



# Mineral Composition of Important Shell Fish Species from the Escravos River Estuary, Delta State, Nigeria and their Nutritional Significance

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

This study was conducted to evaluate the mineral composition (phosphorus, sodium, potassium, magnesium, calcium, iron, copper, manganese and zinc) of important shell fish species from the Escravos River Estuary, Delta State, Nigeria. A total of five shell fish species including the Pink shrimp (*Peneaus notialis*), Tiger shrimp (*Peneaus monodon*), Blue crab (*Callinectes amnicola*), Perewinkle (*Tympanostonus fuscatus*), and Mangrove oyster (*Crassostrea gasar*) were collected and used for the study. The shell fishes were collected from the fish landing sites of the estuary between March 2022 and June 2022 and analyzed for mineral composition following standard methods. The findings of this study showed that all the shell fish species evaluated were rich in minerals including phosphorus (P), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) which varied significantly ( $P < 0.05$ ) among the shell fish species. This is the first study to evaluate the mineral composition of important shell

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fish species that are of particular public health significance in the Escravos river estuary. The findings of this study have provided baseline information or database of minerals in shell fishes from the Escravos River. Therefore, shell fish consumers within the Escravos river will be sufficiently knowledgeable on the mineral composition of each shell fish species examined with the flexibility of consuming the shell fishes according to their mineral need. Also, the mineral profile of these shell fishes would provide a guideline for nutritionists and medical practitioners in the prescription of diet charts for the inhabitants of the Escravos river estuary and beyond.

**Keywords:** Mineral content; Escravos River Estuary; health significance; Diets.

## 1. INTRODUCTION

Nigeria is one of the countries in the world that is blessed with diverse fisheries resources including fin and shell fishes which are major sources of good nutrition, especially for the inhabitants of coastal areas. Fish and their products have been documented to be composed of high nutritional values including nutrients and minerals [1]. These nutrients are fundamentally useful in global food security as they are a crucial part of healthy diets. Interestingly, the consumption of fin and shell fishes has provided health benefits to consumers including improved mental health, stroke and age-related macular degeneration and prevention of cardiovascular diseases [2]. In pregnant women and young children, consumption of fish in their diet helps in neurodevelopment during the growth of a young or unborn child [3]. Minerals and trace elements such as iodine, potassium, calcium, phosphorus, copper, iron, iron, selenium, zinc, and manganese are found in fish [4]. Minerals help in maintaining acid–base balance in the system and development and formation of bones [5]. According to Mendil et al. [6], minerals control and regulate water balance in the human body, help in the structural formation of teeth and bones and also plays a crucial role in catalyzing various metabolic reactions. Apart from the nutritional and physiological roles of minerals as ingredients in food, they affect food texture, contribute to flavor, and activate or inhibit enzyme-catalyzed and other metabolic reactions [7]. Fish bones and muscles serve as important sources of essential minerals with the minerals stocked in the skeleton and basically in the vertebra with about 65 % [8,9]. Despite the richness in essential minerals, bones and heads of fish are among the discarded parts of fish. Importantly, trace elements are very crucial in the physiological functioning of several systems in the human body such as the development of the brain, and where they are deficient, stunted, or poor growth may occur [4]. Trace element

moderates oxidative stress and also possess an antioxidant property which helps in the reduction of the risk of developing chronic diseases such as cancer, cardiovascular disorders, and degenerative diseases related to age [10]. With the establishment and take off of the Nigeria Maritime University in Okerenkoko, an Island community in Delta State which is rich in diverse fisheries resources, the fast-growing University community is totally dependent on the surrounding Escravos River for food fish. The Escravos River Estuary has great potential and benefits for artisanal fishers which positively impacts their livelihood [11]. This shows the need to evaluate the nutritional composition of these important food fishes from the Escravos River. Apart from diverse fin fish species such as Croaker, Silver Catfish, Red Snapper, Tongue Sole, Mullet, Thread fin, Creville Jack, Barracuda, etc., the Escravos River Estuary is also rich in shell fish species such as blue crab, tiger shrimp, pink shrimp, mangrove oyster, and periwinkle. The inhabitants of this estuary are dependent on these shell fishes as their major source of nutrients and minerals in their daily diets. Some of the inhabitants of this estuary also depend solely on these fin and shell fishes as their major source of livelihood. Presently, there is no information on the mineral composition of shell fishes in the Escravos river estuary and this study is designed to fill this gap by providing this important baseline information. Therefore, this study aims to evaluate the mineral composition of selected shell fishes from the Escravos River Estuary and their nutritional significance.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

This study was carried out in the Escravos River Estuary, Warri South-West Local Government Area of Delta State, Nigeria. The Escravos River lies between latitude 5.6°N and longitude 5.3°E (Fig. 1). The Escravos River Estuary is located in a mangrove swamp forest [12,13] and is rich in

different species of mangrove vegetation. The dominant mangrove species found in the estuary are the red mangrove (*Rhizophora racemose*) and white mangrove (*Avicennia africana*) while *Nypa* palm has a patchy distribution. The climate of the study area is a typical tropical rainforest climate with a long wet season beginning from April to October, followed by a dry season from November to March. The main occupation of the inhabitants of the estuary includes fishing, fish processing, net manufacturing, and petty trading and the major language spoken in the area is Ijaw language, Pidgin English, and English language.



**Plate 1. Pink shrimp (*Peneaus notialis*)**



**Plate 2. Tiger shrimp (*Peneaus monodon*)**

## 2.2 Reconnaissance Survey and Sample Collection

Before samples were collected, the study area was visited and contact was made with the local fisher folks in Kurutie, and Okerenkoko fishing communities and adequate arrangements on how and when to collect fish samples for the study was put in place. A total of five (5) shell fish species belonging to 4 families were collected

fresh from fishermen as soon as they landed at the landing port. The shell fishes including the Pink shrimp (*Peneaus notialis*) (Plate 1), Tiger shrimp (*Peneaus monodon*) (Plate 2), Blue crab (*Callinectes amnicola*) (Plate 3), Perewinkle (*Tympanostonus fuscatus*) (plate 4) and Mangrove oyster (*Crassostrea gasar*) (plate 5). Gears used in catching the shell fishes include beach seine and push net for Pink shrimp (*P. notialis*) and Tiger shrimp (*P. monodon*) and basket net with dead fish as bait for blue crab (*C. amnicola*). Perewinkle (*T. fuscatus*) was hand-picked during low tide in the intertidal area of the river while mangrove oyster (*C. gasar*) was harvested from the mangrove plant within the sampling location. The samples were collected for a period of four (4) months (between March 2022 to June 2022). The collected shell fishes were carefully washed with deionized water to remove dirt and debris and thereafter packed in an ice box with ice cubes at an ice/fish ratio of 2:1 (w/w) according to [14]. The preserves shell fishes were transported to the Department of Biochemistry Laboratory, University of Uyo, Nigeria for mineral analysis.



**Plate 3. Blue crab (*Callinectes amnicola*)**



**Plate 4. Perewinkle (*Tympanostonus fuscatus*)**

## 2.3 Morphometric Measurements of Fish Samples

The average length (carapace length for *C. amnicola*) and weight of shell fishes used in this study were measured to the nearest 0.1 centimeter and 0.1 gram using a measuring board for length and an electronic scale (model METLAR- 2000D) for weight.



Plate 5. Mangrove oyster (*Crassostrea gasar*)

## 2.4 Tissue Preparation

The shell fishes were dissected with a sterilized stainless steel knife and the head (for (*P. notialis* and *P. monodon*), viscera and shells were discarded. The flesh and muscle which is mostly consumed were minced after cutting it into smaller pieces. To avoid flesh and muscle contamination, non-metallic equipment such as plastic buckets, plastic cutting board, and plastic cutting knives were used in extracting flesh.

## 2.5 Determination of Mineral Composition

Calcium (Ca), sodium (Na), potassium (K), phosphorus (P), and magnesium (Mg) are macro minerals and some trace minerals including iron ((Fe), copper (Cu), manganese (Mn), and zinc (Zn) were analyzed in the flesh and muscle of the shell fishes. To analyze the minerals, ash samples were weighed accurately before digesting with  $\text{HNO}_3$  (nitric acid),  $\text{HClO}_4$ , and deionized water (Pauwels et al. 1992). Mineral contents were determined in the digested samples by flame atomic absorption spectrophotometry for Ca, K, Na, Mg, Zn, Cu, Fe, and Mn (Benton and Case, 1990). For phosphorus, the spectrophotometric colorimetric method with a UV spectrophotometer was used [6].

## 2.6 Data Analysis

Data obtained in this study were subjected to Analysis of Variance to test for the significant difference at  $p = 0.05$  using SPSS version 19. Means with  $p < 0.05$  were considered significant.

## 3. RESULTS

### 3.1 Mineral Composition of Some Important Food Fishes from the Escravos River Estuary

Mineral composition (Table 1) of selected shell fish species from the Escravos River Estuary including phosphorus (P), sodium (Na), potassium (K), magnesium, calcium, iron, copper, manganese, and zinc were analyzed. All the minerals were significantly different ( $p < 0.05$ ) in the examined fish species.

#### 3.1.1 Phosphorus

Results obtained showed that phosphorus was  $7.13 \pm 0.24$  mg/100 g for *P. notialis*,  $17.07 \pm 0.53$  mg/100 g for *P. monodon*,  $3.57 \pm 0.09$  mg/100 g for *C. amnicola*,  $7.37 \pm 0.19$  mg/100 g for *T. fuscatus*, and  $30.20 \pm 0.15$  mg/100 g for *C. gasar*.

#### 3.1.2 Sodium (Na)

In *P. notialis*, sodium was  $165.24 \pm 0.18$  mg/100 g, *P. monodon* ( $153.06 \pm 2.07$  mg/100 g), *C. amnicola* ( $205.76 \pm 0.30$  mg/100 g), *T. fuscatus* ( $178.09 \pm 0.04$  mg/100 g), and *C. gasar* ( $46.50 \pm 0.15$  mg/100 g).

#### 3.1.3 Potassium (K)

In *P. notialis*, potassium was  $181.33 \pm 0.62$  mg/100 g, *P. monodon* ( $164.32 \pm 0.43$  mg/100 g), *C. amnicola* ( $446.23 \pm 0.64$  mg/100 g), *T. fuscatus* ( $151.67 \pm 0.88$  mg/100 g), and *C. gasar* ( $46.50 \pm 0.15$  mg/100 g).

#### 3.1.4 Magnesium (Mg)

Results obtained for magnesium showed that in *P. notialis*, magnesium was  $34.69 \pm 0.78$  mg/100 g, *P. monodon* ( $31.69 \pm 0.44$  mg/100 g), *C. amnicola* ( $385.04 \pm 2.50$  mg/100 g), *T. fuscatus* ( $167.98 \pm 3.8$  mg/100 g), and *C. gasar* ( $13.23 \pm 0.01$  mg/100 g).

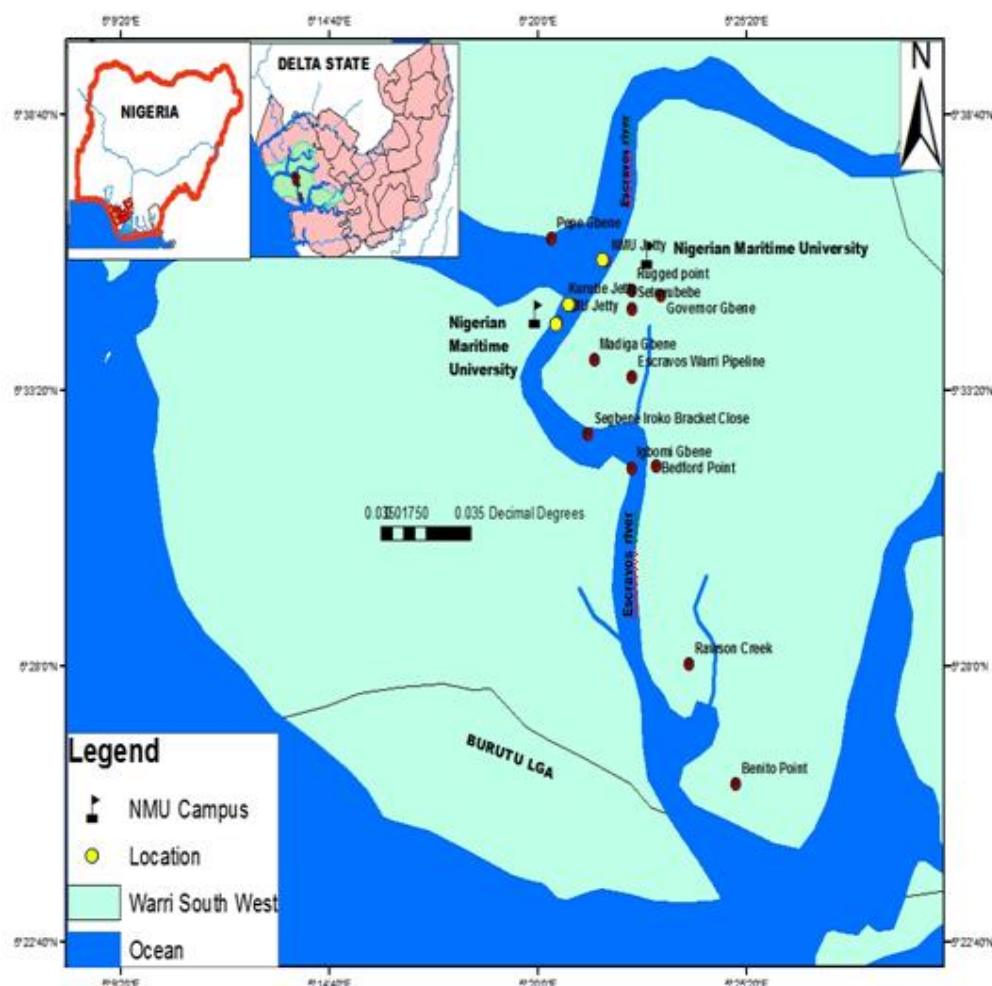


Fig. 1. Map of the Study Area showing sampling points along River Estuary

### 3.1.5 Calcium (Ca)

For *P. notialis*, calcium was  $131.88 \pm 0.75$  mg/100 g, *P. monodon* ( $132.04 \pm 1.51$  mg/100 g), *C. amnicola* ( $383.44 \pm 0.64$  mg/100 g), *T. fuscatus* ( $180.42 \pm 0.08$  mg/100 g), and *C. gasar* ( $94.44 \pm 0.19$  mg/100 g).

### 3.1.6 Iron (Fe)

Results obtained for iron showed that *P. notialis*, had  $6.87 \pm 0.07$  mg/100 g, *P. notialis*, *P. monodon* ( $6.22 \pm 0.14$  mg/100 g), *C. amnicola* ( $1.01 \pm 0.10$  mg/100 g), *T. fuscatus* ( $1.41 \pm 0.03$  mg/100 g), and *C. gasar* ( $7.83 \pm 0.02$  mg/100 g).

### 3.1.7 Copper (Cu)

Results for copper showed that *P. notialis* had  $1.71 \pm 0.02$  mg/100 g, *P. monodon* ( $1.70 \pm 0.07$

mg/100 g), *C. amnicola* ( $0.41 \pm 0.05$  mg/100 g), *T. fuscatus* ( $7.85 \pm 0.14$  mg/100 g), and *C. gasar* ( $3.13 \pm 0.02$  mg/100 g).

### 3.1.8 Manganese (Mn)

Manganese was  $2.34 \pm 0.19$  mg/100 g in *P. notialis*, *P. monodon* ( $2.13 \pm 0.04$  mg/100 g), *C. amnicola* ( $3.52 \pm 0.04$  mg/100 g), *T. fuscatus* ( $2.48 \pm 0.29$  mg/100 g), and *C. gasar* ( $0.13 \pm 0.01$  mg/100 g).

### 3.1.9 Zinc (Zn)

Results obtained for zinc showed that *P. notialis* had  $41.07 \pm 0.55$  mg/100 g, *P. monodon* ( $40.02 \pm 0.01$  mg/100 g), *C. amnicola* ( $0.75 \pm 0.01$  mg/100 g), *T. fuscatus* ( $0.71 \pm 0.01$  mg/100 g), and *C. gasar* ( $1.82 \pm 0.01$  mg/100 g).

**Table 1. Mineral composition of some important food fishes from the Escravos River in mg/100 g**

| Common name     | Family      | Scientific name    | Phosphorus   | Sodium        | Potassium     | Magnesium     | Calcium       | Iron        | Copper      | Manganese   | Zinc         |
|-----------------|-------------|--------------------|--------------|---------------|---------------|---------------|---------------|-------------|-------------|-------------|--------------|
| Pink shrimp     | Penaeidae   | <i>P. notialis</i> | 7.13 ± 0.24  | 165.24 ± 0.18 | 181.33 ± 0.62 | 34.69 ± 0.78  | 131.88 ± 0.75 | 6.87 ± 0.07 | 1.71 ± 0.02 | 2.34 ± 0.19 | 41.07 ± 0.55 |
| Tiger shrimp    | Penaeidae   | <i>P. monodon</i>  | 17.07 ± 0.53 | 153.06 ± 2.07 | 164.32 ± 0.43 | 31.69 ± 0.44  | 132.04 ± 1.51 | 6.22 ± 0.14 | 1.70 ± 0.07 | 2.13 ± 0.04 | 40.02 ± 0.01 |
| Blue crab       | Portunidae  | <i>C. amnicola</i> | 3.57 ± 0.09  | 205.76 ± 0.30 | 446.23 ± 0.64 | 385.04 ± 2.5  | 383.44 ± 0.64 | 1.01 ± 0.10 | 0.41 ± 0.05 | 3.52 ± 0.04 | 0.75 ± 0.01  |
| Periwinkle      | Potamididae | <i>T. fuscatus</i> | 7.37 ± 0.19  | 178.09 ± 0.04 | 151.67 ± 0.88 | 167.98 ± 3.87 | 180.42 ± 0.08 | 1.41 ± 0.03 | 7.85 ± 0.14 | 2.48 ± 0.29 | 0.71 ± 0.01  |
| Mangrove oyster | Ostreidae   | <i>C. gasar</i>    | 30.20 ± 0.15 | 46.50 ± 0.15  | 437.33 ± 0.64 | 13.23 ± 0.01  | 94.44 ± 0.19  | 7.83 ± 0.02 | 3.13 ± 0.02 | 0.13 ± 0.01 | 1.82 ± 0.01  |

#### 4. DISCUSSIONS

Shell fishes are rich sources of minerals that are naturally available in aquatic water bodies including freshwater, brackish water, and seawater. The nutritional composition of freshwater and marine finfish and shellfish species has been studied in different water bodies [15]. In this study, results obtained showed that in all the shell fish species, minerals contents including phosphorus (P), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) varied significantly ( $P < 0.05$ ). This finding agrees with that of Ivon & Eyo [16] that the mineral contents of shell fishes from the Calabar river varied significantly. The variation may be attributed to several factors such as seasonal differences and biological differences like age, species, muscle complexion, size, sexual maturity, processing method, geographical location, food source, sex, and environmental parameters like salinity, water temperature, water chemistry and contaminants [17-19]. The variation in minerals contained in the shell fishes may be due to the different levels of the minerals in the water bodies [20], the state of the physiology of the shell fish and the mineral absorption ability of the fish from the water bodies and diets [21]. In this study, phosphorus contents of fin fishes ranged from  $3.57 \pm 0.09$  mg/100 g for *C. amnicola* to  $30.20 \pm 0.15$  mg/100 g in *C. gasar*. Phosphorus richness in fish species could be due to the fact that phosphorus is a protein component [22]. In living organisms, sodium helps in pH regulation, the transmission of nerve impulses, osmotic pressure, water balance, transportation of glucose, and transportation of amino acids [23]. The findings of this study showed that the highest value of sodium was recorded in *C. amnicola* ( $205.76 \pm 0.30$  mg/100 g), followed by, *T. fuscatus* ( $178.09 \pm 0.04$  mg/100 g), and the least in *C. gasar* ( $46.50 \pm 0.15$  mg/100 g). Sodium level obtained in the present study is similar to the findings of Udo and Arazu [24] and Ivon and Eyo [16] for *C. amnicola* and *T. fuscatus* in a similar water body in Nigeria. According to Hughes et al. [25], variations in sodium levels in fishes could be attributed to the kind of food eaten by the fish and the varying types of minerals absorbed directly through the body surfaces and gills from their aquatic habitat in which they live. Potassium is another important mineral that helps in muscle contraction, impulse transmission in the nerves, and the metabolism of sugar [26]. The

concentration of Potassium ranged between 245 - 443 mg/100 g which is within the FAO range of 19 - 502 mg/100 g. Levels of potassium in this study showed that shell fishes generally have higher concentrations with *C. amnicola* recording the highest value of  $446.23 \pm 0.64$  mg/100 g. Despite the varying levels of potassium, the recorded concentrations for fish species in this study were within the range recommended by FAO (19 - 502 mg/100 g) in fish muscle. Results obtained for magnesium in this study showed that the highest value was recorded in *C. amnicola* ( $385.04 \pm 2.50$  mg/100g) and least value in *C. gasar* ( $13.23 \pm 0.01$  mg/100g). Magnesium is a vital bone component in fish and the levels recorded in this study were within the FAO recommended range of 4.5 – 452mg/100 g. Magnesium content obtained in this study is quite higher than the values reported by Njinkoue et al. [14] for fin fishes including *P. typus* and *P. elongaus* on the Cameroonian coast. This may be attributed to the differences in the environment where the fish was caught [17] and also to the fact that the latter are all fin fishes. Calcium plays a major role in bone development, shell formation, blood clotting, metabolic processes, and contraction of the muscles [27,28,16]. In this study, calcium was the least ( $94.44 \pm 0.19$  mg/100 g) in *C. gasar* and highest ( $383.44 \pm 0.64$  mg/100 g) in *C. amnicola*. The range reported for calcium in this study for all the species was within FAO recommended mean values of 19 – 881 mg/100 g. However, calcium content in the muscle of *C. amnicola* and *T. fuscatus* reported in this study is higher than the findings of Ivon and Eyo [16] and Davies and Jamabo [29] from Calabar river and Okpoka Creeks. According to Davies and Jamabo [29], differences in calcium content in fin and shell fishes may be due to differences in environmental parameters and feeding habits of the fishes. Also, Davies and Jamabo [29] opined that shell fishes are having higher calcium contents than fin fishes because they feed on rich mineral resources from the aquatic environment. Generally, iron is known to help in oxygen transport in the body. In this study, iron was high in the shell fishes because shellfishes feed on rich mineral resources and also can absorb the minerals directly from the aquatic environment [25,29]. Iron was lowest ( $1.01 \pm 0.10$  mg/100 g) in *C. amnicola* and highest in *C. gasar* ( $7.83 \pm 0.02$  mg/100 g). Copper is necessary for good health and is a part of many enzymes which occur in very low concentrations in food [26,16]. In the present study, copper was least  $0.41 \pm 0.05$  mg/100 g in *C. amnicola* and

highest ( $7.85 \pm 0.14$  mg/100 g) in *T. fuscatus* for shellfishes. The range reported for copper in this study for all the species was within FAO recommended range. Ivon and Eyo [16] attributed the variation in copper concentration of shell fishes in the Calabar River to the nature of food consumed by the shell fishes and also the type of minerals present in their environments. Manganese is a requirement for normal body function and also a co-factor of prolidase which is an enzyme that helps to build up collagen which is a major skin structural component [30]. In this study, manganese was the least ( $0.13 \pm 0.01$  mg/100 g) in *C. gasar* and highest ( $3.52 \pm 0.04$  mg/100 g) in *C. amnicola*. The range reported for manganese in this study was within FAO recommended range of (0.0003 - 25.2 mg/100 g). Like manganese, zinc is also required for normal body function, is useful for cellular growth and gene expression, and is a component of several metallo-enzymes [26]. Zinc ranged from  $0.71 \pm 0.01$  mg/100 g in *T. fuscatus* to  $41.07 \pm 0.55$  mg/100 g in *P. notialis*. The range reported for zinc in this study was within FAO recommended range of 1.63 - 8.47 mg/100 g for both fin and shellfishes except for *P. notialis* and *P. monodon* which had higher values of  $41.07 \pm 0.55$  mg/100 g and  $40.02 \pm 0.01$  mg/100 g. These findings may be attributed to the anthropogenic activities in the Escravos river such as illegal crude oil refining.

## 5. SUMMARY AND CONCLUSION

This study has successfully evaluated the mineral composition (phosphorus, sodium, potassium, magnesium, calcium, iron, copper, manganese and zinc of some important shell fishes (*P. notialis*, *P. monodon*, *C. amnicola*, *T. fuscatus*, and *C. gasar*) from the Escravos river estuary. In conclusion, this study shows that these shell fishes are excellent sources of these minerals that could sufficiently provide the daily recommended amounts required by the body for optimal growth and good health. Therefore, the consumption of these shell fishes is highly recommended to the inhabitants of the river for good health and optimal growth.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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