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RESEARCH ARTICLE

PHYSICAL PROPERTIES OF VERMICOMPOST PRODUCED BY LOCALLY ISOLATED EARTHWORMS FROM TEMPERATE KASHMIR REGION

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ABSTRACT

Earthworms were collected from three different locations (Wadura, Shalimar and Gulmarg). Mature earthworms and their cocoons collected from various sites at each location were pooled together forming a composite sample. The earthworms from each location were identified at (Centre of Research for Development, P.G. Department of Environmental Science, University of Kashmir) and mass multiplied in appropriate media. The species *Eisenia foetida, Apporectodea rosea* and *Apporectodea caliginossa* were identified from Wadura, *Eisenia foetida* and *Apporectodea caliginossa* were identified from Shalimar and *Eisenia foetida* and *Apporectodea caliginossa* were identified from Gulmarg. Preliminary screening of the identified worms from each location was carried out on the basis of vermicomposting potential to select the best isolate for further studies. *Apporectodea rosea, Eisenia foetida* and *Apporectodea caliginossa* from Wadura, Shalimar and Gulmarg were selected for vermicomposting process. An experiment was carried out in vermibeds of 3 x 10 feet at vermicomposting unit to develop the nutrient and microbe rich vermicompost using locally isolated earthworms and standard species, *Eisenia foetida*. The experiment was laid in completely randomized design which comprised of 16 treatments of 4 waste combinations including cow dung and mixture of organic wastes (kitchen wastes, municipal waste, crop residues, sheep/poultry manure, apple pomace) cow dung (24 kg) and organic waste (60 kg). The ratio of waste combinations was maintained as: 0:1 = (0% cow dung + 100% organic waste); 1:1 = (50% cow dung + 50% organic waste); 1:2 = (33% cow dung + 67% organic waste); 1:3 = (25% cow dung + 75% organic waste). The results indicated that the *Eisenia foetida* isolated from Shalimar proved to be having the best vermicomposting potential due to its individual capability and better adaptability to the local temperate conditions as compared to standard *Eisenia foetida* and other local isolates.

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INTRODUCTION

India generates more than 350 million tonnes of biodegradable agricultural wastes per annum (CSIR, 2009). In this on an average, it is estimated that 0.2-0.6 kg of solid waste is generated per capita per day. The per capita per day MSW generations in Srinagar city (Kashmir valley) has been estimated to be 274 grams (Parvaiz and Bhat, 2008). The amount of waste generated in Srinagar city is 370 metric tons/day and only 250 metric tons of solid waste is being collected by Srinagar Municipal Corporation (Wani and Shamim, 2013). The problem of municipal solid waste management in Kashmir valley is becoming more and more complicated and requires long-term and sustainable practices and planning programmes for its solution. Vermicomposting in recent years has gained importance because of its more economic value over traditional methods of composting. The vermicompost, chiefly the faecal matter of earthworm, is rich in plant nutrients, plant growth promoters and beneficial microflora. Several attempts have been made to solve the problems of environmental pollution by employing physical and chemical processes and to some extent with certain biosystems which includes bacteria, fungi, actinomycetes, algae, yeasts, macrophytes, aquatic plants etc. Earthworms are conveniently being employed for bioremediation like degrading and decomposing the agricultural and industrial wastes (Ghosh *et al.*, 1999). *Eisenia foetida,* a temperate species of earthworm is most commonly used for the management of organic wastes by vermicomposting. Although *Eisenia foetida* has adapted to the temperate conditions of Kashmir valley, its

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vermicomposting ability gets drastically reduced during winter months. Therefore, it is important to look for local worms that can tolerate low temperature and perform better under such conditions. The local earthworms are supposed to adapt to the low temperatures because during winter months, vermicomposting process gets drastically slow due to the unfavourable temperatures.

MATERIALS AND METHODS

The investigation was conducted at vermicomposting unit Regional Research Station, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar (J&K).

Experimental Details

Collection and Identification of Earthworms

Earthworms were collected from three different locations Wadura (altitude of 1589 meters ASL with atmospheric temperature of -05 to +35 ^{0}C), Shalimar (altitude of 1680 meters ASL with atmospheric temperature of -10 to +35 ^{0}C) and Gulmarg (altitude of 2650 meters meters ASL with atmospheric temperature of -20 to +35 ^{0}C). Mature earthworms and their cocoons collected from various sites at each location were pooled together forming a composite sample.

Table 2. Details of treatments and waste combinations

Treatments	Combinations	Composition
T_1	S_1C_1	S_1 *Aporrectodea rosea* (Wadura isolate) C_1 (0% cow dung +100% organic waste)
T_2	S_1C_2	S_1 *Aporrectodea rosea* (Wadura isolate) C_2 (50% cow dung + 50% organic waste)
T_3	S_1C_3	S_1 *Aporrectodea rosea* (Wadura isolate) C_3 (33% cow dung +67% organic waste)
T_4	S_1C_4	S_1 *Aporrectodea rosea* (Wadura isolate) C_4 (25% cow dung + 75% organic waste)
T_5	S_2C_1	S_2 *Eisenia foetida* (Shalimar isolate) C_1 (0% cow dung +100% organic waste)
T_6	S_2C_2	S_2 *Eisenia foetida* (Shalimar isolate) C_2 (50% cow dung + 50% organic waste)
T_7	S_2C_3	S_2 *Eisenia foetida* (Shalimar isolate) C_3 (33% cow dung +67% organic waste)
T_8	S_2C_4	S_2 *Eisenia foetida* (Shalimar isolate) C_4 (25% cow dung + 75% organic waste)
T_9	S_3C_1	S_3 *Aporrectodea caliginosa* (Gulmarg isolate) C_1 (0% cow dung +100% organic waste)
T_{10}	S_3C_2	S_3 *Aporrectodea caliginosa* (Gulmarg isolate) C_2 (50% cow dung + 50% organic waste)
T_{11}	S_3C_3	S_3 *Aporrectodea caliginosa* (Gulmarg isolate) C_3 (33% cow dung +67% organic waste)
T_{12}	S_3C_4	S_3 *Aporrectodea caliginosa* (Gulmarg isolate) C_4 (25% cow dung + 75% organic waste)
T_{13}	S_4C_1	S_4 *Eisenia foetida* (standard isolate) C_1 (0% cow dung +100% organic waste)
T_{14}	S_4C_2	S_4 *Eisenia foetida* (standard isolate) C_2 (50% cow dung + 50% organic waste)
T_{15}	S_4C_3	S_4 *Eisenia foetida* (standard isolate) C_3 (33% cow dung +67% organic waste)
T_{16}	S_4C_4	S_4 *Eisenia foetida* (standard isolate) C_4 (25% cow dung + 75% organic waste)

Table 3. Collection and identification of earthworms

S. No.	Site of Collection	Isolates/ Number	Taxonomic characteristics			Identified as
1.	Wadura	W_1	Body Shape	:	Cylindrical	*Eisenia foetida*
			Colour	:	Purple	
			Body Length	:	35-130 mm	
			No. of Segments	:	80-120	
		W_2	Body Shape	:	Cylindrical	*Apporectodea rosea*
			Colour	:	Reddish	
			Body Length	:	20-110 mm	
			No. of Segments	:	100-150	
		W_3	Body Shape	:	Cylindrical	*Apporectodea*
			Colour	:	Brown	*caliginosa*
			Body Length	:	50-150 mm	
			No. of Segments	:	100-180	
2.	Shalimar	S_1	Body Shape	:	Cylindrical	*Eisenia foetida*
			Colour	:	Red	
			Body Length	:	30-120 mm	
			No. of Segments	:	80-110	
		S_2	Body Shape	:	Cylindrical	*Apporectodea*
			Colour	:	Brown	*caliginosa*
			Body Length	:	20-100 mm	
			No. of Segments	:	100-145	
3.	Gulmarg	G_1	Body Shape	:	Cylindrical	*Eisenia foetida*
			Colour	:	Reddish purple	
			Body Length	:	35-130 mm	
			No. of Segments	:	80-110	
		G_2	Body Shape	:	Cylindrical	*Apporectodea*
			Colour	:	Grey	*caliginosa*
			Body Length	:	50-145 mm	
			No. of Segments	:	100-140	

Details of layout

The experiment comprised of 16 treatments which included waste combinations and different earthworm species. Earthworm species used are S_1: *Aporrectodea rosea,* S_2: *Eisenia foetida,* S_3: *Aporrectodea caliginosa* and S_4: *Eisenia foetida* (standard isolate).

Waste/waste combination used are C_1 = 0:1 (0% cowdung + 100% organic waste), C_2 = 1:1 (50% cowdung + 50% organic waste), C_3 = 1:2 (33% cowdung + 67% organic waste) and C_4 = 1:3 (25% cowdung + 75% organic waste). Organic wastes include a mixture of kitchen wastes, municipal waste, crop residues, sheep/ poultry manure, apple pomace in equal proportions.

The experiment was laid in completely randomized design which comprised of 16 treatments of 3 replications each.

Details of treatments and waste combinations

Vermibeds of dimensions 3 x 10 feet for vermicomposting of different wastes were made with the following treatment details:

Pre-decomposition of wastes

All the Organic wastes (kitchen wastes, municipal wastes, crop residues, sheep manure, poultry manure and apple pomace) were shredded and chopped into small pieces and mixed with cow dung (one week old) in its required proportions as per the treatment details. The mixed substrates were kept for three weeks for pre-decomposition under shade and rain proof shed.

Statistical Analysis

The data collected on different observations were analyzed statistically using the standard procedures followed by Gomez and Gomez (1984).

Experimental Findings

Collection and Identification of Earthworms

Earthworms were collected from three different locations (Wadura, Shalimar and Gulmarg). Mature earthworms and their cocoons collected from various sites at each location were pooled together forming a composite sample. The earthworms from each location were identified on the basis of taxonomic characteristics and mass multiplied in appropriate media.On the basis of body shape, colour, body length and number of segments, *Eisenia foetida*, *Apporectodea rosea* and *Apporectodea caliginosa* were identified from Wadura; *Eisenia foetida* and *Apporectodea caliginosa* were identified from Shalimar and *Eisenia foetida* and *Approectodea caliginosa* were identified from Gulmarg (Table 3).

Screening of earthworm isolates

On the basis of matuaration time, carbon, nitrogen, phosphorus and potassium contents and C:N ratio of vermicompost, *Apporectodea rosea, Eisenia foetida* and *Apporectodea caliginosa* from Wadura, Shalimar and Gulmarg respectively were selected for vermicomposting process (Table 4).

Apporectodea caliginosa

Apporectodea rosea

Eisenia foetida

Plate 5. Identified earthworms

Physical Characteristics

The results of physical parameters obtained are discussed as under:

Table 4. Screening of earthworm isolates for vermicomposting

S. No.	Site of Collection	Isolates	Maturation of vermicompost (days)	Carbon (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	C:N ratio
1.	Wadura	*Eisenia foetida*	45	22.10	1.04	1.08	4.70	15.40
		Apporectodea rosea	35	27.00	1.50	1.04	4.50	18.00
		Apporectodea caliginosa	40	20.10	0.89	1.02	4.00	15.50
2.	Shalimar	*Eisenia foetida*	37	28.00	1.53	1.26	5.05	19.50
		Apporectodea caliginosa	40	20.50	0.95	1.03	4.31	16.20
3.	Gulmarg	*Eisenia foetida*	45	20.80	0.98	1.12	5.01	16.40
		Apporectodea caliginosa	40	23.10	1.52	1.03	5.00	17.89

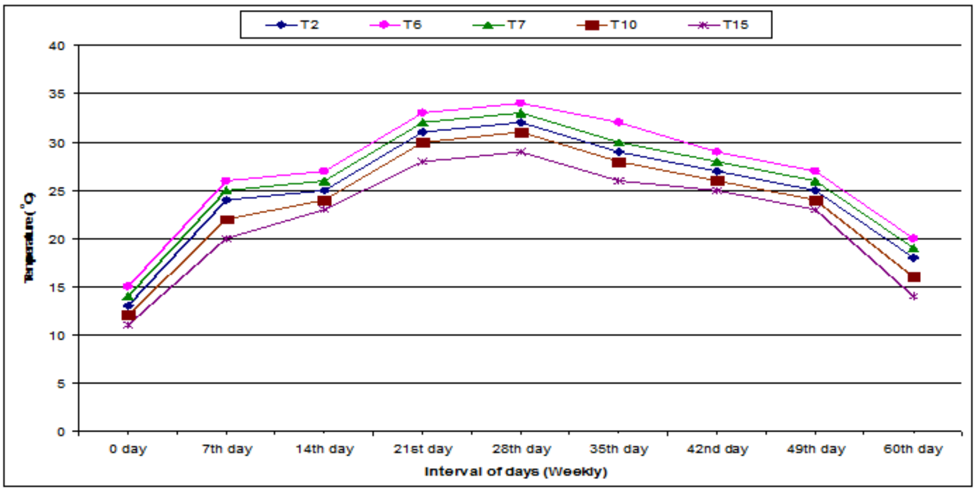

Fig.1. Temperature (°C) recorded during the process of vermicompost

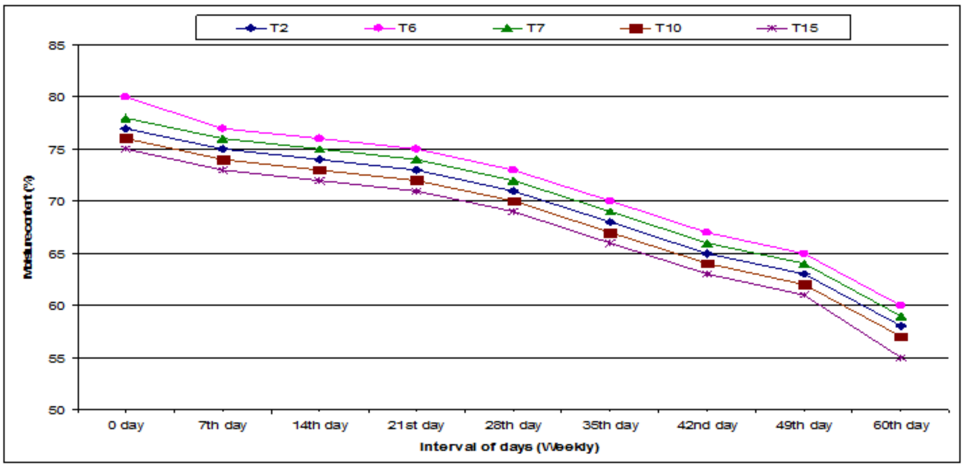

Fig. 2. Moisture content (%) recorded during the process of vermicompost

Table 5. Volume reduction (%)

Treatments		Earth worm isolate (location)	Vermicompost		
			Initial	Final	Volume reduction (%)
T_1	(0% cow dung +100% organic waste)	*Apporectodea rosea* (Wadura)	15940	11034	30.7
T_2	(50% cow dung + 50% organic waste)		17304	13553	21.6
T_3	(35% cow dung +65% organic waste)		17303	13489	22.0
T_4	(25% cow dung + 75% organic waste)		16408	12543	23.5
T_5	(0% cow dung +100% organic waste)	*Eisenia foetida* (Shalimar)	18920	14844	21.5
T_6	(50% cow dung + 50% organic waste)		19488	15789	18.9
T_7	(35% cow dung +65% organic waste)		17993	13849	23.03
T_8	(25% cow dung + 75% organic waste)		17990	13987	22.2
T_9	(0% cow dung +100% organic waste)	*Apporectodea caliginosa* (Gulmarg)	16808	12503	25.6
T_{10}	(50% cow dung + 50% organic waste)		17498	13598	22.2
T_{11}	(35% cow dung +65% organic waste)		17986	13783	23.3
T_{12}	(25% cow dung + 75% organic waste)		16543	12555	24.1
T_{13}	(0% cow dung +100% organic waste)	*Eisenia foetida* (Standard)	13683	10438	23.3
T_{14}	(50% cow dung + 50% organic waste)		13795	10989	20.3
T_{15}	(35% cow dung +65% organic waste)		13854	10888	21.4
T_{16}	(25% cow dung + 75% organic waste)		13798	10653	22.7
	C.D ($P \leq 0.05$)			5.32	

Temperature

Temperature was recorded with thermometer and is depicted in Fig:1. The temperature of the substrates varied from 11°C to 15°C. It showed an increasing trend upto 28th day; thereafter a declining trend was recorded till maturation of vermicompost.

The waste combination of 50% cow dung + 50% organic waste, (T_6) treated with *Eisenia foetida* (Shalimar) exihibited maximum temperature 34°C. *Eisenia foetida* (Shalimar) worked best because of the maximum temperature condition. The heat released by the oxidative action of intensive microbial activity on the organic matter resulted in the rise in

Table 6. Time of maturity (days) of vermicompost

Treatments		Earth worm isolate (location)	Maturation (days)
T_1	(0% cow dung +100% organic waste)	*Apporectodea rosea* (Wadura)	49.00
T_2	(50% cow dung + 50% organic waste)		45.00
T_3	(33% cow dung +67% organic waste)		47.00
T_4	(25% cow dung + 75% organic waste)		48.00
T_5	(0% cow dung +100% organic waste)	*Eisenia foetida* (Shalimar)	40.00
T_6	(50% cow dung + 50% organic waste)		35.00
T_7	(33% cow dung +67% organic waste)		38.00
T_8	(25% cow dung + 75% organic waste)		39.00
T_9	(0% cow dung +100% organic waste)	*Apporectodea caliginosa* (Gulmarg)	56.00
T_{10}	(50% cow dung + 50% organic waste)		52.00
T_{11}	(33% cow dung +67% organic waste)		54.00
T_{12}	(25% cow dung + 75% organic waste)		55.00
T_{13}	(0% cow dung +100% organic waste)	*Eisenia foetida* (Standard)	60.00
T_{14}	(50% cow dung + 50% organic waste)		58.00
T_{15}	(33% cow dung +67% organic waste)		58.00
T_{16}	(25% cow dung + 75% organic waste)		59.00

Table 7. Measurement of identified worms (mm)

S. No.	Site of Collection	Isolates	Length	Diameter
1.	Wadura	*Eisenia foetida*	50-141	4-5
		Apporectodea rosea	30-125	3-4
		Apporectodea caliginosa	55-175	3-5
2.	Shalimar	*Eisenia foetida*	40-137	3-5
		Apporectodea caliginosa	30-115	4-6
3.	Gulmarg	*Eisenia foetida*	40-135	3-6
		Apporectodea caliginosa	54-147	2-4

temperature during the first mesophilic phase of composting process (Peigne and Girardin, 2004). The results were in conformity with Neuhauser *et al.* (1988) who reported that the potential of several earthworm species to grow in sewage sludge, and they concluded that all these species have a range of preferred temperatures for growth, ranging between 15°C to 35°C

Moisture content (%)

Moisture content of vermicompost depicted in fig:2 showed a decreasing trend upto the 60th day, where moisture content was 55 to 60 per cent. The waste combination of 50% cow dung + 50% organic waste (T_6) treated with *Eisenia foetida* (Shalimar) exihibited maximum moisture content of 80 per cent. *Eisenia foetida* (Shalimar) exihibit more moisture content as showed rapid growth of earthworms. The optimum moisture content varied from 50 to 70% (Nagavallemma *et al.*, 2006). The results were in accordance with Domínguez and Edwards, (1997) reported that *Eisenia foetida* and *Eisenia andrei* can survive in moisture ranges between 50% and 90%, but they grow more rapidly between 80% and 90% in organic wastes.

Volume reduction (%)

The waste combination of 50% cow dung + 50% organic waste (T_6) treated with *Eisenia foetida* (Shalimar) reduced more volume of 31.55% and minimum reduction of 24.27% under the waste combination of 0% cow dung +100% organic waste (T_{13}) treated with *Eisenia foetida* (standard) as depicted in (Table-5). The earthworm *Eisenia foetida* (Shalimar) is the efficient worm as it reduced more volume due to the additional supplement of organic wastes. This result is in conformity with the results of Singh *et al.* (2005).

Time of maturity of vermicompost (days)

The data present in Table 6 show that under waste combination of 50% cow dung + 50% organic waste (T_6), treated with *Eisenia foetida* (Shalimar), matured only after 36 days followed by 38.5 days under the waste combination of 33% cow dung +67% organic waste (T_7) treated with *Eisenia foetida* (Shalimar). All the waste combinations treated with *Eisenia foetida* (Standard) matured last of all (57 days) which was significantly lower than that of *Eisenia foetida* (Shalimar).

Size of earthworms

The length and diameter of the earthworms identified from three different locations were measured with ruler, presented under Table 7.

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