HEAVY METAL ACCUMULATION IN FIRE WORM *EURYTHOE COMPLANATA* (PALLAS, 1766) UNDER THE INFLUENCE OF INDUSTRIAL WASTE

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Abstract

Polychaetes are usually the most abundant taxon in benthic communities and have been most often utilized as indicator species of environmental conditions. The contamination through untreated industrial waste has become an issue of primary concern. Industrial waste generally contains large amounts of organic and inorganic pollutants including toxic heavy metals. Fire worms *Eurythoe complanata* are the important part of ecosystem. Therefore, it was thought that if these wastes specially sludge or ashes dumped in water channels what would be the possible effects on fire worm. For this purpose an aquarium based trial was conducted with Chemical industry wastes. The number of worms including fresh and dry weights was measured. Five heavy metals Zn, Fe, Co, Mn and Pb were analyzed in water and tissues (dry biomass) of this species to know the possible accumulation of these metals in the food chain through their tissues. Chemical industrial sludge-ash showed deleterious effects on overall growth parameters of this species. Growth parameters of the worms (wet weight $P<0.01$and dry weights $P<0.001$) were significantly reduced in both ash and sludge treatments. Study on fire worm for heavy metal accumulation is important with respect to the food chain.

Introduction

Industries cause pollution in streams and rivers, when industrial effluents containing pollutants mainly metals are discharged into running water (Asaolu *et al.,* 1997 and Rejomon *et al*., 2010). Due to persistent nature of heavy metals in the environment, these are not usually eliminated either by bioaccumulation or by chemical means. They are mostly accumulated into aquatic organisms through the process of bioaccumulation and biomagnification and become part of the food chain (Papagiannis *et al.,* 2004). According to Asaolu and Olaofe (2005) the presence of these metals both in fresh and marine water has been found to disturb the delicate balance of the aquatic ecosystem.

Polychaetes are the most copious organisms of benthic communities and most frequently used as indicator species of poor environmental conditions. They may be used as sensitive monitors of water quality especially in terms of the effects of pollutants on life history characteristics (Dean, 2008). In temperate coastal areas polychaetes, inhabiting natural environments are known accumulators of trace metals in their tissues (Mendez and Paez-Osuna, 1998).

Eurythoe complanata (fire worm) belongs to the polychaete family, Amphinomidae commonly reported from tropical seas, also found in both sides of America (Hartmann, 1968). With regards to the use of *E. complanata* as an indicator of heavy metal concentrations, Méndez and Páez-Osuna (1998) monitored levels of Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn in *E. complanata* collected from Mazatlán Bay in the Gulf of California (Mexico). Bindra, (1927) reported this species from Manora and Oyster Island, Karachi Pakistan. He defined the taxonomic characteristics and keys for the identification of Genus and species however, the information concerning uptake of heavy metals of this species is uncertain. Bearing these considerations in mind, the present study was designed to investigate the growth of fire worm under the influence of industrial waste and accumulation of trace metal in *E. complanata*.

It would also shed light on the toxicological potential of industrial waste, its potential danger when discharged into coastal areas and bring awareness of the proper waste management.

Materials and Methods

An aquarium based trial was setup in the laboratory of Dendrochronology and Plant Ecology, Federal Urdu University, Karachi. Two types of industrial wastes namely, chemical industry sludge and chemical industry ash were used to prepare treatments. Three treatments with three replicates were prepared including control. Nine aquariums were maintained in each aquarium, 100g waste powder was spread as a first layer of aquarium while second layer of fine gravel was spread over the first layer of treatment. All the aquariums were then filled with 25 liters of seawater and left for 10 days to prepare two different types of polluted water maintaining the ratio 4: l waste (g) /seawater (l). Four pairs of adult *E. complanata* worms were transferred into aquarium. Air pump was placed in each aquarium for the adequate supply of oxygen. The populations of fire worms were recorded up to three months. After the termination of the experiment, the numbers of individual worms were collected. Fresh and dry weights were recorded.

Aquarium water samples and the tissues of worms were prepared for the analysis of heavy metals following Onwuka (2005), while industrial wastes samples were prepared following Khan (2011). Five heavy metals *i.e.* Zn, Fe, Co, Mn and Pb were analyzed by Atomic absorption spectrophotometer (Model PG 990). The data were subjected to software COSTAT ver.3 and analysis of variance (Steel and Torrie, 1984; Duncan, 1955) were performed on data.

Result and Discussion

The concentration of heavy metals (Zn, Fe, Mn, Co and Pb) in industrial sludge and ash are presented in Table 1. Chemical industry sludge and ash are considered hazardous due to the presence of high levels of heavy metals. The concentrations of analyzed metals were found higher in ash compared with sludge due to incineration of the sludge. This clearly evident that the concentrations of heavy metals in industrial waste depends upon the nature of the industrial process.

Table 2 presents the results of ANOVA for the heavy metal analysis of aquarium water. The F-values of ANOVA showed that Zn ($F=37.49$, $P < 0.001$), Fe ($F=34.44$, $P < 0.001$), Co ($F=187.24$, $P < 0.001$), Mn ($F=75.81$, $P < 0.001$) and Pb ($F=45.20$, $P < 0.001$) were found significantly higher with respect to treatments. All metals were found significantly higher in ash and sludge treatment compared with control. The highest concentrations of metals in ash treatment were presented in decreasing order Fe 53.37 ± 6.99 > Pb 50.86 ± 5.72 > Mn 45.09 ± 3.54 > Co 39.91 ± 1.84 > Zn 35.21 ± 4.55 mg/l. However, the concentrations of all metals were found significantly higher in both treatments compared to controls. This has occurred due to the discharge of high concentrations of metals in the aquarium water from the sludge and ash placed at the bottom of the aquarium.

Table 3 shows the number and the analysis of variance of wet and dry weight of *E. complanata*. The length of worms ranged 9.7-10.9 cm while mean length was 10.23 ± 0.15 and the initial wet weight ranged was 3.10-3.55 g while initial mean wet weight was 3.35 ± 0.06g. No reduction was recorded in number of worms during experiment while, final wet weight ($F=14.95$, $P < 0.01$) and dry weight ($F=31.45$, $P < 0.001$) were significantly reduced in both sludge and ash treatments as compared to control. The minimum wet weight 2.11 ± 0.25g and dry weight 0.50 ± 0.03g were significantly reduced in ash treatment related to controls. The maximum reduction in wet weight (37.02%) and (16.41%) were estimated in ash and sludge treatments respectively compared with initial wet weight of worms. It may be due to the tendency of this species to accumulate heavy metals. It is often the case that pollutants co-occur in nature and, as Reish and Gerlinger (1997) noted, there can be synergistic effects when test organisms are exposed to a mixture of toxic metals. This finding is in agreement with Mendez and Paez-Osuna (1998) who suggested that polychaetes have ability to accumulate heavy metals in their tissues. They found high uptake of Cu and Pb in *E. complanata*. Mauri *et al.*, (2003) found that the concentrations of Zn in other polychaete species *D. gyrociliatus* which placed minor effect on survival but decreased the fecundity, growth rate and generation time. Many workers (Reish *et al.,* 1989, Marcano *et al.,* 1996, 1997, Nusetti *et al.,* 1998 and Vázquez-Nüñez *et al.,* 2007) have conducted laboratory studies to finout the uptake of heavy metals using Cd, Cu, Hg and Zn and found deleterious effects on this species. However, Dean (2008) reported that *Eurythoe complanata* seemed to be fairly tolerant for certain metals.

Table 4 shows the analysis of variance multiple range test of the heavy metals accumulation in fire worm (dry biomass). The F-values of ANOVA described that Zn ($F=8.714$, $P < 0.05$), Fe ($F=10.96$, $P < 0.01$), Co ($F=10.93$, $P < 0.01$) and Mn ($F=7.64$, $P < 0.05$) were highly significant among treatments, while Pb ($F=5.08$, ns) was found non significant. The higher accumulation of Zn (8.78 ± 1.21), Mn (8.21 ± 1.79), Fe (7.76 ± 1.21), Pb (6.50 ± 1.78) and Co (6.32 ± 0.64) was observed in the tissues of the worms placed in ash treatment compared with sludge and control. The significantly higher values of heavy metals in worms tissues, found in the current study, corroborates with the findings Maloney (1996) and King *et al., (*2004). They noted the same situation in their studies involving other species of nereid polychaetes for metals. Present study was not designed to determine levels of heavy metals in individual organs. Bryan *et al*., (1987) reported that, in other polychaete species *N. diversicolor* requires Zn for the development of its jaws and also enhance body size during growth period. Even low levels of Pb is known to interfere with haeme biosynthesis, is one of the important effects of Pb on blood (WHO, 1987). Additionally, trace metals have the ability to form complexes with proteins rather than these being excreted from the body of the animals (Hamilton-Amachree, 2009).

However, it is apparent that this species accumulate heavy metals. *E. complanata* is a part of food chain which can ultimately cause contamination in other animals and may cause hazards to their health. It is suggested that this type of study be extended to other polychaete species. It is also concluded that dumping these wastes (sludge and ash) into water channels or close to the coastal areas should be banned.

Table 1. Heavy metal analysis of industrial sludge and ash.

Treatments	Co	Mn	Fe	Zn	Pb
Chemical sludge (mg/kg)	130	120	589	117	210
Chemical sludge-ash (mg/kg)	243	398	1563	150	515

Table 2. Analysis of variance and Duncan's multiple range test of heavy metals in prepared polluted aquarium water.

Treatments	Zn mg/l	Fe mg/l	Co mg/l	Mn mg/l	Pb mg/l
F – values	37.496***	34.443***	187.24***	75.81***	45.20***
Control	0.90±0.08b	1.82±0.11b	0.62±0.17c	1.63±0.38b	0.74±0.11b
Sludge	28.15±2.34a	46.15±4.35a	25.60±1.70b	36.75±2.88a	41.91±3.81a
Ash	35.21±4.55a	53.37±6.99a	39.91±1.84a	45.09±3.54a	50.86±5.72a
LSD (0.05)	10.23	16.45	5.02	9.16	13.75

Note: ***=p<0.001, Figures followed with same letters in a column are non significantly different

Table 3. Analysis of growth parameters of *E. complanata.*

Parameters	Number of worms	ANOVA	
		Wet weight (g)	Dry weight (g)
F-values	-	14.95**	31.45***
Control	8±0	3.41±0.20a	0.89±0.06a
Sludge	8±0	2.80±0.39b	0.68±0.08b
Ash	8±0	2.11±0.25c	0.50±0.03c
Lsd (0.05)	-	0.546	0.120

Note: **=p<0.01, ***=p<0.001. Figures followed with same letters in a column are non significantly different.

Table 4. Analysis of variance and Duncan's multiple range test of heavy metal accumulation in *E. complanata* (dry biomass).

Parameters	Zn µg/g	Fe µg/g	Co µg/g	Mn µg/g	Pb µg/g
F-values	8.714*	10.96**	10.93**	7.64*	5.08ns
Control	3.73±0.64b	2.51±0.06b	1.35±0.03b	2.17±0.06b	1.59±0.28b
Sludge	5.76±0.58b	4.96±0.64b	5.33±1.21a	4.50±0.63ab	3.23±0.64ab
Ash	8.78±1.21a	7.76±1.21a	6.32±0.64a	8.21±1.79a	6.50±1.78a
LSD $_{(0.05)}$	2.98	2.75	2.75	3.80	3.83

Note: *=P<0.05, **= P<0.01, ns= non significant, same letter in a same column are non significantly different.

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