AJEAM-RAGEE Volume 9 October 2004 page 1-17

DISTRIBUTION OF HYDROCARBONS AND HEAVY METALS IN SEDIMENT AND A CRUSTACEAN (shrimps – *Penaeus notialis*) FROM THE BONNY/NEW CALABAR RIVER ESTUARY, NIGER DELTA

Alex Chuks Chindah[1], Amabaraye Solomon Braide[1] and Onyebuchi Cordelia Sibeudu[2]

1) Institute of Pollution Studies
Rivers State University of Science and Technology
P M B 5080, Port Harcourt, Rivers State, Nigeria

2) Department of Petroleum Resources
Nigerian National Petroleum Corporation,
Moscow Road, Port Harcourt.

Correspondence: Alex C. Chindah; alexchindah@hotmail.com

ABSTRACT

Levels of hydrocarbons and heavy metals in sediment and a crustacean (Shrimp – ***Penaeus notialis***) along Bonny/New Calabar River Estuary were studied to cover the two dominant (wet - September 2000 and dry - January 2001) seasons, in ten selected stations located in 3 main ecological zones along the Bonny / New Calabar river estuary which lies between longitude 7^{o} 00' to 7^{o} 15' E and latitude 4^{o} 25' to 4^{o} 45'N. Samples were collected and analyzed using appropriate tools and methods. The results obtained showed the distribution of total hydrocarbon concentration for sediment and Shrimp – ***Penaeus notialis*** body tissue for the three ecological zones a consistent longitudinal sequence of Upper > lower > middle for wet and dry seasons respectively. In addition, both sediment and organism (Shrimp – ***Penaeus notialis***) had total hydrocarbon and metal (Cr, Cd, V and Pb) concentrations that demonstrated seasonal differences with significant higher values in wet than in the dry season, except Zn and Cu that showed a contrary pattern. Furthermore, indications of hydrocarbon and metal bioaccumulation in organisms were observed. The possible source of total hydrocarbon and metals in the body tissue of the Shrimp – *Penaeus notialis* was highlighted by this study.

Key words: Total hydrocarbon, Heavy metals, shrimp, sediment, bioaccumulation New Calabar River, Niger Delta.

INTRODUCTION

There had been substantial increases in the industrial and agricultural development in the Niger delta in the past four decades with the attendant population growth. Apparently, these activities have resulted in the direct discharge of organic and inorganic substances including crude oil and refined products through normal operation (as effluents), operational failures and sabotage to facilities into the adjoining water bodies. Often times as these components get to the water body they finally settle at the sediment which acts as sinks of contaminants in aquatic systems (Adams et al, 1992, Burton and Scott, 1992, Mucha et al., 2003). These contaminants generally contain different hydrocarbon components and heavy metals that may be deleterious to humans. The possible thought of the pathway and fate of these contaminants in the environment are of great concern to the scientific community, governmental agencies and non governmental bodies (Ekweozor 1985, Kakulu and Osibanjo 1986, Ekweozor and Snowden 1987, Ekweozor et al., 1987, Kakulu *et al* 1987, Kakulu and Osibanjo 1988, IPS 1990, Dambo, 1992, Kakulu,and Osibanjo 1992 and Chindah, 1998 and Chindah *et al* 2000).

These studies were however limited in scope, as they did not cover most of the ecological areas of the systems (Kakulu and Osibanjo 1988, 1992, Joiris *et al* 1998 and Joiris and Azokwu 1999). In order to bridge the existing gap in knowledge on the distribution of hydrocarbon and heavy metals in the Bonny/NewCalabar River system, there is therefore the need to provide information on the hydrocarbon concentrations and the macroinvertebrates especially the sediment scavenging forms. These have been considered as valuable indicators for the assessment of hydrocarbon and heavy metals in estuaries and rivers because of their accumulation potential (Phillips, 1977 Ekweozor and Snowden 1987, Kakulu and Osibanjo 1988, 1992). This was achieved by studying sediment and macro fauna (crustacea - **shrimps – *Penaeus notialis***) the extent and magnitude of these parameters along the entire ecological zones.

MATERIALS AND METHODS

Study area

The study area stretched from lower reach of Bonny River at Bonny town (close to Peterside) to Choba in the upper reach of the New Calabar River. The entire stretch from the Bonny to Choba, about 20km, is largely influenced by the tidal cylce, and lies between longitude 7^o 00″ to 7^o 15″ E and latitude 4^o 25″ to 4^o 45″ N (Fig. 1). The tidal amplitude is generally high and above 2m at the Bonny terminal jetty (Chindah, 1998). However, the water levels increase and decrease depending on the lunar cycle. Salinity increases at high tides, and decreases at low tides. Sea influence is experienced more at high tide regime than at low tide, the effect decreasing especially within the upper limits when fresh water input dominates in the zone (RPI 1985). The climatic condition is humid, typical of the semi hot equatorial type (Gobo, 1988). The area experiences heavy rainfall from April to October and sporadic rainfalls are experienced during the dry season months of November to March. The mean annual rainfall is estimated to be about 2,405 mm (Gobo, 1988).

Ten (10) sampling stations were established in the three (3) ecological zones (Upper, middle and lower reaches) of the systems as follows:

Stations 1-3 are within the upper limits where industrial activities and salinity influence are low (oligohaline). The vegetation is mixed, comprising mangrove (*Rhizophora racemosa*, *R. mangle*, *Avicennia africana* and *Phoenix reclineata*) and fresh water flora (*Dalbergia* sp., *Drepanocarpus* sp.*Ralphia* sp and *pandanus*).

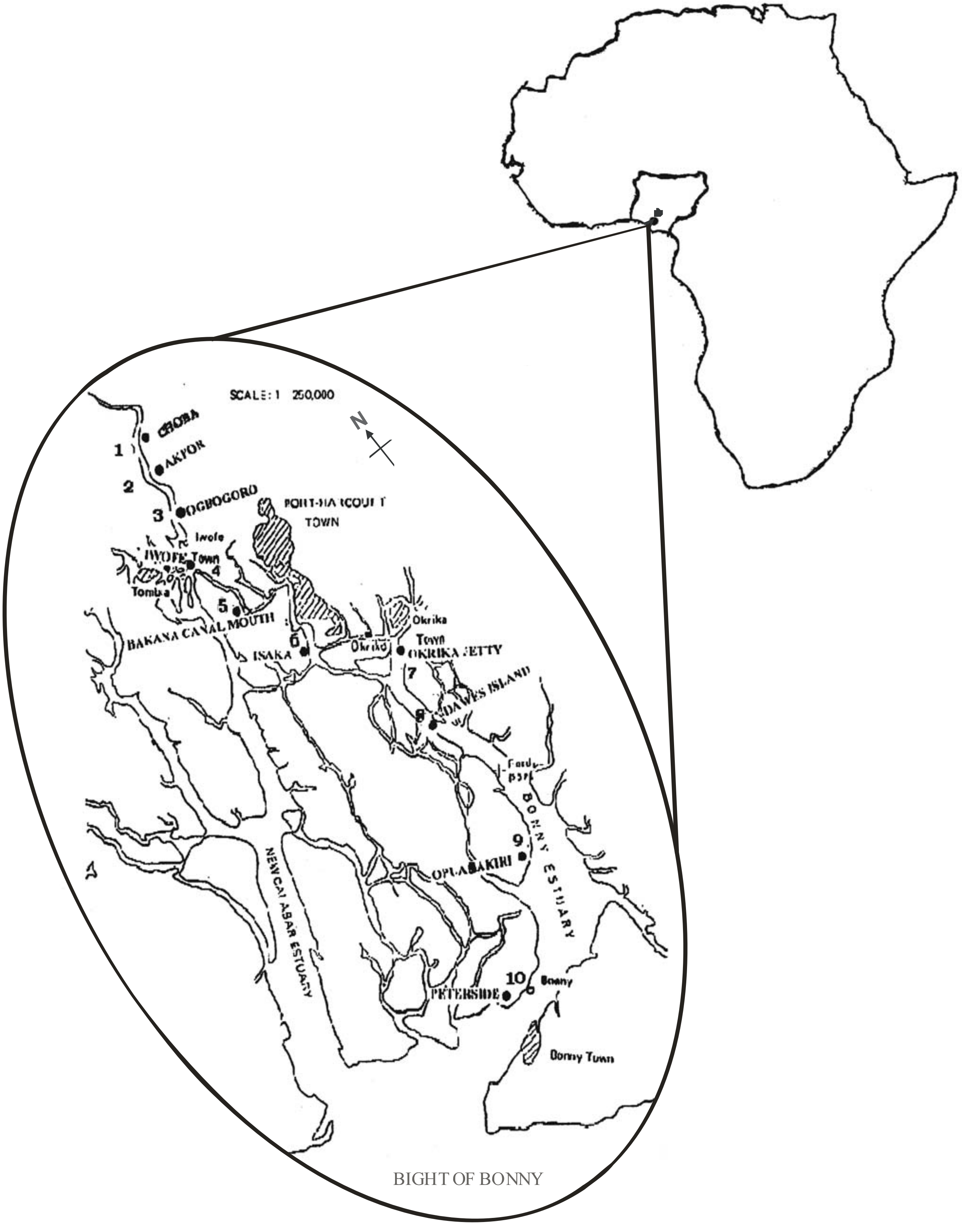

Fig. 1: Map of Africa, Nigeria, showing the sampling stations in Bonny New-Calabar Estuary

The middle reach stations (4-7) lie within the mesopolyhaline limit with several activities especially from municipal and industrial discharges, especially from Port Harcourt Refinery and related activities. The vegetation is predominantly mangrove; y *R. racemosa*, *R. mangle*, *Avicennia africana*, *Laguncularia.racemosa*.

Stations 8 – 10 lie within the lower limit around the Bonny River mouth receiving discharges from the middle reach and oil related activities such as flow stations, crude oil tank farm, condensate plant, and liquefied natural gas plant (NLNG). This zone is essentially polyhaline in nature all the year round. Also the vegetation is mangrove dominated by *R. racemosa*, *R. mangle*, *Avicennia africana*, *Lagunculena recemosa and Acrostichum aureum* (mangrove fern).

Sampling strategy
Samples were collected in wet (September 2000) and dry (January 2001) seasons from the 10 stations. Samples were collected for total hydrocarbon and heavy metal concentrations in sediments and tissues of the shrimp.

Sediment

Sediment samples for Total Hydrocarbon concentrations (THC) were randomly collected during low tide from the mid intertidal limits of the stations. At each station, three (3) replicates of sediment samples were collected at surface layer (0-15cm-depth) using soil augers. The three (3) replicate samples were composed and placed in an aluminum foil for hydrocarbon analysis, and another set of replicates for metal analysis were placed in cellophane bags. All samples were immediately stored in an ice-cooled box and transferred to the laboratory.

Biological Samples

Shrimp samples for THC and heavy metal concentrations were collected at low tide regime using locally employed gears for shrimp fishing particularly beach seine nets of small mesh size. Occasionally hand nets were also used. The samples were wrapped in aluminum foil and cellophane bags respectively, labeled and preserved in an ice chest at (-4^{o}C). All samples were transferred immediately to the laboratory.

Laboratory Analyses

Samples were air dried for about three (3) weeks. Five (5) g of air dried, ground and sieved soil samples, were weighed into a conical flask and 10mls of toluene added. This was shaken for about 1 minute and filtered using ashless filter paper. The filtrate was measured in a glass cuvette at 420nm with a Spectronic 21 spectrophotometer.

Metal samples were analyzed using Four (4) g of finely ground soil samples that were weighed into a platinum crucible and 50ml of de-ionised water added. 10ml of concentrated Hydrochloric (HCl) acid and Iml. of concentrated Nitric acid (HNO_3) were added in succession. The mixture was heated in a steam bath to a thick yellow liquid. The crucible was allowed to cool down; its contents filtered and made up to 100ml with de-ionised water. The extract was stored in plastic bottles and analyzed using atomic absorption spectrophotometer (AAS -Perkin Elmmer, 3110 Model).

Tissue Studies

Hydrocarbon samples were analyzed using five (5) grams of homogenized tissue sample and extracted using 10ml of toluene. This was filtered and the absorbance value of the filtrate measured at 420nm using a spectronic 21 spectrophotometer.

Heavy metals were determined with four (4g) of finely ground tissue samples homogenized with 50mls of de-ionised water after 10mls of concentrated HCl and Iml of conc. HNO_3 in succession. The mixture was heated in the steam bath to a thick yellow liquid before allowed to cool. The mixture was filtered and the filtrate made up to 100ml with distilled water. This was stored in plastic bottles and analyzed in Atomic absorption spectrophotometer (Perkin Elmmer 3110 model)

Each set of samples was accompanied by complete system blank, spiked blank and reference material, which was carried through the same process as part of quality control measures adopted for the analyses.

RESULTS

Total hydrocarbon (THC) and metals concentrations for sediment and biological tissue (shrimp-) for wet and dry seasons are presented in Figures 2(a-g) and 3(a-g).

In the entire study area, chromium (Cr) levels ranged from 0.01 - 0.83 ppm in wet season but maintained very low uniform concentration of 0.002ppm in the dry season. The zonal chromium concentration for the river system, maintained a uniform distribution pattern of lower limit (0.01-0.83 ppm) > middle limit (0.01- 0.55 ppm) > upper limit (0.01- 0.41 ppm). In dry season, zonal differences in the distribution were not distinct .

Changes in Cd concentration were observed in only wet season but values for dry season were uniform for the entire stretch of the system. The ranges of Cd concentrations were: middle reach zone (0.016 - 0.034ppm) > Lower reach (05 - 0.029ppm) > upper limit (0.014 - 0.022ppm) respectively.

Generally, vanadium concentrations ranged from 0.02 - 0.13 ppm in wet season while dry season values were < 0.04 ppm. The distribution sequence was lower limit (0.02 ppm - 0.13ppm) > middle limit (0.02ppm and 0.04ppm) in wet season.

Lead (Pb) concentrations ranged from 0.003 - 0.027 ppm in wet season, while the dry season maintained uniform levels of 0.01ppm in all the stations. The distribution of Pb concentration in wet season was in the order of upper limit (0.010 - 0.27ppm) > lower limit (0.008 - 0.023ppm) middle limit (0.009 - 0.020ppm).

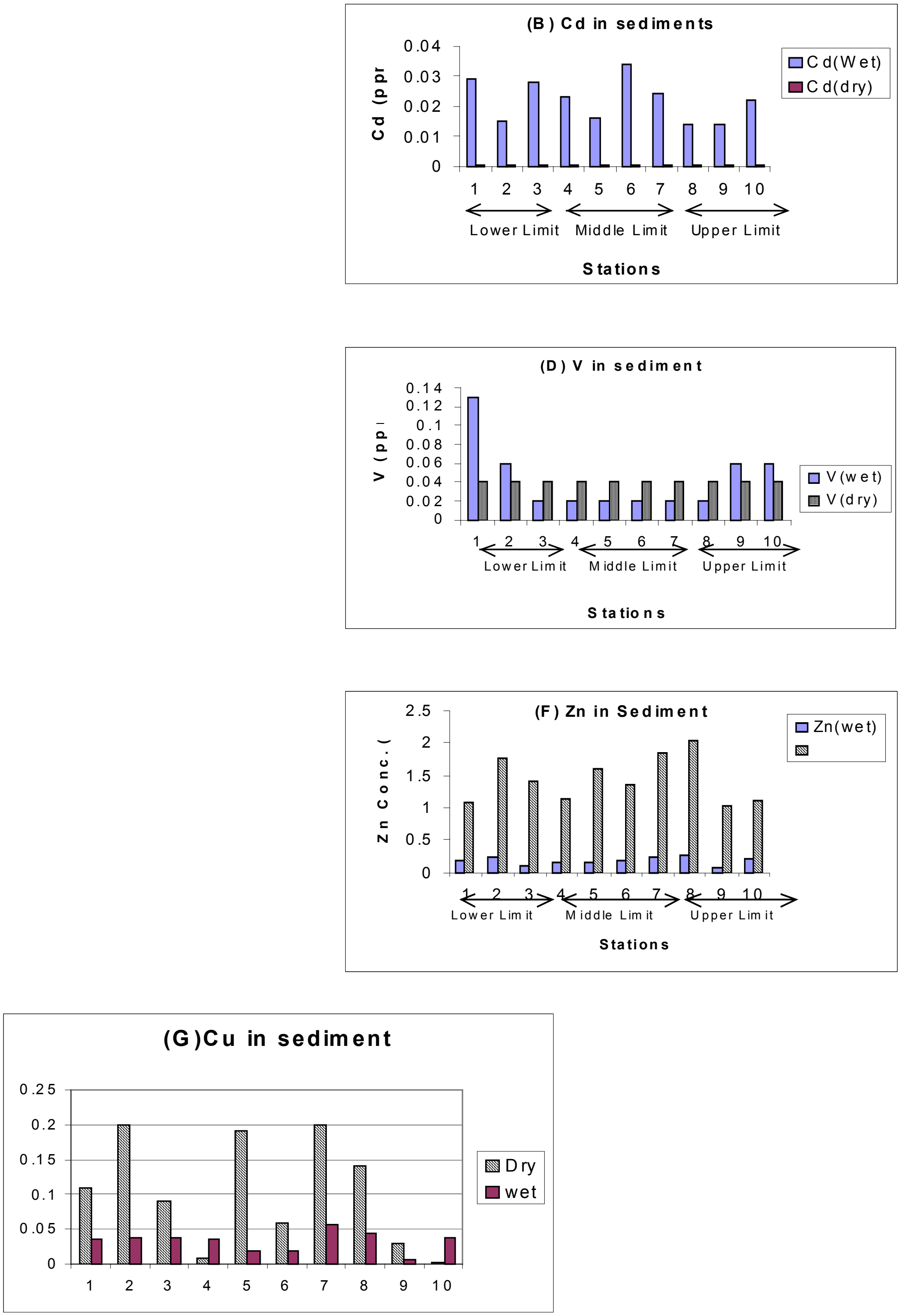

Figure 2: The total hydrocarbon (a) and heavy metals concentrations in sediment for wet and dry seasons

The differences in concentration between seasons for Zn were remarkable with wet and dry season values for the 3 zones being in the range of 0.063 - 0.277 ppm and 1.03 - 2.04 ppm respectively. The distribution showed that the upper limit zone (0.063 – 0.277ppm) > lower limit (0.107 – 0.231ppm) > middle limit (0.003 – 0.020ppm) in the wet season and upper limit zone (1.03 – 2.04) > middle limit (1.13 – 1.80ppm) > lower limit (1.07 – 1.78 ppm) in the dry season.

Copper concentrations ranged from 0.007 - 0.057ppm in wet season and 0.001ppm - 0.20ppm in the dry season. The lower and the middle limit of the river system recorded higher concentrations of Cu in the dry season than in the wet season. The sequence of distribution of this metal was middle limit zone (0.019 - 0.057 ppm) > upper limit (0.007-0.044 ppm) > lower limit (0.036 - 0.039 ppm) in the wet season and upper limit zone (0.001- 0.14 ppm) > lower limit (0.09 – 0.20 ppm) = middle limit (0.1 – 0.20 ppm) in the dry season.

Total hydrocarbon concentrations (THC) recorded higher ranges in wet season (0 - 798.25 ppm) than in the dry season (246.92 - 571.63 ppm). The distribution in the zones was in the sequence of Upper (0 – 798.25ppm) > lower (20.29-365.30 ppm) > middle (6.76 -358.53 ppm) and upper (287.50-571.63ppm) > middle (287.50-571.63 ppm) > Lower (287.50 - 487.07 ppm) for wet and dry seasons respectively.

Biological (Shrimp tissue)

The spatio-temporal distribution of metals and THC levels in shrimps in the study area, for wet and dry seasons is presented in (Figs 3 a-g). These indicated seasonal dependent variations in tissue hydrocarbon and metal concentrations.

The levels of chromium in both wet and dry seasons along the river system were low with the wet season values recording below 0.01ppm in all the stations while dry season concentrations were below 0.002ppm in all the stations.

The upper limit recorded Cr levels of 0.01ppm and 0.002ppm with mean levels of 0.01 ± 0.01 ppm and 0.002ppm in the wet and dry seasons respectively. Both seasons had a coefficient of variation of 50% within the zone. The middle and lower limits, recorded a mean of 0.01ppm in wet season, with no variation in spread within the two ecological zones. The dry season showed a similar trend with a mean of 0.002ppm for both middle and upper limits (with no variation in spread). This could be an indication of low Cr values along this river system

Cadmium concentration ranged from 0.0005ppm to 0.073ppm for the two seasons. However, the upper limit of the river system has ranges from 0.001 - 0.073ppm in wet season with a mean of 0.03 ± 0.04ppm (C.V. 140.4%) while dry season were generally below 0.0005ppm (with coefficient of variation of 50%). The middle limit showed a similar trend with wet season ranging from 0.006 - 0.032ppm (c.v. 77.6%), while the dry season maintained values < 0.0005ppm. In wet season, Cd in the lower limit of the river system, ranged from 0.011 - 0.019ppm (c.v. 27.9%). The dry season were generally < 0.0005ppm.

Generally, vanadium concentrations in shrimps, during the wet season were uniform in all the locations (0.02ppm) except at station 6 (Bakana), where the value was 0.06ppm. The dry season values were uniform in the three ecological zones.

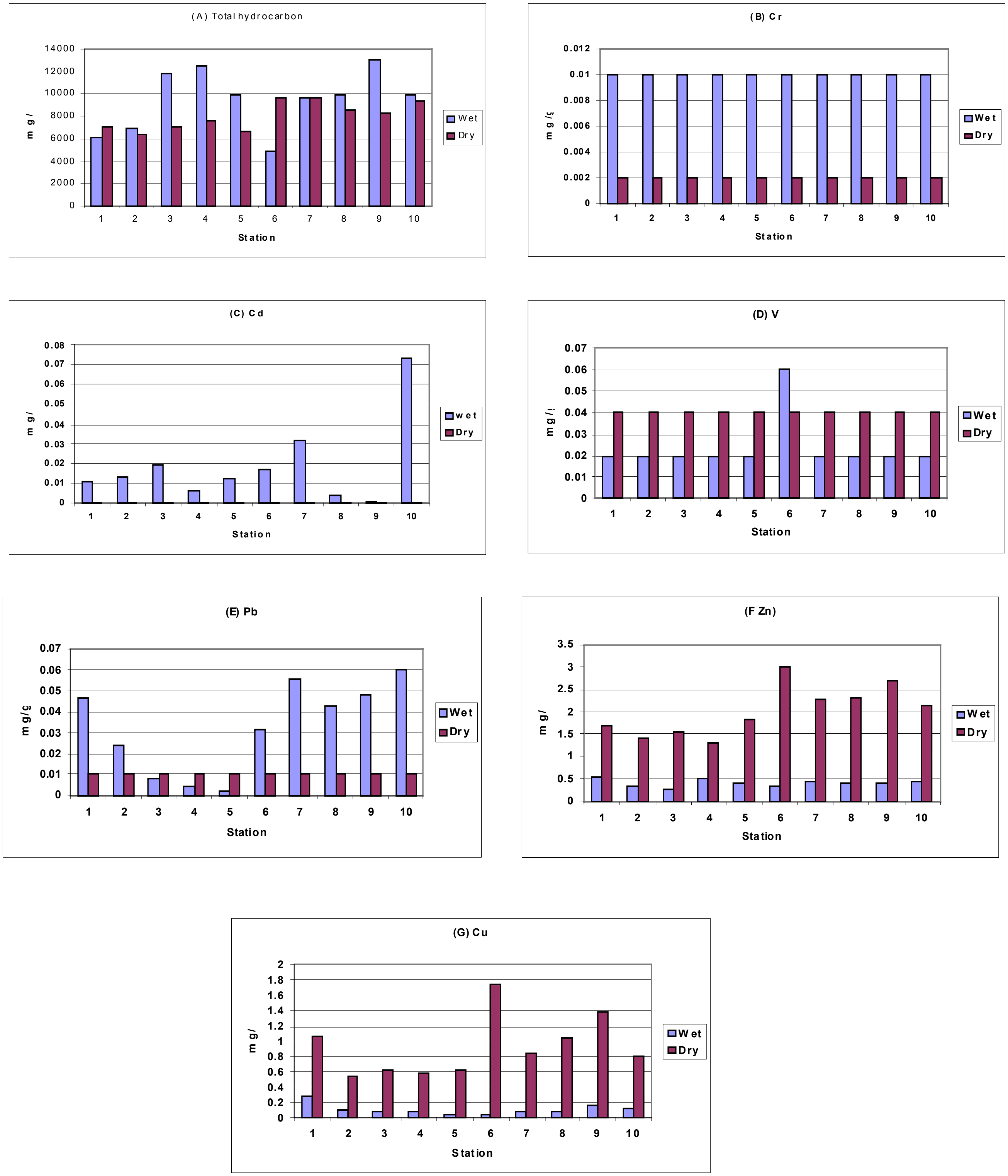

Figure 3: The total hydrocarbon (a) and heavy metals concentrations in sediment for wet and dry seasons

In the upper limit, Vanadium concentrations showed 50% coefficient of variation during the wet season having a mean value of 0.02 ±0.01ppm. The dry season values for the same section of the river system were generally below 0.04ppm with no variation in spread. The values for the middle and lower limits of the river system ranged from 0.02ppm to 0.06ppm in the wet season with mean values of 0.03 and 0.02ppm respectively. There was no variation observed in the two zones. The dry season values showed similar trend, recording values below 0.04ppm in all the stations within the zone.

Tissue lead (Pb) concentrations were higher in wet season, than in dry season. In the upper limit of the river system, Pb levels ranged from 0.043 - 0.060ppm (C.V. of 59.6%) while the levels maintained a uniform concentration of <0.01ppm in dry season. The middle reach of the river system had Pb concentrations ranging from non-detectable to 0.056ppm (C.V. of 82.3%) in wet season. The dry season levels were < 0.01ppm. In the lower limit of the river system, concentrations ranged from 0.008 - 0.047ppm in wet season (C.V. 74.1%). Pb concentrations remained uniform at 0.01ppm in dry season. The concentrations therefore had a sequence of upper limit > lower limit > middle limit in wet season, while dry season values remained uniform through out the river system.

Tissue Zn values ranged from 0.276ppm in wet season to 3.010ppm in dry season along the river course. In the upper limit, concentrations ranged from 0.383 - 0.447ppm (C.V. of 54.3%) in wet season while higher levels were obtained in the dry season (2.14 - 2.70ppm and C.V. of 44.8%). The middle limit of the river system showed similar seasonal variation with Zn concentrations ranging from 0.345 to 0.441ppm (C.V. of 7.4%) while the dry season values were higher (1.30 - 3.01ppm and C.V. of 23.5%). The lower limit demonstrated the similar lower concentrations in the wet season (0.276 - 0.544ppm; C.V. of 34.7%) than in the dry season (1.42 - 1.700ppm; C.V. of 5.15%).

Copper (Cu) in the three ecological zones of the river system, varied in the decreasing concentration order of lower limit (0.080 - 0.284ppm, C.V. of 64.97%) > upper limit (0.081 - 0.159ppm; C.V. of 51.9%) > middle limit (0.042 - 0.091ppm 0.07ppm) in the wet season and upper limit (0.80 - 1.39ppm, C.V. of 37%) > middle limit (0.58 - 1.74ppm C.V. of 13.76%) > lower limit (0.55 - 1.07ppm, C.V. of 29.33%) in the dry season.

THC levels in shrimps were generally high during the wet season ranging from 4870.66 - 13,056.06ppm, while dry season levels ranged from 6,508.18 - 9,622.93ppm.

THC values in the Upper limit of the river system, varied from 9,842.78 - 13,056.06ppm (C. V. of 45.5%) and 8,303.79 - 9,40.07ppm (C.V. of 53.95%) for wet and dry seasons respectively. The middle limit had concentrations of 4,870.66 - 12,514.85ppm (C.V. of 16.2%) during the wet season, and 6,622.90 - 9,622.93ppm (C.V. of 12.2%) in the dry season. In the lower limit of the river system, THC concentrations ranged from 6,054.50 - 11,838.40ppm (C.V. of 34.99%) in the wet season while concentrations for the dry season ranged from 6,508.18 - 7,086.13ppm (C.V. of 25%). Generally, THC concentrations for both seasons were higher in the middle and the upper reaches of the river than at the lower reach. This may be due to the flushing effect of the tidal regime that is most pronounced at the lower reach of the water system. The middle and upper reaches, although with high petroleum activities, experience less flushing effect of the tide resulting in higher retention time for the organisms to bio-accumulate the contaminants.

Amongst the heavy metals, the copper and zinc appeared to be the most bioaccumulated in the shrimp tissue, with relatively higher bioaccumulation factor (BAF) Table 1. These BAF tendencies appeared more pronounced at the upper and lower reach zones of the system.

This phenomenon was further evaluated using the mathematical model for explaining the correlation between the mean concentrations of contaminants in organisms and sediment was observed to follow a linear regression equation of the form:

$Y = a + bx$ ……………………………………………. (Equation 1)
Where:
Y = mean concentration of contaminants in the organism.
a and b = coefficients corresponding to the intercept on y axis and slope respectively.
x = concentration of contaminant in the sediment.

The lines connecting the data points give an insight into projected trends with the actual data from this study. When compared with respective dependent and independent variables, there is compelling evidence that most of the metals and Total hydrocarbon components for the two organisms followed the modeled trend

The regression analysis output of THC concentration in shrimp and sediment using mean values for both seasons was significant ($p<0.05$) and is demonstrated by the expression $Y=9739.97-7.067x$

The regression analysis on THC concentration in shrimp and sediment was significant ($p < 0.05$). Testing significance of the determination coefficient r^2 showed that 4.07% of the variation in shrimp THC concentration might be due to sediment THC load which implies that THC concentrations in shrimps increased by 4.07% per unit increase in sediment. Sediment THC values might be contributing to shrimp THC values for values of THC above 7541.1ppm in shrimps but THC values of 7541.1ppm and below may not be dependent on sediment THC. The regression equation is given by: $Y = 7541.1 + 4.07X$**.** Amongst these, virtually no Cr component in shrimp ($R^2 = 0\%$), attributed to the sediment source is indicated in Figs 3. Other changes in metal components (Cd, r2 = 4%, V, r = -1770%, Pb, = 4.9%, Zn r =0.07% and Cu, r = 1.3%) in shrimp body burden as a function of sediment (Fig. 4 a-g).

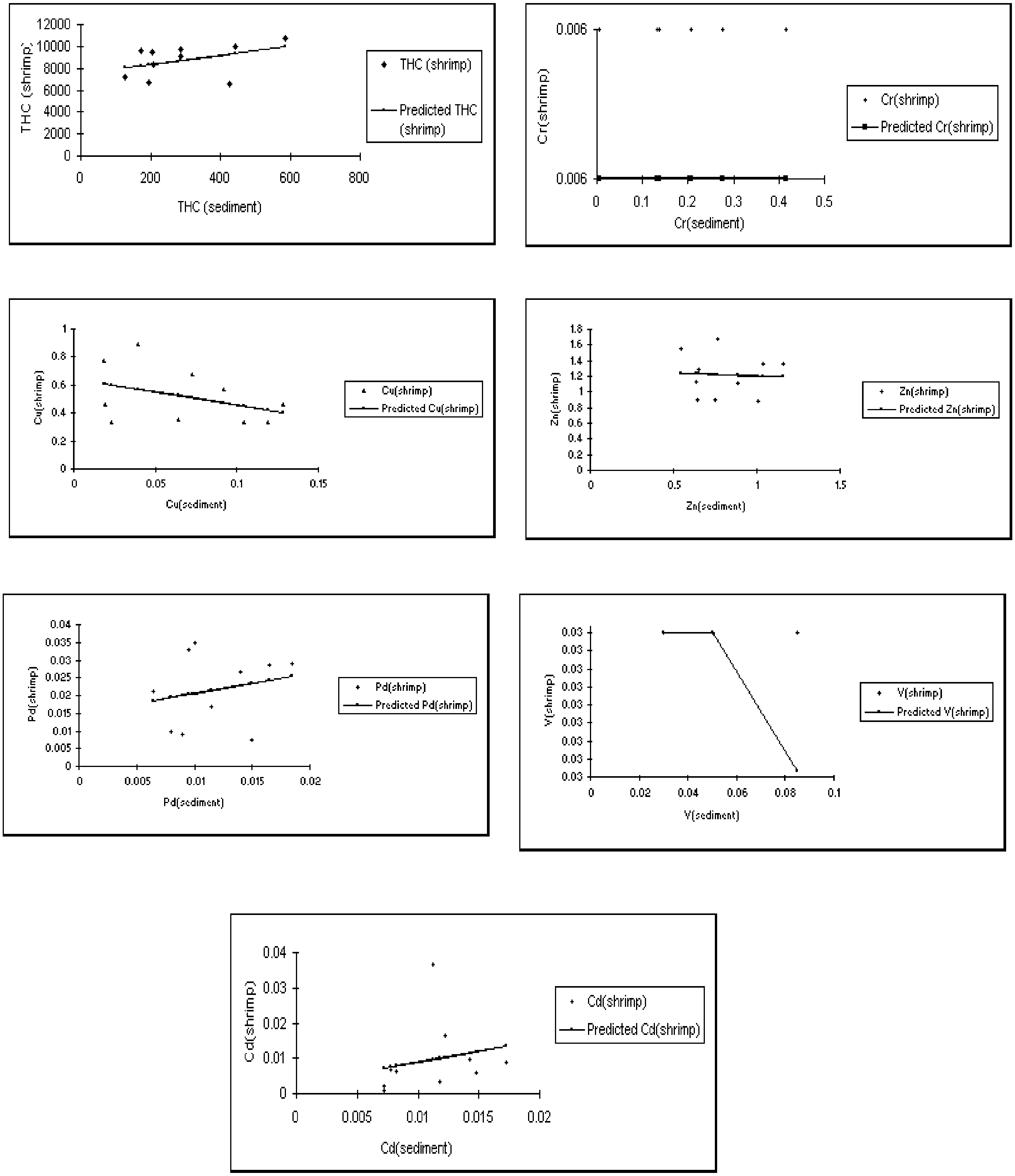

Figure 4: Regression plot showing line of fit in the relationship between shrimp tissue and sediment hydrocarbon and heavy metal concentrations (actual and predicted values)

DISCUSSION

Chemical and biological monitoring are efficient and reliable means of ascertaining status of the environment, compliance to regulatory limits and prevention of possible potential hazards of contaminants to the environment (Kakulu & Osibanjo 1992).

In this study, the sediment THC levels for all the stations in the ecological zones, which were observed to be higher than background limits, indicating the anthropogenic contribution of hydrocarbon into the system. This can be explained by improper discharge of wastes from various human activities in the study area, especially from the industrial oil sub-sector and municipal discharges (Kakulu & Osibanjo 1992, Chindah 1998, Joiris *et al* 1998, Joiris and Azokwu 1999). The distribution of THC in the sediment along the river course which showed a pattern of upper limit > lower limit > middle limit in that respective order of declining concentration appeared to follow the hydrological dynamics as well as the proximity to the vicinity of discharge. Abam (2001) reported that Bonny-New Calabar system has very poor flushing rate, thus crude oil spills, crank case oil and other hydrocarbon sources (from industrial and municipal discharges) into the water body that are carried upstream during flood tides, take several days to get flushed out of the river system. It is therefore possible that with the high residence time, these hydrocarbons may undergo processes that will facilitate their deposition on the sediment of the upstream limits more than at the other ecological zones. This may account for the highest concentrations of heavy metals in this ecological zone for the two seasons. The THC levels in the lower limit are expected as most of the oil exploration and exploitation activities are carried out within this ecological zone.

Furthermore, the observed seasonal differences with higher concentrations of THC in wet than in the dry season may be attributed to increased land based run off to the water body. Other possible reasons may be due to increased water current and wave action, which may largely disturb the sediment, with the concomitant resurfacing of the previously leached hydrocarbon into the sediment. The higher concentration of THC in body tissues of the organism than in the sediment demonstrates evidence of bioaccumulation of hydrocarbon by the organisms in the environment probably through contact, respiratory and feeding activities (Micheel *et al*, 1998, Lim *et al* 1998). This underlines the ability of the shrimp, a deposit feeder to ingest sediment and associated algae and other organic components (Chindah et al 1993).

Despite the high THC concentrations in the sediment and shrimp, the metal levels particularly those related to crude oil sources were considerably low and within permissible limits (Saad *et al* 1990). This implies that regardless of the various activities in the environment that associated heavy metals do not seem to constitute an immediate environmental hazard. However, the relative high levels of Cu, and Zn concentrations in sediment and shrimp suggest a high bioavailability in the studied water body.

The seasonal dependent variation in the sediment and tissue concentrations of the heavy metals may be associated with several factors such as nature of sediment scavenged, type of food, nature of run off, and or the water quality (Bryan 1973, Szefer *et al* 1999). Noteworthy is the consistent higher concentrations of Zn and Cu in the dry season than in wet season for sediment and the organism (shrimp - *Penaeus notialis*). This observation is consistent with findings made by Biney (1991) and Everaats *and* Swennen (1987). Similar observation was made in a related study on algae, fish and sediment in the Niger Delta area (Ndiokwere 1984, Kakulu and Osibanjo 1986, Okoye *et al* 1991). The predominance of Zn and Cu in dry season may suggest anthropogenic influence possibly from municipal sources.

However, other metals studied showed a different pattern from Zn and Cu, with values being consistently higher in wet season than in dry season for sediment (environment) and body tissue of shrimp - *Penaeus notialis*. These seasonal changes in metal concentrations may in addition be attributable to changes in biological activity associated with increase in food availability resulting from higher and longer days (Tam and Wong, 1996). Another possible reason may be due to increased productivity, which induces a rise in the metabolite concentration in seawater, which in turn increases the possibility of organic complexation of metals and subsequent changes in metal bioavailability (Orson et al 1992, Tam and Wong, 1995 &1996, Metwally *et al* 1997). Joiris and Azokwu (1999) observed similar limited seasonal variation for Pb and Cd, but reported significant differences in values for Fe, Zn and Cu in bloody cockle from Bonny River estuary in the Niger Delta.

In all, distribution of metals in tissues of shrimp - *Penaeus notialis* did not show distinct pattern with ecological boundary. This however makes it very difficult for interpretation. Despite these inconsistencies in the distribution of metals in tissues, the metal concentrations found in the tissue of shrimp - *Penaeus notialis* are similar to observations reported in previous studies in the Niger Delta (Kakulu et al., 1987,and Joiris and Azokwu 1999), These levels are considered to be within WHO recommended heavy metals from the environment (Fowler 1990; Bryan and Langston 1992) it is therefore necessary for industrial and effluent discharges to be monitored to ensure that critical limits are not reached. The fact that the highest and lowest concentrations of the metals were not observed at the same sampling stations, indicates that there is some degree of independence in pollution by different metals in the system or pattern of behaviour of the metals following differences in microenvironment.

In addition, the relatively higher concentrations of the metals in tissue of organisms against that of the environment (sediment) suggest bioaccumulation, and the extent of bioaccumulation differed with metals. The possible reason for this may be due to organisms' absorption efficiency, feeding pattern, bioavailability or partitioning of compounds into lipids (Phillips, 1995),

Of all the heavy metals studied in the body tissues of shrimps, Pb and Cu had even distribution with high bioaccumulation factor (BAF) for all the ecological zones. Noteworthy is the fact that BAF for Cr is also significantly increase in shrimps, during the wet season particularly at stations 3 of the upper limit, , station 4 of the middle limit and station 10 of the lower limit. The reason for this is not certain but could be due to the fact that Cr; is readily available in the system during the period and the possible uptake and bioaccumulation over time by the organisms. In addition to the presence of Cr in the environment as possible factor responsible for bioaccumulation, other factors such as ionic balance, redox potential are likely to influence the rate of bioaccumulation by organisms (Wang and Fan, 2001, and Combs 1977). The observed significance in BAF for shrimp indicated that these metals are present and over time; bioaccumulated by the organism. This scenario is possible as the organisms obtain their food from the sediment, which perhaps contain a proportion of these metals ingested through food (by browsing and scavenging) on the sediment (Mergeay, 1991 Fraser et al, 2002). This observation in shrimp - *Penaeus notialis* indicates that the species have the propensity to bioaccumulate certain heavy metals in the environment than others. This suggests that the organism can be used as possible bioindicator for monitoring of the specific metals in the Niger Delta. Similar result has been reported on epibenthic and infaunal deposit feeders (Prahl and Capenter, 1993).

It is also necessary to observe that the significant bioaccumulation of the metals by the organism even when the concentrations of such metals are low in the environment, may suggest the potential problems of bioaccumulation of metals despite the very low concentration in the environment. Although the values obtained for metals in this study are below documented toxic levels, the tendency for bioaccumulation of these metals in body tissue of the organism underscores the need for continuous monitoring of sensitive environment to ensure that dangerous levels are not attained.

From this study, it is therefore evident, that the shrimps – *Penaeus notialis*, possesses the requisite features to be used as a bioaccumulator/bioindicator for metal pollution monitoring programme in the Niger Delta region and perhaps elsewhere.

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