CONCENTRATION OF HEAVY METALS OF SOILS FROM DUMPSITES IN ANYIGBA, DEKINA LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA

OTENE, I.J.J.[1], SULEIMAN, A.A.[2], KAYODE, E.A.[3], MUHAMMED B. [1], OKOH, M.O. [1], MALGWI, O.D. [1], KADIRI, A.B.[4], DAVID C.[5], GABRIEL, L.O.[1]

[1]Department of Soil and Environmental Management, Faculty of Agriculture Kogi State University, Anyigba Kogi State, Nigeria
[2.] School of Natural and Environmental Sciences, Faculty of Science, Agriculture and Engineering, Newcastle University, Newcastle Upon Tyne, UK.
[3]Federal University of Lafia, Faculty of Agriculture, Department of Agronomy, P.M.B. 146, Lafia, Nasarawa State
4Soil Science and Land Management, Federal University of Agriculture, Abeokuta
[5]Department of Geography and Planning, Faculty of Social Sciences, Kogi State University Anyigba, P.M.B. 1008 Kogi State, Nigeria

ABSTRACT

This study was conducted to assess the concentration of heavy metals in the soils of dumpsites in Anyigba, Dekina Local Government Area, Kogi State. Dumpsites were elected from the four axes (Idah road, Ankpa road, Dekina road, and Iyale road) of Anyigba. The purposive sampling method was used to collect soil samples at the surface and subsurface depths (0-15 and 15 – 30 cm respectively) with the aid of a soil auger from each dumpsite. Six replicate samples were taken from each dumpsite (3 surfaces and 3 subsurfaces) and also control sites adjacent to the dumpsites giving a total of 48 soil samples that were analysed for heavy metals [lead (Pb), cadmium (Cd), Cop-per (Cu), Zinc (Zn) and Iron (Fe)]. The results of soil analysis were subjected to the Analysis of Variance (ANOVA) of GENSTAT Discovery software. Significant means was separated using the Duncan Multiple Range Test (DMRT) at a 5 % level of probability. The permissible limits of WHO (1996) were used to compare the concentrations of the heavy metals analysed. The results of data analysis showed that the concentration of Cd (1.70 to 8.10 mg/kg) and Cu (39.90 to 86.30 mg/kg) in the surface soils of all the dumpsites including the control plots in all the axes in Anyigba were above permissible limits. Similarly, the concentration of Zn (120.00 to 3.88.00 mg/kg) in the surface region of all the axes in Anyigba was above the permissible limit. The results also revealed that the level of Ni (41.70 to 67.10 mg/kg) in the surface soil of the dumpsites and also the control plots in all axis in Anyigba were above the permissible limit (35 mg/kg). The level of Pb (96.95 to 107.20 mg/kg) in the surface soils of the dumpsites and control plots of Ankpa was within the permissible limit of 85 mg/kg but the other axes (Idah, Iyale and Dekina) were all above the permissible limit. On the other hand, the concentration of Cd (3.75 to 10.10 mg/kg) in the subsurface soils of the dumpsite and its control plots in all the locations were all above permissible limits. The Cu in the subsurface soils from dumpsites in Iyale (32.70 mg/kg), the control plots of Ankpa (29.10 mg/kg), and the control plots of Iyale (31.30 mg/kg) were below the permissible limit while the other locations were above the permissible limit. The level of Ni in the subsurface soil of Ankpa and Dekina dumpsites (40.10 and 42.50 mg/kg) and Ankpa, Dekina, and Idah control plots (52.90, 47.90, and 58.80 mg/kg respectively) were all above the permissible limit. Furthermore, the concentration of Pb in the subsurface soils of dumpsites in the Ankpa axis and Iyale axes was below the permissible limit while other axes were all above the permissible limit. Finally, the concentration of Zn in the subsurface soils of the dumpsites (67.30 to 248.80 mg/kg) and control plots of Idah (280.9 mg/kg mg/kg) were above the permissible limit but the control plots for Ankpa, Dekina and Iyale (23.00, 37.5, and 43.2 mg/kg respectively) were below permissible limits.

Keywords: *Heavy metals, dumpsites, soil contamination, permissible limits, Kogi State*

INTRODUCTION

Improper waste disposal practices lead to the degradation and decomposition of waste materials resulting in the release of heavy metals into the surrounding soil, air, and water (khan et al., 2018; Boroujerdnia et al., 2020; Gaur, 2021). Dumpsites are recognized as potential sources of heavy metal pollution in the environment (Oyedeji et al., 2020). Heavy metals in soils from dumpsites can be transported through the soil profile via leaching leading to contamination of groundwater or nearby water bodies (Olajire et al., 2018). Waste materials such as electronic waste, batteries, and industrial activities such as mining, smelting, and manufacturing processes release by-products which contain significant amounts of heavy metals which can leach into the soil over time (Abasi et al., 2018; Yang et al., 2018). Agricultural practices involving the use of fertilizers, pesticides, and sewage sludge can introduce heavy metals into the soil (Oyedeji et al., 2020; Wei et al., 2020).

Soil contamination with heavy metals can negatively impact plant growth and reduce soil fertility, leading to significant economic consequences (Fasidi & Ajibade, 2020). When heavy metals are released into the soil, they can accumulate over time leading to increased concentrations that exceed safe limits (Khan et al., 2018). Various studies have reported the negative impacts of heavy metal contamination on soil microbial activity, nutrient cycling, and overall soil fertility (Smith et al., 2019; Li et al., 2020). Plants growing in contaminated soil can take up heavy metals through their roots, potentially entering the food chain and posing risks to human health (Wang et al., 2018). The risks associated with heavy metal contamination in soil and its impacts on human health highlight the importance of regular monitoring and assessment of soil quality. Soil testing and analysis can help identify areas of heavy metal contamination and inform appropriate management strategies to mitigate the risks (Gaur, 2021). Therefore, evaluating the mobility and bioavailability of heavy metals in soil is crucial for assessing their potential impacts on ecosystems and developing appropriate management strategies.

In recent years, the proliferation of dumpsites in Anyigba, Dekina Local Government Area of Kogi State, Nigeria, has raised concerns about the potential contamination of surrounding soils with heavy metals. The absence of a proper waste disposal system has resulted in the indiscriminate dumping of waste in residential areas, markets, and water bodies. Additionally, the lack of awareness about the dangers of heavy metal contamination and the need for proper waste management practices represents a significant challenge. The presence of various commercial activities in Anyigba including automobile repair workshops, and metal fabrications has contributed to the increased number of dumpsites and may exacerbate the problem of heavy metal contamination in the area. Understanding the mechanisms of heavy metal mobility and bioavailability is essential for assessing their potential risks to the environment and human health. The aim of this study was to assess the concentration of heavy metals of the soils of dumpsites in Anyigba.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in Anyigba, Dekina Local Government Area, Kogi State. Dumpsites were elected from the four axes (Idah road, Ankpa road, Dekina road, and Iyale road) of Anyigba (Figure 1 and Appendix 1).

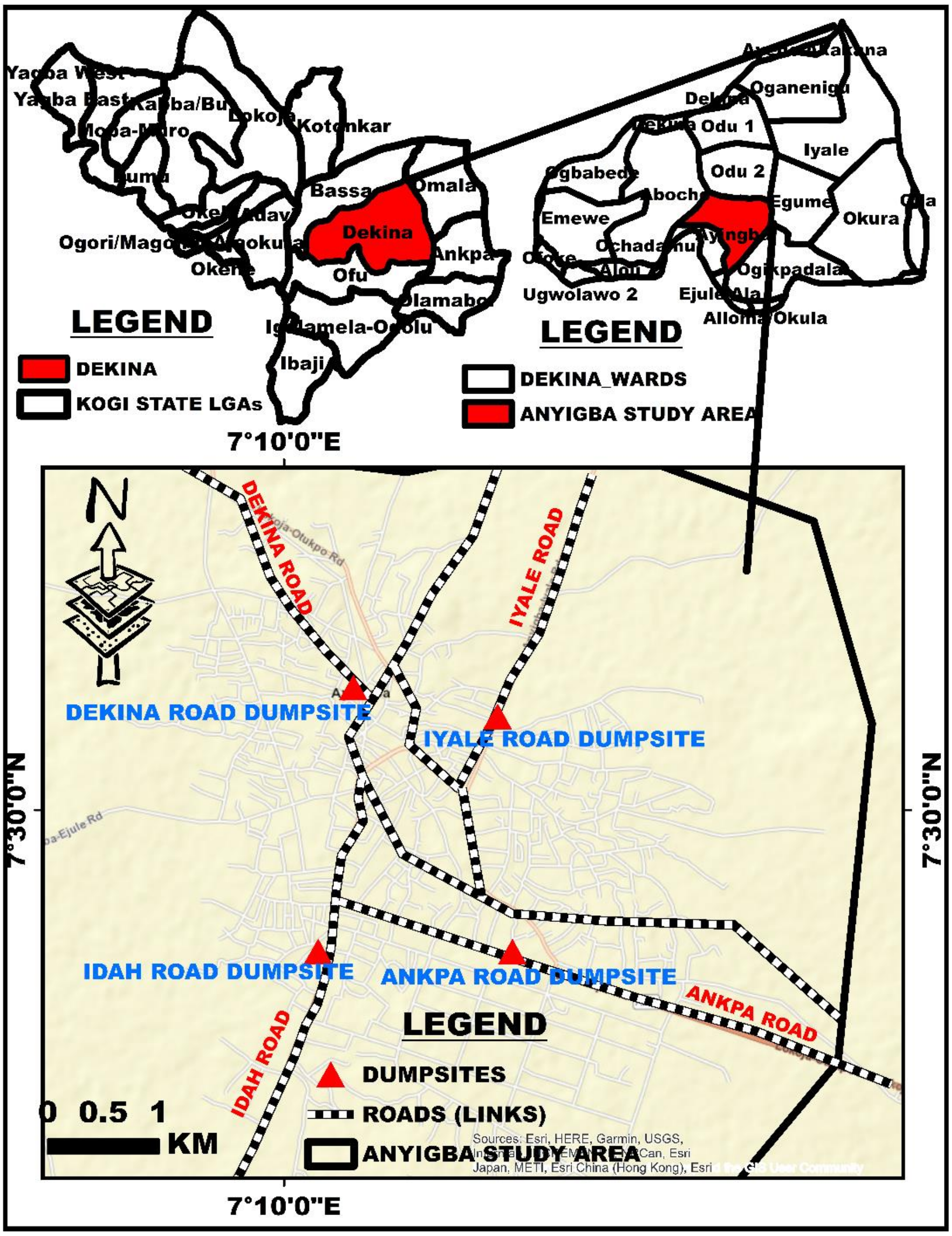

Figure 1: Study Area

Collection of Samples

The purposive sampling method was used to collect soil samples at the surface and subsurface depths (0-15 and 15 – 30 cm respectively) with the aid of a soil auger from each dumpsite. Six replicate samples were taken from each dumpsite (3 surface and 3 subsurface) and from control sites adjacent to the dumpsites giving a total of 48 soil samples.

Laboratory Analysis

The collected soil samples were air-dried at room temperature, gently crushed, and passed through a 2mm sieve. The sieved samples were stored in labelled polythene bags in preparation for laboratory analysis of selected heavy metals. Heavy metals were determined by the Aqua Regia method as modified by Salt (1998). Air- dried and previously sieved soil samples were weighed to obtain 0.5 g and this quantity was digested with concentrated nitric acid (HNO_3) and filtered through ashless filter paper. The clear digest was diluted in a 50 ml acid-cleaned standard flask with distilled water up to the required mark. Atomic Absorption Spectrometer (AAS) (Shimadzu double beam AA-6300 and Perkin Elmer Analyst 400) was used to analyze the amount of lead (Pb), cadmium (Cd), Cop- per (Cu), Zinc (Zn) and Iron (Fe) in the sample solutions. For sulphate and nitrate, 10 g of the soil sample was weighed into a 50 ml centrifuge tube and 25 ml of distilled water was added. The solution was stirred occasionally for 30 min with a glass rod on an orbital shaker. The solution was filtered using filter paper. Pilos of sulphate and nitrate were added to the clear filtrate. The samples were then taken to a spectrophotometer for detection and reading.

Statistical Analysis

The data collected was analyzed using the Analysis of Variance (ANOVA) of GENSTAT Discovery software. Significant means WERE separated using the Duncan Multiple Range Test (DMRT) at a 5 % level of probability.

RESULTS

Concentrations of Heavy Metals from Surface Soils of Dumpsites in Anyigba, Dekina Local Government Area, Kogi State

The concentrations of heavy metals in surface soils from dumpsites in Anyigba, Dekina Local Government Area are presented in Table 1. The results showed that there was no significant difference in the Cd concentration of surface soils of dumpsites in Ankpa, Dekina, Idah, and Iyale (7.50, 5.38, 8.10, and 6.19 mg/kg respectively). However, significantly lowest Cd concentration (1.70 mg/kg) was observed from the control plots along the Dekina axis.

Highest Cu levels were recorded from Idah (86.35 mg/kg) and Dekina (66.50 mg/kg) dumpsites followed by Iyale (50.00 mg/kg), and Ankpa (39.85 mg/kg) dumpsites. However, it is important to note that there was no significant difference in Cu levels of surface soils of Ankpa and Iyale. Similarly, there was no significant difference in the Cu levels of control soils in Ankpa (25.30 mg/kg), Idah (37.53 mg/kg), and Iyale (19.00 mg/kg). Highest concentration of Ni was observed in Idah (67.10 mg/kg) and also in Iyale axis (mg/kg). However, no significant difference was recorded for control Dekina (50.52 mg/kg), Dekina (48.55 mg/kg), Ankpa (43.45 mg/kg) and control Ankpa (41.75 mg/kg). But the lowest control was recorded in control Iyale dumpsite (26.95 mg/kg).

The results of the analysis showed that highest level of Pb was revealed in Idah (107.20 mg/kg) and no significant difference between Iyale (101.35 mg/kg), Dekina (97.30 mg/kg), control for Idah (97.18 mg/kg), control Iyale (96.95 mg/kg), control for Dekina axis (95.05 mg/kg), control for Ankpa (80.50 mg/kg). However, the lowest level was recorded in Ankpa dumpsite axis (59.40 mg/kg). Finally, the results revealed that the highest concentration of Zn was recorded from the surface soils of dumpsites in the Idah axis (388.0mg/kg) followed by Dekina (272.00mg/kg), and Iyale (237.20mg/kg). There was no significant difference in the Zn levels observed between Ankpa dumpsite (121.00 mg/kg) and Idah control soils (175.50 mg/kg). The lowest Zn concentrations were observed from the control plots in Dekina (68.00mg/kg), Iyale (62.30 mg/kg) and Ankpa (11.4 mg/kg).

Table 1: Concentrations of heavy metals of surface soils from dumpsites in Anyigba, Dekina Local Government Area

Axis	Cd	Cu	Ni mg/kg	Pb	Zn
Ankpa	7.50a	39.9cde	43.4bc	59.4c	120.9de
Dekina	7.38ab	66.5ab	48.5bc	97.3ab	271.9b
Idah	8.10a	86.3a	67.1a	107.2a	388.0a
Iyale	6.19a	50.0bc	5.5ab	101.3ab	237.2bc
Ankpa control	4.64ab	25.3de	41.7c	80.5bc	11.4f
Dekina control	1.7b	43.3cd	50.5bc	95.05ab	68.0ef
Idah control	4.47ab	37.5cde	47.1bc	97.2ab	175.5cd
Iyale control	5.05ab	19.00e	26.9d	96.95ab	62.3ef
LSD	3.996	20.53	11.80	22.50	90.1
SEM	1.284	6.77	3.89	7.42	29.7

Note: Means in a column with different letters are statistically significant at 5 % level of probability. LSD = Least Significant difference; SEM = Standard Error of Mean.

Concentrations of Heavy Metals from Subsurface Soils of Dumpsites in Anyigba, Dekina Local Government Area, Kogi State

Table 2 shows the concentrations of heavy metals of subsurface soils from dumpsites in Anyigba, Dekina Local Government Area. The result revealed that subsurface concentration of Cd in the control axis of Ankpa (10.100 mg/kg) was the highest followed by Dekina (8.150 mg/kg), control for Idah axis (7.900 mg/kg) and control for Dekina (4.217 mg/kg) and no significant difference between control Dekina (4.217 mg/kg), Idah (4.200 mg/kg), Ankpa (4.150 mg/kg). However, the lowest level was recorded in Iyale axis (3.752 mg/kg).

The highest concentration of copper was recorded in the control axis of Idah road (97.65 mg/kg) followed by Dekina having (61.45 mg/kg) but no significant difference between Idah axis (51.35 mg/kg), control for Dekina axis (46.47 mg/kg), Ankpa (41.05 mg/kg), Iyale (32.65 mg/kg) and the control plot for Iyale road (31.30 mg/kg). The lowest level was recorded control of Ankpa plot (29.10 mg/kg). The results further showed that the highest level of Ni was recorded in the control plot of Idah (85.80 mg/kg). However, there was no significant difference between the control plot of Ankpa (40.15 mg/kg), Iyale (32.30 mg/kg) and Idah (30.30 mg/kg) and the lowest level was recorded in the control plot of Iyale (19.00 mg/kg).

Highest Pb concentration was recorded from the control of Ankpa dumpsite axis (147.0 mg/kg) and the control axis of Idah (143.8 mg/kg) followed by the control for Dekina axis (123.7 mg/kg) showing no significant difference between Ankpa(118.2 mg/kg), Dekina (113.7 mg/kg) the control for Iyale dumpsite axis (96.8 mg/kg) and Iyale (84.3 mg/kg)having the lowest level recorded in Idah axis (75.3 mg/kg).

Finally, the result showed that the highest level of Zn that was recorded from the subsurface soil of dumpsite in the control axis of Idah (280.9 mg/kg) followed by Dekina (248.8 mg/kg), Idah (182.3mg/kg) showing no significant difference between Ankpa (154.5 mg/kg), Iyale (67.3 mg/kg) and the control for Iyale Axis (43.2 mg/kg), and control for Dekina (37.5 mg/kg) the lowest Zn concentration was observed from the control plots of Ankpa (23.0 mg/kg).

Table 2: Concentrations of heavy metals of Subsurface soils from dumpsites in Anyigba, Dekina Local Government Area

Axis	**Cd**	**Cu**	**Ni**	**Pb**	Zn
			mg/kg		
Ankpa	4.15b	41.0bc	40.1bcd	11.8adc	154.5acd
Dekina	8.15a	61.4b	42.5bcd	113.7abc	248.8ab
Idah	4.20b	51.4bc	30.3de	75.3c	182.2abc
Iyale	3.75b	32.7c	32.3cde	84.3bc	67.3cde
Ankpa Control	10.10a	29.1c	52.9b	147.0a	23.0e
Dekina Control	4.22b	46.5bc	47.9bc	123.7ab	37.5de
Idah Control	7.90a	97.7a	58.8a	143.8a	280.9a
Iyale Control	7.95a	31.3c	19.0e	96.8bc	43.2de
LSD	2.443	25.69	15.74	42.61	90.1
SEM	0.800	8.47	5.19	14.05	29.7

Note: Means in a column with different letters are statistically significant at 5 % level of probability. LSD = Least Significant difference; SEM = Standard Error of Mean.

DISCUSSIONS

Concentrations of Heavy Metals from Surface and Subsurface Soils of Dumpsites in Anyigba, Dekina Local Government Area, Kogi State

The concentration of Cd and Cu in the surface soils of all the dumpsites including the control plots in all the axes in Anyigba were above permissible limits of 0.8 mg/kg and 36 mg/kg respectively by WHO (1996). Similarly, the results also reveal that the level of Ni in the surface soil of the dumpsites and the control plots in all axes in Anyingba shows were above the permissible limit (35 mg/kg) except for the control axis of Iyale (26.9mg/kg) which is below the permissible limit by WHO (1996). The level of Pb in the surface soils of the dumpsites and control plots of Ankpa was within the permissible limit of 85 mg/kg (WHO, 1996) but the other axes (Idah, Iyale and Dekina) were all above the permissible limit. On the other hand, the concentration of Zn in the surface region of all the axes in Anyigba was above the WHO (1996) permissible limit of 50 mg/kg except for the control plots of Ankpa (11.4 mg/kg) which was below the permissible limit.

The concentration of Cd in the subsurface soils of the dumpsite and its control plots in all the locations in Anyigba were all above permissible limits of WHO (1996) of 0.8 mg/kg. The results also showed that the concentration of Cu in the subsurface soils from dumpsites in Iyale, the control plots of Ankpa, and the control plots of Iyale were below the permissible limit of 36 mg/kg of WHO (1996) while the other locations were above the permissible limit. The levels of Ni in the subsurface soil of the dumpsites were all above the WHO (1996) permissible limit of 35 mg/kg except for Idah and the control plots of Iyale axis. Furthermore, the results of the analysis showed that the concentration of Pb in the subsurface soils of dumpsites in Ankpa axis and Iyale axes were below the permissible limit of 85 mg/kg according to WHO (1996) while other axes were all above the permissible limit. Finally, the concentration of Zn in the subsurface soils of the control plots of Iyale plots was above the permissible limit of 50 mg/kg but the control plots for Ankpa, Dekina and Iyale were below permissible limits.

The presence of elevated levels of heavy metals can disrupt soil microbial activity and nutrient cycling processes, leading to reduced soil fertility and productivity (Smith et al., 2019). Soil microorganisms play essential roles in nutrient cycling and organic matter decomposition, and their activities can be inhibited by high concentrations of heavy metals (Li et al., 2020). This can result in decreased nutrient availability for plants and negatively impact plant growth and development. Plants growing in heavy metal-contaminated soil can take up these metals through their roots. Once inside the plant, heavy metals can accumulate in various plant tissues, including leaves, stems, and fruits. High concentrations of heavy metals in plants can disrupt essential physiological processes, such as photosynthesis, enzyme activities, and nutrient uptake (Fasidi & Ajibade, 2020). This can lead to reduced crop yields, poor plant health, and even plant death.

Consuming crops or food products contaminated with heavy metals can pose significant risks to human health. Certain heavy metals, such as lead, cadmium, and mercury, are known to be toxic and can cause a range of health problems when ingested (Khan et al., 2018). Chronic exposure to heavy metals through contaminated food can lead to the accumulation of these metals in the body over time. Heavy metals can affect various organs and systems, including the nervous system, liver, kidneys, and reproductive system (Khan et al., 2018). They can cause neurological disorders, kidney damage, respiratory issues, and developmental abnormalities, particularly in children (Khan et al., 2018).

Implementing good agricultural practices, such as proper waste management, judicious use of fertilizers and pesticides, and soil amendment with organic matter, can help reduce heavy metal contamination in agricultural soils and minimize human exposure (Fasidi & Ajibade, 2020). Adequate regulation and enforcement of environmental policies are necessary to ensure that industrial activities comply with standards and minimize heavy metal emissions and waste disposal (Owoade et al., 2020). Public awareness and education campaigns can also play a vital role in promoting responsible waste management practices and reducing the risks associated with heavy metal pollution.

CONCLUSIONS

The results of the analysis from this study showed the following:

- ***Surface Soils:*** The concentration of Cd and Cu in the surface soils of all the dumpsites including the control plots in all the axes in Anyigba were above permissible limits. Similarly, the concentration of Zn in the surface region of all the axes in Anyigba was above the permissible limit except for the control plots of Ankpa which was below the permissible limit. The results also revealed that the level of Ni in the surface soil of the dumpsites and the control plots in all axes in Anyigba were above the permissible limit except for the control axis of Iyale which was below the permissible limit. The level of Pb in the surface soils of the dumpsites and control plots of Ankpa was within the permissible limit but the other axes (Idah, Iyale and Dekina) were all above the permissible limit.
- ***Surface Soils***: On the other hand, the concentration of Cd in the subsurface soils of the dumpsite and its control plots in all the locations were above permissible limits. The Cu in the subsurface soils from dumpsites in Iyale, the control plots of Ankpa, and the control plots of Iyale were below the permissible limit while the other locations were above the permissible limit. The level of Ni in the subsurface soil of the dumpsites was all above the permissible limit except for Idah and the control plots of the Iyale axis. Furthermore, the results of the analysis showed that the concentration of Pb in the subsurface soils of dumpsites in the Ankpa axis and Iyale axes was below the permissible limit while other axes were all above the permissible limit. Finally, the concentration of Zn in the subsurface soils of the control plots of Iyale plots was above the permissible limit but the control plots for Ankpa, Dekina and Iyale were below permissible limits.

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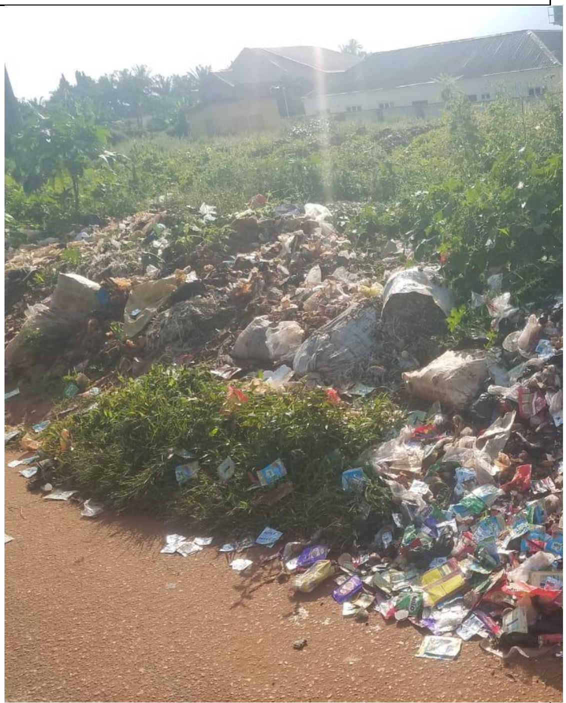
Appendix 1: Dumpsites in Anyigba, Dekina Local Government Area, Kogi State

1a) Ankpa Dumpsite

1b) Dekina Dumpsite

1c) Idah Dumpsite



1d) Iyale Dumpsite