# DISTRIBUTION AND ENVIRONMENTAL IMPLICATION OF HEAVY METALS IN SOIL AND WATER RESOURCES OF YENAGOA AND ENVIRONS, NIGER DELTA, SOUTHERN NIGERIA.

**BY**

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**THE DEPARTMENT OF GEOLOGY**

**FACULTY OF PHYSICAL SCIENCES**

**UNIVERSITY OF BENIN**

**BENIN CITY**

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**IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF Ph.D IN ENVIRONMENTAL GEOLOGY**

**THE DEPARTMENT OF GEOLOGY**

**FACULTY OF PHYSICAL SCIENCES**

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## CERTIFICATION

This is to certify that this research work is carried out by ANGIAMOWEI VICTORIA SEIYEFA with **Mat No: PG/PSC2016206** of the Department of Geology, Faculty of Physical Sciences, University of Benin, Nigeria.

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## DEDICATION

This research project is dedicated to my greatest source of strength, the giver and sustainer of life God Almighty whose love has been my divine help.

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## ABSTRACT

Due to industrialization, population growth and urbanization in Yenagoa and environs, anthropogenic activities are increasing daily and could introduce contaminants into soil and water resources.This study evaluated the causes, distribution, and environmental effects of heavy metal pollution in groundwater, surface water, and soil in Yenagoa and environs, Niger Delta, Southern Nigeria. The study sought to compare concentrations with control values for soil, surface and ground water, and regulatory standards (WHO and NSDWQ) for groundwater, as well as assess the degree and variability of heavy metal pollution across various anthropogenic sites, including waste disposal sites, mechanic shops, cassava mills, and areas affected by crude oil spills.

A total of one hundred and twelve (112) samples were randomly collected for each season, including 77 soil samples depth 30cm and 35 surface and ground water samples. These samples were then evaluated using standard laboratory technique, Atomic Absorption Spectrophotometer (AAS) during both the wet and dry seasons. Soil contamination levels were measured using pollution indicators such the Geo-accumulation Index (Igeo), Enrichment Factor (EF), Contamination Factor (CF), and Pollution Load Index (PLI), and groundwater quality was assessed in relation to allowable limits.

Results showed that all site types exhibited elevated concentrations of key heavy metals including iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), lead (Pb), cadmium (Cd), chromium (Cr), and vanadium (V). Crude oil spill sites recorded the highest soil contamination, with lead reaching 15.354 mg/kg and

cadmium 2.755 mg/kg. The Igeo for copper exceeded 5 at mechanic workshops, indicating extreme pollution, while lead exceeded an Igeo value of 4 at spill sites. EF revealed significant anthropogenic influence, particularly for vanadium, which peaked at 19.47 in workshop soils, and cadmium, with EF values greater than 16 at dumpsites. PLI values exceeded 1.5 across all sites, and reached over 5.0 in some spill zones, confirming progressive and severe environmental degradation. Analysis of groundwater showed ongoing violations of legal requirements. While Cd and Fe peaked at 0.092 and 0.811 mg/L, respectively, well above their respective safety standards, lead concentrations around crude oil spill sites reached 0.133 mg/L, more than thirteen times the permissible limit. During the wet season, surface water tests were significantly affected; Cu levels exceeded 2.43 mg/L and Zn levels near mechanic shops and dumpsites reached 7.176 mg/L. Water samples displayed increased pollution during the rainy season as a result of leaching and runoff, while seasonal trends showed higher metal build-up in soil during the dry season. Analysis of Variance (ANOVA) revealed that heavy metal concentrations varied significantly both spatially and seasonally across the study area, with crude oil spill–affected sites exhibiting the highest contaminant levels and overall metal concentrations significantly elevated in the dry season compared to the wet season ($p < 0.05$). Correlation analysis further demonstrated strong positive inter-metal associations across soil, groundwater, and surface water samples, exemplified by a high iron–manganese correlation ($r \approx 0.9$) that suggests common anthropogenic sources and linked geochemical behavior in these environments.The study concludes that uncontrolled human activities are the principal drivers of heavy metal contamination in the study area. Pollution profiles varied by site and season, but all exceeded environmental safety benchmarks. The consistently high pollution index values and unsafe water quality measurements underscore the urgent need for site-specific remediation, stricter waste disposal controls, and sustained environmental monitoring to protect human and ecological health in Yenagoa and environs.