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Impact of Climate Change on the Influx of Hydrocarbon and Heavy Metals into a Fresh Water System

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Authors' contributions

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

Original Research Article

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ABSTRACT

Meteorological events are posing serious environmental challenge especially in freshwater pollution control. Imo River serves as a source of water for domestic uses, agricultural irrigation, fishery and recreational activities and exposed to pollution. Surface water samples were collected in dry and rainy seasons for 2 years, with the aid of 1-liter water sampling cans, from seven major human impacted points. Copper (Cu), zinc (Zn), oil and grease levels, all in mg/L, and pH were determined according to standard methods for the examination of water. There were significant variations in seasons (P=0.05) for oil and grease at all the locations; Ekenobizi (1.42±0.01-1.33±0.01), Udo (1.91±0.01-1.32±0.01), Owerrinta (3.74±0.57-2.36±0.01), Alulu (1.52±0.01-1.22±0.01), Owaza (6.73±1.00-4.22±0.01), Obigbo (4.55±0.01-3.13±0.01), and Akwette (13.75±0.0112.42±0.01). There were significant variations in seasons for copper (mg/L) (P=0.05) at Udo (0.09±0.01-0.06±0.01), Obigbo (0.14±0.01-0.11±0.01), and Akwette (0.19±0.010.15±0.01), while there were none (P=0.05) at Ekenobizi (0.13±1.060.06±0.01), Owerrinta (0.04±0.01-0.02±0.01), Alulu (0.01±0.01-0.01±0.01), and Owaza (0.30±0.10-0.24±0.01). There were no significant variations in seasons (P=0.05) for zinc at; Ekenobizi (0.03±0.01-0.02±0.01), Udo (0.04±0.01-0.03±0.01), Owerrinta (0.04±0.01-0.03±0.01), Alulu (0.04±0.04-0.01±0.01), Owaza (0.20±0.10-0.13±0.06) and Akwette (0.08±0.01-0.07±0.01) while there were significant variations in

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seasons (P=0.05) at Obigbo (0.14±0.01-0.12±0.01). There were significant variations in seasons (P=0.05) for pH at Ekenobizi, Udo, Owerrinta, Alulu, Owaza and Akwette, while, there were no significant variations in seasons (P=0.05) at Obigbo. Rainfall event contributed to the diffusion of pollutants into Imo River. Environmentally sustainable waste management programs and policies will prevent and protect it from subsequent destruction of the quality.

Keywords: Climate change; rainfall; pollution; freshwater quality.

1. INTRODUCTION

Imo River is one of the major rivers in the southeastern Nigeria. It probably originated from Isiochi in Abia State and cuts across three states including Abia, Imo, and Rivers States. Imo River flows from the eastern-north to the eastern-south, emptying in the Atlantic Ocean. The river serves as source of water for domestic uses, fishery, recreational activities, and agricultural irrigation programs for more than 5 million people settling close to the water body [1]. Apart from the afore listed uses, the river serves as recipient of industrial effluent discharges and oil spill from oil exploration and activities, dumping site for domestic wastes including sewage and industrial solid waste, and runoffs from agricultural lands. Some major human impacted points of the river include Ekenobizi, Udo, Owerrinta, Alulu, Owaza, Akwette, and Obigbo.

Discharge of organic waste in Nigeria is on the increase [2]. Apart from oil spill, industries sited along the rivers discharge their effluents into these water bodies [3]. Water bodies contaminated with oil spillage and refinery effluent have been found to be very high in phenol, oil and grease, ammonia, COD, BOD, TDS, PO_4^{2-} and heavy metals [4].

In the Niger Delta region of Nigeria upstream and downstream activities of the petroleum industry, may have introduced high concentrations of oil and grease, and heavy metals into rivers, streams and other waterways [5]. Discharge of pollutants such as oil and grease into the water can lead to an increase in the temperature of the receiving water bodies several degrees above the normal and affect aquatic organisms both directly and indirectly [6]. Phenol is one of the major pollutants found in refinery effluents [4]. Phenols have been observed to be very toxic to fish and other aquatic organisms and have a nearly unique property of tainting the taste of fish if present in marine environment in concentration ranging from of 0.1 to 1.0mg/l [7]. Otokunefor and Obiukwu [4] in their work on impact of refinery effluent on the physicochemical properties of a water body in the Niger Delta, Nigeria, reported a dramatic reduction in the number of viable microorganisms found at the point of impact.

Heavy metals have a great ecological significance due to their toxicity and accumulative behaviour. The contamination by heavy metals causes a serious problem because they cannot naturally degrade like organic pollutants and they accumulate in different parts of the food chain [8]. The release of metals such as Al, As, Cd, Cr, Cu, Fe, Hg, Pb, Tl, and Zn into water bodies may lead to major destruction of aquatic ecosystems [9]. A number of metals cause toxic responses to fish and other organisms in the local rivers, especially Cu, Zn, Cd and Al [10-12].

Meteorological events and pollution are a few of the external factors that affect physicochemical parameters of water bodies [13]. These parameters have major influence on speciation of heavy metals that occur within the water. Sudden changes of these parameters may be indicative of changing condition in the water. Freshwater exhibits a high natural variability in their physical and chemical properties due to local differences in geology and climate. They are therefore more susceptible to anthropogenic influence than the aquatic environment [14]. Seasonal changes can influence the discharge of pollutants in the aquatic systems, bringing about deterioration of the water quality and subsequent colossal impact on aquatic chemistry, biota and sustainability.

These possible effects underscored the need to ascertain the impact of seasonal changes on the discharge of Cu, Zn, oil and grease and on the quality of Imo River in Nigeria.

2. MATERIALS AND METHODS

2.1 Sample Collection

The study area is Imo River and is as shown in Fig. 1 (Location map of Imo River showing the sampling points). Surface water samples were collected from seven major human impacted points of Imo River. Samples were collected in triplicates with the aid of 1-liter water sampling cans. Collected samples were immediately transported to the laboratory. The samples were collected in two seasons–dry and rainy seasons for two years. The dry season was between November and March while the rainy season was between May and September.

2.2 Chemical Analysis

The oil and grease, copper (Cu) and zinc (Zn) all in mg/L concentrations of the water samples were determined as described in the Standard Methods for the Examination of Water and Wastewater [15].

3. RESULTS AND DISCUSSION

3.1 Results

Table 1 shows seasonal variation in oil and grease, copper, zinc (all in mg/L) and pH.There were significant variations in seasons (P=0.05) for oil and grease at all the locations; Ekenobizi (1.42±0.01-1.33±0.01), Udo (1.91±0.01-1.32±0.01), Owerrinta (3.74±0.57-2.36±0.01), Alulu (1.52±0.01-1.22±0.01), Owaza (6.73±1.00 - 4.22±0.01), Obigbo (4.55±0.01 - 3.13±0.01), and Akwette (13.75±0.01 - 12.42±0.01).

There were significant variations in seasons for copper (mg/L) (P=0.05) at Udo (0.09±0.01 - 0.06±0.01), Obigbo (0.14±0.01-0.11±0.01), and Akwette (0.19±0.01-0.15±0.01), while there were none (P=0.05) at Ekenobizi (0.13±1.06-0.06±0.01), Owerrinta (0.04±0.01-0.02±0.01), Alulu (0.01±0.01-0.01±0.01), and Owaza (0.30±0.10-0.24±0.01).

There were no significant variations in seasons (P=0.05) for zinc at; Ekenobizi (0.03±0.01-0.02±0.01), Udo (0.04±0.01-0.03±0.01), Owerrinta (0.04±0.01-0.03±0.01), Alulu (0.04±0.04-0.01±0.01), Owaza (0.20±0.10-0.13±0.06) and Akwette (0.08±0.01-0.07±0.01) while there were significant variations in seasons (P=0.05) at Obigbo (0.14±0.01-0.12±0.01).

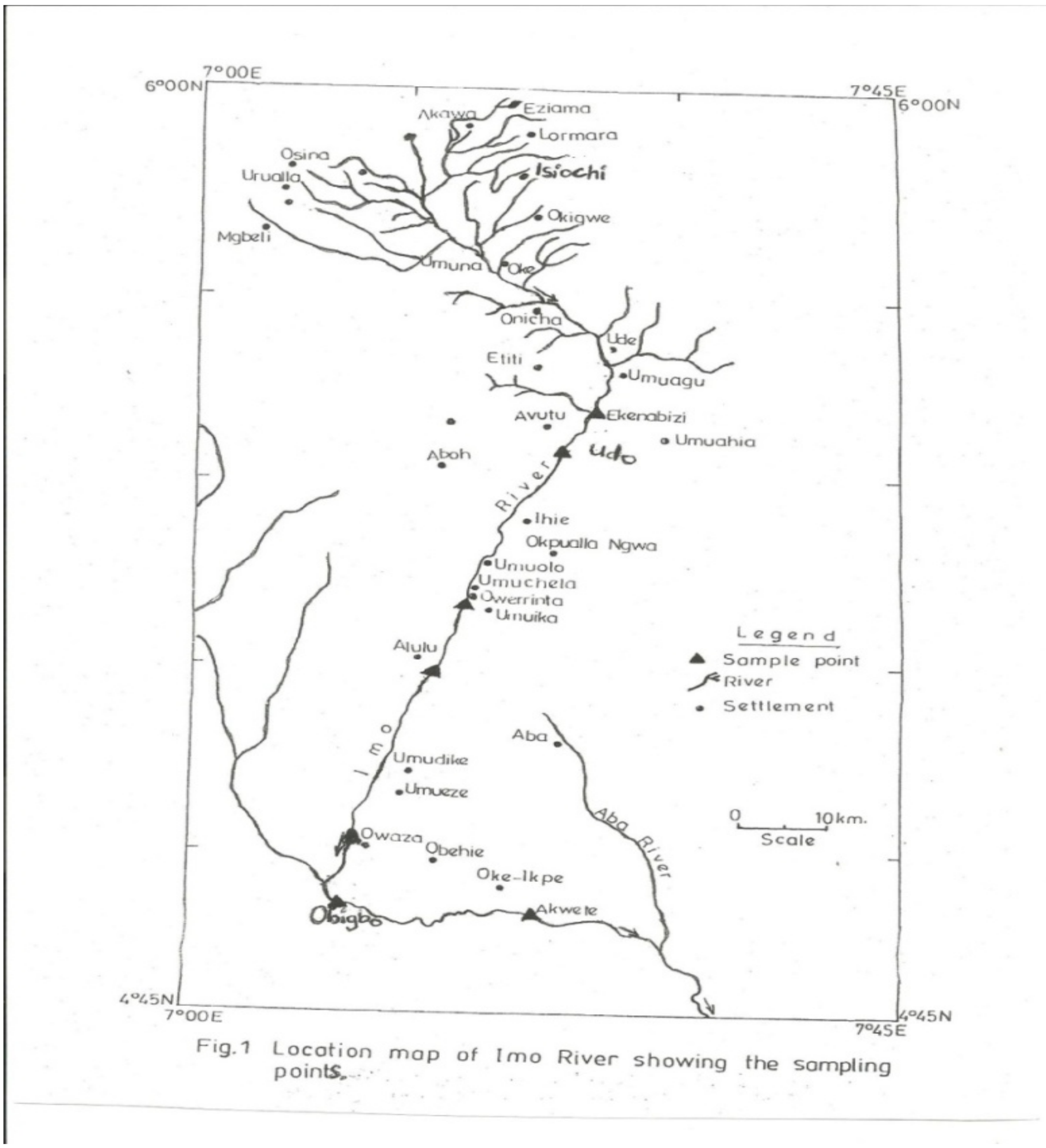

Fig. 1. Location map of Imo river showing the sampling points

There were significant variations in seasons (P=0.05) for pH at Ekenobizi (6.35±0.00-6.16±0.00), Udo (6.36±1.01-6.02±0.01), Owerrinta (5.94±0.02 - 5.66±0.01), Alulu (5.80±0.10 -5.18±0.01), Owaza (6.16±0.01-5.80±0.10) and Akwette (5.92±0.01-5.83±0.01), while, there were no significant variations in seasons (P=0.05) at Obigbo (5.65±0.07-5.49±0.28).

3.2 Discussion

Activities of oil pipeline vandalization at Akwette Point of Imo River and oil exploration and oil spill at Owaza and neighbouring areas of Obigbo might be responsible for large quantities of oil discharged to the surface water especially through run-offs during rainy season. Apart from other locations, the concentrations of oil and grease at Akwette point of Imo River (12.42 and 13.75mg/L) exceeded the maximum permissible limit of 10mg/L [16]. The discharge of spent oil by mechanic workshops, oil spills at some oil prospecting areas of the study area, leakage of oil pipelines and tanks, direct disposal of oily containers and reservoirs might have contributed to significant inputs of oil and grease in the water body. Flooding and heavy rainfall events common in the Southeastern and South-southern parts of Nigeria where the River is located might have increased the discharge of higher concentrations of oil and grease and heavy metals in the rainy season more than during the dry season.

Table 1. Seasonal variation in oil and grease, Cu, Zn and pH

Locations	Season	Oil and Grease	Cu	Zn	pH
Ekenobizi	Dry	1.33±0.01A	0.06±0.01B	0.03±0.01B	6.35±0.00A
	Rainy	1.42±0.01A	0.13±1.06B	0.02±0.01B	6.16±0.01A
Udo	Dry	1.32±0.01A	0.06±0.01A	0.03±0.01B	6.02±0.01A
	Rainy	1.91±0.01A	0.09±0.01A	0.04±0.01B	6.36±1.01A
Owerrinta	Dry	2.36±0.01A	0.02±0.01A	0.03±0.01B	5.66±0.01A
	Rainy	3.74±0.57A	0.04±0.01A	0.04±0.01B	5.94±0.02A
Alulu	Dry	1.22±0.01A	0.01±0.01B	0.04±0.04B	5.18±0.01A
	Rainy	1.52±0.01A	0.01±0.01B	0.01±0.01B	5.80±0.10A
Owaza	Dry	4.22±0.01A	0.30±0.10B	0.13±0.06B	6.16±0.01A
	Rainy	6.73±1.00A	0.24±0.01B	0.20±0.10B	5.80±0.10A
Obigbo	Dry	3.13±0.01A	0.11±0.01A	0.14±0.01A	5.49±0.28B
	Rainy	4.55±0.01A	0.14±0.01A	0.12±0.01A	5.65±0.07B
Akwette	Dry	12.42±0.01A	0.19±0.01A	0.08±0.01B	5.83±0.01A
	Rainy	13.75±0.01A	0.15±0.01A	0.07±0.01B	5.92±0.01A

At P=0.05, values with A-letter are significantly different from each other; At P=0.05, values with B - letter are not significantly different from each other

Petroleum hydrocarbons aretoxic to aquatic life, Lipophilic hydrocarbons can accumulate in the membrane lipid bilayers of microorganisms and interfering with their structural and functional properties [17]. The high concentration of oil and grease observed in the river in combination with other pollutants could lead to possible depletion of aquatic life [4].

Odokuma and Ijeomah [5] reported seasonal variation in zinc but recorded higher level during the dry season against the result of this work. The higher levels of zinc recorded during the rainy season at Obigbo might be due to diffused pollution caused by heavy rainfall events. Choudhury and Srisvastava [17] reported that considerable variation in heavy metal content of freshwater systems could result from three major sources: differences in the underlying bedrock, as well as pollution resulting due to human activities and biosphere, resulting either from bioaccumulation or leaching of metals from soils. Indiscriminate dumping of industrial waste on undesignated places might expose the chemical constituents including toxic heavy metals, to leaching and erosion and subsequent deposition into Imo River. The zinc levels are below the FEPA limits (<1mg/l), [16].

The pH ranged between 5.1 and 6.36 and was not within FEPA standard [6-9]. The pH at some locations was acidic. This was influenced by the influx of carbonate-bicarbonate and carbon (IV) oxide equilibrium [18]. Apart from pollution, climate change or meteorological event (seasonal change) can affect pH of aquatic systems. This was supported by the report of Bezuidenhout et al. [18]; Odokuma and Okpokwasili [19] have made similar observations.

Slightly alkaline pH is preferable in waters, as heavy metals are removed as carbonate or bicarbonate precipitates. Heavy metals are not as toxic to aquatic life at alkaline pH as they are present mostly in the unavailable form. This corroborates the reports of Hacioglu and Dugler [20]. Water pH affects metal toxicity in two ways, firstly the speciation and bioavailability of metals may change, and secondly, the uptake and toxicity of metals was affected by changes in the sensitivity of the cell surfaces. This is in consonance with the works of Campbell and Stokes [21]. The study revealed that the pH range favored increased heavy metals speciation, bioavailability, and toxicity in Imo River. The works of Hacioglu and Dugler [20] support this.

Those areas that showed no seasonal variations in the measured parameters, might be exposed to continuous direct dumping of wastes, in and out of season in the water body and might also be that there were no discharge of such pollutants at the areas at all.

4. CONCLUSION

This study showed that climatic events like rainy season contribute significantly to the diffusion and deposition of pollutants into freshwater bodies which poses serious problem on water quality and survival of biota.

COMPETING INTERESTS

Authors declare that there are no competing interests.

REFERENCES

1. Ihejirika CE, Njoku JD, Nwaogu LA, Obenade M, Ebe TE, Ejiogu CC, Iwuji MC. Effects of meteorological events on the levels and interactions of chemical indices of a polluted freshwater system. International Journal of Environmental Science, Management and Engineering Research. 2012;1(1):31-37.
2. Odokuma LO, Okpokwasili GC. Seasonal Ecology of Hydrocarbon-utilizing microbes in the surface waters of a river. Environmental Monitoring and Assessment. 1993;27:175-191.
3. Ihejirika CE, Emereibeole EI, Nwaogu L, Uzoka CN, Amaku GE. Physicochemical dynamics of the impact of paper mill effluents on Owerrinta River, eastern Nigeria. J. Environ. Chem. Ecotoxicol. 2011;3(11):298-303.
4. Otokunefor TV, Obiukwu C. Impact of refinery effluent on the physicochemical properties of a water body in the Niger Delta. Apllied Ecology and Environmental Research. 2005;3(1):61-72.
5. Odokuma LO, Ijeomah SO. Seasonal changes in the heavy resistant bacterial population of the New Calabar River, Nigeria. Global Journal of Pure and Applied Sciences. 2002;9(4):425-433
6. Alabaster T, Pearce JA, Mallick DIJ, Elboushi IM. The volcanic stratigrapgy and location of massive sulphide deposits in the Oman ophiolite, in Panayiotou A ed., Ophiolites: Proceedings of the International Ophiolite Symposium: Nicosia, Cyprus, Cypus Ministry of Agriculture and Natural Resources, Geology Survey Department, 1980;75-757.
7. Staples CA, Dorn PB, Klecka GM, O'Block ST and Harris LR. A review of the environmental fate, effects and exposures of bisphenol A. Chemosphere, 1998;36:2149-2173.

8. Smejkalova M, Mikanowa O, Borunka L. Effect of heavy metal concentrations on biological activity of heavy metal concentrations on biological activity of soil microorganisms. Plant, Soil and Environment-UZPI. 2003;49(7):321-326.
9. Masnado RG, Geis SW, Sonzogni WC. Comparative acute toxicity of a synthetic mine effluent to *Ceriodaphnia dubia,* larval fathead minnow and the fresh–water mussel *Anodonta imbecilis.* Environmental Toxicol. Chem. 1995;14(11):1913–20.
10. Gundersen P, Steinnes E. Influence of pH and TOC concentration on Cu, Zn, Cd, and Al speciation in rivers. Wat Res. 2003;37:307-318.
11. Kevin F, Ramsey P, Frazar C, Moore JN, Gannon JE, Holben WE. Differences in hyporheic–zone microbial community structure along a heavy-metal contamination gradient. Applied and Environmental Microbiology. 2003;69(9):5563-5573.
12. Obiajurul OC, Ogbulie JN. Bacteriological quality of some fishes and crab from rivers within Imo River Basin. J. Aquat. Sci. 2006;21(1):1-2.
13. Nurcihan H, Basaran D. Monthly variations of some physicochemical and microbiological parameters in Biga stream (Biga, Canakkalo, Turkey). African Journal of Bacteriology. 2009;8(9):1929-1937.
14. Kpee F, Ozioma E, Ihunwo L. Seasonal variation of Cd, Ni, Cu, and Pb in Catfish, sediments and Water samples from Ipo stream in Ikwere District of Rivers State, Nigeria. J. Appl. Sci. 8 Environ. Manage. 2009;13(2):63-67.
15. APHA/AWWA/W/WPCF. Standard Methods for the Examination of Water and Waste water. 16th ed. American Public Health Association Washington D.C.1985;76– 538.
16. FEPA. Effluent limitation guidelines in Nigeria for all categories of industries. Federal Republic of Nigeria Official Gazette; 1991.
17. Choudhury R, Srivastava S. Zinc resistance mechanisms in bacteria. World J. Microbiol. Biotechnol. 2001;17:149–153.
18. Bezuidenhout CC, Mthembu N, Puckee T, Lin J. Microbiological evaluation of the Mhlathuze River Kwazulu-Natal (RSA) Water SA. 2002;28(3):281-286.
19. Odokuma LO, Okpokwasili GC. Seasonal Ecology of Hydrocarbon-utilizing microbes in the surface waters of a river. Environmental Monitoring and Assessment. 1993;27: 175-191.
20. Hacioglu N, Dugler B. Monthly variation of some physic-chemical and microbiological parameters in Biga Stream. African Journal of Biotechnology. 2009;8(9):1929-1937.
21. Campbell PGC, Stokes PM. Acidification and toxicity of metals to aquatic biota. Canadian Journal of Fish and Aquatic Sciences. 1985;42:2034-2049.

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