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Full Length Research Paper

Chemical changes of spinach waste during composting and vermicomposting

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In Punjab (India), Spinach is the most widely used leafy vegetable in tempting cuisines like 'Palak paneer' and 'Sarson ka Saag', but more than 50% of its remnants are directly dumped as garbage, which otherwise can be utilized as source of organic manure. Considering this, the present study was planned to prepare compost and vermicompost of spinach collected from the supermarket of Amritsar and to estimate various chemical changes; nitrates, phosphates, sodium, potassium, calcium and pH during its composting and vermicomposting. It was observed that fresh vegetable sample of spinach showed higher contents of sodium, magnesium, phosphate and potassium when compared to its composted and vermicomposted samples. However, the contents of nitrates and calcium were higher in compost than other two samples. All the samples were found to be alkaline in nature with composted sample showing the maximum pH of 7.97.

Key words: Composting, vermicomposting, spinach, organic waste, *Eisenia foetida*.

INTRODUCTION

Population explosion and rapid industrialization in India has resulted in massive migration of people from rural to urban areas. As a result, about 50 million ton municipal waste is being generated every year in various cities of India (CPCB, 2000; Sharholy et al., 2008; Saha et al., 2010; Hazra and Goel, 2009; Kumar et al., 2009). This annual generation of waste has generated the challenging issues related to disposal of waste (Idris et al., 2004; Kumar et al., 2009). A study revealed that approximately 960 million tons of solid waste generated annually in India was the by product of industrialization, mining, municipal, agricultural and other processes (Pappu et al., 2007). It was further reported that out of this, approximately 350 million tons came directly from agricultural practices (Pappu et al., 2007). Sharholy et al. (2008) reported that more than 90% of these wastes were sent for unscientific land fillings, creating problems to public health and environment.

At present, the management of organic waste is a major concern worldwide, as unscientific disposal of waste can adversely affect the environment by causing offensive odor, ground water contamination and soil pollution (Garg et al., 2006). This is also posing a risk to human health (Sharholy et al., 2005; Ray et al., 2005; Rathi, 2006; Pappu et al., 2007; Sharholy et al., 2008). There are various physical, chemical and microbiological methods of disposal but they are time consuming and need very high cost and input. Thus, in recent years, vermicomposting and composting have turned out to be promising way out for safe disposal of organic waste. Vermicomposting is a technique of biodegradation or stabilization of organic waste (natural/anthropogenic) by using earthworms and microbes (Hand et al., 1988; Garg et al., 2006; Suthar, 2007; Mainoo et al., 2009). There are several species of earthworms like *Eudrilus eugeniae*, *Eisenia foetida*, *Perionyx excavatus* and *Lumbricus rubellus* (Garg et al., 2006; Suthar, 2007, 2009; Mainoo et al., 2009) which are mostly used for vermicomposting. However, *E. foetida* is the most common and favorable species of earthworms for vermicomposting of vegetables waste as they have high tolerance to environmental variables like pH, temperature and moisture content (Kaviraj and Sharma, 2003; Garg et al., 2006; Suthar, 2007, 2009). Composting on the other hand is an economical and sustainable option for organic waste

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management as it is comparatively easy, provided it is managed properly to produce a good quality product. It is a technique which facilitates mass reduction of waste resulting in its stabilization (Nair et al., 2006).

Punjab is an agriculture state producing large amount of vegetables along with many other crops. But along this, it is also produces maximum vegetable waste due to insufficient storage facilities. Among various types of vegetable wastes produced, the waste generated from leafy vegetables is of special concern. As it contains the high content of N, P and K. Considering the extensive use of spinach in most tempting cuisines like 'Palak paneer' and 'Sarson ka Saag' in Punjab state, the present study was planned to evaluate the various physico-chemical parameters; pH, nitrates, phosphates, potassium and calcium of three types of spinach samples (fresh, composted and vericomposted).

MATERIALS AND METHODS

Collection of samples

About 5 kg spinach sample was purchased from the supermarket (6-ten Complex) situated near Guru Nanak Dev University, Amritsar, Punjab in January, 2009.

Composting of spinach

The sample was washed under tap water and was chopped finely. 250 g chopped spinach sample (in triplicates) was filled in muslin cloth pallets (10 × 10 cm) and open ends were sealed with the help of a thread. A small pit (10 × 10 × 10 cm^3) was dug out in the Botanical Garden of Guru Nanak Dev University, Amritsar. These pallets were placed inside the pit and were covered with soil. The sample was left for 21 days under anaerobic conditions. After 21 days, the pallets were removed and dried in hot air oven for 24 h at 50°C.

Vermicomposting of spinach

Chopped 2 kg spinach sample was kept for 3 days in plastic tub in open air for pre-composting. After pre-composting, 300 g sample (triplicates) was weighed and poured over an earthen pot containing 2" layer (300 g) of pre-composted animal dung. The earthen pot containing only cow dung was considered as control. The experiment was set under the shady conditions. In each pot including control, 30 adult earthworms (*E. foetida*) were released and pots were gently moistened with water. All the samples were routinely shuffled for proper aeration and daily watered to maintain the moisture (~60%). The pots were covered with the jute sheets so that external contamination and harm to earthworms could be avoided. The process was carried out for 45 days and after that, the pots were harvested for vermicomposting. The vermicompost thus obtained, was first dried at room temperature and then in hot air oven at 50°C for 24 h. The dried vermicompost was crushed fine with the help of pestle and mortar and analyzed for various physico-chemical parameters.

Preparation of extracts

One gram (1 g) from each sample in dried form spinach (composted and vermicomposted) were taken and dissolved in 100 ml distilled water (w/v). The solution was kept on a mechanical shaker for 12 h. The solution was filtered through Whatmann No.1 filter paper. The extract was further diluted to ten times with distilled water and was analyzed for different physico-chemical parameters like calcium, magnesium, sodium, potassium, phosphates, nitrates and pH (Trivedy et al., 1987).

Analysis of physico-chemical parameters

pH was estimated by using pH meter (Systronics; µ pH system 361). Calcium and magnesium were estimated by titrometric method. Nitrates and phosphates were estimated by using colorimetric method with the help of spectrophotometer (Systronics; GS5701A). Sodium and potassium were estimated by Flame Photometer (ELICO; CL 26D).

RESULTS AND DISCUSSION

The results of the experiment are described in Table 1. It was observed that fresh vegetable sample of spinach showed higher contents of sodium (779.94 mg/g), magnesium (30.319 mg/g) and potassium (16.883 mg/g) as compared to its composted (143.383, 18.265 and 7.056 mg/g) and vermicomposted forms (7.683, 9.119 and 9.546 mg/g), respectively. All the other parameters like calcium, nitrates, phosphates and pH were found to be enhanced in composted sample. When vermin-composted sample was compared to fresh sample, content of nitrates was found to be higher than rest of the parameters.

Composting and vermicomposting are biooxidative processes which alleviate the organic matter. Jadia and Fulekar (2008) found that pH was enhanced initially during composting and then, was reduced. In the present study, pH was found to be slightly increased during composting (7.96), while reduced during vermin-composting (7.42). This increase in pH may be due to progresssive utilization of organic acids and increase in mineral constituents of waste (Tufts, 1993; Cekmecelioglu et al., 2005; Nair et al., 2006; Jadia and Fulekar, 2008). The increasing trend of pH during composting was also reported by other authors (Crawford, 1985; Guoxue et al., 2001; Garg et al., 2006; Saha et al., 2010). In the case of vermicomposting, the decrease in pH may be due to production of CO_2, ammonia, NO_3^- and organic acid by microbial decomposition during vermicomposting (Suthar, 2009). In another study, Mainoo et al. (2009) have reported the increasing trend of pH for pineapple waste during vermicomposting due to acidic nature of waste.

The calcium content was low in both fresh (0.347 mg/g) and vermicomposted (0.213 mg/g) samples as compared to composted sample (0.400 mg/g). Whereas, content of magnesium was high in fresh sample (30.319 mg/g) but decreased during composting (18.265 mg/g) and vermicomposting (9.119 mg/g) of spinach. Similar results were also given by Chaudhuri et al. (2000) and Ahmed et al. (2007).

Table 1. Chemical characteristics of spinach sample during composting and vermicomposting.

Parameter	Spinach from supermarket			Animal dung	
	Fresh sample	Composted sample	Vermicomposted sample	Before vermicomposting	After vermicomposting
pH	7.693 ± 0.038	7.96 ± 0.005	7.426 ± 0.012	7.493 ± 0.003	7.313 ± 0.003
N (NO_3^-) (mg/kg)	0.018 ± 0.000	0.0412 ± 0.000	0.038 ± 0.000	0.038 ± 0.005	0.036 ± 0.000
P (PO_4^-) (mg/kg)	2.227 ± 0.040	2.530 ± 0.003	0.518 ± 0.006	0.340 ± 0.005	0.837 ± 0.022
Na (mg/g)	779.94 ± 23.07	143.38 ± 14.85	7.683 ± 0.93	9.363 ± 0.14	10.873 ±0.338
K (mg/g)	16.883 ± 0.206	7.056 ± 0.04	9.546 ± 0.02	13.406 ± 0.086	3.013 ± 0.026
Ca (mg/g)	0.347 ± 0.070	0.400 ± 0.046	0.213 ± 0.02	0.213 ± 0.026	0.267 ± 0.026
Mg (mg/g)	30.319 ± 1.829	18.265 ± 0.668	9.119 ± 0.680	5.786 ± 1.131	5.066 ± 0.693

Sodium and potassium were decreased during composting (7.056 and 143.383 mg/g, respectively). Ahmed et al. (2007) have reported similar observations during composting of industrial tannery sludge. In the present study, during vermicomposting, the content of potassium (9.546 mg/g) and sodium (7.683 mg/g) were found to be lower as compared to fresh sample. This may be due to leaching of these soluble elements by water. However, when compared to composted sample, the concentration of potassium in vermicompost was enhanced; this can be correlated to the fact that microbiological flora has influence on level of available potassium (Garg et al., 2006). The acid production by these microorganisms seems to be prime mechanism for solubility of insoluble potassium (Garg et al., 2006). Some other authors have also observed similar trend for potassium and sodium in different types of organic wastes (Hartenstien and Hartenstien, 1981; Elvira et al., 1998; Garg et al., 2006; Suthar, 2007; Tajbakhsh et al., 2008).

Phosphate content in composted sample (2.530 mg/kg) was found to be higher than vermicomposted sample (0.518 mg/kg) and the fresh sample (2.227 mg/kg). Chaudhuri et al. (2000) also reported decrease in phosphate content in kitchen waste during vermicomposting (40 days) but increased phosphate content during composting (after 20 days) process.

The nitrate content was high in both composted (0.0412 mg/kg) and vermicomposted (0.038 mg/kg) samples as compared to the fresh sample (0.018 mg/kg). The increased nitrate in composted sample indicates that there was no loss of nitrogen during the process of composting (Francou et al., 2005). Similarly, in vermin-composting, nitrogen released by earthworms during formation of various metabolic products like growth stimulating hormones and dead tissues gets attached to the available nitrogen (Tripathi and Bhardwaj, 2004; Araujo et al., 2004; Garg et al., 2006; Jadia and Fulekar, 2008). Apart from this, pH has a significant role in concentration of nitrate during vermicomposting. Neutral pH stabilizes the content of nitrates, while at high pH, nitrogen is lost as volatile ammonia (Hartenstien and Hartenstien, 1981; Garg et al., 2006; Suthar, 2007).

Conclusion

Forty (40) to sixty (60) percent solid wastes generated in India are organic in nature and unscientific disposal of these wastes have given birth to some major problems like global warming, scarcity of land and contamination of environment. The open dumped sites of organic waste act as breeding ground for various disease vectors. Therefore, there is need to properly dispose the waste. Considering the organic importance of leafy vegetables, their remnants can be converted to manure by adopting methods like composting and vermicomposting. The present study suggests that spinach contains high amounts of nitrates, phosphates and potassium along with other important cations like calcium, magnesium and sodium. Therefore, the remnants of spinach can turn out to be good source of agronomically important products like biofertilizers, if processed properly. Moreover, the present study is an initiative in the direction of organic waste management by using composting and vermicomposting techniques for sustainable development.

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