab & Puchades, 2002).

Global greenhouse gas emissions occur with 44% methane (CH_4), 29% nitrous oxide (N_2O) and 27% carbon dioxide (CO_2) to the atmosphere (Haro Reyes & Gómez Bravo, 2018). Increased concentrations of these gases have led to surface warming and destruction of the stratospheric ozone layer.

One way to reduce methane emissions from digestive processes in dairy cattle is to manipulate and improve feed composition with chemical additives such as bromochloromethane or α-cyclodextrin, which are halogenated methane analogues that reduce methane production in the dairy. rumen of the cow (Morocho, 2012), however it is also mentioned that the fats present in bovine diets since they reduce the physical action of methanogenic bacteria, likewise the lipids rich in unsaturated fatty acids have the ability to trap the molecules of hydrogen through the biohydrogenation of these, decreasing the availability ofH_2 so that methane can be formed (Aguiar & Rojas, 2014) cited by (Valencia & Rojas, 2019).

The objective of this work was to evaluate the greenhouse gas emissions caused by cattle manure and how they behave after being treated by composting.

Materials and methods

The methods applied for the development of this review investigation were desk research which consists of a technique that uses existing and publicly available information from studies carried out that includes material from investigative documents and other materials of this type from Google Scholar, articles, scientific journals, and theses (Martínez et al., 2022) and the deductive method to test the validity of the result.

Analysis and discussion of results

The main techniques for making compost use organic residues that mainly include fresh cattle excreta, food residues, shavings and fats that are degraded by microorganisms since they serve as food for them and allow the creation of a compost that can improve the structure of the soil. through the contribution of nutrients (Peralta et al., 2016).

Most organic materials can be composted. In figure 1, materials suitable for composting are shown according to Román et al., 2013.

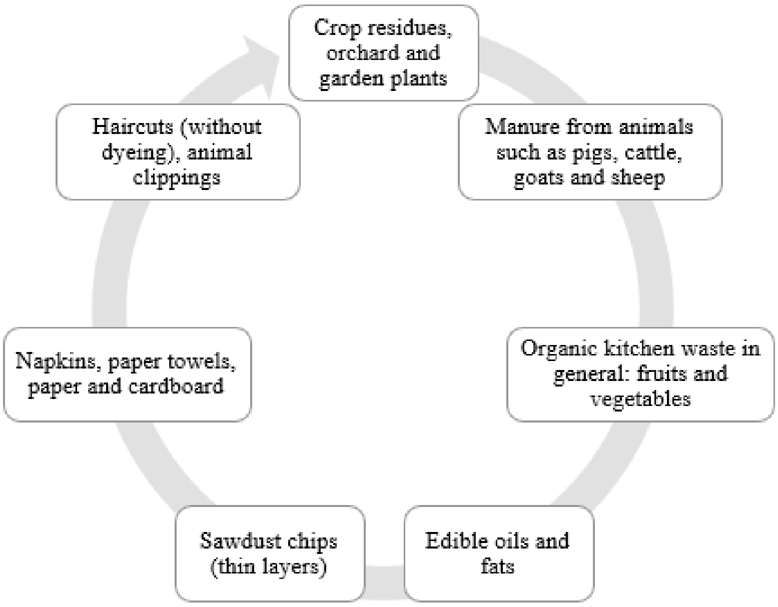

Figure 1. Materials suitable for composting

Source: (Román et al., 2013)

There are some materials that should not be added to the process because they are inert, toxic or harmful, such as: adhesive residues, paints, synthetic chemicals, kerosene, petroleum, vehicle or motor oil, solvents, gasoline; non-degradable materials such as glass, metal, plastic; boards or plywood (or sawdust, chips or shavings); tobacco because it contains powerful biocides such as nicotine and various toxins; cleaning agents such as detergents, chlorine products; antibiotics or drug residues; animal carcasses (must be burned under special conditions or placed in special compost piles); remains of prepared food (Román et al., 2013).

Many of these products that are dumped in the waste should not be used as they could damage the process, so it is necessary that they can be separated from the beginning of the raw material (manure) collection chain.

The use of dietary additives and pharmaceuticals administered to animals can cause the accumulation of certain undesirable compounds in the manure, limiting its use as fertilizer. An example is copper, a highly polluting heavy metal, which has already been shown to be the primary route of contamination in manure-fertilized agricultural soils (Xiong et al., 2010).

The biological treatment of manure (composting) is always the safest solution for agriculture. Although the short-term availability of some nutrients, such as nitrogen, is reduced compared to fresh manure, composting significantly reduces the negative impact of pollutants. Most common veterinary antibiotics, such as chlortetracycline, monensin, sulfamethazine and tylosin, have been shown to break down during the process (Dollivera et al., 2008).

To make the compost, a detailed process must be followed, in table 1, where the different stages through which the compost passes, starting with the mesolithic and ending in the maturation stage, are shown, thus applying the fermentation method to obtain of organic fertilizer from bovine manure. Likewise, in a study carried out by (De La Cruz et al., 2019) it is suggested that the mounds be turned once a week to maintain adequate aeration throughout the process.

Table 1. Compost preparation stages

Stage	Description
mesophile	The vegetable mass is at room temperature and the mesophilic microorganisms multiply rapidly, appearing between 15 °C and 35 °C and initially consuming the carbohydrates contained in the organic matter. As a result of metabolic activity, the temperature rises, and organic acids are formed that lower the pH.
thermophilic	Exothermic reactions occur at a temperature of 40 °C, thermophilic microorganisms transform nitrogen into ammonia and the pH of the environment becomes alkaline. At 60ºC these thermophilic fungi disappear and sporogenic bacteria and actinomycetes appear. These microorganisms are responsible for breaking down waxes, proteins and hemicelluloses.
Cooling	When the temperature is below 60 °C, thermophilic fungi reappear and re-enter the mulch and break down the cellulose. When the temperature drops below 40 °C, the mesophiles also resume their activity and the pH of the medium drops slightly.
Maturation	This is a period that requires months at room temperature, during which the metabolic capacity decreases, secondary polymerization and condensation reactions of the humus take place, the less degradable compounds decompose, and humus precursors appear, the volume of the soil decreases by 40%. stack.

Source: (Cajamarca, 2012); (Vargas et al., 2018)

Behavior of GHG emissions

The properties of cow manure depend on many factors, such as the breed of the animal, diet, age, the drugs used for it, the beds or the production system used to collect the manure (Knowlton et al., 2010).

The growth of livestock activity increases the production of manure, which generates significant environmental impacts that can occur gradually or immediately. Therefore, composting is an acceptable way to reduce environmental impact, as it can significantly lessen the damage to the environment in which life thrives. Theoretically, all organic waste can be composted, the acceptance of this process depends on the composition of the waste and the method used.

Composting process

The composting process basically consists of three stages, mentioned below (Zapata, 2009):

- Initial or mesophilic (30-40 °C), decomposition is carried out by mesophilic microorganisms, which consume soluble and easily degradable substances such as sugars, amino acids, short-chain fatty acids, among others. This causes a rapid increase in temperature. The heat generated by metabolic activity during the decomposition of organic matter by microorganisms is greater than the heat dissipated.
- Thermophilic (50-60 °C), during which proteins, cellulite material, etc. are broken down. with formation of carbon dioxide, water and ions. Stable organic compounds are formed, phytotoxic substances and other pathogens are eliminated, it can last several weeks. When temperatures enter the thermophilic range (>45°C), significant changes in microbial

populations occur. Microorganisms that do not tolerate high temperatures die or form spores, while thermophilic bacteria are favored and predominant. However, when the temperature reaches values between 55°C to 60°C, thermophilic bacteria are affected, and their activity is reduced.

● Stabilization, cooling or ripening where the temperature drops, the rate of decomposition decreases, and mesophilic organisms recolonize the mass. An organic and stable material is achieved, that is, a mature compost. The final state of curing, which consists of the prolongation of the state of stabilization and mineralization and exceeds the stage of maturity.

Composting is an aerobic process, although in most cases anaerobic conditions exist on a microscopic scale. However, biodegradation occurs mainly in an oxidized environment if aeration is managed properly. During the decomposition process, organisms consume organic matter and produce carbon dioxide, water, heat, and other substances (Zapata, 2009).

In figure 2**,** The temperature and pH changes during different stages of the composting process are shown, where through controlled conditions the temperature decreases during a certain period due to the reduction of feed reversals and the decrease in microbial activity, during the composting process. composting, the temperature of the pile drops until it approaches room temperature.

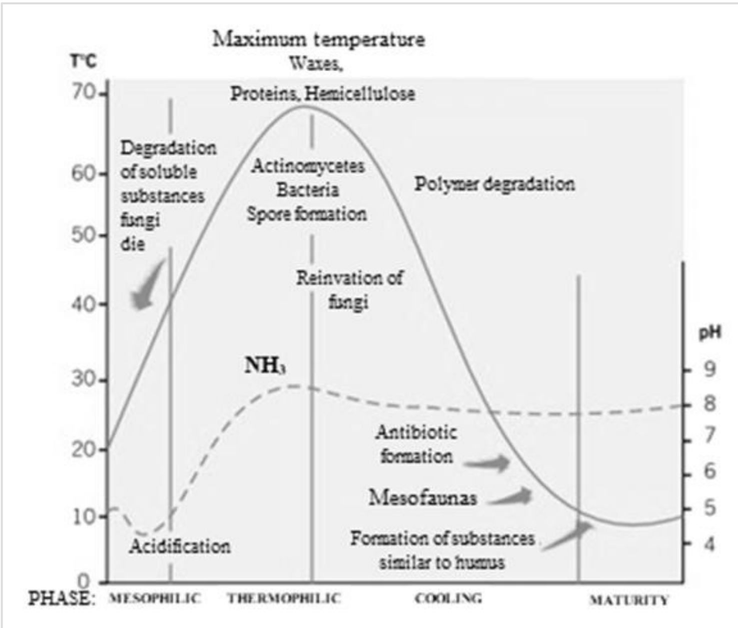

Figure 2. Changes in temperature and pH during the different stages of the composting process.

Source: (Zapata, R., 2009)

Figure 3 shows that the composting process determines each state of decomposition of the manure as time passes., the first state is rapid breakdown of high energy compounds (carbohydrates and proteins) by bacteria and high energy (heat) release occurs. During the second microorganisms change to fungi and actinomycetes, they produce little energy. In the third state, the condensation process continues, reaching more stable forms.

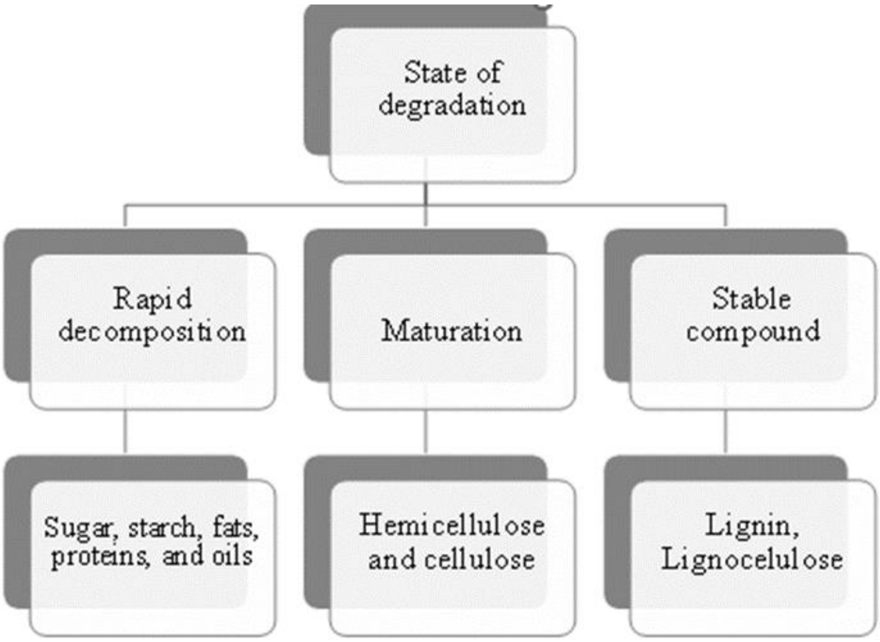

Figure 3. Degradation of different types of substances over time, in the different stages of the composting process

Source: (Zapata, R., 2009)

In figure 4**,** A diagram of the main stages of the composting process is observed, where it begins with the selection and separation, either manual or mechanical, of the waste that will be mixed with the bovine manure, followed by pre-composting, which is a previous activity in the which a partial colonization of microorganisms is carried out, followed by crushing and grinding to reduce the size of the particles. Among the composting methods are composting beds and piles, it also includes vertical or horizontal reactors, the system will be formed depending on whether the process is aerobic or anaerobic, being open or closed (Solans et al., 2001).

From the decomposition of the residues to the maturation of the compost, the stages are covered: mesophilic, thermophilic and stabilization of the compost proposed by (Zapata, 2009). To finalize and obtain the final product (compost), control tests are also carried out to maintain its quality.

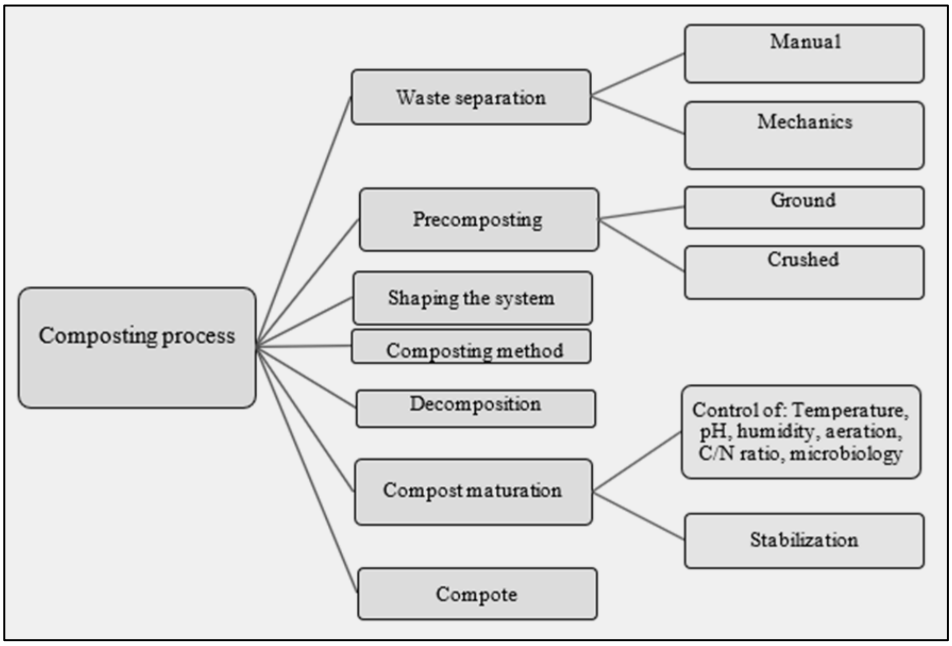

Figure 4. Main steps of the composting process

Source: (Uicab-Britto & Sandoval, 2003)

The methane emitted by cattle is the consequence of food fermentation in the digestive tract, this gas is emitted as a by-product of the microbial fermentation of carbohydrates specifically in the rumen and in the large intestine, which leads to a degradation to acids. volatile fatty; Carbohydrate fermentation is the result of the production of hydrogen that is used by methanogenic bacteria to decrease carbon from theCO_2 a CH_4 (Reategui, 2017).

methaneCH_4 that is put into the atmosphere, it is done by belching and breathing or flatulence; manure methane, enteric methane and nitrous oxide emissions are 40, 113 and 10$TgCO_2Eq$ (Reategui, 2017).

Methane is a greenhouse gas (GHG) 23 times more potent than carbon dioxide (CO_2), and manure contributes 16% of global emissions (IPCC, 2006). Manure emissions originate from methane produced by intestinal fermentation and by anaerobic decomposition of organic matter in manure (De Klein et al., 2008). Manure contributes approximately 50% of the total ammonia emissions into the atmosphere, because its volatilization rate is greater than 23% (Reategui, 2017).

Total manure methane emissions in Ecuador according to (Cornejo & Wilkie, 2010), were 182$GgCO_2Eq$ (Gigagrams of carbon dioxide equivalent). Livestock excreta represent a severe problem of environmental contamination, so the production of compost represents a viable way to reduce these emissions (López, 2019).

Based on the research carried out, it has been possible to have as a result that up to 50% of the methane emitted can be reduced by applying composting in bovine manure beds compared to the method of storage in piles (Chen et al., 2014), however the constant turning of bovine manure compost piles represents a 2.7 higher GHG emission compared to composting without turning (Alvarado et al., 2023).

The anaerobic digestion of dairy bovine liquid manure is an effective method for reducing GHG compared to its storage, highlighting theCH_4 as the one with the highest incidence, while those ofN_2O appear after application to the soil.

Conclusions

Compost production is a viable alternative to reduce greenhouse gas emissions caused by cattle manure due to the increase in livestock activity that has increased the generation of manure, discarding a large amount of nutrients, intensifying the environmental impact if it is not treated and stored correctly. The composting stages must be completed in order to obtain a quality compost that can be used as a product that meets the conditions for reducing polluting emissions.

Based on the information collected, it can be concluded that composting is a feasible methodology that transforms organic waste into stable and beneficial organic matter as fertilizer for agricultural soils; In this way, it contributes to the reduction of the environmental impact generated by greenhouse gas emissions, achieving a reduction of up to 50% of the methane emitted through the application of composting in bovine manure beds compared to the method of storage in piles.

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