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APPLICATIONS AND IMPLICATION OF MICROBIAL COMMUNITIES IN COMPOST

Compost is a combination of substances that is used to nourish plants and enhance the physical, chemical, and biological qualities of soil. It is frequently made by composting manure, organic waste, and plant and food waste. The resultant combination is full of nutrients for plants as well as healthy bacteria, protozoa, nematodes, and fungus. Compost increases soil fertility and decreases reliance on synthetic chemical fertilizers in organic farming, urban agriculture, horticulture, and gardening. Long-term overuse of chemical fertilizers has caused soil quality metrics such soil microbial biomass, communities, and nutrient content to deteriorate, which in turn impacts crop health, productivity, and soil sustainability. The purpose of this study was to accurately measure soil quality parameters through the application of manure compost and bacteria fertilizers or their combination during maize development in order to establish a quick and effective method for repairing deteriorated farmland soils. We looked at the dynamic effects on the variety of community structure, basal respiration, and microbial count and biomass in soil. Composting types: vermi-composting, windrow composting, aerated static pile composting and in-vessel. Organic waste has been managed for generations through the self-heating biological process of composting. The composting byproduct can be utilized as an organic fertilizer and soil additive in addition to handling organic waste. Over the years, composting research has advanced significantly, particularly in *regards to expediting and enhancing the quality of compost. Recalcitrant organic pollutants are biodegraded by the various microbial communities found in composting materials. These three types of breakdowns include catabolism, total metabolism, and general extracellular oxidation.*

Keywords: Microbial communities, compost, productivity, applications and implication.

Introduction

Compost is a mixture of ingredients used as plant fertilizer and to improve soil's physical, chemical, and biological properties. It is commonly prepared by decomposing plant and food waste, recycling organic materials, and manure. According to the European Landfill Directive, by 2016, there should be a 75 % decrease in the amount of biodegradable municipal trash being disposed of compared to 1995 levels. Composting municipal, agricultural, and industrial wastes is one of the bio waste treatment methods that is most often utilized in Europe. Anaerobic digestion, which turns organic substrates into methane-rich biogas suitable for producing heat and power, is another increasingly popular method. At the end of the procedure, a dig estate that includes nutrients as well as organic components that have not yet digested and those that cannot be degraded remains. Composting and anaerobic digestion working together to handle bio waste has gained more and more support recently. The benefit is the simultaneous production of biogas and compost, which improves soil, as well as energy and material goods.However, the financial structure and technical setup need to be assessed and adjusted before adding an anaerobic digestion unit to an existing composting operation [6].

Applying composted manure to the soil may help promote soil microbial activity, which will improve crop development and deter pests and illnesses. Manure compost has been thoroughly evaluated and found to be beneficial in boosting nutrient availability to crops, hence raising grain output in a financially sensible and ecologically responsible way. The addition of manure compost can also raise the amounts of organic matter and enhance the soil's biological activity, structural stability, moisture retention, and nutrient availability. Therefore, if the damaged farmland is thought to be regenerated, it is becoming increasingly common practice to add manure compost to the soils. In ecological processes including nutrient cycling and the creation of soil aggregates through the breakdown of organic matter, soil microbes are crucial players. The pace of soil processes is significantly impacted by the stability of the microbial community structure. For instance, differences in the composition of the soil's microbial population have an impact on the rates of nitrification, nitrification, and nitrogen fixation. Both natural and synthetic substances despite the fact that fertilization has increased crop output, the soil microbial characteristics have not significantly improved as a result of this application. Even some asserted that the bacterial communities of developed and unimproved grassland did not significantly vary from one another. The dynamic patterns of bacteria, fungus, and actinomycetes under various forms of fertilization have remained mysterious despite the fact that several research have looked into the impacts of organic fertilization on microbial communities [16].

Finally, the small size and rapid growth of microorganisms allow for complex community interactions to be studied much more readily than with plants or animals. For example, temporal dynamics in response to natural successional processes or experimental manipulation can be tracked for microbial communities because of their high potential for temporal or spatial change [7].

Materials and methods

In order to investigate this important and basic topic, compost is a mixture of components that are used as plant fertilizers and improve the physical, chemical and biological properties of the soil. Applications and implication of microbial communities in compost, manure compost, especially manure compost bacterial fertilizer, consistently resulted in higher levels of soil respiration rate, cultivable microorganisms, and soil enzyme activities. I conducted this research by looking at various scientific and academic references, which include academic articles, library and other research, and I mostly used review article method.

Results and discussion

Structure of the Microbial Community during Composting

Composting is a natural process characterized by microbial community successions that actively decomposes the biodegradable and putrescent organic waste under wet, self-heating, and aerobic conditions. The makeup of the microbial community and the relative abundance of its members are considered to be the components of microbial community structure. Both bacteria and fungus, which are representative of the microbial community structure of the composting environment, are present during the composting process and actively participate. Different bacteria or fungus might have a good or detrimental impact on the composting process as a whole [12]. Stages of Composting: The composting process is divided into three main phases: the mesophilic phase, the thermophilic phase, and the cooling or maturation phase. During these phases, a variety of microflora, including mesophilic and thermophilic bacteria, fungi, and actinomycetes, are present to stabilize and convert organic waste to humus.

First Stage: Mesophiles with a mixture of bacteria, actinomycetes, and fungi can grow at temperatures between 15 °C and 45 °C and reach their optimal growth range at 30 °C to 39 °C [16] due to the mesophilic temperature and availability of carbon-rich substrate at this early stage of the composting process.

Second stage: the thermophilic phase, is where the majority of the breakdown occurs. In this step, thermophilic microorganisms, primarily fungus and bacteria, degrade the organic matter (fats, cellulose, hemicelluloses, and some lignin).

Third stage: A temperature even lower than 25 °C characterizes the last development phase. The thermophiles' microbial activity stops when the substrate supply runs out [12]. Food waste and other organic waste may be ecologically friendly treated by anaerobic composting. FW degrades quickly and produces more methane because it has a high amount of easily degradable organic materials. However, China's FW often has a C/N ratio of less than 20, and it is devoid of trace elements. Co-composting has been widely utilized to enhance compost performance because it may control the substrate's physical and chemical qualities. Urban management efforts frequently create garden waste (GW). Due to its high lignocellulose content, GW is a significant renewable biomass resource. As a result, it degrades slowly, requires more time to digest, and emits less methane. The C/N ratio can be adjusted while preventing the buildup of volatile fatty acids during the quick breakdown of food waste by combining garden waste with food trash. Additionally, by co-composting GW and FW, both waste categories, which make up a sizable amount of municipal solid waste in many developing nations, are managed in a synergistic manner. As a biological process, the composting process is primarily driven by the activity of aerobic bacteria. It was proposed that the microbial population and its evolution in each step of composting were significantly impacted by the composting feedstock. Numerous feedstocks have been utilized to make compost, and high-throughput sequencing technology has been extensively employed to study the microbial dynamics involved. The process of the FW digestate co-composting with GW has received little research, despite increased interest in the co-composting of FW digestate and other organic materials, such as sewage sludge and biochar [15].

Different types of composting processes

Composting on-site: Recycling of home wastes such as leftover cooked or uncooked food, grasses, and leaves from the garden, require a little area and little effort. In many houses, it is used.

Vermicomposting: is the process of turning organic waste from the compost pile into fertilizer by using soil invertebrates like earthworms, red wigglers, and others.

Windrow composting: This method creates long, thin stacks of wind-rows in a proportionally wider area. It is occasionally made outside. However, when it is covered, it has to be aerated with the aid of cooling devices.

Composting in a vessel: For this approach, a covered, sizable container is utilized. It is connected to several electrical regulating systems for correct temperature, aeration, and turning adjustments, among other things [13].

The Microbial Functions in the Aerobic Digestion Process

Composting that occurs aerobically, or in the presence of oxygen, is a typical method for turning agricultural waste into organic fertilizer. This is a useful method to put this inventive waste product to use. In aerobic fermentation, aerobic microorganisms (bacteria, actinomycetes, fungi, etc.) may oxidize organic molecules in fermentation substrates to provide the energy required for biological growth. The proper ventilation, oxygen supply, temperature, moisture content, pH value, CO2/N ratio, particle size, etc. are used throughout this process [13].

The Microbial Functions in the Anaerobic Digestion process

Anaerobic digestion is mostly dependent on microbial activity; for this process to be efficient, variables including syntrophic interactions between bacteria and delicate balances among them are taken into account. Hydrolysis, acidogenesis, acetogenesis, and methanogenesis are the four steps of anaerobic digestion that typically occur in succession; the first three processes are handled by bacteria, and the final stage is carried out by archaea [13].

Techniques for Profiling the Microbial Community Structure in Compost

The continual fluctuation of physicochemical factors including temperature, moisture, the C/N ratio, oxygen consumption, and pH affects how the makeup of microbial communities' changes during the composting process. Numerous studies have also emphasized the function of the microbial population in the breakdown of organic waste, proteins, lipids, cellulose, and lignin during composting. The structure of the microbial community in compost must be determined since changes to this community's makeup can have a detrimental impact on crop quality and production.

Biochemical Approach: Microbes are traditionally categorized according to their phenotypic traits using biochemical approaches in microbial identification. Due to inconsistent findings, the validity of biochemical testing is frequently questioned. Nevertheless, these methods are still employed because they are inexpensive.

Microarray analysis: is a molecular biology technique that involves arraying thousands of known DNA fragments, or «probes,» on a chip in order to concurrently identify many genera of interest. 1- Genotyping and Fingerprinting; the structure of one community can be reflected by the fingerprinting technique known as T-RFLP (Terminal Restriction Fragment Length Polymorphism). 2- Denaturing Gradient Gel Electrophoresis: This polymerase chain reaction technique separates DNA fragments linearly based on the electrophoretic movement of partially melted

DNA by using polyacrylamide gel that contains a linear gradient mixture, such as urea and formamide. 3- Single-Strand Conformation Polymorphism: Single-strand conformation polymorphism is based on the purification of single-stranded DNA from DNA fragments, such as denatured PCR products, on a nondenaturing polyacrylamide gel.

Next Generation Sequencing; is an effective method for figuring out the makeup of microbial communities in environmental samples since it can sequence numerous samples at once at high throughput [12].

The modified ester-linked fatty acid technique was used to identify the makeup of the microbial population. This procedure was carried out in three phases. First, 3 g of lyophilized soil were treated with 10 mL of 0.2 M KOH for 1 hour at 37 °C and 180 rpm of orbital steering to extract the fatty acids. 10 mL of n-hexane was added to a 50 mL centrifuge tube after the pH of the solution had been adjusted with 1.0 M acetic acid. The combined solution was vortexed for 1 minute before being centrifuged at 1600 rpm for 20 minutes. In order to create N2 gas, 5 mL of the supernatant (hexane layer) was placed into a 10 mL tube. The residue was dissolved in 170 L of a 1:1 mixture of hexane and methyl-t-butyl ether before 30 L of internal fatty acid, 0.01 M methyl nonadecanoate (19:0), was added. [9] For example, Citrus rootstocks' interactions with compost may affect the bacterial populations that are active in the rhizosphere, which affects the concentrations of nutrients in the roots. The rootstock specifically affected the number, diversity, and community composition of the bacteria in the rhizobiome in response to compost [5].

Leading foodborne pathogen Listeria monocytogenes may infect fresh produce in a farm environment, leading to lethal outbreaks. A variety of microorganisms, including those that may be competitive exclusion microorganisms against L. monocytogenes that have evolved to the compost environment, can be found in composts. Both dairy- and poultry-based composts (n = 12) were infected with L. monocytogenes and then subjected to next-generation sequencing and culture techniques for analysis in order to elucidate interactions between the pathogen and the compost microbiota. [14]

Biochar and compost production and application

Production of biochar and compost, as well as their use: Biochar was produced by pyrolyzing yellow pine sawdust for 48 hours at 350 degrees Celsius. Tree clippings (leaves and branches) that were crushed to pass through a 10 cm sieve, moistened to 50 % wetness, and piled in windrows three meters high were used to create compost. Every three days, the windrows were extensively mixed to disperse the particles for even composting and to maintain a temperature of 55 C, with water supplied to maintain a moisture level of 50 %. 15 days after the windrows were produced, the procedure was repeated until stable temperatures and CO2 evolution were attained. Table 1 lists the physicochemical characteristics of the amendments [3].

Table 1 – Basic characteristic of unamended soil, green waste compost and biochar (0–15 cm) [3].

Parameter	Unamended Soil	Green Waste Compost	YP350 Biochar
pH	8.34	7.7	7.45
Electrical conductivity (EC) ds m^{-1}	1.3	2,4	0.12
Total nitrogen (%)	1.1	0.67	0.33
Ammonia (NH_4-N) (mg kg^{-1})	-	21	24
Nitrate (NO_3-N) (mg kg^{-1})	4.2	<1	1
Organic nitrogen (%)	-	0.67	0.33
Phosphorus (mg kg^{-1})	25	1300	122
Potassium (mg kg^{-1})	61	6100	1476
Organic Carbon (%)	0.46	38	75.6
Particle Size (cm)	-	11.7	0.04

Analysis of Physicochemical Parameters

Digital thermometers were used to monitor the temperature at the top, middle, and bottom of the composting heaps every day. The average temperature on each sample day was utilized for analysis. Near the composting heaps, the temperature of the surrounding area was also measured. The fresh samples were shaken in water at a ratio of 1:10 (w/v) for 60 minutes to evaluate pH, and the moisture content was assessed by oven drying to a constant weight at 105 °C.Total organic carbon (TC) was measured using the dry combustion method; total nitrogen (TN) was measured using the Kjeldahl method and ammonium (NH4 +-N) and nitrate (NO3 – N) were extracted with 2 mol/L KCl and analyzed by Dual channel flow analyzer [11].

PCR Amplification, DNA Extraction, and Sequencing

Compost samples as reported in Liu et al. (2011) were used to extract the genomic DNA, which was then purified using a DNA gel purification kit (Omega, United States) in accordance with the manufacturer's instructions. By electrophoresis in 1.0 % agarose gel, the DNA's purity was evaluated, and the concentration was determined using a spectrophotometer. The 515F and 909R primers. The 16S rRNA gene and the ITS gene were amplified using ITS4 and gITS7, respectively. A total 25.0-liter reaction solution including 12.5 liters of

Taq-HS PCR Forest Mix, 0.2 liters of each primer, 1.0 liters of template DNA, and 11.1 liters of ddH2O was used to conduct the PCR amplification. See the Supplementary Material for further information on the thermal cycling conditions. Purified PCR products were processed to the Environmental Genome Platform of Chengdu Institute of Biology, Chinese Academy of Sciences' Illumina MiSeq platform with concentrations >10 ng/L and OD 260/OD 2801.8 [11].

The Advantages of Microbial Communities Composting

Composting has a number of advantages, particularly for the environment and the natural world. Composting will increase soil structure and water retention, and when utilized as fertilizer, compost's organic content helps protect plants from pests and disease. 1-Environmental Advantages; In general, all waste management operations involve five major steps: trash collection, sorting, storage, disposal, and transportation to a waste recycling or sorting center. The most obvious benefit of composting is the reduction and reuse of food waste. 2- Stakeholders in the Food Value Chain; the effectiveness of managing food waste depends on the participation of stakeholders. Positive cost analyses, experimenting with current management procedures, and altering the current business model are the driving forces behind waste management strategies across all industries [12].

The definition of composting is a bio-oxidative process that results in the mineralization and transformation of organic materials. The finished product is regarded as stabilized and pathogen- and phytotoxic agent-free. The process of composting normally comprises three phases: initial activation, thermophilic phase, and maturation phase. Simple organic molecules like sugars are mineralized by microbial communities during the first activation, which typically lasts 1–3 days. This process generates CO2, NH3, organic acids, and heat [4].

For conventional agriculture to ensure soil fertility and sustained food production, there are significant obstacles to overcome. There are many deteriorated agricultural soils in the globe, and several solutions are being developed to repair them. Due to their significance in the development of sustainable agricultural practices, research on beneficial soil microorganisms has gained more and more attention. Soil microbial activity is crucial for the balance and preservation of ecosystem services such biomass conversion, nitrogen cycling, plant development, and health. Therefore, it's crucial to encourage its formation and spread. The creation and use of compost is an age-old method that promotes soil biodiversity [1].

A prospective source of novel organisms and thermostable enzymes for use in commercial and environmental processes is composting. This composting has a consistent thermophilic profile between 50 and 75 degrees Celsius, which appears to inhibit fungus activity [2]. And the macronutrients carbon, nitrogen, phosphorous, and potassium, as well as the micronutrients necessary metals and minerals, are needed by the microorganisms in the compost. The substrate or feedstock that is available to these microbes is the source of these nutrients. How quickly bacteria can break down substrates is another element to take into account. For instance, refractory compounds like cellulose and lignin would require more time to degrade than fructose [10]. Our existing knowledge indicates that significant and persistent changes in soil microbial communities need nitrogen management techniques applied to agricultural soils over a number of years. However, other studies contend that even occasional, one-time infusions of organic matter can help agricultural soils [8].

Conclusion

The term «soil microbiome» refers to the diverse and interconnected communities of bacteria, archaea, fungus, protozoa, and viruses that are present in soils. They contribute to one of the planet's most dynamic and diversified ecosystems. The soil microbiome serves important environmental and ecological activities, from nutrient cycling to carbon storage and bioremediation. It also protects plants from biotic (like infections) and abiotic (like excessive heat) stresses. But due to human activity, significant land degradation has occurred, impeding the ability of the soil microbiome to sustain vital ecosystem functions. Every site will have a distinct soil microbiome, thus it's critical to comprehend how it affects and is affected by the regional and global environment. Food waste has become one of the world's biggest problems over the past ten years since it has a detrimental effect on both the environment and human health. Rotting releases methane, which has a warming impact and harmful health consequences when it comes into contact with agricultural land and water systems owing to pathogenic microbes or toxic leachates. Composting is used as a strategy to manage and minimize food waste in accordance with international sustainable development goals. Microorganisms play an essential role in the composting process. This work used Illumina MiSeq sequencing to track the succession of microbial communities in a composting pile of food waste digestate and garden waste in order to disclose the bacterial and fungal compositions present there. In order to determine if the composting system was functioning well, we investigated the effectiveness of composting different microorganisms. The findings demonstrated that the bacterial and fungal structures were dramatically altered during the composting process. The dominating phyla of the bacterial communities were Firmicutes, Proteobacteria, and Bacteroidota, whereas the dominant phylum of the fungus communities was Ascomycota.

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МИКРОБТЫҚ ҚОҒАМДАСТАРДЫҢ КОМПОСТА ПАЙДАЛАНУЫ ЖӘНЕ ӘСЕРІ

Компост – өсімдіктерді қоректендіретін және топырақтың физикалық, химиялық және биологиялық қасиеттерін жақсарту үшін қолданылатын заттардың жиынтығы. Ол көбінесе көңді, органикалық қалдықтарды, өсімдік және тамақ қалдықтарын компосттау арқылы жасалады. Алынған комбинация өсімдіктерге, сондай-ақ сау бактерияларға, қарапайымдыларға, нематодтарға және саңырауқұлақтарға арналған қоректік заттарға толы. Компост топырақ құнарлылығын арттырады және органикалық егіншілікте, қалалық ауыл шаруашылығында, бау-бақша мен бау-бақшада синтетикалық химиялық тыңайтқыштарға тәуелділікті азайтады. Химиялық тыңайтқыштарды ұзақ уақыт бойы шамадан тыс пайдалану топырақтың микробтық биомассасы, қауымдастықтар және қоректік заттардың мазмұны сияқты топырақ сапасы көрсеткіштерінің нашарлауына әкелді, бұл өз кезегінде дақылдардың денсаулығына, өнімділігіне және топырақтың тұрақтылығына әсер етеді. Бұл зерттеудің мақсаты тозған ауылшаруашылық жерлерін қалпына келтірудің жылдам және тиімді әдісін құру үшін жүгері өсіру кезінде көң компосты мен бактерия тыңайтқыштарын немесе олардың комбинациясын қолдану арқылы топырақ сапасының параметрлерін дәл өлшеу болды. Біз қауымдастық құрылымының әртүрлілігіне, базальды тыныс алуына, микробтар саны мен топырақтағы биомассаға динамикалық әсерлерін қарастырдық. Компосттау түрлері: верми-компосттау, желді компосттау, газдалған статикалық қада компосттау және ыдыста. Органикалық қалдықтар ұрпақтар бойы компосттың өзін-өзі жылыту биологиялық процесі арқылы басқарылды. Компосттың жанама *өнімі органикалық қалдықтарды өңдеуге қосымша органикалық тыңайтқыш және топырақ қоспасы ретінде пайдаланылуы мүмкін. Осы жылдар ішінде компосттау бойынша зерттеулер, әсіресе компост сапасын жеделдету және жақсартуға қатысты айтарлықтай алға жылжыды. Қайталанбайтын органикалық ластаушылар компост материалдарында кездесетін әртүрлі микробтық қауымдастықтармен биоыдырады. Бұзылулардың бұл үш түріне катаболизм, жалпы метаболизм және жалпы жасушадан тыс тотығу жатады.*

Кілтті сөздер: Микробтық қауымдастықтар, компост, өнімділік, қолдану және салдары.

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ПРИМЕНЕНИЕ И ВЛИЯНИЕ МИКРОБНЫХ СООБЩЕСТВ В КОМПОСТ

Компост представляет собой комбинацию веществ, которые используются для питания растений и улучшения физических, химических и биологических свойств почвы. Его часто получают путем компостирования навоза, органических отходов, растительных и пищевых отходов. Полученная комбинация полна питательных веществ для растений, а также здоровых бактерий, простейших, нематод и грибков. Компост повышает плодородие почвы и снижает зависимость от синтетических химических удобрений в органическом сельском хозяйстве, городском сельском хозяйстве, садоводстве и садоводстве. Длительное чрезмерное использование химических удобрений привело к ухудшению *показателей качества почвы, таких как микробная биомасса почвы, сообщества и содержание питательных веществ, что, в свою очередь, влияет на здоровье сельскохозяйственных культур, продуктивность и устойчивость почвы. Цель этого исследования состояла в том, чтобы точно измерить параметры качества почвы путем применения навозного компоста и бактериальных удобрений или их комбинации во время развития кукурузы, чтобы установить быстрый и эффективный метод восстановления ухудшенных почв сельскохозяйственных угодий. Мы рассмотрели динамическое воздействие на разнообразие структуры сообщества, базальное дыхание, количество микробов и биомассу в почве. Типы компостирования: вермикомпостирование, компостирование в валках, аэрируемое компостирование в статических кучах и в емкости. С органическими отходами на протяжении поколений обращались посредством саморазогревающегося биологического процесса компостирования. Побочный продукт компостирования можно использовать в качестве органического удобрения и добавки к почве в дополнение к обработке органических отходов. За прошедшие годы исследования компостирования значительно продвинулись вперед, особенно в отношении ускорения и повышения качества компоста. Стойкие органические загрязнители подвергаются биологическому разложению различными микробными сообществами, присутствующими в материалах для компостирования. Эти три типа нарушений включают катаболизм, общий метаболизм и общее внеклеточное окисление.*

Ключевые слова: микробные сообщества, компост, продуктивность, применение и значение.

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