

Effects of Solid Waste Management on Soil Degradation in Uvwie Local Government Area in Delta State, Nigeria

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Abstract—Solid waste management (SWM) is a major environmental challenge in developing countries, where inadequate infrastructure, poor enforcement, and limited awareness exacerbate environmental risks. This study examined the effects of SWM practices on environmental quality in Uvwie Local Government Area (LGA) of Delta State, Nigeria, with emphasis on soil degradation and contamination. Data were collected from 71 respondents using questionnaires, interviews, and field observations, supplemented by secondary sources. Descriptive statistical analyses were conducted using Microsoft Excel. Findings revealed that household refuse is dominated by organic and plastic wastes, with open dumping (65%) and burning (55%) as the most common disposal methods. Only 32% of respondents were aware of the 4Rs (Reduce, Reuse, Recycle, Recover), and waste segregation was largely absent. Residents reported reduced soil fertility, stunted plant growth, and increased vector-borne diseases as consequences of poor waste management. Fourteen soil samples were collected from topsoil (0–15 cm) and subsoil (15–30 cm) across dumpsites. Wide concentration ranges across sampling points reflected uneven waste distribution and localized hotspots. The study also identified inadequate governmental involvement, weak policy enforcement, and low public participation. Overall, ineffective SWM practices are contributing to soil contamination and declining environmental health. The study recommends integrated waste management, promotion of waste-to-energy initiatives, stricter pollution control enforcement, and enhanced community engagement, with strengthened government–private sector partnerships to achieve sustainable waste management and environmental protection in Uvwie and similar urban areas.

Keywords— Solid Waste Management, Environmental Degradation, Soil Contamination, Uvwie, 4Rs, Nigeria.

I. INTRODUCTION

Solid waste management (SWM) remains a central pillar of sustainable urban development and environmental protection. It involves the systematic processes of collecting, transporting, treating, recycling, and disposing of waste generated from domestic, industrial, and commercial activities (Guerrero, Maas, & Hogland, 2013). Rapid population growth, industrialization, and urbanization have significantly increased global waste generation, creating environmental and public health challenges (Hoornweg & Bhada-Tata, 2012). When poorly managed, solid waste—ranging from household refuse to construction debris and industrial residues—can cause soil and water contamination, air pollution, and greenhouse gas emissions (Wilson, Velis, & Cheeseman, 2006).

In Nigeria, SWM challenges persist due to weak institutions, limited infrastructure, low funding, and poor public awareness (Ojo, 2017). Open dumping and burning remain widespread despite the United Nations' (2020) emphasis on effective waste governance as a pathway to achieving the SDGs. Fragmented policies, inadequate technology, and weak enforcement further hinder progress. Although solid waste includes diverse streams requiring structured systems (Tchobanoglous, Theisen, & Vigil, 1993), cities such as Warri and Uvwie depend on open dumpsites, resulting in soil contamination and pollution. Sustainable solutions require integrated approaches combining recycling, energy recovery, and community engagement (Moqsud et al., 2011).

In Uvwie Local Government Area (LGA) of Delta State, ineffective waste management practices are evident in widespread open dumps along roads and residential areas. The absence of engineered landfills, irregular waste collection, and weak collaboration between local authorities and private contractors exacerbate environmental degradation. These practices contribute to soil contamination through leachate infiltration, loss of soil fertility, and increased disease risks. Furthermore, limited application of the 4Rs (Reduce, Reuse, Recycle, Recover) and poor community involvement indicate the need for a more integrated approach.

Globally, sustainable waste management now emphasizes the circular economy, focusing on waste minimization, resource recovery, and environmental sustainability (Moqsud et al., 2011). Adopting an Integrated Solid Waste Management (ISWM) framework—combining policy, technology, and community participation—is vital for developing sustainable systems in areas like Uvwie.

Empirical studies from Delta State show that uncontrolled dumping leads to heavy-metal leaching, altered soil properties, and risks to agricultural productivity and groundwater safety. Poor segregation and limited application of the 4Rs exacerbate these impacts (Ojo, 2017). In Uvwie LGA, weak government–private sector collaboration continues to undermine system efficiency.

The Sustainable Development Theory emphasizes balancing economic, environmental, and social outcomes, while Systems Theory frames SWM as an interconnected process involving policy, technology, and community behavior. Overall, the literature shows that effective SWM in Uvwie and similar contexts requires strong institutional frameworks,

enforcement, stakeholder collaboration, and community-based awareness to mitigate environmental degradation.

This study, therefore, examines the effect of solid waste management on environmental quality, with emphasis on soil degradation and contamination in Uvwie LGA. It assesses waste generation patterns, disposal methods, segregation levels. Findings from this research are expected to inform sustainable waste management strategies, enhance local policy implementation, and promote community participation toward improved environmental governance.

II. MATERIALS AND METHODS

3.1 Study Area

The study was carried out in Uvwie Local Government Area (LGA) of Delta State, situated in Nigeria's South-South geopolitical zone within the Niger Delta region. Uvwie lies between latitudes 5°30'N and longitudes 5°45'E, covering about 95 km², and is bordered by Okpe, Udu, and Warri South LGAs (Mohammed et al., 2025). Major settlements include Ekpan, Enerhen, Ugborikoko, Jakpa, and Ugbomoro. The area has a humid tropical climate with two distinct seasons: a rainy season (March–October) and a dry season (November–February). Mean annual temperature ranges from 25°C–32°C, while rainfall averages 2,000–3,000 mm (NIMET, 2020). Flat terrain and poor drainage make Uvwie prone to seasonal flooding, affecting both settlements and waste management. The Warri River and its tributaries, which support domestic and industrial activities, are increasingly polluted by human waste. Socioeconomically, Uvwie is highly urbanized and industrialized, with a population of about 188,000 (NPC, 2006), now significantly higher due to urban growth. Economic activities revolve around the oil and gas sector, trade, and civil service. See figure 1 for map of study area.

3.2 Research Design

Exploratory research was used in this study so as to obtain the preliminary investigation of the subject matter. This has to do with general nature of problem at hand discovered and variable related to the topic. In collecting information about the study, survey was used in interviewing the government officials, waste collectors, residents etc. While the secondary data was sourced from numerous books, journals, paper presentations, the internet, amongst others which has to do with the management of solid waste disposal in Uvwie local government area, Delta State.

3.3 Sampling and Sampling Techniques

Purposive sampling was used to select major dumpsites. Control samples were collected from locations at least 500 meters away from dumpsites. Although this study primarily relied on questionnaire data to assess solid waste management practices and their environmental impacts, supplementary soil sampling and laboratory analysis were conducted to provide empirical evidence of contamination around major dumpsites in Uvwie Local Government Area.

3.4 Method of Data Collection

Data used in this study were drawn from both primary and secondary data. Primary data was obtained through interviews, administration of questionnaires are. On the other hand,

secondary data were sourced through relevant textbooks, journals, research thesis, publications and internet materials. Soil samples were collected from selected dumpsites to determine the presence and distribution of heavy metals associated with improper waste disposal. A total of fourteen (14) samples were collected at two depths:

Topsoil: 0–15 cm

Subsoil: 15–30 cm

These depths were selected because the topsoil is directly exposed to surface waste materials and leachate, while the subsoil provides insight into downward migration of contaminants. Samples were obtained using a stainless-steel auger, placed in labeled polyethylene bags, and transported to the laboratory for analysis.

3.5 Sample Preparation and Digestion

In the laboratory, the soil samples were air-dried, crushed gently, and sieved through a 2 mm mesh. A 1 g subsample was digested using standard acid digestion procedures (APHA, 2012) with nitric acid (HNO₃) and hydrochloric acid (HCl) mixtures until a clear solution was obtained. Filtrates were diluted to 50 ml with distilled water for metal analysis.

3.6 Research Instruments

There are three principal methods widely used for data collection. These are oral interview, questionnaire and observation methods. In this research work, the researcher collected the information through the three methods.

- i. Questionnaire: A set of structured questions numbered in sections was designed to collect information and opinions of the respondents.
- ii. Oral interview: The researcher obtained information from the respondents through oral interview. The Oral interview method used was face to face.
- iii. Observation: The researcher also obtained information from respondents through observation which involves watching events or behaviors as in real time.
- iv. Soil Sampling: Fourteen (14) soil samples at two different depths: topsoil (0–15 cm) and subsoil (15–30 cm) was collected and analyzed from each dumpsite.

3.7 Population of the Study

The questionnaire was distributed to 80 respondents. A total of 71 respondents across selected communities in Uvwie Local Government Area responded to the survey.

3.8 Method of Data Analysis

Microsoft Excel 2016 was employed for recording, organizing, and analyzing numerical data, including calculations of averages, means, and standard deviations. Data visualization and documentation were carried out using Microsoft Word. The data generated from questionnaire were analyzed using descriptive statistics and results were presented in tables and charts for clarity. Also, heavy metal concentrations from AAS results were summarized using: Means, Ranges, Depth comparisons (topsoil vs. subsoil). These results were used only to support and validate the questionnaire findings on soil degradation and contamination.

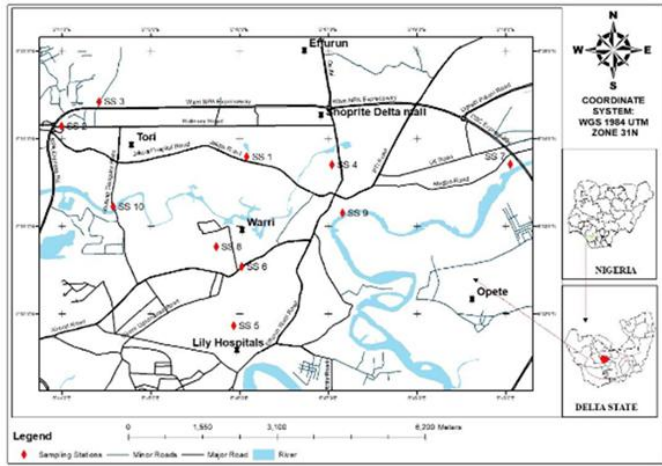


Figure 1: Map of Uvwie Local Government Area indicating waste dump sites

III. RESULTS AND DISCUSSION

4.1 Respondent Demographics

The questionnaire was distributed to 80 respondents. A total of 71 respondents across selected communities in Uvwie Local Government Area responded to the survey. The demographic distribution revealed a balance across gender and age categories, with the majority falling within the 25–50 age range (Table 1 & Figure 2). Most respondents had attained at least secondary education, reflecting a literate population capable of providing informed responses (Figure 3). Additionally, a large proportion had resided in their communities for over 10 years, which underscores their long-term exposure to the prevailing solid waste management practices and associated effects on soil quality.

S/N	Question	Category
1	Age Distribution	<18: 5%, 18-25: 15%, 26-35: 30%, 36-45: 25%, 46-55: 15%, >55: 10%
2	Gender	Male: 53%, Female: 45%, Prefer not: 2%
3	Education Level	Primary: 10%, Secondary: 35%, Diploma/NCE: 20%, B.Sc/HND: 25%, Postgraduate: 10%
4	Most Common Waste Type	Organic: 85%, Plastics: 70%, Metals: 55%, Others: 30%
5	Waste Generation Frequency	Daily: 60%, 2-3 times/week: 25%, Weekly: 10%, Irregular: 5%
6	Common Disposal Methods	Open Dumping: 65%, Burning: 55%, Dumpsites: 40%, Government bins: 20%
7	Awareness of 4Rs	Yes: 32%, No: 68%
8	Waste Segregation Practice	Always: 5%, Sometimes: 15%, Rarely: 25%, Never: 55%
9	Perceived Effectiveness of Waste Management	Very Effective: 5%, Effective: 10%, Neutral: 15%, Ineffective: 45%, Very Ineffective: 25%
10	Observed Soil Effects	Reduced fertility: 60%, Low crop yield: 55%, Stunted plants: 50%, Water pollution: 40%
11	Awareness of Government Campaigns	Yes: 30%, No: 70%

This finding aligns with the 198-household survey by Igben & Ihayere (2024), which noted that 62.1% of households were headed by males, and the primary age group was between 21

and 40 years. Both studies highlight the urbanized and dynamic workforce in Uvwie, where respondents are mainly involved in secondary and tertiary occupations. This stands in stark contrast to rural Nigerian local government areas, where agricultural jobs are more prevalent (Owamah et al., 2017).

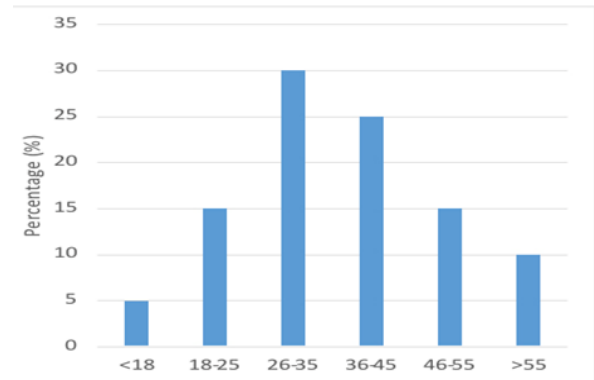


Figure 2: Respondent Age Distribution

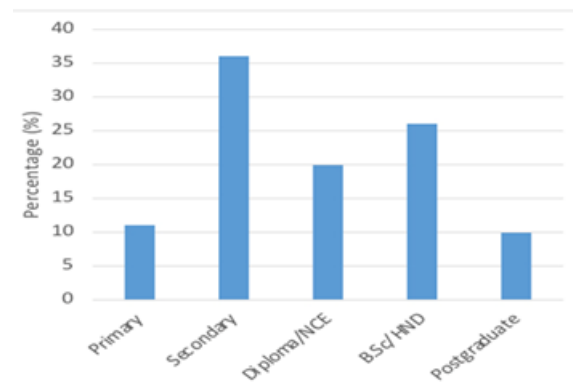


Figure 3: Respondent Education Level

4.2 Solid Waste Generation and Disposal Practices

The responses indicated that organic waste (food scraps and garden residues), plastic waste, and metal scraps were the most generated household and community wastes (Figure 4). This is consistent with trends in Nigerian urban centres, where biodegradable and plastic wastes dominate the municipal waste stream (Adewumi et al., 2019). Most respondents reported that waste was generated either daily or several times per week, emphasizing the persistent nature of waste generation (Figure 5). In terms of disposal, the findings revealed a heavy reliance on open dumping and burning, followed by community dumpsites (Figure 6). Only a small fraction of respondents reported access to government-provided waste bins or organized collection systems. This gap reflects the inadequacy of formal waste management infrastructure in the study area. Such practices not only contribute to soil contamination through leachates also expose residents to health risks from uncontrolled burning and littering (Nwachukwu et al., 2020). This finding is consistent with Igben & Ihayere’s (2024) research, which identified plastics, food waste, paper, and metal cans as the leading waste types. Earlier studies from Ughelli and Uyo (Efe, 2013; Ukpong & Udofia, 2011) also support this trend. The similarities across these studies emphasize the dominance of biodegradable and plastic waste in Nigerian

municipal waste streams, reflecting shifts in consumption habits and a lack of effective recycling practices. For waste disposal practice, Igben & Ihayere (2024) found a similar trend, reporting that 33.7% of waste was disposed of in bushes, 22% in open areas, and merely 13.6% through Private Sector Partnerships (PSP). This consistent pattern highlights the lack of organized waste collection and the ongoing reliance on informal, environmentally hazardous disposal methods. Oyije et al. (2020) and Babayemi & Dauda (2009) also confirm that these issues are systemic challenges in Nigeria.

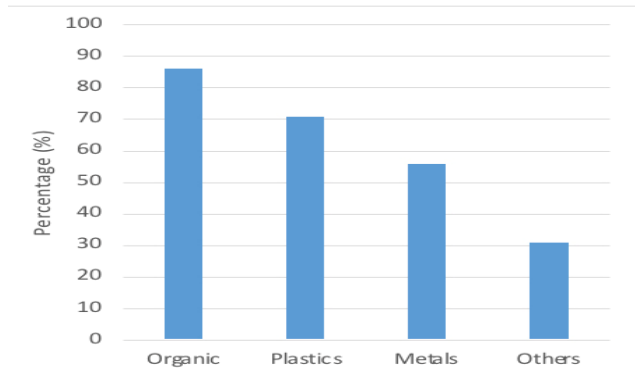


Figure 4: Most Common Waste Type

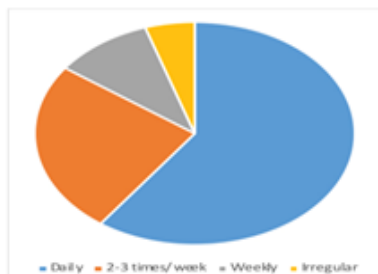


Figure 5: Waste generation Frequency

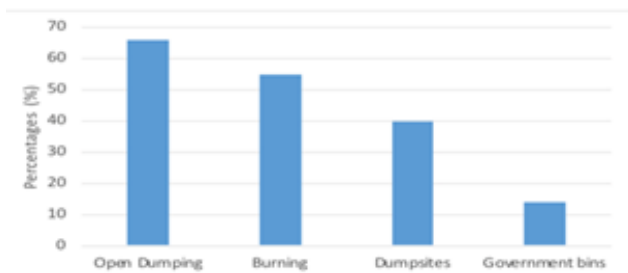


Figure 6: Common Waste Disposal Method

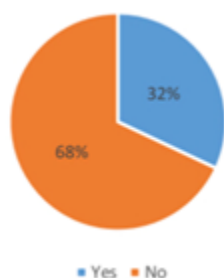


Figure 7: Respondent Awareness of 4Rs.Method

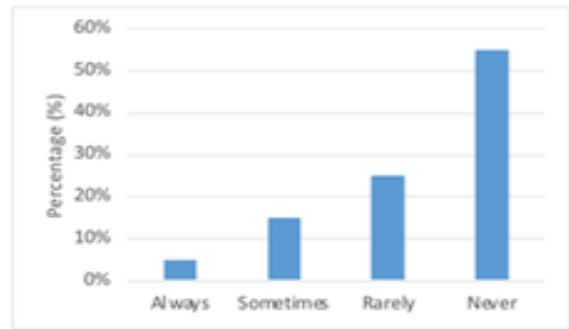


Figure 8: Respondent Waste Segregation Practice

4.4 Respondent Perceptions of Waste Management Effectiveness

A significant proportion of respondents rated current waste disposal methods in Uvwie as ineffective or very ineffective. Nearly all participants confirmed the presence of visible signs of poor waste management, such as open dumps, littering, blocked drains, and burning sites (Figure 9). The associated effects included unpleasant odours, proliferation of pests (mosquitoes and rodents), and flooding due to blocked waterways. These findings reveal widespread dissatisfaction with existing waste management systems and highlight urgent gaps in service delivery and enforcement. Most respondents believe that waste management is ineffective, pointing out issues such as open dumps, burning waste, blocked drains, and pest problems. This aligns closely with the findings of Igben & Ihayere (2024), where 47.2% rated waste disposal as poor and 39.1% as very poor. Both studies emphasize the community's frustration and the urgent need for improved collaboration between the government and the community to enhance infrastructure and enforcement.

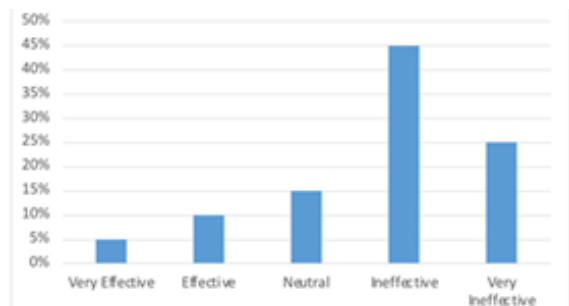


Figure 9: Respondent Perceived Effectiveness of Waste Management

4.5 Observed Impacts on Soil and Human Health

Most respondents associated solid waste dumping with reduced soil fertility, low crop yields, and stunted plant growth (Figure 10). In addition, they reported deteriorating water quality and increased prevalence of vector- and waterborne diseases such as malaria, cholera, and diarrhoea. These community observations align with scientific evidence that links poor waste management practices with soil degradation, contamination, and adverse health outcomes (WHO, 2007; UNEP, 2016). The persistence of open dumping and burning further exacerbates both ecological risks and public health vulnerabilities. This findings is consistent with Igben & Ihayere (2024), who observed that unsustainable waste disposal in

bushes and holes causes environmental harm. Additional research in Delta communities (Efe, 2013; Owamah et al., 2017) also highlights soil contamination, pest issues, and health risks, reinforcing local concerns with solid evidence.

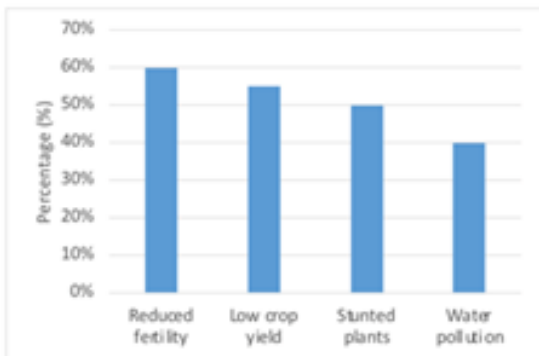


Figure 10: Observed Soil Effects

4.6 Community Awareness and Government Engagement

When asked about awareness of policies and government involvement, the majority of respondents indicated that waste management awareness campaigns were either rare or ineffective (Figure 11). While some campaigns were reported through schools, NGOs, or mass media, these efforts were deemed insufficient to drive meaningful behavioural change. Nonetheless, respondents expressed willingness to participate in clean-up campaigns and government–community partnerships, suggesting that improved collaboration could foster shared responsibility for environmental management. This findings aligns with the study by Igben & Ihayere (2024), which indicated that awareness campaigns are infrequent and not very effective, despite residents' eagerness to participate in clean- up initiatives. This suggests a significant opportunity for community-driven waste management, provided there is adequate awareness and the necessary infrastructure in place.

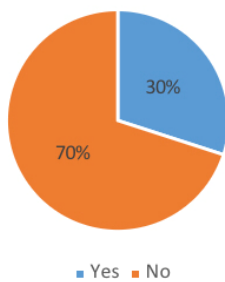


Figure 11: Respondent Awareness of Government Campaigns

The concentrations of heavy metals in soils from Uvwie

Local Government Area in Table 2 shows a consistent pattern of higher values in the topsoil (0–15 cm) than in the sub-soil (15–30 cm), indicating that contamination is primarily surface-driven and strongly influenced by anthropogenic activities related to solid waste disposal. The elevated topsoil concentrations of Cr, Mn, Ni, Fe, Co, Cu, and Pb reflect direct deposition from mixed municipal waste streams, including discarded electronics, batteries, metal scraps, paints, plastics, and household refuse, thereby confirming that inadequate waste management is a major contributor to soil metal accumulation in the area. Iron exhibited the highest concentrations in both soil layers, a trend associated with the widespread presence of ferrous materials, construction debris, and corroded metal objects within the waste stream, while manganese also appeared at relatively elevated levels typical of urban waste inputs.

Although present at lower absolute concentrations, toxic metals such as lead, chromium, and nickel are of particular environmental concern due to their persistence, toxicity, and potential for long-term health effects. Maximum topsoil values for Pb (12.983 mg/kg), Cr (14.982 mg/kg), and Ni (13.376 mg/kg) suggest localized hotspots of contamination likely arising from the uncontrolled disposal or burning of hazardous waste materials, especially electronic and battery components. Comparison with international and national regulatory guidelines, including standards from FEPA, WHO, and FAO, indicates that most measured concentrations fall below permissible limits; however, the continued deposition and degradation of solid waste may lead to gradual accumulation over time, particularly in surface soils where biological activity and human exposure risks are highest.

The consistent decline in concentrations with depth demonstrates limited vertical migration of metals, implying that the contamination is relatively recent or ongoing and not derived from geological sources. This pattern is further supported by the clay-rich and moderately compacted soil characteristics of the Niger Delta region, which tend to restrict downward percolation. The wide ranges observed across sampling points indicate substantial spatial variability and reflect the uneven distribution of waste disposal and burning practices, with certain locations functioning as informal dumpsites and therefore exhibiting higher contamination levels. Overall, the results provide clear evidence that current solid waste management practices in Uvwie are contributing to measurable soil contamination, which, although still within regulatory limits, poses potential future risks to soil quality, agricultural productivity, and public health if left unaddressed.

Table 2: One-Way ANOVA Analysis of the Heavy Metal Concentration in the soil

Metal	mean topsoil (0-15cm)	mean subsoil (15-30cm)	grand mean	SSB (total)	SSW (total)	df between	df within	MSB	MSW	F	p-value
Cr	4.849	3.8488	4.34915	5.007002	363.322546	1	18	5.007002	20.184586	0.248061	0.624474
Mn	20.492	16.516	18.50435	16.675692	3536.071941	1	18	16.67569	196.448441	0.0850418	0.36863
Ni	7.4117	6.9107	7.1612	0.366757	60.743191	1	18	0.366757	3.374621	0.10815	0.732423
Fe	1079.04	956.7681	1017.9077	2364.8975	90148.19301	1	18	2364.898	5008.233	0.473245	0.500268
Co	0.1909	0.1603	0.1756	0.000915	30.827455	1	18	0.000915	1.712636	0.000053719	0.819328
Cu	7.4054	5.4689	6.43715	17.796214	360.092217	1	18	17.79621	20.005123	0.889334	0.359202
Pb	4.3535	2.7977	3.5756	12.102568	255.573323	1	18	12.10257	14.198518	0.852382	0.36809

NB:

n topsoil/nsubsoil= Number of samples in the topsoil group and subsoil group.

mean top /mean sub= The average concentration of the heavy metal in topsoil and subsoil.

grand mean= The overall mean across both the topsoil (0-15cm) and subsoil (15-30cm) groups combined.

SSB = Sum of Squares Between groups.

SSW = Sum of Squares Within groups.

df between = Degrees of Freedom Between groups.

df within = Degrees of Freedom Within groups.

MSB = Mean Square Between groups.

F = F-statistic (F-ratio).

p-value = Probability value.

IV. CONCLUSION

This study examined the effects of solid waste management practices on environmental quality in Uvwie Local Government Area, with emphasis on soil degradation resulting from uncontrolled waste handling. The results show that waste management in the area is dominated by open dumping and burning, poor segregation, minimal application of the 4Rs principles, and weak regulatory enforcement. These systemic shortcomings, together with inadequate infrastructure and limited institutional coordination, impede the adoption of sustainable waste management strategies. The survey evidence indicates that the predominance of organic and plastic wastes, coupled with indiscriminate disposal, has contributed to declining soil fertility, increased contamination, and heightened risks of water- and vector-borne diseases. Complementing these findings, the soil assessment reveals that heavy metal concentrations are consistently higher in the topsoil than in the sub-soil, indicating surface-driven contamination directly associated with anthropogenic inputs from poorly managed municipal waste. Overall, the study demonstrates that current practices are contributing to progressive environmental degradation and underscores the need for a strengthened integrated solid waste management framework that incorporates improved regulatory oversight, adequate infrastructure, and active community participation to safeguard environmental and public health in Uvwie LGA.

V. RECOMMENDATIONS

1. Implement an integrated solid waste management (ISWM) system emphasizing segregation, recycling, and safe disposal.
2. Enforce existing environmental laws and strengthen institutional capacity.
3. Establish engineered landfills and explore waste-to-energy conversion.
4. Intensify community awareness and participation in waste management.
5. Conduct periodic environmental monitoring and soil quality assessments.

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