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Heavy Metals Accumulation from Municipal Solid Wastes with Different Animal Dung Through Vermicomposting by Earthworm *Eisenia fetida*

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Abstract: The concentration of heavy metals Co, Cr, Cd, Ni, Pb and As were estimated in combinations of municipal solid wastes with different animal dung. The significant decrease in heavy metals concentration was observed in all the combinations of different animal dung with MSW after vermicomposting by *E. fetida*. Maximum significant decrease of Co in buffalo dung with MSW, Cr and Pb in cow dung control, Ni was observed in all animal dung with MSW, Cd in cow dung with MSW and As were observed in combination of goat dung with MSW. From the present study it is clearly demonstrated that *E. fetida* significantly decrease the different heavy metals in the final vermicompost during vermic-activity. The technology is useful for management of MSW as well as prevents the heavy metal concentration in human food which causes serious problems to the human and animal health.

Key words: *Eisenia fetida* · Municipal solid wastes (MSW) · Heavy metals and human health problems and vermicomposting

INTRODUCTION

Industrialization of the developing countries in Asia of rapid economic growth has created serious problem of waste disposal due to rapid urbanization [1]. Management of municipal solid wastes is posing a great face to India and other developing countries [2]. The total annual generation of MSW in USA in 2003 is 236 million tones per year, which is 50% higher than MSW generated in 1980 [3], New Delhi is capital of India in 136 kg/ person/ year [4, 5]. Municipal solid wastes contain many toxic elements and their compound caused various ill effects on human health and environment, if their proper management and practice are not available [6, 7]. The livestock excreta and industrial sludge are also a serious problem for the society [8-10]. Disposal of municipal solid wastes and household hazardous wastes including batteries, paint residue, ash, treated woods and electronic wastes increase the heavy metals in soil [11, 12].

Heavy metals caused serious problems to the human and animal health by accumulation particularly in kidney and liver [13]. Different kind of heavy metals caused many disorder in human body, Co, Cr, Pb, Ni, Cd and As are the chief heavy metals of MSW [14]. Roels *et al*. [15] reported that Cd and Ni encountered in industries dealing with pigment, metal plating, some plastic and batteries. These heavy metals entered in the human body by ingestion of contaminated foodstuff specially grains, cereals and leafy vegetables. It can cause several respiratory irritation lung disease, cancers and kidney problem [16-17]. High level of Pb exposure in body caused several damage to brain and kidney which ultimately leads to death; pregnant woman cause miscarriage, whereas to men can damage the organ responsible for sperm production. Cobalt (Co) can be responsible for the beer hearth syndrome in the human [18]. Chromium spreads the disease in human being, life breathing problem such as asthma, cough wheezing and skin contact can causes skin ulcer. Arsenic is carcinogens and causes cancer of skin, lung and liver; lower level of exposure causes nausea and vomiting, decreased production of RBCs, WBCs and damage to blood vessels. Heavy metals release naturally by erosion of rocks, volcanic activity, forest fire and artificially by many industries, paper mills, vehicles and human activities and it can release in large quantities directly effect the flora, fauna as well as human population [19].

Eisenia fetida have to accumulate the heavy metals in their bodies from soil as well as different biological wastes during vermicomposting [20-24]. The *Eisenia fetida* and *Eudrilus eugeniae* are most important species for effective reducing of the metal toxicity from municipal

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solid wastes [25]. Earthworms are important link in the food chain and they can accumulate the hazardous elements from the soil [26, 27]. The use of redworm for processing sewage sludge increases the content of nutrients easily assemble for plants in a vermicompost, which affects better quality of plant biomass and management of some bacterial and fungal diseases [28].

The aim of the present study is to investigate the heavy metal content accumulated by earthworm *E. fetida* from the combination of different animal dung with MSW by estimating the level of content in initial vermibed and final vermicompost. The heavy metal content is also estimated in the earthworm body before inoculation in the vermibeds and after vermicomposting.

MATERIALS AND METHODS

Collection of Wastes

Collection of Animal Wastes: Animal wastes (cow, buffalo, sheep, goat and horse dung) were collected from different farm houses of the Gorakhpur district.

Municipal Solid Wastes: Municipal solid wastes were collected from different part of Gorakhpur city and exposed to sun light for 5 to 10 days for removal of various harmful organism and noxious gases.

Collection of Earthworm: Earthworm *Eisenia fetida* an epigeic species have cultured in vermiculture research center, Department of Zoology, D.D.U. Gorakhpur University, Gorakhpur. The collected earthworms were cultured in laboratory condition, temperature (20°C to 30°C) and aeration, moisture have maintained up to 40% to 60% for proper growth and survival of earthworms.

Experimental Setup for Vermicomposting: The vermicomposting conducted on cemented earth surface. The different combinations of animal dung and municipal solid wastes in 1:1 ratio were used for preparation of vermibeds. The size of each vermibed is 3m x 1m x 9cm. After formation of vermibed moist it and inoculated 2kg of cultured *Eisenia fetida* in each bed. The beds were covered with jute pockets and moisten the beds daily up to 40 to 50 days for maintaining the moisture content. After one week interval, each vermibed were manually turned over up to 3 weeks. After 60 days granular tea like vermicompost appear on the upper surface of each bed. The prepare vermicomposts and inoculated earthworm were used for experiments.

Analysis of Heavy Metals

In Initial Feed Mixture and Final Vermicompost: The heavy metal content of the initial feed mixture and final vermicompost were measured by the method of Maboeta [29]. About 1 gm of initial feed mixture and final vermicompost required the samples. These sample will be subjected to digestion by adding excess of nitric acid (1:1) and were placed on hot plate and heated for 4 hours at 90°C to 100°C. It will be take care to ensure that simple did not dry out during digestion. After digestion sample will be poured into 100 ml flask through Whatman No 41 filter paper and injected into flame atomic absorption for determination of the heavy metal concentration.

In Earthworm Body: The heavy metals in the earthworm body tissue will be digested using by the method of Katz and Jenneis [30]. Earthworm will be individually dried, ground and burned to ash at high temperature. Afterwards the ash will be placed in test tube about 10 to 15 ml of 55% nitric acid will be added in it. The solution will be left for 12 hrs at room temperature. After that the sample will heated a temperature of 40°C to 60°C for 2 hrs and then at a temperature of 120°C to 130°C for one hrs solution will be called at room temperature. Reheated the sample at 120°C to 130°C and 1 ml of 70% perchloric acid will be added. The sample will be allowed to cooling before adding 5 ml of distilled water. Samples will be again reheated up to 130°C until white fumes emitted. The sample will be allowed to cool finally before being micro filtered. The solution will be filtered through Whatman No 41 filter paper in to 100 ml flasks and will be measured. The heavy metals content in earthworm body by flame atomic absorption.

RESULTS AND DISCUSSION

There was significant reduction ($P<0.05$ 't' test) in heavy metals (Co, Cr, Cd, Ni, Pb and As) was observed in final vermicompost of municipal solid wastes with different animal dungs with respect to initial feed mixture (Table 1, 2). The significant reduction of Co was observed in combination of Buffalo dung with MSW, where as in cow dung only have significant maximum reduction in level of Cr (0.074±0.003) and Pb (0.008±0.006) than the initial feed mixture and final vermicompost of all the combinations of different wastes (Table 1). Table 2. shows that there was no content of Ni in all the combination of different animal dungs with municipal solid wastes. The content of Cd in significantly reduced

Table 1: Concentration of heavy metals (mg/kg) in different combinations of animal dung with municipal solid wastes in initial feed mixture and final vermicompost

		Heavy metals (mg/kg)					
		Co		Cr		Pb	
Vermicompost	Ratio	Initial	Final	Initial	Final	Initial	Final
MSW		0.180±0.006	0.162±0.004*	0.864±0.005	0.141±0.002*	0.965±0.003	0.063±0.003*
Buffalo dung		0.029±0.008	0.006±0.003*	0.672±0.003	0.085±0.003*	0.782±0.006	0.043±0.003*
Buffalo dung + MSW	1:1	0.017±0.007	Nil	0.708±0.004	0.109±0.005*	1.773±0.008	0.058±0.003*
	1:2	0.037±0.003	0.009±0.002*	0.753±0.006	0.127±0.004*	0.185±0.005	0.034±0.003*
	1:3	0.035±0.004	0.011±0.004*	0.740±0.003	0.098±0.006*	NIL	NIL
Cow dung		0.029±0.006	0.009±0.002*	0.848±0.003	0.074±0.003*	0.024±0.004	0.008±0.006*
Cow dung + MSW	1:1	NIL	Nil	0.872±0.005	0.110±0.003*	0.030±0.005	0.011±0.005*
	1:2	0.062±0.007	0.017±0.003*	0.749±0.003	0.084±0.005*	0.088±0.003	0.018±0.004*
	1:3	0.053±0.008	0.008±0.002*	0.799±0.003	0.087±0.004*	0.092±0.004	0.023±0.003*
Goat dung		0.022±0.002	0.004±0.003*	0.860±0.008	0.108±0.004*	NIL	NIL
Goat dung + MSW	1:1	0.076±0.004	0.007±0.004*	0.843±0.007	0.092±0.003*	0.184±0.004	0.042±0.003*
	1:2	NIL	Nil	0.906±0.006	0.101±0.003*	1.674±0.004	0.109±0.003*
	1:3	0.068±0.003	0.015±0.003*	0.844±0.004	0.094±0.004*	0.278±0.005	0.057±0.003*
Horse dung		0.018±0.002	0.007±0.004*	0.795±0.003	0.098±0.005*	0.199±0.002	0.038±0.003*
Horse dung + MSW	1:1	0.025±0.003	0.008±0.008*	0.827±0.007	0.107±0.005*	0.108±0.003	0.029±0.008*
	1:2	0.060±0.003	0.015±0.003*	0.802±0.005	0.104±0.003*	0.069±0.003	0.026±0.007*
	1:3	0.079±0.006	0.011±0.005*	0.868±0.003	0.106±0.004*	0.058±0.004	0.015±0.004*
Sheep dung		0.055±0.003	0.027±0.004*	0.819±0.005	0.109±0.007*	0.748±0.005	0.046±0.004*
Sheep dung + MSW	1:1	0.170±0.003	0.043±0.003*	0.821±0.003	0.101±0.006*	0.573±0.004	0.035±0.003*
	1:2	0.024±0.003	0.008±0.003*	0.808±0.007	0.097±0.004*	0.906±0.006	0.112±0.006*
	1:3	0.061±0.005	0.012±0.005*	0.799±0.006	0.090±0.005*	0.757±0.007	0.033±0.005*

MSW = Municipal Solid Wastes

Each value is the Mean ± SD of six replicates

*Significant P<0.05 "t" test between initial feed mixture and final vermicompost

Table 2: Concentration of heavy metals (mg/kg) in different combinations of animal dung with municipal solid wastes in initial feed mixture and final vermicompost

		Heavy metals (mg/kg)					
		Ni		Cd		As	
Vermicompost	Ratio	Initial	Final	Initial	Final	Initial	Final
MSW		0.089±0.003	0.019±0.003*	0.287±0.003	0.027±0.004*	0.081±0.008	0.026±0.003*
Buffalo dung		0.126±0.003	Nil*	0.398±0.006	0.041±0.004*	0.168±0.005	0.014±0.005*
Buffalo dung + MSW	1:1	0.100±0.003	Nil*	0.292±0.003	0.022±0.002*	0.091±0.005	0.012±0.003*
	1:2	0.093±0.003	Nil*	0.087±0.002	0.016±0.004*	0.083±0.003	0.016±0.002*
	1:3	0.109±0.004	Nil*	0.080±0.006	0.014±0.005*	0.102±0.001	0.027±0.003*
Cow dung		0.107±0.005	Nil*	0.158±0.005	0.018±0.005*	0.057±0.004	0.019±0.005*
Cow dung + MSW	1:1	0.192±0.004	Nil*	0.090±0.007	0.009±0.002*	0.053±0.008	0.018±0.002*
	1:2	0.124±0.007	Nil*	0.828±0.008	0.118±0.003*	0.058±0.005	0.015±0.004*
	1:3	0.128±0.005	Nil*	0.258±0.003	0.015±0.004*	0.075±0.003	0.025±0.003*
Goat dung		0.844±0.005	Nil*	0.391±0.003	0.019±0.005*	0.118±0.005	0.016±0.003*
Goat dung + MSW	1:1	0.115±0.004	Nil*	0.450±0.004	0.028±0.005*	0.109±0.003	0.014±0.004*
	1:2	0.117±0.008	Nil*	0.166±0.001	0.021±0.002*	0.059±0.003	0.009±0.003*
	1:3	0.090±0.004	Nil*	0.137±0.004	0.017±0.003*	0.040±0.002	0.006±0.002*
Horse dung		0.106±0.003	Nil*	0.483±0.001	0.105±0.003*	0.099±0.006	0.011±0.006*
Horse dung + MSW	1:1	0.077±0.007	Nil*	0.258±0.004	0.024±0.004*	0.098±0.005	0.016±0.007*
	1:2	0.095±0.003	Nil*	0.312±0.008	0.019±0.004*	0.079±0.003	0.012±0.004*
	1:3	0.092±0.003	Nil*	0.291±0.003	0.012±0.006*	0.061±0.007	0.015±0.005*
Sheep dung		0.172±0.005	Nil*	0.288±0.004	0.037±0.003*	0.061±0.004	0.016±0.004*
Sheep dung + MSW	1:1	0.108±0.007	Nil*	0.218±0.006	0.028±0.005*	0.053±0.008	0.013±0.008*
	1:2	0.101±0.003	Nil*	0.259±0.007	0.029±0.007*	0.067±0.003	0.015±0.002*
	1:3	0.086±0.002	Nil*	0.193±0.003	0.025±0.006*	0.057±0.005	0.011±0.005*

MSW = Municipal Solid Wastes

Each value is the Mean ± SD of six replicates

*Significant P<0.05 "t" test between initial feed mixture and final vermicompost

Table 3: Concentration of heavy metals (mg/kg) in different combination of animal dung with municipal solid wastes in final earthworm body after vermicomposting

		Heavy metals (mg/kg)					
Vermicompost	Ratio	Co	Cr	Pb	Ni	Cd	As
During inoculation							
Earthworm body (Control)		6.734±0.004	114.515± 0.006	9.438±0.005	6.339±0.002	61.645±0.004	9.450±0.003
After vermicomposting							
MSW		6.801±0.005*	115.252±0.003*	10.265±0.004*	6.402±0.004*	61.802±0.006*	9.471±0.003*
Buffalo dung		6.753±0.003*	115.017±0.002*	10.112±0.003*	6.465±0.005*	61.854±0.003*	9.590±0.003*
Buffalo dung + MSW	1:1	6.812±0.005*	115.081±0.005*	11.007±0.002*	6.439±0.003*	61.712±0.002*	9.552±0.002*
	1:2	6.884±0.002*	115.108±0.002*	9.501±0.004*	6.432±0.005*	61.683±0.003*	9.560±0.003*
	1:3	6.901±0.003*	114.991±0.005*	9.438±0.003*	6.448±0.005*	61.680±0.003*	9.602±0.005*
Cow dung	-	6.740±0.003*	115.255±0.006*	9.448±0.003*	6.444±0.004*	61.741±0.004*	9.471±0.003*
Cow dung + MSW	1:1	6.734±0.003*	115.276±0.004*	9.451±0.004*	6.431±0.002*	61.715±0.003*	9.454±0.007*
	1:2	6.782±0.004*	115.098±0.002*	9.469±0.002*	6.463±0.003*	62.346±0.004*	9.460±0.003*
	1:3	6.779±0.005*	115.124±0.004*	9.498±0.007*	6.467±0.004*	61.719±0.005*	9.503±0.004*
Goat dung		6.743±0.003*	115.262±0.003*	9.438±0.002*	7.183±0.002*	61.814±0.004*	9.531±0.002*
Goat dung + MSW	1:1	6.776±0.002*	115.203±0.004*	9.501±0.006*	6.454±0.005*	61.926±0.003*	9.507±0.005*
	1:2	6.734±0.002*	115.316±0.003*	11.004±0.003*	6.456±0.003*	61.703±0.002*	9.465±0.005*
	1:3	6.792±0.005*	115.202±0.003*	9.523±0.004*	6.429±0.005*	61.734±0.005*	9.457±0.003*
Horse dung		6.740±0.003*	115.119±0.002*	9.561±0.004*	6.443±0.004*	62.161±0.003*	9.474±0.003*
Horse dung + MSW	1:1	6.751±0.003*	115.257±0.006*	9.501±0.007*	6.416±0.003*	61.829±0.002*	9.536±0.007*
	1:2	6.765±0.003*	115.220±0.004*	9.461±0.006*	6.434±0.003*	61.904±0.003*	9.527±0.005*
	1:3	6.772±0.004*	115.301±0.006*	9.452±0.003*	6.431±0.003*	61.821±0.004*	9.509±0.004*
Sheep dung		6.761±0.004*	115.224±0.004*	10.103±0.003*	6.511±0.004*	61.807±0.003*	9.478±0.003*
Sheep dung + MSW	1:1	6.823±0.006*	115.237±0.004*	9.936±0.007*	6.447±0.006*	61.821±0.004*	9.472±0.003*
	1:2	6.765±0.007*	115.211±0.007*	10.247±0.005*	6.440±0.002*	61.834±0.002*	9.486±0.007*
	1:3	6.753±0.003*	115.216±0.003*	10.168±0.003*	6.425±0.003*	61.811±0.005*	9.467±0.003*

MSW = Municipal Solid Wastes

Each value is the Mean ± SD of six replicates

*Significant P<0.05 "t" test between earthworm body before inoculation in vermibeds and after vermicomposting

in the combination of cow dung with municipal solid wastes mixed in ratio of 1:1. There was a maximum significant reduction observed in the level of As in the goat dung with municipal solid wastes. The organic matter ingested by earthworm under goes different chemical and microbial changes during vermic activity, the part of organic matter is digested and pH of the microbial activity content increased [31].

After the preparation of vermicompost in the body of inoculated earthworms have significant increased amount of different heavy metals (Co, Cr, Pb, Ni, Cd and As) in all combination of different animal dung with municipal solid wastes vermicompost beds (Table 3). The maximum significant increase content of Co, Pb and As was observed buffalo dung with municipal solid wastes and Cr in goat dung with municipal solid wastes but Cd was observed in cow dung with municipal solid wastes, whereas Ni was observed in the earthworm body in the combination of different wastes (Table 3). Data emerging from results there was a significant reduction in final vermicompost of different animal dung with solid wastes in the content of heavy metals, it is clear that the reduction of metal content was directly related to earthworm activity in the wastes decomposition system. In vermicomposted different wastes, the reduction in metal content was significantly higher than initial feed mixture. The observed differences in metal content in final vermicompost are related to the different rate of physiological metabolism of metals [32]. Gupta *et al*. [33] and Suthar and Singh [34] reported that the earthworms have ability to bioaccumulation the heavy metals in their body. In comparison of heavy metals content of initial feed mixture and inoculated earthworm body with respect to final vermicompost and earthworm body have a slit different may be due to the slit amount of heavy metals was leached with the water poured over the vermicompost bed for maintaining the moisture during vermicomposting. It may be due to the comparison of buffalo, cow and goat dung with municipal solid wastes increased the vermic activity, growth and development of earthworms and ability of heavy metal accumulation [35]. The maximum significant increased in the content of heavy metal in the body of inoculated earthworms after vermicomposting in all the combination of animal dung with municipal solid wastes because the earthworm tissue accumulates the heavy metals during vermic activity [36, 37]. Significantly changed fraction distribution and bioavailability of these heavy metals (Zn, Pb, Fe, Mn, Cr, Co and Cu) during

earthworm activity [38-40]. Although the earthworm *Eisenia foetida* is able to accumulate Cd in body tissue [41-43].

The maximum significant increased content of heavy metals (Co, Cr, Pb, Ni, Cd and As) in buffalo dung with MSW and Ni in all the combination of different wastes. It is the possible that the combination of buffalo dung with municipal solid wastes promotes the ability of accumulation of heavy metals in earthworm body. The Ni accumulation power of earthworm body is higher than the inoculated earthworm of all the combination of animal dung with MSW because it may to due to the Ni easy accumulate into the body of earthworm during metabolism.

CONCLUSION

It is clear from results that the *E. fetida* was accumulate heavy metals in its body tissue and significant decrease heavy metal concentrations in the final vermicomposts of different animal dung with municipal solid waste. The earthworm *E. fetida* was a most important invertebrate to accumulate the higher concentration of heavy metals by the application of a vermicompost of different animal dung (buffalo, cow, goat, horse and sheep dung) with MSW, therefore safe for environment and human health.

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