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EFFECT OF SOME HEAVY METALS ON *LAMPITO MAURITII* KINBERG (ANNELIDA : OLIGOCHAETA) IN MUNICIPAL WASTES DISPOSAL SITE AND A RESERVE FOREST FLOOR SITE OF WEST BENGAL, INDIA

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INTRODUCTION

As a result of the increasing interest paid to the recycling of wastewater, municipal wastes and sewage sludge in agricultural practice, it becomes necessary to study the uptake of heavy metals in invertebrates in general and earthworm in particular.

It is evident that earthworm can accumulate heavy metals from surrounding polluted soils and other media in their body (Gish and Christensen, 1973; van Hook, 1974; van Rhee, 1975; Ireland, 1979, 1983; Ash and Lee, 1980; Beyer, 1981; Beyer *et al.* 1982; Kruse and Barrett, 1985). But no such work has been carried out in India. To fill up this lacuna the present study has been conducted with the following objectives :

To determine whether this dominant species of *L. mauritii* could be use to absorb the heavy metals in contaminated soil and to compare them with a less polluted controlled reserve forest floor.

MATERIALS AND METHODS

Earthworm samples were collected month wise at random by digging and hand sorting method. Collected samples were repeatedly washed in water and then kept in double distilled water for 72 hours to evacuate soil from its gut. After that period earthworm samples were preserved in 10% formalin. Preserved samples were washed in double distilled water and then oven dried at 65°C for 48 hours Dried samples were crushed, weighed on a microbalance and acid (Nitric and Perchloric) digested on a hot plate.

KEYWORDS : Earthworm, *Lampito mauritii*, Heavy metals, Cadmium, Zinc, Lead, Copper, Wastes disposal site.

During collection of earthworm, soil samples were also collected at random. Collected soil samples of each month was air dried, crushed and mixed thoroughly. Acid digestion of soil samples were done in the same way.

Analysis of Zn, Cd, Pb and Cu was done using a Varian Techtron AA-575 atomic absorption spectrophotometer in R.S.I.C., Bose Institute, Kolkata. Wavelength (nm), Slit (nm) and Lamp current (mA) was used 213.9, 1.0, 5; 228.8, 0.5, 3.5; 217.0, 1.0, edl and 324.8, 0.5, 3.5 for Zn, Cd, Pb and Cu respectively.

p^H of the soil was determined by the electronic p^H meter (Model No. 335–Systronics). Electrical conductivity of the soil was determined by direct reading conductivity meter (Model No. 304–Systronics, conductivity cell type C. D-10). Organic carbon content of the soil was determined by "Rapid Titration Method" (Walkley and Black, 1934).

The Statistical analysis has been conducted by using BMDP Statistical Software, Inc.

CHARACTERISTICS OF THE STUDY SITES

Site–I : *Dhapa-Municipal wastes disposal site (DP)*

The site is dumping ground of city wastes, located by the side of Eastern Metropolitan By Pass, Kolkata. "Organic Fertilizer Pvt. Ltd." and 'Conversation of City Solid Wastes into Organic Fertilizer in Collaboration with Kolkata Municipal Corporation and Eastern Fertilizer Pvt. Ltd.' demarcate the area. The main constituents of the dumped materials were household wastes, industrial effluents and the residues of vegetables. Some parts of this sampling site regularly used for cultivation of different seasonal vegetables like cauliflower, maize, cucurbita, lettuce, red green leafy vegetables, cabbage etc. The soil is alluvial in nature, silty sand to sandy in texture, blackish in colour.

Site–II : *Bethuadhari Reserve Forest (BRF)*

It is a man made forest, located at Bethuadahari, by the side of NH-34, about 138 km. North of Kolkata, in the district of Nadia, at the eastern part of West-Bengal is being situated in the Gangetic plain. Tropic of cancer runs across the middle of the district. Annual rainfall ranges from 77-84.70 cm. The forest contains major trees like, *Shorea robusta*, *Tectona grandis*, *Dalbergia sisso*, *Ficus religiosa*, *Mangifera indica* and *Azadirachat indica* and under growths like, *Sporobolus diander*, *Dichanthium annulatum*, *Eragrostis brachyphylla*, *Digitana marginata*. *D. royleana*, *Euphoriba hirta* and *Lantana camara*. The soil is alluvial in nature, blackish brown in colour and sandy silt in texture.

RESULTS

Cadmium, zinc, lead and copper were present with in the range between 2.5–6.25 ppm., 550–750 ppm. 250–410 ppm. and 166–300 ppm. respectively in the soil of Site-I whereas 0.2–3.25 ppm., 48–132 ppm., 17–41 ppm. and 10–42 ppm. respectively in the soil of Site-II (Tables 1 and 2). In the tissue of earthworm species, 10–25 ppm., 670–1045 ppm., 150–292 ppm., 60–200 ppm. of cadmium, zinc, lead and copper respectively was present at Site-I whereas in the same species when collected from Site-II it was 3–10 ppm., 66–122 ppm., 10–28 ppm. and 10–29 ppm. respectively (Tables 1 and 2).

It was observed that the accumulation of cadmium and zinc in the whole earthworm tissue of studied species were in higher level in comparison to the surrounding soil from the studied sites whereas a reverse results were found in case of the accumulation of heavy metals like copper and lead (Figs. 1-8)

Bioconcentration (E / S) factor of cadmium was 3–10 in polluted soil whereas in forest soil it was 2.16–15. Bioconcentration factor of zinc was 1.1–1.39 and 1.08–1.69, for lead it was 0.44–0.73 and 0.3–0.88, for copper it was 0.28–1.61 and 0.62–0.93 in polluted soil and in forest soil respectively. Only two examples for copper in forest soil was found where bioconcentration factor was one or more (Tables 1 and 2).

The level of concentration of heavy metals in soil and its accumulation in earthworm tissue varies from one month to another and as well as with in the studied year. In Site-I highest concentration of cadmium in soil was found in Sept. ’02, Feb. ’03 and in earthworm tissue accumulation of this metal was highest in Jan. ’02, Dec. ’02, March ’03; highest concentration of zinc was found in March ’03 in both soil and in earthworm tissue; for lead concentration in soil was high in Jan. ’03 and in earthworm tissue it was in March ’03; highest copper concentration in soil was found in Jan. ’02, Dec. ’02 and in earthworm tissue it was in Oct. ’01 (Table-1).

In Site-II highest concentration of cadmium in soil was found in May ’02 but in earthworm tissue accumulation of this metal was high in Jan. ’03; highest concentration of zinc in soil was found in May ’03, but for earthworm tissue it was in June ’03, lead concentration in soil was high in March ’03, but for earthworm tissue it was high in Nov. and Dec. ’01; copper concentration in soil was high in May ’03 and for earthworm tissue it was in July ’02 (Table-2).

From figures 9-12 it has been found that the level of heavy metal accumulation in the earthworm tissue is directly proportional to the amount of heavy metals in soil.

Organic carbon, p^H and electrical conductivity the soil of site-I and II is given in Table 4.

STATISTICAL TREATMENT OF DATA

Data pertaining to the level of heavy metals in the soil and in earthworm tissue were subjected to statistical analysis. The application of linear correlation was undertaken in the present study involving the data of soil factors, heavy metal content of soil and of earthworm tissue for each site. Analysis was carried out by pulling together data for 24 months (as species not found in February ’03) in Site-I (DP) and for 18 months (as species not found in January, April, May, ’02 & February–May, ’03) in Site-II (BRF).

LINEAR CORRELATION

From this analysis (Tables 3a and 3b), it is found that level of accumulation of Cd, Zn, Pb and Cu of earthworm tissue showed significant positive correlations with the level in soil of Site-II (BRF) but in Site-I (DP), level of accumulation of only Zn and Pb of earthworm tissue shows significant positive correlations with that of the level of Zn and Pb in soil.

In site-I (DP) significant negative correlations found between level of soil organic carbon and level of zinc and lead in soil; but in Site-II only lead content of soil shows significant negative correlations with soil organic carbon.

DISCUSSION

It is evident from the present study that heavy metal contents of soil and in earthworm tissue were much higher in Municipal wastes disposal site than that of the Reserve forest (Figs. 1-8). There was a seasonal variation in the level of concentration of heavy metals in the soil as well as its accumulation in earthworm tissue (Tables 1 and 2). Higher accumulation of heavy metals in the tissue of earthworm was found mainly in the dry season *i.e.*, in winter and summer; it may be due to the lower activity of earthworm at that time. Ireland (1975a) and Anderson (1979) was made similar observation regarding the variation of accumulation of heavy metals in earthworm tissue as well as in the soil. The absorption level of cadmium and zinc were maximum in earthworm than the soil in both studied area, on the other hand copper and lead concentration in earthworm tissues were low than the concentration of these heavy metals in surrounding soil (Figs. 9-12). This might be due to an active regulation of Cu and Pb in the body of earthworm but not of Cd and Zn. This observation coincide with the findings of Carter *et al.* (1980) in *Lumbricus rubellus* and *Allolobophora chlorotica*, Pietz *et al.* (1984), Beyer *et al.* (1987) in *A. tuberculata*, Morgan *et al.* (1986) in *L rubellus.*

The present study reveals that this species has the capability to withstand toxicity concentration of Cd, Zn, Pb, and Cu upto 6.25 ppm, upto 750 ppm, upto 410 ppm and upto 300 ppm respectively in the soil. Moreover this species might have capable to increase absorption rate of Cd in its body from as low as 3 ppm to 25 ppm, Zn from 66 to 1045 ppm, Pb from 10 to 292 ppm and Cu from 10 to 200 ppm (Tables 1 and 2). But bioconcentration factor tends to fall for each metal in polluted site (Site-I) than least polluted environment (Site-II). Edwards and Bohlen (1996), after reviewing several literatures, opined that the bioconcentration factor for many heavy metals in earthworms tends to fall as soil concentrations rise.

Accumulation level of Cd, Zn, Pb and Cu in this species shows a significant positive correlation with that of the concentration of these metal in soil in least polluted forest site, but accumulation level of only Zn and Pb of earthworm tissue shows significant positive correlation with that of the concentration of these metals in polluted soil in wastes disposal site. Zietek and Pytasz (1979) also found a high correlation between concentrations in earthworm tissues and soils for both Zn and Pb. Mariño *et al.* (1998) showed significant interactions of Cu and Cd ions on *Lumbricus rubellus.* It suggests that when soil Cd and Cu content is in the higher level, then accumulation of Cd and Cu in tissue either influenced by other factors or may be the leveling off of these metals in earthworm tissue. Carter *et al.* (1980) opined that the leveling off of Cd levels in earthworm tissue without a concomitant increase in faecal levels might have been due to the high Cd levels in the soil having toxic effects. Ireland and Wooton (1976) found that Zn levels in tissue were not related to soil Zn levels where soil levels were high, on the contrary in this work concentration of Zn in tissue of this species shows significant positive correlation with the amount of Zn in soil in both these sites and bioconcentration factor of Zn is more than one in both cases.

The order of concentration factors of Cd, Zn, Pb and Cu in this species was Cd > Zn > Cu ≥ Pb. Ma (1982) was made similar observations in populations of *Aporrectodea caliginosa.* Significant negative correlations existed between concentration factors and soil organic matter content for Cu only (Ma, 1982), but Van Rhee (1975) showed positive correlations between the copper and organic matter content. Present study indicates that soil organic carbon has significant negative correlations with zinc and lead content of soil in polluted site. Regarding the question of high densities of this species in such environments, where there is a great deal of heavy metals, it might be due to the sub-lethal effects of these heavy metal poisoning. The toxic effects of heavy metals are partly determined by soil p^H and the content of organic matter, high values being protective (Peredney and Williams, 2000). Perhaps also others factors, not investigated here, had a protective effects on earthworm viability as, for example, bioavailibity of Zn, Pb and Cd is limited in the presence of phosphorus compounds (Maenpaa *et al.* 2002).

From the foregoing discussion it is seen that the uptake pattern of heavy metals in earthworms are a complicated matter. There are differences in rates of uptake attributed to soil p^H, to interactions in the environment and in the earthworms' internal chemistry between various combinations and relative concentrations of heavy metals that occur together, to the chemical form in which the heavy metals occur, to adsorption of heavy metals onto surfaces of clay or organic matter particles and to selection of food by the earthworms (Lee, 1985). Helmke *et al.* (1979), Morgan (1986), Beyer *et al.* (1987) stressed the value of using earthworms to assess heavy metal contamination. This study indicates that analysis of tissue of this earthworm species could be proved to be a useful for lowering down the heavy metal pollution at any particular site.

With respect to the question of earthworms being a source of contamination for other animals it seems clear that earthworms are preyed on by various birds, amphibians, reptiles and mammals living near municipal waste disposal site will be subjected to ingestion of considerable amount of Cd, Zn and some amount of Pb and Cu from this species. The studies on this aspect are also in progress.

Table 1. : Showing amount of heavy metals in soil and in whole tissue (per gm. dry wt.) of *L. mauritii* collected from Dhapa (Municipal wastes disposal site of Kolkata).

Month	Cd (ppm)			Zn (ppm)			Pb (ppm)			Cu (ppm)		
	Soil	Earth-worm	E/S	Soil	Earth-worm	E/S	Soil	Earth-worm	E/S	Soil	Earth-worm	E/S
June '01	4	12	3	550	670	1.21	280	190	0.67	201	90	0.44
July '01	3	12	4	580	700	1.2	270	155	0.57	220	102	0.46
Aug '01	3	16	5.33	600	810	1.35	290	160	0.55	220	95	0.43
Sept '01	3	16	5.33	600	720	1.2	301	170	0.56	170	88	0.51
Oct '01	2.75	10	3.63	630	700	1.11	345	205	0.59	265	200	0.75
Nov '01	2.5	10	4	650	790	1.21	320	186	0.58	250	190	0.76
Dec '01	2.5	23	9.2	650	800	1.23	360	201	0.55	270	170	0.62
Jan '02	2.75	25	9.09	670	835	1.24	390	190	0.48	300	163	0.54
April '02	5	15	3	650	830	1.27	320	170	0.53	250	125	0.5
May '02	6	18	3	650	842	1.29	320	163	0.5	210	140	0.66
June '02	5	23	4.6	610	801	1.31	260	177	0.68	230	79	0.34
July '02	4	14	3.5	610	780	1.27	260	165	0.63	210	160	0.76
Aug '02	4	13	3.25	580	750	1.29	300	170	0.56	190	150	0.78
Sept '02	6.25	20	3.2	650	864	1.32	330	164	0.49	250	147	0.58
Oct '02	3	23	7.66	660	755	1.14	316	164	0.51	204	197	0.96
Nov '02	3	14	4.66	630	825	1.3	380	275	0.72	190	173	0.91
Dec '02	2.5	25	10	690	780	1.13	350	180	0.51	300	150	0.5
Jan '03	3	20	6.66	650	755	1.16	410	290	0.7	220	172	0.78
Feb '03	6.25	n.f.		680	n.f.		380	n.f.		200	n.f.	
Mar '03	5.5	25	4.5	750	1045	1.39	400	292	0.73	166	125	0.75
April '03	4	18	4.5	630	720	1.14	340	150	0.44	220	166	0.75
May '03	5	18	3.6	650	720	1.1	322	160	0.49	195	142	0.72
June '03	5	20	4	570	680	1.19	285	162	0.56	210	60	0.28
July '03	3	14	4.66	580	680	1.17	250	176	0.7	200	130	0.65
Aug '03	3	14	4.66	600	755	1.25	270	185	0.68	170	130	0.76

*n.f. = Specie not found

Table 2. : Showing amount of heavy metals in soil and in whole tissue (per gm. dry wt.) of *L. mauritii* collected from Bethuadahari Reserve Forest, Nadia.

Month	Cd (ppm)			Zn (ppm)			Pb (ppm)			Cu (ppm)		
	Soil	Earth-worm	E/S	Soil	Earth-worm	E/S	Soil	Earth-worm	E/S	Soil	Earth-worm	E/S
June '01	2	9	4.5	94	102	1.08	34	20	0.58	35	28	0.8
July '01	0.76	4	5.26	80	100	1.25	22	15	0.68	20	16	0.8
Aug '01	1	7	7	70	88	1.25	20	16	0.8	16	14	0.87
Sept '01	1	6	6	70	94	1.34	28	22	0.78	22	20	0.9
Oct '01	1	4	4	65	82	1.26	26	18	0.69	25	20	0.8
Nov '01	2	8	4	60	88	1.46	32	28	0.87	32	22	0.68
Doc '01	2	9	4.5	94	114	1.21	36	28	0.77	32	22	0.68
Jan '02	2.75	n.f.		80	n.f.		30	n.f.		35	n.f.	
April '02	3	n.f.		90	n.f.		30	n.f.		40	n.f.	
May '02	3.25	n.f.		100	n.f.		30	n.f.		40	n.f.	
June '02	1.55	4.5	2.9	65	94	1.44	32	25	0.78	22	16	0.72
July '02	0.2	3	15	56	95	1.69	18	15	0.83	18	29	1.61
Aug '02	0.5	6.5	13	63	90	1.42	25	18	0.72	26	26	1
Sept '02	0.7	5.5	7.85	65	83	1.27	33	10	0.3	21	19	0.9
Oct '02	1.25	4	3.2	60	80	1.33	25	20	0.8	20	18	0.9
Nov '02	1.5	3.25	2.16	70	90	1.28	25	22	0.88	24	19	0.79
Dec '02	2	6	3	75	93	1.24	30	22	0.73	30	26	0.86
Jan '03	3	10	3.33	86	100	1.16	30	20	0.66	30	28	0.93
Feb '03	3	n.f.		90	n.f.		36	n.f.		38	n.f.	
Mar '03	2.88	n.f.		100	n.f.		41	n.f.		40	n.f.	
Agril '03	2.5	n.f.		120	n.f.		32	n.f.		40	n.f.	
May '03	3	n.f.		132	n.f.		38	n.f.		42	n.f.	
June '03	2.6	8	3.07	105	122	1.16	30	24	0.8	38	28	0.73
July '03	0.5	7	14	48	70	1.45	26	18	0.69	14	10	0.71
Aug '03	0.8	7	8.75	50	66	1.32	22	15	0.68	16	10	0.62

*n.f. = Species not found

Table 3. : Showing correlations between different variables in the different sampling sites.

Table 3a : Site–I / DP

	Cd-Soil	Cd-Tis	Ratio 1	Zn-Soil	Zn-Tis	Ratio 2	Pb-Soil	Pb-Tis	Ratio 3
Cd-Soil	1.000								
Cd-Tis	0.200	1.000							
Ratio 1	–0.580**	0.658**	1.000						
Zn-Soil	0.133	0.610**	0.403	1.000					
Zn-Tis	0.377	0.478*	0.095	0.770**	1.000				
Ratio 2	0.419*	0.105	–0.246	0.127	0.728**	1.000			
Pb-Soil	–0.083	0.450*	0.440*	0.748**	0.515**	0.000	1.000		
Pb-Tis	–0.121	0.174	0.170	0.450*	0.465*	0.222	0.695**	1.000	
Ratio 3	–0.116	–0.204	–0.174	–0.134	0.115	0.298	–0.061	0.669**	1.000

	Cd-Soil	Cd-Tis	Ratio 1	Zn-Soil	Zn-Tis	Ratio 2	Pb-Soil	Pb-Tis	Ratio 3	Cu-Soil	Cu-Tis	Ratio 4
Cu-Soil	–0.249	0.276	0.511*	0.288	0.034	–0.221	0.304	–0.147	–0.462*	1.000		
Cu-Tis	–0.356	–0.030	0.280	0.473*	0.126	–0.299	0.524**	0.256	–0.164	0.334	1.000	
Ratio 4	–0.206	–0.145	0.015	0.352	0.162	–0.132	0.370	0.376	0.130	–0.263	0.814**	1.000
p^H-Soil	0.105	–0.278	–0.248	–0.296	–0.229	–0.011	–0.301	–0.441*	–0.320	0.116	–0.143	–0.228
EC	–0.191	0.155	0.237	0.367	0.239	–0.013	0.460*	0.370	0.020	–0.131	0.397	0.493*
OC	0.135	–0.247	–0.304	–0.470*	–0.173	0.220	–0.406*	–0.078	0.292	–0.259	–0.508*	–0.377

	p^H-Soil	EC	OC
p^H-Soil	1.000		
EC	–0.659**	1.000	
OC	–0.124	0.055	1.000

Table 3. : *(Contd.).*

Table 3b : Site–II / BRF

	Cd-Soil	**Cd-Tis**	**Ratio 1**	**Zn-Soil**	**Zn-Tis**	**Ratio 2**	**Pb-Soil**	**Pb-Tis**	**Ratio 3**	**Cu-Soil**	**Cu-Tis**	**Ratio 4**
Cd-Soil	1.000											
Cd-Tis	0.620**	1.000										
Ratio 1	–0.738**	–0.115	1.000									
Zn-Soil	0.721**	0.484*	–0.547*	1.000								
Zn-Tis	0.597**	0.315	–0.383	0.900**	1.000							
Ratio 2	–0.610**	–0.492*	0.643**	–0.738**	–0.381	1.000						
Pb-Soil	0.634**	0.542*	–0.493*	0.504*	0.410	–0.449	1.000					
Pb-Tis	0.650**	0.340	–0.528*	0.379	0.476*	–0.095	0.553*	1.000				
Ratio 3	0.146	–0.154	–0.142	–0.033	0.180	0.332	–0.306	0.617**	1.000			
Cu-Soil	0.806**	0.537*	–0.540*	0.783**	0.737**	–0.517*	0.692**	0.620**	0.063	1.000		
Cu-Tis	0.473*	0.235	–0.124	0.564*	0.674**	–0.129	0.296	0.253	0.050	0.740**	1.000	
Ratio 4	–0.376	–0.394	0.520*	–0.189	0.069	0.542*	–0.475*	–0.388	0.061	–0.220	0.480*	1.000
p^H-Soil	–0.034	–0.090	0.169	0.079	0.117	0.079	–0.248	–0.030	0.216	–0.015	–0.037	–0.006
EC	0.397	0.135	–0.331	0.336	0.382	–0.110	0.286	0.354	0.168	0.401	0.313	–0.060
OC	–0.415	–0.266	0.534*	–0.354	–0.208	0.492*	–0.545*	–0.205	0.278	–0.406	–0.249	0.182

	p^H-Soil	**EC**	**OC**
p^H-Soil	1.000		
EC	0.334	1.000	
OC	0.749**	0.103	1.000

**Significant at 1% level, *Significant at 5% level.

Table 4. : Showing organic carbon, electrical conductivity and p^H of soil collected from Site–I and Site–II.

	Site–I			Site–II		
Month	**P^H**	**EC (dSm^{-1})**	**OC (%)**	**P^H**	**EC (dSm^{-1})**	**OC (%)**
June '01	7.1	0.25	3.66	7.5	0.52	2.27
July '01	7.2	0.36	3.54	7.2	0.18	2.54
Aug '01	7.3	0.63	3.86	7.1	0.31	2.42
Sept '01	7.1	0.56	3.33	6.3	0.23	2.1
Oct '01	7.08	0.76	3.46	6.5	0.21	1.93
Nov '01	7.15	0.36	2.69	6.7	0.33	2.16
Dec '01	7.2	0.33	3.02	6.83	0.1	2.07
Jan '02	6.86	0.84	3.29	6.7	0.3	1.78
Apr '02	7.22	0.3	2.96	7.3	0.14	1.46
May '02	7.16	0.59	3.23	6.8	0.33	2.01
June '02	7.15	0.22	2.94	7.5	0.59	2.8
July '02	7.24	0.31	3.86	7.5	0.22	3
Aug '02	7.3	0.67	3.73	7.2	0.29	2.95
Sept '02	7.15	0.35	3.5	6.62	0.15	2.08
Oct '02	6.9	0.9	2.33	6.5	0.2	2.54
Nov '02	7.2	0.42	2.55	7.9	0.28	2.71
Dec '02	7.3	0.29	2.86	6.9	0.16	2.01
Jan '03	6.94	0.91	3.46	6.7	0.3	2.1
Feb '03	6.5	1.5	3.39	6.9	0.22	1.85
Mar '03	6.93	0.73	3.38	7.3	0.19	2.3
Apr '03	7.38	0.19	2.21	7.5	0.14	0.74
May '03	7.2	0.62	3.23	7.2	0.21	1.51
June '03	7.16	0.18	4.23	7.7	0.4	2.82
July '03	7.16	0.23	3.68	7.3	0.13	2.91
Aug '03	6.9	0.7	4.1	7.63	0.1	3.07

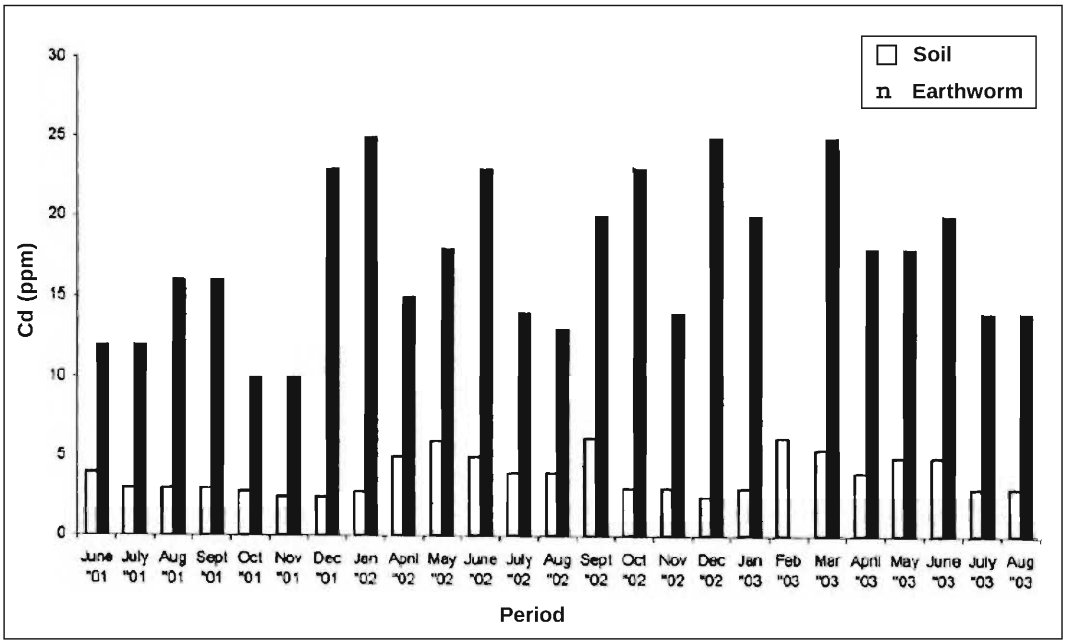

Fig. 1. : Showing amount of cadmium in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Dhapa (Municipal wastes disposal site of Kolkata).

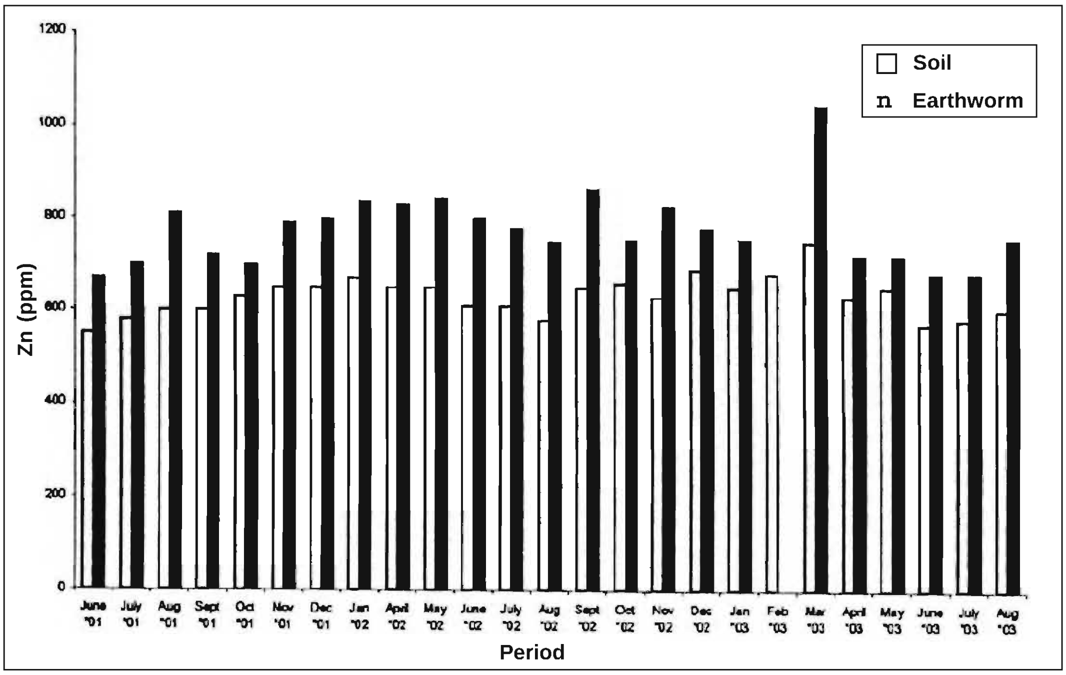

Fig. 2. : Showing amount of zinc in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Dhapa (Municipal wastes disposal site of Kolkata).

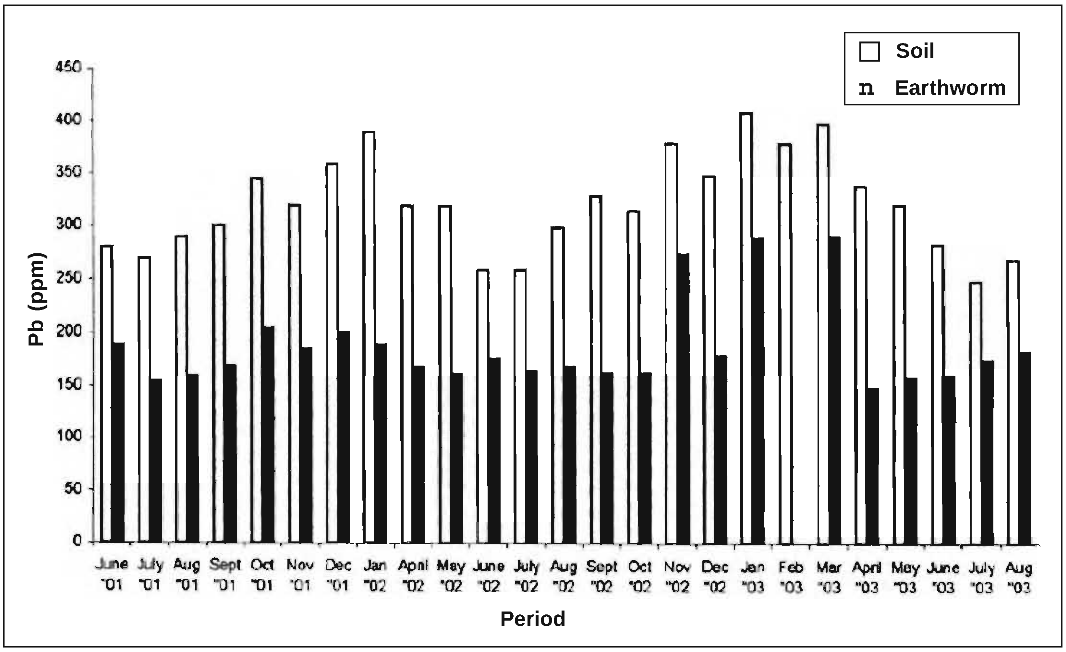

Fig. 3. : Showing amount of lead in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Dhapa (Municipal wastes disposal site of Kolkata).

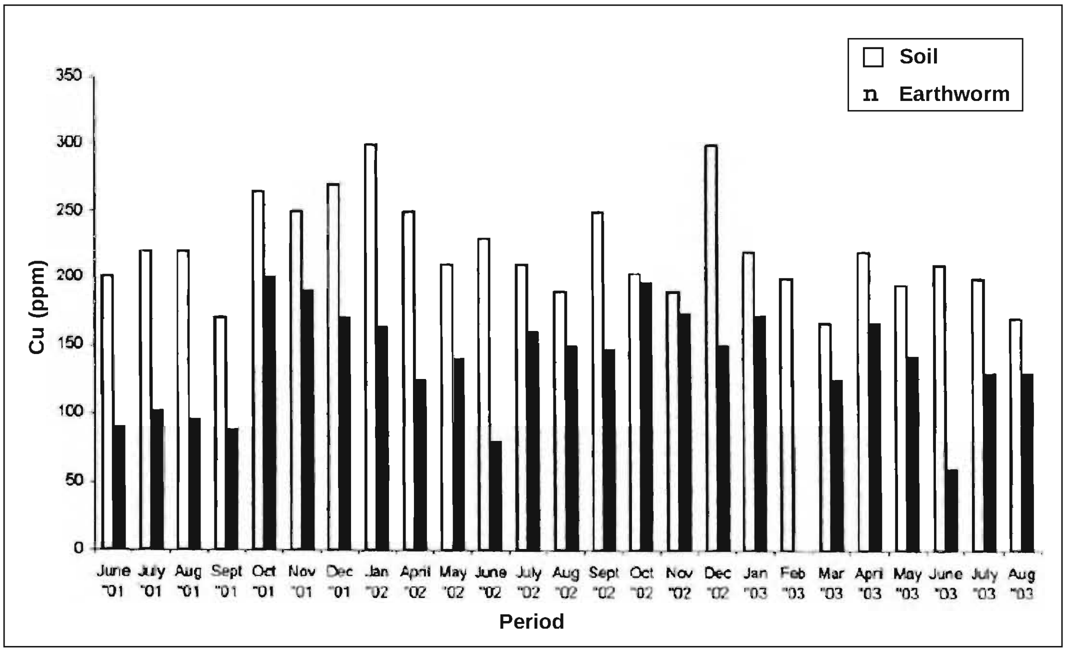

Fig. 4. : Showing amount of copper in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Dhapa (Municipal wastes disposal site of Kolkata).

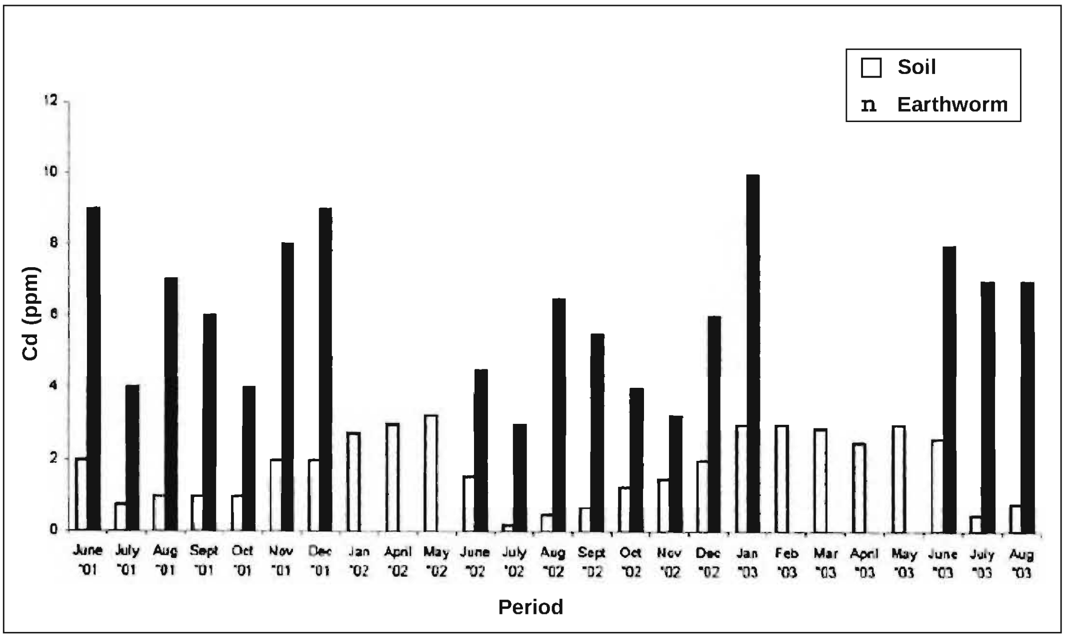

Fig. 5. : Showing amount of cadmium in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Bethuadahari Reserve Forest, Nadia

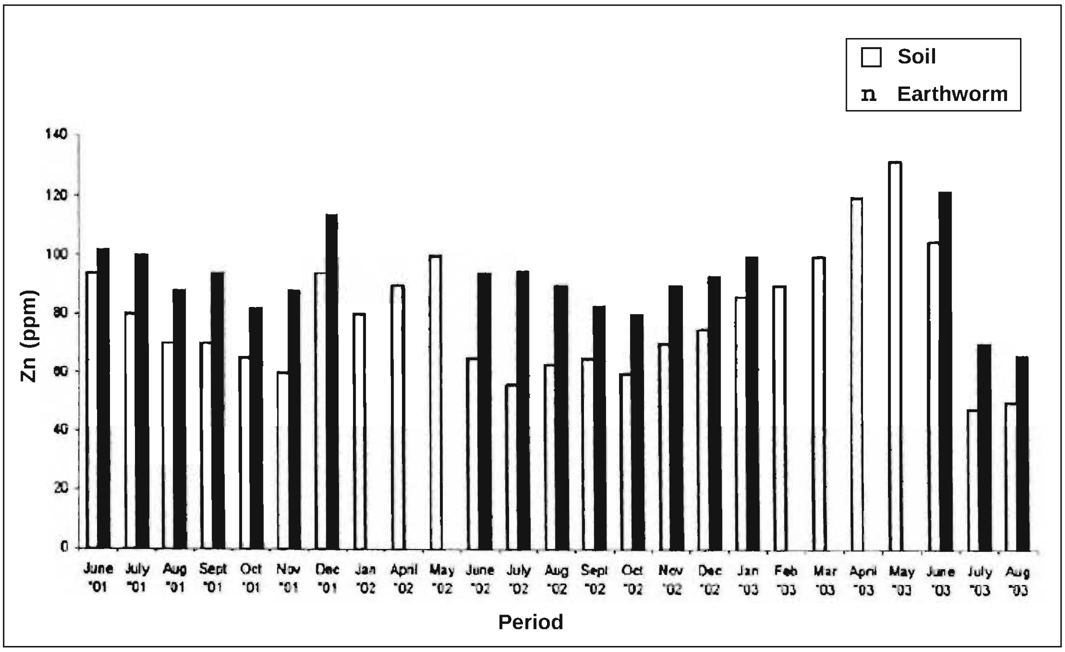

Fig. 6. : Showing amount of zinc in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Bethuadahari Reserve Forest, Nadia

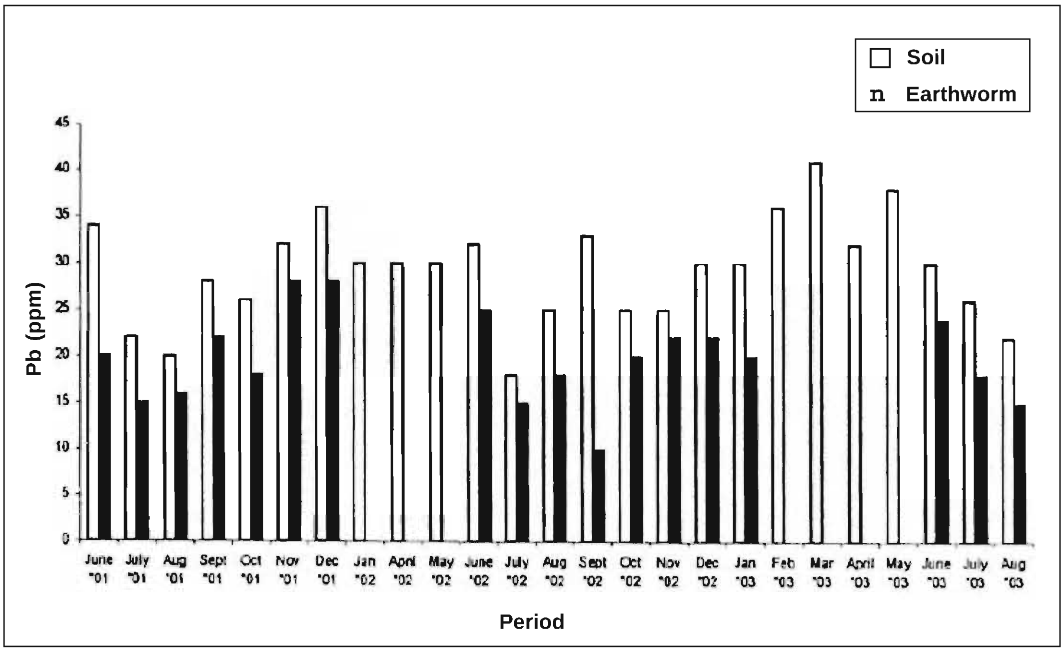

Fig. 7. : Showing amount of lead in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Bethuadahari Reserve Forest, Nadia

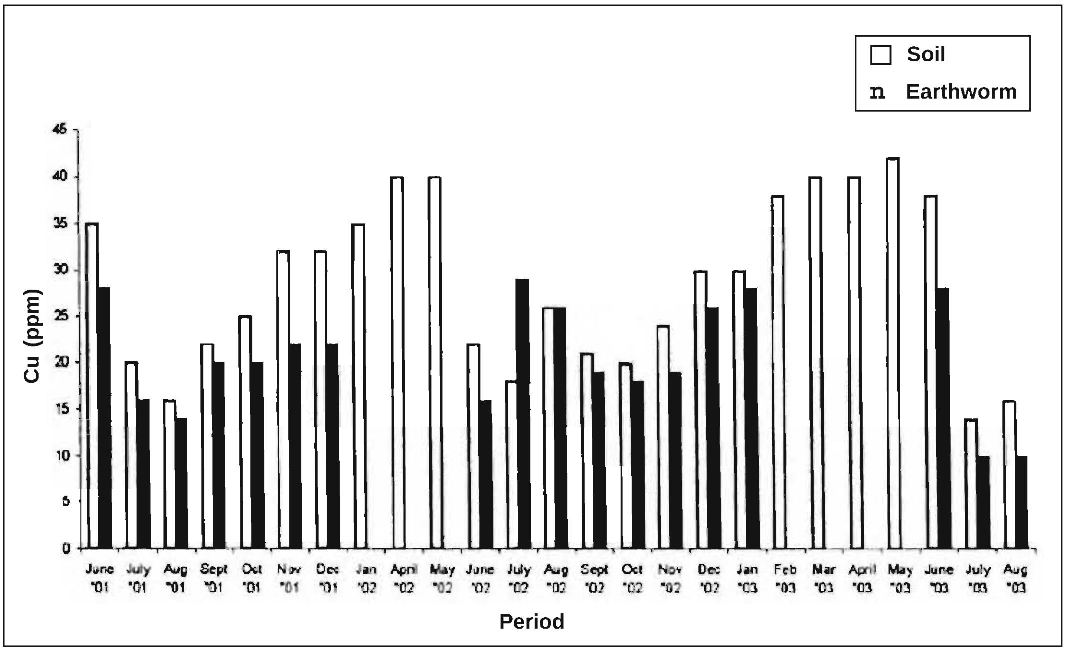

Fig. 8. : Showing amount of copper in per gm. soil and whole tissue (per gm. dry wt.) of *L. mauritii* collected from Bethuadahari Reserve Forest, Nadia

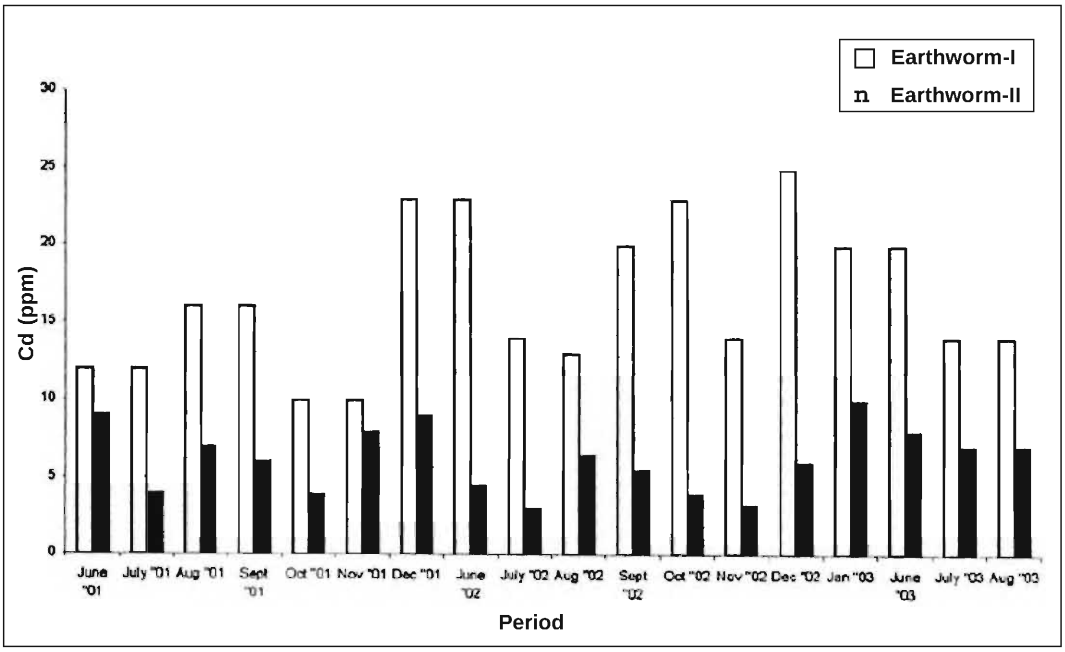

Fig. 9. : Showing comparison between the levels of cadmium of whole tissue (per gm. dry wt.) of *L. mauritii* collected from site–I and site–II.

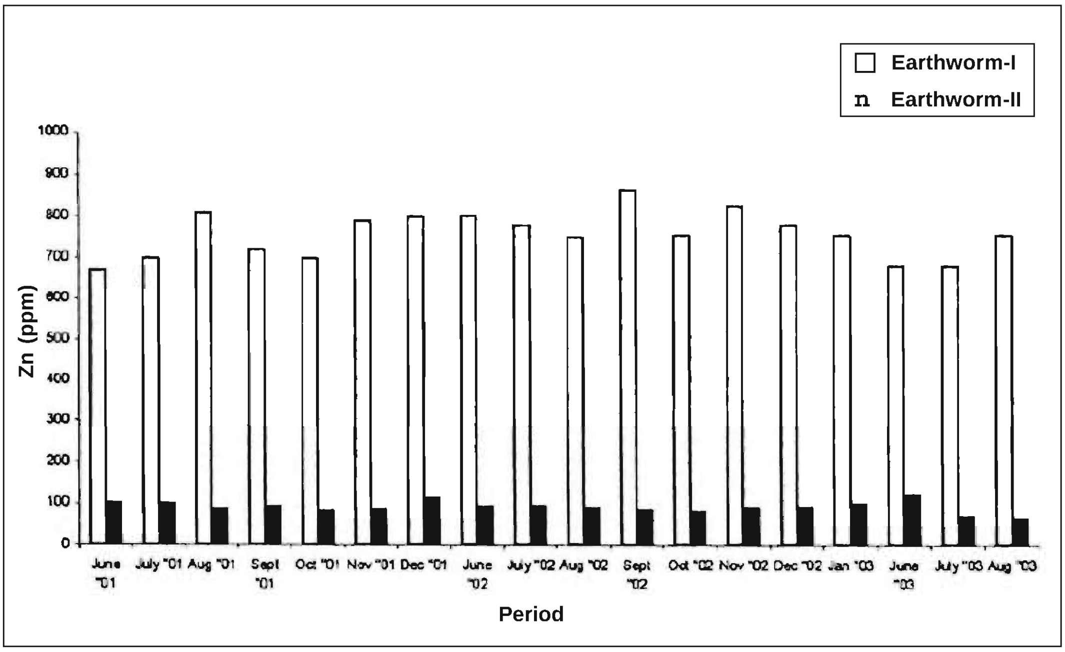

Fig. 10. : Showing comparison between the levels of zinc of whole tissue (per gm. dry wt.) of *L. mauritii* collected from site–I and site–II.

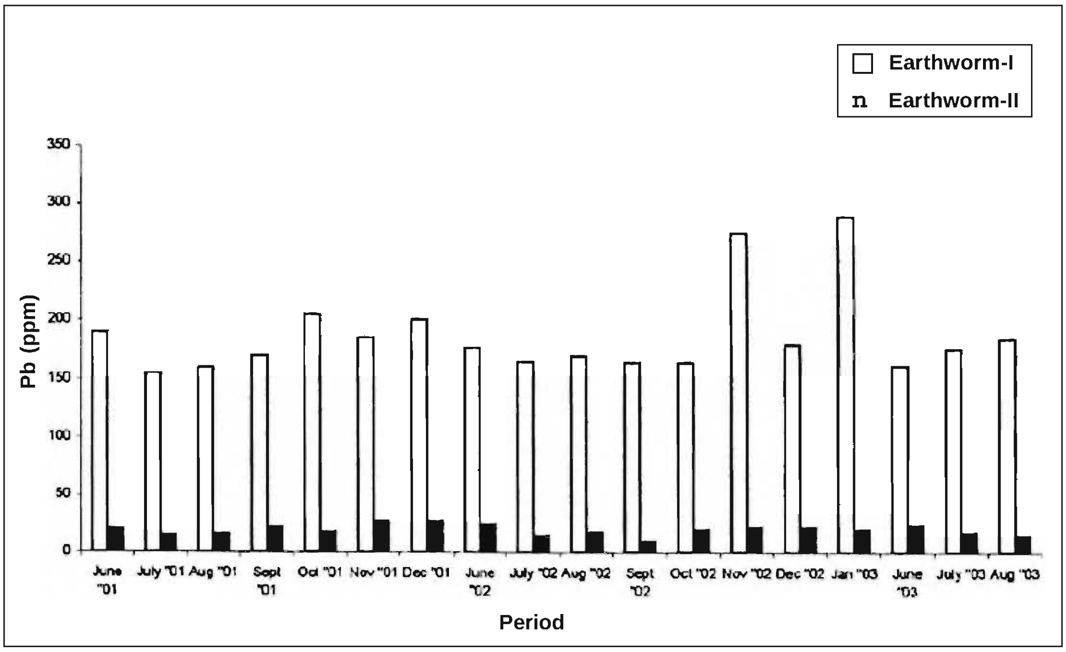

Fig. 11. : Showing comparison between the levels of zinc of whole tissue (per gm. dry wt.) of *L. mauritii* collected from site–I and site–II.

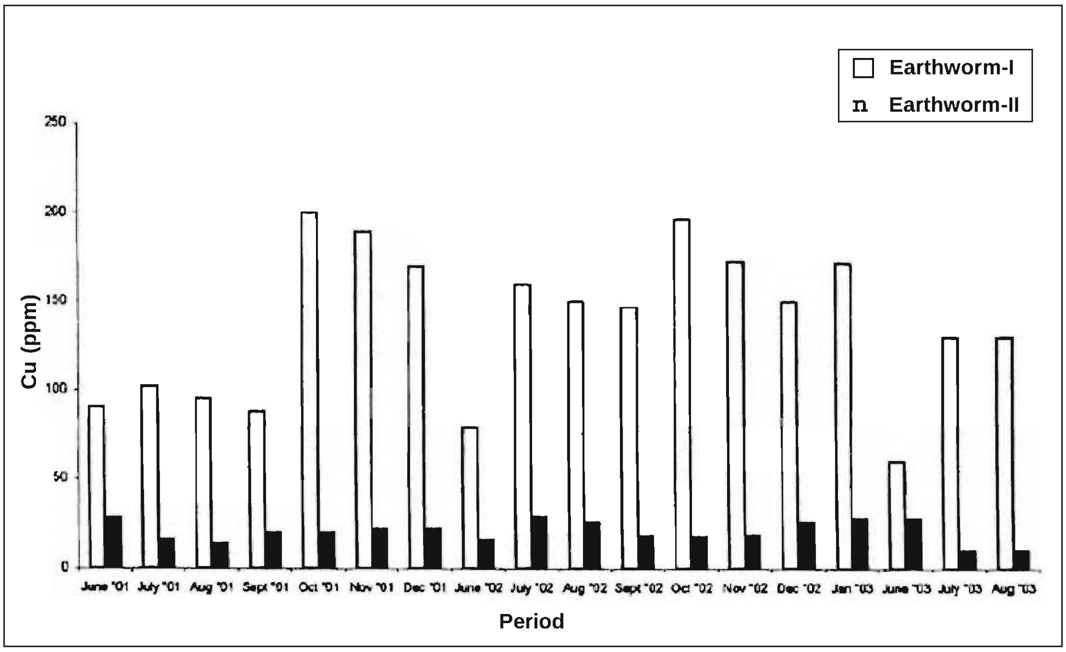

Fig. 12. : Showing comparison between the levels of copper of whole tissue (per gm. dry wt.) of *L. mauritii* collected from site–I and site–II.

SUMMARY

Study has been conducted during the period from June, 2001 to August, 2003 (total 25 months) to know the level of accumulation of some heavy metals in the tissue of *L. mauritii* (Annelida : Oligochaeta) collected from the municipal wastes disposal site of Kolkata, as well as from a reserve forest floor and to determine whether this dominant species could be use as a tool for the absorption of heavy metal in a contaminated soil. Metal content was estimated from whole earthworm tissue and in the surrounding soil (per gm. dry weight). Besides soil features like organic carbon, p^H and electrical conductivity were also analyzed. The concentration levels of studied metals were varied from the earthworm tissue and the surrounding soil in both the sites, as well as from one month to another. Accumulation of some heavy metals in earthworm tissue was in higher level in comparison to surrounding soil Detail analyses on all these aspects have been discussed. The earthworms being a very good source of food for other vertebrates, therefore the study on the effect of consumption of this contaminated species by those animals are also in progress.

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REFERENCES

Andersen, C. 1979. Cadmium, lead and calcium content, number and biomass, in earthworms (Lumbricidae) from sewage sludge treated soil. *Pedobiologia*, **19** : 309-319.

Andersen, C. 1980. Lead and cadmium content in earthworms (Lumbricidae) from sewage sludge amended arable soil In : Dindal, D.L. (Ed), *Soil Biology* as *Related to land use practices.* Proceedings of the VII International colloquium of soil zoology, 148-156.

Ash, C.P.J. and Lee, D.L. 1980 Lead, cadmium, copper and iron in earthworms from roadside sites. *Environ. Pollut.*, **22A** : 59-67.

Beyer, W.N. 1981. Metals and terrestrial earthworms (Annelids : Oligochaeta). In : *Workshop on the Role of Earthworms in the Stabilization of Organic Residues* (M. Appelhof, Compiler), Vol. I, Proc., Beech Leaf Press, Kalamazoo, Michigan, 137-150.

Beyer, W.N., Chaney, R.L. and Mulhern, B.M. 1982. Heavy metal concentrations in earthworms from soil amended with sewage sludge. *J. Environ. Qual.*, **11** : 381-405.

Beyer, W.N., Hensler, G. and Moore, J. 1987. Relation of p^H and other soil variables to concentrations of Pb, Cu, Zn, Cd and Se in earthworms. *Pedobiologia*, **30** : 167-172.

Carter, A., Hayes, E.A. and Laukulich, L.M. 1980. Earthworms as biological monitors of changes in heavy metal levels in an agricultural soil in British Columbia. In : Dindal, D.L. (Ed), *Soil Biology as Related to land use practices.* Proceedings of the VII International colloquium of soil zoology, 344-357.

Curry, J.P. and Cotton, D.C.F. 1980. Effect of heavy pig slurry contamination on earthworms in grassland. In : Dindal, D.L. (Ed), *Soil Biology as Related to land use practices.* Proceedings of the VII International colloquium of soil zoology, 336-343.

Edwards, C.A. and Bohlen, P.J. 1996. *Biology and Ecology of Earthworms* (3rd Ed). Chapman & Hall, London, 426 pp.

Gish, C.D. and Christensen, R.E. 1973. Cadmium, nickel, lead and zinc in earthworm from roadside soil. *Environ Sci. Technol.* **7** : 1060-1062.

Hartenstein, R., Neuhauser, E.F. and Collier, J. 1980. Accumulation of heavy metals in the earthworm. *Eisenia foetida. J. Environ. Qual.*, **9** : 23-26.

Helmke, P.A., Robarge, W.P., Korotev, R.L. and Schomberg, P.J. 1979. Effects of soil applied sewage sludge on concentrations of elements in earthworms. *J. Environ. Qual.*, **8** : 322-327.

Homa, J., Niklinska, M. and Plytycz, B. 2003. Effect of heavy metals on coelomocytes of the earthworm. *Allolobophora chlorotica*. The 7th international symposium on earthworm ecology. *Pedobiologia* : 1-47.

Ireland, M.P. 1975a. The effect of the earthworm *Dendrobaena rubida* on the solubility of lead, zinc and calcium in heavy metal contaminated soil in Wales. *J. Soil Sci.*, **26** : 313-318.

Ireland, M.P. 1979. Metal accumulation by the earthworms *Lumbricus rubellus*, *Dendrobaena veneta* and *Eiseniella tetraedra* living in heavy metal polluted sites. *Environ. Pollut.*, **19** : 201-206.

Ireland, M.P. 1983. Heavy metal uptake and tissue distribution in earthworms. In : Satchell, J.E., (Ed). *Earthworm Ecology.* Chapman and Hall, London, 247-265.

Ireland, M.P. and Wootton, R.J. 1976. Variations in the lead, zinc and calcium content of *Dendrobaena rubida* (Oligochaeta) in a base metal mining area. *Environ. Pollut.*, **10** : 201-208.

Kruse, E.A. and Barrett, G.W. 1985. Effects of municipal sludge and fertilizer on heavy metal accumulation in earthworms. *Environ. Poll. (Ser. A)*, **38** : 235-244.

Lee, K.E. 1985. *Earthworms : Their ecology and relationships with soils and land use.* Academic Press, Sydney, Australia, 411 pp.

Maenpaa, K.A., Kukkonen, J.V.K. and Lydyn, M.J. 2002. Remediation of heavy metal-contaminated soils using phosphorus : evaluation of bioavailability using an earthworm bioassay. *Archives of Environmental Contamination Toxicology*, **43** : 389-398.

Mariño, F., Stürzenbaum, S.R., Kille, P. and Morgan, A.J. 1998. Cu–Cd interactions in earthworms maintained in laboratory microcosms : the examination of a putative cooper paradox. *Comparative Biochemistry and Physiology, Part C*, **120** : 217-223.

Ma, Wei-Chun. 1982. The influence of soil properties and worm related factors on the concentration of heavy metals in earthworms. *Pedobiologia*, **24** : 109-119.

Morgan, A.J. 1986. Calcium-lead interactions involving earthworms : a hypothesis. *Chem. Ecol.*, **2** : 251-261.

Morgan*, A.J., Morris, B., James, N. *et al.* 1986. Heavy metals in terrestrial macroinvertebrates : species differences within and between trophic levels. *J. Chem. Ecol.*, **2** : 319-334.

Morgan, J.E. and Morgan, A.J. 1999. The accumulation of metals (Cd, Cu, Pb, Zn and Ca) by two ecologically contrasting earthworm species *(Lumbricus rubellus* and *Aporrectodea caliginosa)* : implications for ecotoxicological testing. *Applied Soil Ecology*, **13** : 9-20.

Nahmani, J., Lavelle, P., Lapied, E. and Folkert Vanoort, F.V. 2003. Effects of heavy metal soil pollution on earthworm communities in the north of France. The 7th international symposium on earthworm ecology. *Pedobiologia*, **47**.

Peredney, C.L. and Williams, P.L. 2000. Utility of *Caenorhabditis elegans* for assessing heavy metal contamination in artifical soil. *Archives of Environmental Contamination and Toxicology*, **39** : 113-118.

Pietz, R.I., Peterson, J.R., Prater, J.E. and Zenz, D.R. 1984. Metal concentrations in earthworms from sewage sludge amended soils at a strip mine reclamation site. *J. Environ. Qual.*, **13**(4).

Van Hook, R.I. 1974. Cadmium, lead and zinc distributions between earthworms and soils : potentials for biological accumulation. *Bull. Environ. Contam. Toxicol.*, **12** : 509-511.

Van Rhee, J.A. 1975. Copper contamination effects on earthworms by disposal of pig waste in pastures. In : Vanek (Ed), *Progress in Soil Zoology.* 451-457.

Walkley, A. and Black, I.A. 1934. An examination of Deg-Jareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.*, **37** : 29-38.

Zietek, B. and Pytasz, M. 1979. Lead and zinc accumulation in the soil and tissues of the earthworm *(Lumbricus terrestris)* along the highroads in the province of Katowice. *Acta Physiol Pol.*, **30** : 223.

*not seen in original.