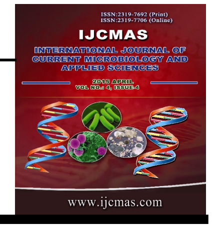
*Int.J.Curr.Microbiol.App.Sci* (2015) 4(4): 356-365

*International Journal of Current Microbiology and Applied Sciences*
*ISSN: 2319-7706* **Volume 4 Number 4 (2015) pp. 356-365**
**http://www.ijcmas.com**




**Original Research Article**

# Vermicomposting of Biodegradable Municipal Solid Waste Using Indigenous *Eudrilus* Sp. Earthworms

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**A B S T R A C T**

Biodegradable residential solid waste was divided into its constituents like food waste, paper waste, vegetable waste and garden trimmings with grass and leaves. Each of these separately with cow dung slurry and a mixture of biodegradable waste with and without cow dung slurry were used as substrates for vermicomposting, using indigenous Eudrilus species earthworms procured from CPCRI, Kasargod. The vermicomposts obtained were subjected to microbial analysis for general communities and specific communities. The general communities include Bacteria, Fungi and actinomycetes and specific community includes Fluorescent Pseudomonads, P- Solubilizers and $N_2$ – Fixers. The study shows that the Eudrilus species was effective in converting residential waste into vermicompost except for food and vegetable wastes. Study highlights the inevitability of cow dung slurry in vermicomposting by using Eudrilus species. The present study not only underscores the feasibility of conversion of biodegradable municipal solid waste into vermicompost but also notes the presence and importance of beneficial and biologically active soil microorganisms in the vermicompost obtained.

**Keywords**

Biodegradable, cowdung slurry, *Eudrilus* Sp., microorganisms, municipal solid waste

## Introduction

Management of municipal solid waste is a gigantic task for cities and city corporations. Along with open dumping, sanitary landfill, incineration etc., there are eco-friendly methods like composting and vermicomposting that are gaining momentum. Each municipal city corporation witnesses huge amounts of organic and compostable waste generation every day (Sequeira and Chandrashekar, 2015). Among the various methods to treat municipal solid waste, vermitechnology has been found very useful. This study attempts to check the feasibility of indigenous *Eudrilus* sp., earthworms in converting the constituents of municipal solid waste like- food waste, vegetable waste, paper waste, garden trimmings with leaves and grass, mixture of all the wastes with cowdung slurry and without cowdung slurry- into useful bio-fertilizer. After introducing the variety of worms used in this study the paper notes the importance of cowdung as the sub-substrates for vermicomposting. Subsequently, the microbial enumeration of the vermicomposts obtained from various substrates of municipal solid waste is explained in order to emphasize their role in soil quality enhancement, plant growth and agriculture.

## Materials and methodology

Microbial analysis of the vermicompost samples obtained from biodegradable residential solid waste, which was divided into its constituents like food waste, paper waste, vegetable waste and garden trimmings with grass and leaves were separately with cow dung slurry and a mixture of biodegradable waste with and without cow dung slurry were used as substrates for vermicomposting, using indigenous Eudrilus species earthworms. Population of general (aerobic heterotrophic bacteria, filamentous actinomycetes, fungi) and plant beneficial communities (free-living $N_2$ fixers, fluorescent pseudomonads & phosphate solubilizers) were determined in the vermicomposts by pour plate on selective and semi-selective media. Total numbers of culturable aerobic heterotrophic bacteria were counted on nutrient agar (Allen, 1959) after incubating for 48 h at 28 °C, fungi on Martin's rose Bengal agar (Martin, 1950) counted after 4 days incubated at 28°C, filamentous actinomycetes on Ken Knights and Munaier's agar (Allen, 1959) counted after 5-7 days incubated at 28°C, free-living nitrogen fixing bacteria counted after 4 days on N-free media (King, 1954) for fluorescent pseudomonads producing green or greenish blue fluorescence; King's B agar (Becking, 1959) was used and the colonies were counted under UV light after incubation for 24-48h at 28°C, , and phosphate solubilizers were counted by locating the clear halo formed around the colonies on Pikovskaya agar (Pikovskaya, 1948), 5-7 days after incubation at 28°C. The results of the microbial analysis were given as CFU $g^{-1}$ dry weight of samples. Each CFU value was the average of 3 plate replications per sample.

## Result and Discussion

### The selection of worms

There are wide variety of worms that are used for the conversion of the organic wastes into vermicompost like *Megascolex mauritii, Eisenia fetida, Eudrilus eugeniae, Perionnyx excavatus, Lampito mauritii, Eisenia andrei, Lampito rubellus and Drawida willis* (Domínguez and Edwards, 2011; Manyuchi and Phiri, 2013). Among these *Eisenia foetida* and *Eudrilus eugeniae* are the widely used varieties of worms.

The worm variety used for the present study is Epigeic earthworm, *Eudrilus sp*. The vermicompost production technology from coconut palm leaf litter using the strain of *Eudrilus* sp was standardized at CPCRI, Kasaragod during 1998 (Gopal *et al*, 2010; Thomas *et al*, 2012). Though it is named African night crawler it is an indigenous variety and has nothing do with Africa. This particular variety has been tried for the vermicomposting of coconut leaves or palm leaf litter, pineapple waste, banana leaves, glyricidia and sugarcane successfully (Gopal *et al*, 2010; Thomas *et al*, 2012). This study attempts to show that this particular species works for biodegradable MSW too.

### Cowdung slurry and vermicomposting

There is hardly any vermicomposting without cowdung as a substrate. Cowdung slurry is used in various proportions in vermicomposting. In the present study the vermicompost was also obtained without using cowdung slurry, but with much difficulty and on a very small scale. First and foremost without cowdung the degradation rate of the waste or the conversion rate of waste into compost is very low. The yield obtained in this case too is very low. The worms can be added only at a stage when the waste is considerably decomposed. Since the worms are devoid of food, the mortality rate of the worms is very high. Thus the role of cowdung in vermicomposting is to be highlighted. Curry and Schmidt (2007) have rightly noted that most kinds of animal dung are highly attractive and nutritious food sources for earthworms and cowdung forms the important part of the worm-diet. The cattle dung is able to increase the stability of the material to be converted into vermicompost as feed for both microbes and earthworms (Kaur *et al*, 2010). Cowdung minimises the mortality rate and maximises the population build up of the worms (Kaur *et al*, 2010; Natarajan and Gajendran, 2014; Biruntha *et al*, 2013). The increase of cowdung can also increase the length of the worms significantly (Manyuchi and Whingiri, 2014). This shows the need of cowdung as one of the sub-substrates for vermicomposting. However, in the present study only a trace of cowdung was used. In other words the cowdung usage was kept to a minimum keeping in mind the city condition where the cowdung availability is very less and costly.

**Food and vegetable waste and vermicomposting**

It has been observed that the variety of worms used in the present study do not effectively work for food waste and vegetable wastes. The major reason is the high oil content and moisture content in the food and vegetable wastes. The dense packing of food waste material also makes the aeration difficult resulting in making the living conditions difficult for worms. High oil and moisture content increases the mortality rate of the worms. Since in the present study the amount of cowdung used too is very less; which could be another reason for the failure of these particular worms to convert food and vegetable waste into vermicompost. Gunadi and Edwards (2003), in a similar study found that the high electrical conductivity, high $NH_4$ content, high moisture content waste and low pH of the vegetable and of the fruits waste lead to the conditions detrimental to the worm life for *Eisenia fetida.* The above conditions must be very difficult for *Eudrilus sp.*, which likes more aeration and hard lignin like material.

Studies have shown that the worms like *night crawler,* work for food and vegetable wastes too. But, it needs to be noted that in this case the food waste was subjected to washing to remove its oil content. The food was dried at the constant temperature of 60 degree to remove excess moisture content and the dry cubes were subjected to vermicomposting (Othman, 2012). Similarly, the supermarket vegetable wastes were adjusted to approximately 80% by air-drying or by spraying using distilled water (Gunadi and Edwards, 2003). The washing and drying of the food waste is a difficult task and may not be very feasible when all biodegradable waste is mixed together. The handling of the food waste for washing and drying is not easy too. This way, the vermicomposting of food waste alone or vegetable waste alone many not be easy. However, when the waste is mixed together the present study too yielded good results as discussed below.

**Vermicomposting of Paper, garden trimmings and mixture of organic household wastes**

*Eudrilus sp.* works very well for wastes such as paper, garden trimmings and mixture of household waste when all treated with cowdung slurry. The vermicomposting of household organic waste mixture without cowdung slurry is ineffective and the reasons to which have been already discussed above.

## Microbial analysis of the vermicompost

### Bacteria, Fungi and Actinomycetes

Vermicomposts are rich in microbial populations and diversity, particularly fungi, bacteria and actinomycetes. The presence of high level of these beneficial and biologically active soil microorganisms is the main characteristics of vermicompost which makes it much sought for as effective fertilizers. In the present study (Table 1; Figures 1 and 2) we see the bacteria count per gram of vermicompost obtained from waste paper is 110X$10^5$, garden trimming leaves vermicompost is 350X$10^5$, mixed organic garbage vermicompost is 255 X$10^5$ and mixed organic garbage without cowdung slurry vermicompost is 634 X$10^5$. Fungi count per gram as follows: waste paper vermicompost is 17X$10^3$, garden trimming leaves vermicompost is 113 X$10^3$, mixed organic garbage vermicompost is 39 X$10^3$ and mixed organic garbage without cowdung slurry vermicompost is 73 X$10^3$. Count of Actinomycetes waste paper vermicompost is 570 x$10^4$, garden trimming leaves vermicompost is 64.9 x$10^4$, mixed organic garbage vermicompost is 167 x$10^4$ and mixed organic garbage without cowdung vermicompost is 699 x$10^4$. This shows a rich presence of microorganisms in the vermicompost prepared from household organic solid waste. Thus, vermicomposts made of paper and garden trimmings a good source of actinomycetes.

According to Moradi *et al* (2014), although it has been shown that earthworms utilize microorganisms as their main source of nutrition, there are usually greatly increased numbers of bacteria, actinomycetes and fungi in freshly-deposited earthworm casts than in the surrounding soil. Such increases may be due to enhancement of microbial populations, occurring during passage through the earthworm's intestine; either because the food selected by the earthworm forms a richer substrate for microbial activity or because fragmentation of organic matter in the earthworm's gizzard increases the available surface area for microbial activity (Dkhar and Mishra, 1986; Tiwari and Mishra, 1992). There is considerable research evidence that earthworms can stimulate the microbial decomposition of organic matter significantly, both during the passage through the earthworm gut and in their casts, for some time after the casts are deposited (Daniel and Anderson, 1992).

### Phosphorous solubilizers

Phosphorous solubilization is an important aspect of plant nutrition as well as reduction of environmental pollution due to phosphorous accumulation. Microbes possess the ability to convert insoluble phosphates to soluble phosphates by acidification, chelation, ion-exchange and production of low molecular mass organic acids (Chen *et al*, 2006). Bacteria such as Pseudomonas, Bacillus, Rhizobium, Agrobacterium, Achromobacter, Micrococcus, Aerobacter, Enterobacter, Flavobacterium and Erwinia are known to be the efficient phosphate solubilisers (Gulati *et al*, 2009). In the present investigation (Table 2), the count of P-Solubilizers per gram of vermicompost obtained from waste paper is 7X$10^2$, garden trimming leaves vermicompost is 12X$10^2$, mixed organic garbage vermicompost is 14X$10^2$ and mixed organic garbage without cowdung vermicompost is 7X$10^2$ . One of the major activity of P-solubilizers is the production of HCN. Microbial production of

HCN is considered as an important antagonistic trait to suppress plant root-infecting fungi (Wahyudi *et al*, 2011).

**Fluorescent Psudomonads**

In the present study (Table 2; Figure 3) the counts of Pseudomonads of vermicompost obtained from from waste paper is $60X10^2$, garden trimming leaves vermicompost is $34X10^2$, mixed organic garbage vermicompost is $56X10^2$ and mixed organic garbage without cowdung vermicompost is $136X10^2$. Involvement of HCN produced by fluorescent pseudomonads in disease suppression by induction of plant resistance has been reported by (Voisard *et al*, 1989).

**Nitrogen fixers**

The presence of Nitrogen fixing bacteria in the vermicompost makes it most useful manure. The microorganisms increase N2 fixation by both nodular and free living Nitrogen fixing bacteria and thus enhance plant growth. Vermicompost has been proved as cheapest source of nitrogen and other essential elements for better nodulation and field particularly in legumes. Such plants can meet their N needs through both biological nitrogen fixation (symbiosis) and native nitrogen in the soil (Parthasarthi and Ranganathan, 2002).

Present study shows (Table 2; Figure 4) the count of N2 fixing bacteria in waste paper vermicompost is $286X10^2$, garden trimming leaves vermicompost is $62X10^2$, mixed organic garbage vermicompost is $73X10^2$ and mixed organic garbage without cowdung vermicompost is $50X10^{2.}$ It can be observed that the vermicompost produced from paper waste has high Nitrogen fixing bacteria compared to other composts under study.

Sinha *et al* (2010) reported that the effect of vermicompost on the growth of free living N2 fixing bacterial colonies was observed as a reflection in the increment of number of bacterial colonies in soil. The increment of free living nitrogen fixing bacteria was due to the fact that vermicoposting earthworms encourage the formation in the organic substrate of conditions favorable for the nitrogen fixing bacteria, changes in the structure of the microbial community of the substrate in support of non-spore forms of bacteria, and suppression of the growth of saprophyte bacilli, the main competitors of nitrogen fixing bacteria for carbon nourishment sources (Tereshchenko and Naplekova, 2002).

**Moisture content:**

According to Nagavallemma *et al.*, (2006), moisture content of vermin composts ranges from 32–66%. Present study shows (Table 3) the % of moisture content of paper vermicompost is 63.5, garden trimming leaves vermicompost is 71.6, mixed organic garbage vermicompost is 42.1 and mixed organic garbage without cowdung slurry vermicompost is 55.6. The rate of mineralization and decomposition becomes faster with the optimum moisture content (Singh *et al*, 2004). According to Liang *et al.*, (2003), the moisture content of 60–70% was proved having maximal microbial activity, while 50% moisture content was the minimal requirement for rapid rise in microbial activity. Vermicompost samples during the present study showed moisture content which may be due to their high absorption capacity, and may also be because of assimilation rate by microbial population indicating the higher rate of degradation of waste by earthworms. Results obtained are shown in the table below.

**Table.1** General Communities*

| Vermicompost Sample | Bacteria ($x10^5$) | | | | Fungi ($x10^3$) | | | | Actinomycetes ($x10^4$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | $R_3$ | Mean | $R_1$ | $R_2$ | $R_3$ | Mean | $R_1$ | $R_2$ | $R_3$ | Mean |
| S1- Paper Vermicompost | 112.3 | 115 | 104 | 110 | 14 | 22 | 14 | 17 | 564.3 | 575.3 | 570 | 570 |
| S2- Garden Trimming Leaves Vermicompost | 341.1 | 359.1 | 349 | 350 | 116 | 113 | 109 | 113 | 651.4 | 662 | 634 | 649 |
| S3- Organic garbage Vermicompost | 263 | 257.3 | 244 | 255 | 43 | 34.5 | 40 | 39 | 164 | 171 | 166 | 167 |
| S4- Garbage mixed without cow dung slurry Vermicompost | 637.3 | 631 | 633 | 634 | 67 | 72 | 79 | 73 | 698.1 | 703 | 696 | 699 |

**Table.2** Function Specific Communities*

| Vermicompost Sample ID (P.No) | Fluorescent Pseudomonads ($x10^2$) | | | | P- Solubilizers ($x10^2$) | | | | $N_2$ – Fixers ($x10^2$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | $R_3$ | Mean | $R_1$ | $R_2$ | $R_3$ | Mean | $R_1$ | $R_2$ | $R_3$ | Mean |
| S1- Paper Vermicompost | 60 | 60 | 60 | 60 | 3 | 10.4 | 9 | 7 | 290.4 | 296 | 271.2 | 286 |
| S2- Garden Trimming Leaves Vermicompost | 35.2 | 28.1 | 39 | 34 | 8 | 14 | 14 | 12 | 53 | 63.3 | 70.4 | 62 |
| S3- Organic garbage Vermicompost | 60.4 | 52 | 55.2 | 56 | 14 | 17 | 12 | 14 | 69 | 77 | 72.5 | 73 |
| S4- Garbage mixed without cow dung slurry Vermicompost | 135.1 | 140 | 133 | 136 | 8 | 5 | 7 | 7 | 45 | 50 | 56 | 50 |

In the above tables, $R_1$, $R_2$ and $R_3$ are replications and * Microbial Enumeration (CFU/G Dry Sample) Pour Plate: 1ml/Inoculum.

**Table.3** % Moisture

| **Sample ID** | **% Moisture** |
|---|---|
| Paper Vermicompost | 63.5 |
| Garden Trimming Leaves Vermicompost | 71.6 |
| Organic garbage Vermicompost | 42.1 |
| Garbage mixed without cow dung slurry Vermicompost | 55.6 |

**Figure.1** Bacterial Colonies

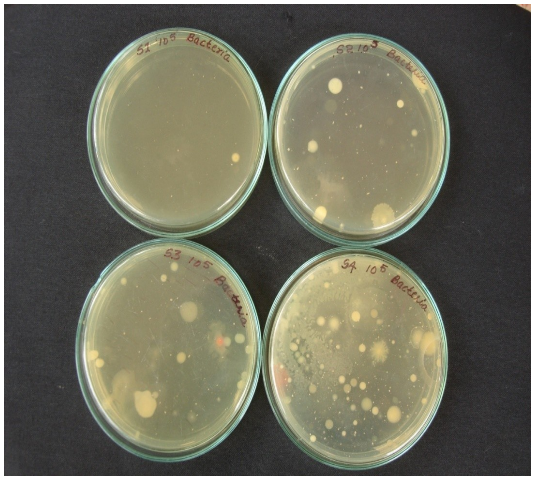


**Figure.2** Fungal Colonies

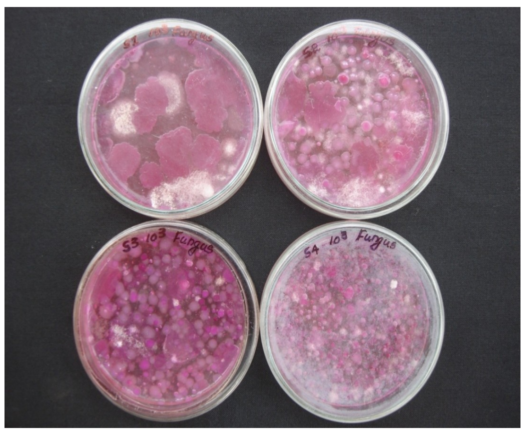


**Figure.3** Fluorescent Psudomonads

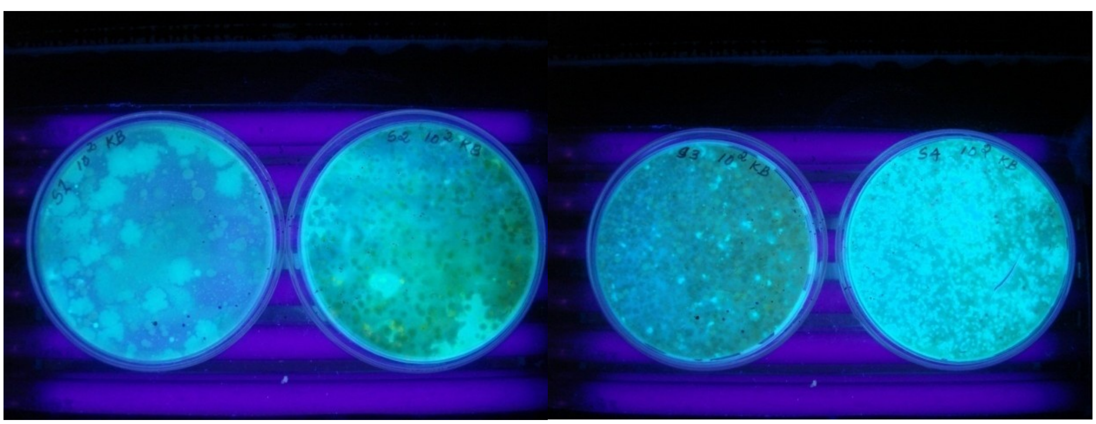
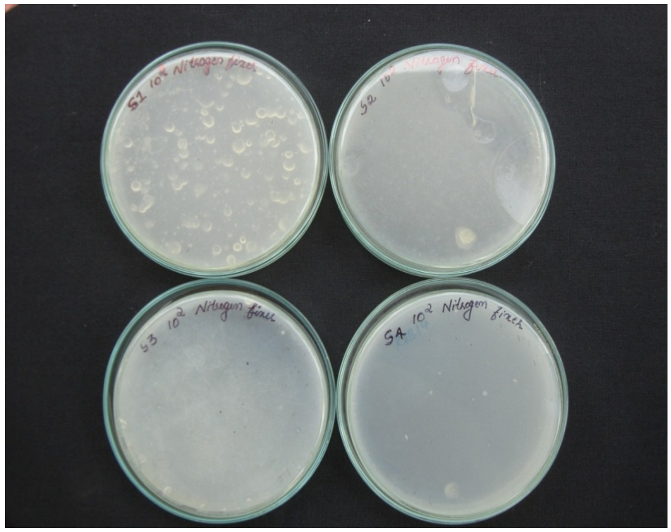


**Figure.4** Nitrogen Fixers



Vermitechnology of municipal solid waste using the *Eudrilus sp.* yields good quality vermicompost that is rich in soil quality enhancing microorganisms. Though this particular variety of worms are not advisable to the vermicomposting of food and vegetable wastes separately, when mixed with various other kinds of organic wastes and treated yield good results. In the city setup where there is difficulty of procuring cowdung, vermicomposting in the city households seems to be difficult too. However, it is to be noted that even dilute cowdung slurry is sufficient to practice vermicomposting in a small scale to manage the biodegradable waste in the households. The vermicompost obtained is free of any kind of foul smell or odor which is the main concern with municipal waste. The presence of useful microorganisms is a measure of soil quality which is very essential for agriculture and plant growth. The costly chemical fertilizers are unable to provide these microorganisms but vermicompost produced from a waste raw material is able to procure them with a very low cost. When the unique ability of these earthworms is realized and utilized in vermicomposting on a large scale the large heap of waste indeed can turn into a goldmine!

## Acknowledgements

I am grateful to Dr Murli Gopal and his staff at Central Plantation Crops Research Institute (CPCRI), Kasargod, for making available the required earthworms and for doing the microbial analysis of vermicompost. I am thankful to Bishop of Mangaluru Diocese, Most Rev Dr Aloysius Paul D'Souza for providing financial assistance for this study.

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