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Research article

AN ECO-FRIENDLY MANAGEMENT OF HOUSEHOLD GENERATED ORGANIC WASTE

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Abstract

The household organic wastes commonly include dust, food and kitchen waste, garden waste, paper waste etc. that generated everyday from every house. This highly nutritive organic waste is the house of infectious bacteria, vector and insect. A study was conducted to explore the possibility of vermicomposting of household generated organic waste at home level. For this study household waste (HW) and garden (leaves with soil-dust) waste (GW) were selected. They were mixed with dried dung powder (DDP) and vermicompost (VC) in different ratios. The mixture (20 kg) was subjected for pre-decomposting for a period of 15-20 days, followed by release of 50 earthworms (*E. eugeniae)*, with regular observations (moisture remain up to 60-70%, pH, temperature (20-28°C), survivability of earthworms) in different culture media were recorded up to 80 days. At end of the experiment observations were made in terms of number and weight of earthworms, juveniles and cocoons. Analysis of vermicompost was also done for values of pH, nitrogen, phosphorus and potassium. The best results of earthworm as well as vermicompost parameters were obtained in the mixture containing equal quantity of KW+DDP+GW+VC with a maximum increase in worm population and worm biomass. Maximum fertilizer values of nitrogen, potassium and phosphorus content were observed in this mixture. It can be concluded that organic waste generated from home and gardencan easily be converted into high quality valuable compost at home level with fruitful outcome.

Keywords: Household waste; Dry dung powder; *Eudrilus eugeniae*; Garden waste; Vermicomposting; Waste recycling.

INTRODUCTION

The problem of solid waste management has been increased due to rapid increase of population, intensive agriculture and industrialization. Accumulation and improper methods of disposal of waste, including heaping, dumping, land filling and incineration, cause pollution and hazards to human and environmental health. Large quantities of organic waste are produced and they pose major environmental (offensive odours, contamination of ground water and soil) and disposal problems worldwide (Edwards and Bater, 1992). Effective disposal of different types of waste has become important to maintain healthy environment (Senapati and Julka, 1993). To solve this problem scientists are in search of better management alternative, which should be eco-friendly, cheap and rapid particularly suited to general conditions. Vermicomposting has become an appropriate alternative for the eco-friendly and cost effective management of organic solid wastes (Hand *et al.,* 1998; Raymond *et al.,* 1988; Harris *et al.*, 1990; and Lodgsdon, 1994). Earthworms decompose organic waste leading to the production of vermicompost which is high in nutrients content compared to their simple compost (Buchanam *et al.*, 1988). This vermicompost will be an alternate for chemical fertilizers which are used to improve soil fertility, growth and yield of plants.

Vermicomposting is the application of earthworm in producing vermifertilizer, which helps in the maintenance of better environment and results in sustainable agriculture (Senapati, 1996). Vermicomposting of organic solid wastes is the physio-biochemical process of earthworms; substrate aeration, mixing as well as grinding include physical process while the biochemical process is influenced by microbial decomposition of substrate in the intestine of earthworms (Hand *et al.,* 1998). Vermicomposting of organic wastes accelerates organic matter stabilization (Neuhauser *et al.*, 1998 and Frederickson *et al.*, 1997) and gives chelating and photohormonal elements (Tomati and Galli, 1995) which have a high content of microbial matter and stabilized humic substances.

Several studies have demonstrated that owing to their high nutrient value, organic waste (food and vegetable waste) could provide valuable resource, if properly handled through recycling including composting and vermicomposting. The native organic waste is not suitable for survival and growth of environment friendly aerobic bacteria and earthworms due to high moisture content, bulk density, improper C/N ratio, acidic pH and anaerobic conditions. If these conditions are optimized by amending the waste with other stuffs, vermicomposting can be successfully performed. Earlier studies have demonstrated that organic (vegetable and kitchen wastes) can be successfully processed through vermicomposting after mixing with other waste stuffs and cattle dung (Chaudhary *et al.*, 2000; Bharadwaj, 2010; Chauhan *et al.*, 2010; Khwairakpam and Kalamdhad, 2011; Gezahegn*et al.*, 2012; Sunitha, 2012; Mehta and Karnwal, 2013). These experiments were conducted in the laboratory and have complex and cumbersome steps involving chopping, sun / air drying, powdering, mixing with large amounts of cattle dung were involved. It has been demonstrated household organic waste can be vermicomposted in combination with sand-soil mixture and shredded paper using a simpler method in bamboo baskets (Dandotiya and Agrawal, 2013). Simple methods of vermicomposting of particular waste category should have high degree of adaptability.Considering all above facts, the present study assessed the simple method of organic waste of household management at home level.

MATERIALS AND METHOD

In the present study efforts were made to recycle organic waste of household and garden through culture of earthworm *Eudrilus eugeniae* in plastic containers (20 kg capacity), with four holes in the bottom for removal of excess of liquids. Experiments were conducted in different ratios of household organic waste (HW), garden waste (GW), dry dung powder (DDP) and vermicompost (VC). The mixtures were well mixed with each other with respect to their ratio and kept it with proper moisture for pre-decomposition for 15-20 days. During this total period of 15-20 days heat and foul smell produced by anaerobic bacteria based decay of waste get reduced, pathogenicity declines and activities of aerobic bacteria get enhanced. Now 50 earthworms (*E. eugeniae)* were released in each container and the containers covered with garden mesh, were maintained for 80 days. Water is sprinkled for maintaining proper moisture and timely turning of waste mixture compulsory for aeration. The earthworm population and cocoons were estimated by hand sorting and counted at the completion of 80 days through washing over a sieve (Kale and Krishnamoorthy, 1982).

Then observations on the number and weight of adult, baby worms, juveniles and cocoons, worm population growth and biomass production were recorded.All results reported are the means of three replicate. The results were statistically analyzed at 0.05 levels using one way analysis of variance (ANOVA) and Bonferroni t- test was used as a post-hoc analysis to compare the means (Sigma Stat, Version 3.5).

The followings chemical parameters of vermicompost were analyzed: Total Kjeldahl nitrogen (N) was determined as per method of (Bremner and Mulvaney, 1982). Available phosphorus was analyzed by employing method (Olsen et al. 1954) and Potassium was determined by ammonium acetate extractable method (Simard, 1993). The pH of the composts was determined using glass electrode pH meter (Jackson, 1973).

RESULTS AND DISCUSSION

It was observed in separate preliminary experiment that earthworms do not survive in decaying fresh/pre-decomposed household and garden waste. Their performance was not satisfactory in pre-decomposed mixtures of household waste and garden waste. On the other hand, earthworms survived well in 3 or 4 types of waste mixtures of household organic waste (HW), garden waste (GW), dry dung powder (DDP) and vermicompost (VC).Thus it was decided to use variable amount of household organic waste (HW) and garden waste (GW) with dry dung powder (DDP) and vermicompost (VC) in order to balance its moisture and nutrient content and C/N ratio. It was observed that the number of adult worms, total bio-number (Adults + baby worms+ juveniles + cocoons) and respective biomass increased when household organic waste (HW) and garden waste (GW) mixed with dry dung powder (DDP) and vermicompost (VC) mixture. Thus the best results were recorded in HW+DDP+GW+VC (1:1:1:1) with a maximum increase in worm population (434%) and worm biomass (269.30%) increase in biomass which is better in comparison of their standard medium dung in which 406.68 % increase in worm population and 248.66 % increase in biomass. With household waste alone and garden waste alone rather lesser or negative number of worms, babies and cocoons and lesser amount of biomass were observed (Table 1, 2 and Fig. 1), indicating that alone household waste creates unsuitable conditions of pH, aeration, C/N ratio for the life of earthworms and an optimum ratio of waste materials is required for satisfactory vermicomposting performance. It was noticed that foul smell begins to emerge from the decaying waste biomass from 2-3rd day and the biomass gets heated. In household waste alone, the foul smell was very strong, long-lasting and unbearable, while in mixtures of three or four wastes, the smell was mild and disappeared within 10 days. The temperature of the mixture also cooled down a faster rate. The pH of the organic waste is vary from acidic to basic (2.5 up to 9.5) during predecomposition and basic to neutral (9.5 up to 7.1) during vermicomposting.

The observations further revealed that number and weight of earthworms (including adult, baby worms and juveniles) increased in all waste. Higher values of both parameters (number and weight of worms) in the form of percent change in number and weight of worms were reported, *viz.* 22 % and 84.58 % in HW+DDP (1:1), 36.66 % and 116.28 % in HW+GW+VC (1:1:1), 38.66 % and 121.01 % GW+VC (1:1), 43.34 % and 120.65 % in GW+DDP (1:1), 48 % and 127.38 % in HW+DDP+GW(1:1:1), 60.66 % and 146.39 % in HW+DDP+VC (1:1:1), 62.66 % and 155.03 % in GW+DDP+VC (1:1:1), 68 % and 176.55 % in dung alone (+ve control) and the highest percent change in number (78.66 %) and weight of worms (192.37 %) were observed in HW+DDP+GW+VC (1:1:1:1) are depicted in figure- 1. Number and weight of cocoons increased in all waste combinations except household waste alone and garden waste alone (table 1 and 2). The results of population growth and biomass production of earthworms showed variations in different culture media was 226.66 % and 127.01 % in HW+DDP (1:1), 292.66 % and 166.02 % in HW+GW+VC (1:1:1), 303.98 % and 173.88 % GW+VC (1:1), 332.66 % and 175.75 % in GW+DDP (1:1), 352.66 % and 188.44 % in HW+DDP+GW(1:1:1), 388 % and 208.85 % in HW+DDP+VC (1:1:1), 396 % and 220.04 % in GW+DDP+VC (1:1:1), 406.68 % and 248.66 % in dung alone (+ve control) and the highest percent population growth (434 %) and weight of worms (269.3 %) were observed in HW+DDP+GW+VC (1:1:1:1) are shown in figure- 1. Thus it seems that household waste, garden waste, dry dung powder and vermicompost mixture is a suitable medium for vermicomposting.

After predecomposition period of 15-20 days, pH value of all these raw organic waste was observed as high during the vermicomposting process, pH value of phases was increasing due to mixing of inoculants and this was slightly decreasing as shown in graph. It shows that the alkalinity of the bio-compost is slowly reducing in the process (Fig.2). The chemical composition of compost and vermicompost including total nitrogen (N), total phosphorus (P) and potassium (K) content have shown in fig. 3, 4 and 5 respectively. These values were found maximum in vermicompost than simple compost. It has been proved that vermicompost is highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective farm input' against the 'destructive' chemical fertilizers which have destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NPK (nitrogen 2-3%, phosphorus 1.55-2.25%, and potassium 1.85-2.25%), micronutrients, beneficial soil microbes and it also contains plant growth hormones and enzymes.

Vermicompost retains nutrients for longer time, while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NPK to the plants. Vermicompost contains plant hormones like auxin and gibberlins and enzymes which are believed to stimulate plant growth and discourage plant pathogens. It improves the fertility and water holding capacity of the soil. It also enriches the soil with useful microorganisms which add different enzymes like phosphatases and cellulases to the soil.

As early as in 1910 it was reported by Russel that earthworms rapidly decompose organic matter and increase nitrification in the soil which increases crop production. Later on it was observed that of epigeic earthworms can be used for bioconversion of large amounts of organic wastes into high quality compost and the process is known as vermicomposting (Edwards *et al*., 1998; Kale *et al*., 1982; Benitez *et al*., 2000; Aira *et al*., 2002; Agrawal, 2005 a, b, 2008; Agrawal and Agrawal, 2006; Ranganathan, 2006; Kaur *et al*., 2010; Suriyanayanam *et al.*, 2010). It was reported by Kale and Krishnamoorthy (1978) that different species of earthworms have different preferences towards organic matter and cattle dung is the best medium for vermiculture. Different types of organic wastes can be used for vermicomposting, mostly in combination with cattle dung.

Some earlier workers have demonstrated that household (food and kitchen) waste mixed with other waste stuffs and cattle dung can be subjected to vermicomposting process. Small pieces of sun and air - dried kitchen waste topped by garden soil in earthen bowls was used for vermicomposting using *Perionyx excavates* (Chaudhary *et al*., 2000). Chauhan *et al.* (2010) employed mixture of equal amounts (W/W) of small pieces of partially decomposed vegetable waste and partially decomposed cow dung for vermicomposting in plastic containers using *Eisenia foetida*, *Eudrilus eugeniae*, and *Perionyx excavates*. The best results were obtained with *Eisenia foetida*, followed by *Eudrilus eugeniae.* It was reported by Khwairakpam and Kalamdhad (2011) that vegetable waste was not ideal for growth and reproduction of earthworms, but when amended with cattle manure produced high quality stable compost free from pathogens using different earthworm species *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavates* in monocultures and polyculture set ups. In most of the studies larger amounts of dung was mixed with kitchen waste, without considering the fact that the target waste is organic waste, not the dung. Further, the target waste was usually subjected to cumbersome processes of chopping, air drying, powdering, mixing it with cattle dung, aerobic self-composting and finally vermicomposting (Bharadwaj, 2010; Chauhan *et al.*, 2010; Khwairakpam and Kalamdhad, 2011; Gezahegn*et al.,* 2012; Punde and Ganorkar, 2012; Mehta and Karnwal, 2013). Such complicated techniques are un-desirable and may become hurdle in popularization of vermicomposting.

The present findings showed similarity to Sunitha (2012) who has identified that leachate, fly menace, obnoxious odors are the major problems of decaying food and kitchen wastes. These problems could be solved by simple use of Leachate Absorbing Raw Material (LARM) like cocopith, bagasse or jute waste for complete aerobic composting and vermicomposting. Such LARM (cocopith, bagasse or jute waste) are not available everywhere, therefore in the present study dry dung powder and vermicompost act as LARM and serve for the purpose of balancing the nutrient content, C/N ratio and bulk density of the waste medium to make it suitable for vermicomposting. It is interesting to note that vermicomosting performance of household organic waste (HW), garden waste (GW), dry dung powder (DDP) and vermicompost (VC) (1:1:1:1) mixture was at par with dung alone (control). Hence household and garden waste can be easily vermicomposed at home level without involvement of complex and cumbersome processing. The results of present study on increase in number and weight of earthworms were in accordance with that of other workers (Chauhan *et al*., 2010 and Shweta *et al*., 2006).

Chemical composition of compost and vermicompost:

pH value of all these raw organic waste was observed as high during the vermicomposting process, pH value of phases was increasing due to mixing of inoculants and this was slightly decreasing as shown in graph. It shows that the alkalinity of the bio-compost is slowly reducing in the process (Fig.2). The near-neutral pH of vermicompost may be attributed by the secretion of NH_4^+ions that reduce the pool of H^+ ions (Haimi and Huhta, 1987) and the activity of calciferous glands in earthworms containing carbonic anhydrase that catalyze the fixation of CO_2 as $CaCO_3$, thereby preventing the fall in pH (Kale and Krishnamoorthy, 1982).

The chemical composition of vermicompost including total nitrogen (N), total phosphorus (P), and potassium (K) content was maximum than compost (shown in fig. 3, 4 and 5 respectively). The chemical composition of vermicompost of present study is in consistence with the findings of Kale (1995) who have described the composition of the vermicompost as: total nitrogen - 0.5 to 1.5%, available phosphorus - 0.1 to 0.3% and available potassium - 0.15 to 0.56%. The vermicompost acts as an excellent base for the establishment and multiplication of beneficial / symbiotic microbes.

According to Dominguez *et al*. (1997) vermicompost is rich in nutrients like nitrogen, phosphorus, potassium, calcium, sodium, magnesium, iron, zinc, manganese, copper, boron and aluminum. Srivastava and Beohar (2004) reported that vermicompost is a good substitute for chemical fertilizers and has more NPK than normal heap manure. Significantly accelerated mineralization of organic wastes and increased total nitrogen, potassium and phosphorus contents were also reported by Garg *et al.* (2006); Hashemimajd *et al.* (2006); Yang *et al.* (2006); Hernandez *et al.* (2007) and Suthar (2007).

Increase in nitrogen and phosphate in all the ratios may be due to mineralization of added soil through earthworm activity. As we know vermicomposting is an aerobic, bio-oxidation and stabilization non thermophilic process of organic waste decomposition that depends upon earthworms to fragment, mix and promote microbial activity (Gunadi *et al*., 2002). Soil might have provided organically bound nitrogen and phosphate which after breakdown by earthworms and micro-organisms converted into inorganic forms which are readily available to plant utilization. As our results indicated, Ghosh *et al*. (1999 and 2000) also found that inoculation of epigeic species of earthworms to the organic wastes during composting helps to enhance the transformation of organic phosphorous into mineralization form.

Vermicomposting is a natural and efficient way of recycling organic household waste. Given the right environment and appropriate routine attention, our household waste can be converted to valuable compost faster than the traditional composting procedure. Worm composting also prevents stinking smells from the decomposing materials due to the fast action of the worms in eating those garbage. With the right equipments, vermicomposting is quite clean and odourless and can be conducted indoors. Development of simple method of vermicomposting of household (food and kitchen) and garden waste should be a welcome event as it will help in solving problems of solid waste management and in improving community health.

CONCLUSION

It can be concluded from the present study that household and garden waste or domestic organic waste can be recycled at consumer (home) level by amending with dry dung powder and/or vermicompost in container or tank units. Except during early periods of experiment, no problem of foul smell and insect nuisance was observed. The method is simple, efficient, inexpensive and user friendly. The physicochemical parameter pH was found that the earthworms were sensitive to pH (6.8 to 9.5). In vermicompost, fertilizer values were found in higher concentration than compost. Vermicomposting of household waste at home level must be promoted for management of waste at their origin and large scale vermicomposting practice may have far reaching effect in environmental conservation, organic farming, sustainable development and improving community health. It will reduce the burden of Nagar Nigam and would ease their tasks. Moreover, this waste management technology mediated by earthworms could also be utilized for self employment, resource generation in rural areas and a big income generation resource especially in urban cities.

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Table -1. Showing number of adults, juveniles and cocoons of *E. eugeniae*

S.N.	Organic Ratio	Initial No. of worms	Final No. of worms (Mean±S.E.)	No. of baby worms and Juveniles (Mean±S.E.)	No. of cocoons (Mean±S.E.)
1	HOW alone	50	0.0*	0.0*	0.0*
2	GW alone	50	0.0*	0.0*	0.0*
3	HOW+DDP (1:1)	50	61.00 ±2.3*	70.00±4.58*	52.33±3.53*
4	HOW+GW (1:1)	50	0.0*	0.0*	0.0*
5	HOW+VC (1:1)	50	29.00 ±4.72*	15.33±2.02*	0.0*
6	HOW+GW+VC+ (1:1:1)	50	68.33 ±2.4*	73.33±2.6*	54.67±4.41*
7	HOW+DDP+VC (1:1:1)	50	80.33 ±0.88#	85.00±2.3#	19.67±1.45#
8	HOW+DDP+GW (1:1:1)	50	74.00±1.73*	83.33±2.33*	69.00±1.15*
9	HOW+DDP+GW+VC (1:1:1:1)	50	89.33 ±2.02ns	93.00±2.3 ns	84.67±1.76 ns
10	Dung alone (control)	50	84.00±2.88	91.67±2.4	80.67±2.6

Values are expressed as mean± SE of three observations (n=3)P<0.050
(*) = values are significant when compared to control
(#) = values are at par when compared to control
(ns)=Not significant value when compared to control

Table -2. Showing weight (gm) of adults, baby worms, juveniles and cocoons of *E. eugeniae*.

S.N.	Organic Ratio	Initial wt. of worms (gm)	Final wt. of worms (gm) (Mean±S.E.)	Wt. of baby worms and Juveniles(gm) (Mean±S.E.)	Wt. of cocoons(gm) (Mean±S.E.)
1	HOW alone	65.48±1.2	0.0*	0.0*	0.0*
2	GW alone	64.72±1.72	0.0*	0.0*	0.0*
3	HOW+DDP (1:1)	67.0±1.28	123.67±3.38*	28.09±2.51*	0.34±0.02*
4	HOW+GW (1:1)	64.3 ±1.3	0.0*	0.0*	0.0*
5	HOW+VC (1:1)	65.48±1.2	36.24±4.94*	4.5±0.6*	0.0*
6	HOW+GW+VC+ (1:1:1)	62.95±1.29	136.15±6.09*	30.95±1.1*	0.36±0.03*
7	HOW+DDP+VC (1:1:1)	65.45±1.29	161.26±1.57#	40.21±2.15#	0.67±0.03#
8	HOW+DDP+GW (1:1:1)	65.89±1.8	149.82±3.75*	39.73±1.93*	0.5±0.07*
9	HOW+DDP+GW+VC (1:1:1:1)	61.56±2.26	179.98 ±3.75ns	46.64±0.46 ns	0.72±0.01 ns

10	Dung alone (control)	63.85±1.23	176.58±3.75	45.36±1.00	0.68±0.01

Values are expressed as mean± SE of three observations (n=3)P<0.050
(*) = values are significant when compared to control
(#) = values are at par when compared to control
(ns)=Not significant value when compared to control

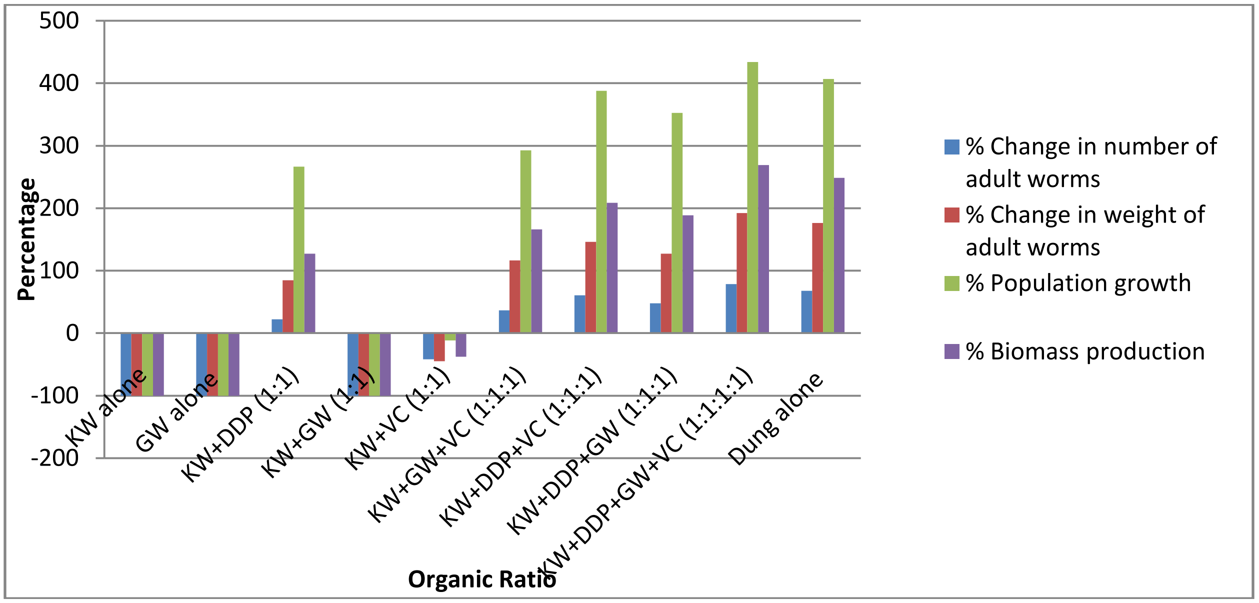

Figure- 1- Percent change in number, weight of adults, Population growth rate & % biomass production in different combination.

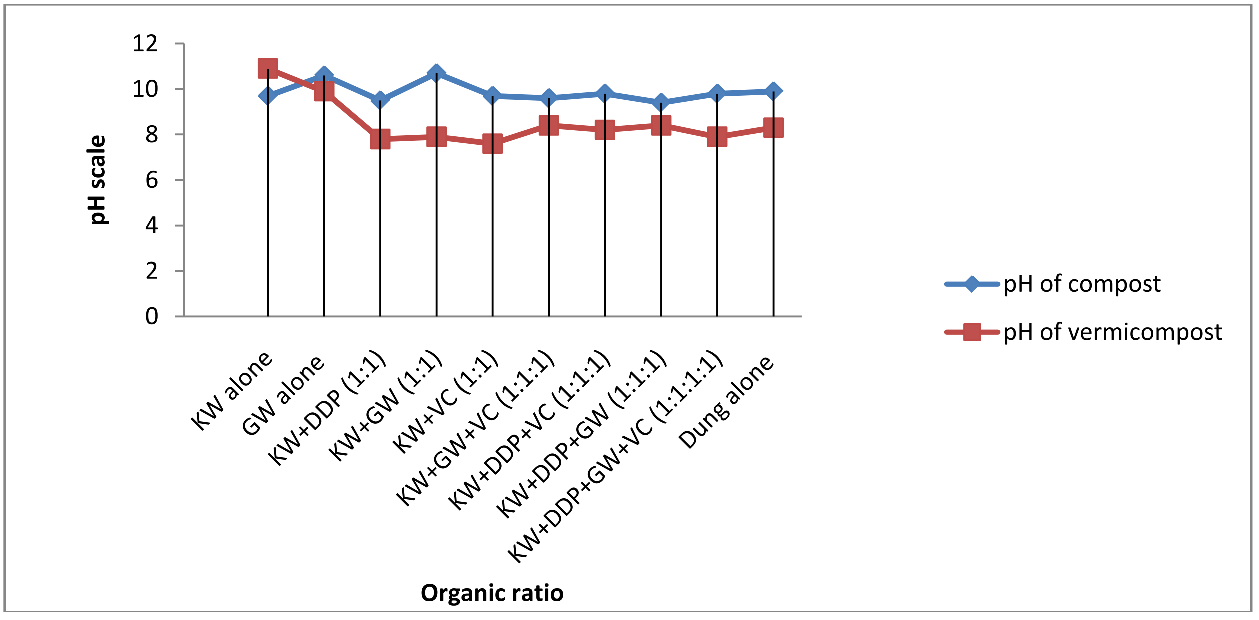

Figure-2- Showing variation of pH in compost and vermicompost of different organic ratio

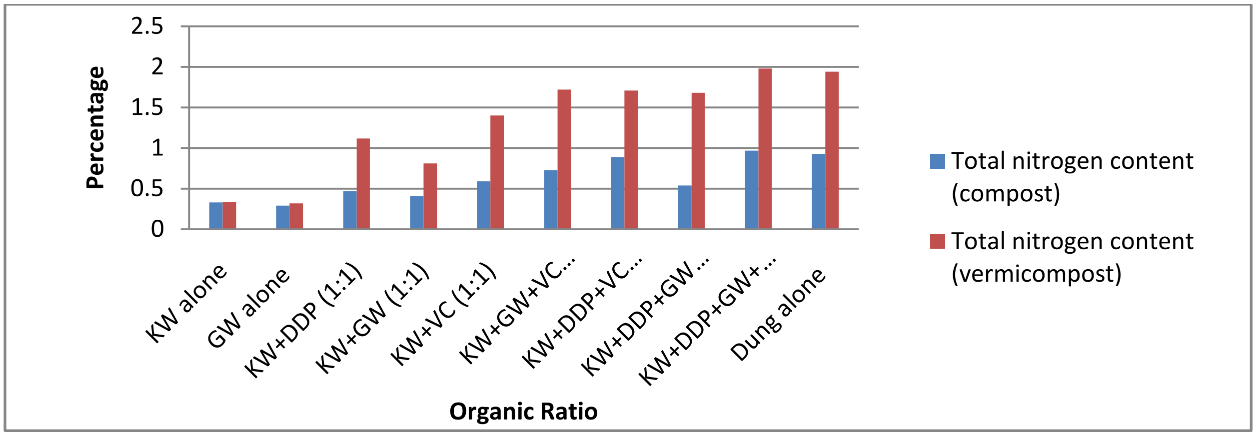

Figure- 3- Showing variation of Total Nitrogen in compost and vermicompost of different organic ratio

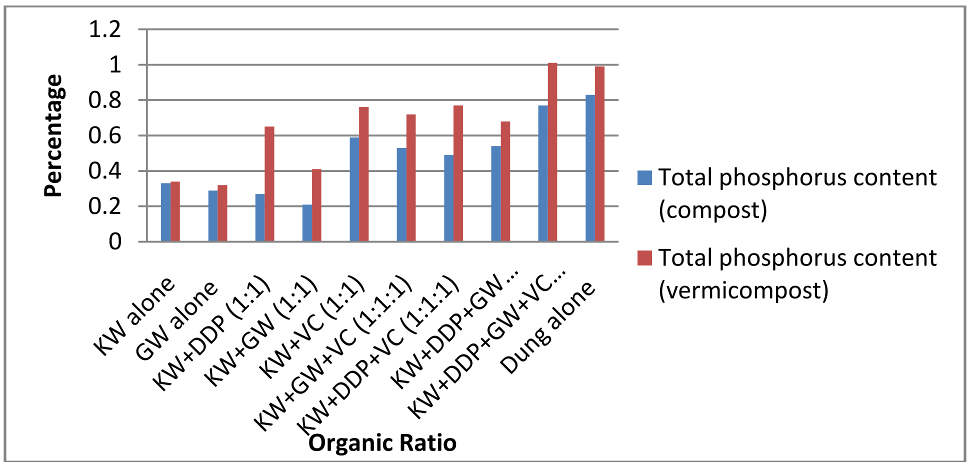

Figure- 4- Showing variation of Total Phosphorus in compost and vermicompost of different organic ratio

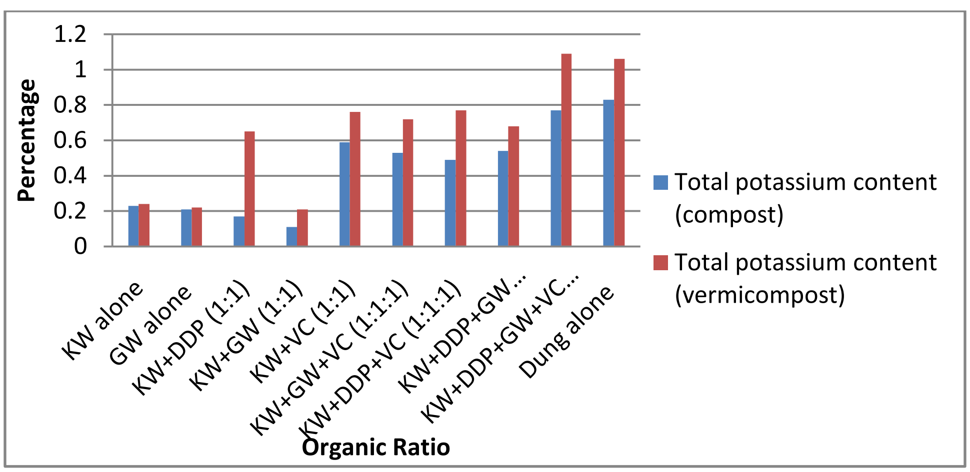

Figure 5- Showing variation of Total Potassium in compost and vermicompost of different organic ratio