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International Journal of Current Research
Vol. 5, Issue, 10, pp.3051-3057, October, 2013

INTERNATIONAL JOURNAL
OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

TREATMENT OF SEWAGE SLUDGE THROUGH VERMICOMPOSTING USING *Eisenia fetida*

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ARTICLE INFO

Article History:
Received 16th July, 2013
Received in revised form
25th August, 2013
Accepted 20th September, 2013
Published online 23rd October, 2013

Key words:
Sewage sludge waste,
Vermicomposting,
Eisenia fetida

ABSTRACT

As a consequence of population explosion, economic development and large scale urbanization, huge quantities of solid and liquid waste materials are produced in India. Their disposal and management are difficult and cumbersome tasks which are associated with serious environmental and health problems. Sewage water and sludge is released in large drainages called nallah from where the sludge is collected and disposed off in agricultural fields, open dumps, along the roadside or railway tracks and poorly designed sanitary land-fills which can pollute surface or ground water causing public health hazards.Nowadays, vermicomposting is attracting much attention as a method of management of organic waste including sludge stabilization worldwide due to its simple technology and lack of need for expensive equipments. This has also been recommended for increasing soil fertility, detoxication, organic farming and sustainable agriculture. In the present study it has been observed that in a mixture of sewage sludge, cattle dung and rice husk vermicomposting earthworms, *Eiseniafetida* survive, reproduce and the population and biomass of different and suitable mixture.

INTRODUCTION

Safe and non-hazardous management of waste is a problem of the modern civilized society. The diversity and quantity of solid waste have shown tremendous increase with rapidly increasing human population, urbanization and high rate of industrialization. Due to declining interest in organic composts and non judicious use of chemical, fertilizers (green revolution), biodegradable organic wastes have become extra source of pollution. Usually in-adequate and in-appropriate methods of waste management, such as dumping, land-filling, burning etc. are adopted which are not safe to the environment and for human health. In cities problems are much more serious due to shortage of dumping sites, high inputs of labour and money, poor management and following of environmental legislations. We are facing escalating socio-economic, environmental and economic problems in dealing with current and future planning of disposal and management of waste, particularly the sewage sludge. Sewage is the waste and wastewater produced by residential and commercial sources and discharged into sewers (drainage system). The sewers can be of different types and sizes. The sewage sludge is a semi-solid residue from any source of sewage or sewers. It is a difficult task to define sewage in strict sense, because there are no definite criteria about its nature and composition. In simple words sewage is the waste residue of human life that is disposed off through water. The organic wastes from residential colonies and commercial sectors (fruit and vegetable market, factories, food processing units etc.) that are released in the drainage or nullahs are also considered to be the sewage waste. As compared to other waste sewage is more hazardous to environment and human health. Sludge is heterogeneous mixture variety of materials, its composition varies from one place to another and even from time to time at the same site.

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The composition of sewage sludge is mainly dependent upon the population density of human beings, their live stock, their food, feeding and behavioral habits as well as type of nearby industrial base. Following principal groups of sludge components can be identified- Decaying waste refuge (vegetable, fruit and other food wastes) from human habitats, plantation wastes, animal and sometimes human excreta which possess biodegradable (nutrient) elements like proteins, carbohydrates, fats, vitamins, minerals and other components.Non-biodegradable substances, soil, sand, silt, stones, glass, plastic etc. Potentially toxic substances and heavy metals (Aboulroos*et al.*, 1989, Chaney, 1990a). Organic pollutants which may exert adverse influence on plants. Pathogenic agents and vectors which cause plant, animal and human diseases (Gerba, 1983 and El-Motaium and Badawy, 2000). The importance of safe disposal of sewage with an objective to recover useful end product was first emphasized by Gottas (1956). Potential of compost earthworms for treatment of sewage sludge was realized by Hartenstein (1978) and Mitchell (1978). Then other earlier works have demonstrated that the sewage sludge can be successfully and safely treated with vericomposting (Hartenstein *et al.*, 1979; Hartenstein, 1981;Mitchell *et al*., 1980); Neuhauser *et al.*, 1980; Kaplan *et al.,* 1980; Malaeki*et al.,* 1982). It was reported that anaerobic sludge is not suitable for earthworm culture, but aerobic sludge is accepted as food by them. In inoculated medium, waste biomass is decomposed rapidly resulting in growth and reproduction of earthworms, disappearance of foul smells and rapid reduction of population of pathogenic microorganisms. During recent years, applied use of earthworms in the breakdown of a wide range of organic residues, including sewage sludge, animal wastes, crop residues, and industrial refuse to produce vermicompost, has been recommended (Mitchell *et al*., 1980; Reinecke and Venter, 1987; Edwards and Neuhauser, 1988; Chan and Griffiths, 1988; Hartenstein and Bisesi, 1988; Haimi, 1990; Van Gestel*et al*., 1992; Dominguez and Edwards, 1997; Edwards, 1998; Kale, 1998; Garg *et al.,* 2006).

A special class of high performance species of earthworms (epigeics) have been identified which can be employed for large scale bioconversion of organic waste into vermicompost. In fact the earthworms work in collaboration with aerobic bacteria. This type of waste degradation and composting system is proving to be economically and environmentally suitable technology over the conventional microbial degradation and composting technology, as it is rapid and nearly odorless process, reducing composting time by more than half, significantly reducing the environmental hazards, improving quality of the compost and the end product is both disinfected and detoxified (Loehr*et al*., 1984; Edwards *et al*., 1998). Mitchell (1978) and Mitchell *et al.* (1980) demonstrated that aerobic sewage sludge can be ingested by *E. foetida*and the sludge is decomposed and stabilized about 3 times faster than non-ingested sludge. Moreover, a marked reduction in pathogenic microbial population of *Salmonella*, *E. coli* and other enterobacteriaceae was also observed. Hartenstein (1978, 1981), Hartenstein *et al.* (1979) reported that fresh anaerobic sludge is not suitable for earthworms and it could hinder their growth and activity and may also exert toxic influence. The inhibitory effect is due to oxygen deficiency and presence of toxic compounds originating from the anerobic process of sludge stabilization. Proper aeration of the sludge and mixing it with other suitable waste make it good stuff for feeding by worms.

According to Princine*et al.* (1980) *E. fetida* is highly suitable for vermicompostingof municipal solid wastes and municipal wastewater sludges. Graziano and Casalicchio (1987) demonstrated that sludge and municipal wastes can be processed by using worm casting techniques. Neuhauser *et al.* (1988) presented a review on the potential of earthworms for managing sewage sludge. A synopsis of relevant literature on the use of earthworms for bioconversion of sewage sludge and municipal waste was presented by Blakemore (1995). Neuhauser *et al*. (1988) in addition to aeration of the sludge, age of the sludge is also very important to relate the rate of earthworm growth, its nutritive value to the earthworms decreases rapidly with increasing age whereas the ash content of the sludge increases with the time, an indication of sludge stabilization. It was pointed out by Bhiday (1995) that vermistablization of sewage sludge by earthworms is linked to the aerobic stage and moisture content of the sludge. The worms have a strong and positive effect for aerobic than anaerobic sludge. It has also been reported that both excessive and insufficient moisture can adversely impact earthworm growth (Neuhauser *et al*., 1988). Use of California red worm in sewage sludge transformation was studied by Delgado *et al.* (1995).claimed that one ton of earthworm biomass can process one ton of sludge into vermicompost within five days. Production of good vermicompost (sole earthworm excreta is characterized by a high nutritive value) requires strict following up of recommended process and provision of suitable conditions in the bedding. Vermicompost is mature peat-like material with a high porosity, aeration, water holding capacity and microbial activity which are stabilized by interaction between earthworms and microorganism in a non-thermophilic process (Edwards and Burrows 1988). Vermicompost has large particulate surface area that provides many micro sites for the strong retention of nutrients (Shi-wei and Fu-zhen, 1991). Vermicompost is rich in microbial populations and diversity particularly fungi, bacteria and actinomycetes (Edwards, 1998; Tomati *et al.*, 1987).

Application of vermicompost increases the total microbial population of nitrogen-fixing bacteria and actinomycetes in the soil. Due to increased microbial activity in the soil, degradation of organic waste continues in the soil also and it also improves the availability of phosphorous and nitrogen for the growing plants. Vermicomposting program was launched in India in the 1990s and Prof. Radha D. Kale (Banglore), Prof. B.K. Senapati (Sambalpur), Dr. UdayBhawalkar (Pune) were among the pioneer workers. Commendable works on vermicomposting have also been done at Bhawalkar Earthworms Research Institute (BERI), Pune, Tata Energy Research Institute (TERI), Delhi, National Environmental Engineering Research Institute (NEERI), Nagpur, INORA, Pune. Khwairakpam and Bhargava (2009) employed three earthworm species *E. fetida*, *E. eugeniae*, and *P. excavatus*in individual and combinations for their vermicomposting study of sewage sludge. It was reported that different species co-existed well and pure and mixed cultures worked efficiently almost equally. The mixed cultures showed better performance in some aspects while the pure cultures were ahead in other terms.Haimi and Huhta (1986) explored the potential of vermicomposting of contents of garden residues and composting toilet using crushed bark as mixture material garden residues and contents of composting toilet using crushed bark as mixture material. They concluded that *E. foetida* thrives well and reproduces in household garbage both in summer and winter conditions.

Benitez *et al.* (1999, 2000, 2002, 2005) expensively studied of sewage sludge mixed with olive waste using *Eiseniafoetida*. A relationship was established between increase in earthworm biomass and enzyme activities during sewage sludge vermicomposting. Later on hydrolase (Glucosidase, urease, BAA hydrolysing protease and phosphatase) and dehydrogenase enzyme activities showed a decrease as available organic compounds (water-soluble carbon) decreased due to their decomposition. Ndgewa*et al.* (2000) investigated the vermicomposting of biosolids amended with paper mulch and observed that a stocking density of 1.60 kg worms/m 2 and a feeding rate of 1.25 kg feed/kg of worm/day provided best results with regards earth worm biomass production.Vigueros and Camperos (2002) have used water hyacinth (30%) and sewage sludge (70%) for vermin composting using *Eisenia fetida*. Maboeta and Van Rensburg (2003) have demonstrated that vermicomposting of sewage sludge utilizing *Eiseniafetida* can be done by mixing with industrially produced woodchips. Sinha *et al.* (2002) studied the degradation and composting abilities of three species of earthworms on community wastes (cattle dung, raw food wastes and garden wastes) and reported that the worm *Eudrilus euginae* was a better waste degrader followed by *Eiseniafetida*. Sinha *et al.* (2008) reported that both municipal (domestic and commercial) and industrial (livestock, food processing and paper industries) wastes can be managed by earthworms. Sinha *et al.* (2010) excellently reviewed the role of vermiculture in sustainable development programmes including waste and land management and production of valuable bioactive com-pounds of great medicinal values has grown considerably in recent years. According to them earthworms are both “protective” & “productive” for environment and society.

MATERIAL AND METHODS

Collection of sewage sludge, rice husk and cattle dung:

The sewage sludge was collected from large open type of drainage system, usually known as Nallah situated at Agra – Bombay Road, Gwalior. Therice husk (RH) was procured from Dhan Mill, Kampoo, Gwalior. Cattle dung was procured from buffalo dairy farms.

Maintenance of Stock Culture of Earthworms:

Three promising species of epigeic earthworms, *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus* are being successfully cultured and used for vermin composting purpose in the Vermi composting Center, located in Charak Udyan of Jiwaji University, Gwalior.

Designing of experiment:

Vermi composting experiments were conducted in plastic containers of the size 50 X 33 X 14 cm (length x width x depth) (Fig. 1) by culturing *E. fetida* in sewage sludge mixed with rice husk and cattle dung in different proportions (Table: 1). Three replicates were taken for each combination of the waste mixture. The waste mixture was first equilibrated for a period of 15 days by the method of pre-decomposition, before release of earthworms to begin the experiment.

Fig. 1. Experimental culture units of vermicompostdifferent substrate combination

Table 1. Different combinations of culture media for *E. fetida* containing sewagesludge (SS), rice husk (RH) and dung (D)

S. No.	Organic Matter Combinations	Ratio
1.	Sewage sludge without earthworm (SSC)	-
2.	Sewage sludge with earthworm (SSE)	-
3.	Rice huskwith earthworm (RHE)	-
4.	Dung with earthworm (DE)	-
5.	SS+D	[1:1]
6.	SS+D	[2:1]
7.	SS+D	[3:1]
8.	SS+RH	[1:1]
9.	SS+RH	[2:1]
10.	SS+RH	[3:1]
11.	SS+RH+D	[1:1:1]
12.	SS+RH+D	[2:1:1]
13.	SS+RH+D	[3:1:1]
14.	SS+RH+D	[1:2:1]
15.	SS+RH+D	[1:3:1]

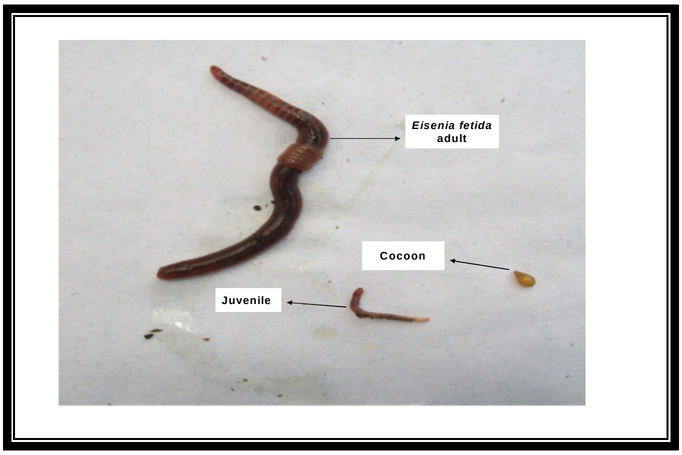

Fig. 2. Composting earthworm *Eiseniafetida*

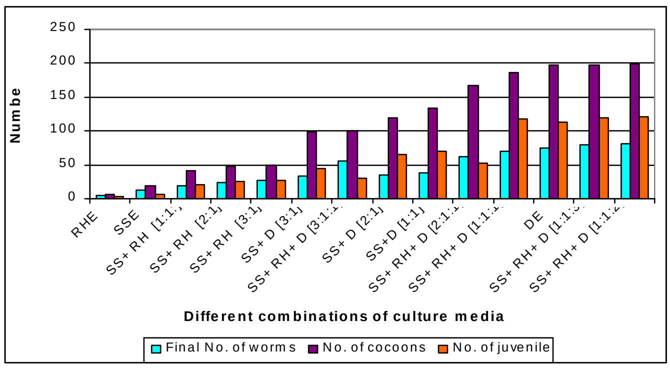

Fig. 3. Percent increase in bio-number (population growth) of *E. fetida* in different culture media

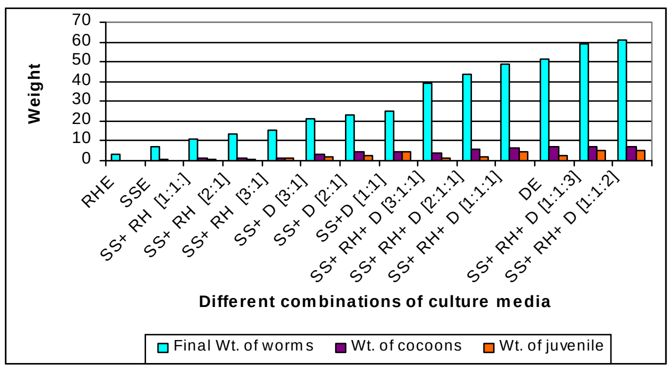

Fig. 4. Percent increase in biomass production of *E. fetida* in different culture media

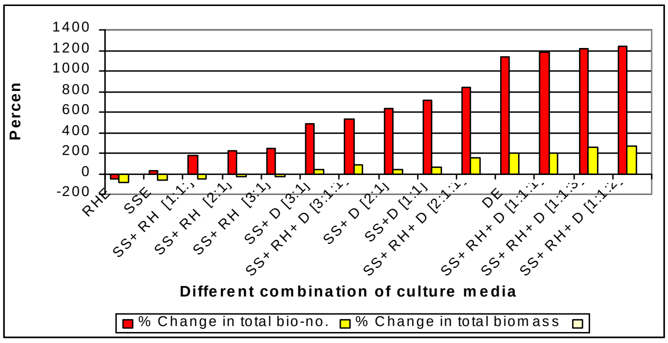

Fig. 5. Percent change in the number and weight of adult *E. fetida* in different substrate

The experimental containers were filled with 5 kg of pre-decomposed waste mixture (culture medium) and were kept covered by garden mesh cloth. Next day, a total number of 30 mature, adult, clitellate earthworms (*E. fetida*), taken from a stock culture, were uniformly released on top of the medium. Weight of the earthworms was measured before releasing. The containers, covered with garden mesh, were maintained in shade for a period of one month with timely sprinkling of water and shuffling of the waste medium (Naddafi*et al.,* 2004). Than after 63 days the content of each container were carefully separated on the plastic sheet one by one. Adult worms, cocoons and juveniles were separated from the content and were counted and weighed. After this, entire material was dry for some hour and was separated by sieving through sieve. After this, the sieved material and upper residual part were weighed. In the process of experimental observation initial and final number of adult earthworms, initial and final weight of adult earthworms, number and weight of juveniles, number and weight of cocoons, percent change in number and weight of adult earthworms, hatching percentage, degree of composting and cocoon-juvenile ratio were observed. The quantity of compost was determined by weighing and the values were used for calculation of degree (percentage) of composting. Thus the observations included following parameters.

Number of adult worms
Number of cocoons
Weight of cocoons
Number of juveniles
Weight of juveniles
Data thus collected was subjected to differential statistics (Mean + S. D.).

RESULT AND DISCUSSION

Bio-number and biomass production of *Eisenia fetida* of different combinations of three waste media -:

Remarkable variations have been noticed with regards to the number and weight of adult worms as well as total bio-number and biomass production in different substrate media indicating that all combinations of substrates were not equally suitable for survival, growth and reproduction of *Eisenia fetida*. The average results on the number of adults, cocoon and juveniles. Similarly the average results on the weight of adults, cocoons and juveniles. The initial number of adult earthworms inoculated was 30 and the final number of adult worms varied widely from 5.33±3.52 to 81.33±6.18. The number of adult earthworms was significantly reduced in containers containing higher amounts of rice husk and sewage sludge as a medium. Maximum reduction (from 30 to 5.33 = 82.22%) was found in rice husk (RH) followed by sewage sludge (SS) (from 30 to 12 = 60%), SS+RH [1:1] (30 to 19.67 = 34.44%), SS+RH [2:1] (30 to 24= 20%) and SS+RH [3:1] (30 to 27.67 = 7.78%). (Table: 2)

In all other media, the number of adult worms showed an increasing trend. The minimum (8.89%) increase was noticed in SS+D [3:1], followed by 18.89% in SS+D [2:1], 30% in SS+D [1:1], 87.78% in SS+RH+D [3:1:1], 107.78% in SS+RH+D [2:1:1], 132.22% in SS+RH+D [1:1:1], 146.67% in dung only, 167.77 in SS+RH+D [1:1:3] and 171.11% in SS+RH+D [1:1:2]. (Table: 2)

Observations on weight of adult earthworms in different substrate media also showed considerable changes showing weight reduction in unsuitable media and weight gain in favourable media. The maximum decline (21.21 gm to 2.93 gm = 86.17%) was noticed in rice husk followed by sewage sludge (21.55 gm to 7.2 gm = 66.59%), SS+RH [1:1] (24 gm to 10.86 gm = 54%), SS+RH [2:1] (21.88 gm to 13.2 gm = 39.67%), SS+RH [3:1] (18.57 gm to 15.21 gm = 18.08%), SS+D [2:1] (21.20gm to 23.18 gm = 9.33%). (Table: 3)

In other waste mixtures, in which ratio of dung was increased, the weight of adult earthworms showed an increase. The sequence from lower to higher degree of increase was noticed to be: SS+D [3:1] (19.46gm to 21.23gm = 9.07 %), SS+D [1:1] (20.74gm to 25.35gm = 22.22%), SS+RH+D [3:1:1] (24.01gm to 39.43gm = 64.21%), SS+RH+D [2:1:1] (20.45gm to 43.63gm = 133.30%), SS+RH+D [1:1:1] (20.38gm to 48.76gm = 139.21%), dung alone (20.39 to 51.21 = 151.07%), SS+RH+D [1:1:3] (19.91 gm to 59.24 gm = 197.53 %) and SS+RH+D [1:1:2] (19.88gm to 60.99gm = 207 %. (Table: 3)

From the data of number and weight of adult worms in different substrates, the percent change of respective parameters was calculated. These values are shown in table. In broad sense, the media in which, the number and weight of adult worms are increasing, may be considered suitable for vermiculture. The number and weight of adult earthworms are the indicators of growth and biomass production, whereas the number and weight of cocoons and juveniles are the parameters of reproductive performance. It was observed that even in the culture media in which a significant number of adults could not survive, some cocoons were laid by the surviving individuals from whom baby worms were hatched out. The number of cocoons and baby worms showed much variation in different culture media. Minimum number of cocoons (6.67) was recorded in rice husk. The substrate media may be arranged in a sequence / order showing an increasing no. of cocoons:19.67 in sewage sludge, 42 in SS+RH [1:1], 48 in SS+RH [2:1], 49.33 in SS+RH [3:1], 99.33 in SS+D [3:1], 101 in SS+RH+D [3:1:1], 119.67 in SS+D [2:1], 134.33 in SS+D [1:1], 167 in SS+RH+D [2:1:1], 198 in SS+RH+D [1:1:1], 185 in dung, 197.33 in SS+RH+D [1:1:3] and 199.33 in SS+RH+D [1:1:2]. (Table 2) Similar to the number of cocoons, minimum cocoon weight was also observed in rice husk (0.233gm) and an increase in cocoon weight was

Table 2: Initial and final number of adult earthworms and number of cocoons and juveniles during vermicomposting of various organic matters by using *E. fetida*

S.No.	Organic matter	Initial no. of worms	Final no. of worms	% Change in no. of adult worms	Final no. of cocoons	Final no. of Juveniles	% Change in total bio-no. (population growth)
1.	SS+ RH+ D [1:0:0]	30	12.00±4.07	-60.00	19.67±3.53	7.00±2.00	28.89
2.	SS+ RH+ D [0:1:0]	30	5.33 ±3.52	-82.22	6.67±2.15	3.00± 4.12	-50.00
3.	SS+ RH+ D [1:1:0]	30	19.67 ±2.03	-34.44	42.00±5.53	20.67±3.57	174.45
4.	SS+ RH+ D [2:1:0]	30	24.00±7.98	-20.00	48.00±2.32	25.00±5.22	223.33
5.	SS+ RH+ D [3:1:0]	30	27.67 ±2.12	-7.78	49.33±4.00	27.67±3.53	248.49
6.	SS+ RH+ D [0:0:1]	30	74.00±6.23	146.67	185.67±2.52	112.67±2.53	1141.11
7.	SS+ RH+ D [1:0:1]	30	39.00±5.58	30.00	134.33±4.53	70.00±3.00	710.00
8.	SS+ RH+ D [2:0:1]	30	35.67±8.52	18.89	119.67±3.08	65.00±2.08	634.45
9.	SS+ RH+ D [3:0:1]	30	32.67±6.53	8.89	99.33±5.53	44.33±4.53	487.78
10.	SS+ RH+ D [1:1:1]	30	69.67±5.08	132.22	198±2.65	117.67±2.52	1184.45
11.	SS+ RH+ D [2:1:1]	30	62.33±3.53	107.78	167.00±1.19	52.67±2.53	840.00
12.	SS+ RH+ D [3:1:1]	30	56.33±4.08	87.78	101.00±2.00	31.00±2.65	527.78
13.	SS+ RH+ D [1:1:2]	30	81.33±6.12	171.11	199.33±2.34	121.33±2.31	1239.99
14.	SS+ RH+ D [1:1:3]	30	80.33±6.12	167.77	197.33±2.41	119.33±2.33	1222.22

Table 3: Initial and final weight of adult earthworms and weight of cocoons and juveniles during vermicomposting of various organic matters by using *E. fetida*

S.No.	Organic matter	Initial wt. of worms	Final wt. of worms	% Change in wt. of adult worms	Wt. of cocoons	Wt. of Juveniles	% Change in total biomass
1.	SS+ RH+ D [1:0:0]	21.56±3.23	7.20±1.51	-66.59	0.65±3.18	0.27±1.34	-62.35
2.	SS+ RH+ D [0:1:0]	21.21±0.41	2.93±2.64	-86.18	0.23±2.32	0.11±0.04	-84.54
3.	SS+ RH+ D [1:1:0]	24.00±1.18	10.82±0.36	-54.93	1.34±0.06	0.79±1.06	-46.06
4.	SS+ RH+ D [2:1:0]	21.88±0.83	13.20±0.58	-39.68	1.54±2.02	0.95±2.02	-28.32
5.	SS+ RH+ D [3:1:0]	18.58±1.51	15.22±1.90	-18.09	1.58±0.04	1.05±2.12	-3.94
6.	SS+ RH+ D [0:0:1]	20.39±0.36	51.22 ±3.79	151.07	6.49±1.06	4.51±3.03	205.06
7.	SS+ RH+ D [1:0:1]	20.74±1.11	25.35±3.39	22.23	4.70±0.01	2.80±0.03	58.39
8.	SS+ RH+ D [2:0:1]	21.20±0.47	23.18±3.55	-9.33	4.19±0.32	2.60±2.01	41.35
9.	SS+ RH+ D [3:0:1]	19.47±1.41	21.23±1.73	-9.08	3.48±0.15	1.68±2.12	35.59
10.	SS+ RH+ D [1:1:1]	20.39±1.39	48.77±1.45	139.21	6.93±1.66	4.71±1.44	196.29
11.	SS+ RH+ D [2:1:1]	20.46±1.41	43.63±0.28	133.30	5.85±1.24	2.05±0.34	151.92
12.	SS+ RH+ D [3:1:1]	24.03±2.28	39.43±2.80	64.22	3.54±3.04	1.18±1.07	83.84
13.	SS+ RH+ D [1:1:2]	19.87±0.89	60.99±0.69	207.01	6.98±0.06	4.85±0.03	266.59
14.	SS+ RH+ D [1:1:3]	19.92±3.13	59.25±1.59	197.53	7.14±0.03	5.01±0.07	258.55

observed in agreement with the trend observed with regards to the cocoon number: 0.649gm in sewage sludge, 1.344 gm in SS+RH [1:1], 1.536gm in SS+RH [2:1], 1.578gm in SS+RH [3:1], 3.476gm in SS+D [3:1], 3.535gm in SS+RH+D [3:1:1], 4.188 gm in SS+D [2:1], 4.701gm in SS+D [1:1] ,5.845gm in SS+RH+D [2:1:1], 6.498gm in SS+RH+D [1:1:1], 6.93gm in dung, 6.24gm in SS+RH+D [1:1:3] and 6.976gm in SS+RH+D [1:1:2]. (Table: 3)

As the number and weight of cocoons differed in waste combinations containing sewage sludge. The number and weight of baby worms(Juveniles) also showed much variation in different culture media. The data recorded for the number and weight of baby worms also showed a similar pattern. Minimum number (3) and weight (0.114 gm) of baby worms were recorded in rice husk and both the parameters increased in the following sequence: 7 and 0.266gm in SS, 20.667 and 0.785gm in SS+RH [1:1], 25 and 0.95gm in SS+D [2:1], 27.667 and 1.051gm in SS+D [3:1], 31 and 1.178gm in SS+RH+D [3:1:1], 44.33 and 1.684gm in SS+D [3:1], 52.667and 2.054gm in SS+RH+D [2:1:1], 65 and 2.6gm in SS+D [2:1], 70 and 2.8 gm in SS+D [1:1], 112.667 and 4.506 gm in dung, 117.667 and 4.706 in SS+RH+D [1:1:1], 199.33 and 4.28gm in SS+RH+D [1:1:3], 121.33 and 4.853gm in SS+RH+D [1:1:2] respectively. (Table: 3) All combinations of substrates employed in the present study can be grouped into three different categories (A) sewage sludge + dung, (B) sewage sludge + rice husk (C) sewage sludge + rice husk + dung. When the results were displayed in these groups, it became clear that the sewage sludge as such was not suitable for vermicomposting by *E. fetida*.Mixing of rice husk or dung or both improved the performance of earthworms in substrate media. Substrate combinations with high amount of sewage sludge were less suitable for the worms. The acceptance or the suitability of the medium increased with decreasing amount of sewage sludge and increasing amount of dung. Dung is generally considered to be the best culture medium for vermicomposting with respect to population growth, biomass production of worms and this was confirmed in the present study. The mixture of three substrates (SS+RH+D – 1:1:1) was found to be little inferior than the dung. Further the overall performance index (OPI) of SS+RH+D (1:1:2) was much better than the dung and it was observed that further increase of dung caused insignificant change in the OPI (Table: 2&3).

***SSC**- Sewage sludge without earthworms, **SSE**- Sewage sludge with earthworms, **RHE**- Rice husk with earthworms, **DE**- Dung with earthworms

Conclusion

The red wriggler worms, *E. fetida* can not be cultured for vermicomposting in rice husk and sewage sludge alone.Cattle dung is highly suitable and ideal medium for growth and multiplication of *E. fetida* and for vermicomposting.Sufficient quantities of cattle dung and rice husk are to be mixed in sewage sludge for successful vermicomposting.Population growth, biomass production and degree of composting are the appropriate parameters to demonstrate the suitability of substrate media for earthworm culture and vermin composting. Highly suitable substrate media for vermiculture show maximum values of population growth and biomass production.

Acknowledgement

Authors are highly thankful to DRDE Gwalior for providing financial assistance under the project. Authors are also grateful S.O.S. in Zoology, Jiwaji University, Gwalior.

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