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THE RELATIONSHIP BETWEEN IRON, LEAD AND COBALT CONTENT IN WATER, SEDIMENTS, NILE TILAPIA AND AFRICAN RIVER PRAWN OF LAKE ASEJIRE, NIGERIA

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Abstract

This study evaluated interrelationships between iron, lead and cobalt content in African river prawn, Nile tilapia, sediment and water from Lake Asejire. In the six-month study, the metals were measured in samples collected monthly from three locations sited up-, mid- and downstream. Of all the sample types, iron and cobalt had the highest and lowest concentration, respectively. The relatively low concentration of iron and lead, in addition to non-detectable cobalt, in water samples shows that the lake water is free of iron, lead and cobalt pollution. The metals were also found at low levels in sediment, tilapia and prawn samples. The sediment serves as metal reservoir, since it contains greater metal concentration than water and the two aquatic organisms. The significant correlative relationship between iron and lead content in the water and sediment may be attributed to the role of sediment in releasing metals into the water column. Differences in the metal intake, requirement, and excretory mechanisms may be responsible for the negative correlation between the iron content of tilapia and river prawn. The fact that both organisms share the same sources of cobalt and lead, among other metals, may have contributed to the unitary correlation observed between cobalt and lead content in the organisms.

Based on the findings of this study, the African river prawn, Nile tilapia, sediment and water of Lake Asejire can be considered free from iron, lead and cobalt pollution. Periodic metal content assessment is important to allow for adequate monitoring of the lake's pollution status.

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ZALEŻNOŚĆ MIĘDZY ZAWARTOŚCIĄ ŻELAZA, OŁOWIU I KOBALTU W WODZIE, OSADACH ORAZ W TILAPII NILOWEJ I AFRYKAŃSKIEJ KREWETCE RZECZNEJ Z JEZIORA ASEJIRE (NIGERIA)

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Słowa kluczowe: jezioro Asejire, zanieczyszczenia wody, organizmy wodne, współzależność metali.

Abstrakt

Badania dotyczyły zależności między zawartością żelaza, ołowiu i kobaltu w afrykańskiej krewetce rzecznej, tilapii nilowej oraz w wodzie i osadach jeziora Asejire. Stężenia metali mierzono przez sześć miesięcy (pomiar raz w miesiącu) na stanowiskach usytuowanych w górnej, środkowej i dolnej części jeziora. Spośród wszystkich badanych metali, żelazo i kobalt miały odpowiednio najwyższe i najniższe stężenia. Stosunkowo niskie stężenia żelaza i ołowiu oraz niewykrywalny poziom kobaltu świadczy o tym, że woda nie jest zanieczyszczona tymi pierwiastkami. Niskie stężenia metali stwierdzono również w osadach, tilapii i krewetkach. Nieco większe stężenia metali w osadach niż w wodzie i organizmach wodnych świadczą o tym, że pełnią one rolę kumulującą. Istotna korelacja między stężeniem żelaza i ołowiu w wodzie i osadach dennych wskazuje na możliwość uwalniania metali z osadów do wody. Różnice w poborze metali, zapotrzebowaniu i mechanizmach wydalniczych mogą być odpowiedzialne za ujemną korelację między zawartością żelaza w tilapii i krewetkach. Fakt, że oba organizmy dzielą te same źródła kobaltu i ołowiu, mógł przyczynić się do istotnej korelacji między zawartością w nich kobaltu i ołowiu.

Na podstawie wyników badań można stwierdzić, że afrykańska krewetka rzeczna i tilapia nilowa, a także osady i wody jeziora Asejire są wolne od zanieczyszczeń żelaza, ołowiu i kobaltu. Okresowa ocena zawartości metali jest ważna, aby umożliwić odpowiednie monitorowanie stanu zanieczyszczenia jeziora.

Introduction

The exploitation of aquatic environments for various fish and non-fish resources has benefited human existence immensely. Aquatic resources play several roles in ensuring the sustainable livelihood of human communities, but the desire of man to live near water bodies and in coastal areas has made water bodies more vulnerable to pollution (OLADELE and DIGUN-

-Aweto 2017). Furthermore, anthropogenic activities that are linked to increases in population, agricultural growth, and industrial development have contributed to the pollution of water bodies worldwide (Islam et al. 2014, Kennish 2017).

Reports from the Great Lakes Commission in 2003 reveal that until approximately 50 years ago, most pollution was not seen in our oceans, since waste materials were mainly metals and glass, which sink, and paper and cloth, which decay (Oladele 2011). Global industrial development has led to the production of more persistent waste materials. Due to inadequate waste management systems, which are common in developing countries, the deposition of waste materials has risen to harmful levels in terrestrial and aquatic environments. Owing to the vast size and capacity of marine waters to absorb wastes, the impact of pollution is lower than what is manifested in freshwater bodies. Increase in pollution levels as well as over-exploitation of water for domestic consumption and agricultural and industrial use have significantly reduced the assimilative capacities and self-cleaning abilities of many rivers and lakes (Oladele and Jenyo-Oni 2015).

In Nigeria, it is of great concern that over 80% of the nation's industries discharge their solid, liquid and gaseous wastes and effluents into the aquatic environments without pre-treatment, whereas only 18% of them undertake fundamental recycling processes before disposal (Olowu et al. 2010). The upsurge in urban population and the production of household products have resulted in increased production of household waste materials (Simonyan and Fasina 2013) and, subsequently, added to Nigeria's problem of waste disposal. Also, surface run-off and erosion from chemically treated agricultural farms find their way into water bodies (Mallampati et al. 2007). Some of the constituents of the wastes and effluents discharged in aquatic environments include heavy metals, nutrient elements, synthetic chemicals, organic compounds, and sewages, whose presence poses significant threats to living organisms in aquatic environments (Bukola et al. 2015, Oyebode 2015, Ayangbenro and Babalola 2017).

Lake Asejire is one of the human-made lakes in South-Western Nigeria, constructed to supply potable water to surrounding communities. In addition to this primary purpose, Lake Asejire houses dominant populations of tilapia and Chrysichthys species (Ogunleye 1982, Ipinmototi 2013). These and other aquatic organisms are fished by fishermen to meet dietary and economic needs. Edible aquatic organisms are essential links in the food chain, aiding in the transfer and accumulation of metals from polluted water bodies to humans, mainly through consumption of water and water resources from such water bodies. For this reason, these organisms serve as a transport route for metals from polluted water bodies to humans. The importance of river sediment in serving as harbour and natural buffer for pollutant materials in water bodies has been reported in several studies (JAFFA et al. 1998, ADEYEMO et al. 2008, OLOWU et al. 2010, WANG et al. 2014, SINGOVSZKA et al. 2017, KONG et al. 2018). The presence of residential buildings, industrial establishments, and agricultural farms within the vicinity of the lake predisposes the water body to wastes from these sources.

According to OGUZIE and OKOSODO (2008), heavy metals are common constituents of domestic, industrial and agricultural wastes. Exposure to low concentrations of heavy metals such as iron, lead, cobalt, mercury, zinc, and copper over a long period of time has resulted in the development of several acute and chronic diseases in humans (OGUZIE and OKHAGBUZO 2010). Before the emergence of toxicology as a field of science, the diagnosis of acute lead poisoning has been carried out by Greek and Roman physicians for several decades. Acute exposure to lead can result in headache, sleeplessness, loss of appetite, abdominal pain, fatigue, hallucinations, hypertension and renal dysfunction (JAISHANKAR et al. 2014). Similarly, lead has been reported to interfere with the proper functioning of several essential elements such as iron, zinc, calcium, and copper. Lead has been implicated in inhibiting red blood cell-enzyme systems, displacing calcium in bones, inactivating cysteine containing enzymes, liver and kidney damage, nervous system dysfunction, infertility, abortions, and fetal and neonatal deaths (BALA et al. 2008, MOR et al. 2009, DUTTA et al. 2013).

Although iron and cobalt are essential elements, they become toxic in high concentrations. Iron accumulation beyond the nutritional threshold has been implicated in human health problems such as cellular damage, mutation and malignant transformation, which leads to an array of diseases (GRAZULEVICIENE et al. 2009). Some of the effects of cobalt accumulation in humans include reproductive maladies such as infertility, menstrual and lactation problems, altered sexual behaviour, the altered onset of puberty, altered pregnancy periods, and altered menopause problems (SENGUPTA et al. 2014).

The occurrence of iron (Fe), lead (Pb) and cobalt (Co), among other metals, in industrial, agricultural and domestic wastes and their toxicity and bioaccumulation potential in aquatic biota prime them for significant consideration in aquatic toxicology. Therefore, the primary objective of the study was to investigate the existing relationships in the concentrations of iron, lead and cobalt in four (4) sample types such as African river prawn, Nile tilapia, sediment and water of Lake Asejire.

Materials and Methods

Lake Asejire is located in the Egbeda local government area of Oyo State in the south-western part of Nigeria. It is sited along the Ibadan-Ife expressway, about 33.8 km distance from Ibadan. The lake has an approximate gross storage of 7,403 million litres (EGBORGE 1977), which are regulated through dam gates. It lies at 04°07' East and 07°21' North at an altitude of 137 metres above sea level, covering a length of 19.5 km (AYOADE et al. 2007). Although Lake Asejire can be described as tilapia and Chrysichthys fisheries due to the dominant population of these two fish species, about 25 fish species have been identified in the lake (OGUNLEYE 1982, IPINMOROTI 2013).

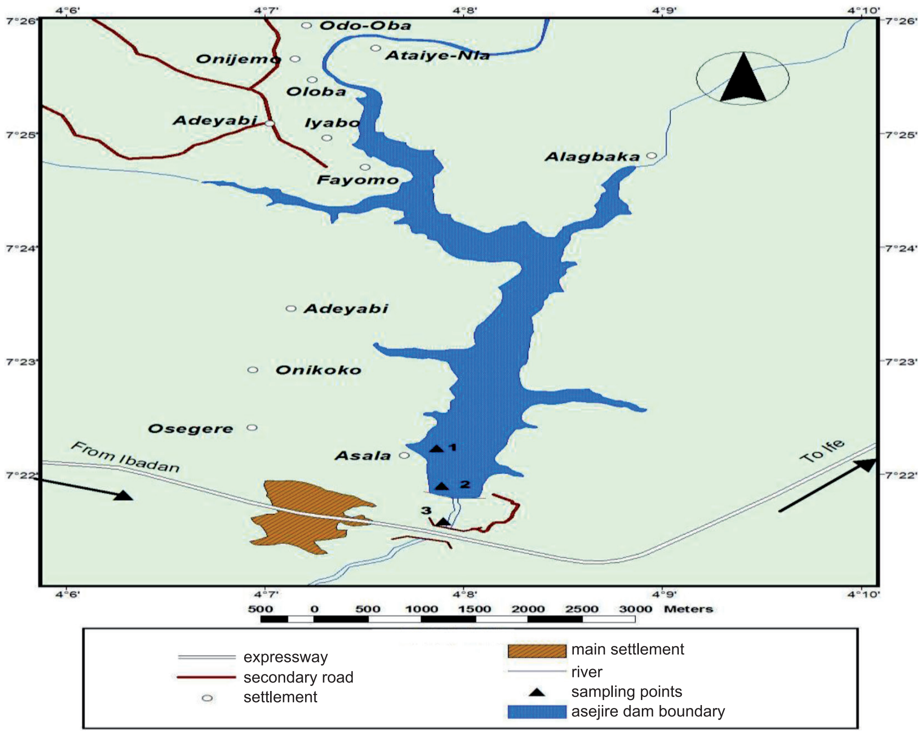

Fig. 1. Map of Asejire Lake showing the sampling stations

To determine the concentration of iron, lead and cobalt in Lake Asejire, samples of water, sediments, Nile tilapia (*Oreochromis niloticus*) and African river prawn (*Macrobrachium vollenhovenii*) were collected over a period of six months (January to June, 2017) from three locations sited on the lake, as described by JENYO-ONI and OLADELE (2016). Along the watercourse, sampling locations were sited with regard to the proximity of the river's damming point. As such, the sample locations were situated upriver, mid-river and downriver, and labelled locations 1, 2 and 3, respectively. Three (3) replicate samples were collected monthly from each of the three locations.

Samples of water, sediment, tilapia, and prawn were collected between 7:00 and 10:00. In line with APHA's (1992) methods, water samples from each sampling location were collected in triplicate in two-litre plastic bottles. A Van Veen grab was used to collect sediment samples from the three sampling locations. The sediment sample for each location was made representative through collection and mixture of sub-samples obtained from three sampling points within each location. The resulting composite sediment samples were transported in labelled polyethylene bags that have been pre-treated with 5% nitric acid and rinsed with distilled water (ACHIONYE-NZEH and ISIMAIKAIYE 2010). In the laboratory, sediment samples were air-dried under room temperature.

Nile tilapia and African river prawn were collected from each sampling location with the aid of licensed local fishers. The fresh samples were transported under low temperature, using ice flakes, to the laboratory where they were weighed and oven-dried at 105°C until constant weights were obtained. Dried sediment samples, as well as dried and grounded tilapia and prawn samples, were sieved, using a 0.5 mm sieve, before digestion and heavy metal determination.

Metal concentrations in the water samples were determined by using a Buck scientific atomic absorption spectrophotometer (VGP 210/211 model) in line with the methods of PREER and ROSEN (1997). The same method was used to determine the metal concentration of digested sediment, tilapia and prawn samples. Data obtained was analysed by using the SPSS statistical package. Mean and standard deviation were used to describe the metal concentration in each of the locations across the four sample types, analysis of variance (ANOVA) was used to test the significant difference between the metal concentrations, and correlation was used to test the relationship that exists between the metals in the sample types.

Results

The concentration of iron, lead and cobalt in water, sediments, tilapia and prawn samples are presented in Tables 1–4, respectively. As evident in Table 1, iron was detected only in location 1; the lead was present in all three locations, whereas cobalt was not detected in any of the sampling locations.

Table 1

Iron, lead and cobalt concentration [mg l^{-1}] in water samples

Location	Iron	Lead	Cobalt
Location 1	0.020 ± 0.044	0.032 ± 0.072	Nd
Location 2	Nd	0.046 ± 0.103	Nd
Location 3	Nd	0.064 ± 0.088	Nd
–	–	0.047 ± 0.016	–

Nd = not detected

Metal concentration in sediment samples showed some level of variation across the locations, with iron having the highest concentration (2.392 ± 0.017 mg kg^{-1}) and cobalt the lowest (0.027 ± 0.001 mg kg^{-1}), as is evident in Table 2. No significant difference ($P < 0.05$) was observed among concentrations recorded for each of the metals across the three (3) sampling locations. Despite the high iron concentration in sediment samples, lead and cobalt concentrations were less than 0.1 mg kg^{-1}. It is obvious from Tables 1 and two that sediment samples had higher metal concentrations than water samples.

Table 2

Iron, lead and cobalt concentration [mg kg^{-1}] in sediment samples

Location	Iron	Lead	Cobalt
Location 1	2.374 ± 0.107	0.072 ± 0.018	0.026 ± 0.006
Location 2	2.400 ± 0.076	0.074 ± 0.017	0.026 ± 0.013
Location 3	2.402 ± 0.081	0.076 ± 0.022	0.028 ± 0.016
–	2.392 ± 0.017	0.074 ± 0.002	0.027 ± 0.001

Similarly, all the metals were present in detectable concentrations in the tilapia samples (Table 3). In these tilapia samples, the iron concentration was also the highest (7.431 ± 0.162 mg kg^{-1}), followed by lead (0.053 ± 0.002 mg kg^{-1}), whereas cobalt had the lowest concentration (0.006 ± 0.001 mg kg^{-1}). No significant difference ($P < 0.05$) was observed within each metal across the three locations. It is important to note that although iron concentration in the tilapia samples (7.431 ± 0.162 mg kg^{-1}) was higher than the concentration in sediments (2.392 ± 0.017 mg kg^{-1}), the lead and cobalt concentrations in tilapia samples (0.053 ± 0.002 mg kg^{-1} and 0.006 ± 0.001 mg kg^{-1}) were lower than in sediment samples (0.074 ± 0.002 mg kg^{-1} and 0.027 ± 0.001 mg kg^{-1}, respectively).

Table 3

Iron, lead and cobalt concentration [mg kg^{-1}] in Nile tilapia samples

Location	Iron	Lead	Cobalt
Location 1	7.408 ± 1.192	0.052 ± 0.011	0.004 ± 0.005
Location 2	7.604 ± 1.285	0.052 ± 0.004	0.006 ± 0.009
Location 3	7.282 ± 1.083	0.056 ± 0.013	0.006 ± 0.009
–	7.431 ± 0.162	0.053 ± 0.002	0.006 ± 0.001

Table 4

Iron, lead and cobalt concentration [mg kg^{-1}] in African river prawn samples

Location	Iron	Lead	Cobalt
Location 1	1.614 ± 0.091	0.098 ± 0.008	0.004 ± 0.005
Location 2	1.578 ± 0.079	0.098 ± 0.026	0.006 ± 0.006
Location 3	1.638 ± 0.168	0.114 ± 0.017	0.006 ± 0.009
–	1.610 ± 0.030	0.104 ± 0.009	0.005 ± 0.001

Metal concentration in the prawn samples displayed a similar pattern to the concentration in tilapia samples, with iron having the highest concentration (1.610 ± 0.030 mg kg^{-1}), followed by lead (0.104 ± 0.009 mg kg^{-1}), and cobalt having the lowest concentration (0.005 ± 0.001 mg kg^{-1}) – Table 4. There was no significant difference between the concentrations of the different metals observed across the locations. Samples of tilapia had higher iron and cobalt concentrations (7.431 ± 0.162 mg kg^{-1}and 0.006 ± 0.001 mg kg^{-1}) than African river prawn (1.610 ± 0.030 mg kg^{-1} and 0.005 ± 0.001 mg kg^{-1}, respectively), although lead concentration was lower in the tilapia samples (0.053 ± 0.002 mg kg^{-1}) than in the prawn samples (0.104 ± 0.009 mg kg^{-1}).

The correlation coefficients of the metals within and across the sample types are presented in Tables 5 to 11. In these tables, the metal concentration in each sample type was represented by the chemical symbol of the metals with suffices such as -W, -S, -NT and –ARP, which are used as the abbreviations for water, sediment, Nile tilapia, and African river prawn, respectively. The correlation coefficients of the metals in each of the sample types are presented in Tables 5–8.

In Table 5, the correlation coefficients of the relationship between iron and cobalt, as well as lead and cobalt, could not be computed due to non-detection of these metals in water samples. However, iron and lead concentrations were strongly negatively correlated (-0.828). The concentration of iron and lead in water samples are represented in Table 5 with Fe-W and Pb-W, respectively.

Table 5

Correlation coefficients of iron and lead in water samples

Specification	–	Fe-W	Pb-W
Pb-W	Pearson correlation	-0.828	1
	sig. (2-tailed)	0.379	–

Table 6

Correlation coefficients of iron, lead and cobalt in sediment samples

Specification	–	Fe-S	Pb-S	Co-S
Fe-S	Pearson correlation	1	–	–
	sig. (2-tailed)	–	–	–
Pb-S	Pearson correlation	0.896	1	–
	sig. (2-tailed)	0.293	–	–
Co-S	Pearson correlation	0.554	0.866	1
	sig. (2-tailed)	0.626	0.333	–

Similarly, iron, lead and cobalt concentration in sediment samples are represented in Table 6 by Fe-S, Pb-S and Co-S, respectively. Iron content in sediment samples had positive correlations with lead and cobalt (0.896 and 0.554, respectively), whereas lead and cobalt were also positively correlated (0.866). Similarly, as evident in Table 7, metal concentrations in Nile tilapia had both positive and negative correlation coefficients. Although iron had a negative correlation with lead and cobalt (-0.924 and -0.132, respectively), the relationship between lead and cobalt was a positive correlation (0.500).

Table 7

Correlation coefficients of iron, lead and cobalt in Nile tilapia samples

Specification	–	Fe-NT	Pb-NT	Co-NT
Fe-NT	Pearson correlation	1	–	–
	sig. (2-tailed)	–	–	–
Pb-NT	Pearson correlation	-0.924	1	–
	sig. (2-tailed)	0.249	–	–
Co-NT	Pearson correlation	-0.132	0.500	1
	sig. (2-tailed)	0.916	0.667	–

Table 8

Correlation coefficients of iron, lead and cobalt in African river prawn samples

Specification	–	Fe-ARP	Pb-ARP	Co-ARP
Fe-ARP	Pearson correlation	1	–	–
	sig. (2-tailed)	–	–	–
Pb-ARP	Pearson correlation	0.803	1	–
	sig. (2-tailed)	0.407	–	–
Co-ARP	Pearson correlation	-0.115	0.500	1
	sig. (2-tailed)	0.927	0.667	–

The type of association that exists among the metals in African river prawn is not similar to what was observed in Nile tilapia (Table 8). Iron was positively related to lead (0.803) but negatively related to cobalt (-0.115). Similar to the relationship between lead and cobalt in Nile tilapia, the relationship between lead and cobalt was positively correlated (0.500) with the same magnitude. It is noteworthy that lead and cobalt shared the same correlation coefficient (0.500) in both Nile tilapia and African river prawn.

The association between the metal content across the four (4) sample types is presented in Tables 9–11. Table 9 reveals the correlation coefficients of iron across the sample types. The iron content in water and sediments is strongly negatively related (-0.998), whereas the iron concentration in water and the concentration in Nile tilapia and African river prawn were positively related (0.132 and 0.115, respectively).

Table 9

Correlation coefficients of iron (Fe) in samples of water, sediment, Nile tilapia and African river prawn from Lake Asejire

Specification	–	Fe-W	Fe-S	Fe-NT	Fe-ARP
Fe-W	Pearson correlation	1	–	–	–
	sig. (2-tailed)	–	–	–	–
Fe-S	Pearson correlation	-0.998*	1	–	–
	sig. (2-tailed)	0.041	–	–	–
Fe-NT	Pearson correlation	0.132	-0.195	1	–
	sig. (2-tailed)	0.916	0.875	–	–
Fe-ARP	Pearson correlation	0.115	-0.051	-0.970	1
	sig. (2-tailed)	0.927	0.968	0.157	–

*. Correlation is significant at the 0.05 level (2-tailed).

Unlike water, the iron content of sediment is negatively associated with tilapia (-0.195) and African river prawn (-0.051). Similarly, iron content in the two aquatic organisms is negatively related (-0.970). Of all these relationships, the relationship between iron concentration in water and in sediments is significant at a 5% confidence level.

Table 10 shows the correlation coefficients of lead across the sample types. The relationships between lead content and all the sample types were positive, although with different levels of strength. It is worth mentioning that the correlation between lead concentration in water and in sediment (0.997) is significant at a 5% confidence level, whereas the relationship between lead concentrations in the two aquatic organisms is unitary (1.000), which is significant at a 1% confidence level.

Table 10

Correlation coefficients of lead (Pb) in samples of water, sediment, Nile tilapia and African river prawn from Lake Asejire

Specification	–	Pb-W	Pb-S	Pb-NT	Pb-ARP
Pb-W	Pearson correlation	1	–	–	–
	sig. (2-tailed)	–	–	–	–
Pb-S	Pearson correlation	0.997*	1	–	–
	sig. (2-tailed)	0.046	–	–	–
Pb-NT	Pearson correlation	0.900	0.866	1	–
	sig. (2-tailed)	0.287	0.333	–	–
Pb-ARP	Pearson correlation	0.900	0.866	1.000**	1
	sig. (2-tailed)	0.287	0.333	0.000	–

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

As evident in Table 11, correlation coefficients of cobalt in water were not computable due to non-detection of this metal in water samples. However, positive relationships were observed in the cobalt content in sediment, Nile tilapia, and African river prawn. Notable is the fact that the correlation coefficient of cobalt concentration in sediment and each of the two aquatic organisms is 0.500, whereas the correlation between cobalt content in the two aquatic organisms is unitary (1.000), which is significant at a 1% confidence level.

Table 11
Correlation coefficients of cobalt (Co) in samples of water, sediment, Nile tilapia and African river prawn from Lake Asejire

Specification	–	Co-S	Co-NT	Co-ARP
Co-S	Pearson correlation	1	–	–
	sig. (2-tailed)	–	–	–
Co-NT	Pearson correlation	0.500	1	–
	sig. (2-tailed)	0.667	–	–
Co-ARP	Pearson correlation	0.500	1.000**	1
	sig. (2-tailed)	0.667	0.000	–

** Correlation is significant at the 0.01 level (2-tailed).

Discussion

Non-detection of cobalt in water samples of Lake Asejire points to the metal's very low concentration in the water column. However, the detection of iron and lead does not indicate iron and lead pollution, since their concentration levels were also relatively low (less than 0.05 mg l^{-1}). Dilution, flowing, assimilative and self-cleansing capacities of Lake Asejire, like those of many other lakes and rivers, may have been responsible for non-detection and very low concentration of the metals in the water column. Based on this result, the water of Lake Asejire can be considered free from iron, lead and cobalt pollution. There is therefore the need for sediment analysis in evaluating qualities of the total ecosystem of the water body in addition to the water sample analysis, which is carried out in several other studies.

Detection of varying concentrations of the metals in sediment samples across the locations throughout the sampling period supports the findings of OGBEIBU and EZEUNARA (2002), namely that sediments serve as an ultimate sink for most metals in aquatic ecosystems. This is further corroborated by submissions of ZHANG et al. (2014) and LUNDY et al. (2017) on using water sediments as indicators of metal pollution in aquatic environments. The use of sediment as an indicator for monitoring pollution relates to the fact that the concentrations detected in water samples do not necessarily reflect the degree of pollution. Furthermore, ADEMOROTI (1996) submitted that sediments are the primary depository of metals, in some cases holding over 99% of the total amount of metals present in the aquatic ecosystem. According to ADEYEMO et al. (2008), pollutants are conserved in sediments over an extended period in line with their chemical persistence and the physical-chemical and biochemical characteristics of the substrate.

Similarly, all the metals were found in Nile tilapia and African river prawn samples; however, the metal content was lower when compared with the concentrations recorded in the sediment. The finding agrees with the findings of ADEMOROTI (1996), stating that metal concentrations in aquatic biota are lower than those in sediments, since nearly all metal contents in aquatic environments reside in water sediment. High iron concentration recorded in the aquatic organisms may be ascribed to iron utilisation, as iron is an essential micronutrient required by many proteins and enzymes for normal functioning of the organisms' body systems (GIL et al. 1997).

The ferruginous nature of tropical soils may also have contributed to the presence of iron content in water, sediment and aquatic organisms sampled from the lake. OLOWU et al. (2010) reported that the high iron concentration in most Nigerian soils is a result of their formation-formed basement rock minerals, which are rich in iron oxides. Also, low levels of other metals in the flesh of the aquatic organisms may be accredited to the cobalt trace requirement and non-dietary nature of lead in the organisms' bodies (OBASOHAN 2008). The difference in metal concentrations observed in tilapia and prawn samples may be attributed to the anatomic differences that exist between the two aquatic organisms (GLENN et al. 2009).

The strong and significant correlation in iron and lead concentrations between water and sediment supports the submissions of LUNDY et al. (2017), claiming that metal content in the water column is influenced by the releasable metal concentration in the sediments. Continuous uptake of iron and its use as an essential dietary element may have accounted for the inverse relationship that exists between iron concentrations in water and sediment samples.

Despite non-detection of cobalt in the water column, which indicates an extremely low concentration, the detection of the metal in both the tilapia and prawn of the lake may have resulted from persistent exposure to minute concentrations of the metal in the water body. This finding corroborates the reports of SINGOVSZKA et al. (2017), which reveal that long-term pollution of sediments could lead to metal accumulation in aquatic organisms and humans utilising the overlying water for life activities, even if the emission rate of the pollutant is low and pollutant concentrations are present in levels lower than water quality standards.

The correlative negativity in the iron content of Nile tilapia and African river prawn may be due to the differences that exist between the two organisms in their iron intake and dietary requirements, as well as their removal (excretory) mechanisms. This is in accordance with the reports of GLENN et al. (2009), who indicated that bioaccumulation of metals in aquatic organisms is species dependent in addition to being a function of the organism's homeostatic mechanisms.

The unitary correlative relationship between cobalt concentrations in the two aquatic organisms may be partly ascribed to its requirement as an essential dietary element; however, this not true of lead. The fact that both organisms share the same sources of cobalt and lead, among other metals, may have contributed to the unitary relationship observed. Beyond anthropogenic activities, natural sources such as rock minerals, processes of soil formation and volcanic eruption are main routes of metal introduction to aquatic environments (SINGOVSZKA et al. 2017).

Conclusion

The concentration of iron, lead and cobalt in African river prawn, Nile tilapia, sediment and the water of Lake Asejire is relatively low, and according to this finding, the lake can be considered free from iron, lead and cobalt pollution. However, the finding does not entirely preclude discharge of pollutants from natural and human-made sources. Erosion from surrounding chemically treated agricultural farms and deposition of domestic wastes, especially during the rainy season, are likely point pollution sources that may have contributed to the metal content of the lake. The role of underlying soil and rock types cannot be overlooked, since soil formation processes can also lead to the release of metal and mineral elements.

The detection of these metals in African river prawn, Nile tilapia, sediment and water calls for adequate attention and pollution control. Persistent presence and accumulation of pollutants may lead to a build-up of metals in the lake's ecosystem. Cases of food poisoning may result from the utilisation of untreated water and consumption of metal-polluted resources from the lake. Continuous efforts to safeguard the lake from the deliberate deposition of domestic, agricultural and industrial wastes are crucial, owing to the importance of the lake in providing potable water and safe aquatic food organisms for human consumption. At the moment, periodic assessment of metal content of the lake, among other pollution indices, is recommended in order to allow for adequate monitoring of the pollution status of the lake and its resources. Further studies on other metals are necessary to reveal the pollution status of Lake Asejire with respect to those metals.

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