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# TEMPORAL PATTERNS AND STATION-WISE VARIATION IN HEAVY METAL CONCENTRATIONS IN GLADIATOR CRAB (*CALLINECTES PALLIDUS*) FROM AWOYE RIVER, ONDO STATE, NIGERIA

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## ABSTRACT

Heavy metals in aquatic organisms provide important information on biological exposure and accumulation in coastal environments. This study evaluated station-wise, monthly and seasonal variations in Fe, Zn, Mn, Cu, Ni, Cd, V, Cr and Pb concentrations in gladiator crab (*Callinectes pallidus*) from Awoye River, Ondo State, Nigeria. Crab samples were collected from NNPC Platform, Stone Jetty and Awoye Gulf between January and June 2015, acid-digested and analysed using atomic absorption spectrophotometry. Fe showed the strongest spatial variation, with the highest mean concentration at NNPC Platform (75.74 ± 35.97 mg/kg), while Mn and Cr also showed significant differences between selected stations. Monthly variation was evident for several metals, with Zn, Mn, Cu, Ni, Cd, V, Cr and Pb attaining their highest mean concentrations in June, whereas Fe peaked in March. Seasonal comparisons showed higher numerical concentrations of most metals during the rainy period across the three stations, although Fe at NNPC Platform showed the opposite pattern. The study concludes that heavy-metal accumulation in *C. pallidus* was metal-specific and varied spatially and temporally rather than following a uniform accumulation pattern. Continued monitoring of metals in aquatic organisms alongside environmental matrices is recommended to improve assessment of biological exposure and changes in the aquatic environment.

**Keywords: *Callinectes Pallidus*; Heavy-Metals, Bioaccumulation, Spatial Variation; Temporal Variation; Awoye River**

## 1. INTRODUCTION

Heavy metals are persistent pollutants that are introduced to aquatic environments via natural and anthropogenic sources such as industrial effluents, urban run-off, agricultural and petroleum activities (Akubuo et al., 2023; Ewutanure & Ukuli, 2024). These metals may be found in the aqueous phase, bound to particulate matter in suspension or retained within sediments. Some metals, including Fe, Zn, Mn and Cu have known biological roles, whereas others, Cd and Pb do not have any known essential physiological function. However, high concentrations of these metals can be harmful. Therefore, metal concentrations in aquatic organisms provides additional insight on biological exposure to metals, as the availability of metals in the environment is dependent on various chemical and environmental factors.

Crabs are an ideal species to investigate biological metal accumulation as metals can be taken up from the aqueous phase, particulate matter bound to sediments and diet. Once taken up, tissue concentrations depend on assimilation, regulation, storage and excretion. This will lead to different patterns of metal accumulation in different tissues (Ihunwo et al., 2022; Nwaonyeche & Ofurum, 2025; Ubong & Ekwere, 2022). *Callinectes pallidus*, commonly known as the gladiator swim crab, is a portunid crab found in coastal waters in West Africa and Nigerian estuaries. Metal accumulation has been observed in *C. pallidus* and other Callinectes species in coastal systems in Nigeria (Adeboyejo et al., 2023; Anyanwu, 2023; Udiba et al., 2025).

Concentrations of metals in aquatic organisms can vary between different locations. This may be due to varying metal availability, sediment quality, water flow, human activity around the location and biological exposure. Concentrations can also vary between different times of the year. This may be due to the effect of rainfall, run-off, river flow and sediment movement on metal concentrations. However, not all metals will be affected in the same way (Adamu et al., 2025; Angaye et al., 2025; Ndinwa, 2026). Metal concentrations can also vary between months. This will provide more detailed information on the patterns of metal accumulation in organisms.

The Awoye River is found in Ilaje Local Government Area in Ondo State, Nigeria. This is a coastal site with mangrove and swamp environments and fisheries. Three sites were studied within this river. These included NNPC Platform, which is a petroleum site, Stone Jetty which is a site with boat, household and other human activity and Awoye Gulf, which is towards the downstream end of the river. Previous studies have shown that there was variation in metal concentrations between different locations and times of the year (Aribo, 2026). Crabs were sampled once per month between January and June 2015. Therefore, this study will provide information on metal concentrations in C. pallidus during this time period. This should not be considered as current metal concentrations.

Studies have shown that Callinectes and other crab species accumulate metals in coastal areas of Nigeria. However, the patterns of accumulation differ depending on the metal, species, tissue, location and time of sampling (Oladunjoye et al., 2021; Ihunwo et al., 2022; Anyanwu, 2023; Angaye et al., 2025; Udiba et al., 2025). As a result, metal concentrations cannot be inferred from environmental samples. The water component of the Awoye River has been characterised in 2015 (Aribo, 2026). However, metal concentrations in *C. pallidus* need to be analysed to determine how they vary between locations and times of sampling.

***Aim***

The aim of this study is to investigate how concentrations of Fe, Zn, Mn, Cu, Ni, Cd, V, Cr and Pb varied between different locations, months and seasons in gladiator crab (*Callinectes pallidus*) in the Awoye River between January and June 2015.

## 2. LITERATURE REVIEW

The levels of metal concentrations occurring within aquatic organisms depend on the interaction between environmental factors and the availability of the metals. The distribution of metals between different phases (dissolved, particulate, and sediment) will affect how much of the metal is potentially available to organisms. Other factors such as water chemistry and sediment will further influence metal concentrations in water. Crustaceans take up available metals via their respiratory surfaces and diet, and can be exposed to contaminants from the bottom sediments and food sources (Ewutanure & Ukuli, 2024; Ihunwo et al., 2022; Ikeogu et al., 2023). Studies undertaken within creeks in Nigeria have shown that the metal concentrations within crustaceans do not reflect the concentrations within the environment (Ihunwo et al., 2022; Ikeogu et al., 2023; Timothy et al., 2025). Bio-monitoring can provide useful data regarding the exposure of crustaceans to contaminants.

The levels of metals within crustaceans will also depend on the physiological and biological factors of the species. Essential metals (Fe, Zn, Mn, Cu) occur in physiological processes and can be regulated to some extent, whilst Cd and Pb do not have any known essential role. However, the levels observed will depend on factors such as the tissues, species, and exposure conditions. Studies undertaken on Callinectes species within Nigeria have shown that there can be large differences in metal concentrations between tissues (hepatopancreas, gills, gut, muscle) (Ihunwo et al., 2022; Nwaonyeche & Ofurum, 2025; Ubong & Ekwere, 2022). Studies have also shown differences between crab species and biological groups, showing that the metal concentrations within organisms cannot be explained by environmental factors alone (Oladunjoye et al., 2021; Anyanwu, 2023). Metal concentrations within crustaceans depend on the interaction between the metal properties, physiological factors, tissue properties, and environmental factors.

There has been variability observed between different areas within Nigeria. Studies undertaken on crabs and other crustaceans within the Niger Delta and surrounding coastal areas have shown differences between areas influenced by different factors (petroleum, maritime, urban, domestic) (Adamu et al., 2025; Angaye et al., 2025; Ndinwa, 2026; Timothy et al., 2025). Similar trends have been observed in Callinectes species within creeks and estuaries in Nigeria (Anyanwu, 2023; Ikeogu et al., 2023; Nwaonyeche & Ofurum, 2025; Udiba et al., 2025). However, there can be variability between different metals and organisms. Having a close proximity to an activity does not necessarily mean that the metals accumulated are from that activity. Factors such as sediment properties, hydrology, diet, and movement can influence the metal concentrations within the organism based on where they were caught. Therefore, trends should be considered on a per metal basis.

Variability can also be seen over time as metal concentrations within the environment and organisms can change over short time periods. Increased rainfall and run-off can increase the terrestrial inputs. Increased discharge can cause dilution and changes in metal distribution and availability (Akubuo et al., 2023; Aribo, 2026). Mobilisation of sediments and changes in salinity and other physicochemical properties can also cause changes in exposure between months and seasons. Studies undertaken on *C. pallidus* within Badagry Creek have shown that Cu and Zn had their highest concentrations in different months (Adeboyejo et al., 2023). Seasonal and monthly variations have also been reported in other aquatic organisms and crustaceans in Nigeria (Akubuo et al., 2023; Davies et al., 2025; Ewutanure et al., 2026). Variability should be considered between monthly and seasonal periods.

In essence, there is evidence to suggest that the metal concentrations within coastal crabs depend on the interaction between environmental exposure, availability, biological factors, and time. Studies undertaken on C. pallidus, C. amnicola, C. sapidus and other coastal crabs have shown that there can be variability between different species, tissues, metals, and locations (Adeboyejo et al., 2023; Anyanwu, 2023; Ihunwo et al., 2022; Udiba et al., 2025; Ubong & Ekwere, 2022). Studies have also shown variability between different locations and times due to environmental factors and hydrology (Angaye et al., 2025; Davies et al., 2025; Ndinwa, 2026). This means that findings from one estuary or crab

population cannot be applied to another. Within the Awoye River it is important to understand how the metal concentrations within C. pallidus varied between stations, months, and seasons between January and June 2015.

## 3. METHODOLOGY

### *Study Area and Sampling Stations*

This study was conducted in the Awoye community in the Ilaje Local Government Area of Ondo State, Nigeria. The area can be described as a water-dominated region with a large percentage of the area covered by water bodies, coastal forests and mangrove swamps. Other activities in the area include fishing and water transport. The area experiences a rainy season from April to October and a dry season from November to March. Three sampling stations were chosen which represent different environments and activities.

Station 1 was chosen as it was located in an area with a large amount of petroleum related activity such as oil wells, pipelines, generators and gas flaring. Station 2 was chosen as it was a heavily populated area with a lot of activity involving boats, agricultural, domestic and petroleum related activities. Station 3 was chosen as it was at the lower end of the river leading out to the Atlantic Ocean. These stations were considered to represent different sampling sites.

### *Sample Collection and Preparation*

Specimens of gladiator crab (*Callinectes pallidus*) were collected from the three stations in the period between January and June in 2015. The crabs were collected using locally made traps. These consisted of a circular frame made out of iron with nets with a mesh size of 2cm. A bait was placed in the centre of the trap. The crabs were then transported to the laboratory in baskets lined with aquatic plants. The crab samples were then dried in an oven at 60 oC for 48 hours. They were then ground into a fine powder. 1g of the ground sample was then placed into a digestion tube.

### *Heavy Metal Analysis*

The crab samples were digested using a wet digestion method with perchloric, nitric and sulphuric acid. 5ml of analytical grade nitric acid was added to the 1g of ground sample. It was left to stand for 2 hours. 1ml of 60% perchloric acid and 1ml of sulphuric acid was then added. The contents were then gently mixed and placed onto a digestion block. The contents were heated until fully digested. This was indicated by the formation of thick white fumes and a colourless solution.

The solution was then left to cool and filtered using Whatman No. 42 filter paper. The filtrate was then topped up to 50ml with deionised water. The samples were analysed using an Atomic Absorption Spectrophotometer (AAS). The concentration of the following metals was determined: Fe, Zn, Mn, Cu, Ni, Cd, V, Cr and Pb. The samples were standardised using stock standard solutions of the relevant metal. The precision of the analysis was determined using replicate samples.

### *Experimental Design and Statistical Analysis*

A factorial design using a completely randomised design was used. Each treatment was performed in triplicate. The concentration of the heavy metals in *C. pallidus* were analysed by sampling 3 stations, over 6 months. January to March represented the dry period and April to June represented the rainy period. The results were presented as the mean with standard deviation. An analysis of variance (ANOVA) was performed to analyse if there were any differences in the concentration of metals between stations and months. If there were significant differences, a Duncan's multiple range test was used to compare the means. An unpaired t-test was used to compare the concentrations between the dry and rainy periods. All statistical analysis was carried out using SPSS Windows 2012. Significance was analysed at $P < 0.05$.

### *Methodological Limitations*

The samples used in this study were historical samples, collected between January and June in 2015. Therefore, the results only represent the concentration of metals at this time and cannot be used to

represent the current conditions of the Awoye River. The statistical analysis did not take into account that the data may have been dependent due to being collected at the same 3 stations over consecutive months. The size, sex and tissue types were not taken into consideration. These may have influenced the metal concentration.

## 4. RESULTS AND DISCUSSION

### *Station-Wise Variation in Heavy Metal Concentrations*

Variation in heavy metal concentrations in *Callinectes pallidus* occurred between stations; however, the extent of variation varied between metals (Table 1). Fe had the greatest variation between stations; with 75.74±35.97 mg/kg found at Station 1, whilst less was found at Station 2 (21.75±10.73 mg/kg) and 16.23±8.00 mg/kg at Station 3. A significant difference was observed between Station 1 and Stations 2 and 3. However, Stations 2 and 3 were statistically similar.

Table 1. Station-wise concentrations of heavy metals in *Callinectes pallidus* from Awoye River, January–June 2015

| Metal | Station 1 | Station 2 | Station 3 |
|---|---|---|---|
| **Fe** | $75.74 \pm 35.97^{a}$ | $21.75 \pm 10.73^{b}$ | $16.23 \pm 8.00^{b}$ |
| **Zn** | $19.88 \pm 6.94^{a}$ | $15.04 \pm 7.42^{a}$ | $21.52 \pm 10.62^{a}$ |
| **Mn** | $15.29 \pm 7.54^{a}$ | $7.43 \pm 3.67^{b}$ | $11.75 \pm 5.80^{ab}$ |
| **Cu** | $6.35 \pm 3.13^{a}$ | $3.84 \pm 1.89^{a}$ | $3.51 \pm 1.73^{a}$ |
| **Ni** | $11.39 \pm 5.62^{a}$ | $6.88 \pm 3.39^{a}$ | $6.29 \pm 3.10^{a}$ |
| **Cd** | $2.07 \pm 1.02^{ab}$ | $1.26 \pm 0.61^{ab}$ | $2.97 \pm 1.46^{a}$ |
| **V** | $3.29 \pm 1.63^{a}$ | $1.99 \pm 0.98^{a}$ | $3.47 \pm 1.72^{a}$ |
| **Cr** | $4.79 \pm 2.36^{a}$ | $3.45 \pm 1.70^{ab}$ | $1.59 \pm 0.78^{b}$ |
| **Pb** | $2.41 \pm 1.19^{a}$ | $1.45 \pm 0.72^{a}$ | $1.33 \pm 0.65^{a}$ |

**Note:** Values are mean ± SD (mg/kg). Means within the same row sharing at least one superscript letter are not significantly different ($P > 0.05$). Station 1 = NNPC Platform; Station 2 = Stone Jetty; Station 3 = Awoye Gulf.

Mn and Cr had differences in concentrations between stations. Mn was significantly higher at Station 1 than Station 2, with Station 3 falling into the medium category. Cr was significantly higher at Station 1 than Station 3, with Station 2 falling into the medium category. Zn, Cu, Ni, V and Pb had no significant differences between stations. Cd had the highest values numerically at Station 3. However, the lack of different superscripts meant that there was no significant difference between stations. The station-wise patterns of heavy metal accumulation are further illustrated in Figure 1.

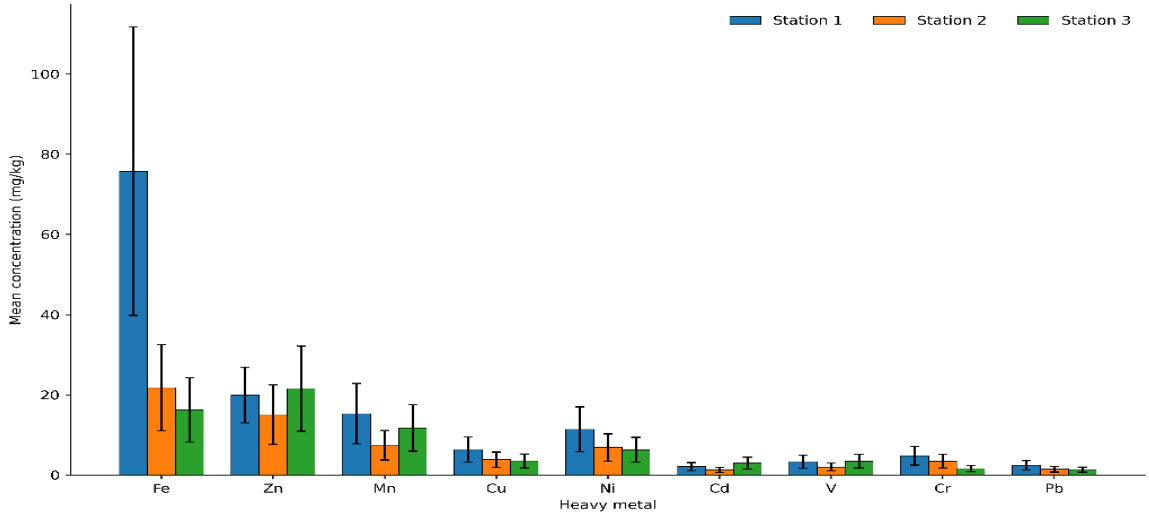


**Figure 1. Station-wise variation in heavy metal concentrations (mean ± SD) in *Callinectes pallidus* from Awoye River, January–June 2015.**

A lack of a consistent pattern in station distribution indicated that accumulation of metals varied between locations. Similar variations have been seen in metals concentrations in coastal crabs from Nigeria, showing that accumulation is metal specific dependent on species and environmental conditions (Angaye et al., 2025; Anyanwu, 2023; Ndinwa, 2026; Udiba et al., 2025). While Fe had much higher concentrations at Station 1 indicating greater accumulation, there is no evidence to show that this was due to any activities relating to petroleum infrastructure. The highest values for Zn, Cd and V were also found at Station 3 which does not support a simple petroleum related gradient.

***Monthly Variation in Heavy Metal Concentrations***

There was considerable variation in the concentrations of heavy metals in each month (Table 2). The concentration of Fe was highly variable, with the highest mean value recorded in March (60.60 ± 70.43 mg/kg) and lowest mean value recorded in May (24.18 ± 4.94 mg/kg). However, the mean values for Fe were not significantly different as they all had the same superscript. The high standard deviation values, especially in the first few months, also suggest that there was a high amount of variation in Fe accumulation. The monthly patterns of heavy metal accumulation in *C. pallidus* are further illustrated in Figure 2.

Table 2. Monthly concentrations of heavy metals in *Callinectes pallidus* from Awoye River, January–June 2015

| Metal | January | February | March | April | May | June |
|---|---|---|---|---|---|---|
| **Fe** | 25.56 ± 29.70$^{a}$ | 39.35 ± 45.74$^{a}$ | 60.60 ± 70.43$^{a}$ | 26.51 ± 20.44$^{a}$ | 24.18 ± 4.94$^{a}$ | 39.65 ± 9.52$^{a}$ |
| **Zn** | 9.08 ± 2.21$^{c}$ | 13.10 ± 3.40$^{bc}$ | 21.54 ± 5.26$^{ab}$ | 15.94 ± 3.88$^{abc}$ | 24.55 ± 5.99$^{ab}$ | 27.80 ± 11.90$^{a}$ |
| **Mn** | **5**.10 ± 1.74$^{c}$ | 7.85 ± 2.68$^{bc}$ | 12.08 ± 4.14$^{bc}$ | 8.94 ± 3.07$^{bc}$ | 13.77 ± 4.71$^{ab}$ | 21.21 ± 7.26$^{a}$ |
| **Cu** | 2.03 ± 0.70$^{c}$ | 3.12 ± 1.06$^{bc}$ | 4.80 ± 1.63$^{bc}$ | 3.56 ± 1.21$^{bc}$ | 5.48 ± 1.86$^{ab}$ | 8.43 ± 2.87$^{a}$ |
| **Ni** | 3.63 ± 1.24$^{c}$ | 5.59 ± 1.90$^{bc}$ | 8.61 ± 2.93$^{bc}$ | 6.37 ± 2.17$^{bc}$ | 9.82 ± 3.34$^{ab}$ | 15.11 ± 5.15$^{a}$ |
| **Cd** | 0.93 ± 0.38$^{b}$ | 1.43 ± 0.58$^{b}$ | 2.21 ± 0.90$^{ab}$ | 1.63 ± 0.67$^{b}$ | 2.51 ± 1.03$^{ab}$ | 3.87 ± 1.58$^{a}$ |
| **V** | 1.29 ± 0.36$^{c}$ | 1.99 ± 0.55$^{bc}$ | 3.07 ± 0.85$^{b}$ | 2.27 ± 0.63$^{bc}$ | 3.50 ± 0.97$^{b}$ | 5.39 ± 1.49$^{a}$ |
| **Cr** | 1.45 ± 0.72$^{b}$ | 2.24 ± 1.10$^{b}$ | 3.44 ± 1.69$^{ab}$ | 2.56 ± 1.25$^{b}$ | 3.93 ± 1.92$^{ab}$ | 6.04 ± 2.97$^{a}$ |
| **Pb** | 0.77 ± 0.26$^{c}$ | 1.18 ± 0.40$^{bc}$ | 1.82 ± 0.62$^{bc}$ | 1.34 ± 0.45$^{bc}$ | 2.07 ± 0.71$^{ab}$ | 3.19 ± 1.08$^{a}$ |

**Note:** Values are mean ± SD (mg/kg). Means within the same row sharing at least one superscript letter are not significantly different ($P > 0.05$).

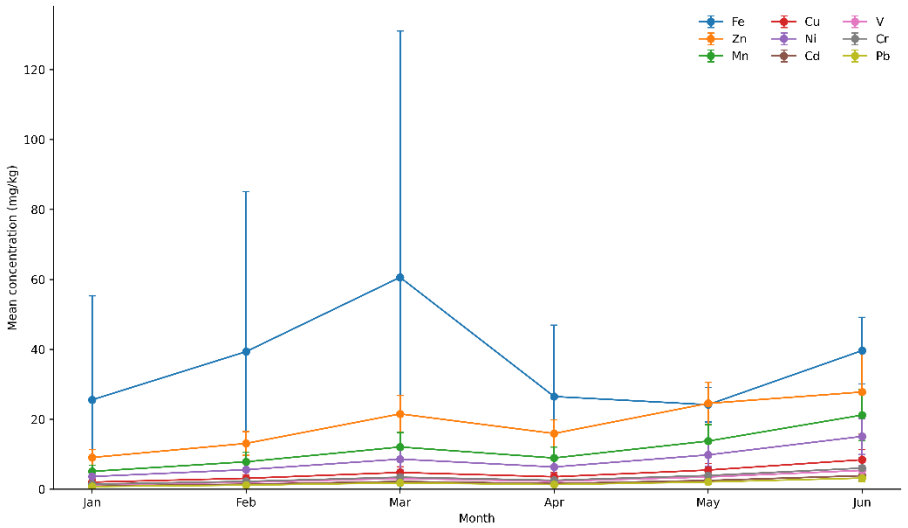



Figure 2. Monthly variation in heavy metal concentrations (mean ± SD) in *Callinectes pallidus* from Awoye River, January–June 2015.

Zn, Cu, Ni, Cd, V, Cr and Pb all had significant differences between their concentrations in at least some months. June had the highest mean concentration of all the heavy metals. January generally had the lowest concentrations. However, several metals had higher concentrations in March compared to January, then decreased in April and increased again in May and June. This means that there was a fluctuating trend in accumulation over time.

Monthly concentrations showed clear metal-specific variation. Zn, Mn, Cu, Ni, Cd, V, Cr and Pb recorded their highest mean concentrations in June, while Fe reached its highest concentration in March. Although most metals generally increased towards the later months, decreases in April for several metals indicate that accumulation did not follow a continuous monthly increase. Similar monthly variations in metal concentrations have been reported for *C. pallidus* in Badagry Creek and other Nigerian aquatic systems (Adeboyejo et al., 2023; Akubuo et al., 2023; Olowojuni et al., 2025). These findings demonstrate that temporal patterns of metal accumulation varied among the metals.

***Seasonal Variation in Heavy Metals Concentrations***

There was a general increase in the concentration of heavy metals in the rainy season (April to June) compared to the dry season (January to March) (Table 3). Zn, Mn, Cu, Ni, Cd, V, Cr and Pb all had higher concentrations in the rainy season at all 3 stations. Fe had higher concentrations in the rainy season at Stations 2 and 3 but decreased at Station 1 from 97.94 ± 41.33 mg/kg to 53.55 ± 7.06 mg/kg.

**Table 3. Seasonal concentrations of heavy metals in *Callinectes pallidus* from Awoye River, January–June 2015**

| Metal | Station 1 Dry | Station 1 Rainy | Station 2 Dry | Station 2 Rainy | Station 3 Dry | Station 3 Rainy |
|---|---|---|---|---|---|---|
| **Fe** | 97.94 ± 41.33 | 53.55 ± 7.06 | 15.80 ± 6.66 | 27.72 ± 11.70 | 11.78 ± 4.97 | 20.68 ± 8.72 |
| **Zn** | 18.06 ± 7.63 | 21.70 ± 7.24 | 10.92 ± 4.61 | 19.17 ± 8.09 | 15.63 ± 6.59 | 27.43 ± 11.58 |
| **Mn** | 11.10 ± 4.68 | 19.48 ± 8.22 | 5.40 ± 2.28 | 9.47 ± 4.00 | 8.53 ± 3.60 | 14.98 ± 6.32 |
| **Cu** | 4.61 ± 1.94 | 8.10 ± 3.42 | 2.79 ± 1.18 | 4.90 ± 2.06 | 2.55 ± 1.07 | 4.47 ± 1.89 |
| **Ni** | 8.27 ± 3.49 | 14.52 ± 6.13 | 5.00 ± 2.11 | 8.78 ± 3.70 | 4.57 ± 1.93 | 8.02 ± 3.38 |
| **Cd** | 1.51 ± 0.63 | 2.64 ± 1.12 | 0.91 ± 0.38 | 1.60 ± 0.68 | 2.16 ± 0.91 | 3.78 ± 1.60 |
| **V** | 2.39 ± 1.01 | 4.20 ± 1.77 | 1.45 ± 0.61 | 2.54 ± 1.07 | 2.52 ± 1.07 | 4.43 ± 1.87 |
| **Cr** | 3.48 ± 1.47 | 6.11 ± 2.58 | 2.50 ± 1.05 | 4.39 ± 1.85 | 1.15 ± 0.49 | 2.03 ± 0.85 |
| **Pb** | 1.75 ± 0.74 | 3.06 ± 1.29 | 1.05 ± 0.45 | 1.85 ± 0.78 | 0.97 ± 0.41 | 1.69 ± 0.72 |

**Note:** Values are mean ± SD (mg/kg). Dry period = January–March; rainy period = April–June. Seasonal differences should be interpreted descriptively where statistical significance indicators are not provided.

The general increase in concentration during the rainy season could be attributed to the increased availability of metals in the environment due to rainfall, run-off and mobilisation of sediment. Increases in discharge can cause dilution and changes in metal speciation. However, the decrease in Fe concentration at Station 1 shows that not all metals will have the same response to rainfall. This variability has also been seen in other aquatic environments in Nigeria (Akubuo et al., 2023; Olowojuni et al., 2025). Therefore, it is better to consider this seasonal variation as metal and site specific.

***Integrated Interpretation of Spatial and Temporal Patterns***

The results show that there was spatial and temporal variation in the metal accumulation in C. pallidus between January and June 2015. The greatest variation was seen in Fe. Mn and Cr also showed some variation between stations. Zn, Cu, Ni, V and Pb had no significant difference between stations but had overall variation in concentration. Cd had overlapping groups. There was no one trend between stations meaning that the metal accumulation could not be shown to follow a single contamination gradient.

There was more variation seen in several metals. Zn, Cu, Ni, Cd, V, Cr and Pb all had variation between months with generally higher concentrations in June. However, there was a decrease within the periods meaning that they weren't linear. Seasonal variation also showed higher concentrations in the rainy season for most metals. However, the opposite was seen for Fe at Station 1 meaning that metal and site-specific factors had an effect. Therefore, the monthly and seasonal data complement each other.

This is expected as the metal accumulation in the crab is an integration of exposure to metals in the water, sediment bound materials and food. This is then regulated by the physiology of the crab. Similar variation between metals, tissues and sites has been seen in Callinectes species in coastal systems in Nigeria (Anyanwu, 2023; Ihunwo et al., 2022; Nwaonyeche & Ofurum, 2025; Ubong & Ekwere, 2022). The mobility of the crab may also mean that there isn't a direct link between the concentration in the tissue and the conditions at the site.

In all, there was some site-specific factors, with several metals showing large variation between months. Also, generally higher concentrations were seen in the rainy season. However, there was no indication of a particular anthropogenic source of the accumulated metals. The patterns observed are likely to be a combination of exposure, temporal variation in metal availability and metal accumulation in the organism during 2015.

## 5. CONCLUSION

The concentrations of heavy metals in Callinectes pallidus in the Awoye river were varied spatially and temporally. The variation of heavy metals was metal specific. Fe had the most variability between stations. Mn and Cr also showed some variability between stations. The other metals had numerical variability but not in a consistent spatial trend. The concentrations of several metals had more variability between months. The concentrations of Zn, Cu, Ni, Cd, V, Cr and Pb were generally highest towards the latter months of the sampling period, particularly June. Comparing the concentrations of metals between seasons, most metals had higher numerical concentrations in the rainy season than in the dry season. However, the concentrations of Fe in Station 1 were the opposite. This shows that the accumulation of metals in this crab species varied temporally in a metal and location specific manner.

This study shows that C. pallidus can provide useful biological data on the spatial and temporal variation of heavy metals in the Awoye river. The findings can provide a historical reference for the 2015 sampling period. This study supports the continued analysis of metals in aquatic organisms. Future studies should include longer sampling periods, biological factors such as crab size, sex and tissue type, and better quality control documentation.

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