

Metals Concentrations in Tissues of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* Caught from Alau Dam, Maiduguri, Borno State, Nigeria

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Abstract: An analysis of intestine, liver, stomach and gill tissue concentrations of heavy metals (Cu, Co, Pb, Cr, Mn, Fe, Ni, Cd and Zn) in three commercially important fish species (*Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*. caught within Alau Dam between the periods of January to August, 2007. These heavy metals were determined using Perkin-Elmer AAnalyst 300 Atomic Absorption Spectroscopy (AAS). Heavy metals contents varied significantly ($p>0.05$) depending on the fish species and on the types of tissues. The concentration of heavy metals in livers and gills tissue were relatively higher than the intestine and stomach tissues of the three species. The distribution of copper and cobalt were in the order of gills>stomach>liver>intestine in the entire fish samples, while the distribution of (Pb, Cr, Mn, Fe, Ni, Cd and Zn) were in the order of liver>gills>stomach>intestine. The concentrations of the entire elements in the three species were within tolerance limits that are safe for human consumption, with exception of lead in gills.

Key words: Metal concentration, Tissues, *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*, Alau Dam, Borno, Nigeria

INTRODUCTION

Heavy metals in aquatic environment are a major concern because of their toxicity and threat to plant and animal life disturbing the natural ecological balance. The specific problem associated with the heavy metals in the environment is their accumulation through food chain and persistent in nature. Uptake of heavy metals such as Copper, Nickel, Manganese, Lead, Cadmium, Iron and Cobalt through the food chain in human being may cause various physiological disorders like hypertension, sporadic fever, nausea and renal damage^[1]. Heavy metal pollution and its management has been a major global concern for environmentalist due to their non-biodegradable and hazardous nature.

With increase agricultural and industrial activities, most of the water sources are becoming contaminated^[2]. Industrial discharges containing toxic and hazardous substances including heavy metals^[3] contribute tremendously to the pollution of aquatic ecosystems. Concentrations of both Mn, Fe, Cr and Co in gonads, Cr in bronchial hearts and Zn in both gills and mantle increased linearly with animal weight^[4].

Many of the dissolved metals that enter rivers are adsorbed onto colloid particulates. Also at high alkalinity and pH, the metals, particularly lead and

cadmium, precipitate by forming complexation dramatically influence metal toxicity^[5,6]. Although many heavy metals are considered as essential macro and micro elements especially at non adverse effect levels^[7,8], they can exert toxic effects at concentrations encountered in polluted environment. Additionally, metals unlike many organic pollutants are known to biopersist in the environment^[9] and can become bioconcentrated in the food chain^[10], so that levels in the upper members of the chain are elevated than concentrations in the overlying water column. In recent years, there has been an increasing interest in the utilization of fishes as bioindicators of the integrity of aquatic environmental systems^[11-14]. Several studies have indicated enhanced levels of both non-essential and essential heavy metal load in muscle and liver tissues of fishes^[8,15,16,17].

The frequent presence of Pb, Cr, Zn and Cd in industrial wastes and its high toxicity along with considerable bioaccumulation in freshwater fishes make them toxicants that should be given due consideration in aquatic toxicology. Fish accumulate xenobiotic chemicals, especially those with poor water solubility and these are the chemicals carries in solution or suspension and also because fish have to extract oxygen from the medium by passing enormous volumes of

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water over the gills. For fish, the gills, skin and digestive tract are potential sites of absorption of water borne chemicals. The chemicals once absorbed are transported by the blood to either a storage point such as bone or to the liver. In the liver, it may be stored, excreted in the bile or passed back into the blood for possible excretion by the kidney or gills or stored in extra hepatic tissues such as fat.

The concentration of heavy metal were found generally higher in the liver and gill than the gonad and muscle tissues in three species *Dicentrarchus labrax*, *D. sparus arata* D. and *Mugil cephalus* L.; the levels of all metals in a given tissue were generally higher in *Mugil Cephalus*^[18]. The muller fish, *Liza Klunzinger*, commercially important and widely relished by Kuwaiti residents and the stressed ecosystem in Kuwait Bay instigated the investigation of toxicity and bioaccumulation tests on heavy metals (Pb, Ni, V, Cu and Fe). Among five metals Pb had the lowest observed effect concentration at tissues-gills, kidneys, liver, skin and muscle of *Clarias batrachus* exposed to sub lethal concentration (7 ppm) of cadmium chloride was investigated and the mean rate of accumulation of exposure was in order gills>kidneys>liver>skin>muscle^[19]. It was Observed that chromium and cadmium in the muscles tissue and gill of six commercially edible fishes is higher than gonads and skin in upper course of gangetic West Bengal, India^[20].

Alau Dam is located in Maiduguri, Borno state, Nigeria. The Dam is nine meter high with a square reservoir area of about 50 square kilometer. The maximum storage capacity is 112 million meter cube. Alau Dam received water from River Yedzram and River Gombole which meet at a confluent at Sambisha and flow as River Ngada into Alau Dam. Alau Dam received a wide variety of waste from agricultural land. This waste generated contaminates Alau Dam with a variety of heavy metals acting as point sources. This Lake is also use for commercial fishing.

The present study was carried out to investigate the concentration of heavy metals (Cu, Co, Pb, Cr, Mn, Fe, Ni, Cd and Zn) in three commercially important species of fishes such as *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* caught within Alou Dam, Maiduguri, Borno state, Nigeria. These species are marketed fresh, smoked and dried.

MATERIALS AND METHODS

Sample and Sampling: The fish samples (*Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*) were caught using gill nets from Alau Dam. The fishes

samples collected were labeled with an identified number. Samples of fishes were taken to the laboratory on the same day and later dissected to remove the intestine, liver, stomach and Gills of each species of fish. Samples were collected six times a month for a period of eight months.

Sample Preparation: The intestines, livers, stomach and gills tissues of each fish samples (8.0 g) were dried at 105°C until they reached a constant weight. Each dried sample was ground, using porcelain mortar and pestle. The ground fish tissues were transferred to porcelain basin and put to a Thermicon P muffle furnace at a temperature of 550°C for 4 hrs. 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^[21]. All the digested liquors were filtered through Whatmann 541 filter paper and diluted to 25 mL with distilled water.

Analysis of Heavy Metals: The concentrations of heavy metals in the fish samples were analyzed using Perkin-Elmer AAnalyst 300 Atomic Absorption Spectroscopy (AAS).

RESULTS

The concentration of heavy metals in intestine samples of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* are presented in Table 1. From the result the concentrations of heavy metals ranged from 0.04±0.06-0.36±0.01 μg g⁻¹ Cu; 0.20±0.01-0.25±0.02 μg g⁻¹ Co; 0.12±0.01-0.31±0.06 μg g⁻¹ Pb; 0.15±0.12-0.19±0.01 μg g⁻¹ Cr; 0.14±0.03-0.32±0.07 μg g⁻¹ Mn; 0.30±0.02-0.34±0.04 μg g⁻¹ Fe; 0.13±0.07-0.18±0.05 μg g⁻¹ Ni; 0.09±0.06-0.32±0.12 μg g⁻¹ Cd; 0.15±0.02-0.43±0.18 μg g⁻¹ Zn.

Levels of heavy metals in Liver samples of the three fish species are presented in Table 2. The concentrations of heavy metals ranged from 0.42±0.01-0.44±0.03 μg g⁻¹ Cu; 0.24±0.05-0.27±0.01 μg g⁻¹ Co; 0.32±0.16-0.40±0.03 μg g⁻¹ Pb; 0.19±0.12-0.26±0.04 μg g⁻¹ Cr; 0.58±0.08-0.62±0.02 μg g⁻¹ Mn; 0.36±0.08-0.43±0.02 μg g⁻¹ Fe; 0.57±0.09-0.62±0.02 μg g⁻¹ Ni; 0.44±0.11-0.49±0.04 μg g⁻¹ Cd; 0.46±0.15-0.52±0.01 μg g⁻¹ Zn.

Table 3 shows the concentrations of heavy metals in Stomach samples of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*. From the result of the study, the

Table 1: Concentrations of heavy metals in intestine samples of *Tilapia gallier*, *Crarias* and *Osteoglossidae* caught from Alau Dam, Maiduguri, Borno State, Nigeria

Species	Concentrations ($\mu\text{g g}^{-1}$)								
	Cu	Co	Pb	Cr	Mn	Fe	Ni	Cd	Zn
<i>Tilapia gallier</i>	0.36 ^a ±0.01	0.25 ^a ±0.02	0.12 ^a ±0.01	0.18 ^a ±0.03	0.14 ^a ±0.03	0.34 ^a ±0.04	0.13 ^a ±0.07	0.09 ^a ±0.06	0.15 ^a ±0.02
<i>Crarias</i>	0.36 ^a ±0.03	0.20 ^b ±0.01	0.13 ^a ±0.02	0.19 ^a ±0.01	0.15 ^c ±0.02	0.32 ^b ±0.07	0.14 ^a ±0.10	0.10 ^a ±0.05	0.17 ^b ±0.03
<i>Osteoglossidae</i>	0.04 ^b ±0.06	0.22 ^c ±0.08	0.31 ^b ±0.16	0.15 ^b ±0.12	0.32 ^b ±0.07	0.30 ^c ±0.02	0.18 ^b ±0.05	0.32 ^b ±0.12	0.43 ^c ±0.18

Note: The values given in the table above are means of replicate values (n = 48) and within columns, means with different letters are statistically significant, (P<0.05)

Table 2: Concentrations of heavy metals in liver samples of *Tilapia gallier*, *Crarias* and *Osteoglossidae* caught from Alau Dam, Maiduguri, Borno State, Nigeria

Species	Concentrations ($\mu\text{g g}^{-1}$)								
	Cu	Co	Pb	Cr	Mn	Fe	Ni	Cd	Zn
<i>Tilapia gallier</i>	0.44 ^b ±0.03	0.27 ^a ±0.01	0.40 ^a ±0.03	0.26 ^a ±0.04	0.35 ^a ±0.02	0.40 ^a ±0.03	0.62 ^a ±0.02	0.49 ^a ±0.04	0.52 ^a ±0.01
<i>Crarias</i>	0.42 ^b ±0.01	0.25 ^b ±0.04	0.38 ^b ±0.03	0.25 ^a ±0.03	0.30 ^b ±0.09	0.43 ^b ±0.02	0.57 ^b ±0.09	0.44 ^b ±0.11	0.48 ^b ±0.08
<i>Osteoglossidae</i>	0.42 ^b ±0.03	0.24 ^b ±0.05	0.32 ^c ±0.16	0.19 ^b ±0.12	0.32 ^c ±0.07	0.36 ^c ±0.08	0.59 ^c ±0.05	0.47 ^c ±0.05	0.46 ^c ±0.15

Note: The values given in the table above are means of replicate values (n = 48) and within columns, means with different letters are statistically significant, (P<0.05)

Table 3: Concentrations of heavy metals in stomach samples of *Tilapia gallier*, *Crarias* and *Osteoglossidae* caught from Alau Dam, Maiduguri, Borno State, Nigeria

Species	Concentrations ($\mu\text{g g}^{-1}$)								
	Cu	Co	Pb	Cr	Mn	Fe	Ni	Cd	Zn
<i>Tilapia gallier</i>	0.52 ^a ±0.02	0.44 ^a ±0.01	0.40 ^a ±0.02	0.20 ^a ±0.02	0.30 ^a ±0.01	0.30 ^a ±0.03	0.16 ^a ±0.04	0.22 ^a ±0.02	0.18 ^a ±0.02
<i>Crarias</i>	0.49 ^b ±0.06	0.41 ^b ±0.05	0.38 ^b ±0.05	0.23 ^b ±0.01	0.31 ^b ±0.03	0.29 ^b ±0.04	0.15 ^b ±0.02	0.19 ^b ±0.06	0.22 ^b ±0.10
<i>Osteoglossidae</i>	0.41 ^c ±0.20	0.40 ^c ±0.03	0.35 ^c ±0.20	0.20 ^a ±0.02	0.34 ^b ±0.01	0.33 ^b ±0.03	0.19 ^b ±0.05	0.28 ^c ±0.08	0.16 ^c ±0.04

Note: The values given in the table above are means of replicate values (n = 48) and within columns, means with different letters are statistically significant, (P<0.05)

Table 4: Concentrations of heavy metals in gills samples of *Tilapia gallier*, *Crarias* and *Osteoglossidae* caught from Alau Dam, Maiduguri, Borno State, Nigeria

Species	Concentrations ($\mu\text{g g}^{-1}$)								
	Cu	Co	Pb	Cr	Mn	Fe	Ni	Cd	Zn
<i>Tilapia gallier</i>	0.63 ^a ±0.03	0.54 ^a ±0.02	0.53 ^a ±0.04	0.42 ^a ±0.02	0.62 ^a ±0.02	0.33 ^a ±0.01	0.47 ^a ±0.01	0.38 ^a ±0.02	0.36 ^a ±0.02
<i>Crarias</i>	0.58 ^b ±0.12	0.52 ^b ±0.01	0.48 ^b ±0.11	0.44 ^b ±0.01	0.58 ^b ±0.08	0.33 ^b ±0.01	0.44 ^b ±0.07	0.36 ^b ±0.04	0.38 ^b ±0.03
<i>Osteoglossidae</i>	0.61 ^c ±0.06	0.54 ^a ±0.02	0.51 ^c ±0.05	0.49 ^c ±0.14	0.62 ^a ±0.02	0.39 ^b ±0.16	0.38 ^c ±0.17	0.35 ^c ±0.12	0.39 ^b ±0.05

Note: The values given in the table above are means of replicate values (n = 48) and within columns, means with different letters are statistically significant, (P<0.05)

concentrations of heavy metals ranged from 0.41±0.20-0.52±0.02 $\mu\text{g g}^{-1}$ Cu; 0.40±0.03-0.44±0.01 $\mu\text{g g}^{-1}$ Co; 0.35±0.20-0.40±0.02 $\mu\text{g g}^{-1}$ Pb; 0.20±0.02-0.23±0.01 $\mu\text{g g}^{-1}$ Cr; 0.30±0.03-0.34±0.01 $\mu\text{g g}^{-1}$ Mn; 0.29±0.04-0.33±0.03 $\mu\text{g g}^{-1}$ Fe; 0.15±0.02-0.19±0.05 $\mu\text{g g}^{-1}$ Ni; 0.19±0.06-0.28±0.08 $\mu\text{g g}^{-1}$ Cd; 0.16±0.04-0.22±0.10 $\mu\text{g g}^{-1}$ Zn.

The concentrations of heavy metals in Gills samples of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* are presented in Table 4. The concentrations of heavy metals ranged from 0.58±0.12-0.63±0.03 $\mu\text{g g}^{-1}$ Cu; 0.52±0.01-0.54±0.02 $\mu\text{g g}^{-1}$ Co; 0.48±0.11-0.53±0.04 $\mu\text{g g}^{-1}$ Pb; 0.42±0.02-0.49±0.14 $\mu\text{g g}^{-1}$ Cr; 0.30±0.09-0.35±0.02 $\mu\text{g g}^{-1}$ Mn; 0.33±0.01-

0.39±0.16 $\mu\text{g g}^{-1}$ Fe; 0.38±0.17-0.47±0.01 $\mu\text{g g}^{-1}$ Ni; 0.35±0.12-0.38±0.02 $\mu\text{g g}^{-1}$ Cd; 0.36±0.02-0.39±0.05 $\mu\text{g g}^{-1}$ Zn.

DISCUSSION

Copper accumulated in Gills, intestine, liver and stomach tissues of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*. The distribution of copper were in the order of gills>stomach>liver>intestine in the entire fish samples. Gills concentrate higher levels of copper while the lowest detected concentrations were found in the intestine. This high levels of copper, is due to the fact that freshwater fishes gills might be expected to be the

primary route for the uptake of waterborne pollutants^[22]. Copper toxicity in fish is taken up directly from the water via gills, the present study showed the similar accumulation of copper in the gills^[23]. Effects of high concentrations of copper on fish are not well established; however, there is evidence that high concentrations in fish can experience toxicity^[24]. Copper can combine with other contaminants such as ammonia, mercury and zinc to produce an additive toxic effect on fish^[25,26]. However, the concentrations of copper levels in gills, intestine, liver and stomach tissues of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* from Alau-Dam were below the maximum level of $1.0\mu\text{g g}^{-1}$ reported by^[27].

The maximum concentrations of cobalt were detected in the gills of all species collected from Alau Dam. Cobalt has not been considered in compliance policies or MCL and NCBP guideline. In *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* livers were the target organs of cobalt (Table 4), while intestine showed the lowest concentration (Table 1). The concentrations of Cobalt in the livers range from 0.52 ± 0.01 - $0.54\pm 0.02\mu\text{g g}^{-1}$ and in intestine 0.20 ± 0.01 - $0.25\pm 0.02\mu\text{g g}^{-1}$. The result is in line with the work of^[28] which indicate that in fish, the liver is the major storage organs for cobalt. Accumulation in the liver can be the result of detoxicating mechanisms and may originate from metal in the food. However, the liver is the preferred organs for metals accumulation as could be deduced from the present study^[29,30].

Lead accumulates significantly in gills, livers, stomach and intestine tissue of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*. The concentrations of lead were higher in the following order gills>liver>stomach>intestine. Similar findings were reported by^[31] that highest concentrations were in gills, kidney and spleen in rainbow trout.^[32] Noticed in *O. niloticus*, the gill consistently accumulated higher amount of lead as lead nitrate. Lead is highly toxic to aquatic organisms, especially fish^[26].

The biological effects of sublethal concentrations of lead include delayed embryonic development, suppressed reproduction and inhalation of growth, increased mucous formation, neurological problems, enzyme inhibition and kidney disfunction^[26,33]. Lead concentrations in the gills of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* exceeded the $0.5\mu\text{g g}^{-1}$ dry weight having the potential to harm fish reproduction and survival^[34]. While levels of lead in livers, stomach and intestine tissue of *Tilapia gallier*, *Crarias lazera*

and *Osteoglossidae* were below the $0.5\mu\text{g g}^{-1}$ limits^[34]. The concentration of chromium in the gills tissues are varied from 0.42 ± 0.02 - $0.49\pm 0.14\mu\text{g g}^{-1}$ in the three species of fish to 0.15 ± 0.12 - $0.19\pm 0.01\mu\text{g g}^{-1}$ in the intestine. It was found that the concentrations of chromium in the different organs of three fish species caught from Alau Dam varied from one organ to another. Their lowest detection concentrations were found in the intestine tissues (Table 1). On the other hand, the highest concentrations of Cr were found in gills (Table 4). Chromium is an essential trace element in human and some laboratory animals^[35], but in excess, it could have lethal and sublethal effects on fish and wildlife^[36]. No guideline documents are available for Chromium in the edible part of fish; neither was it assessed by NCBP or FEPA.

In view of other sanctions, the present Chromium concentrations 0.42 ± 0.02 - $0.49\pm 0.14\mu\text{g g}^{-1}$ in gills which was the highest are well below the levels validated by USEPA (53.8 ppm) for fish tissue^[37]. However, surveys of contaminants in edible shellfish conducted by FDA^[38] and National Marine Fisheries Service reported chromium levels from 0.1 up to $0.9\mu\text{g g}^{-1}$ ^[39], which is in line with the above threshold. The present chromium tissues concentrations (Table 1-4) are also below $4.0\mu\text{g g}^{-1}$ levels suggested by^[40] as indicative of Cr contamination.

Manganese (Mn) occurs naturally in sediments; in *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*, it seems that Mn tend to reside in the liver (Table 2), while intestine is the least accumulated organ. Hence, Mn concentrations in the entire species of fish were below guide line limit of $0.7\mu\text{g g}^{-1}$ set by^[41] and do not constitute any treat upon the consumption of these species of fish.

Earlier reports showed Fe to be normally highest in gills^[42] or in the liver^[41], in contrast the present study showed liver with the highest Fe concentrations (Table 2). The highest concentrations of 0.36 ± 0.08 - $0.43\pm 0.02\mu\text{g g}^{-1}$ for Fe (Table 2) were below the high residue concentrations of Fe (34-107 ppm) in fish samples on MNW Refuge^[41].

The maximum concentrations of Nickel were detected in the livers of all species collected from Alau-Dam. From the result of these study, the concentrations of nickel are in the order liver> gill>stomach>intestine. The highest concentrations of Ni observed in liver tissues of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* ranged from 0.57 ± 0.09 - $0.62\pm 0.02\mu\text{g g}^{-1}$ (Table 2).

Nickel level of $0.7\mu\text{g g}^{-1}$ is considered potentially lethal to fish and aquatic birds that consume them^[43]. Nickel concentrations of $2.3\mu\text{g g}^{-1}$ or greater, may cause reproductive impairment and lack of recruitment in fishes^[44]. None of the samples in this study approached these levels of concern. Hence, nickel concentrations in the entire species of fish do not constitute any treat upon the consumption of these species of fish.

Cadmium is a nonessential trace metal that is potentially toxic to most fish and wildlife, particularly freshwater organisms^[36]. The highest concentrations of Cd ($0.44\pm 0.11-0.49\pm 0.04\mu\text{g g}^{-1}$) were observed in liver tissues of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*, while the lowest concentrations of ($0.09\pm 0.06-0.32\pm 0.12\mu\text{g g}^{-1}$) were detected in intestine. These values detected exceeded the NCBP concentration of $0.05\mu\text{g g}^{-1}$ ^[27]. The highest concentration of ($0.44\pm 0.11-0.49\pm 0.04\mu\text{g g}^{-1}$) in liver tissues approached the $0.5\mu\text{g g}^{-1}$ threshold considered harmful to fish and predators^[34].

Zinc (Zn): Zinc was detected in all the fish samples and the highest concentrations were observed in liver tissues followed by Gills and stomach, while intestine shows the least concentrations. The concentrations of Zn in *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* were below the NCBP $34.2\mu\text{g g}^{-1}$. Fish can accumulate zinc from both the surrounding water and from their diet^[45]. Although zinc is an essential element, at high concentrations, it can be toxic to fish, cause mortality, growth retardation and reproductive impairment^[46]. Zinc is capable of interacting with other elements and producing antagonistic, additive or synergistic effects^[44]. Zinc does not appear to present a contaminant hazard to fish within this portion of Alau Dam.

Results of analysis of variance (ANOVA) indicate that variations among species were statistically significant for all the metals with exception of some metals ($p>0.05$). In general, this study revealed that the livers and gills tissues of *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae*, indicating higher preference for the bioaccumulation of metals than the stomach and intestine.

CONCLUSION

Since there are many environmental factors which have been claimed by various researchers to influence the bioaccumulation of heavy metals to toxic levels in organisms, it would be unreasonable to attribute the

levels of these metals in *Tilapia gallier*, *Crarias lazera* and *Osteoglossidae* to any specific factors. It is perhaps more rational to posit that these elemental tissue load might have been largely influenced by their feeding habits as well as the contamination gradients of the Alau Dam.

From the results of this study, the concentration of heavy metals in the livers, gills, intestine and stomach tissues of the three species investigated did not exceed the acceptable levels proposed for human consumption (USEPA, 1995) with exception of lead in gills. However, the levels of metals in the species call for serious concern as they could bioaccumulate and bioaccumulate in these tissues over time.

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