International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 5, July-August 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Chemical and Microbial Reactions Occurring during Vermicomposting

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ABSTRACT
Vermicomposting is a unique process that occurs in earthworm's gut to convert organic wastes into organic fertilizer or vermicompost by using joint action of earthworms and microorganisms. Organic wastes used were the mixture of spent mushrooms waste, coconut husks, cow dung, vegetables residue, and leaf litter. Locally available earthworms are also used for vermicomposting but their mode of feeding is very slow and the earthworm which lives below the soil is also not suitable for vermicompost production. The Red worms (*Eisenia foetida*) and African earthworm (*Eudrillus engenae*) are promising worms used for vermicompost production. All the two worms can be mixed together for vermicompost production. In the composting process, egg shells flour and fish meal are added into the vermicompost as additives materials. The results indicate that the combined vermicomposting and composting process with addition the additives materials improves the chemical composition of vermicompost compared to using vermicomposting process alone. The percentage of nitrogen, phosphorous, potassium, calcium and magnesium in vermicompost was found to increase while C: N ratio, pH and total organic carbon declined as a function of the vermicomposting.

How to cite this paper: Dr. Atul Kumar Sharma | Dr. Kamlesh Rawat "Chemical and Microbial Reactions Occurring during Vermicomposting" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-5, August 2021, pp.1101-1105, URL: www.ijtsrd.com/papers/ijtsrd45029.pdf

IJTSRD45029

Although vermicomposting has been shown to effectively reduce organic biomass and generate high-quality fertilizer for plants, little is known about the bacterial communities that are involved in this decomposition process. The process in the alimentary canal of the earthworm transforms organic waste to natural fertilizer. The chemical changes that organic wastes undergo include deodorizing and neutralizing. This means that the pH of the castings is 7 (neutral) and the castings are odorless. The worm castings also contain bacteria, so the process is continued in the soil, and microbiological activity is promoted. *Vermicomposting* is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Castings contain: 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good topsoil. Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms burrowing action, enhances the permeability of water in the soil. Worm castings can hold close to nine times their weight in water. "Vermiconversion," or using earthworms to convert waste into soil additives, has been done on a relatively small scale for some time. A recommended rate of vermicompost application is 15-20 percent.

INTRODUCTION

Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycets, and growth hormones auxins, gibberlins and cytokinins, is a suitable alternative to chemical fertilizers, being an excellent growth promoter and protector for crop plants. Thus, vermiculture not only results in management of soild waste but also produces excellent nutrient enriched vermicompost. Vermicompost is beneficial for sustainable organic agriculture and maintaining balanced ecosystem.[1]

A good quality vermicompost is consistent, moist, dark black medium and has a pleasant earthy smell. It contains water-soluble nutrients and is an excellent, nutrient-rich organic fertilizer and soil conditioner. A well-balanced vermicompost comprises of NPK, Sulphur, Calcium, magnesium and iron. It also contains micronutrients like manganese, Zinc, Copper, Boron and molybdenum. Nutrient wise, vermicompost is superior to cow-dung manure.

Procedure for Vermicomposting

1. The compost can be prepared in concrete tank (size is depending upon the availability of raw materials) could be used.
2. Collect and heap the weed biomass under sun for about 7-10 days or until well decomposed. Chop the hard materials required.
3. Sprinkle cow dung slurry on the heap for quick decompose[2]
4. Place a thin layer of surface soil/sand (1-2 inch) at the bottom of the tank.
5. Place fine bedding material such as partially decomposed cow dung/dried leaves etc. over the soil or sand layer
6. Place the chopped bio-waste and partially decomposed cow dung layer-wise in the tank up to a depth of 0.5-1.0 ft. [3]
7. Release about 1000-2000 worms/m 2 of any of the above earthworm species over the mixture.
8. Cover the compost mixture with dry straw or thatch or gunny bag.
9. Sprinkle water as and when necessary to maintain 70-80% moisture content.
10. Provide shade over the compost mixture to protect from rain water and direct sunshine.
11. Stop sprinkling of water when 80-98% bio waste is decomposed. Maturity could be judged visually by observing the formation of granular structure of the compost at the surface of the tank
12. Collect the vermicompost by scrapping layer-wise from the top of the tank and keep it under shade.[4]

The finished product is obtained through that process of composting within 90-120 days

Figure showing preparation of vermicompost

DISCUSSION

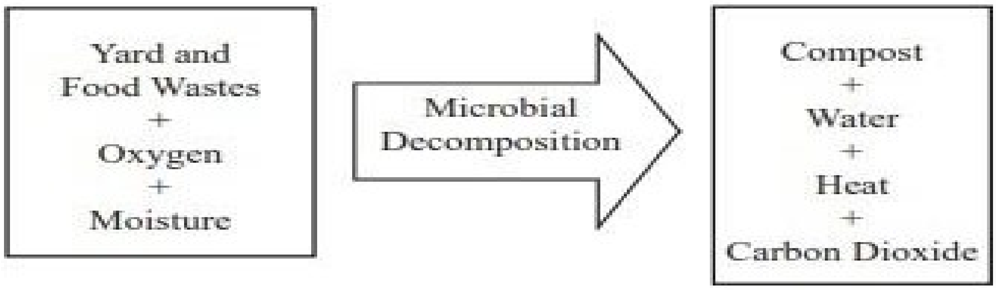
Samples were collected on every 10th day and dried at 40oC and finely powdered. Moisture content was determined by drying at 105^{o}C (Gravimetric method), total N by the Kjeldahl method and organic C by the rapid titration method of Walkley & Black (1934). The pH was measured by ELICO pH-meter (Digital) using suspensions of the material in water, in the ratio 1:5 (w:v). Chemical analysis of total and available P, K, Ca and Mg were carried out following standard methods [5]. N content reduced significantly. This is probably due to NH3 volatilization, incorporation into earthworm tissue and leaching into the bedding material. The relatively high level of N during the last 20 days of vermicomposting compared to composting is probably contributed by earthworms through excretion of NH+ 4 and secretion of mucus. The remainder of nutrients followed more or less similar trend, i.e., P content increased at a fluctuating level while K and Ca decreased and the Mg level remained almost static during composting with and without earthworm. Higher level of transformation of phosphorus from organic to inorganic state, and thereby into available forms during vermicomposting compared to ordinary composting. Rise in the level of P content during vermicomposting is probably due to mineralization and mobilization of P due to bacterial and faecal phosphatase activity of earthworms. [6] The drop in C: N ratio was significant. Thus it can be inferred that microbial decomposition contributes to the overall composting process and presence of earthworm speeds up the decomposition process. The lowering of C:N ratio was probably achieved by the combustion of carbon substances during respiration and the incorporation of plant derived organic material and transit of organic matter through the gut of earthworms.

These processes increase hydraulic conductivity and encourage the water to flow down and leach the salt out. The application of organic matter to salt-affected soil promotes flocculation of clay minerals, which is an essential condition for the aggregation of soil particles. It also plays an important role in increasing biopores spaces, which increase Na^+ leaching. Consequently, decreased the exchangeable sodium percentage (ESP) and the electrical conductivity. The increase of $NaHCO_3$ - extractable P with vermicompost may be attributed to the release of humic acid during organic matter decomposition, results in a convert's unavailable soil phosphate into available forms. In addition, vermicompost is a high phosphorus content. [7]

The initial cellulose level in control lot was 440.20 mg/g which reduced to 385.89 mg/g which shows a poor decrease in cellulose content of total 12.34 % in 48 days. While in experimental lots the gradual increase in percentage cellulose reduction was observed with increase in moisture content. The maximum reduction in cellulose content was observed at 75 ± 5 % moisture content which was initially 440.80 mg/g reaching a level of 32.8 mg/g on 48th day of experimentation. The decrease of cellulose by 92.56% is maximum among all the moisture content levels, the next lower reduction in 48 days. Cellulose is a problematic organic waste which impedes the biodegradation process. Cellulose breakdown calls for a prolonged pretreatment as it contains several components like cellulose, hemicellulose, lignocelluloses, lignin, protein and fats. Enzymatic degradation proceeding as exothermal reaction retards the activity of earthworm beyond limit of their thermal tolerance. This may sweep of earthworm population from vermicompost thus causing reduction of fixed nitrogen and potassium level. It is therefore essential that use of specific inoculum for rapid degradation and higher nutritive values demand for control of liberated heat.[8]

RESULT

The results showed that soils amended with vermincompost had significantly ($P \leq 0.05$) greater soil bulk density in comparison to control plots. The increase of the rates of vermicompost reduced soil bulk density. Compost addition caused a significant increase of bulk density due to the more porosity added to the soil. The greater porosity in the soil treated with vermicompost was due to an increase in the amount of rounded prose.[9]

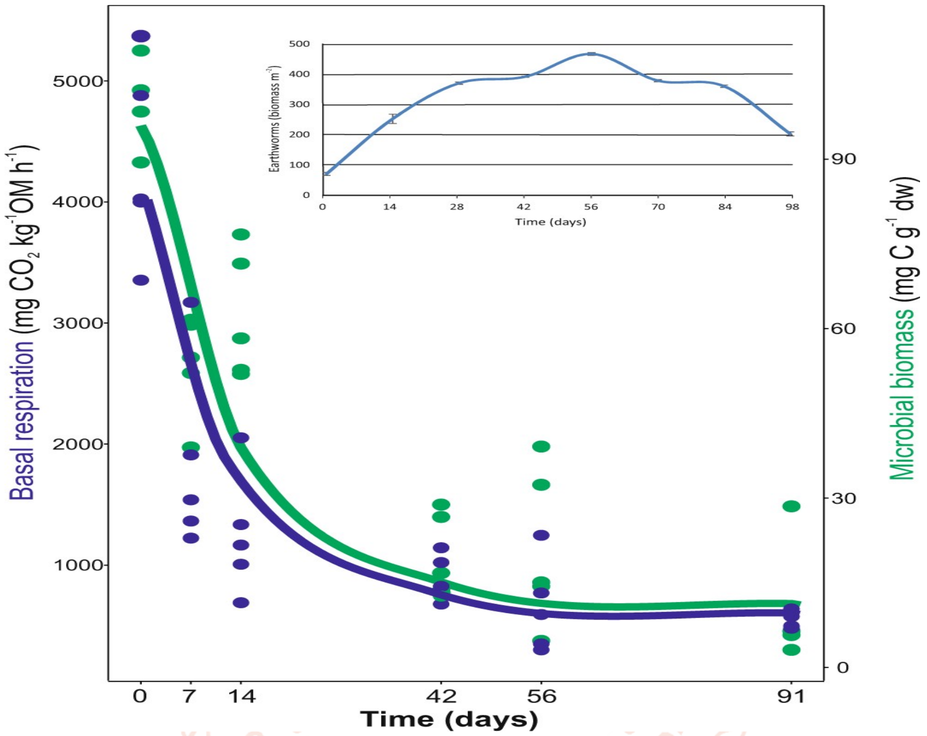


The beneficial impacts of vermicompost on soil:
1. Increase the 'Soil Organic Matter' (SOM), soil structure and prevent soil erosion.
2. Increase beneficial soil microbes, microbial activity and nutrients.
3. Improve cation exchange capacity.
4. Reduces bulk density of soil, prevents soil compaction and erosion.
5. Suppression of soil-born plant diseases. [10]
6. Increase water-holding capacity of soil.
7. Remove soil salinity and sodicity.
8. Maintain optimal pH value of soil.

Vermicompost is ideal organic manure for better growth and yield of many plants due to following reasons:
1. Vermicompost has higher nutritional value than traditional composts.
2. This is due to increased rate of mineralization and degree of humification by the action of earthworms. [11]
3. Vermicompost has high porosity, aeration, drainage, and water-holding capacity.
4. Presence of microbiota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth. Nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost.

5. Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present in vermicompost.
6. Production of cytokinins and auxins was found in organic wastes that were processed by earthworms.
7. Earthworms release certain metabolites, such as vitamin B, vitamin D and similar substances into the soil.
8. In addition to increased N availability, P, K, Ca and Mg availability in the casts are found.

Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B. The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases. Worms and vermicompost promoted excellent growth in the vegetable crop with more flowers and fruits development. [12]



Vermicompost can have dramatic effects upon the germination, growth, flowering, fruiting and yields of crops. Vermicompost stimulated growth of tomato transplants, with up to a 2.2-fold increase occurring in shoot biomass. Differences in growth were attributed mainly to differences in nutrient content of the potting mixtures, but some changes in physical and biological properties of the substrate could also be responsible. The perusal of the data revealed that "*Parthenium* Vermicompost" applied at 5 t/ha enhanced the growth of eggplants (*Solanum melongena*). Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant. [13] Organically grown fruits and vegetables especially on 'earthworms and vermicompost' have been found to be highly nutritious, rich in 'proteins, minerals and vitamins' and 'antioxidants' than their chemically grown counterparts and can be highly beneficial for human health. They have elevated antioxidants levels in about 85% of the cases studied. They have been found to be protective against several forms of 'cancers' and against 'cardiovascular diseases.[14]

Accordingly, vermicompost also protects plants against various pests and diseases either by suppressing or repelling them or by inducing biological resistance in plants. Vermicompost can have dramatic effects upon the germination, growth, flowering, fruiting and yields of crops.

CONCLUSION

The issue of organic waste generation is a constant nowadays; recycling and reduction are expensive physical and chemical processes, so the use of vermicomposting techniques reduces production costs and decontaminates the environment. Earthworms decompose organic matter and generate a product called vermicompost. Vermicompost is obtained from a wide variety of organic waste including residual sludge; when sewage sludge is managed with vermicomposting techniques, the resulting product supplies nutriments, more stable organic matter and works as a soil conditioner. The present bibliographic review underscores its importance via the use of diverse sorts of organic waste to reincorporate them into the environment. The parameters considered to produce vermicompost are: pH, temperature, moisture, total solid contents, nitrogen, carbon, C/N ratio and humic acids. [15] The importance of this text is to be found in the need to use vermicompost amendments from the use of sewage sludge to be transformed into fertilizer and be utilized in the growth of plants, thus turning it into an alternative in agricultural soils and a solution for its final end. Separately, earthworms take part as agents that bio-accumulate heavy metals and reduce the levels of toxicity in the environments; thereby these organisms, in addition to produce vermicompost, are considered an agent that bio-accumulates heavy metals from the environment.[16]

Vermiculture reduces the production costs of organic fertilizers and in the agricultural sector, requires experiences where new nonconventional sources of C and N are studied, such as SS, in which the biological, physical and chemical parts of the worm are known so that with the help from practitioners, can attack the problem from the productive and environmental viewpoint. Because of this, it is necessary to continue testing dosages and different mixtures, and apply them as an alternative in the short and middle terms in the agricultural and forest spheres.

The stabilization of SS (Sewage Sludge) via vermicomposting or composting generates a series of advantages which are:

- Measure and control pollutants ;
- Attenuate the content of metals available in the soil by means of the complexation of these on organic residues;
- Reduce the availability and adsorption of metal in plants
- Decrease the levels of pathogens in organic residues
- and, Facilitate enzymatic and microbial activities,
- make the nutriments for plants available [17]

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