Determination of Cadmium and Lead in Fish Tissues and Water from Khartoum City Sudan

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Abstract: The aim of this study is to determine levels of some heavy metals (HMs) contaminating Nile water and their bioaccumulation in various organs of Tilapia species (*Oreochromis niloticus*). Water and fish samples were taken from two stations in Khartoum city, one located on the Blue Nile River and the other on the White Nile River. Lead (Pb) and cadmium (Cd) were analyzed quantitatively using Perking Elmer Atomic Absorption Spectrophotometer. The Water of the Blue Nile contain high level of lead concentration ranging from 9.658 ± 0.445 to 9.934 ± 0.050 mg/L compared to the White Nile Pb range 2.430 ± 0.246 to 2.292 ± 0.317 mg/L. Cd concentration in the Blue Nile water ranges of 0.480 ± 0.018 to 0.390 ± 0.101 while in the White Nile range 0.353 ± 0.037 to 0.326 ± 0.028 mg/L. Studies on the different parts (gills, liver, flesh) of the fish revealed higher concentration of 5.352 ± 0.106 mg/g dw in the liver followed by 3.001 ± 0.028 mg/g dw in the gills, while flesh recorded low level of 1.877 ± 0.050 mg/g dw Pb. The highest concentration of 4.304 ± 0.037 mg/g Cd was detected in the liver, lowest concentration with a value of 0.348 ± 0.018 mg/g dw in the flesh. Strong correlation observed was between the amount of Cd and Pb in the water and the accumulation in the fish tissues.

Key words: Heavy metals, fish tissues, bioaccumulation, Blue Nile, White Nile

INTRODUCTION

The contamination of fresh waters with a wide range of pollutants has become a matter of concern over the last few decades. The natural aquatic systems may extensively be contaminated with HMs released from domestic, industrial and other man-made activities. Heavy metals are the most hazardous pollutants due to the spread of their dissemination in biosphere and their accumulative concentration. They permeate the environment by various means, penetrate the circle of metabolism, become toxic and disturb physiological function of organisms. Among animal species, fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants. Fish species are often the top consumers in aquatic ecosystems and are widely used to evaluate the health of ecosystems, because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic system. One of the main environmental problems in Sudan is the problem of water pollution. This is particularly true for Khartoum more than in any other city along the rivers, because Khartoum is the biggest city (Capital) in Sudan and has the largest population, also it is located between the two main rivers Blue and White Nile. Therefore it is important to know the impact of this city on the water quality and to the Fish species. *Oreochromis niloticus* is the most popular and highly esteemed economic fish in Khartoum city, and for this reason it has been selected for the present study.

The objective of this research is to quantify the concentration of Cd and Pb in the water of the Blue and White Nile and their accumulation in the flesh, gills and liver of *Oreochromis niloticus*.

MATERIALS AND METHODS

Sampling was carried out in accordance with the recommendation of UNEP reference method for marine pollution studies. Fish and water samples were taken from two stations located on the Blue and White Nile rivers. Samples were collected twice with an interval of one month. *Oreochromis niloticus* was caught from the two locations using gill nets, which were left over night in the river by local fishermen. Fresh fish were properly cleaned, then collected into pre-cleaned polythene bag and then frozen at –18 °C prior to analysis.

For analysis of fish samples were defrosted for two hours. The scales were removed and the gills, liver and...
flesh were separated using a plastic knife. The fish parts were dried at 80 °C for two hours in oven. Approximately 2.0 gm of each sample were weighed and ashed in the furnace at 550 °C for 90 min. The ash was dissolved in 5 ml concentrated nitric acid and made up to 25 ml volume. The elements Pb and Cd were assayed using Atomic Absorption Spectrophotometer (Perkin–Elmer 2880) and the results were given as mg/g dw. The detailed analytical procedures for metal determination were given by Chapman and Partt[9].

Water Samples: Surface water samples from the two stations were collected in ultra clean sampling bottles (200 ml) and certain precautions were made to avoid contamination. The water dedicated for the metal analysis were acidified immediately when they reached the laboratory by adding 1 ml of 50% nitric acid to each bottle. Pb and Cd were determined by using Perkin Elmer Atomic Absorption Spectrophotometer. Surface water temperature was measured by a thermometer (0.1 °C resolution), turbidity was measured by Secchi disc and the pH was measured by a pH–meter (Hach portable meter). The results of analysis were processed using the statistic program soft-ware "SPSS" version 10.

RESULTS AND DISCUSSION

Complementary analyses and statistics show that there are two types of waters, that Blue and White Nile river. The waters have different concentration and different flows which lead to fluctuating concentration along the transportation through Khartoum city.

The water temperature was measured at the sampling sites. The observed temperatures at the two stations were within the range 26.0 ± 0.10 to 37.1 ± 0.10 °C (Table 1) which is slightly higher in the Blue Nile than the White Nile, this is due to the presence of two thermal electric power stations that discharge cooling waters into the Blue Nile in the vicinity of the sampling station. The pH of pure water is 7 In general, water with pH lower than 7 are considered acidic and with a pH above 7 alkaline. The normal range for pH in surface water system is 6.5 to 8.5 (APEC). Fresh water fishes can live normally in water with pH between 5.0 and 9.0. Acidic and alkaline waters have various effects on fish, and it was found that young fish are more sensitive of pH fluctuation than adult ones[12]. The results from the pH measurements showed that all the samples were in the range considered normal for surface water. However, the white Nile was more alkaline than the Blue Nile with pH values of 7.4 ± 0.12 and 6.9 ± 0.21 respectively.

Low value of transparency (high turbidity) was observed in the two rivers (table 1) ranging from 25.0 ± 0.50 to 27.0 ± 0.10 cm. This low transparency may be attributed to fact that the Blue Nile and White Nile are the main collectors of all materials spread by human industrial and agriculture activities around Khartoum city. Also Blue and White Nile rivers are characterized by large amounts of silt especially in the flood seasons like many rivers in the tropical regions. Temperatures, transparency and pH values, were significantly different (P> 0.05) in the two rivers at the sampling time (Table 1).

The concentration of Cd in the Blue Nile was 129.2% higher than that observed in the White Nile. The level observed in the Blue Nile might be attributed to the much higher industrial activities along the river, or it could also be explained by the denser population living along the Blue Nile as compared to the White Nile[3]. The concentration of Cd in the Blue Nile ranges between 0.395 ± 0.10 and 0.483 ± 0.018 mg/L while in the White Nile it ranges from 0.326 ± 0.028 to 0.352 ± 0.036 mg/L (Table 1). The concentration of Cd in the two rivers was higher than the recommended maximum acceptable limit as set by WHO Guidelines[21] at 0.005 mg/L.

The concentration of Pb in the Blue Nile was 415% higher than that observed in the White Nile. High level of Pb observed is a result of human activities Pb might originate from car engines and batteries (people are washing their car in the river). Also, exhausts from vehicles might contribute to increased concentration of Pb in the Blue Nile because exhausts are regarded as the major source of environmental contamination by Pb. According to the Guidelines of WHO[20] the maximum acceptable concentration for Pb is 0.05 mg/L. The Blue and White Nile had high concentration compared to the standard level and would therefore be considered as ecologically harmful.

In food, the allowed amount of HMs is defined by norms, which are based both on the WHO recommendations and local requirements, norms for HMs vary in each country, for example Pb in fish meat is 1.5 mg/g according to the Austrian standard ANZFA guideline limit. The maximum concentration of Pb of 1.88 ± 0.050 mg/g dw found in the flesh of fish from the Blue Nile exceeding the ANZFA values 1.2 times. Flesh is one of the ultimate tissues for HMs accumulation. Pb accumulation in fish tissue closely relates to Pb level in water up to a concentration of 5 mg/L, this was also observed in the Blue Nile. The minimum amount of 0.417± 0.0183 mg/g dw Pb was recorded in the flesh of fish from White Nile.
Table 1: Physical parameters and heavy metal concentration in the Blue and White Nile river

<table>
<thead>
<tr>
<th></th>
<th>Temperature °C</th>
<th>Turbidity cm</th>
<th>pH</th>
<th>Pb mg/L</th>
<th>Cd mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Nile</td>
<td>Min 30.1±0.368</td>
<td>25.0±0.05</td>
<td>6.5±0.12</td>
<td>9.658±0.445</td>
<td>0.3945±0.10</td>
</tr>
<tr>
<td></td>
<td>Max 37.1±0.100</td>
<td>25.13±0.153</td>
<td>7.2±0.12</td>
<td>9.934±0.050</td>
<td>0.4830±0.0183</td>
</tr>
<tr>
<td>White Nile</td>
<td>Min 26.0±0.100</td>
<td>26.0±0.200</td>
<td>6.9±0.21</td>
<td>2.2924±0.317</td>
<td>0.3262±0.0280</td>
</tr>
<tr>
<td></td>
<td>Max 26.3±0.368</td>
<td>27.0±0.100</td>
<td>7.4±0.12</td>
<td>2.4303±0.246</td>
<td>0.3533±0.035</td>
</tr>
</tbody>
</table>

Table 2: Regression analysis of the effect of Lead & Cadmium concentration in water to the fish organs

<table>
<thead>
<tr>
<th>Pb &amp;Cd mg/dw in fish organs</th>
<th>Linear effect</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb on liver</td>
<td>1.819-0.128X</td>
<td>0.975</td>
</tr>
<tr>
<td>Pb on gills</td>
<td>6.974-0.693X</td>
<td>0.998</td>
</tr>
<tr>
<td>Pb on flesh</td>
<td>24.355-2.476X</td>
<td>0.997</td>
</tr>
<tr>
<td>Cd on liver</td>
<td>3.718-23.112X</td>
<td>0.620</td>
</tr>
<tr>
<td>Cd on gills</td>
<td>1.221+109.245X</td>
<td>0.631</td>
</tr>
<tr>
<td>Cd on flesh</td>
<td>0.461-4.070X</td>
<td>0.647</td>
</tr>
</tbody>
</table>

Fig. 1: Accumulation of Cd & Pb μg/g dw in gills.

Fig. 2: Accumulation of Pb & Cd μg/g dw in liver.

The maximum concentration of Cd 0.348 ± 0.0183 mg/g dw was found in the flesh fish from the Blue Nile. Cd is used in Nickel- Cadmium rechargeable batteries and for planting, also used in some paints, plastic and ceramic[19]. All these activities are found along the Blue Nile river in Khartoum city which could explain the high level of Cd, (almost 1.8 times higher than ANZFA norm value of 0.2 mg/g dw). (fig 1).

It should be stressed that the level of HMs in fish flesh may not necessarily represent the real extent of HMs impact on ichthyofauna or the whole hydrosphere[14]. Elements from water are taken by fish
through gills and the gastrointestinal tract, where they can be accumulated in inner organs, leading to pathological changes\(^4\). In order to determine the level of contamination of fish inner organs, concentrations of HMs were analyzed in fish gills and liver. The gill is an important site for the entry of HMs that provokes lesions and gills damage\(^8\). The range of Pb was 2.99 ± 0.046 - 3.001 ± 0.028 mg/g dw and 2.507 ± 0.050 - 2.6103 ± 0.255 mg/g dw in fish gills from the Blue Nile and White Nile respectively. The maximum concentration of Cd (1.474 ± 0.050 mg/g dw) was found in the Blue Nile while the White Nile recorded low level of Cd (0.339 ± 0.104 mg/g dw) in the fish gills (Fig 2).

The concentration level of Pb and Cd in the gills could be attributed to the fact that water always passes through mouth and gills when the water is filtered, this is correlated with the findings of FAO\(^3\).

The range of Pb concentration in liver was 5.333 ±0.049—5.352 ±0.106 mg/g dw and 3.467 ± 0.117—3.602 ± 0.037 mg/g dw and that of Cd was 4.304 ±0.037—4.294 ±0.050 mg/g dw and 0.567 ±0.244— 0.591 ± 0.038 mg/g dw for the Blue Nile and White Nile respectively. (Fig 3). The higher accumulation in liver may alter the levels of various biochemical parameters in liver. This may also cause severe liver damage\(^13\). The information from this study can be used to evaluate the concentration of Pb and Cd in fish organs. The higher recorded concentration was in the liver followed by the gills and flesh. No similar studies were previously conducted in the Sudan for determining Pb and Cd accumulation in fish tissues.

Regression analysis shows that Pb accumulation in all tissues are highly correlated with its concentration in water, where as Cd is correlation was less pronounced (Table 2).

Accoding to the results of present study it could be inferred that the Blue Nile river is more polluted than the White Nile river but both are less polluted than the Nile river in Egypt\(^3\).

**Fig. 3:** Accumulation of Pb & Cd \(\mu g/g\) dw in flesh.

**REFERENCES**