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Sustainable Development of Organic Farming using Water Hyacinth *Pontederia crassipes* Over Vermitechnology by *Eisenia fetida*

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Abstract

Our planet is really lovely, and there are plenty of living organisms here. Among these organisms, human beings are also contributing to the planet. However with a growing population of human beings, there is a growing need for food, which is entirely dependent on agriculture, several strategies have been employed to boost agricultural output, including inorganic fertilizers and synthetic pesticides. Inorganic fertilizers have largely enhanced productivity as well, but they also have several negative health impacts. However, continued use and reliance on these inputs has reduced crop productivity and deteriorated the quality of natural resources and the ecosystem. So, to overcome these problems and for sustainable development, long-term agricultural expansion may be achieved with organic farming while also preserving the environment. It may take time to switch from chemical to organic farming, which could reduce the farmer's profits. Advancements in organic farming, using *Eisenia fetida* to promote the vermicomposting of water hyacinth (wastewater weed) and employing more organic fertilizer while decreasing inorganic fertilizer usage in farming. However, the farmer will only make the changeover if he is persuaded that organic farming has long-term advantages over chemical farming. Vermicompost is a type of organic fertilizer, prepared from earthworms using various unused waste organic materials. It is an alternative source for increasing agriculture production. Many works have shown that vermicompost has beneficial effects on the environment. Various organic waste materials are used by earthworm species to form vermicompost. Water hyacinth poisons water bodies, turning pleasant water into unappealing water by emitting a foul smell. Most times, water hyacinths thrive in sewage water. Controlling this aquatic weed is a major issue, but it is easily solved through vermitechnology. Extremely, in our review study, we are going to give our concentrate on development of organic farming using vermicomposting.

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Introduction

Effect of Chemical Fertilizers on the Environment

Agriculture aims to provide for society's current food needs while leaving a surplus of food available for future use and export. Chemical inputs such as insecticides are becoming more frequently used in agriculture to boost productivity and production. Pesticides are substances that are used as pest control agents. Generally, a pesticide is any biological and chemical agent such as a bacteria, virus, antibiotic, or disinfectant that repels, neutralizes, or eliminates pests. It is widely used to control or eradicate various agricultural pests that can damage crops and livestock and decrease agricultural productivity. By enhancing agricultural productivity, pesticides have shown to be beneficial for both farmers and citizens worldwide. Basically, after the start of the Green Revolution, pesticide input in Indian agriculture enlarged, which in turn helped our nation combat the significant issue of food shortages. Although using pesticides is beneficial, it also has a long-term adverse effect on the ecosystem and human health. India currently ranks 12th in the world for pesticide use and is the major producer of pesticides in Asia. India has a significant problem with pesticide residues even though it consumes far less pesticides on average than many other developed economies.[1]

Agrochemicals and their environmental impacts in Nepal, agrochemicals are viewed as a potent tool or "magic bullet" in developing nations to increase agricultural productivity. Agrochemicals, on the other hand, have been found to pose substantial risks, and several pesticides have been linked to cancer by affecting human immunological and endocrine systems.[2]

In India, anti-malaria initiatives and the "green revolution" led to the usage of pesticides in the mid-1960s. Pesticides harmed people's health even if they helped get rid of pests. These chemicals now pose several risks to human health, especially those that build up in the food chain. It has been demonstrated that the exposure resulting from consuming pesticide-contaminated food can range from 103 and 105 times higher than the exposure resulting from inhaling contaminated air or consuming contaminated water. Reports state that exposure to pesticides can have a range of detrimental effects on health, varying in severity and duration. Pesticides can cause anything from minor allergies, rashes, respiratory issues, neurological harm, and sexual abnormalities to deadly chronic diseases like cancer. This threat to food safety may be addressed by preventive interventions, like the use of other organic farming methods, or mitigation approaches like lowering pesticide exposure from food and water by using different processing procedures.[3]

While the innovations of the 'Green Revolution' initially yielded considerable benefits, the overuse of chemical-based fertilizers in states like Punjab and Haryana has destroyed beneficial microorganisms, worms, and insects from the soil. This has not only disturbed the physicochemical properties and texture of the soil but has also severely harmed the industry in terms of production quantity and quality.[4]

The excessive or improper use of fertilizers, along with neglecting micronutrients, results in poor utilization of essential nutrients. This leads to the accumulation of fertilizer nutrients in the soil or their release into the environment, which leads to environmental degradation and climate change. Imbalanced fertilizer use exacerbates soil and atmospheric pollution that affects water bodies through eutrophication and poses threats to biodiversity and human health.[5]

Excessive and repeated application of nitrogenous fertilizer beyond crop capacity can release carbon dioxide, nitrous oxide, and greenhouse gases into the atmosphere, contributing to climate instability and global warming.[6]

According to a study, DDT was the most widely used and successful pesticide for helping people fight off undesirable organisms and significantly improving farming. However, after several detrimental effects of this insecticide were discovered, DDT use was banned worldwide. Despite the strict regulations, DDT is still used illegally in many places, especially in developing nations. The detrimental effects of DDT on human health were well-known and widely reported to warn the public and prevent unanticipated events. Even though DDT hasn't been used in a while, its long residual efficacy and buildup through the food chain mean that it still has an impact on human health. Many cancers, short- and long-term neurological system injuries, lung damage, reproductive organ damage, endocrine system and immune system dysfunction, and human birth defects have all been linked to DDT exposure.[7]

An excessive number of synthetic fertilizers can cause the soil to become less organic, which can lead to acidification and threaten plant life.[8]

One of the primary reasons crop productions has limited yields worldwide is soil acidity, especially on heavily weathered and leached tropical soils. Various reports have suggested that Ethiopia has a considerable amount of acidic soil. Soil acidity is a well-known issue that limits crop productivity, especially in the western portion of the nation. Corn was one of the possible cereal crops in the area, and as part of the solution to such a problem in soils, the combined application of lime and vermicompost (VC) on maize has been investigated in the area. To evaluate, a field experiment was carried out in the 2020 cropping season at the Lalo Asabi district in western Wollega.[9]

Soil pollution is a prerequisite for farming and can be caused by several variables, including the accumulation of various heavy metals, industrial emissions, the process of mining, the disposal of high metal wastes fertilizer application, pesticides, wastewater irrigation, sewage sludge residues from coal combustion, etc. A significant amount of chemicals is traditionally sprayed on agricultural soils each year as fertilizers and pesticides. These uses could raise the concentration of heavy metallic elements in the soil, including lead (Pb), arsenic (As), and cadmium (Cd).[10]

Biofertilizers are produced by isolating, purifying, and characterizing specific strains of advantageous microorganisms from the soil, then growing them in appropriate farms until they are needed. To supply the plant with nutrients by activating them in the soil or a Rhizosphere layer, they are either mixed with seeds before planting, contaminated with seedlings, or added straight to the soil.[11]

During the 2010–2011 growing seasons, researchers at Islamic Azad University's Par Abad Mogha Branch examined the effects of seed inoculation with Aazotobacter and various nitrogen fertilizer concentrations on sunflower (*Azargol cultivar*) growth and yield. Three replications of a complete randomized block design were used to create a factorial arrangement of the experiment treatments. A factorial combination of four nitrogen fertilizer levels—25, 50, 75, and 100% N—were allocated, together with two levels of Azotobacter with and without Azotobacter (control). The results demonstrated that inoculated plants had considerably higher plant height, grains per ear, and biological yield than non-inoculated plants. In non-inoculated plants, raising the N level above 75% N recommended improved plant height, ear length, grains per ear, biological yield, and grain yield; however, no discernible change was seen between 50 and 100% N recommended. As N levels rose, the beneficial effects of Azotobacter inoculation diminished. Based on the findings of this experiment, Azotobacter could be used as a suitable substitute for chemical nitrogen fertilizer in organic agricultural systems because it performed as expected and could increase grain yield to an acceptable level.[12]

By the above work, we may conclude that continuous use of inorganic fertilizers is leading to disturbs the environmental balance and use of chemically infected crops may lead to health-related problems for current as well as future generations from this the conclusion emerges: If we continue to use inorganic fertilizers like this, then we may have to see a very dangerous situation in the future.

Effect of Organic Fertilizers on the Environment

The buildup of chemicals in agricultural production is the cause of the problem with the overuse of chemical pesticides and fertilizers. Organic agriculture is therefore a potential eco-friendly solution to the issue of chemical input dependency as well as a means of attaining long-term agricultural sector sustainability. Through crop cultivation and agronomic techniques, organic farming has the potential to lower greenhouse gas emissions. Additionally, compared to chemical agriculture, organic farming uses 62–70% less nitrogen.[13]

Organic fertilizer is essential to the sustainability of agriculture and plays a significant role in raising soil productivity. Our study aims to re-evaluate the effect of organic manure on agricultural productivity. The chemical fertilizer offered a temporary benefit, but it had detrimental long-term effects as well, such as soil toxicity and decreased soil fertility. Following that, the idea of organic farming gained traction, and a system for it was developed. The usage of organic fertilizers has the advantage of being affordable, enhancing soil texture, aeration, and structure, boosting the soil's capacity to retain water, and promoting the growth of healthy roots. Organic fertilizer can be found in a variety of places, including plants, minerals, animal sources, and sewage sludge. The quantity of organic nutrients in the soil was increased by plants, animals, and leftovers. Therefore, it is recommended to use a systemic approach to managing nutrients to use organic fertilizers (such as crop residue, animal dung, and sewage sludge) appropriately and scientifically to improve the growth, yield, and quality of the different crops over an extended period.[14]

Organic farming produces safe crop yields that are on par with chemical farming, and its greenhouse gas emissions are 36% less than chemical-based agriculture production's.[15]

At the Farm of Horticulture and Land Scape, Department of Agriculture and Forestry, Mosul University, an experiment was conducted during the 2017–2018 growing season to investigate the effects on the vegetative growth and yield of two pea cultivars: Local (V1) and Holland Ian (V2). The fertilizer applications were applied at the following rates: Chemical (T1), Organic (T2), 3/4 Chemical+1/4 Organic (T3), 1/4 Chemical+ 3/4 Organic (T4), and 1/2 Chemical+ 1/2 Organic (T5). The experiment, which was designed as a factorial experiment with divided plots inside an RCBD with three replications, employed ten treatments. The findings could be summed up as follows: The yield of green seeds, seeds per pod, and biological yield all increased as a result of the interaction between V2 and T2. The ratio of dry matter to percentage of vegetative development, weight, and length of the pods all increased when V1 and T3 were combined. The interaction between V1 and T4 enhanced the total yield of pods as well as the total number of pods obtained per plant and yield per plant yield.[16]

Using organic fertilizer for a few years in a row can decrease the need for inorganic fertilizers. The effect may not be seen in the first year of use or for the first time, but rather develops over time on the same land with a significant increase in yield and quality thanks to the soil's increased nutrient readiness.[17]

Vermicomposting and its Effect on the Environment

Vermicompost made from animal waste with the use of earthworms is generally thought to be good for the soil and plants. To investigate this, the authors have carried out three research on the effects of applying Neem and water hyacinth vermicompost to the crops. Nevertheless, no data demonstrate that the same may be true of vermicast produced from other sources.[18]

Vermicomposting causes a significant change in the feed substrate's pH. Because CO2 and uncertain fatty acids are formed during the initial breakdown stage of vermicomposting, a low pH initial phase is frequently observed. Furthermore, acidity is influenced by the formation of minerals and the oxidation process of N and P.[19]

Gunnarsson and Petersen, (2007) reported that biodegradable waste is composted to return the waste to the plant production cycle as manure and soil conditioner.[20]

Key players in the process are earthworms, which transform the substrate (organic wastes), create favorable conditions for the growth of microbes, and modify biological activity.[21]

The earthworm's digestive tract produces mucus, which is then mixed with the food it has eaten. The ejected material has higher concentrations of nitrate, phosphorus, potassium, ammonium, magnesium, calcium, and soluble organic carbon than the surrounding soil. It frequently shows higher water content.[22]

Eisenia foetida an earthworm species was employed in a variety of ratios to carry out the process of vermicomposting using floral waste and cow dung. The 50:50 and 60:40 ratio of garbage to vermicompost was shown to have a good bioconversion ratio. Throughout the investigation, soil served as the control. Following the vermicomposting process, numerous physical and chemical characteristics were analyzed. It was discovered that the suitable parameters were 8.0 pH,25°C temperature, 1-2mm particle size, black color, 60% moisture content, and 0.88 bulk density, odorless. As a result of vermicomposting, electric conductivity (EC), C: P ratio, and C: N ratio decreased, while phosphorus, nitrogen, potassium, magnesium, sulfur and calcium increased. *Eisenia foetida* Tomato (*Solanum lycopersicum* L.) plants were cultivated in pots with prepared floral waste vermicompost as fertilizer. Several growth parameters, such as mean stem diameter, mean plant height, mean number of leaves, mean length of roots, and yield/plant, showed a substantial increase. When compared to the control, the results demonstrate that the combined effect of all the nutrients in the waste from flowers vermicompost improves tomato plant growth and yield and significantly improves soil characteristics. Thus, vermicomposting the leftover flowers from temples is a great and eco-friendly way to get valuable materials that will leave the environment cleaner and waste-free.[23]

The effects of adding vermicompost to the growing soil of *Eucalyptus citriodora* Hook seedlings at three various amounts (0, 2, and 4% w/w) at three different watering intervals (2, 5, and 7 days) were investigated in a pot experiment. The primary findings demonstrated that 7-day irrigation intervals improved the levels of total proline, total sugar, phenol, and enzyme activity (POX and CAT) while decreasing the levels of total growth parameters considered, mineral contents (N, P, and K% in leaves and roots), photosynthesis pigments, total free amino acids, and water holding of growing media. In comparison to untreated plants plus irrigation intervals, vermicompost actions, especially at 4%, raised the majority of metrics, chemical elements, and water holdings in the soil, and exhibited a beneficial influence on leaf body, except proline concentration, which was lowered. We concluded that vermicompost can be advised to help *Eucalyptus citriodora* grow better in low water conditions.[24]

By working together, with earthworms and micro-organisms that live in composting substrates or their stomachs, vermicomposting breaks down organic materials. Industrial waste can be effectively managed through vermicomposting due to its quick changes in physicochemical and biochemical properties.[25]

When organic waste passes through an earthworm's gut, it speeds up the final stage of the process of decomposing organic waste, which is carried out by microorganisms.[26]

Role of Earthworms on the Environment

A developed vermicomposting technique was used in the study to produce organic compost. The aim is to enhance and improve the exchangeable nutritional composition of the soil for application in sustainable farming practices. In the experiment, kitchen waste, garden tree leaves, sugarcane straw, and cow dung were combined with *Eisenia fetida* worms as a treatment method. According to this study, vermicompost has a significant nutrient value and is a promising solution for increasing crop yield, ensuring long-term food security, and securely disposing of organic waste.[27]

Earthworms comprise a greater percentage (>80%) of the biomass of terrestrial organisms and are important in both structuring and improving the nutritional quality of the land.[28]

A tube-shaped, segmented animal that lives in soil and consumes both living and dead organic matter is called a crawler. The term "wiggler" is often utilized to refer to the majority of Oligochaeta within the phylum annelid. Earthworms are ubiquitous soil organisms found in most environments, and they are crucial to the fertility and structure of soil ecosystems.[29]

Hermaphrodite reproduction in earthworms is unusual, but there is also a lack of knowledge regarding this process. To advance vermiculture-based biotechnology, research on earthworm growth and development is crucial. To determine the organism's vermicomposting potential, this may be useful in understanding the species, choosing prolific breeders, and estimating the characteristics of the population (in activity or in nature) in terms of feeding preferences, temperature, pH, tolerance to moisture, and rates of reproduction.[30]

There are numerous challenges facing the paper mill and dairy industries, especially when it comes to water availability, wastewater discharge, chemical residues, and the disposal or use of solid waste. The majority of the waste produced by the dairy industry is semi-solid, containing roughly 70% moisture and comprising protein, salts, fats, lactose, and additive residues. However, paper sludge is a challenging substance that is usually made up of inorganic additives, starch, clay, synthetic polymers, and cellulose fibers. Vermicomposting has drawn a lot of attention lately as an effective and affordable way to compost organic waste, including paper pulp and sludge from dairy and paper mills.[31]

Impact of Water Hyacinth

Water hyacincth *Pontederia crassipes* Mart. was formerly known as *Eichhornia crassipes*, https://en.wikipedia.org/wiki/Pontederia_*crassipes*[32]

Gupta *et al.*, (2006) investigated that vermicomposting with water hyacinth in various combinations with cow dung produced a high-quality vermicompost.[33]

Gajalakshmi *et al.*, (2001) discovered that *Eudrilus eugeniae* was found to be the most effective candidate for bioconversion of water hyacinth into vermicast, followed by *Perionyx excavatus>Lampit omauritti>Dravidawillsi*.[34]

Various organic waste materials are used by earthworm species to form vermicompost. In our study, we are going to give our concentration to form vermicompost using a water weed i.e., water hyacinth. Water hyacinth poisons water bodies, turning pleasant water into unappealing water by emitting a foul smell. Water hyacinths usually grow best in sewage water. Although managing this aquatic weed is a significant problem, vermitechnology provides an easy solution. The fast growth of these weeds can cause physical disruption to fishing, obstruction of shipping routes, increased evaporation leading to water loss in irrigation systems, obstruction with hydroelectric methods, and improved sedimentation by capturing silt particles. It also creates hygienic problems and lessens the possibility of fishing from the shore.[35]

A thick mat of water hyacinth prevents heat from escaping from the lake's surface into the atmosphere and from being absorbed by the decomposing organic matter in the hyacinth, which causes a slight increase in temperature. The dissolved oxygen level underwater hyacinth decreases with increasing temperature, owing primarily to the metabolic activity of epiphytic organisms and the typical property of water is that it contains less oxygen in warmer temperatures than in colder ones.[36,37]

Since the 2000s, many attempts to eliminate the water hyacinth (*Eichhornia crassipes*), a freshwater weed, have failed and become uneconomical in numerous lakes across the globe, such as Indonesia's Tondano Lake. In this study, we attempted to apply water hyacinth as an organic fertilizer to the yellow maize of the Manado strain, a local crop. Each duplicate of the bedding was constructed in triplicate, using 8–10 different plants. A sequence of measures of leaf width, plant height, and leaf length, were taken at 2 and 12 weeks after plantation. ANOVA was used to analyze the data in one of two ways. When applied at doses of 200 and 250 grams per plant, water hyacinth organic fertilizer quickly showed valuable effects on vegetative growth at 2 weeks of age about plant height, leaf length, and leaf breadth. This effect lasted in terms of plant height up to 12 weeks of the stage, but not about leaf length or width. When used at a rate of 200 grams per plant, water hyacinth organic fertilizer can boost the vegetative growth of the native Manado variety of yellow maize.[38]

To evaluate the impact of yield parameters and maize growth on water hyacinth compost produced using a variety of cultures. For the study, an alternate whole-block design was employed. Location and length of study: From November 2011 to August 2012, Kenyatta University conducted greenhouse testing and Otonglo Division in Kisumu County conducted field trials. To make the compost for water hyacinth, cow dung, molasses, and effective microorganisms (em) the mixture was used separately as starter cultures. Compost was applied to field plots and individual greenhouse growth pots containing maize (H513). The abundant water hyacinth in the area, especially around Lake Victoria, can be composted to make organic fertilizers and effectively used as an organic soil element to enhance soil quality and increase maize yields.[39]

Objectives of Review Study

- Advancements in organic farming.
- Using *Eisenia fetida* to promote the vermi-composting of water hyacinth (wastewater weed).
- Employing more organic fertilizer while decreasing inorganic fertilizer usage in farming.

Fig. 1: Effect of Organic and Inorganic Fertilizers on Enviroment

Review of Literature

Chemical Fertilizers

The application of fertilizers and pesticides on farms causes these substances to be transferred, either directly or indirectly, into vegetable and maize crops, which can affect human health. Furthermore, pesticides are directly consumed by humans and animals when applied to vegetables. Overuse of fertilizers can contaminate underground water with nitrate, which is extremely dangerous for people or cattle. In water containing nitrate, certain hemoglobin in the blood can turn immobile. Organophosphate insecticides are increasingly being used because nitrate-concentrated pesticides become less persistent and harmful to the environment than organochlorine pesticides. But they are associated with acute health problems like wooziness, headaches, nausea, vomiting, and skin and ocular problems in addition to abdominal pain. Several studies have been conducted in an effort to establish a connection between pesticides and cancer. Organophosphate pesticides are linked to cancer and are used on vegetables. They slowly accumulate in people's bodies.[40]

The term "soil" refers to a group of natural bodies that have been profile-formed from a complex composition. It is an important natural resource and part of the terrestrial ecosystem. It is an organic and mineral-based dynamic natural body. The dynamic nature is caused by the activity of little and large-scale organisms, which is sustained by the presence of organic materials. The structure and porosity of the soil are greatly influenced by the activities of each of these soil organisms.[41]

Fertility is the term used to describe the inherent ability of the soil to supply plants with adequate amounts of nutrients in the proper proportions.[42]

Due to indiscriminate usage of soils, considerable losses of their organic matter content and nutrients occur, resulting in an alteration in the chemical, physical, and biological structures of the soils.[43]

Continuing use of chemical fertilizers without the addition of organic materials deteriorates the soil's physical characteristics and pollutes the surrounding area.[44]

Soil is one of the most important components of the ecosystem and environment, necessary for the completion of biological, physical, and chemical processes and activities. Earth may become contaminated as a result of heavy metal accumulation. Nickel is released into the urban environment by electronic debris and vehicle corrosion, especially in the car oil pump. An accumulation of nickel in the body can cause vascular disorders, high blood pressure, lung damage, and kidney problems. At low concentrations, nickel serves as a micronutrient and poses no threat to plants. On the other hand, it prevents the growth of plants and the emergence of toxic symptoms at high concentrations. Vermicomposting is a method of using earthworms to break down organic waste materials into materials that resemble finely broken peat. It's a different approach to waste management that yields vermicompost, which has a greater amount of nutrients than manures and compost. Thus, the purpose of this study was to find out how biochar and vermicompost affected the amount of nickel metal that accumulated in tomato fruit and soil.[45]

Composting eliminates biodegradable waste, which would otherwise serve as breeding grounds for insects and spread diseases. Composting can be used to create manures, which, when properly mixed into the soil, increase crop yield. Waste composting recycles nutrients back into the soil while also lowering farmers' crop-raising costs through the purchase of fertilizers.[46]

Chemical agriculture proponents advocate for the continued or increased usage of synthetic pesticides and chemical fertilizers to address the challenges of food grain manufacture and food safety However, prolonged use and greater dependency on these inputs could lead to decreased crop yields, a drop in the quality of resources from nature, and environmental damage. Biological agriculture offers a way to ensure the ecosystem's protection and sustainable agricultural expansion.[47]

India became independent in food grains thanks to the Green Revolution, but the unchecked use of synthetic pesticides and fertilizers harmed our food and environment. The agricultural province of Punjab, known as the "grain bowl of India," is currently dealing with serious problems like an imbalance in soil nutrients, polluted surface water, residues of chemicals in food and cow's milk, and an increase in the number of farmers getting cancer.[48] The investigation's findings indicated that there is no discernible link between higher agricultural yield and production and higher utilization of chemical fertilizers. It is also found that during this time, agricultural production has varied, possibly as a result of incorrect NPK (nitrogen, phosphate, and potassium) use over years that exceeded the assimilative capacity of the soil. Furthermore, the region's groundwater is being extracted as a result of the overuse of chemical fertilizers.[49]

Agrochemical misuses are a major source of pollution for farmers and agrochemical sellers, as well as large government fertilizer subsidies that incentivize fertilizer overuse, both of these are entirely preventable. Proactive preventative actions, such as environmental preservation and the enforcement of appropriate laws, are required to prevent environmental pollution and occupational diseases.[50]

Effect of Organic Fertilizers on the Environment

Every human being produces some sort of organic garbage that, in the owner's opinion, has no value and must be thrown away. Management of this organic waste is crucial for maintaining a safe and healthy environment. horticultural waste, vegetable waste, agricultural waste animal waste, Kitchen waste, sewage sludge, and other organic wastes are frequently created by contemporary society.[51]

The issue of safely disposing of large amounts of sludge has a negative impact on society. Sludge is an unavoidable, hazardous, and odorous byproduct of conventional wastewater treatment plants that necessitates safe disposal via incineration or landfills, both of which incur significant costs.[52]

Approximately 270 million tonnes of sugarcane are harvested annually in India. Of the approximately 134 million metric tons of sugarcane that are crushed, a total of four million tonnes of pressmud are produced.[53]

Sugarcane press mud has several advantages for soil application, including low cost, trace element presence, large water holding capacity, slower nutrient relief, and protective qualities.[54]

The primary sources of organic fertilizers were peat, agricultural plant wastes, animal wastes (typically from slaughterhouses), and sewage sludge. Peat, slurry, and animal manure from the meat industry are examples of naturally occurring organic fertilizers. Organic fertilizers are carbon-based substances that boost plant growth and productivity. Organic fertilizers were intricate mixtures that included several secondary and micronutrients, far from being refined and simplified chemicals. Significant amounts of micronutrients can be found in powdered rocks (such as lime, rock phosphate, and greensand), blood meal, manures, wood ash, bone meal, and compost. Their textures also improve soil quality rather than worsen it. Organic farming was, in many respects, as much a way of life as a method of farming. reduction in soil nutrition or probable deterioration are key factors in lower crop yields and per capita food production and are seen as substantial challenges to agricultural output.[55]

Four Indian states (Gujarat, Punjab, Maharashtra, and Uttar Pradesh) determined this topic and found that organic farming has lower unit costs of production for cotton and sugarcane than chemical farming does for rice and wheat.[56]

By investigating efficient management, the potential of biomass waste sources as organic fertilizers has been assessed. Due to a shortage of space, a huge portion of this waste is burned or dumped in landfills. If correctly managed, the beneficial nutrients found in biomass waste can be put to good use. They can be processed to remove pathogens and then used to fertilize soil because they have a high organic matter content. Organic matter must mineralize over a longer length of time than chemical fertilizers do. This period for mineralization will be influenced by the soil's properties, moisture content, and temperature.[57]

Apart from serving as an organic material and nutritional source, organic manures may also have an impact on the structure, turnover of nutrients, size, bio*diversity,* and activity of the soil's microbial community in addition to several other relevant physical, chemical, and biological factors.[58]

Strong and rising interest among scientists studying the environment and regulators in soil organisms. This reflects worries about soil contamination, the possibility of chemicals leaking into drinking water, the fertility of the soil on agricultural land, and the impact of these issues on both plants and animals. The need for trustworthy, sensitive indicator organisms to be used in research, monitoring, and regulatory testing has increased due to recent changes in national and international legislation.[59]

In experimental plots at Qingdao Agricultural University, the effects of organic manure and synthetic fertilizer on the growth and development of *Stevia rebaudiana Bertoni* have been investigated. Organic manure cultivation increased root activity forty days after transplanting in comparison to chemical fertilizer cultivation, and 60 days after transplanting, the dry mass of the above-ground growth exceeded chemical fertilizer growth. In the later growth stage, which was the critical time for glycoside synthesis and accumulation, organic manure increased photosynthetic rate and stimulated root activity, which raised stevia biomass and glycoside content.[60]

Vermicomposting and its Effect on the Environment

The mesophilic process of vermicomposting uses earthworms and microorganisms that can survive in temperatures between 10°C and 32°C. Because the material passes through the earthworm's gut, where a significant and as-yet-ununderstood transformation takes place, producing earthworm castings that are high in microbial activity and plant growth regulators along with pest-repelling properties, the process is faster than composting. In summary, earthworms have a kind of biological alchemy that allows them to transform trash into gold.[61]

Vermicomposting is a low-tech, environmentally friendly method of treating organic waste. It has been demonstrated that the results in vermicompost have a number of positive benefits for plant growth and health. This organic fertilizer is growing in popularity as a result. It is being looked at as a possible substitute for peat in greenhouse potting media and/or inorganic fertilizers in agriculture and horticulture.[62]

Using a conventional composting method, earthworms accelerate the process of mineralization and convert manures into castings that have higher levels of humification and greater nutritional value.[63]

Vermicompost has higher concentrations of physiologically active substances like plant growth regulators and humic acid.[64]

When the lignocellulosic maple waste was composted and vermicomposted, the results showed that the vermicompost product was better suited for use as a soil amendment because it had higher levels of N, a larger protein: organic C ratio, and a lower C: N ratio.[65]

Fertilizing quality and chemical characterization of vermicompost generation from various types of organic wastes has become necessary and inevitable.[66]

Earthworms and microorganisms work together to create vermicomposts out of organic waste. Worm compost can improve soil and as a mass medium for plant growth. temperature and Moisture can work in concert during vermicomposting.[67]

Plants can readily absorb nutrients from vermicomposts, such as exchangeable phosphorus, nitrates, and soluble minerals like calcium, potassium, and magnesium.[68]

Methods of research were carried out in a vermibin for 90 days. Prior to the study, each waste of the various substrates had its initial and final physical and chemical characteristics (pH, ash, humidity, organic matter, C: N ratio, carbon, phosphorus, and nitrogen) measured. It was determined that vegetable compost and animal waste (cow, sheep, pig, rabbit, and chicken) could be used to produce earthworms. However, the chemical and biological quality of the materials the accessibility and usability of a nutritional element determine growth and yield.[69]

A common vermicomposting unit can be set up by first adding a layer of coarse sand, about 6-7 cm thick overall, over a basal layer of vermibeds, which are made of broken bricks or pebbles (3–4 cm thick). This will ensure proper drainage. The next layer could be moist loamy soil, about 15 cm thick. Following the insertion of roughly 100 locally sourced earthworms into the soil, small lumps of either fresh or dried cow dung can be applied to the area and a 10-cm layer of feed can be applied on top. Until the entire setup is damp but not soggy, mist it all down with water. Less water kills the worms, but too much drives them away. You can also cover it with discarded jute bags. Continue watering the unit and keep an eye on it for 30 days. By the age of 30, the emergence of young earthworms may be regarded as a positive sign. From the 31st day, organic garbage may be applied, but only in spreads that are no thicker than 5 cm apiece. Yet, adding this much material is something that can be done every day.[70] Despite being around for at least a century, vermiculture is now becoming well-known throughout the world for its ability to achieve a variety of ecological goals, including waste management, regeneration, soil detoxification, and agricultural sustainability. The expansion of industries and the world's population growth have resulted in a greater build-up of waste.[71]

When vermicompost was added to NPK-treated plots, the yields of paddy grain were significantly higher than when NPK was applied alone.[72]

Composting improves nutrient management, and compost land application may help to combat soil organic matter decline and soil erosion.[73]

Vermicomposting has to be studied to see how it affects vegetable production, especially since It is suitable for use as a biofertilizer. Research on vermicomposting will help farmers create an environmentally friendly fertilizer and steer the agriculture sector toward a more sustainable future. Utilizing this technology will help control costs in the agriculture sector, which has expanded recently and put more of a strain on farmers due to the cost of chemical pesticides and fertilizers. The cost for production has increased significantly as a result. One organic fertilizer a resource that could be used to cut costs and increase crop output in place of chemical fertilizers is vermicompost. However, it might also lead to organic produce that commands a higher price in the marketplace. Organic produce, which is raised with only natural fertilizers and pesticides and is thought to be more nutritious for consumers and the environment, is in higher demand. This is a result of global living standards increasing.[74]

Both composting and vermicomposting face challenges due to the presence of heavy metals and toxic substances which restrict their land application without proper processing. The production and utilization of compost have the potential to introduce heavy metals into the environment posing contamination risks.[75]

A finely divided substance with high structure, porosity, drainage, aeration, and moisture-holding capacity is the typical composition of vermicompost. Vermiwash is a liquid extract made from vermicompost and earthworm waste. In order to evaluate the effects of vermicompost and vermiwash on beetroot growth, yield, and yield-related parameters, three replications of randomized complete block design field experiments were carried out in 2013 on the research property of Dilla University's College of Agriculture and Natural Resources in Dilla. The application of vermicompost benefited beets. 7.5 t/ha, the highest amount of vermicompost, produced the most beneficial results for growth, yield, and yield element traits, as per the findings of the vermicompost experiment. All of the crop's characteristics did not significantly differ, according to the vermiwash experiment.[76]

Kitchen waste (KW) and farmyard waste (FYW), temple waste (TW), and floral offerings were recycled by vermitechnology. Vermicompost's effects on seed germination and plant growth characteristics were evaluated (VC). At both 40 and 120 days old, it was discovered that TW VCs had the highest worm biomass when related to KW and FYW VCs. The physicochemical study of worm-worked substrates yielded better results in TW VC, especially for C/N, electrical conductivity, TK and C/P. 10% TW VC-water extract (VCE) induced chickpea seed germination; larger amounts of KW and FYW VCE also had this effect. The growth characteristics were also observed to be impacted by changes in the VC-soil ratio, at 12.5% VC, TW VC outperformed KW and FYW VC regarding shoot length, number of secondary roots, root length, and total biomass.[77]

Since earthworm-processed organic wastes have been shown to have a significantly higher rate of phosphorus form transformation, vermicomposting could be an effective method for improving phosphorus nutrition from a variety of organic wastes.[78]

In 2020–2021, the current field study was carried out at the Horticulture Research Block of the Department of Horticulture, School of Agricultural Sciences, SGRR University, Dehradun, Uttarakhand, to investigate the "Influence of Solid and Liquid Organic manure on Growth, Yield, and Economics of Cabbage (Brassica oleracea L. var. capitata) at Lower Hill of Uttarakhand." The experiment was designed using a randomized block design with three replications and nine treatments. The levels of different organic nutrient concentrations that were included in the treatments were as follows: Control (T1), FYM@10t/ha (T2), Vermicompost@5t/ha (T3), Cow Urine @ 50% (T4), FYM @5t/ha + Vermicompost @ 2.5t/ha (T5), FYM @5t/ha + Cow Urine @ 25% (T6), Vermicompost @ 2.5t/ha + Cow Urine @25% (T7), FYM @10t/ha + Vermicompost @5 t/ha + Cow Urine @50% (T8), and FYM @5t/ha + Vermicompost @ 2.5 t/ha + Cow Urine @ (25%). Observations on various growth, yield, and economic characteristics were made at the 30, 60, and final harvest stages (days after transplantation). The findings indicated that the most significant growth and yield characteristics were those related to treatment T5 (FYM @ 5t/ha + Vermicompost @ 2.5t/ha), which included plant height (cm), the number of leaves, leaf length (cm), and leaf width (cm); numbers of non-wrapper leaves, individual head weight (g), gross head yield (kg/plot), and net head yield (kg/plot). Furthermore, FYM @ 5 t/ha + Vermicompost @ 2.5 t/ha was discovered to be the most profitable treatment when compared to other approaches.[79]

A deeper comprehension of how vermicompost, rhizobacteria, and seasonal fluctuations affect the soil's biological characteristics and maize production was studied as it is necessary to improve the soil quality in arid saline soils. Two field experiments were conducted in the spring and fall of 2021 to examine the effects of relationships among vermicompost, amino acids, and rhizobacteria that encourage plant growth (PGPR; *Azotobacter chroococcum*) on particular soil characteristics and maize grain yield in alkaline soils for various seasons. Vermicompost was added in two quantities—0 and 17 tonnes per hectare—amino acid was supplied in two quantities—0 and 2500 mg per liter, and Azotobacter was infected in two quantities—0 and 10 ml. The findings demonstrated that compared to the autumn season (3361 mg Kg-1 soil), the vermicompost significantly increased soil microbial biomass carbon (MBC) in the spring season (9673 mg Kg-1 soil). In contrast, more Azotobacter was discovered in the autumn (19.75 x 106 CFU dry soil, g Kg-1) than in the spring (0.14 x 106 CFU dry soil, g Kg-1). Additionally, compared to the autumn season (3361 mg Kg-1 soil), the inoculation of Azotobacter significantly increased MBC in the spring season (7494 mg Kg-1 soil). After bacteria were inoculated into plants in the autumn (0.35%) as opposed to the spring (0.20%), there was noticeably more phosphorus present in the plants. Vermicompost, azotobacter, and amino acids also increased crop output in both seasons, but the improvements were more pronounced in the autumn. In conclusion, the biological properties of the soil were significantly impacted by the interaction of amino acids, vermicompost, and Azotobacter. Compared to spring, the autumn grain yield was higher, and this difference was correlated with an increase in the number of Azotobacter, an increase in the phosphorus content of the plants, as well as a decrease in the soil salinity.[80]

The growth and productivity of tomatoes are seriously threatened by nutrient insufficiency. Chemical fertilizers, basic compost, vermicompost, and vermin tea can all be used to lessen this danger. A field experiment was conducted at the Student Research Farm, Department of Agronomy, Faculty of Agriculture, University of Agriculture, Faisalabad, to determine the optimal fertilizer dosage for tomato crops to combat nutrient deficiency in a tunnel. There were five treatments in the experiment, and each one included the following: T0: Control (recommended fertilizers); T1: Vermicompost 100%; T2: Vermicompost 100%; T3: Vermi-tea 100%; T4: Vermicompost + 33% + 34% + 34% Vermi-tea; and T5: Vermicompost 25% + 25% + 25% + 25% Chemical Fertilizers. The evaluation was conducted based on morphological yield. according to the data, treatment T5 had a considerably (p0.05) higher fruit output than all other treatments (1.50 kg/plant, 15.5 kg/plot, and 13657 kg/ha), while treatment T0 had a significantly lower fruit yield (0.87 kg/plant, 8.33 kg/plot, and 7900 kg/ha).[81]

Lablab purpureus (L.) Sweet. demonstrated that compared to the control plots, the growth and yield parameters in the vermicompost, chemical fertilizer, and vermicompost + chemical fertilizer mixture groups were significantly higher ($p < 0.05$). The treatment that received 2.5 tonnes of vermicompost [made with a weed, *Rottboellia exaltata* + cow dung, (1:1) using *P. ceylanensis*] + 1/2 dose of recommended NPK ha-1 had the highest fruit yield (fresh weight), measuring 109 tonnes per hector. In contrast, the fruit yield in the control plots, which did not receive any vermicompost or chemical fertilizer, was 61.9 tonnes ha-1.[82]

Applying certain organic extracts as a spray is considered a beneficial way to supplement artificial fertilizers with additional nutrients. An experimental study was conducted at Egypt's Central Laboratory of Agricultural Climate (CLAC), located at the Agricultural Research Centre in Dokki. Celery plants were sown in a net house during the course of the next two winters, 2018/2019 and 2019/2020. This study examined the effects of foliar application of vermicompost tea, poultry manure tea, and algal extract on the vegetative growth, productivity, and quality of celery plants. For the experiment, a complete block design that was randomized with three replications was employed. Nine treatments of organic extracts were sprayed, with two concentrations (10, 20 ml/l) for algae extract, poultry manure tea, and vermicompost tea, and an additional 5 ml/l molasses for the latter two. This was in contrast to the control (water spray). A mixture of vermicompost tea at 20 ml/l + 5 ml/l molasses followed a mixture of poultry manure tea at 20 ml/l + 5 ml/l molasses, with no appreciable differences between the two registering the best vegetative growth, chemical, yield, and quality characteristics. In contrast, the least metrics of vegetative growth, yield, chemical, and quality traits were achieved by spraying water (control) in both seasons.[83]

Significant environmental harm has resulted from widespread heavy metal contamination in agricultural soil. This experiment looked at the bioavailability of cadmium (Cd) and its effects on the environment in cadmium-contaminated soil. In this work, a field experiment was carried out using dosages of 3 kg/m2 of vermicompost (M1) and vermicompost mixed with minerals (M2), specifically calcium and magnesium. The pilot crop, low-accumulation vegetable aubergine (*Solanum melongena* L.), was planted in field soil contaminated with Cd. It was determined that while M2 is a more promising substance for immobilization remediation of Cd-contaminated soils while producing plants, both M1 and M2 additions can help enhance the safe and high yields of eggplant in Cd-contaminated soil.[84]

The study focused on the reuse and recovery of aquaculture sludge in the North-Western Algerian district of Ain Defla. Aquacultural sludge has been encouraged to be vermicomposted using *Eisenia fetida* earthworms as a biotreatment and ecological stabilization technique. The main goals were to assess how vermicomposting affected the hygienic and stabilizing qualities of aquaculture sludge and to investigate the possibility of using it as a biofertilizer in agriculture without degrading the quality of agricultural products. Vermicompost was utilized to enhance the soil and evaluate how it affected a few *Phaseolus vulgaris* growth parameters. One option was the L snap bean. The chemical and physical properties of the sludge were also evaluated. Significant rises in earthworm weight and length of over 27 and 22%, respectively, were noted after 21 days of sludge vermicomposting. The outcomes also showed that the vermicomposting technique may lower the levels of streptococcus and fecal coliforms in the aquaculture sludge. The end product was a safe biofertilizer for agricultural use.[85]

In order to investigate the effects of humic acid (0, 50, and 100 mg/l) and vermicompost (0, 25, and 50%) on a few traits of *Catharanthus roses* under limited water stress (50 and 100% field capacity), a factorial experiment with a full design was conducted in a greenhouse. Cuttings of *Catharanthus roseus* were grown in a light, wet environment using peat moss, leaf mould, humic acid, and vermicompost treatments. The following month saw low water stress applied. The outcomes demonstrated a significant drop in vegetative indices, cell membrane, and plant pigment as well as an increase in proline under low water stress of 50% FC (field capacity). The highest root fresh weight, shoot dry weight, root fresh weight, and membrane stability were obtained in the 100% FC + 50% vermicompost treatment, while the highest root dry weight, shoot fresh weight, flower number, anthocyanin, all chlorophyll were recorded in the 100% FC + 100 mg/l humic acid treatment. The 50% FC treatment produced the most proline, while the 100% FC + 100 mg/l treatment produced the least. Therefore, in light of the findings, it is possible to suggest using humic acid and vermicompost to lessen the harmful effects of water stress on *Catharanthus roseous*.[86]

The research, "Integrated nutrient management studies in a little gourd (*Coccinia grandis* L.)," was carried out at the Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, District Ratnagiri, College of Horticulture, Dapoli (M.H), during the academic years 2021–2022. Ten treatments, three replications, and three different kinds of organic manure (Vermicompost, FYM, and Neem Cake—as well as biofertilizers and bacteria that solubilize phosphate and Azotobacter) were used in conjunction with inorganic fertilizers to set up the experiment in a randomised block design. During the investigation period, the impact of integrated nutrient management—which includes FYM, Vermicompost, Neem Cake, and biofertilizers—in conjunction with inorganic fertilizers on the little gourd's growth and yield parameters was examined. The results demonstrated that various small gourd production indicators were positively impacted by integrated nutrition management. [87]

The eggplant crop contributes to the fight against hunger, malnutrition, and rural poverty in West Africa because of its higher nutritional content. Nevertheless, this crop has several difficulties, such as low-yielding cultivars and poor soils. It is well known that mycorrhization improves plant nutrition and shields them from certain pests. A study was conducted to evaluate the effects of vermicompost and mycorrhization on the yield and growth of eggplant plants. Arbuscular mycorrhizal (AM) from forest soils was collected using maize roots as a trap, and the resulting group was then used as an inoculum for the Djamba F1 variety of eggplant. This inoculum was used in a 90-day study in a greenhouse, either with or without vermicomposting. Following the trial, specific traits of the soil, as well as indicators of eggplant growth and yield, were recorded. Soil vermicompost alone or in combination with inoculum increased soil parameters like pH, exchangeable base cations, total organic matter, and total nitrogen, as expected, in comparison to control and soil treated only with AM. Soil with AM alone had no discernible effect on eggplant growth or yield. All treatments, however, including vermicompost (both vermicompost alone and vermicompost + AM), led to a significant increase in the metrics indicating the growth and yield of eggplants. These results demonstrated the necessity of screening mycorrhizal fungi from eggplant production areas in order to separate and determine the best strains for symbiosis with eggplant in tropical settings. The vermicompost significantly aided in the eggplant's growth.[88]

This work examined the effect of "vermicompost tea" (VCT), an organic fertilizer, on the germination of seeds belonging to the wild soft herring species *Scorzoneratau-saghyz* Lipsch. et& G.G. Bosse. In the years leading up to the war (1931–1943), S. *tau-saghyzi,* a substitute rubber plant for *Hevea abrasiliensis*, was widely dispersed and thrived on the Tien Shan's northwest spur. Due to anthropogenic influences and the effects of climate change, there are much fewer wild species of S. *Tau-saghyz* in natural populations now than they were just a few decades ago. The number of wild species must now be restored in this situation. One of the most important phases in the domestication and recovery of the remaining S. *tau-saghyz* populations is seed germination. Efforts to enhance seed germination through stratification and ethyl mercuric chloride seed treatment have yielded mixed results. In the current study, short-term seed treatments lasting four and eight hours were conducted using 1, 5, and 10% VCT. Priming S. *tau-saghyz* seeds with 10% VCT was found to increase germination from 39.0 (in the control) to 76.7% and to significantly improve seedling weight, seedling vigour, and mean germination time. By immersing the seeds in 10% VCT for eight hours and raising the seedlings in soil supplemented with 20% vermicompost, the germination and growth of the seeds were further improved. The vermicompost incorporation extended the main root, which normally gathers rubber, and increased its crude biomass by 1.6 times compared to the control.[89]

The current experiment aimed to investigate the effects of cocopeat and vermicompost on cucumber yield and growth. Three different fertigation levels—120%, 100%, and 80% RDF—were used as main treatments in 2019 and 2020 in naturally ventilated polyhouses. Three different combinations of soilless media—100% cocopeat, 100% vermicompost, and 50% cocopeat + 50% vermicompost—were used as sub main treatments. The results showed that the treatment combination of 50% cocopeat + 50% vermicompost and 100% RDF produced the highest yield and the best crop performance. None of the treatment combinations had the best rates of plant growth, despite the fact that the highest rate of application of fertilizer had the largest nutrient content. While excessive fertilizer use prevented an increase in yield, it did help to maintain availability of nutrients during the growth period when added to soilless growing media such as cocopeat and vermicompost.[90]

The research looked at the growth of mature *T. cacao* trees established in three farms in the Philippine provinces of Batangas (Lipa) and Laguna (Liliw and Magdalena), as well as the rhizosphere soil microbial community. The study evaluated the effects of a novel formulation of biochar, biofertilizer, and vermicompos*t. Cacao* trees were improved by using the MYKORICH® (MR) with or without 15% bamboo biochar (15% BB) and vermicompost. Over the course of the three-year experiment, the stem diameter increments of the cacao treated with BB in Magdalena and Lipa were 19% and 5% larger than those of the control group, measuring 56.09 mm and 49.08 mm, respectively. On the other hand, the stem diameter increments of the MR and MR + BB-treated plants in Liliw were 34–35% higher than those of the control. Soil microbial analyses revealed that mycorrhizal spore counts in BB-amended soils were 133% (Liliw), 262% (Magdalena), and 109% (Lipa) higher than the control. It was discovered that nitrogen-fixing bacteria were 216% more abundant in MR + BB-altered soils in Liliw and 81% more abundant in BB-treated soils in Lipa than in controls. The three cacao farms' soil nitrogen and potassium levels also increased by 26–85%. The substantial effects that bamboo biochar and mycorrhizal fertilizer, either separately or in combination, have on the growth of cacao, the microbial population, and the nutrient status of the cacao rhizosphere soil make this method beneficial to cacao growers as well as practically all crops in an agroforest environment.[91]

Compost and vermicompost tea are two examples of aqueous extracts used in organic farming that frequently exhibit ionic imbalances and micronutrient deficits. However, plant growth-promoting bacteria (PGPB) are often combined with organic materials when used as fertilizers, which can increase the availability of nutrients. In order assist horticulture crops get the nutrition they needed without the use of artificial fertilizers, PGPB was used as a tool in this study. In two tomato production cycles, the effects of three different bacterial species *Bacillus megaterium* (BM), *Azotobacter vinelandii* (AV), and *Frateuria aurantia* (FA) when they were (i) added to an aqueous vermicompost extract and (ii) given directly by fertigation to the growing medium—were investigated. The results showed that PGPB did not have to be added in order to produce a liquid and aerated vermicompost solution that still produced a balanced nutrient solution with adequate amounts of the major nutrient ions. In the second experiment, the quantity and quality of tomato fruit were greatly increased by adding PGPB to the tomato-growing medium that had previously been fertigated with vermicompost tea.[92]

The effects of Plant Growth-Promoting Rhizobacteria (PGPR) and vermicompost tea on the chemical and physical properties of pomegranate (*Manfalouty cultivar*) fruits were investigated in this study during the growing seasons of 2020 and 2021. Three distinct treatments were given to the trees three times a year: PGPR (3 milliliters per liter of water), vermicompost tea (1 liter/20 liters of water), and vermicompost added to the soil (1 liter/5 liters of water). After the fruit set, the first treatment was administered in the middle of July. The second and third treatments were administered one month apart. The results showed that all treatments improved and increased all metrics when compared to the control. The physical and chemical properties of the fruits were somewhat better in the second season than in the first because of the cumulative effect of vermicompost in the soil. Comparing the three treatments (foliar application, soil addition, and combination) to the other treatments during the two seasons, the combination treatment proved to be the most successful.[93]

This study aimed to compare the effects of two native tree species, the *tiara*, Podocarpus totara, and the *radiata pine*, *Pinus radiata* D. Don, and one exotic species, the *radiata pine*, *Pinus radiata* D. Don, on soil enzymatic activities, growth, seedling mycorrhizal colonization, and nutrition. Methods: Three tree species (*radiata pine*, *tiara*, and *manuka*) were subjected to a 12-month pot trial with six treatments (T1 control, T2 chemical fertilizer, T3 HS compost, T4 HS vermicompost, T5 LS vermicompost, and T6 CM vermicompost). (1) a compost made from 50% septic tank waste + 40% palm fiber + 10% tomato prunings made without worms (called HS-compost), (2) a vermicompost made from 50% septic tank waste + 40% palm fiber + 10% tomato prunings + worms (called HS-vermicompost); (3) a vermicompost made from 30% septic tank waste + 60% palm fiber + 10% tomato prunings + worms (called LS-vermicompost), and (4) a vermicompost made from 30% cow manure + 60% palm fiber + 10% tomato prunings + worms (called CM-vermicompost). We assessed the main effects and relationships of treatment and species on soil chemical and biological properties, plant development, and nutrient responses. When compared to the untreated control (T1), the application of vermicomposts (T4–T6) and compost (T3) significantly improved the chemical properties and enzymatic activities of the soil. It also increased the total dry weight of seedlings by 160–260% and the concentrations of nitrogen (N) and phosphorus (P) in the shoots by 54–97% and 61–91%, respectively. According to research, native tree species could benefit from the use of vermicomposting byproducts from septic tank waste in place of inorganic fertilizers when applying soil or greenhouse potting media.[94]

Globally, abiotic stressors pose serious obstacles to decreasing crop productivity. Salinity is one of the most harmful environmental factors reducing agricultural output. Seeking long-term, environmentally sound solutions is imperative to lessen salinity's detrimental effects on plants. Vermicompost and a low-dose liquid sorghum extract are therefore useful tools for reducing the harmful effects of salt on *Zea mays* L. (corn) seedlings.[95]

In order to help quinoa adapt to drought, the current study looked into the mechanisms by which biostimulants work on the plant as well as how they affect the physicochemical characteristics of agricultural soil under two different water regimes. We examined the effects of two treatments—5 and 10 t/ha—of vermicompost and arbuscular mycorrhizal fungi, either applied alone or in combination, on the agro-physiological and biochemical traits of quinoa and soil fertility in open-field settings under two distinct water regimes (well-watered and drought-stressed). Exposure to drought decreased stomatal conductance, biomass, leaf water potential, and raised levels of malondialdehyde and hydrogen peroxide. Mycorrhiza and/or vermicompost stimulated plant development by starting the photosynthetic machinery and nutrient assimilation process. This raised total proteins, and soluble sugars, to promote plant development, mycorrhiza and/or vermicompost stimulated the photosynthetic machinery and nutrient assimilation, which in turn raised total soluble proteins, sugars, and antioxidant enzyme activities in the root and leaf. This data broadens our knowledge of the interactions between soil and plants and suggests that the co-application of mycorrhiza and vermicompost influences the physiological and biochemical mechanisms that allow quinoa to withstand drought.[96]

To comprehend the effects of various plant growth stimulants applied topically on Italian basil's foliar growth, chemical composition, and oil yield. For each ground treatment of vermicompost, the experimental strategy involved applying clay soil at two rates (25:75 and 50:50%) (1:3 and 1:1v/v) in separate experiments via a randomized full-block design with four replications. The following plant growth stimulants were used in 13 foliar spraying treatments: vermicompost tea at 250 and 500 g/L; seaweed extract at 20, 40, and 60%; yeast extract at 2, 4, and 6 g/L; and chitosan at 500, 750, and 1000 ppm. Growing Italian basil in media composed of 25% vermicompost: 75% soil yielded better results than another medium composed of 50% vermicompost: 50% soil, which developed the greatest values of all tested features. The greatest values of all the studied attributes were obtained when chitosan was sprayed at 750 ppm on Italian basil plants. Under the environmental conditions of Dakahlia Governorate, Egypt, Italian basil (*Ocimumbasilicum L. var. Genovese*) can be grown with improved oil percentage, growth, and chemical composition by using growing media consisting of 25% vermicompost and 75% clay soil, along with foliar spraying with chitosan at 750 ppm or vermicompost tea at 750 ml/L.[97]

Drought stress poses a serious threat to maize, which negatively impacts its physiological, morphological, and biochemical changes. Vermicompost (VC), a living organic soil amendment, is a safe and effective fertilizer that lessens the damage that chemical fertilizers may cause to crops when used in agricultural practices. Additionally, several plant growth processes as well as plant responses to drought stress are influenced by the nitric oxide (NO) donor sodium nitroprusside (SNP). In the ongoing research on cultivars of (*Zea mays* L.). Applying NO along with VC might end up being a standard procedure to mitigate the adverse effects of inorganic fertilizers and promote photosynthesis in drought-tolerant maize crops.[98]

Nutrient-rich vermicompost (VC), mixed with soil, was used in this investigation. Four distinct environments were used to transplant three mature rose seedlings (Vinca rosea valiant, *Pelargonium peltatum,* and *Pegasus patio*) into individual pots: Mix one (Soil: VC:70-30% w/w), Mix two (Soil: VC:50-50% w/w), and mix three (Soil: VC:40:60% w/w) are the control and mix, respectively. The study's results demonstrated that for all three species of roses, the mix-three mediums yielded the best values for growth parameters and chlorophyll Metre SPAD. These results indicated that a 40% soil and 60% VC treatment would be the most fruitful medium for developing ornamental plants.[99]

Plants can be protected from harsh environmental conditions, such as drought, by using their organic and biological environment to aid in nutrition. Plants were propagated in 2-liter pots with garden soil (as the control group), garden soil and algae in a 1:1 ratio, or garden soil and vermicompost in a 1:1 ratio in the current study. To examine the impact of dry stress on spinach, four seeds were planted in each pot. By the time the leaf appeared, there were only two spinach seedlings left in each pot. Two spinach cultivars (*cv. Matado*r and *cv. Catrina*) were used in the investigation. Until the field was sufficiently full, the spinach plants received a watering every two or three days, based on the water level in the pots. In the research that examined plant fresh weights, leaf count, K, Ca, Mg, Cu, Fe, and Zn contents, the effects of drought stress on the soil environment were greater for the Matador and *Catrina spinach cultivars* than for vermicompost + soil and algae + soil media. It has been discovered that vermicompost and algal medium increase the levels of K, Ca, Mg, Cu, Fe, and Zn; they also lessen the effects of drought, increase leaf number, and plant weight, and encourage healthy plant growth.[100]

Vermicompost and biostarter have been shown to affect the growth and photosynthetic rate of *Echinacea purpurea. Echinacea purpurea* (L.) *Moench*, commonly known as purple coneflower, is a native of North America that was first grown as a medicinal herb in Indonesia. A proper strategy is needed to promote growth and development to adapt to and grow in tropical areas such as Indonesia. Purple coneflower, or *Echinacea purpurea* (L.) *Moench* is a medicinal plant that was first cultivated in Indonesia but originated in North America. Its growth and development must be improved using the right technique to adapt to and flourish in tropical regions like Indonesia. The objective of this investigation was to ascertain how biostarter and vermicompost affected the growth and rate of photosynthetic activity of E. *purpurea.* Split-Plot Randomized Complete Block Design was therefore applied. Vermicompost and biostarter are two examples of organic materials that were considered in this study. Both can speed up *E. purpurea's* photosynthetic rate and plant growth. The growth and photosynthetic rate of E. *purpurea* were found to be significantly impacted by the combination of vermicompost and biostarter in this study.[101]

For use as green vegetables, spinach leaves are frequently cultivated. Spinach contains vitamins, proteins, fats, carbohydrates, and minerals. On the Indonesian island of Lombok, scientists studied the effects of NPK fertilizer and vermicompost on the growth of spinach. The objectives of the study were to determine the following: (1) how vermicompost affects spinach growth, (2) how NPK fertilizer affects spinach growth; and (3) how vermicompost and NPK fertilizer together affect spinach growth. This study was conducted using a factorial, completely randomized design consisting of two components and three replications. The study's conclusions were as follows: (1) the number of leaves, length, width, stem height, and stem diameter of spinach were significantly affected by the application of NPK fertilizer, (2) the number of leaves, length, width, and stem height were significantly affected by the application of vermicompost, (3) the optimum amount of NPK fertilizer was 1 gram per plant; and (4) the treatment with 1.8 kg of vermicompost yielded the best results.[102]

Vermicomposting, which uses earthworms to break down organic wastes like food, sewage, and other organic wastes, is becoming more and more popular. The addition of vermicompost to soils can enhance plant growth by making nutrients more accessible and reducing the amounts of pollutants present in other compost products. This study examines how vermicompost affects tomato plants' (*Solanum lycopersicum* L., var. Firenze) tolerance to salinity through greenhouse pot experiments. Plants were grown on four substrates, denoted by letter identifiers: With 100% organic soil, the control treatment (designated as "T"), 20% vermicompost plus 80% organic soil (designated as "Vc"), 20% compost plus 80% organic soil (designated as "C"), and 10% vermicompost plus 10% compost (designated as "M") comprised the mixture treatment. The four treatment groups were given three quantities of sodium chloride (0, 50, and 150 mM); the experiment was set up as a fully randomized block inside the greenhouse. Superior growth and resistance to salinity stress were demonstrated by plants grown on Vc substrate. The organic matter (vermicompost, compost, and a mix of the two), which provides soluble nutrients and helps release minerals gradually to reduce abiotic stressors, had a positive effect on the parameters under investigation. Given the challenges of cultivating food crops in drier, more salinized environments, vermicomposting could be a helpful method for reducing the effects of salt stress on tomato plant development.[103]

A novel method was used to introduce vermicompost as an acclimation soil for banana plants. Following the acclimatization phase, the effects of various agricultural media on the vegetative growth and leaf mineral minerals in banana tissue culture plantlets were assessed using various potting mixes consisting of vermiculite, vermicompost, peat moss, and sand. Two seasons' worth of 12- and 24-week trials in these farming media were assessed. The most studied vegetative growth criteria (length of the plants, plant height, and roots, stem diameter, leaf breadth, and fresh and dry weight of the shoots and roots) revealed that the best results were obtained when vermicompost was combined with 33.3% of vermiculite and sand. Additionally, the total amount of chlorophyll in banana plants was significantly increased by 50% vermicompost and 50% peat moss. Vermicompost with a 75% peat moss ratio generated the largest mineral content values throughout the two periods, according to a study on N, P, and K plants. To improve the in vitro-created greenhouse-grown banana plants, vermicompost was introduced to the culture media.[104]

Vermicomposting with Microorganisms

The vermicomposting action of different earthworm species has a significant impact on the community of microorganisms in sludge. Following passage through the gut, there is typically an increase in the bacterial population or action of the cast. Potentially active, the microbial population in the cast and gut of earthworms is capable of breaking down a variety of organic substances and polysaccharides, such as starch, chitin, lignin, sugars, cellulose, and polylactic acids.[105]

Earthworms are related to the bacteria that serve as the organic matter's principal consumers rather than the debris and other decomposing organic matter directly. As a result, earthworms are better defined as micropores and are also considered geophagous organisms because they typically consume debris in the form of soil.[106]

Earthworms interact with bacteria in a variety of complex ways. It was crucial for this study on epigeic earthworms to look at various microfungi in casts before moving on to different stomach regions because of the significance of organic materials. Fungi are an important component of the resident microbial community during composting, which are essential to the process of biodegradation and conversion.[107]

The symbiotic relationship between earthworms and their gut microflora. It was discovered that the mucus generated by the glands located in the anterior region of the gut is carried back through the intestine along with food that has been consumed. This mucus serves as an advantageous material for the symbiotic microorganisms that break down complex chemical compounds in the ingesta, benefiting both the earthworms and the microsymbionts. The availability of adequate oxygen, moisture, temperature, pH, organic matter, and elemental nutrients is essential for microbial growth and activity. Earthworms can influence the population dynamics of microorganisms.[108]

Earthworms are common invertebrates of the soil that feed on both mineral soil and organic matter that contains a wide range of microorganisms.[109]

Due to the habitat and food material available for the growth of microorganisms, there has been observed selective proliferation of bacteria in the gut of many types of earthworm organisms in A. Caliginosa.[110]

Earthworms boost the symbiotic gut microflora's ability to break down ingested organic material and release metabolites by priming it with produced mucus and water.[111]

Natural selection was used to choose the bacteria found in the gut walls of anecic and endogeic earthworm species. The primary determinants of this process were ecological group, habitat, and species. Apart from significant microorganisms, the bulk of bacterial and fungal spores are too tiny to be disturbed and frequently enter the gut lumen undamaged.[112]

A variety of relationships between earthworms and microbes, including the fact that microbes are a source of food for earthworms, are abundant in the gut, help spread microbes in vermicompost, and work in tandem with earthworms to humify and help some metal ions chelate and mineralize organic materials.[113]

Organic matter is broken down by earthworms, who also loosen it to create more surface area for microbial colonisation.[114]

If vermicompost is introduced to the soil, its microbiological properties, such as microbial biomass concentration and associated activity, influence nutrient dynamics throughout maturation, causing the immobilization or release of nutrients, and as a result, affecting plant absorption.[115]

Earthworms have a wider variety of bacteria in their guts, which are in charge of several processes, such as soil mineralization and chelation of multiple ions.[116]

The primary enzymes that break down organic matter are those produced by the earthworm and ingested bacteria. Examples of these enzymes are cellulases, chitinases, proteases, and lipases.[117]

Earthworm's digestive system and gut microflora generate the enzymes amylase, cellulase, xylanase, endoglucase, alkaline phosphatase, acid phosphatase, and nitrate reductase, which support soil organic matter's humification and digestion. The enzymes amylase, xylanase, cellulase, cellulase, xylanase, endoglucanase, Amylase, and cellobiase are the enzymes that degrade starch, cellulose, xylan, and cellodextrins. Phosphate and nitrogen metabolism is carried out by acid The enzymes that are in charge of phosphate and nitrogen metabolism are alkaline phosphatase, acid phosphatase, nitrate, and nitrate reductase.[118]

The capacity of the *Bacillus cereus* bacterial strain found in a vermicompost site to manufacture the amylase enzyme. Several earthworm species have diverse isozymes as a result of their different life situations.[119]

Role of Earthworms on the Environment

An increasingly common method of treating waste is the use of earthworms. It's called vermicomposting in common parlance. Potential organic input for sustainable agriculture, vermicompost has major (N, P, K), enzymes, micronutrients, good microorganisms, major (N, P, K) and enzymes, micronutrients, and hormones are all present in vermicompost. This organic input may be used in sustainable agriculture.[120]

Earthworms have a variety of functions in the soil, including biological stimulators, chemical degraders, crushers, and grinders. vegetation such as *Parthenium hysterophorus Linn*. Both Bhang (*Cannabis sativa Linn.*) and water hyacinth (*Eichhornia crassipes*) are weeds that grow in and around various fields, roadsides, and forests. *Hysterophorus Parthenium* L. Congress grass is a hazardous weed that is toxic, pernicious, allergic, and violent, and it seriously endangers both people and animals. It is currently one of the most bothersome and unpleasant weeds in pasture, agricultural land, forests, and wasteland, and it is a nuisance to people.[121]

The earthworm *Perionyx ceylanensis* Mich. reproduces and goes through its life cycle for 340 days in cow dung. According to the results, the mean growth rate for the worms cultured individually, in batches of four, and batches of eight was 1.79, 1.57, and 1.34 mg/worm/day, respectively. The hatching success was found to be between 74.67% and 82.67%, and the cocoon production rate was identified to be between 0.85 and 0.94 cocoons/ worm/day. 95.16–96.77 percent of the cocoons produced just one hatchling. Parthenogenetically reproducing *P. ceylanensis* is indicated by the production of viable cocoons by worms raised in isolation. The life cycle of worms cultured in batches of four and eight was 50 days, while worms cultured singly took ±57 days. Because of its short life cycle, *P. ceylanensis* can be used for a wide range of vermiculture practices.[122]

Earthworm species under controlled conditions in the laboratory at various moisture and temperature regimes: rate of maturation, growth rate, cocoon production, hatching success of cocoons, incubation period, and number of offspring per cocoon.[123]

By rearing groups of 1, 2, 4, 8, or 16 small earth-worms in 100 g of waste in small containers in incubators at 15°, 20°, 25°, and 30°C, researchers were able to examine the growth and reproduction of *Eudrilus eugeniae* (Kinberg) in cattle wastes.[124]

Up until the 70th day, *P. ceylanensis*'s length and biomass were measured every seven days. Up to 160 days, subsequent measurements and weighing were carried out every 15 days. The worms' length and biomass were then measured every 30 days until the experiments' conclusion. The worms' growth rate was computed.[125]

Drawida nepalensis, Metaphire houlleti, and *Perionyx excavatus* were reared in a lab environment for 150 days using cow manure and oak litter, and observations on their biology were made. According to this study, *P. excavatus* and *M. houlleti* can only produce parthenogenetically, but *D. nepalensis* can produce cocoons both parthenogenetically and sexually. The maximum growth rate observed in *P. excavatus* was 3.7 ± 0.05 mg/worm/day. A maximum of 51 ± 8.2 days were needed for *M. houlleti* clitellum development, but cocoon production started after 37

± 5.2 days for *D. nepalensis* and 70 ± 6.4 days for M. houlleti, while only 24 ± 1.6 days were needed for *P. excavatus* cocoon production. Furthermore, *P. excavatus* reached a maximum daily production rate of 1.1 ± 0.05 cocoons. The minimum incubation period for *P. excavatus* was found to be 18.7 ± 1.5 days.[126]

For ninety days, the epigeic earthworm *Eisenia fetida* was studied in a laboratory setting for its capacity to stabilize sludge (produced by a sugar industry distillation unit) combined with cow dung in different proportions: 20% (T1), 40% (T2), 60% (T3), and 80% (T4). The ready vermicompost was assessed for its different physicochemical parameters using standard procedures. According to the research, low-input management of nutrient- and energy-rich distillery sludge may benefit from vermicomposting. This process's byproducts can be applied to long-term land restoration.[127]

The goal of the study was to determine how different organic wastes, kept in uncontrolled laboratory environments, affected and were suitable for the development and reproduction of the epigeic earthworm, *E. fetida.* The earthworm's biomass, growth rate, and cocoon production varied greatly depending on the organic wastes used in the experiments. These wastes included False Ashoka Waste (FAW, *Polyalthia longifolia*), *Parthenium* Waste (PW, *Parthenium hysterophorus*), Cotton Residue Waste (CRW, Gossypium), Lawn Grass Waste (LGW, Agrostis), and Control (Cattle Manure, CM). Based on the findings, it can be deduced that various organic wastes had a significant impact on the biomass, cocoon production, growth rate, and sexual maturity, of the epigeic earthworm, *E. fetida.* These factors in turn had an impact on the quantity and quality of vermicompost produced as well as the worm multiplication process during the vermicomposting process.[128]

Earthworm types *Eisenia fetida* is a common earthworm of economic importance and a valuable farm companion. When used wisely for vermicompost production, it is beneficial to crop agricultural production. When given the right care and regulated environment, earthworms can quickly produce high-quality compost in the form of vermicasts by consuming organic waste. The N.S. Science and Arts College Botanical Garden in Bhadrawati town, in the Chandrapur district of Maharashtra state, is home to terrestrial nuisance weeds that have been successfully transformed into commercially valuable manure through the use of vermitechnology.[129]

India produces millions of tonnes of agricultural, kitchen, and livestock waste every year, which leads to serious social problems. This study looks at the ability of the epigeic earthworm *Eisenia foetida* to convert different waste mixtures into nutrient-rich vermicomposts and vermiwash. Vermicomposting noticeably increases exchangeable potassium, accessible phosphorus, and calcium while notably lowering total electrical conductivity (EC), organic carbon (TOC), and the C: N ratio in vermicomposts and vermiwash. The utilization of vermicomposting or vermiwashing wastes could be advantageous for long-term land restoration techniques because it raises the amount of plant nutrients in the final products of these organic resources. This study unequivocally shows that vermicomposting wastes from homes, farms, and animals produced beneficial vermicompost and vermiwash, as well as final vermicompost with greater amounts of plant growth supplements.[130]

Building a vermicompost station, importing an *Eisenia foetida* compost earthworm, and producing vermicompost from rice straw, dry grass clippings, and cow dung are the various steps involved in the vermicomposting process. End users, such as farmers, may find vermicompost developed with easily available, considerably less costly composting material to be very helpful in substituting chemical fertilizers and securing better prices for organic produce. For vermicomposting, *Eisenia foetida* was employed, along with three treatments: T1 (rice straw), T2 (rice straw plus grass), and T3 (grass). humidity, Temperature, and pH were recorded during the process. After 120 days, the combination of grass and rice straw yielded the highest amount of vermicompost, at 105 kg/m2. Grass and rice straw yielded the least amount, at 102.5 kg/m2 and 87 kg/m2, as well Based on chemical analyses, it was determined that the harvested vermicompost had a great nutritional status and included all necessary macro- and micronutrients.[131]

Over the past few decades, paper waste has become a major issue. "*Eisenia foetida*" uses the method of reusing paper waste in vermiculture. SASTRA collects more than 50 kg of paper waste in addition to organic waste, such as vegetable and animal dung. The experimental setup of the SASTRA lab is located near Nirman Vihar in a Geosynthetic polymer bag. The area is divided into three sections, and in each section, 25 numbers of earthworms and the necessary amount of paper and organic trash were introduced. The setup is lit for adequate aeration, watered daily, and observed occasionally. Following the addition of the earthworms, soil samples were taken after 20, 45, and 60 days. The paper waste, compost, and earthworms are sorted after the experiment has been running for 60 days. The trash volume was compared to the initial volume, and compost was gathered. The vermin-bed soil's elemental analysis is looked at to raise the soil's nutrient content. The total protein is measured in the setup's vermiwashed water. Additionally, the quantity of earthworms is contrasted with the starting point. The degradation of paper waste is most evident in a decreased percentage of both organic and paper waste.[132]

The current study investigates *Eisenia fetida*'s capacity to recycle different fresh waterweed species (macrophytes) that are utilized as substrate in different reactors, including the *Trapa natans* reactor, the *Azolla pinnata* reactor, the *Ceratophyllumdemersum* reactor, the free-floating macrophytes mixture reactor, as well as the submerged macrophytes mixture reactor. The two-month experiment will run. The number and weight of *E. fetida* varied significantly between the reactors and over different fortnights ($P < 0.05$). The highest number was in the *A. pinnata* reactor (343.3 ± 10.23 %; weight 98.62 ± 4.23 %), while the lowest was in the submerged macrophytes mixture reactor (105 ± 5.77 %; weight 41.07 ± 3.97%). As a result, the type of macrophyte in each reactor influences how *E. fetida* grows and reproduces, and adding *A. pinnata* to other macrophyte reactors enhances *E. fetida's* ability to recycle those materials.[133]

Vermicomposting is the process of breaking down organic materials using worms, typically *Eisenia fetida*. There were four replicates and ten treatments in the trial, which was conducted using a randomised design. The remaining alfalfa and wheat straw were examined separately, as well as mixes containing 50 and 75 percent horse and sheep manures. Additionally, tests were conducted on wheat straw alone and in a 75% ratio with 25% chicken dung. The substrate mixtures were enabled to undergo three months of processing following the addition of *E. fetida.* All substrates saw increases in total C and EC during vermicomposting, while all substrates saw decreases in pH, total N, and C: N. The combination of 75% sheep dung and 25% alfalfa had the largest change in EC in the final vermicompost, rising from 12.8 dS.m-1 to 18.6 dS.m-1. Generally speaking, EC increased and pH dropped when making vermicompost.[134]

The ability of the earthworm *Eisenia foetida* to convert cow dung and sugar mill filter press into a product with added value. Ten different ratio combinations of pressmud (PM), cow dung (CD), and waste from the sugar industry were processed during vermicomposting studies. The controls, which were Vc1, Vc2, Vc3, Vc4, Vc5, Vc6, Vc7, Vc8, Vc9, and Vc10 were contrasted with these combinations. The E. foetida development, growth, number of hatchlings and cocoon production were observed for 14 weeks in the controlled, appropriate environment of the research lab, using ten different feed mixture ratios. Extreme growth and reproduction were attained in Vc4 (70%CD+30%PM), while Vc3 (80%CD+20%PM) and Vc2 (90%CD+10%PM) also saw favorable worm growth and reproduction. The addition of filter cake (Pressmud) remnants had a detrimental effect on earthworm development and reproduction. The process of vermicomposting resulted in a notable reduction of the C/N ratio and A rise in major and minor nutrients after 98 days of worm activity throughout the mixture. If cow dung is added in the right amounts, the final product, vermicompost, can be the least expensive solution for the control of sugar mill pressed.[135]

An economical and environmentally friendly method of managing agricultural waste is vermicomposting. The earthworm *Eisenia foetida* is one of the most often used species in vermicomposting. The ideal temperature and relative humidity range for the earthworm feed are 20 to 35 °C and 60 to 80%, respectively. By decomposing organic materials, earthworms also known as farmers' friends—

increase soil fertility. The earthworm castings they produce throughout this process are an especially abundant source of biofertilizer. Physico-chemical analysis shows that vermicomposting raises nitrogen, phosphorus, and potassium (NPK) content while reducing the carbon-nitrogen (C/N) and total organic carbon (TOC) ratio when compared to compost and other agricultural wastes. Its additional applications include agricultural improvement through disease eradication.[136]

Results of an eighteen-week vermicomposting experiment in which cow dung was combined in different ratios (25%, 50%, and 75%) with *Eisenia fetida* of *Parthenium hysterophorus*. Across all treatments, there was a decrease in pH, OC (total), and the C: N ratio, but an increase in heavy metals, EC, N (total), P(aval), Ca (total), and K(total). The growth rate (biomass gain worm (-1) day (-1)) and cocoon formation were maximum in 100% cow dung. The results show that *parthenium*, when mixed with cow manure in the proper proportions, can be utilized as a raw material for vermicomposting.[137]

To maintain its stability, the sewage sludge combined with sugarcane waste in four different proportions—20% (T1), 40% (T2), 60% (T3), and 80% (T4)—epicaeta, or *Eisenia fetida*, an epigeic earthworm. Additionally, the ability of worms to compost was assessed by 100% of sewage sludge treatment facilities (T5). In summary, it was determined that the substrate's chemical properties had altered. *E. fetida* (supplied by a bulking agent, i.e. sugarcane trash) showed improved growth performances in the first three treatments (T1–T3). In vermibeds with higher sludge proportions, earthworm mortality was higher. Vermicomposting may be a useful process for producing value-added goods from small amounts of municipal sewage sludge, according to research. The potential for earthworms to reduce metal toxicity and improve the nutritional profile may be useful in the low-input conversion of hazardous sludge into usable goods.[138]

Vermicomposting food industry sludges (FIS) combined with other organic wastes was done using *Eisenia fetida*. Ten vermicomposting units with different waste mixtures were established. Total nitrogen (N total) (60–214%), total phosphorus available (P avail) (35.8–69.6%), total sodium (Na total) (39–95%), and the total amount of potassium (K total) (43.7–74.1%) all showed significant increases after 15 weeks, whereas pH (8.45–19.7%), the total amount of organic carbon (OC total), and the C: N ratio (61.2–77.8%) all declined. The results show that if FIS is mixed with other types of organic matter in the right amounts during the vermicomposting process, it can be converted into high-quality manure.[139]

Eisenia foetida, a red earthworm, has been used in tests to vermicompost fly ash. Cow dung was mixed in various ratios (20, 40, 60, and 80%) with fly ash from a thermal power plant. Reactors containing 40% fly ash yielded the highest number of vermicasts and juveniles, while reactors containing 20% fly ash produced the greatest increase in earthworm weight. Vermireactors performed similarly up to 60% fly ash, but at 80% fly ash, the reactors' overall efficiency drastically decreased. Before vermicomposting, high concentrations of nickel, chromium, zinc, lead, and copper were found in chemical analyses of different fly ash-cow dung mix samples. Chemical analyses of vermicomposted samples showed a 30–50% decrease of heavy metals up to 60% fly ash and a 10–30% decline in heavy metals in 80% fly ash. Metal analyses revealed a substantial bioaccumulation of heavy metals in the bodies of earthworms. The current study demonstrates that E. foetida can be used to reduce metal toxicity and that vermicomposting can be done efficiently and sustainably using mixtures of up to 60% cow dung and fly ash.[140]

A large amount of de-oiled *Brassica juncea* cake is produced in India and other nations. It is unrelated to the state of the economy. The current project intends to convert it into a vermicompost that is rich in nutrients by using *Eisenia foetida*. In the experiment, there were four treatments: control, buffalo dung +*Brassica juncea* cake+ *Eisenia foetida*, buffalo dung + *Brassica juncea* cake, buffalo dung + *Eisenia foetida*, the experiment included four treatments: control, buffalo dung + *Eisenia foetida*, buffalo dung + *Brassica juncea* cake, buffalo dung + *Brassica juncea* cake + *Eisenia foetida*, and *Brassica juncea* cake + *Eisenia foetida*. Bricks measuring 454521 cm (lbh) were used to construct pits above ground for the experiment. For every treatment, three copies were made. Results indicate that 90 days following production, the vermicompost has a slightly alkaline pH, increased electrical conductivity, accessible potassium, sodium, and phosphorus levels, and decreased levels of total organic carbon, cellulose, and hemicellulose. This treatment impact was demonstrated to be significant at the 5% level for several parameters.[141]

One recycling technique is using urban waste for urban horticulture by composting it. We defined compost made from various municipal trash fractions and assessed its fertilizer value in a container trial with lettuce plants. Seven distinct treatments were investigated: a sand control, two sources with mineral fertilization, and thermophilic compost produced from human and green waste. The most lettuce was produced and the majority of total P, K, Ca, and Mg was absorbed by the plants grown in coir vermicompost. The fecal compost produced the greatest shoot P and K content, but it also produced the lowest shoot uptake of Ca and Mg compared to the other treatments. For lettuce to grow, more nitrogen (N) was required in all composts. From municipal waste, vermicompost and fecal compost exhibit a high rate of Ca, Mg, P, and K delivery to plants. To replace synthetic fertilization, research on alternative sources of nitrogen as well as macronutrient availability is necessary.[142]

Because it tends to cause pollution, solid waste from the leather industry is becoming an issue in today's world. This study assessed the plan to use *Eisenia fetida* earthworms in combination with cow dung to vermicompost leather industry-produced waste such as limbed animal fleshing (ANFL) and chrome shaving waste to achieve sustainable reuse in agriculture. The results show that the earthworm *Eisenia fetida* can turn wastes like shavings and lime esh into nutrient-rich fertilizer products that are made from cow dung.[143]

The effects of vermicompost (0, 10, and 15 tha-1), climate elements like soil moisture (50%, 70%, and 100%), and elevation of soil temperature (1 to 200C) were investigated in a field experiment to determine the chemical and physical properties and nutrient availability of post-harvest calcareous-acid mixed soils following rice production. The previously recommended dosages were applied throughout eighteen treatments. According to the analyses of the soils, there were significant differences ($p < 0.05$) between the treatments' effects on the physicochemical properties and nutrient availability of the soils. In both initial and post-harvest soil conditions, it was found that the following soil parameters, except available sulfur: pH, EC, organic carbon (OC), available nitrogen, potassium, phosphorus, sodium, and calcium, were present in greater quantities in 1:1 (calcareous: acid-soils) mixed soils than in their 1:3 mixed counterparts. The highest values of OC, soil pH, accessible P, and Zn were found in treatment T13. Treatment T6, however, was shown to have the greatest quantity of Mg and Ca availability. The treatments T1, T2, T11, and T16 showed lower soil OC and accessible levels of N, P, Ca, Mg, Zn, and S. In summary, the majority of treatments had a beneficial impact on maintaining an appropriate level of soil physical and chemical parameters in all the subplots because of their inherent qualities.[144]

Vermicomposting and other traditional methods were used in the study to create compost from some poisonous plants. The weeds used in the experiment were marijuana (*Cannabis sativa Linn.*), *Eichhornia crassipes*, and congress grass (*Parthenium hysterophorus Linn*.). The materials mentioned above were used to set up a total of six sets of experiments. Out of them, three were control experiments and the other three were test experiments. In every test experiment, fifty worms were added. The data show a significant increase in potassium, phosphorus, and nitrogen in the *Eisenia foetida* experiment, and a significant decline in organic carbon, C/N, and C/P ratios. As a result, the experiment's potentially harmful weeds are turned into compost that is higher in nutrients.[145]

Fourteen distinct fungal species from the genera Cladosporium, Aspergillus, Chaetomium, Fusarium, Cunninghamella, Mucor, Penicillium, and Rhizopus were found in vermicasts made by the earthworm species *P. ceylanensis* that were raised in a 1:1 ratio of *Polyalthia longifolia* leaf liter to cow dung. While organic carbon and the C/N ratio were lower in vermicasts than in the control (worm-unworked substrate), total phosphorus, nitrogen, calcium, potassium, copper, zinc, and iron had elevated levels in vermicasts.[146]

Utilizing the physical and chemical profiles of three distinct earthworm species *Eudrilus eugeniae*, *Eisenia foetida*, and *Perionyx excavatus*—to determine the quality of vermicompost. To determine the vermiculture quality, various mixes of cow dung with sugarcane thrash, paddy straw, weed biomass, vegetable waste, *eichornia*, and control were employed. In the case of VMC5, vermiculture was found to be occurring at its highest rate because *E.eugeniae* is the most efficient vermicomposting worm. High-quality vermicompost has the following characteristics: pH 7.11, EC 0.63, moisture content 59.61, total nitrogen content 1.062%, the total amount of phosphorus 1.748%, and the total amount of potassium 1.59% in the VMC5 profile derived from *E. foetida*.[147]

Using worms, *Lumbricus rubellus,* for 105 days after 21 days of pre-composting, experiments were carried out to eliminate heavy metals (Cr, Cd, Pb, Cu, and Zn) from urban sewage sludge (SS) treated with spent mushroom compost (SMC). Five different SS/SMC treatment combinations were prepared in triplicate microcosms, each with a control. Ten and fifteen weeks into the vermicomposting process, an analysis of the earthworms' growth and multiplication as well as a laboratory analysis were carried out. According to our findings, there were significant differences between the treatments in terms of both the final biomass of earthworms (mg) and the final number of earthworms ($F=554.70$, $P=0.00$ and $F=729.10$, $P=0.00$, respectively). By week ten, 90–98.7 percent of the heavy metals Cr, Cd, and Pb in vermicompost had been removed, bringing it down from its starting concentrations. Micronutrient concentrations of Cu and Zn, on the other hand, were 10-200 times lower than the Malaysian Recommended Site Screening The amount for Contaminated Land (SSLs) and the biosolid compost limits set by the EU and USA. While the level of heavy metals in the tissue of earthworms was lower than in vermicompost, an increase in heavy metals was observed in all treatments in vermicompost on week fifteen when compared to week ten. Therefore, it is hypothesized that earthworms release heavy metals into their environment, and it was found that the earthworms excreted heavy metals between ten and fifteen weeks.[148]

A laboratory scale was performed to assess the suitability of rubber leaf litters as vermiculture substrates for *Perionyx excavatus*, *Eudrilus eugeniae* and *Eisenia fetida*. Earthworm mortality, their rate of body weight increase and reproduction were recorded.[149]

Impact of Water Hyacinth on the Environment

Almost 2,000,000 hectares of water surface in India are covered in water hyacinth.[150]

An experiment in which the textile industry's effluent was treated in artificial wetlands to remove various pollutants, including pH, EC, sulfate, chloride, BOD, phenols, and COD, was conducted. *Eichhornia crassipes* were used in the experiments, along with a range of process parameters like pH, dilution ratio, contact time, and nutrient dosage, to minimize the different factors present in the effluent from the textile sector. The study found that at the ideal nutrient quantity of 60 g, dilution ratio of 10, pH of 8, and contact period of 6 days, *Eichornia crassipes* achieved the largest percentage reduction in different parameters in wastewater from the textile sector.[151]

Total nutrient uptake by water hyacinth varies with season, with more uptake in the summer when temperatures are higher and more suitable for plant development.[152]

Previously stated that water hyacinths can absorb nutrients from water, and this ability increases with increasing temperature. *Eichhornnia crassipes* have a high capacity for heavy metal uptake, containing Cr, Co, Ni, Hg, Pb, and, Cd which might make them appropriate for biocleaning wastewater from industrial sources.[153]

Eichhornia crassipes has recently received a lot of attention as a potential biosorbent for heavy metal removal.[154]

Numerous human-caused activities, like sewage outflow and nutrient buildup in aquatic environments, cause eutrophication, which hinders recreational activities like boating, fishing, and swimming and causes a massive growth of macrophytes. It also stunts fish growth and lowers localized dissolved oxygen levels, which can result in fish kills. Moreover, overgrowth, particularly in the summer, produces a lot of organic matter, which, when broken down by bacteria and other microorganisms, leads to excessive rates of microbial respiration with low levels of oxygen, endangering aquatic life.[155]

In agricultural society, the utilization of inorganic fertilizers is increasing. Farmers are drawn to these fertilizers because they provide short-term benefits, but they are unaware of the adverse impacts that these fertilizers have on soil fertility and human health. The potential of using poultry litter as a supplement to turn water hyacinth into vermicompost was investigated in a rotary drum reactor. 10% aged poultry litter (0.5 kg), 20% shredded cardboard (1 kg), and 70% groundwater hyacinth paste (3.5 kg) were fed to the reactor along with 0.25 kg of *Eisenia fetida* earthworms. To improve aeration and porosity, the reactor was gently rotated. Every 15 days, the phosphorus, moisture content, carbon content, pH, nitrogen, and potassium levels were measured. The product had been available for 45 days. In this, it was reported that water hyacinth can be used to increase production of agriculture and suitable management of this invasive weed from water bodies.[156]

Vermicomposting of the aquatic weed *Azolla pinnata* using *Eisenia fetida* and discovered that the resulting vermicompost was not only rich in nutrients but also proved to be an effective technology for converting the threat of *Azolla pinnata*.[157]

Water hyacinth has a high potential for reproducing even through its tiny pieces of weed petioles, if left in water bodies, vermicomposting of water hyacinth proved to be an effective method by which water hyacinth after passing through earthworm gut loses its ability to vegetative or sexual reproduction.[158]

Fresh and dry forms of *Eichornia crassipes* were vermicomposted using *Perionyx excavatus*, and the fresh from recycled faster than the dry form.[159]

Azolla sp. and *Eichornia* sp. were vermicomposted by earthworms (*E. eugeniae*), and the impact of vermicompost on eggplant development and yield was investigated.[160]

The earthworms' digestive enzymes and gut microbes improved the nutrients found in the vermicompost made from the marine weed *E. crassipes,* which was made using *E. eugeniae*.[161]

Vermicomposting is effective for managing water hyacinth because it yields a stable, mature product (vermicompost), which is rich in plant nutrients and may be utilized as organic manure. This study used *E. fetida* to convert water hyacinth.[162]

The invasive alien hydrophyte *Eichornia crassipes Mart.Solms* are bad for the environment. Vermicomposting was used in an attempt to bioconvert water hyacinth. In the current study, water hyacinth combined with cow dung (1:3) was composted for 45 days using the earthworm species *Eisenia fetida*. This mixture was used as a good organic manure for the leguminous crop Peanut (*Arachis hypogaea* L.) pot culture, and it was discovered to have better growth and yield.[163]

Water hyacinth vermicomposting was investigated in the lab using the native earthworm *Perionyx excavates* in two seasonal trials that covered the summer and winter seasons. The cow dung (CD) and water hyacinth (WH) were mixed 5:1 in earthen pots for the experiment. Furthermore, there was found to be a seasonal impact on the overall vermicomposting process, with summer being more productive than winter.[164]

Potential for vermicomposting water hyacinth (WH) laced with cow dung (CD). For 147 days, five vermireactors with different ratios of WH and CD were operated in the laboratory. In CD alone, the largest worm growth was noted. In a 75% CD and 25% WH feed mixture, worms multiplied and grew well. The results indicated that WH, when combined with up to 25% cow dung (dry weight basis), could be a valuable raw substrate for vermicomposting.[165]

Study showed that the nutrient value was highest in the vermicomposts created from water hyacinth as compared to organic wastes sourced from seven distinct sources. The seven sources are rice husk, cow dung, a mixture of materials, cabbage, banana pseudostem, coconut coir, and water hyacinth. *Perionyx excavatus*, *Eudrilus eugeniae*, and *Eisenia fetida* are the three species of composting earthworms used in this experiment. Vermicompost produced using water hyacinth has the maximum nutrient value among the seven sources that were tested, it can be concluded.[166]

Common beans, *Phaseolus vulgaris*, are an essential crop for nitrogen fixation through Rhizobium symbiosis and food security. Commercial Rhizobium inoculants are promoted as a means of fixing nitrogen and boosting bean yield in the Lake Victoria region. Rhizobium symbiosis depends on nutrients, especially phosphorus, which is commonly utilized as diammonium phosphate (DAP) in the Lake Victoria basin. *Eichornia crassipes (Mart.) Solms-Laubach* (*Pontederiaceae*) water hyacinth compost has the potential to boost crop yield and stop the plant's disastrous spread to Lake Victoria. Water hyacinth compost's high nutritional content can encourage Rhizobium nodulation and nitrogen fixation, which will improve plant growth and pest resistance.[167]

In Masvingo, variations in the rate at which water hyacinth compost is applied can impact tomato fruit growth characteristics, yield, lead (Pb), nickel (Ni), copper (Cu), and zinc (Zn) heavy metal accumulation. Four different treatments of water hyacinth compost ranging from 0, 37, 55.6, and 74.1 ha−1 were applied in a randomized complete block design setup. While water hyacinth compost application rates had a significant effect on plant height, days to maturity, and yield, they did not affect the number of tomato fruits produced per plant. At an application rate of 74.1 ha−1, the plant height at weeks 6, 9, and 12 was 25%, 56%, and 63% higher than the control. While marginal plant height differences of 4%, 6%, and 4% were seen between the application rate of 34.7 ha−1 and the control at weeks 6, 9, and 12, respectively, plant heights at application rates of 56.6 tha1 were 11%, 13%, and 12% greater than the control. Tomato plants subjected to compost rates of 34.7, 56.6, and 74.1 ha−1 required 10, 17, and 20 days longer to reach maturity than the control group. Applying hyacinth compost at 0, 34.7, 56.6, 74.1, and 52.6 ha−1 produced 52, 55, 60, and 68 ha−1, in that order. As the rate of water hyacinth composting increased, so did the amounts of heavy metals; however, the average concentrations were, at all application rates, 85%, 93%, and 86% less than the permissible levels of Pb, Cu, and Zn established by the Commission of the Codex Alimentarius. Therefore, 74 ha^{-1} of water hyacinth compost can be utilized to boost tomato yield without endangering consumer health.[168]

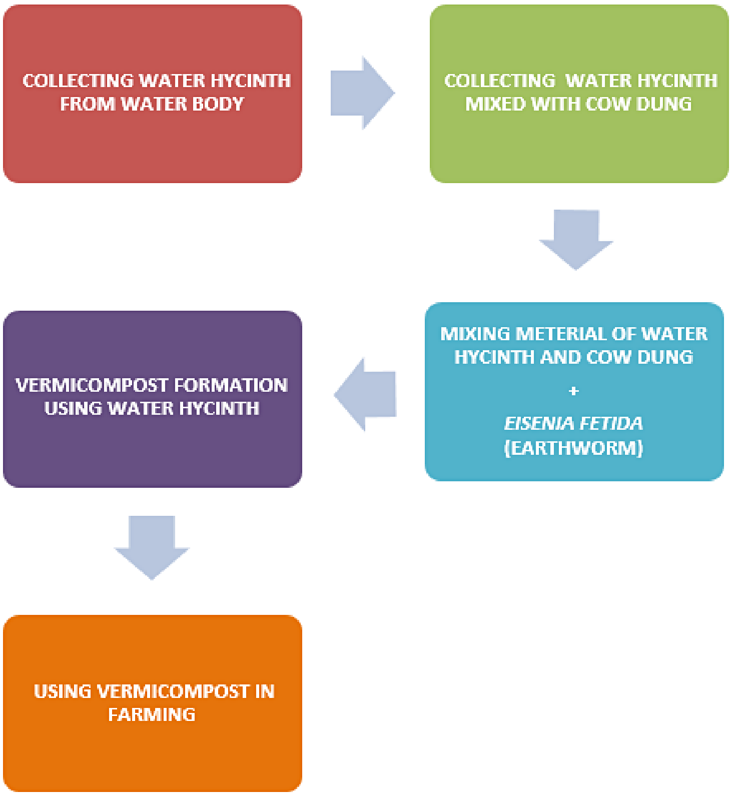

Fig. 2: Vermicomposting from Water Hycinth (Water Weed)

The water hyacinth the floating aquatic weed *Eichhornia crassipes* (*Pontederiaceae*, *Liliales*) is the most dangerous plant in the world due to its detrimental impact on rivers and human livelihood. The water hyacinth issues were not at all resolved despite numerous attempts. In light of this, an experiment was carried out to assess how water hyacinth manure (WHM) affected *Celosia argentea's* growth and yield during the 2011 harvest season at Lagos State Polytechnic's Teaching and Research Farms in Ikorodu. Three treatments were repeated three times apiece: 3.0 kg/plot (60g/plant), 1.32 kg/ plot (30g/plant), and a control treatment without the application of water hyacinth manure. Comparisons were made between treatments for leaf count, stem girth, plant height, before and three weeks following manure application, and yield at maturity. The results demonstrated that the application of water hyacinth manure significantly affected the growth and yield of C. argentea. Among the treatments, water hyacinth manure (WHM) treated at a rate of 2.64 kg/plot (60 g/ plant) produced the best results for all parameters.[169]

Eichornia crassipes, an aquatic weed, has been evaluated for its viability in the present study. We used the following ratios of water hyacinth, garden soil, and cow dung: 1: 2: 1, 2: 1: 1, and 1: 1: 2. Two species of earthworms were used in the experiment: *Eudrilus eugeniae* and *Eisenia fetida*. This is in contrast to the levels of total nitrogen (0.18% in the control and 1.68% in the earthworm-treated), phosphate (0.63% in the control and 1.64% in the earthworm-treated), along with zinc (6.68 ppm in the control and 7.66 ppm in the earthworm treated), which all showed significant decreases. The earthworms enhance the compost by adding a range of nutrients that promote microbial and plant growth. Research on the growth of water hyacinth plants revealed that, in comparison to controls, the root and shoot lengths increased at the fastest rates (8.9 cm and 7.2 cm, respectively). *Micrococcus luteus* and *Bacillus cereus* were found to be the most common species of bacteria in the earthworm's gut, according to studies on the bacteria there. The study indicates that compost derived from aquatic weeds can be used in farming.[170]

Conclusion

Water hyacinth is a highly productive and resilient weed that has withstood numerous attempts to eliminate it using chemical, biological, mechanical, or hybrid approaches. The dense mats it produces obstruct irrigation channels and rivers. The breakdown of water hyacinth, which results in a sharp increase in the water body's nutrient levels, is ultimately the cause of the eutrophication issue in aquatic systems. The best chemical control for water hyacinths is herbicides; nevertheless, research indicates that overuse of herbicides pollutes water supplies. We can use water hyacinth in many ways, including as a substrate for the creation of compost or biogas, since it has been found to have a high organic content based on its dry weight. Many earthworm species prefer to eat highly organic food rather than soil. Earthworms are used to make vermicompost, and cow dung is used as a food source due to their high organic content. We can also use water hyacinth to make vermicompost using many earthworm species and the vermicompost can be used in plant growth and increased agricultural productivity.

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Conflict of Interest

The authors have declared that no competing interests exist.

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