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VARIATION OF HEAVY METAL LEVELS IN THE TISSUES OF *PERIOPHTHALMUS PAPILLIO* FROM THE MANGROVE SWAMPS OF THE BUKUMA OILFIELD, RIVERS STATE

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ABSTRACT

The edible (muscles) and non-edible (viscera and gills) parts of *Periophthalmus papillio* inhabiting the mangrove swamps of the Bukuma oilfield and its environs in the Niger Delta area of Nigeria were analysed for Zn, Pb, Cd, Cu and Ni. The mean levels of heavy metals (μg/g dry wt.) in the edible parts ranged from Zn: 1.30-4.53; Pb 0.14-0.30; Cd ND-0.06; Cu 0.07 – 0.25 to Ni 0.07-0.16; non-edible parts Zn 1.05-2.31 Pb 0.18-0.46; Cd 0.03-0.14; Cu 0.05-0.24 to Ni 0.05-0.27. Apart from Zn that varied distinctly ($P<0.05$) between both tissues, all other metals do not, though they accumulated more in the non-edible parts. Generally elevated metal levels in both tissues were recorded at the stations with wellheads, implicating oil-related activities as the main source of contamination. However, the levels in the edible parts of *P. pappilio* may not pose any health risk to consumers, as they were lower than World Health Organisation (WHO) recommended levels in finfish for human consumption.

KEYWORDS: Mangrove swamp, oilfield, *Periophthalmus papillio*, Bukuma, Niger Delta,

INTRODUCTION

The occurrence of contaminants in excess of natural loads in most parts of the Niger Delta area of Nigeria arising from exploration and exploitation of mineral resources has become a problem of increasing concern (World bank, 1995). Beyond the tolerance limits, they have been implicated in some metabolic malfunctions in humans as they can be taken up directly in drinking water or indirectly by consumption of contaminated aquatic fauna and flora (Nwankwo and Irrechukwu, 1981). Fish often absorb many poisonous substances in a concentrated form, hence eating fish or any other seafood from polluted water may even be more hazardous than drinking the water. Thus, analysis of fish has been a valuable source of information in the evaluation of the concentration and effects of trace metals in the environment (Philips and Rainbow, 1983; Kakulu *et al*, 1987).

Aquatic organisms take up metal and other contaminants through their body surface (Donald, 1972), their gills, mouth, and viscera (Bryan, 1968; Brown *et al.*, 1988) in the environment. The uptake of these contaminants may affect not only the productivity and reproductive capabilities of the organisms but may ultimately pose a health-risk to man that directly depends on these organisms as their major sources of protein. It is on the basis of this that the present study examines the variations of Cd, Pb, Ni, Zn, and Cu in *Periophtalmus papillio* (mudskipper) from the study area (Figure 1) located in the Niger Delta area of Rivers State, Nigeria. The economic importance of mudskipper fish in the Niger Delta, its description, and usefulness as a biomonitor for aquatic pollution studies has been documented in an earlier work (Horsfall *et al.*, 1998).

MATERIALS AND METHODS

The area is a mangrove wetland with lots of creeks and creeklets that link up to the lower reaches of the New Calablar River. The creeks are characterised by high seawater inflow and low freshwater input from runoffs of domestic wastewater from adjoining farmlands and forest. Five sampling stations were chosen within the study area as indicated in Figure 1.

Composite samples of mudskipper fish were collected from the mangrove mudflats bimonthly between November 2001 and October 2002 at five sampling stations in the study area (Fig. 1). Description of the method of collection of samples is as documented in an earlier study (Horsfall *et al.*, 1998). In the laboratory, samples were frozen at –5°C until required for analysis. Fish samples of average sizes 2.5 – 5.0cm total length were used. The mudskipper fish were thawed and dissected to separate the muscles (edible parts) and viscera including the gills (non-edible parts). Each tissue sub samples were weighed and then dried to constant weight at 60°C. Pulverization and homogenisation were achieved by grinding the samples in a teflon mortar. Samples and blanks for analysis were prepared by digesting 1.0g samples of dry material with concentrated nitric acid and perchloric acid (4:1 ratio) using the multiple standard addition method on selected samples to check for possible matrix effects. The metal concentrations were determined by Atomic Absorption Spectrohotometry Buck Scientific 200A (Paez, *et al.*, 1993).

Analysis of variance (ANOVA) and correlation coefficients methods were employed to analyse the data by using SPSS version 10, and Data Tools Analysis all in Microsoft Windows 98. The level of significance was set at 95% and 99% respectively.

RESULT AND DISCUSSION

The mean concentrations of Zn, Pb, Cd, Cu and Ni in edible and non-edible parts of *Periophthalmus pappilio* of the study area and a summary of the statistical analysis of the data are as shown in Table 1. Generally, the concentrations of the metals in the intestines are higher than those of the muscles tissues. Apart from Zn, all the other metals did not differ ($P>0.05$) between the muscles and the viscera and gills. Correlation analysis of the metals between both media gave only significant correlation for Zn ($r = 0.75$: $P<0.01_{0.46}$). However, the pattern of accumulation in the muscles was Zn>Pb>Cu >Ni ≥ Cd, while that of the non-edible was Zn>Pb>Ni >Cu >Cd.

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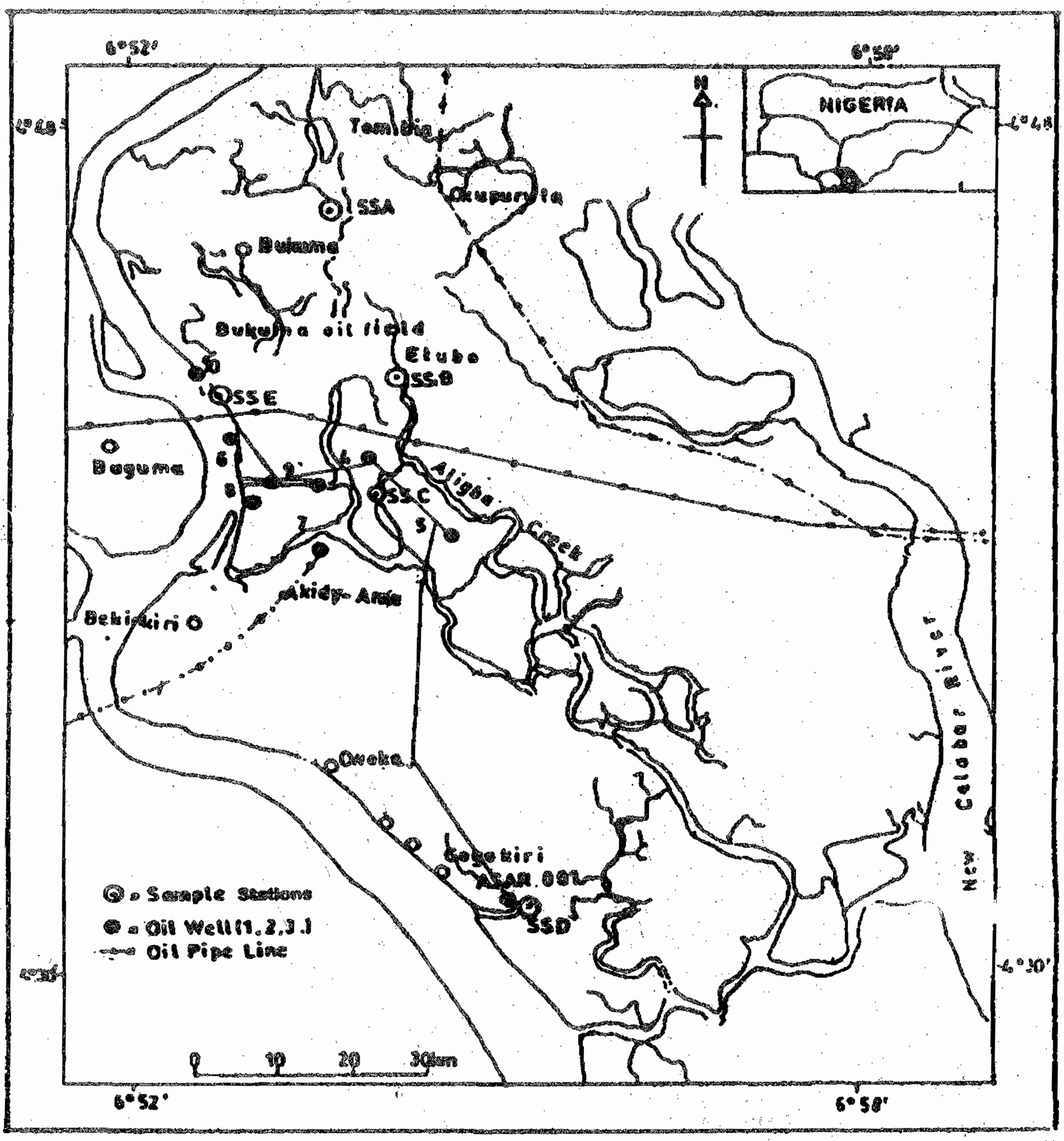

Figure 1 Map of the study area showing sampling stations

The levels of Zn in the *P. papillio* of this study were significantly (P>0.05) higher in the muscles than in the viscera and gills. Again of all the metals studied the Zn levels are higher in both organs than the others. The values ranged between 0.63 – 8.95 ($\bar{X}$ = 2.95 ± 1.2μg/g) in the muscles and 0.68 – 4.93 ($\bar{X}$ = 1.73± 0.71μg/g) in the viscera and gills. The highest mean values in both media occurred in stations E and C (Table 1). The determination coefficients (r^2) of Zn between both media show that 55.9% of the variation in muscles concentration is attributable to the concentration of Zn in the viscera and gills.

Table 1: Mean heavy metal levels (μg/g dry weight) analysed in the tissues of *P. papillio* of the study area

Media	Metal	Stations					Total Mean
		A	B	C	D	E	
Muscles	Zn	1.30 ± 0.61^{b}	1.84 ± 0.70^{b}	4.13 ± 1.99^{a}	2.93 ± 1.34^{bc}	$4.53\pm 2.63a$	3.0 ± 1.2^{A}
	Pb	0.14 ± 0.13^{a}	0.22 ± 0.15^{a}	0.30 ± 0.09^{a}	0.29 ± 0.16^{a}	0.26 ± 0.23^{a}	0.24 ± 0.1^{B}
	Cd	0.01 ± 0.01^{a}	0.02 ± 0.02^{a}	0.04 ± 0.03^{a}	0.03 ± 0.01^{a}	0.06 ± 0.04^{a}	0.04 ± 0.01^{B}
	Cu	0.07 ± 0.03^{c}	0.08 ± 0.02^{c}	0.25 ± 0.19^{a}	0.10 ± 0.03^{bc}	0.23 ± 0.13^{ab}	0.14 ± 0.06^{B}
	Ni	0.12 ± 0.19^{a}	0.07 ± 0.05^{a}	0.16 ± 0.07^{a}	0.08 ± 0.05^{a}	0.14 ± 0.01^{a}	0.11 ± 0.05^{B}
Viscera and gills	Zn	1.05 ± 0.24^{a}	$1.1.0\pm0.12^{a}$	2.04 ± 1.36^{a}	2.17 ± 1.32^{a}	2.31 ± 1.54^{a}	1.73 ± 0.71^{A}
	Pb	0.18 ± 0.10^{b}	0.24 ± 0.13^{ab}	0.39 ± 0.21^{ab}	0.22 ± 0.15^{ab}	0.46 ± 0.24^{a}	0.30 ± 0.12^{B}
	Cd	0.03 ± 0.04^{b}	0.06 ± 0.07^{b}	0.14 ± 0.14^{a}	0.07 ± 0.06^{b}	0.08 ± 0.09^{b}	0.07 ± 0.03^{B}
	Cu	0.05 ± 0.06^{c}	0.10 ± 0.08^{ab}	0.24 ± 0.12^{a}	0.19 ± 0.14^{abc}	0.23 ± 0.14^{ab}	0.16 ± 0.07^{B}
	Ni	0.05 ± 0.05^{a}	0.18 ± 0.29^{a}	0.23 ± 0.26^{a}	0.18 ± 0.25^{a}	0.27 ± 0.29^{a}	0.18 ± 0.07^{B}

-*Within row (Stations), mean ± sem with different superscript are significantly different at $P<0.05$* (n =30).
-*Within column (Total mean), mean ± sem with different superscript are significantly different at $P<0.05$.* (n =30)

The high levels of Zn in the muscles may be due to the role Zn plays as an activator of many enzymes in the organs of some marine organisms (Bryan, 1968 and Ireland and Kuwabara, 1985). In similar studies, Canli and Furnes, (1993), Horsfall *et al*, (1998) also reported that Zn levels are always higher in the muscles of finfish than the viscera and gills. However the observed levels of Zn in this study are lower than that of finfish from the Lagos lagoon (27.5μg/g) (Okoye, 1991) and the WHO's recommended limit (1000μg/g) in finfish (Kakulu *et al*, 1987) hence this may not pose health-risk to the local communities through the consumption of this finfish.

Lead levels between the organs of *P. papillio* were not significant (P>0.05), however they varied as thus ND – 0.65 ($\overline{X}$ = 0.24± 0.10μg/g) for the muscles and ND – 0.79 ($\overline{X}$ = 0.30± 0.12μg/g) for the viscera and gills. Though the highest levels in both media were obtained in stations C and E, there were no significant variations from the stations. The determination coefficient (r^2) shows that only 2.8% of the variation in muscles level may be attributable to the concentration of Zn in the viscera and gills. In a similar study Fowler (1990) indicated that lead accumulates preferentially in the intestines of finfish than in the muscles. Yamazaki *et al.*, (1996) reported that the site of greatest accumulation of lead in fish has been mostly in the liver, kidney, and gall bladder, which in the *P. papillio* constitute the non-edible parts. Similar findings were reported in P. *papillio* from the mangrove swamps of the New Calabar River (Horsfall *et al.*, 1998). This may be accounted for by the fact that Pb is not essential but it is easily attracted to biological tissues. Once it is absorbed, it acts as an accumulative toxin that is capable of deadening nerve receptors in man (Bodansky and Latner, 1978). The levels observed in this study are lower than the WHO limit of Pb in finfish – 2.0μg/g (Kakulu *et al.*, 1987) and that of Lagos lagoon - 2.28μg/g (Okoye, 1991) but it is higher than that of the Philippines in finfish - 0.01 – 0.08μg/g (Gomez *et al.*, 1990).

Tissue variation of Cd between the media is not significant (P>0.05), however the mean value of the viscera and gills ND – 0.34($\overline{X}$ = 0.07± 0.03μg/g) is higher than that of the muscles ND – 0.13μg/g ($\overline{X}$ = 0.04± 0.01μg/g). Stations variations were not also significant (P>0.05) but stations C and E had the highest mean values. The determination coefficients (r^2) of Cd between both media show that 8.8% of the variation in muscles concentration is attributable to the concentration of Cd in the viscera and gills. Higher levels of Cd in the viscera and gills of *P. papillio* from the study area are in line with other studies by Eister, (1981) and Horsfall *et al.*, (1998). Although Cd is non-essential but once it enters a biologic system, it is capable of remaining there, its excretion occurs very slowly and at certain concentrations it causes damage to human and other living organism, especially when present as $CdCl^{+}$ or $CdCl_2$ in aqueous medium (Bryan, 1984). It has also been noted that increased levels of Cd in man causes a disease condition knows as 'Itai-itai' which has killed about a hundred persons between 1947 and 1965 through consumption of seafood containing cadmium (Friberg, *et al.*, 1974). The values obtained in the muscles of this study are higher than the finfish values of the Indonesia and the Philippines (Gomez *et* al., 1990) but lower than those of the Niger Delta and WHO limits for finfish (Kakulu *et al.*, 1987).

Copper levels were relatively higher in the viscera and gills, ND – 0.43 ($\overline{X}$ = 0.16±0.07μg/g) than in the muscles, 0.02 – 0.55($\overline{X}$ = 0.14± 0.06μg/g) but there was no significant variation (P>0.05). Station C and E had the highest levels of Cu in both media. The determination coefficients (r^2) of Cu between both media show that 6.8% of the variation in muscles concentration is attributable to the concentration of Cu in the viscera and gills. Hallawell, (1988) reported that Cu is very toxic to most plants, highly toxic to invertebrates and moderately toxic to mammals. Although it is essential in a number of enzymes but it has been discovered that excessive intake results in its accumulation in the liver (Wong *et al.*, 2001), and in the kidney hence its toxic effects (WHO, 1993). The highest level of copper in the muscles - 0.55μg/g for this study is within the range of those of the Indonesia and the Philippines (Gomez *et al.*, 1990) but lower than the WHO limits in finfish (Kakulu *et al.*, 1987).

The ranges of nickel in both media are ND – 0.5 ($\overline{X}$ =0.11± 0.05μg/gl) for the muscles and, ND – 0.78μg/g ($\overline{X}$ =0.18±0.07μg/g) for the viscera and gills. The determination coefficients (r^2) of Ni between both media show that 9.5% of the variation in muscles concentration is attributable to the concentration of Ni in the viscera and gills. Ni has been classified as very toxic to aquatic life and relatively assessable to these organisms (Forstner and Wittman, 1983), though it is now known to be essential in biological systems (Nielsen, 1990). High levels of Ni have been reported in wastes from petroleum industry (Horsfall and Spiff, 1998); hence the chronic discharges of such wastes into the aquatic ecosystem will result in Ni accumulation in different aquatic media. The highest mean level - 0.16μg/g in the muscles is higher than that obtained from shellfish (Dambo, 2000) but lower than that obtained from finfish by Agbozu (2002) and the acceptable limits (2.0μg/g) in water and food fish (Calamari and Naeve, 1994).

The present study has shown the variability in accumulation of these metals - Zn, Pb, Cd, Cu and Ni in the edible (muscles) and non-edible (viscera and gills) parts of *Periophthalmus pappilio*. The levels seemed to be correlated levels of petroleum related activities of other studies within the Niger Delta region. However, the levels in the edible parts of *P. pappilio* may not pose any health risk to consumers, as they were lower than WHO recommended levels in finfish.

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