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Bioremediation of temple waste (nirmalya) by vermicomposting in a metropolitan city like Mumbai

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Abstract

In India, million tons of temple waste (nirmalya) is produced every day. The waste collected from temple mainly consists of flowers, leaves, fruits, honey, coconuts, camphor, jaggery, milk etc. which is released in the water bodies or dumped at the available land spaces, thereby leading to severe environmental pollution and health hazards. Bioremediation of nirmalya can be carried out by vermicomposting. Vermicomposting is an eco-friendly process of efficiently converting organic waste into compost with the help of soil microorganism and earthworms. In our work Nirmalya was taken from a temple in South Mumbai, which was pre-composted at 30^{o}C and used as a substrate for vermicomposting by earthworm species *Eisenia foetida* for 90 days. The chemical analysis of the vermicompost showed its pH (7.2), the organic carbon content (8.57%), N (0.49%), total P (0.5%), K (0.16%), C: N ratio (17.489) and also contained sufficient concentration of microelements like zinc, manganese, iron and copper. The total bacterial count of vermiwash was found to be 3×10^{9} cfu/ml. The bacteria which were isolated from vermiwash showed various enzyme activities like protease, cellulase, phosphatase, amylase, gelatinase and lipase. The presence of nitrogen fixing bacteria like Azotobacter and Rhizobium from vermiwash was also demonstrated. The vermicompost obtained was checked for its effect on the growth of the test plants like *Tagetes erecta* and *Solanum melongena* using pot culture studies. One of the bacterial isolates was identified as *Bacillus amyloliquefaciens* HY10 by morphological, cultural, biochemical and 16s rRNA sequence analysis which showed protease (32.53units/ml) and lipase activity (3.177units/ml).

Keywords: Vermicompost; *Eisenia foetida;* Nirmalya*; Bacillus amyloliquefaciens*

Introduction

One of the major problems faced by metropolitan cities like Mumbai is garbage disposal. Mumbai city generates approximately six thousand tons of garbage daily. Out of which nirmalya constitutes of 15 tonnes. The nirmalya is been regularly disposed into the dumping grounds and water bodies causing land and water pollution. One of the methods for bioremediation is vermicomposting. Vermicomposting is a bioconversion, oxidation process of organic materials and involves a joint action of earthworms and microorganisms which is widely being used for solid waste management (Manyuchi and Phiri, 2013). In this process, earthworms feed on the organic materials and convert it to vermicompost and vermiwash. Vermicompost has sweet and earthy pleasant smell like the smell of first rain (Kadam, 2004). Earthworms play a vital role in converting the organic matter to a bio-fertilizer. The epigeic earthworm *Eisenia foetida* is the most suitable species for vermicomposting as they have small size, short life

cycle and high rate of reproduction as well as high conversion of organic waste into compost (Nath et al., 2009; Chauhan and Singh, 2012). At the age of 6 weeks earthworms start laying cocoons (eggs). The main part of the digestive system in is anterior intestine that secretes different proteolytic enzymes for digestion of organic food particles and posterior intestine that absorbs nutrients. The earthworms aids in compost formation by acting as a turners, mixers, pathogen controllers, accelerators and aerators. One of the unique features of vermicompost is that during the process of conversion of various organic wastes by earthworms, many of the nutrients are changed to their available forms in order to make them easily utilizable by plants. Vermicomposts have higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the wastes (Buchanan et al., 1988). Edwards (1988) reported that vermicompost could promote early and vigorous growth of seedlings. Vermicompost has found to effectively enhance the root formation, elongation of stem and production of biomass, vegetables, ornamental plants etc. (Grappelli et al., 1985; Kale and Bano, 1986; Kale et al., 1987; Kale, 1998; Bano et al., 1993; Atiyeh et al., 2001b).

In the present work nirmalya (temple waste) was used as a substrate for vermicomposting and chemical analysis of vermicompost was carried out. Effect of vermicompost on plant growth was studied. The vermiwash was used to show presence of different types of bacteria that produce various types of enzymes.

Materials and Methods

Collection of substrate

The nirmalya was collected from a temple in South Mumbai using clean and dry plastic bags.

Collection of earthworms

Earthworm species *Eisenia foetida* was purchased from local supplier Kalpataru, Mumbai.

Setting up of a composting kit

In our work galvanized steel wire mesh kit of dimensions 20”×48”×33” (l×b×h) with a lid was constructed (figure 1A). The kit had proper aeration of minimum 1 cubic feet in volume. Trays of proper dimensions were kept below the kit to collect the drained water from kit. A green shade net was used to prevent the escape of earthworms from the kit and to avoid predators from harming the earthworms. The shade net was stitched according to the size of the container (figure 1B).

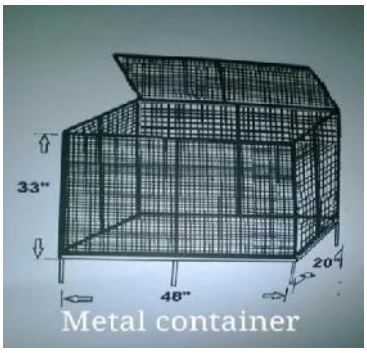

Figure 1A: Metal Container

Figure 1B: Metal Container set up

Preparation of composting bed

The first layer consisted of sugarcane bagasse and coconut flax about 2”- 3’’in height. The second layer was prepared by mixing fresh cowdung with water in 50:50 proportions (Gurav and Pathade, 2011) and was evenly spread on the basal layer. Thin slurry of garden soil was evenly spread on cowdung layer. Water was added to the kit to retain the moisture in the kit.

Addition of nirmalya

After collection of flower waste from temples non-biodegradable part was removed by hand sorting and the biodegradable waste i.e garlands and flowers were segregated and shredded into small pieces. The segregated floral waste was air dried by spreading over paper for 48 hours. Initially three kg of freshly collected and finely chopped and dried nirmalya pieces were added into the kit. This system was kept without disturbance for a week. This process is called as precomposting.

Addition of earthworms

In our work 500 grams of Epigeic species of earthworms *Eisenia foetida* were added to the kit. It is omnipresent with a world-wide distribution. It has good temperature tolerance and can live in organic wastes with different moisture contents. The pile containing nirmalya and earthworms was mixed at an interval of two days. Water was sprinkled on the top layer to ensure proper moisture. About one and a half kg of nirmalya was added thrice a week to the kit.

Following precautions were taken during vermicomposting

Vermicompost kit was protected from direct sunlight. The moisture level was maintained well in the kit for good compost formation. Pests were avoided which might harm the earthworms. The kit was well covered to avoid the earthworms from escaping the kit. Sufficient aeration was provided by proper stirring of the compost pile to get rid of foul odour. A proper shed was built around the kit so that rain water doesn't enter the kit.

Recovery of vermicompost

The processes of vermicomposting were carried out for a period of 90 days. The temperature of 30^0C and 80% moisture content were maintained by sprinkling adequate quantity of water at frequent intervals. Vermicompost was obtained after 90days of incubation. After preparation of vermicompost, water was not added for 5 days to make the compost easy for shifting. The compost was collected in a separate container so that the earthworms settled at the bottom were reused for next batch of vermicomposting. The vermicompost obtained was brownish-black colour having a pleasant earthy smell. The prepared vermicompost was packed in polythene bags and stored.

Extraction of vermiwash

During the process of vermicomposting, drained water was collected as vermiwash which was used for further screening. The vermiwash was collected in trays and transferred into sterile glass bottles and stored in refrigerator at 4^0C.

Chemical analysis of vermicompost

The vermicompost was tested for concentrations of Organic Carbon (Walkley and Black method), Nitrogen (Micro Kjeldahl), Phosphorus (Olsen method), Potassium (Flame photometry), Zinc, Copper, Iron and Manganese (Atomic Absorption Spectrophotometer [AAS]). This analysis was done at Viva centre for Advanced Research and Development, Virar (W), Mumbai

Study of microflora from vermiwash

This vermiwash was filtered using a muslin cloth to remove solid particles. The filtered vermiwash was then serially diluted with sterile phosphate buffered saline (pH7.2) and dilutions used for primary screening were 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6}. From each dilution 0.1 ml was surface spread on sterile media such as Nutrient agar (for total bacterial count), Congo Red Yeast Extract Mannitol Agar (for detection of Rhizobium) and Ashby's Mannitol agar (for detection of Azotobacter) and incubated at 30^0 C for 24hrs. All the media were prepared using Hi Media manual (1998). Colonies on Nutrient agar were counted and cfu/ml was calculated. Different colonies were then picked up and were screened for various enzyme activities using the media as given in the Table 1 (Hi Media manual, 1998).

Table 1: Qualitative detection of Enzymes

MEDIA	ENZYME ACTIVITY
Sterile Starch agar plate	Amylase
Sterile Smith and Goodner's Gelatin agar plate	Gelatinase
Sterile Pikovskaya's agar plate	Phosphatase
Sterile Gorodkowa'sTributyrin agar plate	Lipase
Sterile Milk agar plate	Caseinase
Sterile McBeth's cellulose agar plate	Cellulase

Identification of the isolate

Identification was carried out on the basis of morphological, cultural and biochemical properties using Bergey's Manual of Bacteriology 8th Edition (1974). Further confirmation of the strain was done by 16s rRNA sequencing analysis (Yaazh Xenomics, Mumbai).

Quantitative lipase assay

The colony obtained on Gorodkowa's tributyrin agar medium showing large zone of clearance was enriched in nutrient broth at 30^0C for 48 hours. Lipase activity was assayed by Para-nitro Phenyl Palmatate Assay which is further modified method of Winkler and Stuckmann (1979). The fermented broth was centrifuged at 10,000 rpm at 4^0C for 20 minutes (Joshi et al., 2006).The supernatant obtained was used as a crude enzyme for lipase assay (Qamsari et al., 2011). This crude enzyme (0.75 ml) was mixed with 0.5mM of 4-nitrophenyl palmitate substrate prepared in isopropyl alcohol and 1.95 ml of 50mM Phosphate Buffer (pH7.2) incubated at 30°C for 30 minutes. After incubation the reaction mixture was kept in ice bath for 5 minutes to stop the reaction and 150µl of Triton X-100 was added to the mixture. It was centrifuged at 10,000 rpm for 25 minutes and the absorbance of the supernatant was recorded spectrophotometrically at 420 nm. The reaction mixture containing heat-inactivated crude enzyme (100^0C for 10 min) instead of the active culture supernatant was used as a blank. The absorbance of the test supernatant against the blank was obtained and plotted on the standard graph of *p*-Nitrophenol (2-20µg/ml) to obtain the amount of substrate converted. One unit of lipase activity is the amount of lipase enzyme, which liberates 1 µmole of *p*-Nitrophenol from 4-Nitrophenylpalmitate as substrate per minute under standard assay conditions (Aruna and Khan, 2014).

Quantitative protease assay

The colony obtained on skimmed milk agar medium showing large zone of clearance was selected as protease producers. Protease assay was carried out by Folin Lowry method (Lowry et al., 1951). The colony obtained on skimmed milk agar plate was enriched in nutrient broth with 1% casein flask and incubated at 30^0C for 24 hours on a rotary shaker (1000rpm). The cells were then separated from broth by centrifugation at 5000rpm for 20 minutes. The supernatant obtained was considered as crude enzyme extract. Protease activity was measured using Caseinolytic assay with some modifications (Aruna et al., 2014). The enzyme extract (0.1ml) was reacted with 9ml of 1% casein prepared in phosphate buffer (pH-7) at 30^0C for 20 minutes. After which, 1.5ml of Trichloro acetic acid (5% w/v) was added to arrest the reaction. After 10 minutes the reaction mixture was centrifuged at 5000 rpm for 15 minutes. Absorbance of the supernatant was measured by modified Folin- Ciocalteau method (Lowry et al., 1951), against inactive enzyme. A standard graph of concentration of standard tyrosine (10-100µg/ml) against absorbance at 660nm was plotted.

1 unit of Enzyme activity (unit/ml) =

$$\frac{\text{amount of tyrosine produced (µM)}}{\text{Time of reaction (min)} \times \text{Volume of enzyme (ml)}}$$

Pot culture studies using Vermicompost obtained from nirmalya

Small plastic pots with 1000gms of soil for control and 200gms of vermicompost plus 800gms of soil for test were used for pot culture studies. The two different plants (*Tagetes erecta* and *Solanum melongena)* seeds were purchased from Ratanshi's Agro-Hortitech Store, Mumbai. Daily 30 ml of tap water was added in each pot. Growth parameters like number of leaves, plant height, width and length of plant leaves were measured in (cm) using scale and recorded after 40 days.

Table 2: Different plants used for pot culture studies

Sr no	Common name	Botanical name
1	Marigold	*Tagetes erecta*
2	Brinjal	*Solanum melongena*

Results and Discussion

Nirmalya was used as a substrate for vermicomposting (figure 2) using *Eisenia foetida* (Figure 3) as earthworm species. The temperature 30^0C and moisture content (80%) were maintained by sprinkling adequate quantity of water at frequent intervals. The process of vermicomposting was carried out for a period of 90 days. Vermicompost harvested after 90 days of incubation was granular, dark brown in colour as shown in figure 4. In the vermicomposting bed, the first layer consisting of coconut flax and sugarcane bagasse, which is rich in cellulose, serves as a base for moisture retention. The second layer consisting of cowdung slurry acts as an inoculant which influences and accelerate organic waste breakdown. Nirmalya which used as a substrate is a rich source of complex macromolecules which can be easily broken down by secretory enzymes of earthworms and contained most of the consitituents favourable for the growth. The precomposting being thermophilic in nature prior to vermicomposting helped in pathogen and mass reduction (Nair et al., 2006; Gurav and Pathade, 2011). In our work, the period of vermicomposting using nirmalya was found to be 90 days. However, Singh et al. (2013), Gurav and Pathade (2013), Kohli and Hussain (2016) and Tiwari and Juneja (2016) have reported vermicomposting period using flower waste as 120 days, 30 days, 45 days and 50 days respectively. Vermicomposting period may vary between 25 to 252 days depending upon type of substrate used (Lim et al., 2016).

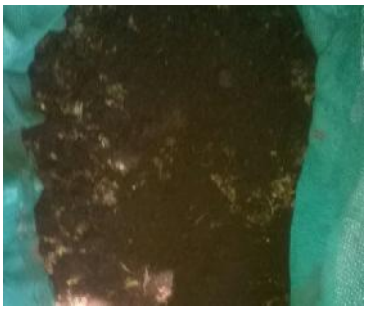

Fig 2: Fine pieces of Nirmlaya. Fig 3: Earthworms (*Eisenia foetida)* Fig 4: Vermicompost

The Chemical analysis of vermicompost was carried out. The analysis report of soil and vermicompost is given in Table 3.

Table 3: Chemical analysis of vermicompost obtained from nirmalya waste

PARAMETERS	SOIL VALUES	VERMICOMPOST VALUES
pH	6.82	7.2
Potassium (%)	0.12	0.16
Organic carbon (%)	1.4	8.57
Total phosphorous (%)	0.8	0.5
Zinc(ppm)	1.44	3.9881
Copper (ppm)	8.18	1.166
Manganese(ppm)	17.68	11.2
Iron(ppm)	21.96	691.9
Nitrogen (%)	0.03	0.49
C:N ratio	46.66	17.489
C:P ratio	1.75	17

In our work the pH value of vermicompost was found to be 7.2. These results are in agreement with the results of Kohli and Hussain (2016) and Jain (2016) who reported that pH of floral vermicompost was 7.53 and 7.2 respectively. Similar results were also obtained from vermicompost from Muncipal waste (Narkhede et al., 2011) and organic waste (Punde and Ganorkar, 2012; Chanda et al., 2011). Chakole and Jasutkar (2014), Singh et al. (2013), Gurav and Pathade (2011), Shouche et al. (2011) and Makhania and Upadhyay (2015) also reported that the pH of the vermicompost from nirmalaya or temple solid waste varies between 7.9 to 8.48 which is slightly higher than our studies. The lowering of pH in our studies might be due to the carbon dioxide and organic acids production by microbial activity during vermicomposting process (Haima and Hutha,1986).The pH range of vermicompost from 6 to 8.5 is best suited to ensure compatibility with the most plants (Hogg et al., 2002). The pH of Vermicompost is reported to be substrate dependent and earthworms maintain the pH of vermicompost in the neutral range (Chakole and Jasutkar, 2014).

Vermicomposts have higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous, soluble potassium, calcium and magnesium derived from the wastes (Buchanan et al., 1988).

The concentration of the total potassium (TK) greatly increased in the vermicompost as compared to soil in our studies. The TK content of the vermicompost in the present study was found to be 0.16% which is in accordance with the results of Kale et al. (1995) and Jaybhaye and Bhalerao (2015) who reported the TK level 0.15% and 0.16% respectively. However, TK was reported in vermicompost prepared from temple waste 0.28% (Gurav and Pathade, 2013), 0.5% (Singh et al., 2013) and 0.81% (Jain, 2016). There are also other reports of TK value 1.4% (Narkhede et al., 2011) and 3% (Ansari and Rajpersaud, 2012) of vermicompost obtained from municipal waste and cow dung waste respectively. A TK value of vermicompost varies from 0.15% to 0.73% (Kohli and Hussain, 2016). Vermicomposting has been established as an effective process for recovering higher K from organic waste (Manna et al., 1997; Suthar, 2007). The generation of acid during decomposition of organic matter by the microorganisms is the crucial process for solubilization of insoluble potassium (Adi and Noor, 2009). The change in the distribution of potassium between exchangeable and non exchangeable forms may lead to an increase in the potassium content in the vermicompost. The earthworm processed the waste material which contained high concentration of exchangeable potassium, due to enhanced microbial activity during the vermicomposting process and it consequently enhanced the rate of mineralization (Achsah and Prabhu, 2013).

The vermicompost had 8.57% of total organic carbon (TOC) as compared to 1.4% of organic carbon content of soil. Vermicompost TOC value varies from 9.8 to 13.4% (Kohli and Hussain, 2016; Ahirwar and Hussain, 2015). However, the level of total organic carbon content in the vermicompost obtained from temple wastes was found to be 18.9 % (Singh et al, 2013), 28% (Gurav and Pathade, 2013), 16.34% (Chakole and Jasutkar, 2014) and 20.76% (Jain, 2016). There are also other reports of TOC value 26.41% and 25.12% from vegetable and paper waste respectively (Kapoor et al., 2015).The incorporation of floral waste vermicompost has been shown to increase organic carbon content in the soil (Nelson and Sommers, 1982). Increase in the level of total organic carbon may be due to the addition of earthworm's cast, which is rich in carbon or due to the presence of high amount of organic matter in waste (Kaviraj and Sharma, 2003) and feeding action of earthworms and decomposition by microbes. The combined process brings about carbon loss from substrates in the form of carbon dioxide. The microbial respiration may lead to rapid carbon loss through CO_2 production and also, digestion of carbohydrates, lignin, cellulose and other polysaccharides from the substrates by inoculated earthworms may cause carbon reduction during the decomposition of organic waste (Kaushik and Garg, 2003;Suthar, 2007;Venkatesh and Eevera, 2008).

Soluble Phosphorus of vermicompost value varies from 0.9-1.02% (Kohli and Hussain, 2016; Chanda et al., 2011).The concentration of soluble phosphorous was found to be 0.5% in the vermicompost in the current study and 0.8% in the soil. These results are in accordance with the results reported by Gurav and Pathade (2011). Similar result was also reported from vermicompost obtained from grass waste where phosphorous level was 0.2-0.6% (Ansari and Rajpersaud, 2012; Jaybhaye and Bhalerao, 2015). However, other results reported the higher phosphorous level 1.3 % in the vermicompost produced from temple waste (Singh et al., 2013) and other organic wastes (Mistry et al., 2015). The conversion of unavailable forms of phosphorus to easily available forms for plants takes place during vermicomposting (Ghosh et al., 1999). The decrease of soluble reactive phosphorous (SRP) can be

explained by the precipitation of soluble phosphorous with other cations making the SRP less soluble (Kiefer, 2012) or because SRP is very easily taken up by the organisms present within the vermicompost (Holtan et al., 1988). The activity of phosphatase is responsible for solubilization of insoluble phosphate.

The micro-organisms in the vermiproducts play a significant role in altering the soil micronutrient content (Manyuchi et al., 2013). Zinc exists in the soil as Zn^{2+}. Zinc content of vermicompost value varies between 4.2 to 11ppm (Kohli and Hussain, 2016). In current studies the level of zinc in vermicompost was found to be 3.988ppm and 1.44ppm in the soil. However, zinc level 12.5ppm in the vermicompost obtained from nirmalya was reported by Gurav and Pathade (2011). The Zinc concentration in the vermicompost is corresponding to the results of Geiklooi and Shirmohammadi (2013). There is also report of 1.47ppm of Zinc in vermicompost obtained from kitchen waste and cow dung (Jaybhaye and Bhalerao, 2015). Their investigation reveals the effect of vermicompost on improving the zinc and iron deficiencies of soil. Zinc is a microelement involved in auxins, carbohydrate, phosphate, proteins, RNA metabolism and ribosome formation in plants. Zinc is also the essential regulatory cofactor of variety of enzymes and hence is required for many metabolic processes in plants (Mengel and Kirkby, 1982). Increasing the vermicompost quantity applied increased the soil zinc content to more than 1.6ppm (Manyuchi et al., 2013).

Copper content of vermicompost value varies between 2.6ppm and 4.8ppm (Kohli and Hussain, 2016). The vermicompost had 8.18ppm of copper content as compared to 1.16 ppm copper content of soil. However, higher level of copper 30ppm in the vermicompost produced from nirmalya was reported by Gurav and Pathade, (2011). Values of Copper content of vermicompost such as 0.54ppm (Jaybhaye and Bhalerao, 2015) and 5ppm (Kaur et al. 2015) are also reported. Copper (Cu) attributes to many physiological processes in plants such as photosynthesis, respiration, carbohydrate distribution, nitrogen metabolism, seed production and disease resistance (Kabata-Pendias and Pendias, 2001). However, high level of copper can be responsible for phytotoxicity and also leads to reduction in seed germination, plant growth and iron uptake (Paz-Ferreiro et al., 2014).

The vermicompost had iron content of 691 ppm as compared to the 21.96 ppm iron content of tested soil. Similar result having high levels of iron content 860ppm in the vermicompost obtained from nirmalya was reported by (Gurav and Pathade, 2011). Usually vermicompost has iron content which shows variation from 205ppm to 1133ppm (Kohli and Hussain, 2016; Jaybhaye and Bhalerao, 2015). In another study the iron level was reported as 175ppm and 146.5 of vermicompost and farmyard manure respectively (Kaur et al., 2015). The presence of enzymes and co-factors in the earthworm gut increase the iron content in the vermicompost. If high concentration of iron is present, Iron replaces Manganese (Mn) in organo-mineral complexes, and the released Mn is precipitated thus reducing the availability of Mn (Smith et al., 2001). The mineralization of partially digested worm fecal by fungi and bacteria and there action in the foregut resulted in high levels of trace elements like Zinc and Iron in vermicompost (Vasanthi et al., 2013).

Manganese content of vermicompost was 11.2ppm while soil showed 17.68ppm content. Similar results were obtained from vermicompost (Yadav, 2015; Jaybhaye and Bhalerao, 2015). However, Manganese content of vermicompost obtained from temple waste was 95ppm (Gurav and Pathade, 2011). Generally manganese content of vermicompost varies between 10.5ppm and 20.38ppm (Kohli and Hussain, 2016). Manganese exists in the soil as Mn^{2+}. Increase in the vermicompost quantity in the soil results in increased manganese content by more than 200ppm (Manyuchi et al., 2013).

The concentration of nitrogen in the vermicompost was found to be 0.49% and 0.03% of the soil. These results are in agreement with the results of Borah et al. (2007) who reported the nitrogen content as 0.38%. However, higher level of nitrogen was reported in vermicompost prepared from temple waste 0.91% by Chakole and Jasutkar (2014) and 1.58% by Gurav and Pathade (2011) while other organic wastes showed nitrogen content 1.32% (Punde and Ganorkar, 2012) and 0.805% (Jaybhaye and Bhalerao, 2015). Generally nitrogen content of vermicompost varies between 0.51% and 1.61% (Kohli and Hussain, 2016; Chanda et al., 2011). Increase in nitrogen content is due to the fact that earthworms enhanced the nitrogen cycle which attributed to the increased levels of nitrogen in vermicompost. The increased nitrogen content may be due to nitrogenous metabolic products of earthworms (Umamaheswari and Vijayalaksmi, 2003). Similar result was reported by Hand et al. (1988) who found that *Eisenia foetida* in cow slurry increased the nitrogen content of the substrate.

The increase in amounts of nitrogen and decrease in carbon content (reduced C: N ratio) is an indication of increased mineralization of the elements due to enhanced microbial and enzymatic activities in earthworm gut (Parthasarathi and Ranganathan, 2000).The C:N ratio of vermicompost in the current studies was found to be 17.489 as compared to 46.6 of soil. These results are in accordance with the results of Mistry et al. (2015). Similar results of C: N ratio 15.54 and 16.03 in the vermicompost obtained from vegetable wastes are present (Kapoor et al., 2015). Vermicompost obtained from flower waste has C: N ratio 12.3 (Kohli and Hussain, 2016) while temple waste vermicompost has C: N ratio 19.36 (Singh et al., 2013), 17.38 (Chakole and Jasutkar, 2014) and 21.55 (Jain, 2016). C: N ratio is one of the most widely used indicators of vermicompost maturation, which declines during the vermicomposting process (Kale, 1998; Gupta and Garg, 2008; Suther, 2008). Decrease in the C: N ratio in vermicompost to less than 20 indicates an advanced degree of organic matter stabilization and mineralization (Senesi, 1989).

The C: P ratio was found to be 17.5:1 in the vermicompost in our studies. C: P ratio obtained in our work is in accordance to the results of Singh et al, (2013) who reported the C: P ratio as 15:1 from temple waste. The ratio C: P of 15:1 in vermicompost indicates stabilization and maturity of organic wastes which is beneficial for better assimilation by plants (Edwards and Bohlen, 1996).

Six liters of vermiwash was collected from the kit after completion of vermicomposting process and it was found as dark brown in colour and odorless. The obtained vermiwash was analysed for beneficial microorganisms. The total bacterial count in the vermiwash was found to be 3×10^9 cells/ml. This result runs parallel to that of Giraddi (2007) who reported the total bacterial count in vermicompost as 1.13×10^8 cells /ml. Devi et al. (2009) also reported presence of bacteria, fungi and actinomycetes during vermicomposting with maximum number of 126×10^6, 28×10^4 and 93×10^5 CFU /g of sample respectively.

The microflora of vermiwash contained Azotobacter and Rhizobium which are nitrogen fixing bacteria. Rhizobia appeared as white coloured colonies on Congo Red Yeast Extract Mannitol agar (CRYEMA*)* plate as shown in figure 5A while Azotobacter has grown on Ashby's Mannitol agar plate (figure 5B). Zambare et al. (2008) reported that vermiwash contains nitrogen fixing bacteria like *Azotobacter* sp. and *Rhizobium sp.,* which make the inorganic nitrogen and amino acids available to plants. The availability of Nitrogen was also increased indicating vermicompost may attribute the significant increase in nitrogen of the soil by using floral vermicompost (Parmelle and Crossley, 1988; Tiwari et al., 1989; Scheu, 1993).

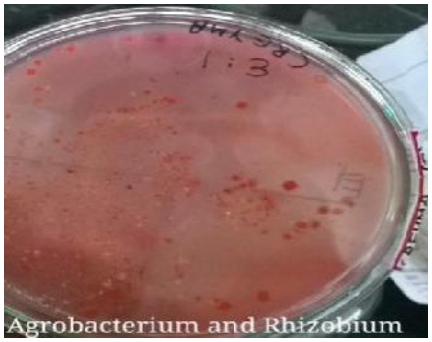

Figure 5A: CRYEMA plate showing growth of Rhizobium.

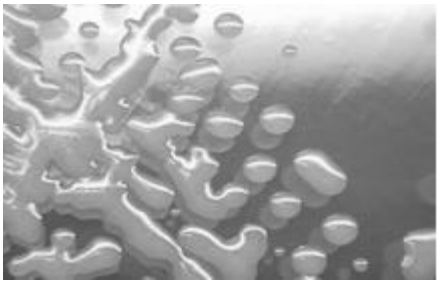

Figure 5B: Ashby's Mannitol agar plate showing growth of Azotobacter spp.

Qualitative detection of the following enzymes like lipase, gelatinase, amylase, cellulase and caseinase produced by different isolates from vermiwash was carried out as shown in figures 6, 7, 8, 9 and 10 respectively. Zambare et al. (2008) have reported that vermiwash contains various enzymes cocktail such as protease, amylase, urease, phosphatase, caseinase and gelatinase. In vermicompost, the maximum enzyme activities (cellulase, amylase, invertase, protease and urease) were observed by Devi et al. (2009). Presence of proteases in soil helps in seed germination while amylases help for availability of simple carbon source for enhancement of plant growth and productivity. Cellulases play an important role in global recycling of the most abundant polymer (cellulose) in nature. Amylases and cellulases are responsible for rate of decomposition process in soil. Hydrolytic enzymes such as cellulase, lipase and proteases are responsible for complete decomposition and humus formation from organic matter (Kiss, et al., 2000, Marialigeti, 1979). Lipases are probably rate controlling during germination and lipase activity is high during seed germination (Brockerhoff and Jensen, 1974).Soil borne microflora is essential for the growth of plants because organic nitrogenous compounds are decomposed and mineralized by different enzymes produced by nitrogen fixing and phosphate solubilizing bacteria (Chaudhary, 2005).

Figure 6: Gorodkowa'sTributyrin agar plate showing Lipase activity

Figure 7: Smith and Goodner's Gelatin agar plate showing Gelatinase activity.

Figure 8: Starch agar plate showing Amylase activity.

Figure 9: Mc Beth agar plate showing Cellulase activity

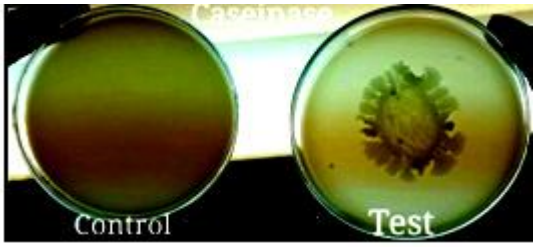

Figure 10: Milk agar plate showing Caseinase activity.

One of the isolates was characterized as aerobic, gram positive and rod shaped bacteria. From the biochemical tests, it was concluded that the isolate belongs to the family of *Bacillus* (Bergey's Manual of Bacteriology 8th edition, 1974). It was identified as *Bacillus amyloliquefaciens* HY10 by carrying out 16s rRNA gene sequence analysis. Quantitative estimations of the protease and lipase enzymes produced by *Bacillus amyloliquefaciens* HY10 were carried out as shown in Table 4. *Bacillus amyloliquefaciens* HY10 considered as growth-promoting rhizobacteria and has the ability to quickly colonize roots. It is also used to fight some plant root pathogens in agriculture, aquaculture and hydroponics (George et al., 1995; Saengsanga et al., 2016). There are several studies which indicate presence of different types of microorganisms including Bacillus species in the vermicompost (Vivas et al., 2009; Vaz-Moreira et al., 2008; Pathma and Sakthivel, 2012)

Table 4: Quantitative estimation of enzymes produces by *Bacillus amyloliquefaciens* HY10

ENZYMES	ENZYME ACTIVITY (Units/ml)	SPECIFIC ACTIVITY (U mg^{-1} Protein)
Protease	32.53	367.98
Lipase	3.177	47.91

Vermicompost and vermiwash used as organic manure has a property of binding with minerals in the form of humus colloids and clay, promoting stable soil aggregates resulting in better aeration and desired porosity to sustain plant vigour (Haynes, 1986). The vermicompost obtained was tested for its effectiveness by monitoring different plant factors such as number of leaves, leaf length, leaf width and plant height for Brinjal plant after an interval of 40 days (*Solanum melongena*) as shown in table 5 and figure 11. The similar growth pattern was also observed for the Marigold Plant (*Tagetes erecta*), as shown in Table 6 and figure 12 where plant of the test as compared to the control used in the studies showed good enhancement of growth. The test was supplemented with vermicompost while control was without supplementation. Similar experimental studies were carried out on brinjal plants by many scientists (Lalitha et al., 2000; Raviv et al., 1998; Singh et al., 1998; Shivsubramanian and Ganeshkumar, 2004; Sailaja et al., 2013; Kashem et al., 2015; Jaybhaye and Bhalerao, 2015) who reported the better growth of plants and higher yield by the application of vermicompost. Vermicompost also has a significant

positive influence on seed germination and seedling vigor (Atiyeh et al., 2001a, 2002; Suthar *et al*. 2005; Arguello et al., 2006; Alam et al., 2007; Ansari, 2008; Gupta et al., 2008; Peyvast et al., 2008; Premsekhar and Rajashree, 2009; Suthar, 2009; Chanda et al., 2011). Flowering capacity, height of plant, breadth and length of leaves are found more in vermicompost supplemented tests as compared to controls (Yadav et al., 2015). Earthworms stimulate microbial activities and metabolism and also influence microbial populations. As a consequence more available nutrients and microbial metabolites are released into the soil (Tomati et al., 1988). Use of vermicompost is effective for improving soil fertility and it contains most of the nutrients in plant available form such as nitrates, phosphates, exchangeable calcium and soluble potassium (Aggelides and Londra, 1999; Mascolo et al., 1999; Albiach et al., 2000; Marinari et al., 2000; Sailajakumari and Ushakumari, 2002; Arancon et al., 2006; Prabha et al., 2007; Azarmi et al., 2008). Vermicomposting contains plant hormones like Auxin and gibberellins and enzymes which believed to stimulate plant growth and discourage plant pathogens (Businelli et al., 1984; Tomati et al., 1988).

Table 5: Pot culture studies for Brinjal 9 (*Solanum melongena)* plant after 40 days.

PARAMETERS	SOIL(control)	SOIL +VERMICOMPOST(test)
Number of leaves	23	35
Leaf length	6cm	12cm
Leaf width	4cm	7.5cm
Plant height	22cm	35cm

Figure 11: Effect of vermicompost on Growth of Brinjal (*Solanum melongena) plant* a- Control (Only soil); b- Test (soil + vermicompost)

Table 5: Pot culture studies for Marigold plant (*Tagetes erecta)* after 40 days.

PARAMETERS	SOIL(control)	SOIL+ VERMICOMPOST(test)
Number of leaves	33	76
Leaf length	1.5cm	5cm
Leaf width	1cm	2cm
Plant height	10cm	24cm

Figure 12: Effect of vermicompost on Marigold Plant (*Tagetes erecta)* a- Control (Only soil); b- Test (soil + vermicompost)

Conclusion

Vermicomposting is a natural process which not only gives a solution for waste management but also provides with nutrient rich compost which can be used for any kind of plantation. Vermicompost increases soil fertility as it consists of nutrients like phosphorus, nitrogen, carbon, zinc, copper, manganese, iron, etc. various enzymes and plant growth hormones like giberellins, auxins and cytokinins and it also decreases the levels of organic carbon, C/N ratio and pH through vermic-activity in the soil. The nutrient content of vermicompost revealed that Nirmalya is a suitable substrate for vermicomposting. Hence, this eco-friendly method can be extended for all temple and alike organic wastes for analyzing the effectiveness of vermicompost. It helped to reduce volume of temple flower waste, but also generate additional revenue. Thus vermicompost technology can be successfully applied in temples as a solid waste management strategy with flowers as the major organic waste.

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References

Achsah, R.S. and M.Lakshmi Prabha 2013. Potential Of Vermicompost Produced From Banana Waste (*Musa paradisiaca*) On The Growth Parameters Of Solanum lycopersicum. International Journal of ChemTech Research. 5(5): 2141-2153

Adi, A., Noor, Z. 2009. Waste recycling: utilization of coffee grounds and kitchen waste in vermicomposting. Bioresource Technology. 100(2): 1027–1030.

Aggelides, S.M., Londra P.A. 1999. Effect of compost produced from town waste and sewage sludge on the physical properties of a loamy and a clay soil. Bioresource Technology. 71: 253-259

Ahirwar Chandan Singh and Hussain Azad. 2015. Effect of Vermicompost on Growth, Yield and Quality of Vegetable Crops. International Journal of Applied and Pure Science and Agriculture. 1(8):49-56

Alam M.N., Jahan M.S., Ali M.K., Islam M.S., Khandaker S.M.A.T. 2007. Effect of vermicompost and NPKS fertilizers on growth, yield and yield components of red amaranth. Australian Journal of Basic and Applied Science. 1 (4): 706-716.

Albiach, R., Canet R., Pomares F., Ingelmo F. 2000. Microbial biomass content and enzymatic activities after application of organic amendments to a horticultural soil. Bioresource Technology. 75: 43-48.

Ansari, A, A. and Rajpersaud, J, 2012. Physicochemical changes during vermicomposting of water hyacinth (*Eichhornia crassipes*) and grass clippings. International Scholarly Research Network, Soil Science, Article ID 984783

Ansari, A.A. 2008. Effect of vermicom-post and vermiwash on the productivity of spinach *Spinacia oleracea*), onion (*Allium cepa*) and potato (*Solanum tuberosum*). World Journal of Agricultural Sciences. 4 (5): 554-557.

Arancon, N.Q, Edwards C.A., Bierman P. 2006. Influences of vermicomposts on field strawberries: Part 2. Effects on soil microbial and chemical properties. Bioresource Technology. 97: 831-840

Arguello, J.A., Ledesma A., Nunez S.B., Rodriguez C.H., Goldfarb M.D.C.D. 2006. Vermicompost effects on bulbing dynamics, non-structural carbohydrate content, yield and quality of 'Rosado Paraguayo' garlic bulb. Hort Science. 41 (3): 589-592.

Aruna, K and Karim Khan 2014. Optimization studies on production and activity of lipase obtained from *Staphylococcus pasteuri* SNA59 isolated from spoilt skin lotion. International Journal of Current Microbiology and Applied Sciences. 3 (5): 326-347.

Aruna, K, Jill Shah and Radhika Birmole, 2014. Production And Partial Characterization Of Alkaline Protease from *Bacillus tequilensis* Strains Csgab0139 Isolated From Spoilt Cottage Cheese. International Journal of Applied Biology and Pharmaceutical Technology. 5(3) 201-221.

Atiyeh, R. M, Arancon, N. Q., Edwards, C.A. , Metzger, J. D. 2001a. The influence of earthworm-processed pig manure on the growth and productivity of marigolds. Bioresour Technol. 81:103–108

Atiyeh, R. M., Arancon, N.Q., Edwards, C.A., Metzger, J.D. 2002. The influence of humic acid derived from earthworms processed organic wastes on the plant growth. Biores Technol. 84: 7-14.

Atiyeh, R.M., Edwards C.A., Sulber S., Metzger J.D. 2001b. Pig manure's vermicompost as a component of a horticultural bedding plant medium: Effects on physiochemical properties and plant growth. Bioresource Technology. 78: 11-20

Azarmi, R., Giglou M.T. Taleshmikail R.D. 2008. Influence of vermicompost on soil chemical and physical properties in tomato field. African Journal of Biotechnology. 7 (14): 2397-2401.

Bano, K., Kale, R. D, Satyavathi GP. 1993. Vermicompost as fertilizer for ornamental plants. In: Rajagopal, D., Kale, R. D. and Bano, K. (Ed.) Proc. IV National Symposium Soil, Biology. Ecology. ISSBE. UAS,Bangalore. pp165-168.

Bergey's Manual of Determinative Bacteriology: 8th edition, 1974. edited by R. E. Buchanan and N. E. Gibbons. xxvii + 1,246 pages, illustrated. The Williams and Wilkins Company, Baltimore, Maryland.

Borah, M. C., Mahanta, P., Kakoty, S. K., Saha, U. K. and Sahasrabudhe, A. D, 2007. "Study of quality parameters in vermicomposting". Indian Journal of Biotechnology. 6:410-413

Brockerhoff, H., R.G.Jensen. 1974. Lipolytic enzymes. Academic Press, Inc. London. 1:1-100.

Buchanan, M A, Russelli E, Block SD. 1988. Chemical characterization and nitrogen mineralization potentials of vermicomposts derived from differing oraganic wastes, in Earthworms in Environmental and waste Management, (eds C. A. Edwards and E. F. Neuhauser), SPB Acad, Publ., The Netherlands, pp. 231-9.

Businelli, M., Perucci, P., Patumi, M., and Giusquiani, P. L. 1984. Chemical composition and enzymatic activity of some worm casts. Plant Soil. 80: 417-422.

Chakole, S. Pallavi and Jasutkar, D.B. 2014. Comparative study of nirmalya solid waste treatment by vermicomposting and artificial aeration composting. Current World Environment. 9(2):412-420

Chanda, G.C., Bhunia G., Chakraborty S.K. 2011. The effect of vermicompost and other fertilizers on cultivation of tomato plants. Journal of Horticulture and Forestry. 3 (2): 42-45.

Chaudhary, P.S. 2005. Vermiculture and Vermicomposting as biotechnology for conservation of organic waste into animal proteins and organic fertilizer. Asian Journal of Microbiology, Biotechnology and Environ Smental Science. 7: 359-370.

Chauhan, H. K., Singh, K. 2012. Effect of binary combinations of buffalo, cow and goat dung with different agro wastes on reproduction and development of earthworm *Eisenia fetida* (Haplotoxida: Lumbricidae). World J Zool. 7:23-29.

Devi S.H., Vijayalakshmi, K., Jyotsna, K.P., Shaheen, S.K., Jyoti, K., Rani, M.S. 2009. Comparitive assessment in enzyme activities and microbial population during normal and vermicomposting. J Environ Biol. 30(6):1013-7.

Edwards, C. A. 1988. Breakdown of animal, vegetable and industrial organic wastes by earthworms. In: Edwards CA, Neuhauser EF (eds) Earthworms in Waste and Environmental Management SPB. The Hague, Netherlands, pp 21–31

Edwards, C.A. and Boglen. 1996. P.J. Biology and Ecology of Earthworms, third ed. Chapman and Hall, London, England.pp426

Geiklooi, Abolfazl, Ebrahim Shirmohammadi, 2013. Effect of enriched vermicompost manure in improve of iron and zinc deficiencies and quality characteristics of peach trees. International Journal of Farming and Allied Sciences. Intl J Farm & Alli Sci. 2 (21): 930-934

George, S, Raju V, Krishnan, MRV, Subramanian, TV. 1995. Production of proteases by *Bacillus amyloliquefaciens* in solid state fermentation. And its application in unhairing of hides and skin process. Biochem. (Oxford). 30(5):457-62.

Ghosh, M., Chattopadhyay, G. N., Baral, K. 1999. Transformation of phosphorus during vermicomposting. Bioresour Technol. 69:149–154

Giraddi, R. S. Radha D. Kale, And D. P. Biradar 2014. Earthworms and organic matter recycling-an overview from Indian perspective. Karnataka J. Agric. Sci. 27 (3): 273-284

Giraddi, R. S., 2007. Vermitechnologies (in Kannada), Univ. Agric. Sci., Dharwad, India, p. 62.

Grappelli, A, Tomati U, Galli E, 1985. Earthworm casting in plant propagation. Hortic. Sci. 20(5): 874-876.

Gupta, A.K., Pankaj P.K., Upadhyaya V. 2008. Effect of vermicompost, farm yard manure, biofertilizer and chem-ical fertilizers (NPK) on growth, yield and quality of *Abelmoschus esculentus*. Pollution Research. 27 (1): 65-68.

Gupta, R. and V.K. Garg. 2008. Stabilization of primary sludge during vermicomposting. J. Hazard Mater.153:1023-1030

Gupta, R., Garg, V. K. 2008. Stabilization of primary sewage sludge during vermicomposting. J Hazard Mater. 162:430–439

Gurav, M. V. and Pathade G. R. 2011. Production of Vermicompost from Temple Waste (Nirmalya): A Case Study. Universal Journal of Environmental Research and Technology. 1(2): 182-192.

Haimi, J., Hutha, V. 1986. Capacity of various organic residues to support adequate earthworm biomass in vermicomposting. Biol. Fert. Soils. 2: 23–27.

Hand, P., Hayes, W.A., Frankland, J.C., Satchell, J.E., 1988. The vermicomposting of cow slurry. Pedobiologia. 31:199-209.

Hogg, D., Eaviono E., Caimi. V., Amlinger F., Devliegher W., Brinton and W., Antler S 2002. Comparison of composts standards within the programme (WARP), Oxon.

Holtan, H., Kamp-Nielsen, L., and O. Stuances, A. 1988. Phosphorus in soil, water, and sediment: and overview. Hydrobiologia. 170(1):19-34.

Jain, Nisha. 2016. Waste management of temple floral offerings by vermicomposting and its effect on soil and plant growth. International Journal of Environmental & Agriculture Research. 2(7): 89-94

Jaybhaye, M. Maya and Satish A. Bhalerao. 2015. Effect of Vermiwash on the Growth Parameters of *Solanum melongena* L. (Brinjal Plant). Int. J. Curr. Res. Biosci. Plant Biol. 2(9): 24-29

Joshi, G. K.,Kumar, S., Tripathi, B.N.,Sharma,V.2006. Production of Alkaline Lipase by *Corynebacterium paurometabolum*, MTCC 6841 Isolated from Lake Naukuchiatal, Uttaranchal State, India. Current Microbiology.52:354 358

Kabata-Pendias, A, Pendias, H. 2001. Trace elements in Soils and Plants, CRC Press,Boca Raton, FL,pp 143-144

Kadam, D.G. 2004. Studies on Vermicomposting of Tendu Leaf (*Diospyros melanoxylon* Roxb.) Refuse With Emphasis on Microbiological and Biochemical Aspects, Ph. D. Thesis, Shivaji University, Kolhapur

Kale, R D, Bano, K, Sreenivasa, M N, Bagyaraj, DJ. 1987. Influence of worm cast (vee comp. E.83 UAS) on the growth and mycorrhizal colonization of two ornamental plants. South Indian Hortic. 35: 433- 437.

Kale, R. D, Bano, K. 1986. Field trials with vermicompost (vee comp. E.83 UAS) an organic fertilizer. In Dash, M. C., Senapati, B. K. and Mishra, P. C. (Ed.) Proceeding National Seminer Org. Waste Utiliz Vermicomp Part B: verms and vermicomposting. Five Star Printing Press. Burla, Orissa. pp. 151-156.

Kale, R.D. 1998. Earthworms: Nature's Gift for Utilization of Organic Wastes; In C.A. Edward (Ed.).'Earthworm Ecology'; St. Lucie Press, NY, ISBN 1-884015-74-376.

Kale, R.D. B.C., Mallesh, K Bano, And D.J. Bhagyaraj. 1992. Influence of Vermicompost Application on Available Macronutrients and Selected Microbial Population In A Paddy Field. Soil Biol. Biochem. 24: 1317 - 1320.

Kapoor, J., Sharma, S., and Rana, N. K. 2015. Vermicomposting for organic waste management. International journal of recent scientific research. 6(1):7956-7960

Kashem, Md. Abul, Ashoka. Sarker, Imam, Hossain, Md. Shoffikul, Islam. 2015. Comparison of the Effect of Vermicompost and Inorganic Fertilizers on Vegetative Growth and Fruit Production of Tomato (*Solanum lycopersicum* L.). Open Journal of Soil Science. 5: 53-58

Kaur, P., Bhardwaj M. and Babbar, I. 2015. Effect of Vermicompost and Vermiwash on Growth of Vegetables. Research Journal of Animal, Veterinary and Fishery Sciences. 3(4): 2320 - 6535

Kaushik, P, Garg VK. 2003. Vermicomposting of mixed solid textile mill sludge and cow dung with the epigeic earthworm *Eisenia foetida.* Biores Technol. 90:311-316

Kaviraj, and S. Sharma. 2003. Municipal solid wastes management through vermicomposting employing exotic and local species of earthworm. Biores. Technol. 90: 169-173.

Kiefer, A. 2012. The Effects of Storage on the Quality of Vermicompost University of wisconsin system solid waste research program.

Kiss, S., Dragan -Bularda, M. and Radulescu, D. 1978. Soil polysaccharides: activity and agricultural importance. In: Burns RG (Ed) Soil enzymes. Academic Press, London, pp 117–147.

Kohli, Ravinder and Hussain, M. 2016.Management of Flower Waste by Vermicomposting International Conference on Global Trends in Engineering, Technology and Management (ICGTETM-) INK. 34-38

Lalitha, R., K. Fathima, and S.A. Ismail, 2000. Impact of biopesticides and microbial fertilizers on productivity and growth of Abelmoschus esculentus. Vasundhara the Earth. 1 and 2: 4-9.

Lee, J.J., Park, R.D. and Kim, Y.W. 2004. Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. Bioresource Technology. 93:21-28.

Lim Su Lin, Leong Hwee Lee, Ta Yeong Wu. 2016. Sustainability of using composting and vermicomposting technologies for organic solid waste biotransformation: recent overview, greenhouse gases emissions and economic analysis. Journal of Cleaner Production. 111:262-278

Lowry, O. H., Rosebrough, N.J., Farr, A.L., Randall, R. L. 1951. Protein measurement with the folin phenol reagent. J.Bio. Chem. 193: 265-273

Makhania, Mitali and Amita upadhyaya, 2015. Study of Flower Waste Composting to Generate Organic Nutrients International Journal of Innovative and Emerging Research in Engineering. 2 (2):145-149

Manna, M. C., Singh, M., Kundu, S., Tripathi, A.K. and Takkar, P.N. 1997. Growth and reproduction of the vermicomposting earthworm *Perionyx excavatus* as influenced by food materials. Biology and Fertility of Soils. 24(1):129-132.

Manyuchi, M. M. Phiri, A., Muredzi, P. 2013. Effect of Vermicompost, Vermiwash and Application Time on Soil Micronutrients Composition. International Journal of Engineering and Advanced Technology. 2(5):215-218

Manyuchi, M. M. and Phiri, A. 2013. Vemicomposting in solid waste management. International Journal of Scientific Engineering and Technology. 2(12):1234– 1242.

Marialigeti, K. 1979. On the community- structure of the gut microbiota of *Eisenia lucens* (Annelida, Oligochaeta). Pedobiologia. 19: 213-220

Marinari, S., Masciandaro G., Ceccanti B., Grero S. 2000. Influence of organic and mineral fertilizers on soil bio-logical and physical properties. Bioresource Technology. 72:9-17.

Mascolo, A., Bovalo, F., Gionfriddo, F., Nardi, S. 1999. Earthworm humic matter produces auxin like effects on *Daucus carota* cell growth and nitrogen metabolism. Soil Biology and Biochemistry. 31: 1303-1313.

Mengel, K. Kirkby, E.A. 1982. Principles of plant nutrition, International Potash Institute, Bern, Switzerland.

Mistry, J., Mukhopadhyay, A.P. and Baur, G.N. 2015. Status of N P K in vermicompost prepared by two common weed and two medicinal plants. Journal of Advanced Studies in Agricultural, Biological and Environmental Sciences. 2(1), 25-38.

Nair, J., V. Sekiozoic and M. Anda. 2006. Effect of precomposting on vermicomposting of Kitchen waste. Biosource Technology. 97: 2091-2095.

Narkhede, S. D., Attarde, S. B. and Ingle, S. T. 2011. Study on Effect of Chemical Fertilizer and Vermicompost on Growth of Chilli Pepper Plant Capsium. Annum Journal of Applied Sciences in Environmental Sanitation. 6 (3): 327-332.

Nath, G, Singh, K., Singh, DK. (2009) Chemical analysis of Vermicomposts/Vermiwash of different combinations of animal, agro and kitchen wastes. Australian J Basic Applied Sci. 3(4): 3672-3676.

Nelson, D.W., Sommers, L.E.,1982. Total carbon and organic carbon and organic matter. In: Page, AL, Miller RH, Keeney DR (eds). Method of Soil Analysis. Am. Soc. Agron. Madison. 539-579.

Parmelle, R.W., Crossley, D.A. Jr. 1988. Earthworm Production and Role in the Nitrogen Cycle of a No-Tillage Agro-Ecosystem on the Georgia Piedmont. Pedobiologia. 32: 353-361.

Parthasarathi, K. and Ranganathan, L.S. 2000. Chemical characteristics of mono and polycultured soil worms casts by tropical earthworms. Environ. Ecol. 18: 742-746

Pathma, Jayakumar and Natarajan Sakthivel. 2012. Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential. Springer Plus. 1:26:1-19

Paz-Ferreiro J., H. Lu1,, S. Fu1, A. Méndez, and G. Gascó. 2014. Use of phytoremediation and biochar to remediate heavy metal polluted soils. Solid Earth. 5:65–75.

Peyvast, G., Olfati, J.A., Madeni, S., For-ghani A. 2008. Effect of vermicom-post on the growth and yield of spinach (*Spinacia oleracea* L.). Journal of Food Agriculture and Environment. 6 (1): 110-113.

Prabha, K.P, Loretta, Y.L., Usha, R.K. 2007. An experimental study of vermin-biowaste composting for agricultural soil improvement. Bioresource Technology. 99:1672-1681.

Premsekhar, M., Rajashree V. 2009. Influ-ence of organic manures on growth, yield and quality of okra. American Eurasian Journal of Sustainable Agriculture. 3 (1): 6-8.

Punde, B. D. and Ganoker, R. A. 2012. Vermicomposting-Recycling Waste into Valuable Organic Fertilizer. International Journal of Engineering Research and Application. 2 (3): 2342-2347.

Qamsari Mobarak E,Kasra-Kermanshahi R. ,Moonasavi-nejad Z. 2011. Isolation and identification of a novel lipase producing bacterium, *Pseudomonas aeruginosa* KM10. Irani Journal. 3(2):92-98

Raviv, M., B.Z. Zaidman and Kapulnik, Y. 1998. The use of compost as a peat substitute for organic vegetable transplants production. Compost Science and Utilization. 6: 46-52.

Rogayan, Tomboc, Paje, Lim, Ararro, Ocampo, Ballon, Ico, Corpus, Gergorio. 2010. Vermiculture and Vermicomposting. San Marcelino, Zambles.

Saengsanga, T. 2016. Molecular and enzymatic characterization of alkaline lipase from *Bacillus amyloliquefaciens* E1PA isolated from lipid-rich food waste. Enzyme Microb Technol. 82:23-33.

Sailaja, D, P. Srilakshmi, Shehanaaz, H. Priyanka, D. Lavanya Bharathi, Ayesha Begum 2013. Preparation of vermicompost from temple waste flower. International Journal of Science Innovations and Discoveries. 3(3), 367-375

Sailajakumari, M.S., Ushakumari, K. 2002. Effect of vermicompost enriched with rock phosphate on the yield and uptake of nutrients in cowpea *(Vigna unguiculata* L. Walp.). Journal of Tropical Agriculture. 40: 27-30.

Scheu, S. 1993. There is an Earthworm Mobilizable Nitrogen Pool in Soil. Pedobiologia. 37: 243-249.

Senesi, N. 1989. Composted Materials as Organic Fertilizers, The Sci. Total Environ. 81/82: 521-524.

Shivsubramanian, K. and Ganeshkumar, M. 2004. Influence of vermiwash on biological productivity of Marigold. Madras Agricultural Journal. 91: 221-225.

Shouche, Shobha, Anil Pandey and Praveesh Bhati. 2011. Study about the changes in physical Parameters during vermicomposting Of floral wastes. Journal of Environmental Research And Development. 6(1): 63-68

Singh, A.K., A.K. Sharma and R. Gouraha. 1998. Environ. Ecology. 16: 669-75.

Singh, Akanksha, Akansha Jain , Birinchi K. Sarma , P.C. Abhilash , Harikesh B Singh, 2013. Solid waste management of temple floral offerings by vermicomposting using Eisenia fetida .Elsevier Journal. 33 : 1113–1118.

Smith, M. W; Cheary, B. S. and Landgra F, B. S. 2001. Manganese deficiency in pecan. Hort. Sci. 36 (6): 1057 -1076.

Suthar, S., Choyal R., Singh S., Sudesh. 2005. Stimulatory effect of earth-worm body fluid (vermiwash) on seed germination and seedling growth of two legumes. Journal of Phytological Research. 18 (2): 219-222.

Suthar, S. 2007. "Nutrients changes and biodynamic of epigeic earthworm Perionyx excavates during recycling of some agricultural waste". Biores.Technology. 1(4):315-320.

Suthar, S. 2008. Bioconversion of post harvest crop residues and cattle shed manure into value added products using earthworm *Eudrilus eugeniae* (King berg). Ecological Engineering. 32: 206-214.

Suthar, S. 2009. Impact of vermicompost and composted farm yard manure on growth and yield of garlic (*Allium stivum* L.) field crop. International Journal of Plant Production. 3 (1): 27-38.

The HiMedia Manual For Microbiology Labortory Practice 1998. HiMedia Laboratories Pvt Limited.

Tiwari, Priyanka, Shelja K Juneja. 2016. Management of floral waste generated from temples of jaipur city through vermicomposting. International journal of environment. 5(1): 1-13

Tiwari, P. 2014. Utilization and Management of Floral Waste Generated in Popular Temples of Jaipur City: The IIS University, Jaipur

Tiwari, S.C., Tiwari, B.K., Mishra, R.R. 1989. Microbial Populations, Enzyme Activities and Nitrogen–Phosphorous–Potassium Enrichment in Earthworm Casts and in the Surrounding Soil of a Pineapple Plantation. Biol. Fert. Soils. 8:178–182

Tomati, U., Grapppelli, A., Galli, E. 1988. The hormone like effect of earthworm casts on plant growth. Biol. Fertil. Soils. 5: 288-294.

Umamaheswari, S. and G.S.Vijayalakshmi. 2003. Vermicomposting of paper mill sludge using an African earthworm species *Eudrilus eugeniae* Kinberg with a note on its physicochemical features. Poll. Res. 22: 339–341

Vasanthi, K; Chairman, K; Ranjit Singh, A. J. A. 2013. Vermicomposting of leaf litter ensuing from the trees of Mango (*Mangifera indica*) and Guava (*Psidium guujuva*) leaves. Int. Adv, Res. 1(3): 33- 38

Vaz-Moreira I, Maria E, Silva CM, Manaia Olga C, Nunes. 2008. Diversity of Bacterial Isolates from Commercial and Homemade Composts. Microbial Ecol. 55:714–722

Venkatesh, RM, Eevera, T. 2008. Mass reduction and recovery of nutrients through vemricomposting of fly ash. App Eco Environ Res. 6(1): 77-84

Vivas, A., Moreno, B., Garcia-Rodriguez, S., Benitez, E. 2009. Assessing the impact of composting and vermicomposting on bacterial community size and structure, and functional diversity of an olive-mill waste. Bioresour Technol. 100:1319-1326

Winkler, U.K., Stuckman,M. 1979. Glycogen, hyaluronate, and some other polysaccharides greatly enhance the formation of exolipase by *Serratia marescens*. J. Bacteriol.138:663 -670

Yadav, Isha, Shelja K. Juneja and Sunita Chauhan. 2015. Temple Waste Utilization and Management: A Review. International Journal of Engineering Technology Science and Research. 2:1-6

Yadav, R Hiranmai, 2015. Assessment of different organic supplements for degradation of *Parthenium hysterophorus* by vermitechnology. J Environ Health Sci Eng. 13:44, 1-7

Zambare, V. P., Padul M. V., Yadav, A. A. and Shete, T. B. 2008. Vermiwash: Biochemical and Microbiological Approach As Ecofriendly Soil Conditioner. ARPN Journal of Agriculture.3(4):1-5

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