Carcinogenic Risk from Heavy Metals Exposure in Oil Producing Areas of Niger Delta, Southern Nigeria

U.G. Eluke, J. Ugbebor, E. Membere

***Abstract*— The study assessed the concentration heavy metals and soil and water samples in oil producing communities of Rivers, Delta, Bayelsa and Akwa-Ibom states. The estimated daily intake of the metals and cancer risk of the inhabitants were also assessed. The average concentration of lead in water samples ranged from 0.27 ±0.08mg/L to 1.07 ±0.20mg/L. The Iron concentration ranged from 7.42 ±1.69mg/L to 11.09 ±1.45mg/L. The Zinc levels ranged from 15.69 ±1.67mg/L to 18.96 ±1.95mg/L. The arsenic concentration ranged from 0.02 ±0.01mg/L to 0.05 ±0.01 mg/L. The Nickel concentration ranged from 0.06 ±0.01mg/L to 0.14 ±0.02mg/L. The estimated daily intake of Cadmium, Nickel, Arsenic and lead was negligible (< 0.1mg/L). The estimated daily intake of Zinc ranged from 0.70 to 0.91mg/L. The daily intake of iron ranged from 0.2 to 0.5mg/L.The estimated cancer risk of adult inhabitants in the study locations. The risk for cancer ranged from 3.6 to 9.2 x10-3 in Rivers state. In Delta state, Cancer risk ranged between 1.8 to 8.6 x 10-3. In AkwaIbom, the risk ranged from 1.2 to 1.8 x 10-3. In Bayelsa state, the risk ranged from 1.2 to 4.1 x 10-3. There is a need for urgent actions need to be taken to treat water sources and curb environmental pollution in the oil producing states of the Niger Delta region.**

***Index Terms*— Heavy metals, cancer risk, oil exploration, Niger Delta.**

I. Introduction

Frequent oil spills in the Niger Delta resulting from pipeline vandalism, theft, and poor maintenance are a major source of environmental pollution. When crude oil or other petroleum products leak into the environment, the different compounds (depending on their physical properties) evaporate into the air, are absorbed by the soil, or enter ground and surface water(Nriagu et al., 2016; Olawoyin et al., 2012). Oil spills also often lead to fires, which release respirable particulate matter (PM) into the air. Hazards to human health may result from dermal contact with soil and water; ingestion of contaminated drinking water, crops, or fish; or inhalation of vaporized product or PM and partly burned hydrocarbons produced by fires(E. Ite et al., 2013; Onojake & Frank, 2013). In addition, onshore oil spills may have indirect health effects via damage of livelihood resources, such as diminished yields from degraded agricultural land and fishing grounds(Bello et al., 2019). While various studies that document significant levels of water and soil contamination in the Niger Delta highlight the potential health hazards of such contamination(Bruederle & Hodler, 2019; Kalagbor et al., 2019).

Along with the various effects oil pollution has had on the Niger Deltas vegetation and agricultural land, oil pollution has also impacted the health of the local residents(Benson et al., 2008; Olawoyin et al., 2012). The ingestion, contact, and inhalation of constituents of spilled crude oil may have acute and long-term health implications(Enuneku et al., 2018). Although the acute manifestations of the exposures are often transient, severe exposures can result in acute renal failure, hepatoxicity and hemotoxicity, and even infertility and cancer(Richard et al., 2019; Ubiogoro & Adeyemo, 2017).Oil pollution in the Niger Delta is an ongoing chronic disaster and an environmental adversity with no end in sight, and entails little or no support for communities and individuals that are affected(Enuneku et al., 2018; Ubiogoro & Adeyemo, 2017). The chronic nature of the oil pollution and its associated environmental and social impacts may have an insidious impact on one's physical health sustained systemic toxicity by oil-related contaminants) and mental health (such as increased risk for high levels of distress) which are different from those of discrete traumatic events(Benson et al., 2016; Nriagu et al., 2016). The study assessed the concentration of heavy metals in environments of oil producing communities with the associated cancer risks.

II. METHODS

Study Area

This study was conducted in selected oil producing communities in the Niger Delta. The Niger Delta is the fan-shaped area of about 70,000 square kilometers in the southern part of Nigeria, through which river Niger and river Benue empty into the Atlantic Ocean. It is basically a huge floodplain, formed primarily by centuries of silt washed down by the rivers Niger and Benue and crisscrossed by a web of creeks that link together the main rivers of Benin, Bonny, Brass, Cross, Forcados, Kwa-Ibo, Nun and other rivulets and streams.

Sample Collection and Preparation

Five sampling stations were established.Three (3) sampling points were selected each from 4 states of the Niger Delta and one state without any form of oil and gas related activity.Soil samples were collected into aluminum foil from the different sampling stations while river water from the different study areas were collected in 2.5 L pre-treated Winchester bottles. Samples were preserved at -4^{0}C using an ice pack. Water samples were collected in brown glass bottles pre-washed with detergent, rinsed with water and pure acetone (99.9%) and then dried before samples collection.

U.G. Eluke, Center for Occupational Health, Safety and Environment, Faculty of Engineering, University of Port Harcourt, Port Harcourt, Nigeria
J. Ugbebor, Center for Occupational Health, Safety and Environment, Faculty of Engineering, University of Port Harcourt, Port Harcourt, Nigeria
E. Membere, Center for Occupational Health, Safety and Environment, Faculty of Engineering, University of Port Harcourt, Port Harcourt, Nigeria

Samples were taken from 0.1 m below the water surface and transported directly to the lab.Soil samples were collected from the top 10-cm layer of the sampling points. Soil samples were obtained with a stainless-steel auger after removal of the uppermost debris from the soil layer. Samples were air-dried for 14 days, then shell and plant fragments will be removed by passing the dried sample through a 2-mm sieve. The sieved samples were powdered and stored in the deep freeze until analysis.The concentrations of Pb, Fe, Zn, As, Ni and Cd was determined by the vigorous digestion method as previously described(Enuneku et al., 2018).

Carcinogenic Risk

Heavy metal Risk Assessment. Significant carcinogenic and non-carcinogenic human health risk associated with heavy metal (Pb, Fe, Zn, As, Ni and Cd) exposure from samples was determined using Estimated daily intakes (EDI)and Carcinogenic risk as previously described(Olawoyin et al., 2012).

III. RESULTS

Table 1 shows the average concentrations of heavy metals in soil samples at the different locations. The mean lead concentration was highest in Delta state (3.22±0.60mg/kg) and lowest in Bayelsa state 0.83 ±0.26mg/kg. The mean Iron concentration was lowest in AkwaIbom (29.69 ±6.79mg/kg) and highest in Rivers state (44.36 ±5.81mg/kg). The mean Zinc concentration was least in AkwaIbom (66.28 ±2.31mg/kg) and highest in Bayelsa state (75.85 ±7.81mg/kg). The mean arsenic concentration was lower in Akwa-Ibom (0.51 ±0.07mg/kg) and highest in Bayelsa state (1.09 ±0.31mg/kg). The Average Nickel concentration was lower in Bayelsa state (1.27 ±0.98mg/kg) and found to be higher in Delta state (3.15 ±0.35). The mean Cadmium concentration was lower in Bayelsa state (0.26 ±0.12mg/kg) and highest in Akwa-Ibom (0.47 ±0.03mg/kg).

Table 1: Average Concentrations of Heavy metals in soil samples from selectedcommunities.

Heavy metals	Rivers	Delta	Akwa-Ibom	Bayelsa	Enugu (Control)
Pb (mg/kg)	1.75 ±0.46	3.22 ±0.60	0.97 ±0.18	0.83 ±0.26	1.38 ±0.58
Fe (mg/kg)	44.36 ±5.81	37.28 ±3.35	29.69 ±6.79	31.58 ±3.44	37.89 ±3.94
Zn (mg/kg)	70.13 ±4.40	66.28 ±2.31	62.79 ±6.68	75.85 ±7.81	64.58 ±4.64
As (mg/kg)	1.05 ±0.30	1.04 ±0.26	0.51 ±0.07	1.09 ±0.31	0.24 ±0.12
Ni (mg/kg)	2.45 ±0.57	3.15 ±0.35	1.41 ±0.03	1.27 ±0.98	3.49 ±1.04
Cd (mg/kg)	0.30 ±0.15	0.44 ±0.05	0.47 ±0.03	0.26 ±0.12	0.22 ±0.11

All values are presented in mean ±SEM.

Table 2 shows the average concentrations of heavy metals in water samples at the different locations. The mean lead concentration was highest in Delta state (1.07 ±0.20mg/L) and lowest in Enugu state (0.01 ±0.01mg/L). The mean Iron concentration was lowest in AkwaIbom (7.42 ±1.69mg/L) and highest in Rivers state (44.36 ±5.81mg/L). The mean Zinc concentration was least in AkwaIbom (66.28 ±2.31mg/L) and highest in Bayelsa state (18.96 ±1.95mg/L). The mean arsenic concentration was lower in Enugu (0.01 ±0.01mg/L) and highest in Rivers, Delta and Bayelsa states (0.05 ±0.01mg/L). The Average Nickel concentration was lower in Enugu state (0.03 ±0.01mg/L) and found to be higher in Delta state (0.14 ±0.02mg/L). The mean Cadmium concentration was lower in Enugu state (0.005 ±0.003mg/L) and highest in Rivers state (0.03 ±0.01mg/L).

Table 2: Average Concentrations of Heavy metals in water samples from selectedcommunities.

Heavy Metals	Rivers	Delta	AkwaIbom	Bayelsa	Enugu (Control)
Pb (mg/L)	0.58 ±0.15	1.07 ±0.20	0.32 ±0.06	0.27 ±0.08	0.01 ±0.01
Fe (mg/L)	11.09 ±1.45	9.32 ±0.83	7.42 ±1.69	7.89 ±0.85	9.47 ±0.98
Zn (mg/L)	17.53 ±1.10	16.57 ±0.57	15.69 ±1.67	18.96 ±1.95	16.14 ±1.15
As (mg/L)	0.05 ±0.01	0.05 ±0.01	0.02 ±0.01	0.05 ±0.01	0.01 ±0.01
Ni (mg/L)	0.11 ±0.03	0.14 ±0.02	0.06 ±0.01	0.06 ±0.04	0.03 ±0.01
Cd (mg/L)	0.03 ±0.01	0.02 ±0.01	0.021 ±0.01	0.011 ±0.005	0.005 ±0.003

All values are presented in mean ±SEM.

Figure 1 shows the estimated daily intake of Cadmium, Nickel, Arsenic and lead was negligible (< 0.1mg/L). The estimated daily intake of Zinc ranged from 0.70 to 0.91mg/L. The daily intake of iron ranged from 0.2 to 0.5mg/L.

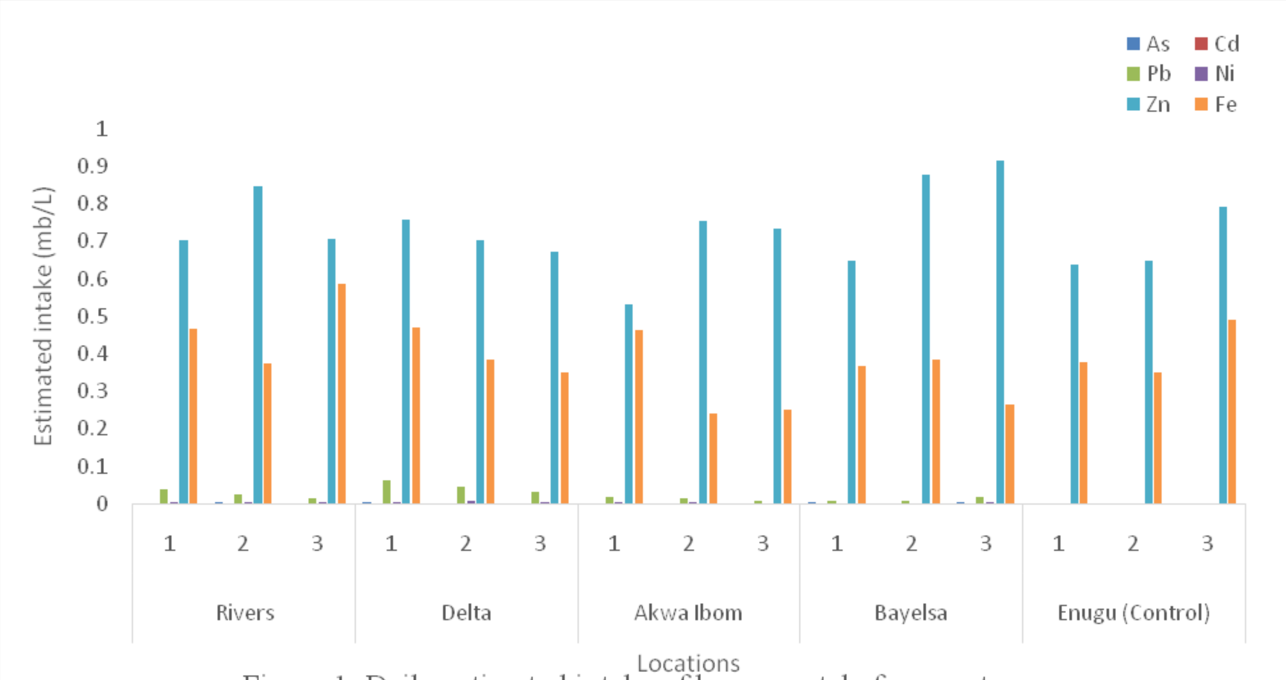

Figure 1: Daily estimated intake of heavy metals from water sources

Figure 2 shows the estimated cancer risk of adult inhabitants in the study locations. The risk for cancer ranged from 3.6 to 9.2 x10-3 in Rivers state. In Delta state, Cancer risk ranged between 1.8 to 8.6 x 10-3. In AkwaIbom, the risk ranged from 1.2 to 1.8 x 10-3. In Bayelsa state, the risk ranged from 1.2 to 4.1 x 10-3

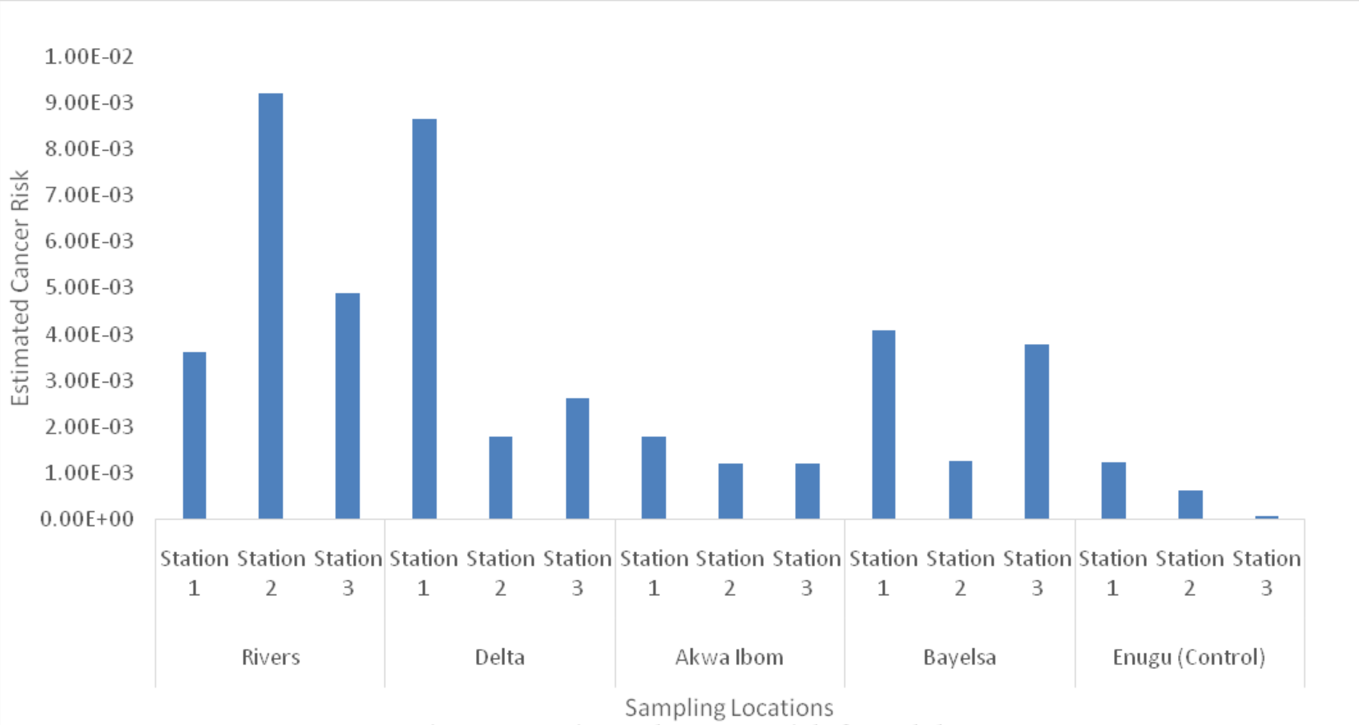

Figure 2: Estimated Cancer Risk for Adults

IV. DISCUSSION

The mean concentration of lead in the soil samples ranged from 0.83 ±0.26mg/kg to 3.22 ±0.60mg/kg. The average concentration of lead in water samples ranged from 0.27 ±0.08mg/L to 1.07 ±0.20mg/L This is consistent with the findings of a similar study that showed average lead levels in soil and water of oil producing communities ranging from 0.5 – 2.5mg/L(Bello et al., 2019; Benson et al., 2013). The variations in lead concentrations have been attributed to the extent of oil exploration ongoing. Oil spills and environmental pollution in many instances have been associated with the higher lead concentrations in soil and water bodies of oil producing areas(Bello et al., 2019; Enuneku et al., 2018; Kalagbor et al., 2019).

The estimated daily intake of Cadmium, Nickel, Arsenic and lead was negligible (< 0.1mg/L). The estimated daily intake of Zinc ranged from 0.70 to 0.91mg/L. The daily intake of iron ranged from 0.2 to 0.5mg/L. The observed estimated daily intakes of Zin and iron were found to be higher than the estimated daily intakes observed in non-oil producing communities in Southern Nigeria as reported in similar studies(Benson et al., 2008, 2016; Bruederle & Hodler, 2019). Generally, the expression of heavy metals in soil and water bodies are reported to be higher in communities where oil exploration occurs compared to non-oil producing communities(Kalagbor et al., 2019; Nriagu et al., 2016; Onojake & Frank, 2013). The estimated cancer risk of adult inhabitants in the study locations. The risk for cancer ranged from 3.6 to 9.2 $x10^{-3}$ in Rivers state. In Delta state, Cancer risk ranged between 1.8 to 8.6 x 10^{-3}. In AkwaIbom, the risk ranged from 1.2 to 1.8 x 10^{-3}. In Bayelsa state, the risk ranged from 1.2 to 4.1 x 10^{-3}. The findings of the study indicate a higher risk for cancer in the oil producing areas in contrast to non-oil producing areas. This is consistent with reports of similar studies. As previously reported, the exploration activities are directly associated with the higher concentration of heavy metals in water and soil formations(Benson et al., 2013, 2016). The heavy metals in soil are absorbed by plants. Similarly, the discharge of by-products into water bodies increases the concentration heavy metals in the water bodies leading to increased intake of toxic and carcinogenic metals.

V. CONCLUSION

The study showed that t of Zinc and Iron had the highest daily intake, with the daily intake of other heavy metals assessed being negligible. The estimated cancer risk was higher in Rivers, Delta and Bayelsa states. It is imperative that urgent actions need to be taken to treat water sources and curb environmental pollution in the oil producing states of the Niger Delta region.

REFERENCES

[1] GBello, S., Nasiru, R., Garba, N. N., & Adeyemo, D. J. (2019). Carcinogenic and non-carcinogenic health risk assessment of heavy metals exposure from Shanono and Bagwai artisanal gold mines, Kano state, Nigeria. *Scientific African*, *6*, e00197. https://doi.org/10.1016/j.sciaf.2019.e00197

[2] Benson, N. U., Anake, W. U., & Olanrewaju, I. O. (2013). Analytical Relevance of Trace Metal Speciation in Environmental and Biophysicochemical Systems. *American Journal of Analytical Chemistry*, *04*(11), 633–641. https://doi.org/10.4236/ajac.2013.411075

[3] Benson, N. U., Enyong, P. A., & Fred-Ahmadu, O. H. (2016). Trace Metal Contamination Characteristics and Health Risks Assessment of Commelina africana L. and Psammitic Sandflats in the Niger Delta, Nigeria. *Applied and Environmental Soil Science*, *2016*. https://doi.org/10.1155/2016/8178901

[4] Benson, N. U., Udosen, E. D., & Akpabio, O. (2008). Interseasonal distribution and partitioning of heavy metals in subtidal sediment of Qua Iboe Estuary and associated Creeks, Niger Delta (Nigeria). *Environmental Monitoring and Assessment*, *146*(1–3), 253–265. https://doi.org/10.1007/s10661-007-0077-5

[5] Bruederle, A., & Hodler, R. (2019). Effect of oil spills on infant mortality in Nigeria. *National Academy of Sciences*, *116*(12), 5467–5471. https://doi.org/10.7910/DVN/Q7MM1G).y

[6] E. Ite, A., J. Ibok, U., U. Ite, M., & W. Petters, S. (2013). Petroleum Exploration and Production: Past and Present Environmental Issues in the Nigeria's Niger Delta. *American Journal of Environmental Protection*, *1*(4), 78–90. https://doi.org/10.12691/env-1-4-2

[7] Enuneku, A., Omoruyi, O., Tongo, I., Ogbomida, E., Ogbeide, O., & Ezemonye, L. (2018). Evaluating the potential health risks of heavy metal pollution in sediment and selected benthic fauna of Benin River, Southern Nigeria. *Applied Water Science*, *8*(8), 1–13. https://doi.org/10.1007/s13201-018-0873-9

[8] Kalagbor, I. A., Dibofori-Orji, A. N., & Ekpete, O. A. (2019). Exposure to heavy metals in soot samples and cancer risk assessment in Port Harcourt, Nigeria. *Journal of Health and Pollution*, *9*(24). https://doi.org/10.5696/2156-9614-9.24.191211

[9] Nriagu, J., Udofia, E., Ekong, I., & Ebuk, G. (2016). Health Risks Associated with Oil Pollution in the Niger Delta, Nigeria. *International Journal of Environmental Research and Public Health*, *13*(3), 346. https://doi.org/10.3390/ijerph13030346

[10] Olawoyin, R., Oyewole, S. A., & Grayson, R. L. (2012). Potential risk effect from elevated levels of soil heavy metals on human health in the Niger delta. *Ecotoxicology and Environmental Safety*, *85*, 120–130. https://doi.org/10.1016/j.ecoenv.2012.08.004

[11] Onojake, M. C., & Frank, O. (2013). Assessment of heavy metals in a soil contaminated by oil spill: a case study in Nigeria. *Chemistry and Ecology*, *29*(3), 246–254. https://doi.org/10.1080/02757540.2012.717619

[12] Richard, G., Nwagbara, M. O., & Weli, V. E. (2019). Seasonality in Particulates Distribution from Dumpsites in the Niger Delta Region of Nigeria: A Health Risk Assessment Approach. *Www.Arcjournals.Org International Journal of Research in Environmental Science*, *5*(2), 2454–9444. https://doi.org/10.20431/2454-9444.0502002

[13] Ubiogoro, O. E., & Adeyemo, O. K. (2017). Heavy metal pollution of aquatic systems in oil producing communities of Delta state, Nigeria. *Journal of Applied Biosciences*, *120*, 11993–11998.