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**Distribution of Lead, Cadmium and
Chromium in Sediment
and their Availability to Various Organs of a
Freshwater Teleost, *Labeo rohita* (Hamilton)**

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Abstract: The present investigation deals with the distributions of three heavy metals, lead (Pb), cadmium (Cd) and chromium (Cr) in sediment and their availability in tissues of *Labeo rohita* (Hamilton) fingerlings. This study showed that Cd was available in exchangeable and carbonate fractions of the sediment, where as Pb and Cr was mainly existed in organic and residual organic fractions. This study revealed that Pb and Cr were more in gill tissues, while Cd was mainly concentrated in viscera. Significant relationships ($p < 0.05$) between metals in different chemical fractions (exchangeable, carbonate, Fe-Mn oxide, organic and residual) of sediment and metals in fish organs (Pb in all organs, Cd in muscle, skin and viscera and Cr in muscle and gill) were found.

Key words: Lead, cadmium, chromium, sediment, *Labeo rohita*

Introduction

During the last two decades, sediment analysis has acquired a new dimension, being used as a tool to trace non natural pollution influences in inland and coastal waters. It is well known that natural processes for the formation of aquatic bottom sediments are altered by human activities. Most hydrophobic organic contaminants, metal compounds and nutrients entering water bodies become associated with particulate matter, which after settling accumulated in bottom sediments. Contaminants in bottom sediments may be released to overlying water or accumulate in the food chain as a result of physical, chemical or biological process.

Consequently, bottom sediments are a source as well as sink of contaminant in an aquatic environment as stated by Johnson and Nicholls (1988). For heavy metal pollution, several studies have stressed the relevance of geochemical partitioning on lagoonal/estuarine sediments to understand metal mobilization, associations, availability to biota and diagenesis (Luoma, 1983; Desouza *et al.*, 1986; Lacerda *et al.*, 1992). The analysis of the total metal concentrations only provides information of metal enrichment of the sediment, but not direct information on the biological effects of metal. This is due to the fact that different chemical forms of a metal in the sediment will determine its behaviors in the environment. On the contrary, sequential extraction which provides information on the speciation of metals can give detailed information concerning the mode of occurrence, metal mobility and bioavailability (Teisser *et al.*, 1979). Usually, the fractions considered are: exchangeable, weakly absorbed, hydrous-oxide, organic linked and the lattice material components (referred as residual). More than ten different sequential extraction procedures have been developed to study the

geochemical phase of metals in aquatic sediments, road dust and sludge (Teisser *et al.*, 1979; Miller and McFee, 1983). Among the various sequential procedures presented, the most widely used is that proposed by Teisser *et al.* (1979) which was originally developed for sediment analysis.

The aim of the present research is to study the different forms of metals in the sediment using sequential extraction to fractionate the metals contained in sediments into six groups: water soluble, exchangeable, carbonate, Fe-Mn oxide, organic and residual fractions; to determine the role of resulting metal distribution in toxicity to the fish which live in contaminated sediment.

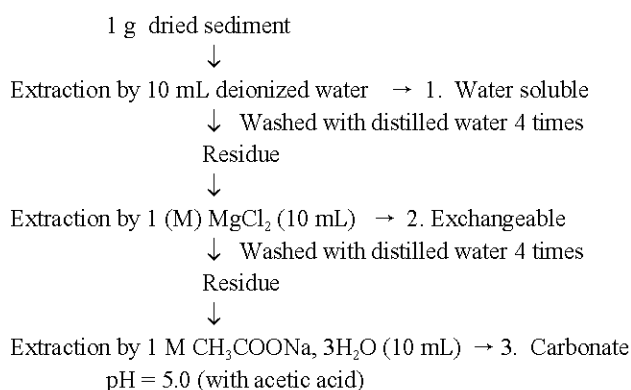
Materials and Methods

Sediment sample was collected from Kolleru lake area, Andhra Pradesh, India, where intensive fish culture is being practiced using industrial effluent and brought to the laboratory. It was dried, powdered and mixed properly. Chemical properties of sediment sample and water were analyzed before experimentation. Sediment sample was transferred to 100 L glass jar with 4" sediment base. Ninety five liter tap water (chloride free) was added to jar and kept for 15 days to attain equilibrium condition. The 1/10th of 96 h LC₅₀ of rohu fingerlings of lead (1.0 mg L⁻¹), cadmium (0.5 mg L⁻¹) and chromium (1.5 mg L⁻¹) were added to respective jars. For each metal three replications were there along with control (without addition of heavy metal). In each jar 10 numbers of *Labeo rohita* fingerlings average weight of 20±0.45 g and length of 12.8±0.55 cm were released and surface water was aerated continuously with air diffuser stones to achieve desired oxygen concentration. The chemical parameters of water were analyzed by the methodologies of APHA (1992) every 7 days interval and Pb, Cd and Cr concentration of water were also measured by the standard procedures of Black (1965). Experiment was continued for 90 days. To ensure reliable tissue metal concentration estimates, food was not supplied to fish from 24 h before sampling of total fish. After the termination of the experimental period, fish samples were collected from each jar and dissected to muscle, skin, gill, eye and whole viscera. Tissues were dried at 60°C overnight. Sediment samples were collected from each jar and dried, powdered and used for chemical fractionation of metals in sediments. The analysis was triplicate for each sediment samples. Characteristics of the processed sediments (<2.0 mm size) were determined.

Chemical Fractionation of Metals in Sediments

To evaluate the heavy metal geochemistry and to assess elemental bioavailability of the sediment, the samples were subjected to sequential chemical extraction techniques proposed by Tessier *et al.* (1979). The flow chart of the fractionation of sediment is as follows:

Sequential extraction procedure



↓ Washed with distilled water 4 times
 Residue
 ↓
 Extraction by 0.04 M NH₂OH, HCl (10 mL) in 25% acetic acid → 4. Fe-Mn oxide
 ↓ Washed with distilled water
 Residue
 ↓
 Extraction by 30% H₂O₂ (10 mL) pH = 2.0 (with HNO₃) → 5. Organic
 ↓ Washed with distilled water 4 times
 Residue
 ↓
 Extraction by conc. HNO₃ and HClO₄ (2:1) 10 mL → 6. Residual

After each successive extraction, the solution was centrifuged at 6000 rpm for 20 min and then filtered through Whatman 42 filter paper and stored in acid rinsed polyethylene bottles at 4°C prior to analysis. The heavy metal concentrations were determined using Atomic Absorption Spectrophotometer (Perkin Elmer, 3011).

Analysis of Total Metal Contents in Sediment and Fish Tissues

One gram finely powered sediment and fish tissues were transferred to porcelain basin and put to a Heraeus Thermicon P muffle furnace at a temperature of about 550°C for 4 to 5 h when all the carbon was destroyed, it was taken to 125 mL Erlenmeyer flask. Samples were digested with tri acid mixture (HNO₃:HClO₄: H₂SO₄ = 10:4:1) at a rate of 5 mL per 0.5 g of sample and was placed on hot plate at 100°C temperature. Digestion was continued until the liquor was clear (AOAC, 1990). All the digested liquors were filtered through Whatmann 42 filter paper and diluted to 25 mL with distilled water.

Measurement of Heavy Metals by Atomic Absorption Spectrophotometer

All heavy metals were measured with a Perkin-Elmer Atomic Absorption Spectrophotometer (Model No. 3110) by specific cathode lamp using wavelength and potential detection limit for respective heavy metals as follows:

| Heavy metals | Wavelength (nm) | Detection limit (µg/g) |
|--------------|-----------------|------------------------|
| Pb | 283.3 | 1.0 |
| Cd | 228.8 | 0.08 |
| Cr | 357.9 | 1.5 |

Heavy metal concentration was calculated as follows:

$$\text{mg/kg in metal in tissue material} = \frac{\text{mg/kg of metal in solution} \times \text{volume of acid}}{\text{g of sample}}$$

Statistical Analysis

Student t-test were used to determine the significance differences at (p<0.05) in terms of metal concentrations in fish tissues between control and treatment. Correlation of coefficients were determined at 0.05 and 0.01 probability levels using two-tailed test to show relationship of metals between various tissues of fish and different chemical fractions of sediment.

Table 1: Physico-chemical characteristics of test water treated with lead, cadmium and chromium with sediment base

| Toxicants | Parameters | | | | | | | | | After | |
|---------------|------------|-----------|----------|----------|-----------|--------------------|--------------------|-------------------------------|------------------|---------|---------|
| | Temp | pH | TA | TH | EC | NH ₄ -N | NO ₃ -N | P _{O₄} -P | Ca ²⁺ | 15 days | 90 days |
| Control | 29.0±0.60 | 8.00±0.05 | 230±0.30 | 190±0.40 | 0.80±0.04 | 0.25±0.02 | 0.33±0.04 | 0.42±0.02 | 50±0.28 | Pb-tr | Pb-tr |
| | | | | | | | | | | Cd-tr | Cd-tr |
| | | | | | | | | | | Cr-tr | Cr-tr |
| Lead (Pb) | 28.6±0.50 | 7.86±0.30 | 175±0.90 | 172±0.30 | 0.64±0.02 | 0.15±0.03 | 0.21±0.11 | 0.41±0.01 | 38±0.52 | 0.01 | Tr |
| Cadmium (Cd) | 29.0±0.40 | 8.02±0.04 | 190±0.60 | 164±0.40 | 0.58±0.06 | 0.25±0.04 | 0.27±0.08 | 0.38±0.03 | 40±0.32 | 0.01 | tr |
| Chromium (Cr) | 28.8±0.30 | 8.12±0.02 | 240±0.50 | 230±0.60 | 0.75±0.03 | 0.31±0.01 | 0.25±0.05 | 0.34±0.12 | 46±0.21 | tr | Tr |

Temp = Temperature, TA = Total Alkalinity, TH = Total Hardness, EC= Electrical Conductivity and pH. TA and TH are in mg L⁻¹, temp. in °C, EC-dS m⁻¹, heavy metals (µg L⁻¹)

Table 2: Chemical characteristics of sediment treated with lead, cadmium and chromium with sediment base

| Toxicants | Parameters | | | | | Sediment composition (%) | | |
|---------------|------------|--------------------------|--------------------|------------------------|------------------------|--------------------------|-------------|-------------|
| | pH | EC (dS m ⁻¹) | Organic carbon (%) | Available-N (mg/100 g) | Available-P (mg/100 g) | Sand | Silt | Clay |
| Control | 7.55±0.03 | 1.58 ±0.07 | 0.57±0.20 | 18.34±0.16 | 4.40±0.32 | 58.30 ±0.55 | 28.00 ±0.60 | 13.70 ±0.50 |
| Lead (Pb) | 7.50±0.04 | 1.34±0.13 | 0.51±0.06 | 13.75±0.19 | 3.60±0.10 | 58.00 ±0.60 | 27.40 ±0.40 | 14.60 ±0.50 |
| Cadmium (Cd) | 7.60±0.02 | 1.46±0.12 | 0.48±0.02 | 15.49±0.23 | 4.60±0.26 | 58.10 ±0.39 | 28.00 ±0.65 | 13.90 ±0.38 |
| Chromium (Cr) | 7.65±0.03 | 1.46±0.07 | 0.70±0.01 | 14.43±0.18 | 4.40±0.15 | 58.00 ±0.45 | 27.60 ±0.25 | 14.34 ±0.48 |

Table 3: Metal contents in different chemical fraction of sediment (mg/kg dry wt.) treated with lead (1.0 ppm), cadmium (0.5 ppm) and chromium (1.5 ppm) with sediment base for 90 days exposure. Values are mean±SE

| Heavy metals | Chemical fractions of sediment | Chemical fraction of total metal (mg/kg) | | Chemical fraction of total metal (%) | |
|--------------------|--------------------------------|--|--------------------------|--------------------------------------|--------------------------|
| | | Control | Treatment | Control | Treatment |
| Lead (1.0 ppm) | Total sediment | 143.02±0.20 | 146.50±0.23 ^a | - | - |
| | Water soluble | t | t | t | t |
| | Exchangeable | 14.17±0.11 | 13.39±0.14 ^{NS} | 9.90±0.11 | 9.90±0.14 ^{NS} |
| | Carbonate | 18.89±0.09 | 18.57±0.09 ^{NS} | 13.20±0.09 | 12.67±0.09 ^{NS} |
| | Fe-Mn oxide | 21.24±0.13 | 26.62±0.07 ^a | 14.85±0.13 | 18.17±0.07 ^a |
| | Organic | 13.69±0.11 | 20.13±0.04 ^a | 9.56±0.11 | 13.74±0.04 ^a |
| Cadmium (0.5 ppm) | Residual | 78.54±0.08 | 67.98±0.12 ^a | 54.91±0.08 | 46.46±0.12 ^a |
| | Total sediment | 6.75±0.14 | 7.25±0.15 ^{NS} | - | - |
| | Water soluble | t | t | t | t |
| | Exchangeable | 2.04±0.11 | 3.20±0.08 ^a | 30.22±0.11 | 44.13±0.08 ^a |
| | Carbonate | 2.85±0.17 | 2.25±0.07 ^a | 42.22±0.17 | 31.03±0.07 ^a |
| | Fe-Mn oxide | 0.84±0.12 | 0.40±0.05 ^a | 12.44±0.12 | 5.51±0.05 ^a |
| Chromium (1.5 ppm) | Organic | 0.28±0.07 | 0.40±0.12 ^{NS} | 4.15±0.07 | 5.51±0.12 ^{NS} |
| | Residual | 0.69±0.05 | 1.00±0.12 ^{NS} | 10.22±0.05 | 13.79±0.12 ^{NS} |
| | Total sediment | 34.5±0.09 | 39.75±0.43 ^a | - | - |
| | Water soluble | t | t | t | t |
| | Exchangeable | t | t | t | t |
| | Carbonate | t | t | t | t |
| | Fe-Mn oxide | 1.38±0.08 | 0.87±0.16 ^{NS} | 4.00±0.08 | 2.18±0.16 ^{NS} |
| | Organic | 3.36±0.07 | 5.15±0.11 ^{NS} | 9.73±0.12 | 12.95±0.11 ^{NS} |
| | Residual | 29.76±0.22 | 34.15±0.09 ^{NS} | 86.26±0.21 | 85.91±0.09 ^{NS} |

t = trace; a = significant at 5% level; NS = not significant

Results

The physico-chemical characteristics of overlying water and sediment are given in Table 1 and 2. The chemical characteristics of overlying water and sediment in various treatments did not vary significantly (p>0.05) from those of the control during 90 days exposure period. During experimental period, no mortality of fish was observed in both control and treatment but fish weight

Table 4: Pearson correlation matrix showing relationship of metals between different tissues of *Labeo rohita* and each chemical fraction of sediment

| | | Whole body | Muscle | Skin | Gill | Viscera | Exchangable | Carbonate | Fe-Mn | | |
|----------|-------------|------------|---------|---------|---------|---------|-------------|-----------|--------|---------|----------|
| | | | | | | | | | Oxide | Organic | Residual |
| Pb | whole body | 1 | | | | | | | | | |
| | muscle | 0.99** | 1 | | | | | | | | |
| | skin | 0.98** | 0.96** | 1 | | | | | | | |
| | gill | 0.96** | 0.94** | 0.96** | 1 | | | | | | |
| | viscera | 0.64* | 0.92** | 0.97** | 0.98** | 1 | | | | | |
| | exchangable | -0.99** | -0.90** | 0.81* | -0.76* | 0.66* | 1 | | | | |
| | carbonate | 0.09 | 0.16 | 0.27 | -0.34 | 0.23 | -0.40 | 1 | | | |
| | Fe-Mn oxide | -0.48 | 0.42 | -0.39 | -0.36 | -0.70* | 0.66 | -0.22 | 1 | | |
| | organic | 0.88** | 0.80* | 0.68* | 0.77* | 0.66* | 0.80* | -0.86** | -0.46 | 1 | |
| residual | 0.24 | 0.47 | 0.27 | 0.90** | 0.97** | 0.97** | 0.98** | -0.89** | 0.90** | 1 | |
| Cd | whole body | 1 | | | | | | | | | |
| | muscle | 0.98** | 1 | | | | | | | | |
| | skin | -0.99** | -0.99** | 1 | | | | | | | |
| | gill | -0.98** | 0.96** | -0.99** | 1 | | | | | | |
| | viscera | -0.96** | -0.95** | 0.99** | -0.98** | 1 | | | | | |
| | exchangable | -0.99** | -0.96** | -0.90** | -0.99** | -0.96** | 1 | | | | |
| | carbonate | -0.88** | -0.97** | 0.98** | -0.60 | 0.98** | -0.96** | 1 | | | |
| | Fe-Mn oxide | 0.40 | 0.56 | -0.85** | 0.55 | -0.45 | 0.80 | 0.62 | 1 | | |
| | organic | -0.19 | 0.29 | -0.15 | 0.32 | -0.35 | -0.40 | 0.28 | -0.39 | 1 | |
| residual | 0.49 | -0.99** | -0.97** | 0.48 | 0.99** | 0.57 | 0.90** | -0.90** | 0.96** | 1 | |
| Cr | whole body | 1 | | | | | | | | | |
| | muscle | 0.48 | 1 | | | | | | | | |
| | skin | 0.99** | 0.54 | 1 | | | | | | | |
| | gill | -0.99** | 0.49 | -0.99** | 1 | | | | | | |
| | viscera | -0.96** | 0.88** | -0.98** | 0.92** | 1 | | | | | |
| | exchangable | - | - | - | - | - | - | | | | |
| | carbonate | - | - | - | - | - | - | | | | |
| | Fe-Mn oxide | -0.92** | -0.50 | 0.40 | -0.27 | 0.30 | - | - | 1 | | |
| | organic | 0.77* | 0.82* | -0.52 | 0.68* | 0.42 | - | - | -0.59 | 1 | |
| residual | 0.84** | 0.99** | 0.59 | -0.60 | -0.19 | - | - | -0.97** | 0.90** | 1 | |

* and ** indicate the correlation coefficients were significant at 0.05 and 0.01 probability levels, using two-tailed test, n = 5. - not detected

was increased in all treatment along with control. Heavy metal (Pb, Cd and Cr) concentration in water was almost traced in amount in both control and treatment during experimental period. There was no significant difference of total Pb concentration in the sediment between control and treatment. Lead was mainly associated with residual, organic and Fe-Mn oxide fractions whereas exchangeable and carbonate fractions were in very less amount (Table 3). Significant differences of Pb were observed between control and treated groups in respect of Fe-Mn oxide, organic and residual fractions. No significant difference of total Cd concentration in sediment between control and treatment group was observed. Cadmium was more associated with exchangeable and carbonate fractions and to some extent Fe-Mn oxide fraction also (Table 3). Organic fraction of cadmium was negligible in amount. Significant differences of Cd were observed between control and treated groups in respect of exchangeable, carbonate and Fe-Mn oxide fractions. Significant differences of total Cr concentration in the sediment were observed between control and treatment. Chromium contents were not detected in exchangeable and carbonate fractions. It was mainly associated with residual fraction (86.41%) and to some extent in organic fraction (11.61%) and Fe-Mn oxide was in negligible amount (Table 3).

Heavy metal (Pb, Cd and Cr) contents in whole body of *Labeo rohita* treated with Pb, Cd and Cr were significantly ($p < 0.05$) different from control. The distribution of Pb was significant in all tissues except muscle and eye tissues, whereas for Cd, skin and eye tissues and for Cr, skin, eye and viscera tissues, the accumulation was not significant. Significantly ($p < 0.05$) higher concentrations of Pb and Cr were found in gill tissue and Cd was concentrated mainly in viscera and gill tissues (Fig. 1A- C). The order of distributions of heavy metals in various tissues of *Labeo rohita* as follows:

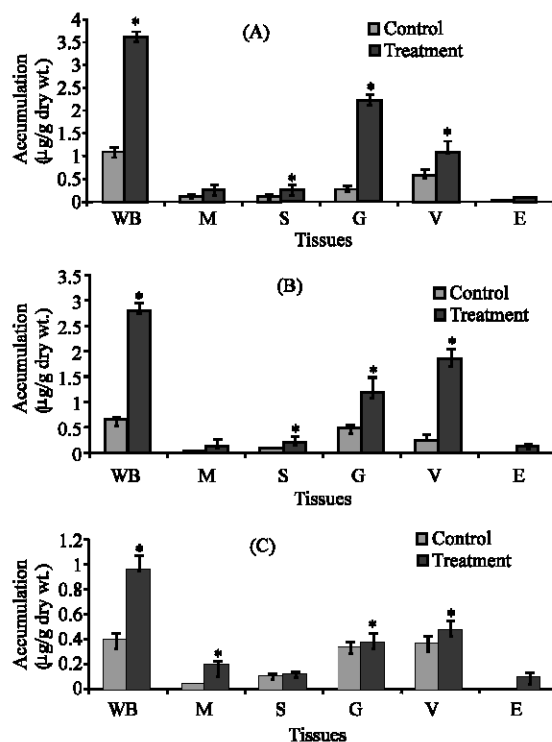


Fig. 1: Variations in metal content in different tissues of *Labeo rohita* between control and treatment in sediment base heavy metals experiment. (A) Pb, (B) Cd and (C) Cr. Vertical line at each point represents standard error. *Significant at 5% level ($p < 0.05$) Legend: WB-whole body, M-muscle, S-skin, G- gill, V- viscera, E-eye

gill > viscera > skin > muscle > eye for Pb and Cr and viscera > gill > skin > muscle > eye for Cd. Significant correlations between different chemical fractions of Pb, Cd and Cr (exchangeable, carbonate, Fe-Mn oxide, organic and residual) in sediments and their accumulation in fish tissues were found (Table 4).

Discussion

Mobility and Bioavailability of Metals in Sediment Base Heavy Metals Treatment

The water soluble, exchangeable and carbonate fractions are considered to be moderately available in the environment (Ma and Rao, 1997). Levels in the residual fraction should be considered as the background value for the elements in the sediments (Tessier *et al.*, 1979). The present study showed that Pb was mainly associated with residual fraction as well as to some extent of Fe-Mn oxide and organic fraction whereas exchangeable and carbonate fractions was very less. The organic matter-bound Pb was more in the sediment indicates the formation of stable Pb organic complexes due to the combination of Pb with organic matter. Similarly, the strong affinity of Pb with humic acid has also been reported (Takenaga and Aso, 1975). The decreasing status with the increase in depth and higher amounts of Pb bound to organic matter had also been reported (Xian, 1989).

The strong adsorption of Pb by minerals present in the soil can increase the amount of Pb bound to Fe-Mn oxide in the soil (MaClaren *et al.*, 1981). The amount of exchangeable Pb was comparatively small due to low solubility and mobility of Pb in the soil (Xian, 1989). The carbonate Pb also may have

lesser mobility due to lesser solubility as the pK_{sp} value of $PbCO_3$ is quite low (12.8) as compared to other Pb compounds. This observation is analogous to Santillan-Medrano and Jurinak (1975). Fernandes (1997) also reported that reducible phase was the most important sink for Pb among the mobile phases in sediments. Lead also formed stable complexes with Fe-Mn oxide and these compounds were more stable (Ramos *et al.*, 1994). According to Zhou *et al.* (1998) Pb was existed in Fe-Mn oxides and organically bound form whereas Maiz *et al.* (1997) reported that residual fraction was the predominant form (62-87%) for Pb.

The study indicated that Cd was more associated with exchangeable and carbonate fraction compared to Fe-Mn oxide and residual fractions. Large amounts of Cd in exchangeable and carbonate fractions suggest that an appreciable percentage of particulate Cd would be available through solubilization with lower in pHs. Tessier *et al.* (1980) reported that large amounts of Cd were present in the carbonate and exchangeable fractions and significant lower values occurred in the residual and Fe-Mn oxide fractions, whereas no interaction of Cd was observed with organic matter. Cadmium was not found in the organic fraction for low adsorption constant and labile complexation with organic matter (Baron *et al.*, 1990). Similar findings were also observed by Zhou *et al.* (1998) and reported that Cd was mainly existed in exchangeable and carbonate fractions whereas, Maiz *et al.* (1997) also reported that Cd was associated with carbonates, exchangeable and Fe-Mn oxides.

Chromium was mainly associated with residual and organic fractions whereas exchangeable and carbonate fractions were negligible in amounts. Similar findings were made by De Souza *et al.* (1986) in which significant Cr concentrations in the oxidizable phase of an organic rich sediment from a polluted river was reported. The predominant lithogenous origin of Cr may be inferred by the high percentage of the residual phase as well as detectable concentrations of the oxidizable phase (Fernandes, 1997). Zhou *et al.* (1998) noted that residual fraction of Cr was the predominant form (79-93%) in the sediment while according to Maiz *et al.* (1997) Cr was mainly associated with Fe-Mn oxide and organically bound forms.

Distribution of Heavy Metals (Pb, Cd and Cr) in Different Tissues of Labeo Rohita in Sediment Base Heavy Metals Treatment

The present study revealed that Cr concentration in the whole fish and also in gill and viscera was significantly ($p < 0.05$) lower than that of Pb and Cd. The accumulation of lead and chromium was more in gill tissue while cadmium was mainly concentrated in viscera. In alkaline pH of water, availability of metals was less due to the precipitation of hydroxide which accumulates in sediments. Bioconcentration of Cd in fish occurred not only from the water but also from the sediment as Cd was also available in exchangeable and carbonate fractions of the sediment whereas Cr and Pb were in mainly existed in residual and organic fractions. Fish were not able to accumulate Pb and Cr directly from the sediment. Such findings suggest that residues may release from sediment into the overlying water column, under natural conditions, viz., water solubility of the compound and organic matter content of the sediment. Results of this study show that waterborne metal is more available than sediment associated metal for uptake by fish. Rohu exposed to waterborne Pb, Cd and Cr (without sediment) accumulated significantly ($p < 0.01$) much more metal than did rohu exposed to metal in the presence of sediment. This difference in bioavailability may be largely due to the sorption of heavy metal to inorganic or organic materials in the sediment (Campbell *et al.*, 1988; Fu and Cao, 1992). Cadmium absorbed to materials in the sediment was probably not readily available for direct uptake by fish (Rodgers *et al.*, 1987). Similar findings with Cd was used by Sherman *et al.* (1987), who found that Cd additions to a pond environment did not produce the expected toxicity based on Cd^{2+} concentrations in laboratory experiments, because high pond pH caused precipitation as $CdCO_3$. Cope *et al.* (1994) also showed that waterborne Cd was more available than sediment associated Cd for uptake by bluegill. This study showed that most of the Pb and Cr were

accumulated in gill tissue as gill is the first target for pollutants in water. Absorption across the gill (Sorensen, 1991; Zhou, 1998) seemed to be the major pathway of Pb, Cd entering tilapia. The relatively high contents of heavy metals found in viscera may be due to the fact that most of the heavy metals are accumulated in the liver and kidney after ingestion (Badsha and Gold Spink, 1982).

Relationship of Metals in Each Fraction of Sediment with Metals Contents in Different Tissues of Fish in Sediment Base Heavy Metals Treatment

Relationships of metals in each fraction (except water-soluble fraction) of sediment with metals contents in different organs of fish were studied using Pearson correlation matrix. The accumulation of Pb in whole fish and each organ were closely related ($p < 0.05$) to the concentrations of this metal in exchangeable and organic fraction whereas gill and viscera in residual portion and viscera in Fe-Mn oxide fraction (Table 4). Cadmium concentrations in whole fish and in each organ were closely related ($p < 0.05$) to exchangeable and carbonate and skin in Fe-Mn oxide fraction whereas skin and viscera in residual portion. As regards Cr, significant correlations were noted in Cr contents in whole fish, muscle and gill tissues with Cr contents in organic and residual portion (Table 4). The effect of heavy metals on aquatic organisms is controlled by the concentrations and chemical forms of the metals in water and sediment. It is observed that complexation of metals by organic substances reduces metal bioavailability and its potential toxicity. It is assumed that bioavailability is related to solubility and six extraction fractions followed the decreased solubility order of water soluble > exchangeable > carbonate bound > Fe-Mn oxide bound > organic bound > residual (Ma and Rao, 1997). Thus metals bioavailability decreased in the same order.

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