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Effect of Municipal Solid Waste compost Treatment on Physico-Chemical Properties of Garden Soil

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Abstract

In the present study amendment of three types of compost made from lemon peels (LP), vegetable waste (VW) and cook food waste (CF) in garden soil was carried out. It was observed that pH in all the treatments increased from control with a maximum in LP with 22% and minimum in CF with 10% at 270 days.The soil temperature was higher than control with a maximum increase of 52% in CF and minimum of 20% in VW at 90 days. A maximum increase of OC was observed in CF compost treated soilwith 106% followed by LP with 64% and 24% in VW at 90 days.TN increased from control upto 90 days with 484, 100 and 46% rise in CF, VW and LP respectively. AP and AK also showed a very high increase rate with maximum of 551% in CF and 703% in LP respectively.

1. Introduction

During recent decades, the generated amount of solid wastes has exponentially increased almost all over the world due to population growth. It was estimated that about 2 billion tons of solid waste were generated in the world's cities during 2016 (World Bank 2019). Compost is made from decomposition of plant and animal remains with the objective of recycling the waste for crop production. The decomposition process during composting converts potentially toxic or putrescible organic matter into a stabilize state which can improve soil quality for plant growth (Adugna 2016). Compost has other beneficial effects, including diverting landfill wastes to alternative uses, removal of pathogens, residues of pesticides and control soil erosion. Compost can improve the capacity to produce safe "clean green" agricultural produce and importantly increase the potential for large-scale organic food production (Paulin and Peter 2008). It contains organic matter providing nutrients to the soil, improves water holding capacity and good aeration providing favorable condition for germination of seeds and root development of crops (Edwards and Hailu 2011).

Soil micro and macro organisms rely on the availability of soil organic matter, therefore, organic amendments protect the soil biodiversity, the functioning of soil processes and the ecosystem services (Siedt et al. 2021).In general, the feedstock material of composts largely determines the quality of the mature compost. Most of the nutrients available from the feedstock materials are consumed by microbes during composting, and are then found in organic forms. Only about 15% of N in mature compost is available in the first year after application, consequently composts are usually not sufficient as the only measure for the management of N in the field(Amlinger et al. 2003). However, due to reduced availability of N-forms in compost, nitrate leaching from soils after compost amendment is reported to be lesser when compared with soil treated with mineral fertilizers (Diacono et al. 2010). Therefore, higher application rate of composts reduces level of groundwater contamination (Erhart et al. 2007). Based upon the types of organic waste generated in different locations, composts having varied quality can be produced. In the present study composts derived from lemon peel, mixed vegetable waste and cooked food waste were selected and amended with garden soil. The change in the physicochemical properties of soil was evaluated in order to investigate the impact of the three types of composts on soil quality.

2. Material And Methods

2.1. Experimental design

Three different types of composts derived from lemon peels (LP), mixed vegetable waste (VW) and cooked food waste (CF) were selected for amendment in garden soil. The study was carried out in Mizoram University Campus located at 20°43'44"N latitude and 92°43'48"E longitude for 270 days during 2019 to 2020. The experimental design of composting and the quality of the composts were described in Lalremruati and Devi (2021).The garden soil used during composting was used for the amendment study. Three pits having length of 58cm, breath of 48cm and depth of 15cm were made for each type of compost amendment in a polyhouse. The removed soil were air dried and mixed with the composts (w/w) at a ratio of 1:1. The soil and compost mixture were kept in the pits. A plot without any treatment of compost was maintained as control (C). The experiment was laid out in completely randomized block design. The plots were sprinkled with water whenever necessary in order to maintain 30 to 35% moisture content throughout the experiment. The experiment was conducted for 270 days.

2.2 Analysis of soil

At an interval of 30 days 300g of the compost amended soil were sampled from each plot from a depth of 0-15cm in order to study the physicochemical properties. Soil sample from the control plot was also collected for the analysis. Three replicates were maintained for each sample totaling to 30 samples. Soil temperature was recorded using a Digital Thermometer at an interval of 30 days in each plot maintaining three recordings in each plot. The composts amended soil were air dried till constant weight, grounded and finely sieved (0.15mm) and evaluated for organic carbon (OC) using Walkley and Black's titration method (Anderson and Ingram 1993), total nitrogen (TN) by using Kjeldahl's digestion method (Bremner 1982), available phosphorus (AP) using molybdenum blue method in $NaHCO_3$ extract (Olson et al. 1954) and available potassium (AK) using Flame Photometer. pH was determined using fresh soil sample taking 1:2.5 compost amended soil :water using Digital pH Meter (Anderson and Ingram 1993).

2.3. Statistical Analysis

Analysis of variance (ANOVA) was used to find variation between the physicochemical properties between the different composts amended soil and between the sampling days. Pearson's coefficient of correlation was evaluated to find correlation between the different parameters. The statistical analysis was done using MS-Excel and SPSS.

3. Results And Discussion

3.1. Change in physicochemical properties

The initial pH in all the composts treated soil was acidic and higher than control (Table 1), with 5.45, 6.52, 6.62 and 6.92 in C, LP, VW and CF composts treatments respectively. During the treatment period it was observed that in all the three types of composts amendment there was no significant variation among the sampling days (Fig. 1), although showing a rise till 120 days and a gradual declining pattern. Maximum increase was recorded in LP with 22% and minimum in CF with 10% ($p<0.01$) at 270 days (Table 2) with nearly neutral pH of 7.1 in LP and a minimum in CF compost treatment with 6.4($P<0.001$).Compost that have a near-neutral or slightly alkaline pH with a high buffering capacity usually elevate pH of acid soils (Shiralipour et al. 1992).Lee et al. (2019) also reported a slight increase in soil pH(7.31 to 7.81) due to treatment of food waste compost at application rates of

10 to 60 Mg/ha compared with control(7.16). Increment in soil pH after compost application was due to decomplexation of metal cations and mineralization of organic N (Amlinger et al. 2007) causing release of K^+, Ca^{2+}, $Mg^{2+}$and OH^-during the degradation of organic products in soil (Erana et al. 2019).

During the amendment period soil temperature in composts treated soils showed a higher level till 240days than control with a maximum range of 28.3 to 45.5°C in CF and minimum of 28.0 to 38.5°C in VW compost treated soil (Fig. 2). Soil temperature showed significant variation among the sampling days (P<0.001)and within the different treatments (P<0.001). At 30 days the increase in temperature was maximum in all the three treatments compared to control with 52, 24 and 20% increase in CF, LP and VW respectively (P<0.01). However, a gradual declining pattern was shown in all composts treatments. At 270 days soil temperature was lower than control in LP and almost similar with control in VW but in CF there was still a 2% higher rate than control. Deguchi et al. (2009) have stated, the main factors contributing to increase in soil temperature due to compost application was the decrease in amount of water drawn from the deeper layers which decreased evaporation. Reduction in evaporation results from reduction in bulk density of soil. Amlinger et al. (2007) have cited more absorbing capacity of solar radiation by the dark colored decomposed organic matter and humic substances contained in the compost. The increase in soil temperature was very high although a gradual decline was observed. The reason can be attributed to the high rate of compost application in the present study. A step to reduce the soil temperature can be, allowing the composts to stabilize for at least 30 days before application in field.

OC was higher in all the composts treated soil compared to control in the initial quality (Table 1). Significant variation of OC was observed among the sampling days (P<0.001)and between the different composts treatments (P<0.001). Maximum range of 3.0 to 4.58% was recorded in CF compost treated soil and minimum in VW with 2.1 to 3.5%during the 270 days period. There was a gradual increase in the initial days, however a declining pattern was recorded till the end of the experiment (Fig. 3).Maximum increase of OC was observed in CF compost treated soil with 106% followed by LP with 64% and 24% in VW at 90 days (P<0.01). At the end of 180 days it was more or less similar with control in VW and LP composts treated soil. However, CF compost treatment showed increase of 2% at 270 days. Brown and Cotton (2011) reported an increase of OC in agricultural soils in California by 3 times due to treatment of compost in comparison to control soils. Riwandi et al. (2015) also reported an increase of OC at 2.76% due to application of compost. Total C increased upto $1.86 gkg^{-1}$ from $0.76 gkg^{-1}$ indicating a rise of 145% and it was positively correlated with microbial community composition(Lee et al. 2019). Application of compost leads to increase in soil organic matter thereby increased OC and providing more void space in soil. The organic matter has a lower density than the mineral fraction of soil which is also refer to as fluff effect (Kranz et al. 2020).

There was a significant variation of TN among the treatments (P<0.001) and within the sampling days (P<0.01). Compared between the three types of composts treatments initial TN was very high in CF with $2.98 gkg^{-1}$ as well as throughout 270 days treatment. In CF the TN increased rapidly upto 60 days recording upto 6.36gkg-1 providing a maximum range of 2.7 to $6.36 gkg^{-1}$. Minimum range was recorded in LP with 1.15 to 1.89 gkg^{-1}. In the composts treated soils a comparatively higher level of TN upto 90 days with 484, 100 and 46% rise in CF, VW and LP (P<0.01) was recorded respectively. However, in LP and VW composts treatments a drastic decline started from 120 days which gradually equals with control at 270 days. However, at 270 days there was still 48% increase of TN in the CF compost treated soil. The high release rate of TN in CF compost can be attributed to the low initial C/N ratio. Similar observations on increase in TN due to treatment of food waste compost was reported by Kelly et al. (2020) with 11%. They also observed that compost derived from food waste provided more N benefits than cow manure-derived composts and have greater nutrient value.

Initial AP was higher in the composts treated soils compared to control (Table 1). Significant variation of AP was observed among the sampling days ($P<0.001$) and within the treatments ($P<0.001$).A gradual increase in AP upto 60 days in all composts treatments was recorded (Fig. 5). Maximum was recorded in CF with a range of 43.42 to 121.03mgg^{-1} throughout the experiment. In VW it varied from 43.73 to 102.42mgg^{-1} and in LP it varied from 32.0to 108.3 mgg^{-1}. At 90 days a maximum increase of 787% in CF, 541% in LP and 532% in VW ($P<0.001$) was recorded followed by a gradual declining pattern. At 270 days there was still a very high increase rate with 551, 350 and 269% in CF, VW and LP treatments respectively. Kelly et al.(2020) reported a similar increase of 127% in AP due to treatment of food waste compost in soil. Manirakiza and Seker (2020) was reported an increase of AP by 48.7$mgkg^{-1}$in soil due to application of compost.

Initial AK was maximum in VW with 320$mgkg^{-1}$and minimum in CF with 80$mgkg^{-1}$. Significant variation of AK was also observed among the sampling days ($P<0.03$) and within the treatments ($P<0.001$). Maximum AK was recorded in VW with a range of 230.2 to 648.42$mgkg^{-1}$ and minimum in CF with a range of 103.3 to 256.0$mgkg^{-1}$throughout the experiment (Fig. 6). Maximum increase of 1383% in VW and minimum of 207% in CF was recorded at 90 days. There was a gradual decline in all treatments however similar to AP at the end of 270 days the level of AK was still high with 703, 503 and 170% increase rate in LP, VW and CF treatments respectively ($P<0.05$). Manirakiza and Seker (2020) reported an increase of AK by 397 $mgkg^{-1}$with 2% application rate of compost due to high presence of potassium in compost which was later released into soil through microbial degradation. Akoijam et al. (2017) also reported a significantly higher level of AK in soil due to treatment of flower waste, fish waste and sugarcane bagasse.

3.2. Correlation among the soil characteristics

In LP compost treated soil OC showed significant positive correlation with AP ($r=0.83;P<0.05$) and AK ($r=0.74;P<0.05$) (Table 3). Significant positive correlation was also recorded between AP and AK in LP compost treatment($r=0.90;P<0.01$). In VW compost treatment significant positive correlation was recorded between AP and AK ($r=0.80;P<0.05$) only. In CF compost treatment significant positive correlation was recorded between soil temperature and OC ($r=0.92;P<0.01$); soil temperature and TN ($r=0.80; P<0.05$) and TN with AP ($r=0.83; P<0.05$). In control only AP was significantly correlated with AK($r=0.82; P<0.05$).The significant correlation of AP and AK in LP, VW and C showed that a similar trend existed in availability and declining pattern of AP and AK in soil. The role of OC and TN in regulating soil temperature in CF compost treatment was prominent from the correlation studies. Since OC and TN was maximum in CF the soil temperature was more regulated.

4. Conclusions

The study showed that treatment of LP and VW compost can lead to an increase in OC upto a period of 180 days and CF compost upto 270 days. Treatment of CF compost leads to a massive increase in TN till 270 days. In LP treatment the TN was regulated only upto 90 days and in VW upto 180 days. The AP and AK in all treatments maintained a high rate of increase till 270 days. The results indicated that the three types of composts can be amended in agricultural fields where seasonal crops are cultivated in place of inorganic fertilizers. Bhogal et al. (2007) estimated that over a 20- year period, the application of garden organic compost at a rate of 10Mg/ha/yr will save around 2282kg CO_2 equivalent green house gas emissions. Application of compost in agricultural fields reduced cost of managing solid waste, provides alternative to inorganic fertilizer and also serves the purpose of reducing impact of climate change.

Declarations

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Credit authorship contribution statement

The authors equally contributed to the present study.

Declaration of competing interest

The authors declare that they have no competing interest.

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References

1. Adugna G (2016) A review on impact of compost on soil properties, water use and crop productivity. Academic Research Journal of Agricultural Science and Resources 4, 93-104. https://doi.org/10.14662/ARJASR2016.010
2. Akoijam Y, Devi AS, Singh JE (2017) Impact of solid wastes treatment on growth pattern of *Capsicum annum* and Soil properties. Environment and Ecology 35:2813-3816
3. Amlinger F, Peyr S,Geszti J (2007) Beneficial effects of compost application on fertility and productivity of soils. Report produced for the Federal Ministry of Agriculture and Forest. Germany, pp 235
4. Anderson JM, Ingram JSI (1993) Tropical Biology and Fertility: A Handbook of Methods. CAB International, Wallingford, UK
5. Bhogal A, Chambers BJ, Whitmore AP, Powlson DS (2007) The effect of reduced tillage practices and organic matter additions on the carbon content of arable soils. Scientific Report SPO561. Department of Environment, Food and Rural Affairs. London UK, p47
6. Bremner JM (1982) Total nitrogen. In: Black CA(Ed) The Methods of Soil Analysis Part II Winconsin American Society of Agronomy Inc Publisher, Madison, pp1149-1178
7. Brown S, Cotton M (2011) Changes in soil properties and carbon content following compost application. Results of on-farming sampling. Compost Science and Utilization 19:87-96
8. Deguchi S, Kawamoto H, Tanaka O, Fushimi A, Uozumi S (2009) Compost application increase the soil temperature on bare Andosol in a cool climate region. Soil Science and Plant Nutrition. https://doi.org/10.1111/j.1747-0765-2009.00420.x

9. Diacono, Mariangela, Montemurro, Francesco (2010) Long- term effects of organic amendments on soil fertility. A review Agronomy for Sustainable Development. https://doi.org/10.1051/agro/2009040
10. Edwards S, Hailu A (2011) How to make compost and use. In:Ching LL, Edwards S and Nadia H S(Eds).Climate change and food systems Resilience in Sub-Saharan Africa. FAO, Italy, pp 379-436
11. Erana FG, Tenkenga TA, Asfaw, SL (2019) Effect of agroindustrial wastes compost on soil health and onion yields environments: Study at field condition. International Journal of Recycling of Organic Waste in Agriculture. https://doi.org/10.1007/S40093-2019-0286-2
12. Erhart, Eva, Feichtinger, Franz H, Wilfried (2007) Nitrogen leaching losses under crops fertilized with biowaste compost compared with mineral fertilization. Journal of Plant Nutrition and Soil Science. https://doi.org/10.1002/jpln.200625181
13. Kelly A, While AC, Maltais-Landry G (2020) Food based composts provide more soil fertility benefits than cow manure-based composts in sandy soils. Agriculture. https://doi.org/10.3390/agriculture 10030069
14. Kranz CN, McLaughlia RA, Johnson A, Miller G, Hutman JL (2020) The effects of compost incorporation on soil Physical properties in urban Soils. A concise review.Journal of Environmental Management. https://doi.org/10.1016/j.jenvman.2020.110209
15. Lalremruati M, Devi AS (2021) Changes in physiochemical properties during composting of three common household organic solid wastes amended with garden soil. Bioresource Technology Reports. https://doi.org/10.1016/J.biteb.2021.100727
16. Lee CH, Park SJ, Hwang HY, Kim MS, Junug H, Luyima D, Homg SY, Oh TK, Kim SH(2019) Effects of food waste saturated and unsaturated soil condition. Applied Biological Chemistry. https://doi.org/10.1186/S/13765-2019-0445-1
17. Manirakiza N, Seker C (2020) Effects of compost and biochar amendments on soil fertility and crop growth in a calcareous soil. Journal of plant nutrition. https://doi.org/10.1080/101904167.2020.1806307
18. Olsen SR, Cole CV, Watanabe FS, Dean LA (1954) Estimation of available phosphorus in soils by extracting with sodium bicarbonate. USDA Circ 939, US Government printing office, Washington DC
19. Paulin B, Peter OM (2008) Compost production and use in horticulture. Western Australian Agricultural Authority Bulletin 4746
20. Riwandi, Handajaningsih M, Hasanudin, Munawar A (2015) Soil quality improvement using compost and its effects on organic-corn production. Journal of Tropical Soils. https://doi.org/10.5400/jts.2015.20.1.11
21. Shiralipour A, McConnel DB, Smith WH (1992) Physical and chemical properties of soils as affected by municipal solid waste compost application. Biomass Bioenergy 3: 261-266
22. Siedt M, Schaffer A, Smith KEC, Nabel M, Rob-Nickoll M, vanDongen JT (2021) Comparing straw, compost and biochar regarding their suitability as agricultural soil amendments to affect soil structure, nutrient leaching, microbial communities, and the fate of pesticides. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2020.141607
23. World Bank Solid Waste Management(2019) http://www.worldbank.org/en/topic/urban development/brief/solid-waste-management

Tables

Table 1: Initial quality of composts amended and unamended soil.

	LP	VW	CF	C
pH	6.52±0.12	6.62±0.12	6.92±0.11	5.45±0.41
OC(%)	2.90±0.04	2.47±0.05	3.37±0.04	2.18±0.02
TN(gkg^{-1})	1.10±0.01	1.10±0.01	2.9±0.5	0.8±0.01
AP(mg kg^{-1})	59.0±2.0	56.0±3.0	66.0±2.5	10.0±0.5
AK ($mgkg^{-1}$)	203.0±12.0	320.0±23.0	80.0±5.6	30.0±2.1
C:N	27	24	16	25

Table 2: Change (%) in soil characteristics due to treatment of composts

PH					Soil temperature				OC			
	90d	180d	270d	P	90d	180d	270d	P	90d	180d	270d	P
LP	30	32	22	P<0.05	24	2	-1	P<0.01	64	10	0	P<0.05
VW	26	27	12	P<0.05	20	0	0.3	P<0.01	24	7	-5	P<0.01
CF	7	1	10	P<0.01	52	14	1.79	P<0.01	106	45	14	P<0.01
	TN				AP				AK			
	90d	180d	270d	P	90d	180d	270d	P	90d	180d	270d	P
LP	46	-2	-2	P<0.05	541	220	269	P<0.05	1063	839	703	P<0.05
VW	101	3	-7	P<0.05	532	339	350	P<0.05	1383	487	503	P<0.05
CF	484	43	48	P<0.05	787	225	551	P<0.05	207	204	170	P<0.06

Table 3: Pearson’s coefficient of correlation (r; n=9) among the soil characteristics

		OC(%)	TN(mkg^{-1})	AP($mgkg^{-1}$)
LP	AP($mgkg^{-1}$)	0.83**	Insig.	Insig.
	AK($mgkg^{-1}$)	0.74**	Insig.	0.90*
VW	AK($mgkg^{-1}$)	Insig.	Insig.	0.80**
CF	Temp (^oC)	0.92*	0.80**	Insig.
	TN(gkg^{-1})	Insig.	Insig.	0.83**
C	AK($mgkg^{-1}$)	Insig.	Insig.	0.82**

Insig.: insignificant; *: significant at p<0.05; **: significant at p<0.01.

Figures

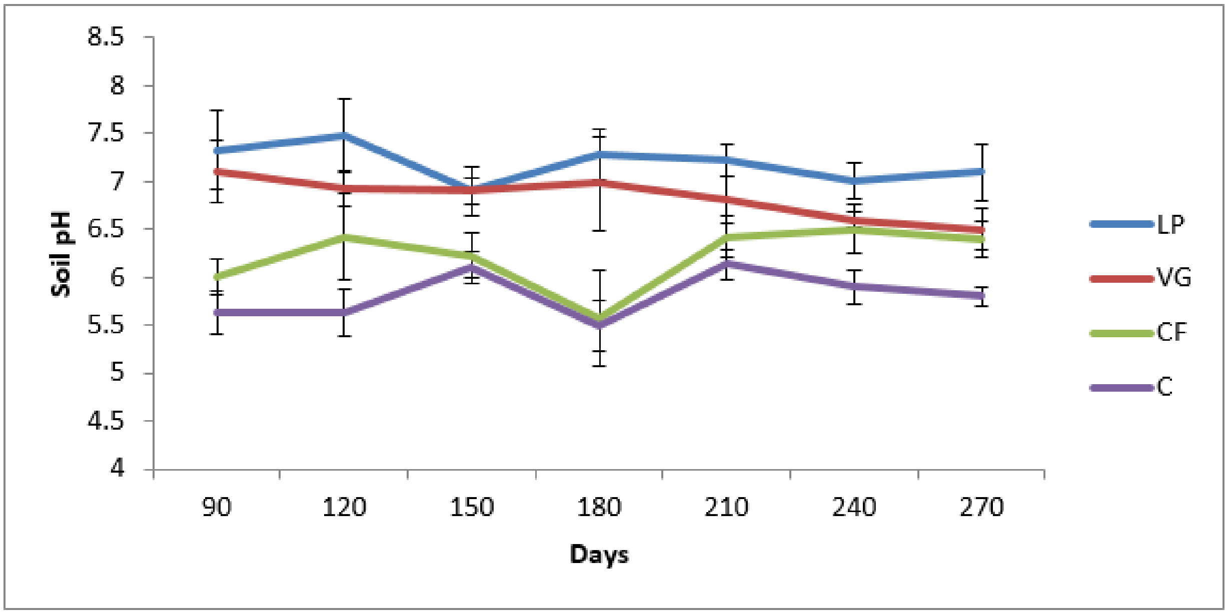

Figure 1

Variation of pH in the composts treated soil and control.

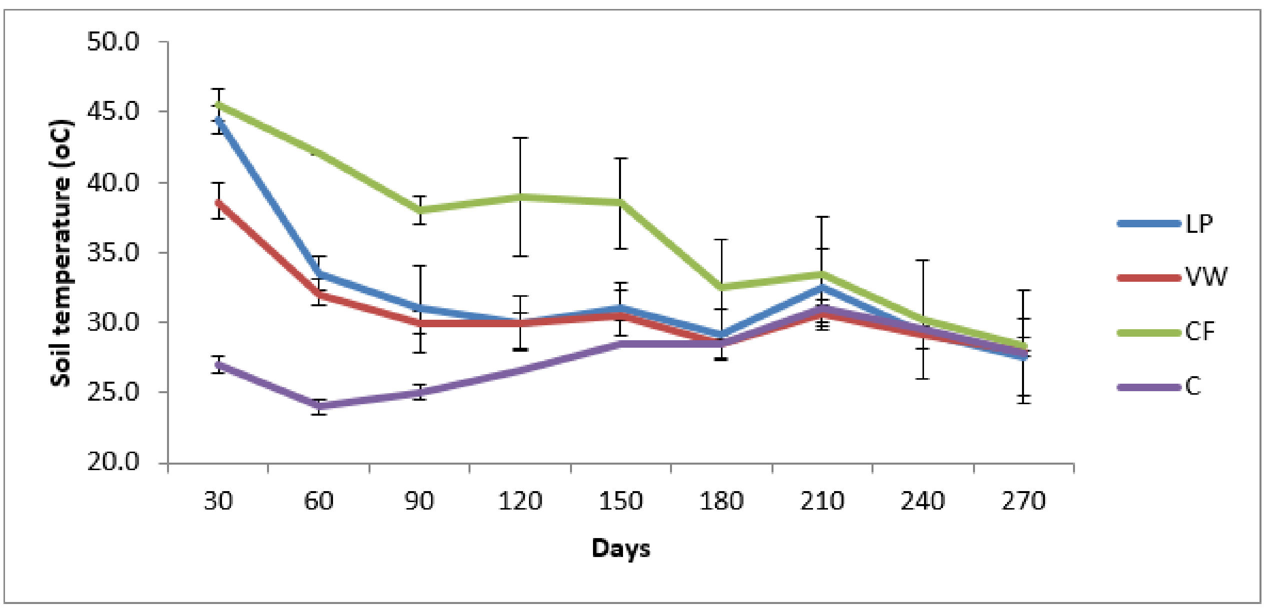

Figure 2

Variation of soil temperature (^{o}C) in the composts treated soil and control.

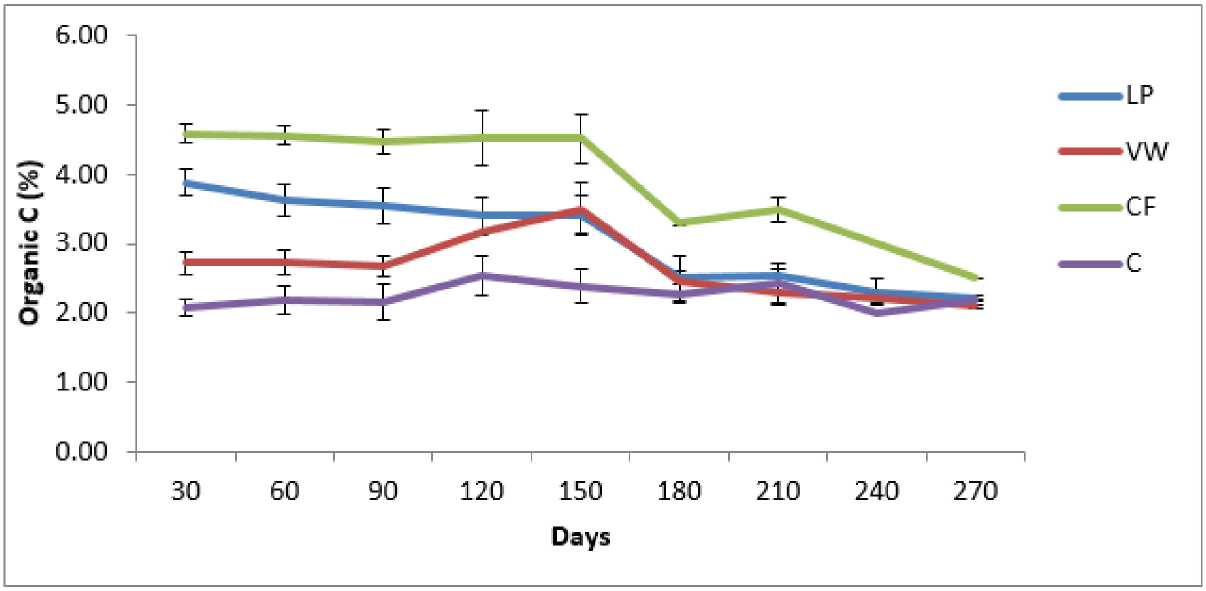

Figure 3

Variation of organic C (%) in the composts treated soil and control.

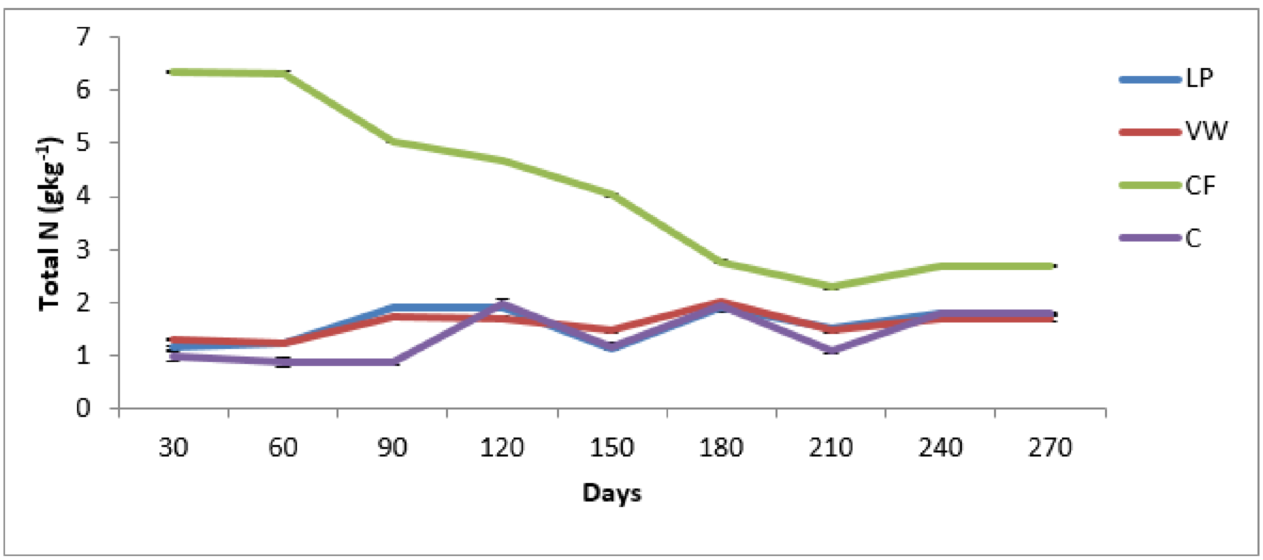

Figure 4

Variation of total N (gkg^{-1}) in the composts treated soil and control.

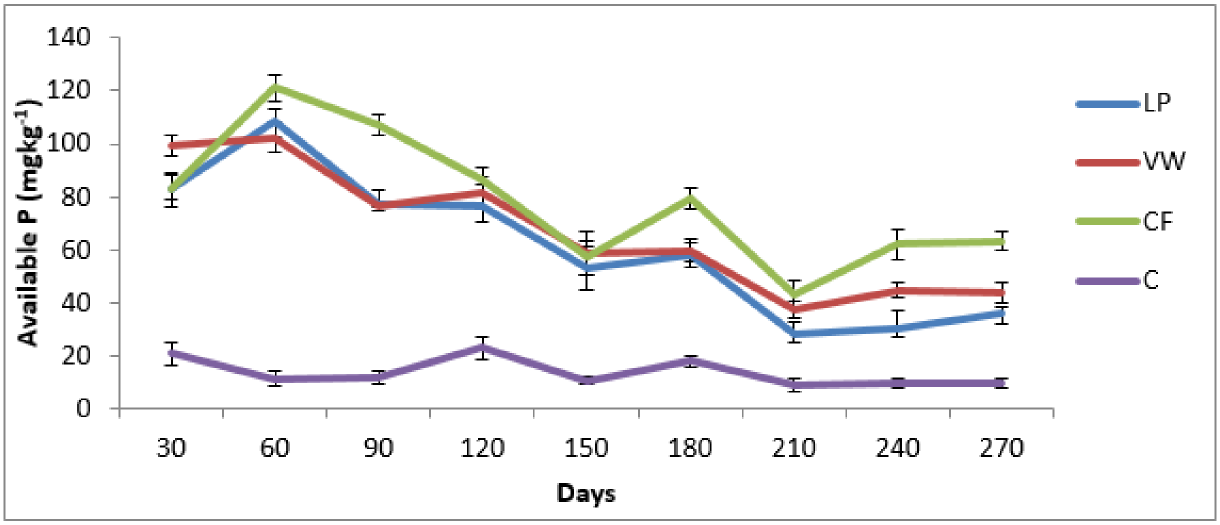

Figure 5

Variation of available P ($mgkg^{-1}$) in the composts treated soil and control.

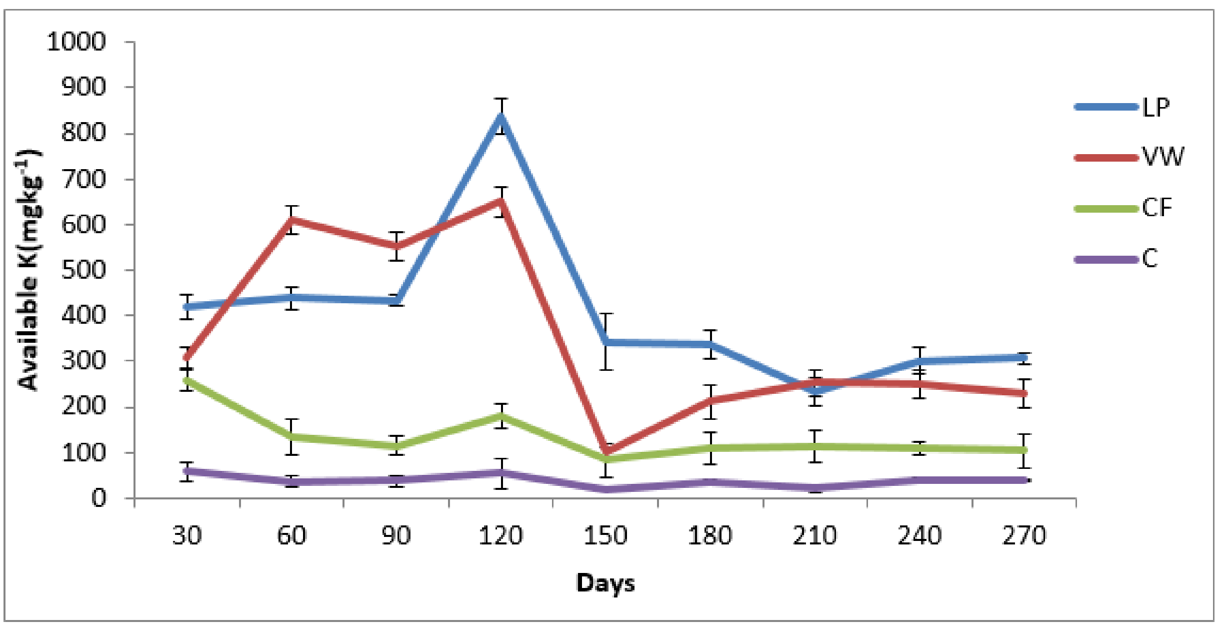

Figure 6

Variation of available K ($mgkg^{-1}$) in the composts treated soil and control.