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Selective Utilization of Organic Solid Wastes by Earthworm (*Eisenia foetida*)

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Abstract

Rapid growth of population in Kathmandu valley has increased solid wastes generation tremendously. One of the best ways of managing the organic wastes is to recycle domestic wastes at the site of its origin by vermicomposting into valuable organic fertilizers. A laboratory experiment was carried out at for proper management of solid wastes of Kathmandu valley, generated from Ayurveda industry, sugar mill (bagasse), wood mill, kitchen, and vegetable and fruit markets. The experiment dealt with the decomposition of solid wastes through the action of red worm (*Eisenia foetida)*. The vermicomposting of mixtures were carried out for 12 weeks. Observations showed that vermicompost obtained from Ayurveda industry wastes was found to be rich in N, P, K and organic matter, and vermicompost from sugarcane bagasse was found best for rapid multiplication of *Eisenia foetida*. Fish scales and sawdust were identified as worst substrate for this worm.

Key words: vermi compost, organic solid wastes, *Eisenia foetida*

Introduction

Green revolution of 1960s tremendously enhanced the agricultural production mainly due to the abundant use of chemical fertilizers and pesticides. However, unilateral use of chemical fertilizers and pesticides, devoid of organic sources, has made our soil sick and problematic, putting agricultural productivity at risk. The awareness of organic matter and concept of sustainable agriculture is gaining impetus among farmers in recent years to produce consumable agricultural products. The national average use of organic manure is about 2.5 to 3 ton/ha/yr (STSS, 2000). At this rate of manure application, it is not possible to meet the nutrient demand of crops. Incorporation of earthworm in bio-composting process has been considered to be an appropriate technology for bio-waste management for producing nutrient enriched compost. Various investigators have established the viability of the technology using earthworms as a treatment system for different wastes (Harris *et al.* 1990, Logsdon 1994, 2000, Elvira *et al.* 1997, Yami *et al.* 2004).

Growing urbanization and increasing trend of mass migration of population in Kathmandu valley leads to more solid waste generation in urban area, turning the cities very dirty and unhygienic. It has been estimated that 83 % of the waste dumps are municipal, 11% agricultural and 6% industrial in Kathmandu valley. On an average one person produces 0.22 to 0.50 kg of wastes in one day. The problem of solid waste management remains unsolved because of lack appropriate technical know how, lack of people's participation and lack of resources. The key management problems are lack of organizational structure, high capital and operating costs and insufficient market development for compost.

In recent years the concept of reuse and recycle is appearing as an acceptable approach to deal with the solid waste problem in community level in Kathmandu valley. However, it needs a systematic handling of the waste and may appear very complicated until a well managed system is established. Perhaps, because of this reason, dumping is often considered as a key solution to solid waste problem in most developing countries including Nepal. Taking the whole volume of solid waste to the dumping site may produce an immediate credit to the responsible authorities but it would not be sustainable way of waste managements.

Incorporation of earthworm in bio-composting process has been considered to be an appropriate technology for bio-waste management for producing nutrient enriched compost especially in urban areas. Earthworm species suitable for vermicomposting are *Eudrillus eugeniae*, *Eisenia foetida, Lamitt mauritii*, *Periony excavatas* and *Pheretima elongate*. Among them, *E. foetida* is considered the best for decomposing organic wastes, because of its wide temperature tolerance (Edwards & Baxter 1992). Worm cast contain five times more nitrogen, seven times more phosphorus and eleven times more potassium than ordinary soil, the main minerals needed for plants growth. It also contains a lot of beneficial soil micro-organisms, which have at least as much to do with the plant growth and soil fertility. The microorganisms in the worms gut also produce useful compounds like antibiotics, vitamins, plant growth hormones, etc, all of which are also present in the castings.

The main objectives of this research were to study vermicomposting processes in different types of solid wastes as feeding materials to determine the rate of vermicomposting and to analyze chemical composition of vermicompost obtained from various substrate.

Material and Methods

The vermi-composting experiment was conducted at the Biotechnology Laboratory, Nepal Academy of Science and Technology (NAST), Lalitpur Nepal. The process was carried out during summer (June 2005 to September 2005).

Collection of wastes

Agricultural, industrial and kitchen wastes were used as substrate for earthworms. Agricultural wastes included rice straw, cow dung, fruit waste and green vegetable wastes. Kitchen wastes included egg shells, fish scales and vegetable wastes. Industrial wastes included the Ayurveda industry wastes from Singhdarbar Baidhkhana, saw wastes from wood mill and sugarcane bagasse from juice centres. The newspapers were also collected for this study.

Preparation of bedding

Plastic buckets of 12 liters capacity were taken and four small holes at the bottom and several holes around the sides were made to allow aeration and avoid excessive liquid. The agricultural wastes such as straw were cut into 4 cm long pieces and used as bedding for the earthworm. The bedding in each of thirty buckets was made up of straw, cow dung and vermicompost. Water was sprinkled on the bedding just to keep it moist. Twenty- five *earthworms (Eisenia foetida)* were placed in each bucket except in control.

Vermicomposting

Altogether ten types of substrate treatments were done using kitchen, agricultural and industrial waste. The treatments were fruit, vegetable, compost, cocktail, sugarcane, wood, ayurveda industry waste I (boiled and non-woody), ayurveda industry wasteII (non-boiled and woody), fish scales and control. Each treatment had three replicates (Table 1). The respective substrates were added in each treatment for first two weeks. During vermicomposting, the contents of the bucket were turned carefully by least disturbing the earthworms. The weight of compost contents and number of earthworms in each bucket were recorded in every two weeks. The buckets were kept closed throughout to avoid direct sunlight and rain. After complete decomposition of all substrates (after 12 week), the earth worms were removed from vermicompost and its samples were used for chemical analysis.

Table 1. Detailes of treatments of the vermicompost experiment (weight in g)

SN	Substrate type	Rice straw	Cow dung	Fruit	Fish scales	Saw dust	Veg. waste	Waste paper	Sugurcane bagasse	Pigeon excreta	Ayur-industry waste- I	Ayur. industry waste-II	Total weight	Final weight (After 2 week)
1	Fruit	200	500	1000									1700	3000
2	Vegetable	200	500	300			1000						2000	3000
3	Cowdung	300	1000	300									1600	3000
4	Cocktail	200	500	500			450	50		300			2000	3000
5	Sugarcane bagasse	200	500	300					1000				2000	3000
6	Saw dust	200	300	200		300							1000	2000
7	Ayerveda industry waste I	200	500	300							1000		2000	3000
8	Ayerveda industry waste II	200	500	300								1000	2000	3000
9	Fish scales	200	300	200	300								1000	2000
10	control	500	1000	300									1800	3000

Chemical analysis

Chemical analysis was carried out at Soil Science Division, Nepal Agricultural Research Council (NARC), Khumaltar. The samples were analysed for total nitrogen, available phosphorus and potassium contents, total organic carbon and pH. The parameters were determined in accordance with the procedures of standard methods.

Results and Discussion

Vermicompost samples were blackish moist and highly porous with the smell of earth. During the process of composting, the substrate was added continuously for the first two weeks. There after, the total loss of weight of the wastes were recorded in every two weeks. The decomposition rate of different types of substrates by *E. foetida* was found variable depending upon the waste type (Table 2). The decomposition of fruit waste was found faster. It took six weeks for complete decomposition. The faster decomposition of fruit waste was also recorded by Yami and Shrestha (2005) and Simko (2000). Vegetables and cow dung decomposed in seven weeks, followed by cocktail, which took eight weeks. In cocktail, decomposition of newspaper was very slowly. Similar result was also recorded by Yami and Shrestha (2005), and Pradhan and Tamrakar (1999). A total of ten weeks were required for the complete decomposition of boiled, non-woody, ayurveda industry waste (ayurveda industry waste I) whereas sugarcane and non-boiled and woody ayurveda industry waste (ayurveda industry waste II) decomposed completely in 12 weeks (Table 3). The bucket containing saw dust and fish waste were not decomposed and the earthworms were found dead after a week. The bucket containing fish waste contained larvae of insect and was producing very strong foul smell. Similar observation was also made by Yami and Shrestha (2005) in cooked meat. In the present study, the fruits were found to be the best substrate whereas the saw dust and fish waste were found to be the worst for *E. foetida.*

Table 2. Time taken for complete decomposition of substrates by *E. foetida*

SN	Substrate used	Total weight (g)	Time taken
1	Fruit	3000	6 weeks
2	Vegetable	3000	7 weeks
3	Cowdung	3000	7 weeks
4	Cocktail	3000	8 weeks
5	Sugarcane bagasse	3000	12 weeks
6	Sawdust	2000	No decomposition
7	Ayerveda industry waste I	3000	12 weeks
8	Ayerveda industry waste II	3000	10 weeks
9	Fish scales	2000	No decomposition
10	Control	3000	16 weeks

The death of the earthworm in saw dust treatment was most possibly due to the lack of sufficient aeration whereas in case of fish-waste treatment, it may be due to highly proliferating larvae and egg of insects, which created adverse environment for earthworm growth. Ismail (1994) and Tamrakar (2005) explained that the amendment with sawdust seemed to promote biomass for worms.

The number of earthworms were counted in every two weeks. The biomass potential of the worms is an important aspect for quick biodegradation of organic wastes (Guerro 1981). The number of earthworms was found to be the highest in sugarcane treatment (418), followed by ayurveda industry waste –I (372) (Table 3). The ayurveda industry waste-II also contained good number of earthworms (327). The number of juvenile and cocoons were observed much higher in sugarcane. The increment in the number of earthworms was found slow in sugarcane and ayurveda industry wastes at the beginning but it increased rapidly in later observations. This may be due to the lack of sufficient food in the beginning, because of slow decomposition rate of sugarcane and ayurveda industry wastes. The earthworm grown on ayurveda industry wastes (I, II) were found to be healthier than any other treatments. The least number of earthworms was found in the cow dung treatment (135). There was no multiplication of the earthworm in the sawdust and fish waste and the inoculated earthworm were found to be dead (Table 3). This observation reflected the fact that sugarcane and ayurveda industry wastes are good for rapid multiplication of the earthworms whereas saw dust and fish waste were worst for the rapid multiplication of earthworms.

Table 3. Earthworm population in due course of vermi composting

		Mean number of earth worm (weeks)						
		0	2	4	6	8	10	12
1	Fruit	25	35	45	78	132	271	335
2	Vegetable	25	32	39	59	97	167	203
3	Compost	25	28	35	52	92	108	135
4	Cocktail	25	30	40	54	102	152	213
5	Sugarcane bagasse	25	27	34	78	187	278	418
6	Saw dust	25	0	0	0	0	0	0
7	Ayerveda industry waste I	25	26	36	60	158	237	372
8	Ayerveda industry waste II	25	27	38	62	169	303	327
9	Fish scales	25	0	0	0	0	0	0
10	Control	0	0	0	0	0	0	0

The pattern of the weight loss of contents of the vermicompost and the observation of the process during the period of study showed that the fruit waste was utilized most rapidly (highest weight loss 59%), followed by vegetable (54%). Yami and Shrestha (2005) also found the highest weight loss in fruit waste treatment (Table 4).

The weight loss was observed very less in ayurveda industry waste I, sugarcane and ayurveda industry waste II i.e. 29%, 37% and 41% respectively. The overall weight loss during composting was observed in the range of 29% to 59.5 %. Singh and Kumar (2004) found 25% weight loss in fruit vermicompost during vermicomposting process. In the view of large scale production of vermicompost, the sugarcane and ayurveda industry wastes are most suitable as their weight loss during vermicomposting were observed to be least (Table 4).

Table 4. Mean weight of vermicompost contents at an interval of one or two weeks

	Mean weight loss (kg)						
	Initial	2nd week	4th week	6th week	8th week	10th week	12th week
Fruits	3	2.3	1.9	1.7	1.4	1.3	1.2
Vegetable	3	2.5	2.1	1.9	1.5	1.3	1.3
Cowdung	3	2.4	2.3	2	1.8	1.71	1.71
Cocktail	3	2.7	2.4	2.3	2.1	1.9	1.8
Sugarcane bagasse	2.4	2.26	2.09	1.8	1.6	1.6	1.5
Saw dust	2	0	0	0	0	0	0
Ayerveda industry waste I	3	2.76	2.37	2.25	2.1	2.1	2.1
Ayerveda industry waste II	3	2.7	2.5	2.37	2.13	1.9	1.7
Fish scales	2	0	0	0	0	0	0
Control	3	2.7	2.5	2.3	2	2	1.7

The vermicomposts from different substrates were found rich in N, P, and K contents (Table 5). Nutritional composition of vermicompost varied with substrate used. The total nitrogen content of vermicompost was found higher than the control. The total nitrogen content of the vermicompost increased with time, due to rapid mineralization of organic nitrogenous compounds. Similar observation was also made by Bansal and Kapoor (2000) showing increased nitrogen content as a result of carbon loss in vermicomposting of crop residues and cattle dung. The nitrogen content of the vermicompost depends on the initial nitrogen concentration of the waste. Further enhanced decomposition results in lowering of C:N ratio (Talashilkar *et al.* 1999). Maximum nitrogen content (2.42%) was found in vermin-compost prepared from fruits followed by ayurveda industry waste I (2.35). Nitrogen content was found equal in both vermicompost prepared from sugarcane bagasse and vegetable wastes (2.31). The nitrogen content was found to be least (1.99%) in the cocktail. The least nitrogen content was found in control (0.45%). Yami and Shrestha (2005) also found least nitrogen content in control treatment.

Table 5. Chemical analysis of vermicompost

SN	Name of sample	pH	OC (%)	N (%)	P(%)	K(%)	Organic matter (%)
1	Fruit	9.1	16.65	2.42	0.54	3.0	28.7
2	Vegetable	9.3	14.7	2.31	0.56	2.15	25.34
3	Compost	9.8	16.2	2.27	0.82	3.1	27.93
4	Cocktail	9.5	14.4	1.99	0.55	2.45	24.86
5	Sugarcane bagasse	8.4	12.15	2.31	0.57	3.05	20.95
6	Ayuerveda I	10.2	15.9	2.35	0.68	3.65	27.41
7	Ayuerveda II	9.3	12.15	2.20	0.64	3.5	20.95
8	Control	7.8	14.65	0.45	0.30	0.25	25.17

Available phosphorus was found to be highest in compost (0.82%) followed by Ayerveda industry waste I (0.68). Potassium was observed highest in ayurveda industry waste I (3.65%). The organic matter was found to be highest in fruit (28.7%) followed by compost and ayurveda industry waste I i.e. 27.93% and 27.41% respectively. The least organic matter content was found in ayurveda industry waste II and sugarcane (20.95%).

In the present study, the mineral content was found to be higher in vermicompost produced by *E. foetida* than in control (Table 5). Padamaja *et al.* (1995) found that compost produced by *E. foetida* and *Perionyx* species is better than produced with conventional method. The result was also supported by the finding of Yami and Shrestha (2005) and Tamrakar (2005).

The findings revealed that decomposition process was enhanced by the presence of earthworm and aerobic heterotrophic population of microorganisms. In the present study, it was found that the most utilizable substrates for *E. foetida* in relation to time was fruit. The vermicompost obtained from ayerveda industry waste I was found to be rich in N (2.35), P(0.68), K(3.65%) content and the weight loss during vermicomposting was least for the same. Vermicompost from sugarcane bagasse was also found rich in N (2.31), P(0.57), K(3.05) contents and was best for rapid multiplication of *E. foetida*, Weight loss during vermicomposting was also observed to be lesser in sugarcane. Ayurveda industry waste and sugarcane bagasse are commonly found wastes in bulk form. In this connection, ayurveda industry waste and sugarcane bagasse can be taken as most suitable substrates for mass production of organic fertilizer through vermi-composting. In this study earthworm could not utilize sawdust and fish scales. However, the sawdust mixed with other suitable substrates could be recycled. From the study it could be concluded that vermiculture biotechnology could be widely used for the management and recycling of agricultural wastes, traditional medicinal plant wastes and sugar bagasse, reducing bulk and the level of pollution at the generation site itself.

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