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Research Article

Addressing Impacts of Heavy Metal Pollutants on Groundwater in E-waste Locations: A Case Study of Alaba International Market and Olusosun Communities in Lagos State, Nigeria

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Abstract

In the study, we examined the complex, interconnected and interdependent nature of social, economic, health and environmental dimensions of the Sustainable Development Goals (SDGs) and offer pathways for policy intervention to address the impacts of heavy metal pollutants in the environment. Potentially toxic metals (PTMs) (also called heavy metal) contamination in groundwater poses a significant threat to public health and environmental sustainability, particularly in urban areas like Alaba International Market and Olusosun communities in Lagos State, Nigeria. This issue highlights the paradoxical nature of sustainable development, where economic activities such as e-waste processing can compromise environmental and social pillars. The Equilibrium Perspectives Paradox Framework suggests that achieving sustainable development requires balancing these interconnected pillars. To address this challenge, a strategic action plan has been proposed: 1.) Establishment of a Stakeholder Committee: Comprising government representatives, scientific organizations, community associations, and NGOs to implement effective management strategies. 2.) Regulatory Enforcement: Strict regulations for e-waste handling and disposal. 3.) Groundwater Monitoring: Continuous quality checks to ensure public health safety. 4.) Health Risk Assessments: Regular evaluations focusing on vulnerable populations like children. 5.) Public Awareness Campaigns: Educating the public about health risks associated with PTMs contamination. Implementing these measures will help mitigate the negative impacts of heavy metal pollutants on groundwater while aligning with Sustainable Development Goals (SDGs) related to health (SDG 3), water quality (SDG 6), and environmental protection (SDGs 11, 12, 14 and 15). This approach underscores the need for integrated policies that balance economic growth with social equity and environmental sustainability.

Keywords

Equilibrium Perspectives, Paradox, Framework, Sustainable Development Goals, Pollutants, E-waste, Heavy Metals, Groundwater, Policy

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1. Introduction

Pollution by potentially toxic metals (PTMs) commonly called heavy metals in groundwater is a significant environmental and health concern, particularly in urban areas with high e-waste processing activities. This policy paper examines the impacts of heavy metal pollutants on groundwater in Alaba International Market and Olusosun communities in Lagos State, Nigeria.

The Alaba International Market and Olusosun communities in Lagos State, Nigeria, are key locations for informal e-waste management. The improper disposal and unregulated recycling processes in these areas have led to significant environmental challenges with social, economic and health consequences, particularly in groundwater contamination due to heavy metal pollutants which demands a nuanced approach towards addressing the problem.

Equilibrium Perspectives and Equilibrium Perspectives Paradox has been employed for its nuanced approach to social, economic, health and environmental science to policy advice. Equilibrium Perspectives and Equilibrium Perspectives Paradox are conceptual and analytical frameworks for addressing multifaceted, interconnected, interdependent and consequential problems based on the understanding of the nature and workings natural and man-made systems for predictability, optimal performance and sustainability (POS) as highlighted in the Sustainable Development Goals (SDGs). There is a clear need for policy intervention to mitigate the social and economic causes of environmental pollution vis-a-vis the consequential health impacts of heavy metal pollutants on groundwater in e-waste locations, in particular, the Alaba International Market and Olusosun communities in Lagos State, Nigeria.

1.1. Background

E-waste processing activities, such as dismantling and burning releases hazardous substances contributing to heavy metal contamination in groundwater [1]. Previous studies have shown that leachate from uncontrolled landfills is a major source of groundwater pollution [2, 3]. In Alaba International Market and Olusosun communities, informal e-waste processing is prevalent, with potential health risks to the inhabitants [3, 4].

E-wastes contain various heavy metals such as lead, cadmium, mercury, and chromium, which are toxic to human health and the environment. Improper handling of e-wastes, including burning and dismantling without proper safety measures, releases these heavy metals into the surrounding environment, leading to groundwater pollution.

PTMs are persistent and bio-accumulate in food chains. They have been linked to various illnesses, including cancer. The leaching of PTMs into groundwater and surface water, impacts on water quality. In Lagos, Nigeria, there are two major electronic waste (e-waste) dump-sites; they are the Alaba International Market and Olusosun electronic waste dump-sites. They are primary avenues for PTMs pollution of portable water for domestic and agricultural uses. There are other locations in Lagos with significant e-waste recycling activities. They include: Ojota Scrap Market, Westminster Market, Ikeja Computer Village, Lawanson Market and Solous Dumpsite. There have been concerns about increased generation and trans-boundary movement of e-waste globally. This is associated with their improper or unregulated recycling and consequential source of environmental pollution. Groundwater near these dump-sites have been found to contain PTMs. The PTMs concentrations were found to decrease with distance from the dump-site. Groundwater samples near the Olusosun dump-site were unsafe for consumption. Though other groundwater studies estimated risks associated with ingestions and dermal exposures to contaminated water, they only assessed physicochemical parameters and concentrations of PTMs in few samples which are somewhat outdated. Fatunsin et al., [5] assessed the quality of groundwater and the associated risks with consumption of groundwater near Olusosun and Alaba International Market e-waste dump-sites in Lagos, Nigeria. Lagos State, considered the commercial nerve centre of the country, is believed to house over ten percent (10%) of Nigeria's population. The Lagos State Government relies on two (2) agencies for the proper handling of hazardous wastes: Lagos Waste Management Authority (LAWMA) and the Lagos State Environmental Protection Agency (LASEPA) through which it offers formal e-waste collection. While households and Ikeja Computer Village e-wastes are collected by LAWMA, LASEPA focuses on e-wastes generated by businesses. The e-wastes collected by these two (2) agencies face different fates. The collection by LAWMA ends up in municipal dump-sites, where informal workers extract valuable materials, while LASEPA's e-wastes are stored until proper recycling solutions becomes available. Furthermore, the two (2) major refurbishing clusters in Lagos - Ikeja and Alaba; boasts of regional significance with private individuals and businesses taking up roles. They comprised around 5,500 formal businesses that are registered/tax-paying and 15,000 skilled personnel, which are involved in these clusters: supplying, refurbishing and recycling electronic equipment. These networks extend beyond Nigeria, reaching West and Central Africa (Basel Convention, 2023). Through a 2-5 years apprenticeship scheme, many of these e-waste workers are educated and trained. In stark contrast, e-waste collection and recycling rely heavily on informal "scavengers" on these Lagos dump-sites. Using handcarts, they first collect metal-containing e-wastes from households and dump-sites, sometimes paying small amounts. Collected e-wastes are dismantled manually to recover steel, aluminum, and copper. These items recovered are usually sold to industries or traders for bulk sales. Unusable materials from the e-wastes are left on dump-sites or burned. Thus highlighting the need for a rethink on strategies for management of e-wastes to avert pollution of the environment.

1.2. Objective

This is a policy paper employing the Equilibrium Perspectives and Equilibrium Perspectives Paradox Framework for Sustainable Development Goals (SDGs) to address the impacts of heavy metal pollutants on groundwater in e-waste locations in Lagos State, Nigeria. The aim is to foster a culture committed to quality and long-term organizational success for effective decision-making in e-waste management. The paper offers scientists and policymakers a working document tailored towards science-policy advice.

2. Impacts on Groundwater

The contamination of groundwater with heavy metal pollutants poses severe risks to the health of residents in Alaba International Market and Olusosun communities which should be concerning to policymakers and public health practitioners, locally and internationally. Heavy metals can cause serious health issues such as neurological disorders, kidney damage, respiratory problems, and various types of cancer. The most vulnerable populations, including children and pregnant women, are at higher risk of exposure and health effects clearly reported in a well published article.

According to Fatunsin et al., [5] the primary source of portable water for agricultural and domestic uses in Lagos, Nigeria, is groundwater. Alaba International Market electronic wastes dump-site in Ojo Local Government Area and the Olusosun electronic wastes dump-site in Kosofe Local Government Area are the largest electronic wastes dump-sites in Lagos, Nigeria. Alaba International Market, is one of largest markets for electronic equipment in West Africa and the Alaba electronic wastes dump-site is situated in it. New and used forms of electronics including outdated televisions and computers among others from US, Western Europe and China are shipped to Alaba Market through the Lagos Harbour. Obsolete and outdated electronic items and those to be discarded are usually mined and burnt for valuable components. The unwanted parts are discarded at the dump-site [6]. The Olusosun dump-site, on the other, is the biggest municipal wastes dump-site/landfill in Lagos. It has a portion dedicated to electronic wastes handling and recycling [7]. For many residents near the two dump-sites, wells and boreholes serve as their major sources of domestic water.

PTMs or simply put, heavy metal pollutants, have been found in groundwater near dump-sites and the concentrations decreased with distance from the dump-site [8-10]. Significantly higher values were also observed for physicochemical parameters of water samples sourced from the surroundings of the Olusosun dump-site in Nigeria by Oluseyi et al., [11]. Aboyeji and Eigbokhan [12] reported the water quality index (WQI) rating and geospatial analyses of groundwater samples from locations near the Olusosun dump-site which showed they were unsafe for human consumption. In addition to the use of WQI [13-15], human health risk associated with ingestions and dermal exposures to contaminated water have been assessed [16-21]. The ecological risk for calculating risk of contaminated water to the ecosystem [22-25], the heavy metal evaluation index (HEI) [22, 26] and heavy metal pollution index (HPI) [19, 26, 27] have also been calculated in other groundwater studies and used to provide measures of the water qualities and safety for consumption.

In previous studies only few metals in few samples were assessed in groundwater around Olusosun and Alaba International Market dump-sites [8, 10, 11, 28]. Besides, neither PTMs indices nor associated risks to human health and environment were assessed. Moreover, Flame Atomic Absorption Spectrophotometer (FAAS), whose limit of detection (LOD) is typically between 1 and 100 g/ L [29] were used in those studies while Fatunsin et al., [5] on the Olusosun and Alaba International Market dump-sites addressed the outdated (approximately 10 years old or more) knowledge gaps of previous studies. Fatunsin et al., (2024) [5] used more sensitive equipment (The Microwave Optical Emission Spectrometer (MPOES) having an LOD and limit of quantification (LOQ) of 0.026 - 0.039 mg/L and 0.08 - 0.11 mg/L respectively [30]) for PTMs and the evaluation of risks associated with groundwater near both Olusosun dump-site and Alaba International Market dump-site with the accuracy to inform policy decisions and their corresponding implementation activities. The purpose of the study by Fatunsin et al., [5] was to assess the quality of groundwater and risks associated with the consumption of groundwater near e-waste dump-sites in Lagos, Nigeria. The findings of Fatunsin et al., [5] below constitutes the rationale for the policy prescriptions in this paper.

3. Findings

PTMs concentrations in groundwater samples from Alaba International Market and Olusosun e-waste locations were above the permissible limits set by the World Health Organization (WHO) for cadmium and chromium [31]. Positive correlations among samples were observed suggesting common metals sources, possibly from anthropogenic activities in the market [31, 32]. The cancer risks (CR) and hazard quotients (HQ) through ingestion and dermal contact of groundwater were determined as in Sheng et al., [24].

The study by Fatunsin et al., [5] showed the following:

1) Cd and Ni concentrations for all the groundwater sampled near Alaba International Market and Olusosun dump-sites exceeded their respective drinking water limits with significant statistical differences between the geographic areas surrounding the e-waste dump-sites.
2) WQIs ranged from 97 to 1049 for the samples

(groundwater near the Alaba International Market and Olusosun electronic waste dump-sites) demonstrating that no groundwater was of excellent quality, one site reportedly had good groundwater quality while the remaining sites varied from very poor to unsuitable for drinking. Most of the samples (75% of the groundwater samples) were unsafe to drink.

3) Values of 162 to 3936 were observed for HPI which exceeded the 30 value for high pollution levels and 100 for critical pollution levels.
4) HEI thresholds and high level contamination of 1 and 20, respectively, in groundwater were exceeded.
5) Values of 490 to 4556 were observed for ERI of ground water samples. These values were all higher than 400 indicating significant ecological risks.
6) The $CR_{Children}$ and CR_{Adult} varied from 10.7×10^{-1} to 1783.3×10^{-1} and 3.7×10^{-1} to 3371.7×10^{-1}, respectively exceeding the cancer risk threshold value of 1 for children and 0.1 for adults.
7) Values of 0.71 to 23.96 and 2.89 to 113.47 were recorded as ranges for $HQ_{Children}$ and HQ_{Adults}, respectively, indicating low to high risks.

4. Policy Recommendations

1) Regulatory Framework: Implement and enforce strict regulations on e-waste management practices to prevent the release of heavy metal pollutants into the environment. This includes proper collection, recycling, and disposal methods in line with international standards.
2) Monitoring and Enforcement: Develop monitoring mechanisms to track e-waste management activities in the communities. Increase enforcement efforts to penalize illegal dumping and improper handling of e-wastes.
3) Public Awareness: Conduct awareness campaigns to educate residents, businesses, and stakeholders in Alaba International Market and Olusosun communities about the risks of heavy metal pollutants on groundwater. Encourage proper e-waste disposal and recycling practices.
4) Health Interventions: Provide healthcare facilities and services for residents affected by heavy metal exposure in the communities. Invest in health programmes focused on early detection, treatment, and prevention of heavy metal-related health conditions.

5. Conclusion

This policy paper has identified the sources and offered potential solutions to addressing the impacts of heavy metal pollutants on groundwater in e-waste locations of Alaba International Market and Olusosun communities in Lagos State, Nigeria. The paper is a policy based on science advice practice applying Equilibrium Perspectives and Equilibrium Perspectives Paradox Framework for Sustainable Development Goals. Equilibrium Perspectives and Equilibrium Perspectives Paradox offers a nuanced approach to addressing the multifaceted, interconnected, interdependent and consequential social, economic, health and environmental problems highlighted in the Sustainable Development Goals (SDGs). The need to address the impacts of heavy metal pollutants on groundwater in e-waste locations such as Alaba International Market and Olusosun communities through a comprehensive policy approach can not be overemphasized. By implementing stringent regulations, enhancing monitoring and enforcement, raising public awareness, and providing health interventions, the relevant authorities can mitigate the health and environmental risks associated with e-waste contamination. It is essential to prioritize the well-being of the affected communities and work towards sustainable e-waste management practices to safeguard the future generations.

Abbreviations

CR	Cancer Risks
ERI	Ecological Risk Index
E-waste	Electronic Waste
FAAS	Flame Atomic Absorption Spectrophotometer
HEI	Heavy Metal Evaluation Index
HPI	Heavy Metal Pollution Index
HQ	Hazard Quotients
LASEPA	Lagos State Environmental Protection Agency
LAWMA	Lagos Waste Management Authority
LOD	Limit of Detection
LOQ	Limit of Quantification
MPOES	Microwave Optical Emission Spectrometer
NGOs	Non Governmental Organizations
POS	Predictability, Optimal Performance and Sustainability
PTMs	Potentially Toxic Metals
SDGs	Sustainable Development Goals
WHO	World Health Organization
WQI	Water Quality Index

Conflicts of Interest

The authors declare no conflicts of interest.

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