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An evaluation of different Methods of composting on Management of Heavy Metals from the Waste dump

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Abstract

A study was conducted to understand the effect of composting on heavy metal contents of waste material at the waste dump yard at Laloor, of Thrissur district in Kerala state. The material collected from Laloor was subjected to aerobic and anaerobic methods of composting with the use of equal quantities of farm yard manure. For aerobic composting waste material and cow dung in 1:1 ratio 100kg each was mixed and heaped. Biogas unit of 0.5m^3 capacity was used for anaerobic composting. Waste material and cowdung of the same quantity (100 kg) as above was mixed and fed to the unit on a daily basis. The slurry collected was used for analysis. Compared to aerobic composting, anaerobic method was better for removal of the heavy metals. The heavy metal content (mg kg^{-1}), was observed to be higher in aerobic compost with an average of total Pb 99.18, Co 6.9, Ni 33.64, Cr 99.52 and Hg 0.29 mg kg^{-1} respectively and slurry it was Pb 2.16 , Co 0.24, Ni 1.2, Cr 28.06 and Hg 0.03 mg kg^{-1} respectively.

Keywords: Aerobic, Anaerobic, Waste Dump.

Introduction

Almost all human activities generate waste, and the way in which it is handled, stored, collected and disposed can pose risks to environment and community health. Solid wastes other than hazardous and radioactive materials are often referred to as municipal solid waste. As there are different types of wastes at the municipal dumping site, the soils of the area will be rich with organic matter, toxic chemicals and pollutants like heavy metals. Among the different pollutants the non bio-degradable nature, long biological half-lives and the potential to accumulate in the body parts makes the heavy metals very harmful compared to others. Various heavy metal reduction techniques are being reported elsewhere. Composting is the process in which organic matter is transformed into compost by aerobic microorganisms which comprises three major phases such as mesophilic, thermophilic and cooling phase[1].

Singh and Kalamhad[2] concluded from their study that composting can reduce the heavy metal content. They concluded that during composting process, the metals content can be reduced by addition of some chemicals, microbial inoculants and earthworm. In comparison to other chemicals, natural zeolite was a good amendment because it had ability to exchange Na and K with toxic metals.

The inoculation of microorganisms could be very useful to improve the composting process by enhancing enzymatic activity and quality level of the compost was acceptable, with very low heavy metal content. During the vermicomposting earthworm could accumulate the high concentration of heavy metals in the non-toxic forms and capable of reducing possible toxic effects of unessential heavy metals by utilizing them for physiological metabolism.

Saha[3] analyzed the metal content in soil samples along the main highways in the central part of Hail city. And the composts prepared from source separated biogenos wastes contained on an average, higher organic matter (by 57%), total N (by 77%) and total P (by 78%), but lower concentrations of heavy metals Zn (by 63%), Cu (by 78%), Cd (by 64%), Pb (by 84%), Ni (by 50%), and Cr (by 63%) as compared to those prepared from mixed wastes.

Zennaro[4] *et al.* reported that municipal solid waste with accumulation of heavy metal when subjected to the composting resulted in large removal of heavy metal which was more critical without a substantial yield loss. In a pot culture experiment conducted to study the effect of accumulated contaminant elements in cultivated crops and their biomagnifications.

Rao and Reddy[5] concluded the heavy metal present in different crops poses no toxic pollution problem in the food chain, as well the heavy metal concentrations in the plant samples are within the limit. With this brief review a study was conducted to understand the effect of composting on heavy metal contents degraded material of waste dump.

Materials and Methods

An experiment was conducted with Completely Randomised Design, five replications and three types of treatments as follows: Waste material (control) – A heap of 100 kg waste material was kept as control. Aerobic composting – 100 kg waste material was taken and mixed with cowdung in the ratio 1:1. Moisture level was uniformly maintained at 60 to 70 per cent by moistening with water at specific intervals of study. Anaerobic composting (Biogas method) -Biogas unit of 0.5 m^3 capacity was used for anaerobic composting. Total of 100 kg waste material and 100 kg cow dung was used for the study. Each day 20 kg material (cowdung: waste material in the ratio 1:1) was fed to the biogas unit and a total of 20 liters of biogas slurry was collected.

The composting treatments was for a period of 2 months and the material after treatment was subjected to the heavy metals analysis of Pb, Co, Ni, Cr and Hg using HNO_3: $HClO_4$ (2:1) and estimated using ICP-AES.

Results and Discussion

The initial physic-chemical properties of the material show that the pH values were higher in slurry (7.1) followed by aerobic compost (6.8) and control had least pH. It was found that there was no significant difference in the pH, which was almost in neutral range for all the three treatments with the highest for slurry. The maximum total carbon (%) was in aerobic compost (4.26 %), followed by control (3.76%) and the least for slurry (2.0%) and there was significant difference for the treatments aerobic compost and control with slurry.

The result of the analysis show that there was no significant difference in total nitrogen among the treatments and it was the highest in aerobic compost (0.35 %) followed by control (0.28 %) and least in slurry (0.18 %). Total P content of all the treatments were on par with each other, control (0.12 %), aerobic (0.12%) and anaerobic slurry (0.13%). Total potassium content was same with no significant difference among the treatments, control had (0.18 %), followed by aerobic 0.18 % and slurry 0.13%. Among the treatments there were significant variation in total Ca with control (0.53 %), followed by aerobic compost (0.42 %) and slurry (0.20 %). The Mg content was higher in control (0.17 %), followed by aerobic treatment and (0.16 %) and the least for anaerobic treatment and (0.12 %) and there was no significant difference in total Mg contents of the different treatments.

All the micronutrients Zn, Cu, Mn and Fe were higher in control and the least in slurry. Zinc content varied from 10.24 mg kg^{-1} in slurry to 432.12 mg kg^{-1} in control and aerobic compost had 287.36 mg kg^{-1}, in all the treatments, significantly different from each other. Mn content ranged 48.4 mg kg^{-1} in slurry to 352.7 mg kg^{-1} in control and aerobic compost had intermediate content of 277.58 mg kg^{-1}. The Mn content in slurry is significantly different from other treatments, but there was no significant difference noted in Mn content of control and aerobic compost. Cu content was the least in 5 mg kg^{-1} in slurry to 166.22 mg kg^{-1} in control and Cu content was intermediate for aerobic compost 122.36 mg kg^{-1}. There was significant difference in Cu content among the different treatments. Iron content was higher in control (3.27 %), followed by aerobic compost (2.28 %) and the least in anaerobic compost (3.13 %), and there was significant difference in Fe content of all the treatments.

There were significant variations in the contents of heavy metals in the different treatments of the experiment. On perusal of data the heavy metals Pb, Co, Ni, Cr and Hg are found to be highest in control. The lead content of the control was 148.6 mg kg^{-1} followed by aerobic 99.18mg kg^{-1} and slurry 2.16 mg kg^{-1}, the three treatments were found to be significantly different. Co content was the highest in control 10.2 mg kg^{-1}, followed by aerobic 6.9 mg kg^{-1} and the lowest Co content was in slurry (0.24 mg kg^{-1}). There was significant difference in Co content of the various treatments. The highest Nickel content was 48.68 mg kg^{-1}in control, followed by aerobic compost (33.64 mg kg^{-1}) and least was 1.22 mg kg-^{1} in slurry. Chromium content was high in control with 142 mg kg^{-1}, followed by aerobic compost 99.52 mg kg^{-1} and the least in slurry 28.06 mg kg^{-1} and there was significant difference between the different treatments. Mercury content was higher in control (0.39mg kg^{-1}) followed by aerobic compost (0.29 mg kg^{1}) which was not significantly different from each other. The least Hg content of 0.03 mg kg-^{1} was reported in slurry and this treatment was significantly different from others.

All the heavy metals accumulated more in control, followed by aerobic compost and the least found for slurry. There was significant difference in the heavy metal accumulation in compost and control compared to slurry. The process of composting with equal doses of cowdung and waste can promote the complexation of heavy metals (with the fractions of fulvic acid) whose mobility and availability tend to decrease. Also there will be dilution effect in aerobic compost as compared to control due to the addition of cowdung. In slurry only the water soluble and easily available heavy metal concentration will be present and hence the concentration of heavy metals will be least compared to other treatments.

The variations in heavy metals under different treatments showed that except for Hg and Cr all others were below the tolerable limit.

Conclusion

Compared to aerobic composting, anaerobic method was better for removal of the heavy metals. The heavy metal content was observed to be higher in aerobic compost with an average of total Pb 99.18, Co 6.9, Ni 33.64, Cr 99.52 and Hg 0.29 mg kg^{-1} respectively and for slurry it was Pb 2.16, Co 0.24, Ni 1.2, Cr 28.06 and Hg 0.03 mg kg^{-1} respectively. After composting also it is mandatory to do the heavy metal analysis of the compost to assure the heavy metal contents are within range.

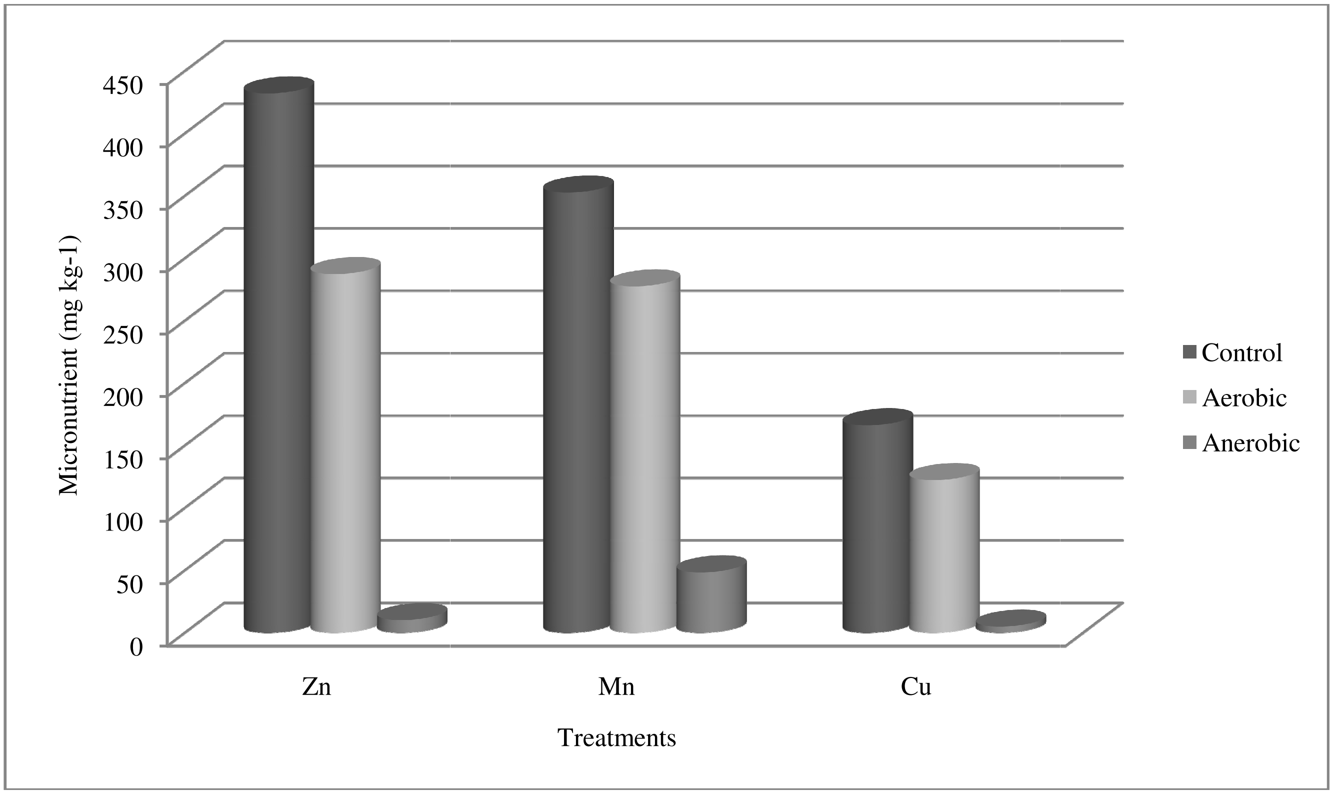

Figure-1
Variations in primary nutrients (%) among the different treatment

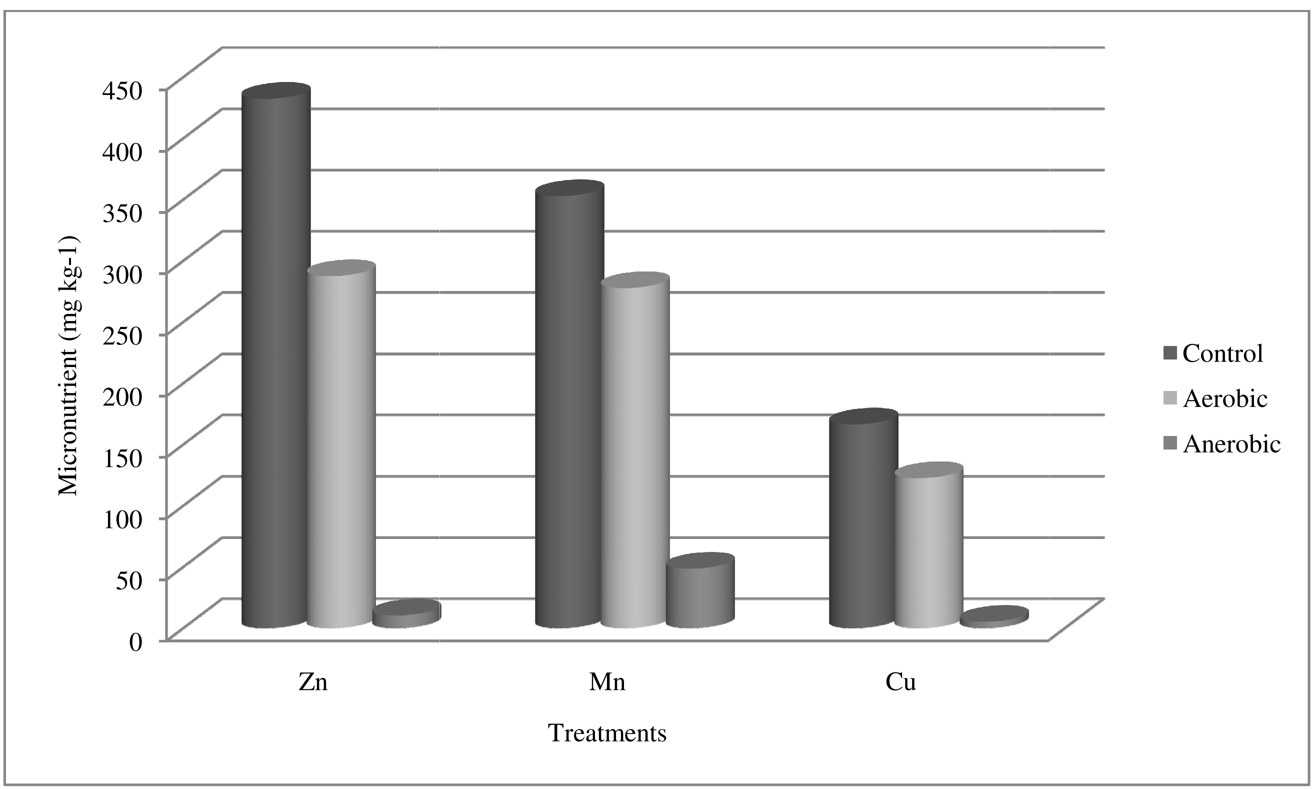

Figure-2
Variations in micronutrient content (mg kg^{-1}) among the different treatments

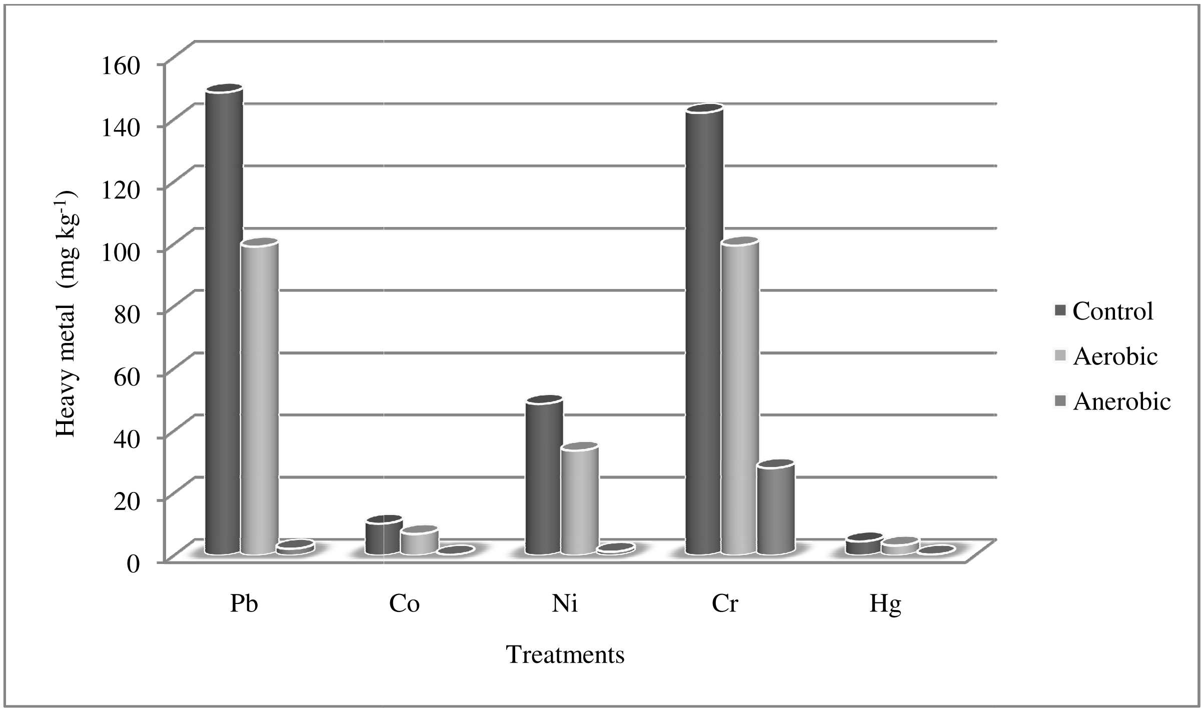

Figure-3
Variations in heavy metal content (mg kg^{-1}) among the different treatments

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