Vermicomposting of Commercial Bio waste as a Solution to Waste Management in a Bio Economy

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Abstract

In this study, bio waste was vermicomposted as waste management strategy. The bio waste was vermicomposted over a period of 70 days with an earthworm loading of 600 earthworms/m^2. Standard compost at the same conditions was also made and the changes in the total organic carbon (TOC), total nitrogen (TKN), total phosphorous (TP), total potassium (TK) and total calcium (TCa) were monitored using standard methods. The significance of the differences in the parameters composition was determined using Statistica 12.0's box plots and *t-test* at 95% confidence interval. The TOC showed a 73% higher decrease in vermicompost in comparison to the standard compost. The TKN, TP, TK and TCa showed superior increases of 30%, 25%, 19% and 50% in the vermicompost in comparison to the standard compost. The TP and TKN showed significant variations between vermicompost and the standard compost at 95% confidence interval.

Keywords: Bio waste, compost, TCa, TKN, TN, TP, TOC, vermicompost

1.Introduction

Huge amounts of municipal waste are generated on a daily basis and these if not properly managed will result in greenhouse emissions and climate change. Municipal waste which is also highly bio degradable presents a raw material for vermicomposting (Garg et al., 2006). The vermicomposting process involves chemical, biological and physical changes whereby bio waste is ingested by the earthworms and expelled as vermicasts. Municipal waste which include agro waste, kitchen waste, industrial waste and sludge's have been reported to be good sources of raw material for vermicomposting (Sosnecka et al., 2016). Furthermore, utilization of the waste as a raw material for vermicomposting results in limited landfilling problems as minimal waste will end up at the landfill (Azizi et al., 2015). Vermicomposting technology also promotes the removal of heavy metals which have the potential to cause carcinogenic diseases (Roshan et al., 2014). This study therefore focused on the potential to vermicompost bio waste as a waste management initiative at the same time providing a source of bio fertilizers. Furthermore, the changes in the physicochemical parameters compared with the standard compost.

2.Materials and methods

The bio waste used for composting and vermicomposting comprised of plants, wood, kitchen waste, fruit and vegetable waste as well as papers. Vermicomposting and composting was allowed to take place over 2 months under standard conditions in beds that were 3m in length by 1m wide and 0.5m in height. The beds were regularly sprinkled with water to ensure the bio waste had adequate moisture to enhance the bio degradation process. Eisenia Fetida earthworms were used as the vermicomposting media and were added at a rate of 600 earthworms/m^2. A sample of 1kg was then collected in both the vermicompost and compost for physicochemical analyses for the total organic carbon (TOC), the total KJheldal nitrogen (TKN), total phosphate (TP), total potassium (TK) and total calcium (TCa).

The total organic carbon (TOC) was measured using the ASTM D3174-11 standard methodology. The total KJheldal method was used to measure the TKN. The changes in the vermicompost and compost were determined by the colorimetric method. The potassium content was measured by the flame photometer method and the phosphorous content was determined by the Olsen's method. All experiments were replicated thrice and an average value was used.

Statistical analyses of the effect of vermicomposting and composting was done using box plots in Statistica 12.0 box plots and two sample *t-test* at 95% confidence interval. A two-sample *t-test* was conducted to determine any significance difference between the vermicompost and compost assuming equal variances, to test for a significant difference between the group means. The hypotheses were:

H_0 : $\mu_v = \mu_c$ (The changes in the parameters in the vermicompost and in the compost are the same)

H_1: $\mu_v \neq \mu_c$ (The changes in the parameters in the vermicompost and in the compost are not the same)

Where μ_v is the value of the parameter in the vermicompost and μ_c is the value of the parameter in the compost.

3.Results and discussion

3.1 Bio waste characteristics

The bio waste used in this study was rich in organic matter content as shown in Table 1. This made it a good raw material for vermicomposting with a TOC content of 60.2%.

Table 1. Bio waste characteristics

Parameter (%)	Value
TOC	60.2
TKN	0.88

TP	0.31
TK	0.32
TCa	0.42

3.2 Effect on TOC

The total organic carbon decreased significantly by 67% during vermicomposting (Figure 1). The decrease was 73% higher in comparison to ordinary composting at the same period. Vermicomposting allowed for the enhanced decomposition of the bio waste resulted in the high TOC reduction. The reduction in the TOC can also be an indication of high biodegradability of the bio waste by the earthworms.

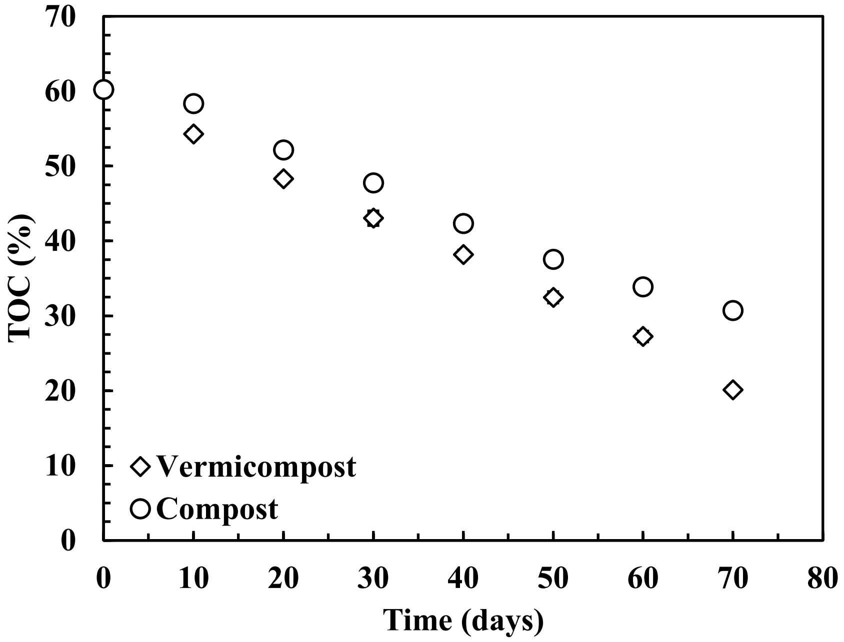

Figure 1. Effect of vermicomposting on TOC

The statistical analyses of the TOC composition using the box plot suggested that TOC (%) was higher in compost compared to vermicompost (Figure 2) using the t-test a p=0.4462 value was obtained. At a significance level of 0.05 we cannot reject the null hypothesis. Statistically there was **no** sufficient evidence that the TOC (%) in Vermicompost differed from that in compost.

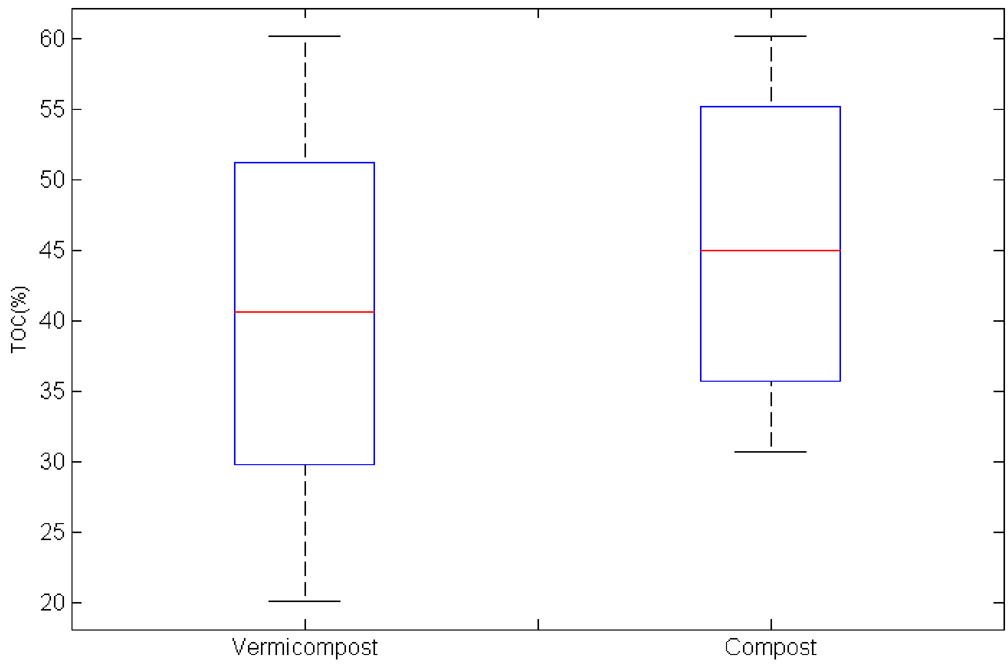

Figure 2. Box plots for TOC (%) in vermicompost and compost

3.3 Effect on TKN

The TKN composition increased significantly by 118% with increase in the vermicomposting period of the bio waste (Figure 3). Vermicomposting allows for increase in TKN due to mineralization of nutrients in the earthworm's gut as well as the release of ammonia rich fluids in the leachate (vermiwash). This was confirmed by the fact that the standard compost had a TKN content that was 30% lower in comparison to the vermicomposted bio waste.

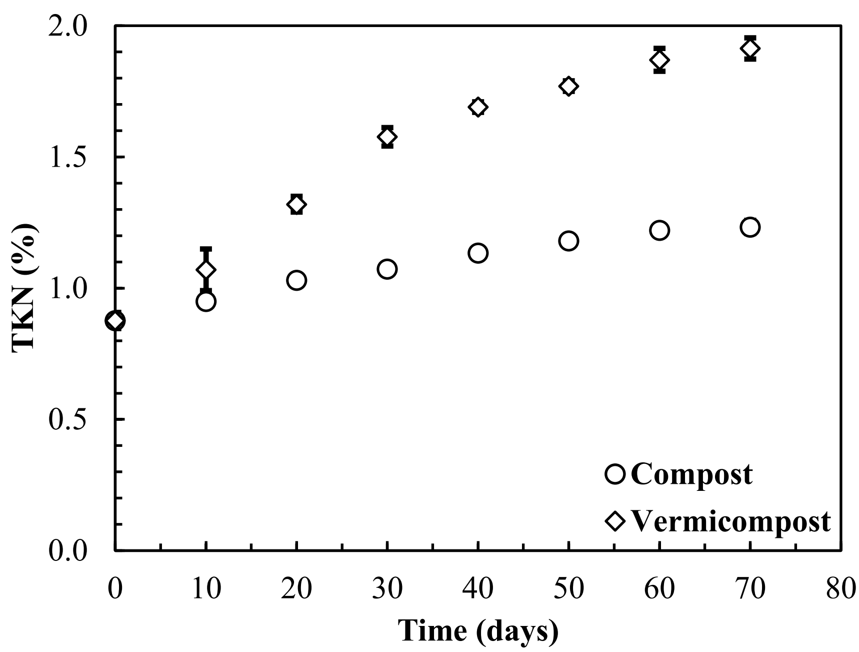

Figure 3. Effect of vermicomposting on TKN

The box plot suggested that TKN (%) was higher in vermicompost compared to compost (Figure 4). Using the t-test we get p=0.0102. At significance level 0.05 we rejected the null hypothesis. There was sufficient evidence that the TKN (%) in vermicompost differs from that in compost.

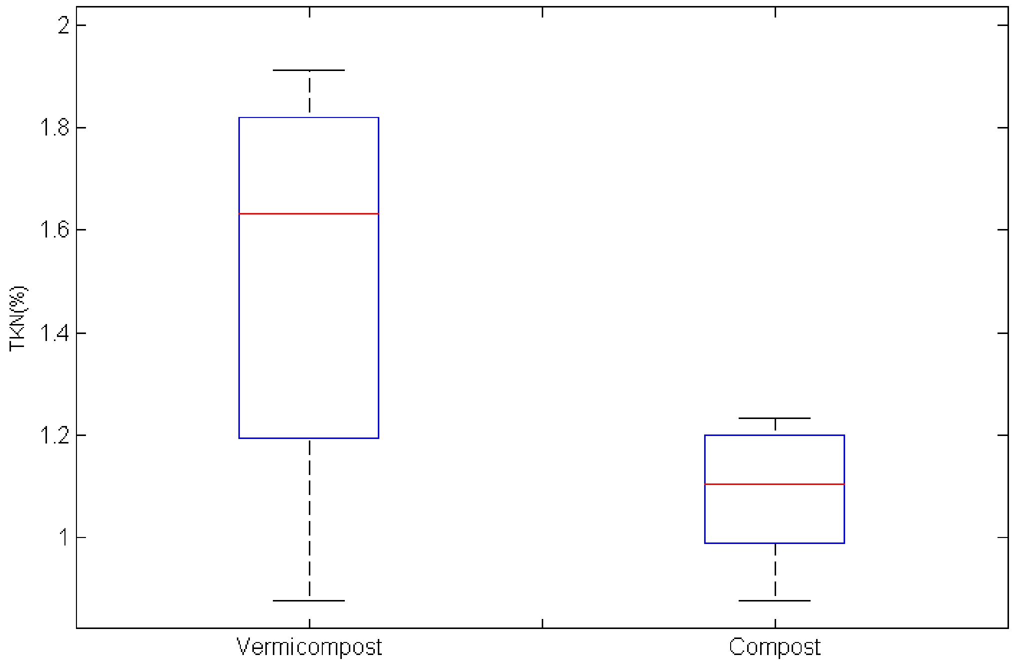

Figure 4. Box plots for TKN (%) in vermicompost and compost

3.3 Effect on TP

The TP composition in the vermicompost increased significantly with the vermicomposting period with a 174% increase being observed (Figure 5). Vermicomposting allows the release of soluble phosphate in the media resulting in the high phosphate content (Khan and Joergensen., 2009; Garg et al., 2012). This can be seen by the high TP content by over 25% in comparison to the standard compost which was composted over the same period.

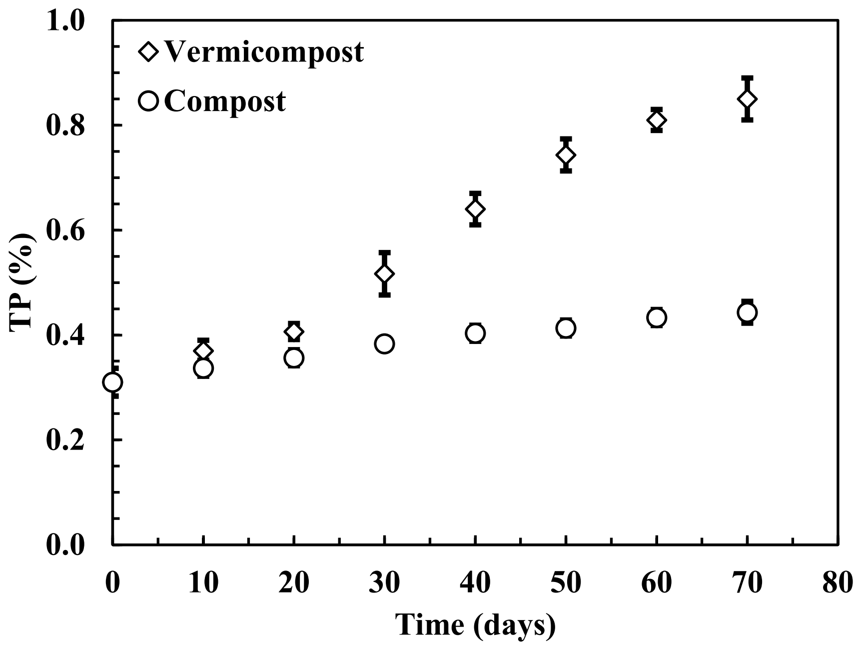

Figure 5. Effect of vermicomposting on TP

The box plot suggested that TP (%) is higher in vermicompost compared to compost (Figure 6). Using the t-test we get p=0.012. At significance level 0.05 we rejected the null hypothesis. There is sufficient evidence that the TP (%) in vermicompost differed from that in compost and hence vermicompost can be considered as a process for obtaining nutrient rich manure.

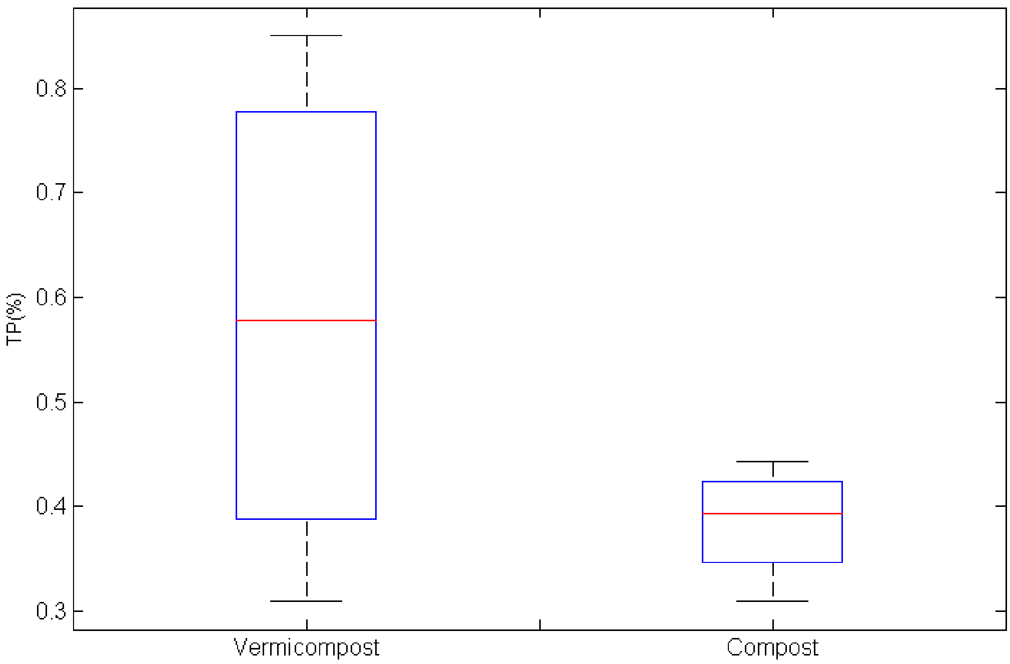

Figure 6. Box plots for TP (%) in vermicompost and compost

3.4 Effect on TK

The TK composition increased significantly withy increase in the vermicomposting period by 139% (Figure 7). The increase in the TK was 19% higher in vermicompost in comparison to the standard compost. The increase in TK was attributed to the increased availability of soluble potassium as the vermicomposting process progressed (Hanc et al., 2011; Pirsaheb and Sharafi, 2013). The effectiveness of vermicomposting as a technology for nutrient recovery from bio waste was alluded by the low TK composition in the standard compost.

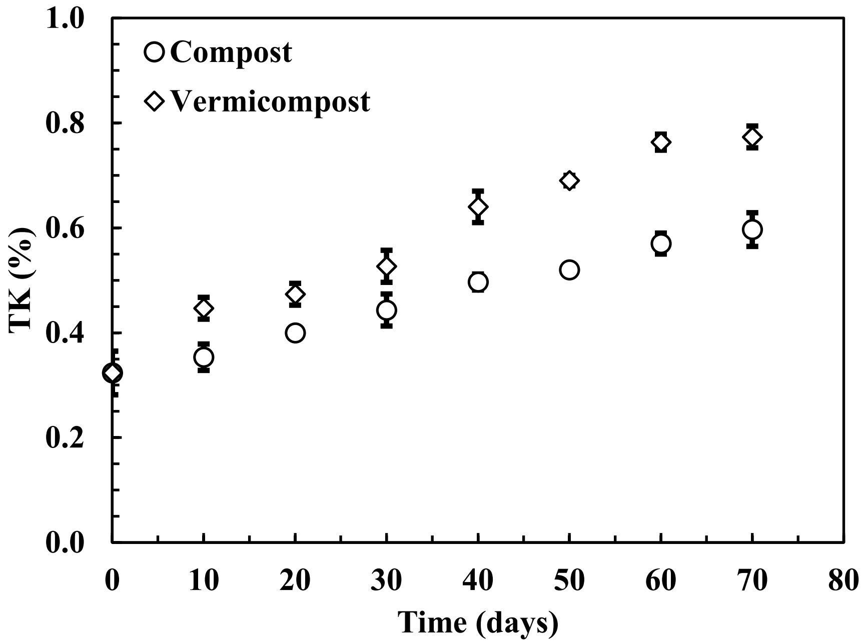

Figure 7. Effect of vermicomposting on TK

The box plot suggests that TK (%) is higher in vermicompost compared to compost. Using the t-test we get p=0.0729. At significance level 0.05 we cannot reject the null hypothesis. There is **no** sufficient evidence that the TK (%) in vermicompost differs from that in compost.

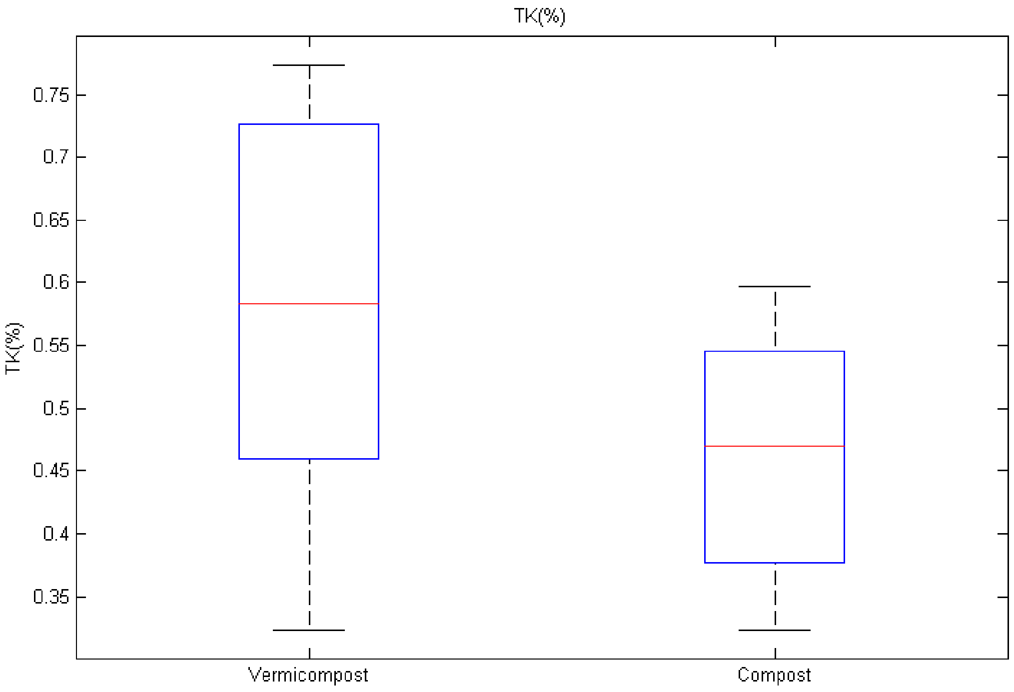

Figure 8. Box plots for TK (%) in vermicompost and compost

3.5 Effect on TCa

The TCa in the vermicomposted bio waste increased with increase in vermicomposting period with a 172% increase in the bio waste being observed (Figure 9). Vermicomposting allows the release of calcium in the bio waste through the earthworm action with the earthworm's gut acting as a bio reactor (Pandit et al., 2012; Bharti et al., 2018). This was alluded by the TCa content which was 50% higher in vermicompost as compared to the standard compost.

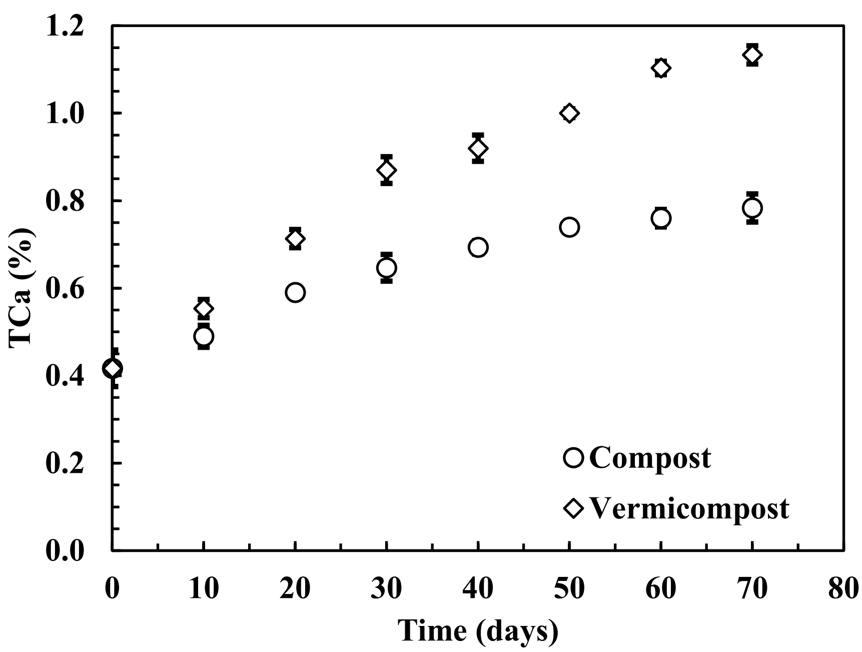

Figure 9. Effect of vermicomposting on Ca

The box plot suggests that TCa (%) is higher in vermicompost compared to compost. Using the t-test we get p=0.0729. At significance level 0.05 we cannot reject the null hypothesis. There is **no** sufficient evidence that the TCa (%) in vermicompost differs from that in compost.

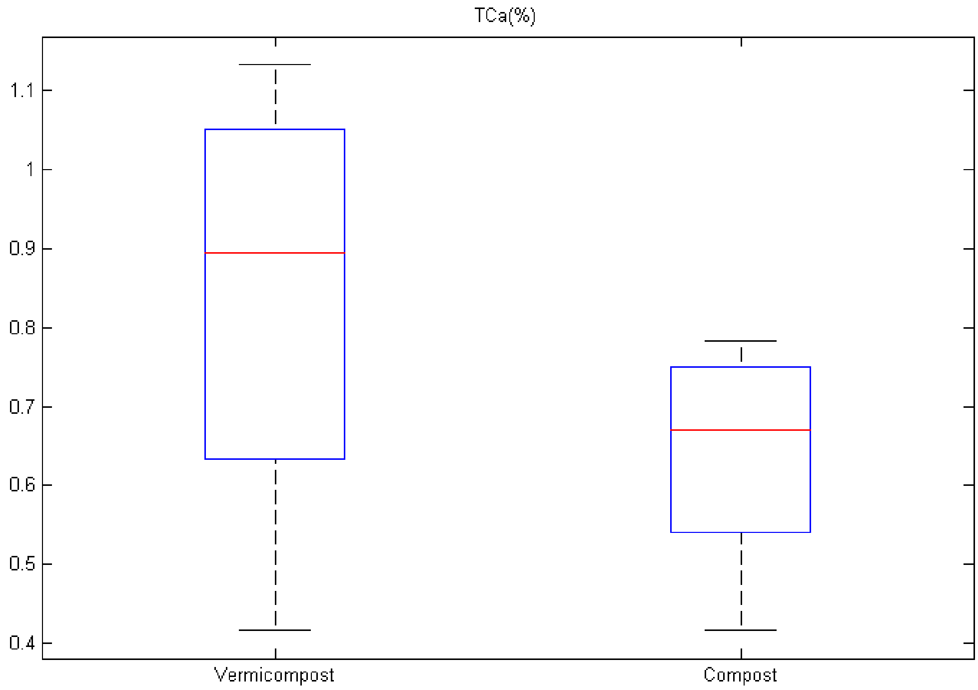

Figure 10. Box plots for TCa (%) in vermicompost and compost

The summary of the bio waste vermicompost and compost is given in Table 2.

Table 2. Bio waste vermicompost and comp0ost after 70 days

Parameter (%)	Vermicompost	Compost
TOC	20.13	30.7
TKN	1.91	1.23
TP	0.85	0.44
TK	0.77	0.60
TCa	1.13	0.78

4. Conclusion

Vermicomposting can be used as a bio waste management strategy at the same time recovering valuable nutrients such as TKN, TP, TK and TCa. Vermicomposting of bio waste resulted in vermicompost with 1.91%, 0.85%, 0.77% and 1.13% in nutrient composition for TKN, TP, TK and TCa respectively. Vermicomposting is critical in enhanced nutrient enrichment with significant changes being noted in TP and TKN.

Acknowledgements

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