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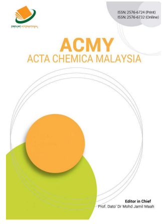

*REVIEW ARTICLE*

# STATUS OF HEAVY METALS IN WATER, SEDIMENTS AND CLAM (GALATEA PARADOXA, BORN 1778) OF THE DIEBU CREEK, BAYELSA STATE, NIGER DELTA REGION, NIGERIA

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**ABSTRACT**

This study was carried out to evaluate the pollution status in water, sediments and whole body tissue of clam (galatea paradoxa, born 1778) of the Diebu Creek, Bayelsa State, Niger Delta Region, Nigeria. The concentrations of the five heavy metals (As, Co, Cu, Fe and Pb) were determined using analyst 400 Perkin Elmer Atomic Absorption Spectrophotometer (AAS). The mean concentration(mg/kg) of the metals in sediment were: (0.66±0.76) Co, (1.56±1.16)Cu, (1812.31±190.31)Fe and (0.94±0.87)Pb, while the mean concentration(mg/kg) of the metals in clam followed decreasing order: Fe(284.22)> Pb(2.30)> Co(1.08)>Cu(0.75) respectively. In attempt to infer anthropogenic input from natural input, linear regression equation, comparison with sediment quality guideline (SQGs) and ecotoxicological sense of heavy metal contamination was employed. The concentration of the studied heavy metals of the Diebu Creek, Fe and Pb exceeded reference standards, however, the concentration does not pose a threat to the sediment dwelling fauna and anyone who consumes aquatic animals particularly clam (galatea paradoxa, born 1778) from the Diebu Creek. According the SQGs, the studied heavy metals of the Diebu Creek sediment were under the category of non-polluted.

**KEYWORDS**

Correlation, regression, significant, water, sediments, galatea paradoxa, Diebu Creek

## 1. INTRODUCTION

Families, communities and states donating land resource for industrial, agricultural purpose etc. is laudable, however, the effect is disastrous such as: impair water quality, sediment, human health and general environmental risk. The discovery, exploration and exploitation of natural resources such as crude oil in the Niger delta spurred urban population growth which have resulted in an increase in the production of different types of municipal solid wastes (MSW) ranging from degradable to non-degradable among are heavy metals [1].

Pollution of the littoral waters of the Niger Delta region of Nigeria has in recent times received much attention because of the high degree of environmental degradation and aquatic perturbations posed by petroleum exploration activities in the oil-bearing states [2]. Heavy metals contamination of river water is one of the major issues in fast growing cities because maintenance of water quality and sanitation infrastructure do not increase along with population and urbanization growth especially in developing countries [3,4].

Heavy metals are one of the serious pollutants in natural environment due to their toxicity, persistence and bioaccumulation problems [5-7]. Heavy metals from incoming tidal water and fresh water sources are rapidly removed from the water body and deposited onto the sediments [8,9].

There are five major sources of heavy metals viz: Geological weathering, (natural phenomenon), industrial processing of ore and metals, the disposal of metals and metal components, leaching of metals from garbage and solid waste heaps and animal and human excretions [10,11]. The knowledge of heavy metal load of a water body is very essential because it gives an insight on the pollution status of the water body and also enables us to take protective measures against excessive exposure either directly or indirectly [12]. Studies on heavy metals in rivers, lakes, sediments and biota have been a major environmental focus especially during the last decade [13]. The commercial and edible species have been widely investigated in order to check for those hazardous to human health [14]. The present study was carried out to investigate the bioaccumulation, distribution enrichment of heavy metals (As, Co, Cu, Fe, Pb,) in water, sediment and edible parts of commonly consumed mollusks the clam (*galatea paradoxa, born 1778***)** obtained from Diebu Creek.

## 2. MATERIALS AND METHODS

### 2.1 Description of Study Area

Diebu Creek is a freshwater non-tidal river that empties into the River Nun. The Diebu Creek is a natural river, geographically located in Bayelsa state, Niger Delta region, Nigeria (Fig. 1). The river lies between the coordinates of latitude 4° 53' 15.855'' North and longitude 6° 22' 25.640'' East. Diebu community has a population of about 16,000 people, they are good farmers and fishermen. Diebu is located in Bomo Central / West Rural Development Area (RDA) of the Southern-Ijaw Local Government

Area (SILGA) Bayelsa State. Diebu is bounded on the North by Polobubou, West by Peremabiri, East by Opuoama, and South by Akassa communities.

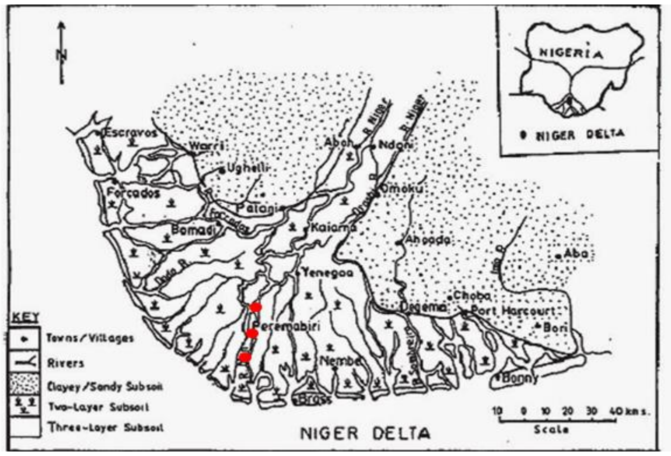


**Figure 1:** Map of study area showing sampling sites.

### 2.2 Sampling and Analysis

The environmental conditions such as industrial and other human activities in the area were considered in the collection of the samples. Sediment samples were collected from three stations: upstream, middle reach and downstream along the Diebu River system. Sediments were sampled using a bottom grab sampler (Hydro-Bios) and then immediately transferred into plastic bags and refrigerated. In order to get a representative sample for each station, several sub-samples were collected and mixed together. At the laboratory, the samples were air dried pulveried and sieved through a 2 mm mesh to remove dirt's and other debris, then stored in closed plastic containers.

The test animals used for this study are clam [*galatea paradoxa, born 1778*]. Galatea Paradoxa (Born 1778) is an important bivalve exploited mainly for food in Diebu community and Bayelsa State in General. It was chosen as the indicator of heavy metal pollution because of the following reason: They are filter feeders and can significantly concentrate many chemical elements from water and sediment. They are abundant in the study area and are relatively long lived. They are easy to sample, hard enough to survive under laboratory conditions and provide sufficient tissues for contaminant analysis. For the clam samples local clam fishermen was used to collect the clam samples. Clam samples were selected based on sizes, large, medium and small.

The total metals from sediment and clam samples were determined using nitric-perchloric acid digestion 2:1. To 1.0g sediment sample, 5 mL of 65 % HNO3 was added, and then the mixture was boiled gently for 30–45 min. After cooling, 2.5 mL of 70 % HClO4 was added, and the mixture was gently boiled until dense white fumes appeared. Later, the mixture was allowed to cool, and 10 mL of deionized water was added followed by further boiling until the fumes were totally released according to standard method by [15,16].

The total metals from water samples were determined using nitric acid digestion. To the sample, 5 mL of 65 % HNO3 was added, and then the mixture was boiled gently over a water bath (90 °C) for 1–2 hours or until a clear solution was obtained. Later, 2.5 mL of 65 % HNO3 was added, followed by further heating until total digestion. Finally, 20 mL of digested samples were taken for analysis [17].

During the digestion procedures, the inner walls of the beakers were washed with 2 mL of deionized water to prevent the loss of the sample. At the final stage of the digestion processes, the samples were filtered with what man number 1 (2.5-μm particle retention) filter paper. Then, a sufficient amount of deionized water was added to make the final volume up to 50 mL

### 2.3 Instrumentation and Statistical Analysis of Data

In this study, Statistical analysis was performed using Microsoft Excel 2010. Both descriptive and inferential statistical analyses were used to interpret the raw data in this study. The digestates were subjected to elemental analysis using an atomic absorption spectrometer (ANALYST 400 Perkin-Elmer AAS), in compliance with manufacturer's instructions and specifications.

## 3. RESULTS AND DISCUSSION

### 3.1 Characteristics of surface water quality

**Table 1:** Variation of total mean concentrations (mg/kg) in water, sediment and clam of Diebu Creek HMs=heavy metals, ND=not detected

| | **WATER (mg/L** | | | | **SEDIMENTS (mg/kg)** | | | | **ABIOTA (mg/kg)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HMs** | **SS1** | **SS2** | **SS3** | **mean** | **SS1** | **SS2** | **SS3** | **mean** | **SS1** | **SS2** | **SS3** | **mean** |
| As | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Co | ND | ND | ND | ND | ND | 0.26 | 1.730 | 0.66 | 1.42 | 0.32 | 1.51 | 1.08 |
| Cu | ND | ND | ND | ND | 0.870 | 0.61 | 3.190 | 1.56 | 0.66 | 0.62 | 0.98 | 0.75 |
| Fe | 8.52 | 9.33 | 8.48 | 8.78 | 1575.94 | 1819.05 | 2041.95 | 1812.31 | 387.50 | 397.76 | 67.41 | 284.22 |
| Pb | ND | ND | ND | ND | 0.24 | 0.410 | 2.17 | 0.94 | 2.99 | 1.03 | 2.89 | 2.30 |

The results of heavy metals in water, sediment and clam (*Galatea Paradoxa, born 1778*) of the Diebu Creek are presented in Table. 1-2, the percentages of the heavy metals are represented graphically in Fig. 2-5, while the correlation between the concentrations of the metals sediments and clam fitted a linear regression and are represented in Fig. 6-9. The results showed that the studied heavy metals: As, Co, Cu and Pb in water samples of the Diebu Creek, were not detected (ND) except iron. The concentration of iron (Fe) ranged from 8.48 – 9.33 with an average of 8.78 ± 0.39m/L. The highest concentration of Fe was recorded at SS2 (9.33m/L), followed by SS1 (8.53m/L) which was closely followed by SS3 (8.48m/L). The results of this study, iron was found to be below the permissible limits of 300μg/L [18].

**Table 2:** Mean concentration levels of heavy metals detected in water, sediments and clam samples and comparison standards ND=not detected

| Sample type | **Heavy metals** | | | | | |
|---|---|---|---|---|---|---|
| | As | Co | Cu | Fe | Pb | Reference |
| | **water** | | | | | |
| Range | ND | ND | ND | 8.48-9.33 | ND | |
| Mean concentration ± standard deviation (mg/L) | | | | 8.87±0.39 | | |
| USEPA | | 10 | 1300 | 300 | 15 | [27] |
| | **sediment** | | | | | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Range | ND | 0.26-1.73 | 0.61-3.19 | 1575.94-2041.95 | 0.24-2.17 | |
| Mean concentration ± standard deviation (mg/kg) | | 0.66±0.76 | 1.56±1.16 | 1812.31±190.31 | 0.94±0.87 | |
| TEL | 5.9 | | 18.70 | | 30.20 | [21] - [23], [3], [18] |
| | **clam** | | | | | |
| Range | ND | 0.32-1.51 | 0.62-0.98 | 67.41-397.76 | 1.03-2.99 | |
| Mean concentration ± standard deviation (mg/kg) | | 1.08±0.54 | 0.75±0.16 | 284.22±153.37 | 2.30±0.90 | |
| FEPA | | | 1.3 | 100 | 0.2 | [26] |

Table 2 reported the total mean concentration of studied heavy metals in sediments of the Diebu Creek and comparison with reference sediment quality guidelines. The concentration (mg/kg) of cobalt in sediments ranged between 0.26 – 1.73 with an average of 0.66 ± 0.76. The highest concentration of cobalt was recorded in SS3, followed by SS2 (0.2), and the lowest of cobalt was recorded in SS1 (ND).

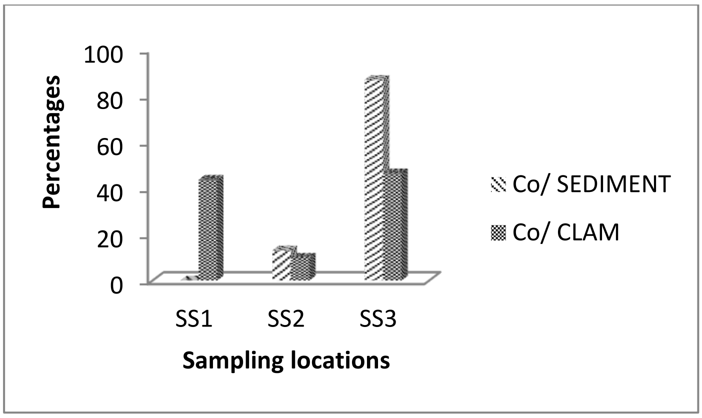


**Figure 2:** Variation in percentages of Co, in clam and sediment

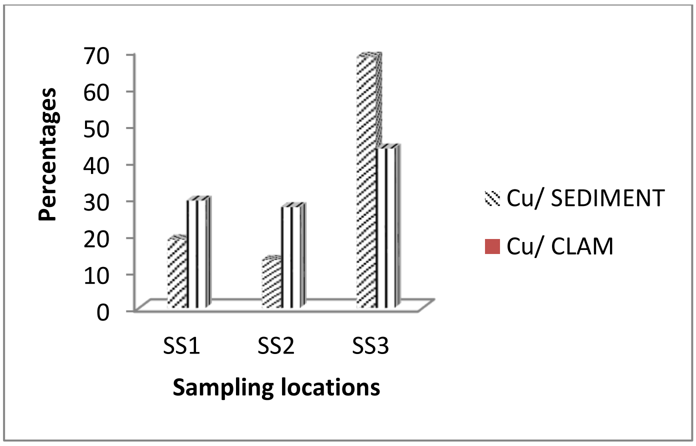


**Figure 3:** Variation in percentages of Cu, in clam and sediment

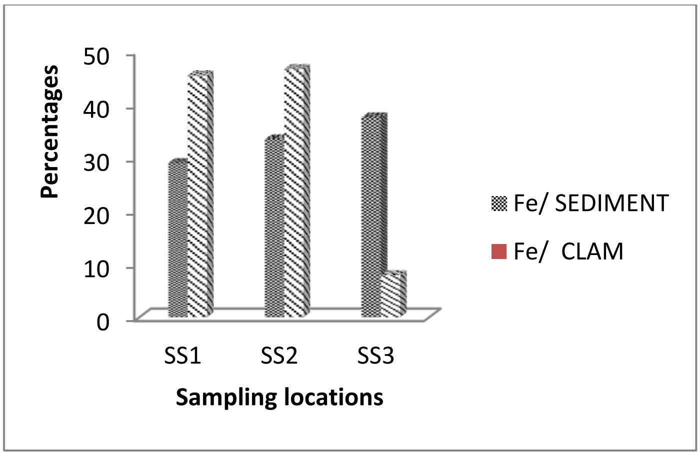


**Figure 4:** Variation in percentages of Fe, in clam and sediment

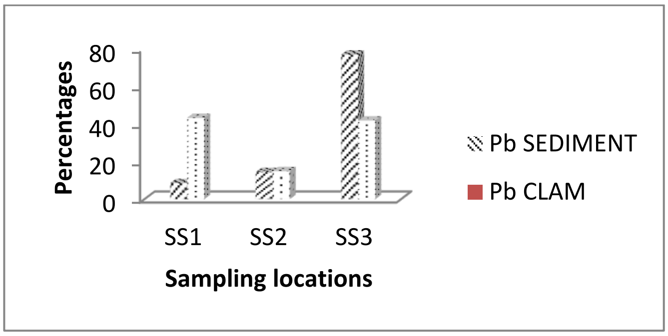


**Figure 5:** Variation in percentages of Pb, in clam and sediment

### 3.2 Characteristics of surficial sediment quality

The higher concentrations of metals measured in sediment than in water indicate that lower pH favored metal accumulation and is in agreement with report that sediments are the major depository of metals holding more than 99% of total amount of a metal present in the aquatic system [19,20]. The correlation between the concentrations of metals in water and sediment fitted a linear regression equation (1) of the form:

$$y = bx + a \qquad 1$$

Where, y = concentrations of metals in clam, $x$ = concentrations of metals in sediment; $b$ and a = coefficients corresponding to the slope and intercept on y axis respectively.

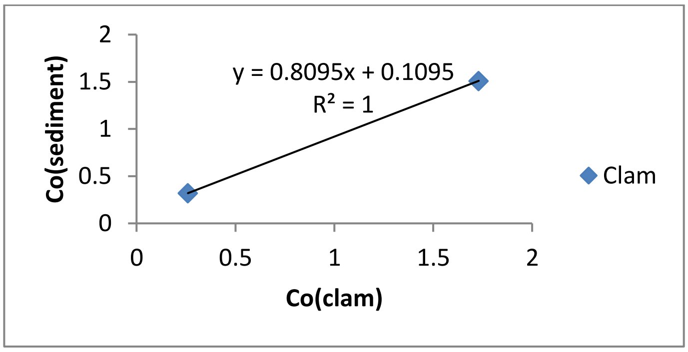


**Figure 6:** Correlation between Co in sediment and Co in cam

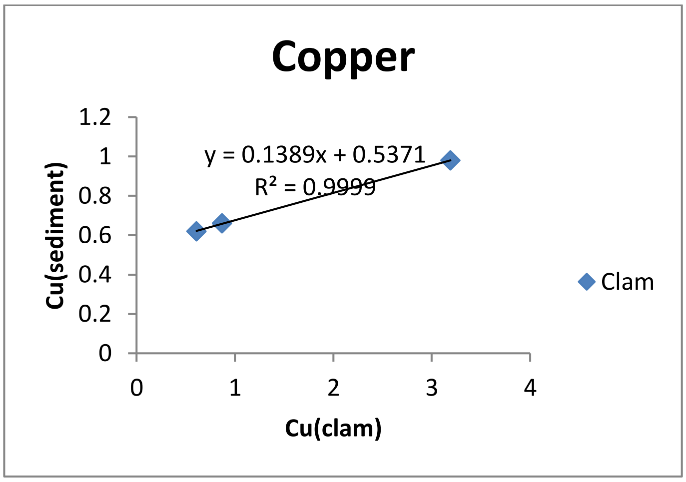


**Figure 7:** Correlation between Cu in sediment and Cu in cam

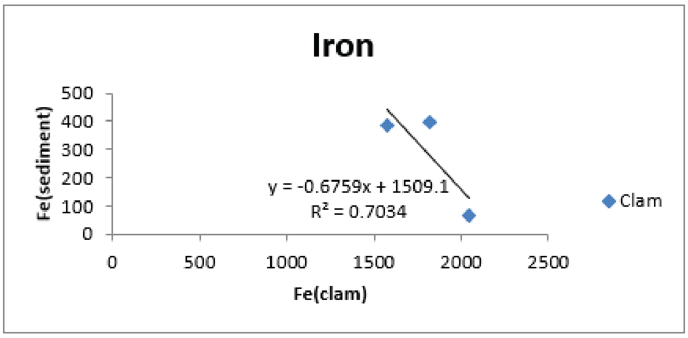


**Figure 8:** Correlation between Fe in sediment and Fe in cam

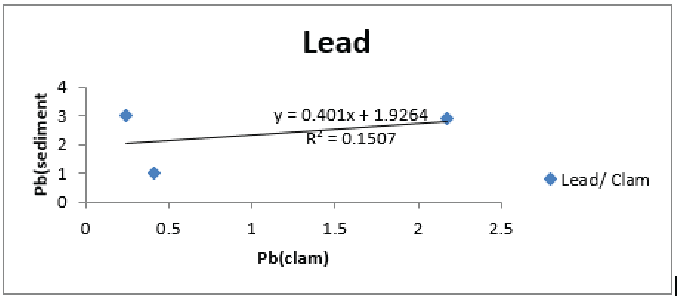


**Figure 9:** Correlation between Pb in sediment and Pb in cam

The concentrations of Co, in sediment and clam in station SS3 was recorded highest (Table 1-2). This implies that the area may be contaminated with cobalt, resulting from activities such agriculture, oil spill, barge ballasting of small and medium size vessels etc. The relationship between the concentrations of Co, in sediment and clam is shown in Fig. 6, the data showed that the slope of the equation was (0.8095), squared correlation coefficient, $R^2$ (1.00) and the intercept on y-axis (0.1095) respectively. This implies that the linear model was significant, and there was a strong correlation and the implication was that Co, in sediment increased with increase in Co content of clam. These results are in concomitant with those reported by [21,22].

The data showed that, concentration (mg/kg) of copper in sediments ranged from 0.61 -3.19 with mean value of 1.56±1.16. The highest concentration of copper was recorded at SS3 (3.19mg/kg), followed by SS1 (0.87mg/kg) and closely followed by SS2 (0.61mg/kg). The concentrations of Cu in sediment and clam at location SS3 were lower than the permissible limit (Table 2). This implies that the area was not contaminated with copper. The relationship between the concentrations of Cu in sediment and clam is shown in Fig. 7, the data revealed that the slope of the equation was (0.1389), squared correlation coefficient, $R^2$ (0.9999) and the intercept on y-axis (0.5371) respectively. This implies that the linear model was significant, and the implication was that Cu, in sediment increased with increase in Cu content of clam. These results are in concomitant with those reported by concentration (range, mean ± standard deviation, mg/kg) for iron was 1575.94 - 2041.95, (1812.313±190.31) in sediments of the Diebu River. The highest concentration of iron was recorded at SS3 (2041.95mg/kg), followed by SS2 (1819.05mg/kg), and closely followed by SS1 (1575.94mg/kg). The relationship between the concentrations of Fe in sediment and clam is shown in Fig. 8, the data revealed that the slope of the equation was (-0.6759), squared correlation coefficient, $R^2$ (0.7034) and the intercept on y-axis (1509.1) respectively. This implies that the linear model was significant, and the implication was that Fe, in sediment increased with increase in Fe content of clam. These results are in concomitant with those reported by [24-28].

The data shows that, concentration (mg/kg) of Pb ranged from 0.24 - 2.17 with mean value of 0.94±0.87 in sediments of the Diebu Creek. The highest concentration of lead was recorded in sampling site, SS3 (2.17mg/kg), followed by SS2 (0.41mg/kg), and closely followed by SS1 (0.24mg/kg). Sediments represent one of the ultimate sinks for heavy metal discharge into the environment. A comparative analysis of concentration Pb levels in sediment with USEPA, 2010 and ISQG, 2002 standards revealed that the results obtained in this study were higher (2.30±0.90). The relationship between the concentrations of Pb in sediment and clam is shown in Fig. 9, the data revealed that the slope of the equation was (0.401), squared correlation coefficient, $R^2$ (1.9264) and the intercept on y-axis (0.1507) respectively. This implies that the linear model was significant, and the implication was that Pb, in sediment increased with increase in Pb content of clam. These results are in concomitant with those reported by a scholar [29].

The Concentration (range, mean ± standard deviation, mg/L) for arsenic, cobalt, copper, iron and lead in clam ranged from BDL(As), 0.32-1.51; 0.62-0.98; 67.41-397.76 and 1.03-2.99 with mean values of, BDL(As), 1.08±0.54, 0.75±0.16, 284.22±153.37 and 2.30±0.90 respectively (Table 1-2). Heavy metal concentrations in clam decreased in the sequence of Fe>Pb> Cu>Co>As. The obtained results revealed that the average values of Pb (2.30), Co (1.08) and Fe(284.22) in clam samples were higher than the respective reference values for [30] and [32], while the mean value of Cu(0.75) was lower than reference standards and As(ND) was not detected.

### 3.2 Comparison SQGs and Ecotoxicological Sense of Heavy Metal Contamination

Sediments were classified as non-polluted, moderately polluted and heavily polluted based on SQGs of USEPA. According to SQGs, the heavy metals studied in sediments of the Pennington River were under the category of non-polluted. The ecotoxicological sense of heavy metal contamination in sediments was determined using sediment quality guidelines developed for marine and estuarine ecosystem.

**Table 3:** Concentration (mg/kg) of heavy metals in Diebu Creek and its comparison with SQGs and ecotoxicological sense of heavy metal contamination

| Element | SQGs non-polluted(mg/kg) | SQGs moderately polluted(mg/kg) | SQGs heavily polluted(mg/kg) | TEL(mg/kg) | PEL | ERL | ERM | This Study |
|---|---|---|---|---|---|---|---|---|
| As | | | | 5.9 | | | | ND |
| Co | | | | | | | | 0.58 |
| Cu | <25 | 25-50 | >50 | 18.70 | 110.00 | 34.00 | 270.00 | 0.77 |
| Fe | | | | | | | | 701.77 |
| Pb | <40 | 40-60 | >60 | 30.20 | 110.00 | 46.70 | 218.00 | 1.00 |

These effects are as follows: (a) the effect range low (ERL) / effect range median (ERM), (b) the threshold effect level (TEL) / probable effect level (PEL). The heavy metals studied in sediments of the Diebu Creek do not exceed TEL values which can lead to adverse impact on the sediments dwelling fauna (Table 3). The guideline thereby further proven that the Diebu Creek may be uncontaminated with (As, Co, Cu, Fe and Pb).

## 4.CONCLUSION

The heavy metals commonly examined based on their potential toxic effects include: As, Cd, Cu, Fe, Pb and Zn. The results showed that heavy metals investigated in the study area, Diebu Creek axis of the Nun River were within the maximum allowed limits and do not pose any treat. In other words, the concentrations observed in the study area cannot cause severe to excessive pollution, capable of serious ecological and public health hazards. This implies that no significant heavy metal toxicity levels were observed and a low source of pollution arriving to the Diebu Creek. It can be thus concluded from the present study that the studied Water, Sediments and Clam (*galatea paradoxa, born 1778*) of the Diebu Creek, Bayelsa State, Niger Delta Region, Nigeria are safe within the limits for human consumption, conservation and commercial purposes. Consequently, the regulatory authorities should institute environmentally friendly framework to maintain the immerse biodiversity and aesthetic value of the Diebu Creek.

**COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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