International Journal of Scientific Research Updates

Journal homepage: https://orionjournals.com/ijsru/

ISSN: 2783-0160 (Online)

Orion Scholar Journals

(Research Article)

Harmful algae bloom and health risk assessment of heavy metals in the lower Taylor Creek, Bayelsa State, Nigeria

Peremobowei Beldin Kpikpi * and Akpevwe Efe Okere

Department of Fisheries and Aquaculture, University of Africa, Toru-Orua, Bayelsa State, Nigeria.

International Journal of Scientific Research Updates, 2026, 11(02), 001-013

Publication history: Received on 28 April 2026; revised on 14 June 2026; accepted on 17 June 2026

Article DOI: https://doi.org/10.53430/ijsru.2026.11.2.0016

Abstract

Introduction: Harmful algae bloom (HABs) and their effects on aquatic life and human health has been a public challenge resulting from excess human input into aquatic environments. Heavy metals are toxic to human and find their way into the water through numerous sources. The study investigates harmful algae bloom and human health risk of some heavy metals in the lower Taylor creek, Nigeria was assessed between July 2024 and February 2025 in 4 stations to determined. **Results:** Total HABs load comprises of 3 taxa Bacillariophyta (diatoms), Cyanophyta (cyanobacteria), and Pyrrophyta (dinoflagellates), 12 genera and 19 species were encountered of which *Akashiwo* sp., *Alexandrium* sp. and *Prorocentrum triestinum* (Dinoflagellates) marked very high abundance and *Nostoc linkia* (Cyanophyta) revealed rare abundance in the study. Cadmium (Cd), Lead (Pb) and Nickel (Ni) were assessed by evaluating the chronic daily intake (CDI), hazard quotient (HQ) and the target hazard quotient (THQ) to determine the hazard indices (HI) in the stations. CDI ranged from 0.00026 to 4.38 mg/kg/day (Adult) and 0.00010 to 8.31 mg/kg/day (Children). Cd and Pb concentrations were above recommended permissible limit in all stations. HQ, HI and the cancer risk (CR) values for adult were below threshold value (1) except for children. **Conclusion:** The cumulative effects indicated by the hazard index (HI) calls for concern and this concern is for children exposed to the water resources through consumption.

Keywords: Harmful algae blooms; Health risk; Heavy metals; Taylor creek; Nigeria

1 Introduction

The appearance of greenery, serves as natural fish food, is triggered by the successful outcome of water bodies with a higher density of microflora [**1**]. Harmful alga blooms (HABs) are life-threatening algae that have thousands to countless numbers several cells than other species [**2**]. Most harmful algae belong to four phylum which include Dinophyte, Bacillariophyta, Chrysophyta, and Cyanophyta. When thrilled with nutrients, harmful algae can produce "red tides," which are a discolouration of water that is red or a shade of brown red. Among the many detrimental consequences, they can have on aquatic habitats are aesthetic ones like beach pollution, oxygen shortages, fish gill obstruction, and organism poisoning.

The estimation of harmful health consequences in organisms (human and aquatic life) exposed to metals concentration in contaminated environments by the use of mathematical equations is known as human health risk assessment. Health risk assessment is an integrated approach a potential risk of exposure to heavy metals ascertains the variety of effects that contaminants have on human health [**3**]. Heavy metals are eventually taken up or absorbed by fish, plankton and other biota through water, food and sediment whether they are essential or non-essential metals which get accumulated in the organism [**4**]. Owing to adaptive and physiological toxicity variations, there may be carcinogenic or non-carcinogenic dangers to human health when exposed to both adults and children.

* Corresponding author: Peremobowei Beldin Kpikpi

Heavy metals are routinely introduced into our food chain as a result of the excessive use of uncontrolled and unregulated contaminants from industrial effluent, agriculture and residential areas, which is a major concern for water safety, human health, and quality assurance [**5**]. These contaminants are bioaccumulated, biotransformed and sequestered in the tissues of edible aquatic life. Heavy metals can contaminate used water or natural water [**6**] and can be harmful if taken in amounts above the permitted limit [**7**]. Thus, copper (Cu) has been linked to liver damage, Extreme cadmium (Cd) exposure result in health problems such as skeletal difficulties Vasseghian *et al.* [**8**], while high-density lipoprotein (HDL) levels and immunological function have been linked to zinc [**9**]. Nickel (Ni) could induce gastrointestinal discomfort, a rise in red blood cells, and a decrease in lung function at hazardous doses [**10**]. High lead (Pb) concentrations cause health issues like elevated arterial pressure and behavioural issues [**11**].

Phytoplankton species are the base of the food chain and are susceptible to the impacts of metals pollution [**12**]. A very small number remains potentially harmful, which can pollute aquatic organisms through contaminants resulting from health risk in human beings, as well as changing habitat structure [**13**]. Harmful algae produce toxins cause paralytic shellfish poisoning (PSP), diarrhetic shellfish poisoning (DSP), amnesic shellfish poisoning (ASP), and neurotoxic shellfish poisoning (NSP), as well as other yet-uncharacterized toxins accumulated and transported through pelagic food webs by feeding interactions, leading to mortality of fish, seabirds, marine mammals and human beings.

Algae have a very high potential for heavy metals accumulation depending on both the hydrological and hydrochemical parameters of the area as well as the harmful algal qualitative and quantitative characteristics [**14**]. Heavy metals are regarded as stress factors for the growth of phytoplankton and cause physical and morphological changes [**15**]. They are characterized by a high bioaccumulation ability and contribute to the transfer of heavy metals to higher trophic organisms resulting changes in aquatic life and human physiological systems, chronic illness and death. Contamination of algae, water, fish, sediment and marine animals with heavy metals has reached unprecedented levels in some parts of Africa [**16**]. As a result, human exposure to toxic metals has become a major health risk. Many studies have detected the occurrence of heavy metals in water and sediment [**17-18**]. But only a few studies refer to the heavy metals content in phytoplankton community [**19**], in Nigeria freshwater bodies. The present study is devoted to determining harmful algae bloom and health risk assessment of heavy metals of the lower Taylor Creek, Bayelsa State, Nigeria.

2 Materials and methods

2.1 Study area

Taylor Creek is typically a fresh water ecosystem with an adjoining River Nun beginning from Polaku community through the stretch of the river through Agbia community. The river is divided into two divisions: the north upstream (Upper Taylor creek) and the south downstream (lower Taylor creek) which include villages like Polaku, Koroama, Obunagha, Ogboloma Okolobiri, Agbia that made the Gbaran clan among others in Yenagoa Local Government Area, Bayelsa State, Nigeria. The lower Taylor creek is located latitude 4° 59' 58" N and longitude 6° 16' 47" E with four distinctive stations, Station 1 (Polaku), Station 2 (Koroama), Station 3 (Okolobiri), and Station 4 (Agbia) were choice for the study as regard human settlement (Figure 1). The river is a major source of livelihood of the indigenous people in the region. The creek also receives industrial wastes from oil exploration, gas exploration, Artisanal dredging, bridge construction, gas pipe line construction, domestic wastes, agricultural farm lands using fertilizers including sewage from residential area.

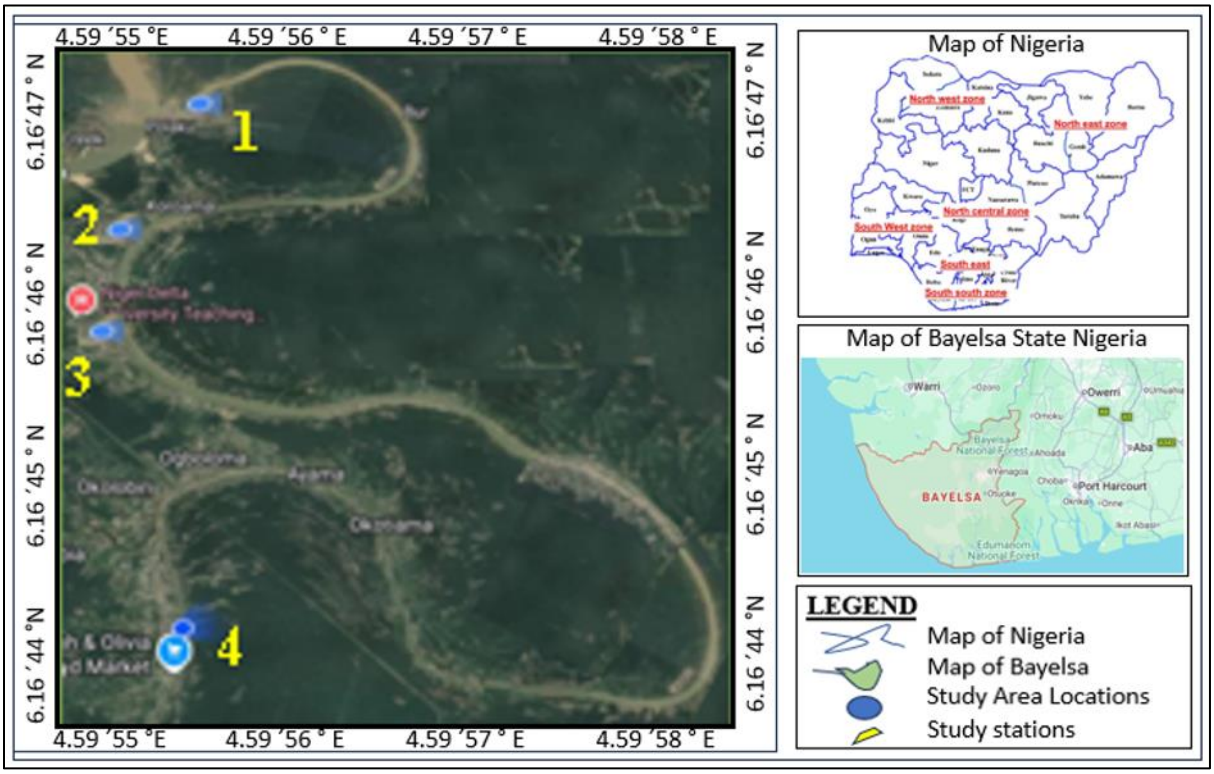

Figure 1 Map of the lower Taylor Creek, Bayelsa State, Nigeria

2.2 Duration of the study

Samples were collected once monthly from July 2024 through February 2025 following standard methods.

2.3 Sampling procedures

Phytoplankton net of 55m mesh size with 50ml transparent plastic sample bottle attached at the base of the net, was dragged against the water current for a minimum of 5 minutes. Thereafter, the sample were transfer into a sterilized sample bottles and fixed with 4% formalin, stored in an iced cooler box and transported to the laboratory for further analysis [**20**, **21**].

2.4 Heavy metal analysis

500 ml separate water samples were collected without fixing and was allowed to stand for 24 hours, thereafter supernatants were decanted. To determine heavy metal concentrations in phytoplankton communities, 50 ml of surface water samples representative of filtrated material was digested using HNO_3 and $HClO_4$ in ratio of (1:3), the samples were diluted up to an appropriate amount of 10 ml with deionized water [**22**], and were estimated by inductively coupled plasma atomic spectrometry (ASTM D 3559).

2.5 Phytoplankton enumeration and identification

In the laboratory the samples were allowed to stand for a minimum of 24 hours before decanting the supernatant. The concentrate was agitated for homogeneity, after which one (1ml) sub-sample was carefully pipetted and transfer to microscope slide for identification and enumeration under a digital microscope (Model Elikliv EDM 11S) with an attached camera. Standard identification guides were consulted [**23**;2**4**; **25]**.

2.6 Human Health Risk Assessment

The human health risk assessment method used in this study was for non-carcinogenic as described by Muhammed *et al.,*[**26**]. The Chronic Daily Intake (CDI) of heavy metals in water was evaluated by the equation [**27].**

$$CDI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

Where, CDI is the daily dose of heavy metals (mg/l) to which consumers might be exposed. CW (mg/l) - concentration of heavy metals in the surface water,

- IR - Ingestion rate, EF is the Exposure frequency,
- ED- Exposure duration,
- BW- Body weight,
- AT - Averaging Time.

The CDI values are presented in (Table1).

Table 1 CDI values characterization

Factor/parameter	Units	Symbol	Adult	Children
Exposure Duration	Years	ED	30	6
Exposure frequency	Days/year	EF	350	350
Averaging time	Days	AT (ED x 365)	10950	2190
Body weight	Kg	BW	70.0	15.0
Ingestion rate	L/day	IRW	2.0	1.0

Source: USEPA [28]

Table 2 Reference dose and cancer slope of heavy metals

Heavy metals	Cancer slope factor (mg/kg/day)	Ref. Dose (mg/kg/day)
Cadmium (mg/l)	6.1	0.001
Lead (mg/l)	-	0.0035
Nickel (mg/l)	0.91	0.02

Source: USEPA IRIS [**29**]

2.7 Target Hazard Quotient (THQ) Method

The potential health risks of heavy metal consumption through plant were assessed based on the target hazard quotient (THQ) method, which was described in detail by the United States Environmental Protection Agency [**30**]. The THQ is given by the following equation:

$$THQ = \frac{EF \times ED \times IR \times C}{RFD \times WAB \times TA} \times 10^{-3}$$

Where EF is the exposure frequency (350 days/year),

ED is the exposure duration (70 years, equivalent to the average lifetime of human population), IR is the food ingestion rate (plant consumption values for adults and children are 301.0 and 231.5 g/person/day, respectively) [**31**].

C is the metal concentration in the plant (mg/kg);

RFD is the oral reference dose (Pb, Cd, Cu, Zn, Ni and As) values were 0.0035, 0.001, 0.040, 0.300, 0.02 and 0.050 mg/kg/day [**32**]

WAB is the average body weight (55.9 kg for adults and 32.7 kg for children) and

TA is the average exposure time for non-carcinogens (ED _ 365 days/year).

If the THQ value is greater than 1, the exposure is likely to cause obvious adverse effects.

Therefore, the total THQ (TTHQ) of heavy metals for plant is given by the following equation

$$TTHQ = \sum_{i=1}^{n} (THQ)_i$$

Storelli [30]

Hazard quotient (HQ) = CDI USEPA [33]

RfD

$$(HQ) = \frac{CDI}{RfD}$$

Hazard index (HI)

$$HI = \sum HQ_i$$

$$HI = HQ_{(Cd)} + HQ_{(Pb)} + HQ_{(Ni)}$$

CR = CDI x CSF

Table 3 Health risk assessment permissible limit in surface water

Risk type	Index	Permissible limit
Non-carcinogenic	Hazard quotient (HQ)	< 1.0
	Hazard index (HI)	< 1.0
Carcinogenic	Cancer risk (CR)	$< 1 \times 10^{-4} – 10^{-6}$

USEPA (IRIS) [29]

2.8 Statistical analysis

Data obtained was subjected to one-way analysis of variance (ANOVA) using IBM SPSS version 25 Statistical software (SPSS Inc., Illinois, USA). Post hoc test Tukey test @ 95 percent confident limit was employed to identify separation of mean from one another.

3 Results and discussions

A total of 3 taxa, 12 genera, 19 species were encounter in the study. The distribution of harmful algal species across the four sampling stations revealed clear spatial variation in species composition and relative abundance (Table 4). Three major phytoplankton phyla associated with harmful algal blooms (HABs) were identified: Bacillariophyta (diatoms), Cyanophyta (cyanobacteria), and Pyrrophyta (dinoflagellates). Among the Bacillariophyta, several potentially bloom-forming diatoms were recorded. *Cyclotella aperculata* was ubiquitous, occurring at all four stations, although at low relative rare abundance. In contrast, *Melosira pusilla* and *Melosira varians* (Station 3) (Bacillariophyta), while *Akashiwo* sp., *Alexandrium* sp., and *Prorocentrum triestinum* (Station 4) dinoflagellates (Pyrrophyta), showed very high marked abundance, *Scrippsiella trochoidea* only occurred at station 4 with common abundance. Conversely, *Cochlodinium fulvescens* was highly abundant only at Station 1, while absent from the other stations. *Prorocentrum* sp. was recorded at rare abundance at Station 2. Species of *Nitzschia*, including *N. sigma* and *N. closterium*, exhibited common abundance at Stations 3 and 4, while remaining absent or common at Stations 1 and 2 (Table 4). Cyanophyta were sparsely distributed, occurring exclusively at Station 4. *Anabaena flos-aquae* recorded common abundance, while *Nostoc linkia* occurred at rare abundance, indicating the presence of cyanobacterial HAB taxa restricted to this station. Three dominant species *Cyclotella aperculata, Melosira pusilla,* and *Nitzschia sp*. belong to the diatoms (Bacillariophyta), a group widely recognized as sensitive indicators of water quality. Their distribution and abundance across the stations reflect varying degrees of nutrient enrichment and ecological disturbance. The widespread occurrence of *Cyclotella* *aperculata* indicates broad ecological tolerance, while the dominance of *Melosira pusilla* and *M. varians* at Station 3 suggests high nutrient availability and strong water column mixing. Similarly, the elevated presence of *Nitzschia* species, particularly *N. sigma* and *N. closterium*, at Stations 3 and 4 is characteristic of stressed environments, with some species known to pose potential toxic risks. Collectively, the dominance of these diatom taxa highlights increasing nutrient loading and ecological stress within the study area, which supported the findings by [**34**, **12**].

Table 4 Checklist of Harmful Algae species of the lower Taylor creek, Bayelsa, Nigeria

Phylum	**Genus/species**	**Stations**			
		1	**2**	**3**	**4**
Bacillariophyta	*Cyclotella aperculata*	+	+	+	+
	Cyclotella sp	+	-	-	-
	Lauderia sp	++	-	-	++
	Melosira pusilla	-	-	++++	-
	Melosira varians	++	-	++++	-
	Navicular rostella	+	-	+	++
	Nitzschia closterium	-	-	++	++
	Nitzschia lanceolata	-	+	-	-
	Nitzschia sigma	++	-	+	++
	Synedra ulna	+	-	+	+
	Nitzschia paradox	+	-	-	-
Cyanophyta	*Anabaena flos-aquae*	-	-	-	++
	Nostoc linkia	-	-	-	+
Pyrrophyta	*Akashiwo sp*	-	-	-	++++
	Alexandrium sp	-	-	-	++++
	Prorocentrum sp	-	+	-	-
	Prorocentrum triestinum	-	-	-	++++
	Scrippsiella trochoidea	-	-	-	++
	Cochlodinium fulvescens	++++	-	-	-

Key: - = absent, + = rare (1- 5), ++ = common (6-10), +++ = moderate abundant,

++++ = high abundant (11 > above)

The percentage variation of harmful algal bloom (HAB) taxa across the four sampling stations of the lower Taylor Creek is presented in (Figure 2). Bacillariophyta accounted for a moderate proportion of HAB taxa at Stations 1, 3, and 4, contributing approximately (3.27–5.27%), while Station 2 recorded a markedly lower percentage (0.91%). Despite these numerical differences, no statistically significant variation was observed among stations ($p > 0.05$ (Figure. 2). Cyanophyta exhibited the lowest overall contribution to HAB taxa, with complete absence at Stations 1–3 (0%) and recorded presence of (4.5%) at Station 4. In contrast, Pyrrophyta showed pronounced spatial variability. Station 4 recorded the highest percentage contribution (11%), followed by Stations 1 and 3 with moderate values (3–033%), while Station 2 showed negligible contribution (0 %). No significant difference among stations ($p > 0.05$).

Hallegraeff [**35**], documented that some species of dinophyta taxa has been linked to fish kills, shellfish contamination, and ecosystem disruption. Species of *Cochlodinium* are notorious for forming dense blooms that can cause hypoxia and mass mortality in aquatic organisms [**36**]. Anderson *et al.* [**37**], state that *Alexandrium* species are globally recognized producers of saxitoxins responsible for paralytic shellfish poisoning. Similarly, the present study observed *Alexandrium sp., Akashiwo sp.,* and *Prorocentrum triestinum*, strongly supported gradual HAB conditions at Station 4. Inclusively, *Cochlodinium fulvescens* at Station 1 further highlights spatial heterogeneity in nutrients dynamics. The study concurred with the report by Kpikpi *et al.* [**12**], that dinophyta group sturdy expediency to compete for nutrients despite the scuffle by other algae taxa. This localized dominance suggests that Station 1 may experience episodic bloom events driven by nutrient pulses. Cyanobacteria taxa to Station 4 are ecologically noteworthy. Cyanophyta such as *Anabaena flos-aquae* are well-documented indicators of eutrophication and thermal stability, often thriving in nutrient-rich, slow-flowing waters [**38**]. Their absence from Stations 1 to 3 suggests that environmental conditions at these sites may be less favourable for cyanobacterial dominance, possibly due to mixing regimes or lower residence time.

3.1 HABs bioaccumulation of heavy metals

Harmful algae species marked a critical role in bioaccumulation and trophic transfer of heavy metals in aquatic ecosystems. The elevated concentrations of Cd and Pb recorded in harmful algae community structure across the study stations indicated strong metal uptake from the surrounding environment, consistent with the high metal-binding affinity of algal cell walls and intracellular ligands [**39-40**]. The increasing trend of Cd in the Stations suggests progressive enrichment, possibly driven by anthropogenic inputs from industrial effluents, oil exploration activities, and urban runoff characteristic of the studied region. The findings of the study showed distribution of heavy metals on contaminated harmful algae could be due to different exposure routes, which could increase human health risk.

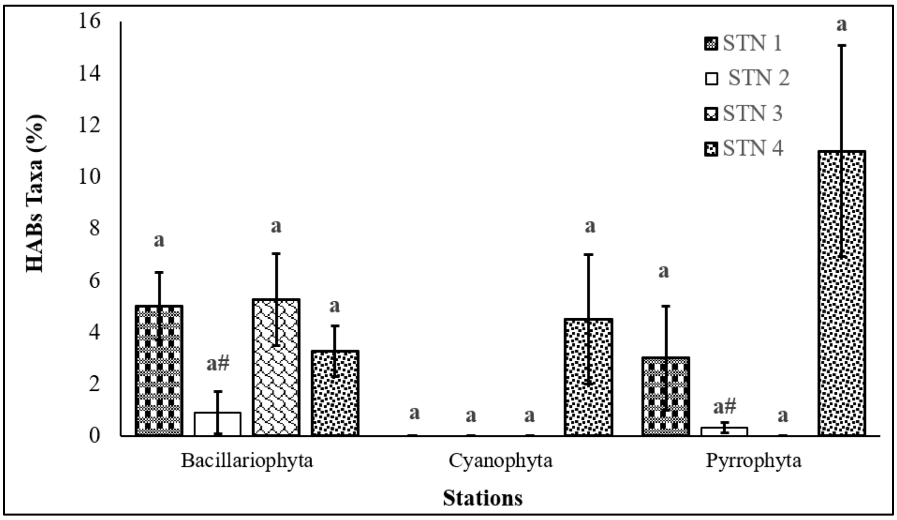

Figure 2 Percentage variation of HABs taxa of the lower Taylor creek, Bayelsa, Nigeria

Table 5 HABs heavy metals accumulation of the lower Taylor creek, Bayelsa, Nigeria

Heavy metals (mg/L)	Station				Overall Mean	Standard
	1	2	3	4		
Cd	0.00966±0.0041[a]	0.017±0.005[a]	0.019±0.0017[a]	0.032±0.013[a]	0.019±0.0035	0.005 USEPA [41]
Pb	0.024±0.013[a]	0.048±0.027[a]	0.015±0.002[a]	0.010±0.004[a]	0.024±0.0072	0.05 USEPA [41]
Ni	0.016±0.0007[a]	0.0011±0.0003[ab]	0.0013±0.0005[ab]	0.0010±0.00[b]	0.0012±0.00	0.07 WHO [42]

Note: HABs-Harmful algae bloom species, Cd- Cadmium, Pb- Lead, Ni- Nickel USEPA (United State Environmental Protection Agency)[41], WHO (World Health Organization)[42]

3.2 Health risk of phytoplankton consumption

The estimated chronic daily intake (CDI) of heavy metals through HABs consumption revealed higher exposure levels in children than adults at all stations (Table 6). For Cd, adult CDI values ranged from 0.00026 mg/kg/day (Station 1) to 0.00087 mg/kg/day (Station 4), while children recorded higher values ranging from 0.00061 mg/kg/day (Station 1) to 0.0020 mg/kg/day (Station 4). Lead followed a similar pattern, with the highest CDI values observed at Station 2 (adult:

0.0013 mg/kg/day; children: 0.0030 mg/kg/day). Nickel exhibited minimal CDI values, and no exposure was recorded at Station 4 (Table 6).

Target Hazard Quotient (THQ) values for Cd and Pb were markedly elevated across all stations, while cadmium recorded the highest THQ values, particularly at Station 4 (adult: 12,061,538; children: 15,858,104), followed by Stations 3 and 2. Lead THQ values were also high, with a maximum (adult: 5,169,231; children: 6,796,330) at Station 2. Nickel exhibited comparatively lower THQ values across stations, and no risk was observed at Station 4 (Table 6). Hazard Quotient (HQ) values indicated that Cd posed no threat of non-carcinogenic risk for adults. HQ values ranged from 0.26 (Station 1) to 0.87 (Station 4), were below the safety threshold of 1. Consequently, HQ values for children exceeded 1 at Stations 2 (1.09), 3 (1.21), and 4 (2.05) respectively, signifying potential adverse health effects. HQ values for Pb and Ni were below unity for both age groups across all stations (Table 6).

The significantly higher CDI, THQ, and HQ values observed for children highlighted their greater susceptibility to dietary metal exposure through phytoplankton-based food webs. In aquatic ecosystems, phytoplankton serve as the primary entry point of contaminants into higher trophic levels, ultimately affecting fish and shellfish consumed by humans [**43**]. The present study revealed exceedance of HQ > 1 for Cd in children at Stations 2, 3 and 4 indicates a high probability of non-carcinogenic health effects. In this creek, heavy metals are absorbed by harmful algae species and this makes them unsafe for ingestion by other trophic level organism. This agrees with the findings by Osae *et al.* [**44**], who recorded significant higher heavy metals in some aquatic plants higher than the permissible HQ for that of children. Cadmium exposure is associated with renal dysfunction, skeletal damage, and long biological retention in humans [**45**]. Although the present study showed Pb, HQ values remained below 1, chronic exposure even at low levels can impair neurological development, particularly in children.

The Hazard Index indicated that cadmium is the dominant contributor to non-carcinogenic risk associated with phytoplankton consumption in the lower Taylor Creek. Although adult HI values remained below the critical threshold, the exceedance of HI > 1 for children at all stations suggests a high likelihood of adverse health effects. This is an indication of HABs positive association that could have positive health effects due to the high levels of heavy metals bioaccumulation and dependency of human immune defence mechanism in children not strong enough to counter human body contamination. Thus, this age dependent risk disparity is widely attributed to higher ingestion rates relative to body weight, and greater physiological sensitivity in children [**41**]. The present study tied with report by Jaishanker *et al.* [**46**], that the amount of heavy metal exposure is closely related to daily intake and composition of organism present. More so, the progressive increase in HI values from Station 1 to Station 4 reflects spatial variation in metal accumulation and highlights Station 4 as a potential contamination hotspot.

Table 6 Health risk assessment of the lower Taylor creek, Bayelsa, Nigeria

Heavy Metals (mg/L)	**Stn**	**CW**	**CDI**		**THQ**		**HQ**	
			Adult	**Children**	**Adult**	**Children**	**Adult**	**Children**
Cd	**1**	0.0096	0.00026	0.00061	36184	4757431	0.26	0.61
Pb		0.024	0.00065	0.0015	2584615	3398165	0.18	0.43
Ni		0.0016	4.38	0.00010	30153.8	39645.26	0.0021	0.0051
Cd	**2**	0.017	0.00046	0.0010	6407692	8424618	0.46	1.086
Pb		0.048	0.0013	0.0030	5169231	6796330	0.37	0.87
Ni		0.0011	3.01	7.03	20730.77	27256.12	0.0015	0.0035
Cd	**3**	0.019	0.00052	0.0012	7161538	9415749	0.52	1.21
Pb		0.015	0.00041	0.00095	1615385	2123853	0.11	0.27
Ni		0.0013	3.56	8.31	24500	32211.77	0.0017	0.0041
Cd	**4**	0.032	0.00087	0.0020	12061538	15858104	0.87	2.045
Pb		0.01	0.00027	0.00063	1076923	1415902	0.078	0.18
Ni		0	0	0	0	0	0	0

Note: Cd= Cadmium, Pb= lead, Ni= nickel, Stn= station, CW= heavy metals concentration in HABs, CDI= chronic daily intake, THQ= target hazard quotient, HQ= hazard quotient

The estimated Hazard Index (HI) values for heavy metals accumulated in HABs varied across stations and are showed in (Table 7). For adults, Cd associated HI values ranged from 0.45 at Station 1 to 0.95 at Station 4. Although all adult HI values remained below the safety threshold of 1. Thus, children consistently recorded higher HI values, exceeding the safe limit (HI > 1) at all stations, with values ranging from 1.06 (Station 1) to 2.22 (Station 4). More so, the highest HI values for both adults and children were recorded at Station 4, followed by Stations 2 and 3, reflecting increasing contamination intensity along the lower Taylor creek. The estimated lifetime cancer risk (CR) values indicated metal specific and age dependent variations (Table 7). Cadmium and Nickel contributed to carcinogenic risk, whereas Lead showed no carcinogenic risk (CR = 0) across all stations. Cadmium related cancer risk values ranged from 0.0016 to 0.0053 for adults and from 0.0037 to 0.012 for children, with the highest risk recorded at Station 4. Nickel presented a substantially higher cancer risk values, particularly for children, with adult CR values ranging from 2.74 to 3.99 and children CR values ranging from 6.40 to 9.31 across Stations 1–3. No cancer risk from Ni was recorded at Station 4.

The cancer risk assessment revealed that both Cd and Ni pose significant carcinogenic threats through phytoplankton mediated exposure pathways. Cadmium cancer risk values exceeded the maximum acceptable limit of 1×10^{-4} at all stations, indicating unacceptable lifetime cancer risk for both adults and children. Cadmium is classified as a human carcinogen, with chronic exposure linked to lung, prostate, and kidney cancers [**45**]. Nickel exhibited extremely high cancer risk values particularly among children, except Station 4 that was absence of Ni related cancer risk suggested either reduced bioavailability or lack of direct contamination sources at this station. Long-term dietary exposure to Ni has been associated with increased risk of respiratory and gastrointestinal cancers [**47**].

Table 7 Hazard index and cancer risks of the lower Taylor creek, Bayelsa, Nigeria

Heavy Metals (mg/L)	**Stn**	**HI**		**CR**	
		Adult	**Children**	**Adult**	**Children**
Cadmium	**1**	0.453072	1.057	0.0016	0.0037
Lead				0	0
Nickel				3.99	9.31
Cadmium	**2**	0.842994	1.96	0.0028	0.0066
Lead				0	0
Nickel				2.74	6.4
Cadmium	**3**	0.639746	1.49	0.0031	0.0074
Lead				0	0
Nickel				3.24	7.56
Cadmium	**4**	0.95499	2.22	0.0053	0.012
Lead				0	0
Nickel				0	0

Note: HI= Hazard index, CR = cancer risk, Stn = Stations

Given that phytoplankton form the base of the trophic structure, contamination at this level could poses cascading risks to zooplankton, fish, shellfish and ultimately human consumers of the study area. The study unfold the risk of cancer development enhance by heavy metals concentration indicating that children were at greater risk than adults, due to the rising influx of anthropogenic incidence observed from the study area.

4 Conclusion

The higher percentages of HAB taxa species from Bacillariophyta and Pyrrophyta highlighted potential flashpoint for harmful algal proliferation of the lower Taylor Creek. Consequently, the extremely high THQ values for Cd and Pb reflect severe ecological stress and contamination potential within the phytoplankton community of the lower Taylor Creek. These findings imply an elevated risk of biomagnification along the aquatic food chain, posing threats to fish, invertebrates, and ultimately human consumers. The preeminent HI and CR values underscore the role of phytoplankton as effective bioaccumulators and vectors for heavy metal transfer through the aquatic food web.

Therefore, the role of harmful algae species (HABs) in the aquatic ecosystems, their contamination serves as an early warning indicator of ecosystem health deterioration. The disproportionately higher risk observed in children HRA in the study, emphasizes the need for targeted public health interventions and stricter regulation of pollutant inputs into the lower Taylor creek.

Recommendations

Continuous monitoring of nutrient inputs, phytoplankton dynamics, and toxin-producing species is therefore recommended.

Preventive management strategies targeting nutrient reduction will be essential to mitigate HAB-related impacts in the lower Taylor Creek.

Regular monitoring of metal concentrations in primary producers, coupled with stringent control of pollution sources, is therefore essential for protecting both ecological integrity and public health.

Abbreviations

- CDI - Chronic Daily Intake
- CW - Concentration of heavy metals in the surface water
- IR - Ingestion rate
- EF- Exposure frequency
- ED- Exposure duration
- BW- Body weight
- AT - Averaging Time
- RFD- Oral reference dose
- Cd- Cadmium
- Pb- Lead
- Ni- Nickel
- Stn- Station
- HABs- Harmful algae bloom species
- THQ- Target hazard quotient,
- HQ- Hazard quotient
- HI- Hazard index,
- CR- Cancer risk

Compliance with ethical standards

Disclosure of conflict of interest

The authors declared no known conflict of interests

Authors contributions

Peremobowei Beldin Kpikpi initiated, developed, interpreted and edited the manuscript data for the study. Also, P. B. Kpikpi is the corresponding author who submitted manuscript to the journal's editor and responsible for correspondences with the editor. The second author Akpevwe Efe Okere provided all literatures, compiled the data for the study and coordinated the research.

References

[1] Backer, L. C. & McGillicuddy, D. J. Harmful algal blooms: at the interface between coastal oceanography and human health. Oceanography. 2006;19 (2): 94-106.

[2] Davies, O. A., Kpikpi, P. B., Eseanwi, L. E & London, A. D. Buffering efficiency of phytoplankton on acidic borehole water for fish production in Port Harcourt, Rivers State. Sumerianz Journal of Scientific Research. 2019; 2 (12); 150-158.

[3] Jafarzadeh, N., Heidari, K., Meshkinian, A., Kamani, H., Mohammadi, A.A & Conti, G.O. Non-carcinogenic risk assessment of exposure to heavy metals in underground water resources in Saraven, Iran: spatial distribution,

monte-carlo simulation, sensitive analysis, Environ. Res. 2022; 204, 112002, https://doi. org/10.1016/j.envres.2021.112002

[4] Kalay, M. & Canli, M. Elimination of essential (Cu, Zn) and non-essential (Cd, Pd) metals from tissues of freshwater fish Tilapia Zilli following uptake protocol. Turkish Journal of Zoology. 2000; 24: 429-436.

[5] Shaheen, N., Irfan, N.M., Khan, I.N., Islam, S., Islam, M.S. & Ahmed, M.K. Presence of heavy metals in fruits and vegetables: Health risk implications in Bangladesh. Chemosphere, 2016; 152, 431–438. doi: 10.1016/j.chemosphere.2016.02.060.

[6] Hajeb, P., Sloth, J.J., Shakibazadeh, S.H., Mahyudin, N.A. & AfsahHejri, L. Toxic elements in food: occurrence, binding, and reduction approaches. Comprehensive Reviews in Food Science and Food Safety, 2014; 13(4), 457–472. doi: 10.1155/2015/973878.

[7] Dghaim, R., Al Khatib, S., Rasool, H. & Ali Khan, M. Determination of heavy metals concentration in traditional herbs commonly consumed in the United Arab Emirates. Journal of environmental and public health, 2015; (1), 973878.

[8] Vasseghian, Y., Almomani, F., Dragoi, E. Health risk assessment induced by trace toxic metals in tap drinking water: Condorcet principle development. Chemosphere. 2022; 2866, 2, 131821.

[9] Chasapis, C.T., Loutsidou, A.C., Spiliopoulou, C.A. & Stefanidou, M. E. Zinc Human health: Update. 2012; 86 (4) 521–534, https://doi.org/10.1007/s00204-011- 0775-1.

[10] Zambelli, B., Uversky, V. & Ciurli, S. Nickel impact on human health: an intrinsic disorder perspective. Biochim. Biophys. Acta, Proteins Proteomics. 2016; 1864 (12)1714–1731. https://doi.org/10.1016/j.bbapap.2016.09.008.

[11] Esmaeilzadeh, M., Jaafari, J., Mohammadi, A.A., Panahandeh, M., Javid, A. & Javan, S. Investigation of the extent of contamination of heavy metals in agricultural soil using statistical analyses and contamination indices. Human Ecolog. Risk Assess. 2019; 25 (5) 1125–1136.

[12] Kpikpi, P. B. & Davies, O. A. Insight into the Species Composition, Diversity, Abundance and Ecology of Plankton Community in the Plastic Tank for Aquaculture. International Journal of Academic Multidisciplinary Research (IJAMR). 2025a; 9 (5):253-260.

[13] Brand, K, Larry, E., Lisa, C. & Eileen, B. The biology and ecology of a toxic genus. Harmful Algae. 2012;14: 156-178.

[14] Szymańska-Walkiewicz, M., Glińska-Lewczuk, K., Burandt, P. & Obolewski, K. Phytoplankton sensitivity to heavy metals in Baltic coastal lakes. Int J Environ Res Public Health. 2022; 19(7):4131. https://doi. org/ 10. 3390/ IJERP H1907 4131

[15] Permana, R. & Akbarsyah, N. Phytoplankton susceptibility towards toxic heavy metal cadmium: mechanism and its recent updates. World News Nat Sci. 2019; 38:83–97.

[16] Yabe, J., Ishizuka, M. and Umemura, T. (2010). Current Levels of Heavy Metal Pollution in Africa. Veterinary Medical Science, 72, 1257-1263. https://doi.org/10.1292/jvms.10-0058

[17] Davies, O. A., Allison, M. E. & Uyi, H. S. Occurrence of heavy metals in sediment, water and periwinkle (Tympanotonus fuscatus var radula) from Elechi Creek, Niger Delta, Nigeria. Environment and Ecology. 2006; 24 (2):472-478.

[18] Kpikpi, P. B., Ogonodi, B. E. & Bubu-Davies, O. A. Temporal Pollution load index and ecological risks evaluation of some heavy metals in the sediment of Elechi Creek, Port Harcourt, Nigeria. Bima Journal of Science and Technology. 2024; 8 (3B), 2536-6041.DOI: 10.56892/bima.v8i3B.847.

[19] Nikolenko, Y. & Fedonenko, E. Analysis of the content of heavy metals in phytoplankton of the Zaporizhia reservoir. Science Rise Biol Sci. 2020; 3(24):12–17. https:// doi. org/ 10. 15587/ 2519- 8025. 2020.210095

[20] Davies, O. A. & Otene, B. B. Zooplankton community of Minichinda Stream, Port Harcourt, Rivers State, Nigeria. European Journal of Scientific Research, 2009; 26(4): 490-498.

[21] Kpikpi, P. B., Ogonodi, B. E. & Enize, B. T. Spatio-seasonal variation of phytoplankton composition and some physico-chemical parameters of the lower Taylor Creek, Bayelsa State, Nigeria. International Journal of Scientific Research Updates. 2025b; 10(02),001-011. https://doi.org/10.53430/ijsru.2025.10.2.0043

[22] Schuhmacher, M. & Domingo J. L. Concentrations of selected elements in oysters (Crassostrea angulata) from the spanish coast. Bull Environ Contam Toxicol. 1996; 56(1):106–113. https:// doi. org/10./s0012 89900 016

[23] Munshi, J. D., Roy, S. P. & Munshi, D. Manual of Freshwater biota. Narendra Publising House, Delhi. 2010;1. 455.

[24] Bellinger, E. G. & Sigee, D. C. Freshwater algae: identification, enumeration and use as bioindicators. John Wiley & Sons, Ltd, 2015; 275.

[25] Guiry, M. D. & Guiry, G. M. AlgaeBase.World-wide electronic publication, National University of Ireland, Galway. 2022. https://www.algaebase.org.

[26] Muhammad, S., Shah, M. T. & Khan, S. Health risk assessment of heavy metals and their source apportionment in drinking water of Kohistan region, north Pakistan. Microchemical journal, 2011; 334-343.

[27] USEPA (United States Environmental Protection Agency). EPA Region III Risk-Based Concentration (RBC) Table 2008 Region III, 1650 Arch Street, Pennsylvania, Philadelphia, 2012; 19103.

[28] USEPA. Guidelines for Carcinogenic Risk Assessment. EPA/630/P-03/001F, Risk Assessment Forum, Washington, DC. 2006.

[29] USEPA (US Environmental Protection Agency)'s Integrated Risk Information System (IRIS). Environmental Protection Agency Region I, Washington DC 20460. 2011; http://www.epa.gov/iris/. Accessed on 21/04/2017.

[30] Storelli, M.M. Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: Estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). Food Chem. Toxicol. 2008; 46, 2782–2788.

[31] Wang, X., Sato, T., Xing, B. & Tao, S. Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. Sci. Total Environ. . 2005; 350, 28–37.

[32] Bortey-Sam, N., Nakayama, S.M.M., Ikenaka, Y., Akoto, O., Baidoo, E., Yohannes, Y.B., Mizukawa, H. & Ishizuka, M. Human health risks from metals and metalloid via consumption of food animals near gold mines in Tarkwa, Ghana: Estimation of the daily intakes and target hazard quotients (THQs). Ecotoxicol. Environ. Saf, 2015; 111, 160–167.

[33] USEPA (United States Environmental Protection Agency). EPA Region III Risk-Based Concentration (RBC) Table 2008 Region III, 1650 Arch Street, Pennsylvania, Philadelphia, 2012; 19103.

[34] Dienye, H. E., Sikoki, F. D., Woke, G. N. & Olopade, O. A. Diversity of bloom forming harmful algal species in the central Bonny estuary, Niger Delta, Nigeria. Marine and Fishery Sciences.2022; 35 (3): 387-402. https://Doi.Org/10.47193/Mafis.3532022010908

[35] Hallegraeff, G. M. Ocean climate change, phytoplankton community responses, and harmful algal blooms: A formidable predictive challenge. Journal of Phycology, 2010; 46(2), 220–235.

[36] Kudela, R. M. & Gobler, C. J. Harmful algal blooms caused by Cochlodinium and related species. Harmful Algae, 2012; 14, 171–184.

[37] Anderson, D. M., Cembella, A. D. & Hallegraeff, G. M. Progress in understanding harmful algal blooms: Paradigm shifts and new technologies for research, monitoring, and management. Annual Review of Marine Science, 2012; 4, 143–176.

[38] Paerl, H. W. & Otten, T. G. Harmful cyanobacterial blooms: Causes, consequences, and controls. Microbial Ecology, 2013; 65, 995–1010.

[39] Wang, W. X. & Dei, R. C. H. Metal uptake in marine phytoplankton: Mechanisms and ecological implications. Environmental Pollution, 2001;111(1), 137–149.

[40] Sunda, W. G. & Huntsman, S. A. Relationships between copper, zinc, and phytoplankton in the sea. Marine Ecology Progress Series, 2004; 282, 13–25.

[41] USEPA. Parameters of water quality interpreted and standards. US Environmental Protection Agency, Wexford. 2001;1-119. https://www.epa.ie/pubs/advice/water/quality/Water_Quality.pdf

[42] WHO. Guidelines for Drinking-Water Quaity-4th edition. World Health Organization WHO Library cataloguing-in-Publication Data. ISBN 9789241548151.2011; 564. https://www.who.int/publications/i/item/9789241548151

[43] Campbell, P. G. C., Kraemer, L. D., Hare, L. & Hontela, A. Biomagnification of metals in aquatic food webs. Science of the Total Environment, 2005; 350(1–3), 1–21.

[44] Osae, R., Nukpezah, D., Darko, D. A., Koranteng, S. S. & Mensah. Accumulation of heavy metals and human health risk assessment of vegetable consumption from a farm within the Korle lagoon catchment. Heliyon. 2023; 9(5): e166005.1-16.

[45] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for cadmium. U.S. Department of Health and Human Services. 2012; 45-210

[46] Jaishankar, M., Tseten, T., Anbalagan, N., Mathew B. B. & Beeregowda, K.N. Toxicity, mechanism and health effects of some heavy metals. Interdisc Toxicol. 2014; 7(2): 60-72.

[47] International Agency for Research on Cancer (IARC). World Cancer Report 2008. 2010; 42-43. https://www.iarc.fr/en/media-centre/iarcnews/2010/globocan2008.php