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SPECIATION OF HEAVY METALS AND MICROBIAL CONTAMINANTS IN HARMATTAN DUST WITHIN THE FEDERAL POLYTECHNIC KAURA NAMODA MAIN CAMPUS, ZAMFARA STATE

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ABSTRACT

Harmattan dust is a natural phenomenon contributing to air pollution due to the presence of heavy metals and microorganisms. This research aimed to determine the speciation of heavy metal and microbial contaminants in Harmattan dust samples within the polytechnic Kaura Namoda. The composite sample of each month, namely, December 2023, January 2024, and February 2024, was collected with the aid of a sterilized petri dish. Five extraction phases were carried out, in order of mobility of the metals: exchangeable ion > metal bound with carbonate > metal bound to iron and manganese oxide > metals bound to organic matter and sulfide > residual phase. This was achieved using Tessie's method and AAS for extraction and analysis. The result for the heavy metals shows Cr (13.6%) and Zn (25.5%) are more abundant in the exchangeable phases in December and January. Metals bound to Fe and MnO extraction phases have Zn (25.50%) abundance in December and January. The residual phase of extraction shows the highest percentage of pb (95.3%) and nickel (85.40%) for December and January. The bacteria and fungi identified are Bacillus cereus, Staphylococcus, Aspergillum, and Clodosporium, respectively. There is no significant difference in physicochemical parameters between the Harmattan dust samples collected in December, January, and February. The percentages of heavy metals in the Harmattan dust are high in the immobility phase of extraction, and bacterial and fungal levels are high in December and January. There is a need for preventive and protective measures to mitigate the health effects associated with Harmattan dust pollution.

Keywords: Speciation**,** Harmattan Dust, Heavy Metals, Microorganism, Kaura-Namoda

INTRODUCTION

Harmattan, a natural phenomenon, contributes to air pollution in Nigeria, alongside soil dust, sea spray, and decaying vegetation (Tahir, 2014). Originating from storms in the arid Northern regions, the dust, reaching far distances, is felt nationwide during December/January, with its source traced to the Faya Largeau area of the Chad basin (Doabi *et al*., 2018). This season stands out due to its dryness and humid tropical air, carrying particulate matter, toxic metals, and microorganisms across regions. Inhalation of Harmattan dust can lead to health issues such as respiratory diseases, cancer, and asthma (Uduma & Jimoh, 2013), (Anne, *et al*., 2009)

The Environmental Protection Agency (EPA) notes that fine particles in Harmattan dust can exacerbate heart and lung diseases, causing premature death and various health problems (Charlesworth *et al*., 2011). Additionally, seasonal dust and dryness may worsen asthma, irritate the throat and eyes, and lead to respiratory infections. Harmattan weather conditions persist from November to mid-March, with dust particles becoming the most abundant aerosol type worldwide, significantly contributing to atmospheric pollution in the western Sahel, including Nigeria (Qi Li *et al*., 2022), (Fagbote & Olanipelau, 2010), (Omoyemi *et al*., 2021).

Pollution from heavy metals and microorganisms is a global concern due to their toxic effects on living organisms. While essential for human development, high concentrations of metals pose risks. Harmattan dust sources include crustal minerals, construction, mining, and agriculture, with heavy metals in atmospheric dust increasing air toxicity. The speciation and bioavailability of heavy metals depend on various factors, including their binding to solids and interactions with soil components (Francis *et al.*, 2023).

Aspergillus and penicillin, two microorganisms identified from Harmattan dust, are known to cause respiratory infections and conditions like asthma and pneumonia. Even though there have been many studies conducted all over the world on heavy metal contamination, little is known about the heavy metals and microorganisms connected to the Harmattan dust of Northern Nigeria, particularly in areas like Zamfara state where illicit mining is common.

Comprehending the levels of heavy metals and microbiological pollutants present in Harmattan dust is essential for safeguarding public health and formulating suitable preventive measures during this time of year (Anegbe, *et al*., 2018).

Figure 1: January Harmattan picture

Figure 2: December Harmattan picture

MATERIALS AND METHODS

Samples Collection

Samples Collection: Dust samples were collected from December 2023 to February 2024 using cleaned sterilized petri dish placed above ground level. Samples were treated as composites for each month.

Brief History of Kaura Namoda

Kaura Namoda, situated in Zamfara State, Nigeria, holds historical significance within the region. Here's a brief overview: Kaura Namoda is a local government area within Zamfara State, one of Nigeria's states located in the northwestern region of the country. It is recognized as one of the fourteen local government areas in Zamfara State. The town of Kaura Namoda serves as its administrative headquarters.

Geographically, Kaura Namoda covers an area of approximately 868 square kilometers. According to the 2006 census, it had a population of 281,367 people. The town experiences a tropical climate with an average temperature of 29°C. During the Harmattan season, which typically occurs between December and February, the area is characterized by dry, dusty winds originating from the Sahara Desert. This leads to widespread dust, with humidity levels around 12%. Kaura Namoda is home to the Kaura Namoda Federal Polytechnic, an educational institution that contributes to the development of the region by providing technical and vocational training.

Agriculture serves as the primary economic activity in Kaura Namoda, providing livelihoods for a significant portion of the population. However, the region faces challenges such as illegal mining activities, which have detrimental effects on the environment. Illegal mining operations contribute to biodiversity loss and environmental pollution, particularly air, water, and soil contamination caused by the release of toxic chemicals. Despite these challenges, Kaura Namoda remains an integral part of Zamfara State, with its rich cultural heritage and natural resources contributing to the overall identity and development of the region. Efforts to address environmental degradation and promote sustainable development are crucial for the well-being of the community and the preservation of its resources for future generations.

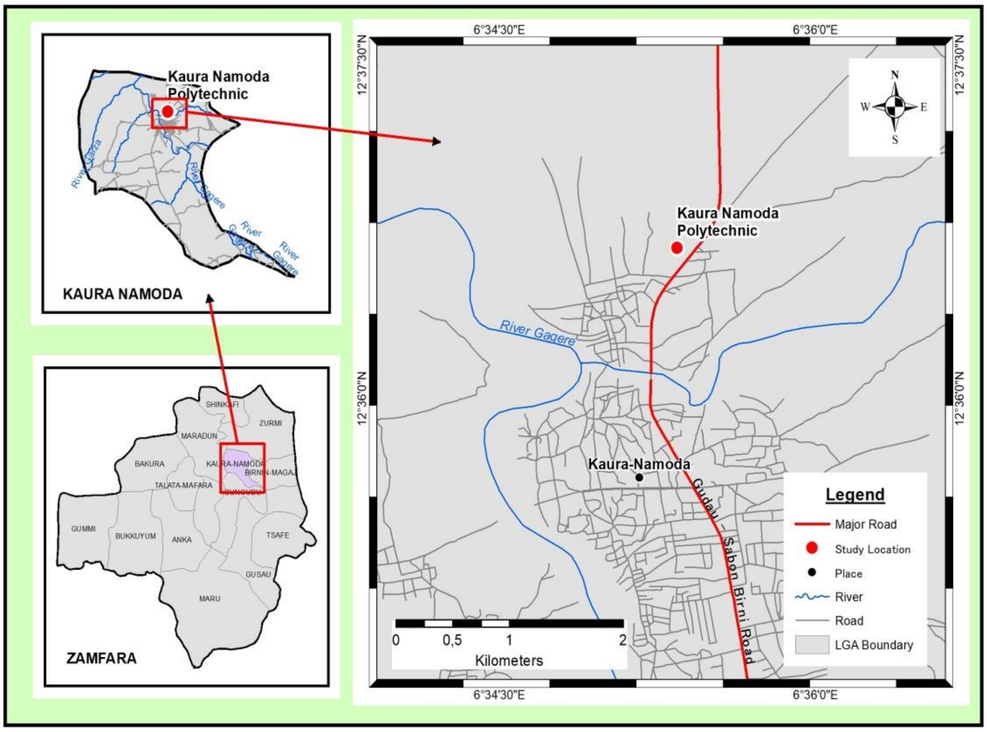

Figure 3: Map of Zamfara state showing Kaura Namoda local government where federal polytechnic is located

Sample Preparation and Extraction

The dust samples were sieved to remove the particulates, then fine dust samples was used for sequential extraction called Tessier's method to obtain the speciation of the selected heavy metals; pb, Cu Cd, Fe, and Cr . The phases of extraction are exchangeable phase, carbonate ligand bond phase, oxide of iron and manganese phase, organic matter phase and residual phases.

First extraction

The exchangeable fraction of the Sample was extracted by weighing 2g of the dust sample mixed with 20 ml of $MgCl_2$ (1M) and agitating at pH of 7 for two hours. The principle is base on adsorption-desorption process, where by weakly adsorbed metals can be released by an ion exchange process as described by (Anegbe *et al.,* 2018).

Second extraction

The second phase of extraction was carried out using the residues from the first phase of extraction, these was done in order to extract metals bond to carbonate by ion exchange using sodium acetate/acetic acid and buffer at pH 5 for almost 6 hours at room temperature. The principle is to co-precipitate the significant amount of metals with carbonate at pH of 5 the extracted metal solution was decanted from the residual and used for the next extraction (Anegbe *et al.,* 2018).

Third extraction

In this phase of extraction, the residue from the second extraction was used to extract metals-bound to iron and manganese oxides under a reducing condition using 0.4M of hydroxyl amine hydrochloride and 25 % acetic acid solution. This was agitated at 96ºC in a water bath for six hours. The principle is based on reducing conditions where Fe (III) and Mn (IV) could release adsorbed trace metals. The extracted metal solution was decanted from the residual an the residue was used for the next phase of extraction (Anegbe *et al.*, 2018).

Fourth extraction

Metal bound to organic matter and sulfide was extracted from the residues obtained from the third extraction. This was oxidized with HNO_3 and 30 % hydrogen peroxide; adjusted pH to 2, the solution was heated at 90ºC with the aid of water bath for 2 hours then allowed to cool. 3M of ammonium acetate in 20 % HNO3 was added. The extracted metal solution was decanted from the residual sediment which was used for the next extraction (Anegbe *et al.,* 2018).

Fifth extraction

The residues from the fourth extraction were oven-dried at 105ºC before digestion (acid digestion) using concentrated HNO_3 and 10 ml of hydrofluoric acid with 10 ml of perchloric acid in Teflon beakers and shaken for 5 hours. This is to extract the metals largely bound with the crystal structure. Analysis was carried out using AAS the instrument was programmed and it carried out metal detection by displaying three absorbance readings. Blanks were also used in order to correct the background and other sources of error. (Anegbe *et al.,* 2018).

Determination of Physicochemical Parameters in Harmattan Dust

pH: The pH of the dust samples was determined using a pH meter, 10g of each dust sample was weighed into three different cleaned beakers, and 50 ml of distilled water was added and stirred for five minutes. The solution was allowed to stand for 30 minutes. The electrode was inserted and the reading was then in triplicate and find the average (Omoyemi *et al*., 2021).

Electrical conductivity (EC): the electrical conductivity was determined from each dust sample.20 g of the dust samples was weighed placed in a cleaned beaker and distilled was added to form a paste. The beaker was then covered with a petri dish. 50ml distilled water was added and shaken for 1 hour. 40 ml of the diluted extract was placed into a 100 ml beaker the conductivity meter was inserted and the electrical conductivity of the soil was recorded in cm- (Tahir, 2014).

Organic Carbon: The organic carbon content of the soils, Cation exchange capacity (CEC) and moisture content were determine using the method describe by (Ichu & Emeagi 2019).

Identification of the Microbe On a nutrient agar medium, the bacterium in the dust was isolated using serial dilution procedures. Viable cultured bacteria were stored, isolated, and their phenotypic traits were assessed using standard microbiological techniques. To identify microorganisms (fungi and bacteria), especially bacteria, in dust samples, the following methodology was followed: 0.2 g of dust was added to 10 ml of buffered peptone water. Subsequently, 0.1 ml of each cascade dilution, ranging from 10-1 to 10-10, is surface-spread on the PCA (Plate Count Agar) medium, and the mixture is incubated for 72 hours to ascertain the aerobic activity of the mesophilic flora. A macroscopic description of the colonies is created and separated on the third day.

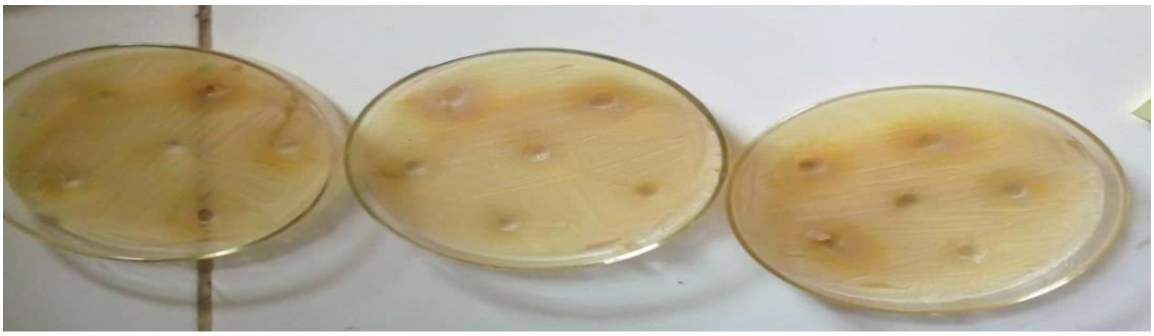

Figure 4: Microbial culture plate for the month of December, January and February

Quality control measures included washing all glassware, petri dishes, plastic containers, crucibles, mortars, and other equipment used in microbiological procedures with detergent, raising with distilled water, and immersing them for 24 hours in a 10% HNO3 solution (Nilufer & Huseyin, 2013). After that, they were cleaned in distilled water and allowed to air dry for five hours at 80°C. All the microbial instrument were sterilized using autoclave at temperature of 105oC

RESULTS AND DISCUSSION

Table 1: Result physicochemical analysis of Harmattan dust

Samples	pH	CEC	OC	OM	SAND	SILT	CLAY
December	4.88±0.09	5.5±0.09	0.35±0.41	1.82±0.05	80.2±0.09	18.9±0.09	1.81±0.05
January	4.60±0.04	5.07±0.10	0.18±0.09	1.83±0.02	80.3±0.09	18.2±0.07	1.76±0.01
February	5.40±0.30	4.80±0.09	0.08±0.07	1.25±0.05	90.6±0.07	8.2±0.02	10.9±0.04

From Table I above, the pH value of the dust samples ranged from 4.8 in December to 5.4 in February. These values indicate an acidic nature, with December and January showing higher acidity. This acidity can influence the mobility and toxicity of heavy metals present in the dust. The percentage of organic matter was lowest in February (1.25%) compared to December and January (both 1.82%). Organic matter tends to adsorb metals and contribute to their mobility (Jimoh, 2012), (Adamiec *et al*., 2016).
Cation exchange capacity (CEC) was highest in December (5.5 cmol/kg), followed by January (5.07 cmol/kg), and lowest in February (4.80 cmol/kg). Higher cation exchange capacity indicates lower leaching potential, possibly due to the higher sand content in the December and January samples. The texture of the dust samples shows that the December and January samples had a higher percentage of sand content (80% and 81%, respectively) compared to the February samples. This indicates that during the Harmattan period, the dust had a higher density of sand particles. The statistical analysis (ANOVA) showed no significant difference among the physicochemical parameters of Harmattan dust samples obtained in December, January, and February in Kaura Namoda, Zamfara State (Jimoh,2012).
Overall, the physicochemical parameters of the Harmattan dust samples indicate variation in acidity, salinity, organic matter, cation exchange capacity, and texture over the months of December, January, and February, but these differences were not statistically significant according to ANOVA analysis.

Table 2: Concentration of Heavy Metal in the Month of December Dust Sample Phases Extraction (%)

Elements	Ni	Cd	Cu	Cr	Pb	Zn
E1	4.20	2.70	0.57	13.60	0.70	6.40
E2	3.90	5.11	0.00	4.34	0.30	8.50
E3	6.80	7.60	9.80	11.40	5.30	25.50
E4	5.80	0.85	54.70	6.50	3.90	9.80
E5	85.40	21.00	44.50	61.00	95.30	45.50

Key: E1-E5, is the extraction phase 1-5

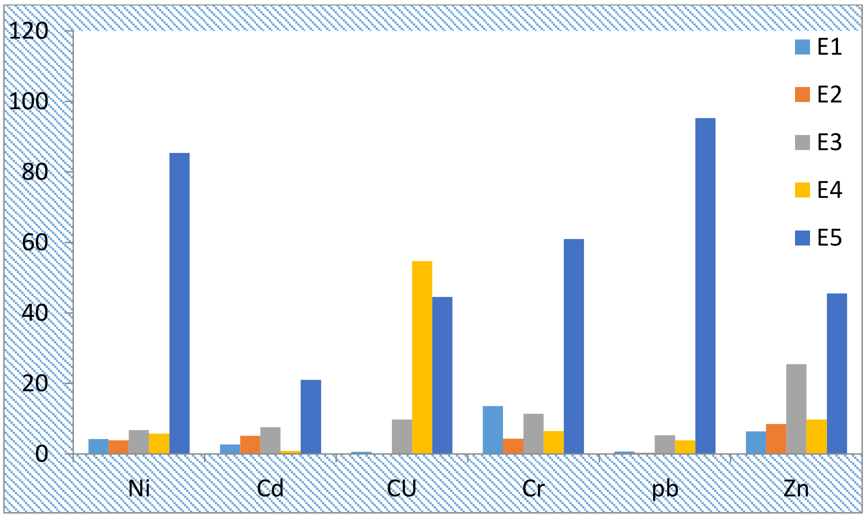

Figure 5: Shows the speciation of heavy metals in the December dust samples in different extraction phase (E1 to E5)

The fractionation and distribution of heavy metals in the Harmattan dust samples were fractionated, and the amount of metals present in the different extraction phases as shown in figure 5 above is expressed as a percentage of the total mass of the metals in the entire extraction fraction of the given metal (Mfonobong *et al*., 2023), (Adekola & Dosumu,2001). Metals of anthropogenic origin are mainly extracted in the first phase of the sequential extraction procedure, while lithogenic metals are found in the second phase of extraction, which corresponds to the residual fraction. Metals found in the phase of extraction, like in the first and last phases, are mostly anthropogenic and lithogenic. Anthropogenic source of heavy metals include mining, industrial activites and agricultural processes while lithogenic source are the metals and metalloid in soil. The metals detected, such as pb, Zn, Ni, and Cr, are abundant in the last phase of extraction, which is residual extraction. This indicates that most of this heavy metal is polluted from lithogenic sources, according to Adebiyi *et al*. (2006).

Table 3: Concentration of Heavy Metal in the Month of January Dust Sample Phases Extraction (%)

Elements	Ni	Cd	Cu	Cr	Pb	Zn
E1	4.50	2.50	0.00	12.80	0.74	6.30
E2	3.89	5.43	0.00	4.10	0.32	8.51
E3	6.76	5.20	8.20	10.70	5.42	25.32
E4	5.40	0.00	50.40	6.30	3.56	9.76
E5	83.90	20.12	44.10	60.98	95.20	45.40

Key: E1-E5, is the extraction phase 1-5

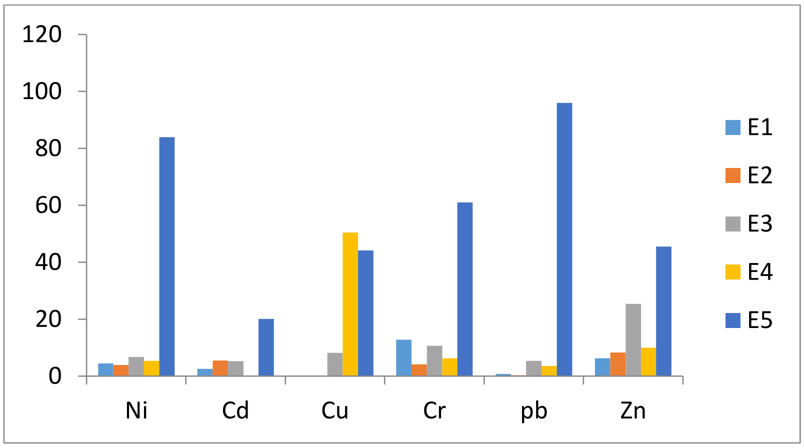

Figure 6: Shows the speciation of heavy metals in the January dust samples in different extraction phase (E1 to E5)

The summaries of the sequential extraction of heavy metals from Harmattan dust samples in January are shown in figure 6 above. Cu was not detected in the exchangeable fraction of extraction, but Cr was the most abundant in that extraction phase. Cd (5.43%) is most abundant in the metals bound to the carbonate by the ion change phase of extraction. But in that phase, Cu was not detected. In the phase extraction of metals bound to iron and manganese oxide, all the metals were detected, but Cr (10.70%) and Zn (25.32%) appeared to be the most abundant in the extraction phases. In the metal bound to organic matter and sulfide extraction phase, Cu (50.40%) is the most abundant, while in the residual phase of extraction, pb, Ni, and Cr of 95.20%, 83.90%, and 60.98%, respectively, have a high percentage of abundance in those phases.

Table 4: Concentration of Heavy Metal in the Month of February Dust Sample Phases Extraction (%)

Elements	Ni	Cd	Cu	Cr	Pb	Zn
E1	2.10	1.45	0.00	0.85	0.48	3.60
E2	0.92	0.00	0.00	0.93	0.23	5.10
E3	4.00	2.12	0.00	0.00	2.50	32.52
E4	5.40	0.00	4.30	2.20	2.15	6.70
E5	54.20	6.78	12.34	30.20	34.56	44.50

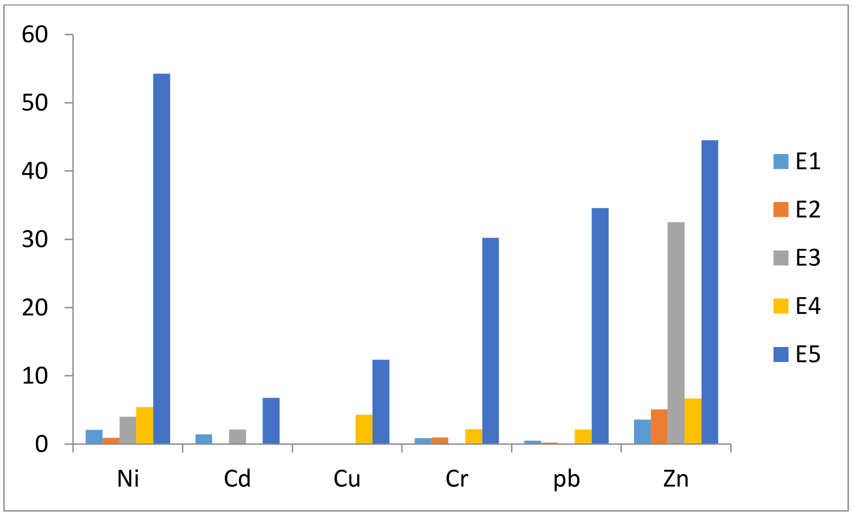

Figure 7: Shows the speciation of heavy metals in the February dust samples in different extraction phase (E1 to E5)

Table 4 shows the summaries of the results of the sequential extraction of heavy metals from the Harmattan dust samples in February. Some of the heavy metals were not detected, such as Cu in the exchangeable fraction, metals bound to carbonate by iron change, and metals bound to iron and manganese oxide. The most abundant heavy metals as shown in figure 7 are detected in the residual extraction: Ni (54.20%), Pb (34.56%), and Zn (44.50%). But Cu was not detected in the exchangeable phase; metals bound with carbonate and metals bound with organic matter. The results indicate that the heavy metal contaminants in December and January are higher than in February.

Metal speciation, which goes through a sequential extraction phase, is essential to determining metal mobility. Considering the order of mobility of metals in the Harmattan dust sample, the fraction of extraction order is exchangeable > bound to carbonate > bound to iron and manganese oxide > bound to organic matter and sulfide > residual, as reported by (Anegbe, *et al.*, 2018). These oxides hold trace metals and can be mobilized under reducing and acidic conditions. The organic phase is relatively stable but can be mobilized under a strong oxidizing condition due to the degradation of organic matter. (Haung *et al.,* 2007).

The results of the sequential extraction of heavy metals in percentage from Harmattan dust samples in December are summarized in Table 2 above. In December 2023, all the heavy metals (Ni, Cd, Cu, Cr, Pb, and Zn) were detected in all the extraction phases, such as the exchangeable fraction, metals bound to carbonate by ion exchange, metals bound to iron and manganese oxide, metals bound to organic matter and sulfide, and residues. Chromium (13.60%) is abundant in the exchangeable phase of extraction, followed by Zn (6.40%). Copper was not detected in the metal bound to carbonate by ion exchange, while Cd and Zn, with 5.11% and 8.50%, respectively, are the most abundant in that extraction phase. All the selected heavy metals are detected in the metals bound to iron and manganese oxide extraction phases, but Cr and Zn show high mobility in the extraction phases. However, Cu and Zn of 54.70% and 9.00% showed abundance in the metals bound to organic matter and sulfide. In the residual extraction, all the heavy metals are abundant, but pb (95%) and nickel (85.40%) are the most abundant heavy metals in the residual phase of the extraction. In all the dust samples under study, pb was abundant in December sample exchangeable fractions, which shows lead was highly mobile and available in the environment. Lead is very toxic to both children and adults upon exposure (whitehead *et al*., 2011).

The source of these heavy metals in Harmattan dust samples is complex and may be associated with industrialization, agricultural activities, mining, and other human activities (Tahir, 2014). This can be attributed to the fact that Zamfara state has been identified by various researchers as having lead pollution in Zamfara. Notwithstanding, it has been identified that the Harmattan wind can bowl in the desert and cover a long distance to deposit dust, and Kaura Namoda is surrounded by illegal mining activities by other local governments. The implication of heavy metals in the Harmattan dust is that when both adults and children's are exposed to these heavy metals, it bio accumulated in the body and lower energy in the brain and damage the function of the brain mostly in children. It can also cause lungs, kidney, liver and other complication to the important organ in the body.

Table 5: Numbers of Microorganisms Isolated from the Harmattan Dust Samples

Microorganisms	December	January	February
Bacterial			
B. cereus	5	5	3
Other bacilli	3	3	0
Staph.	2	2	2
Gram-negative	2	1	0
Gram positive	1	2	0
Fungi			
Aspergillums	1	1	0
Cladosporiun	2	2	2
Yeast	0	0	0

Table 5 above shows the results of microorganisms (bacterial and fungal) isolated from Harmattan dust samples from December, January, and February. Bacteria such as Bacillus cereus and Staphylococcus; others are gram-positive and gram-negative. Fungal species such as aspergillums, cladosporiuns, and yeast were also isolated from the Harmattan dust samples. Bacillus cereus and other bacilli constituted 80% of the Harmattan dust samples in December and January, while the February Harmattan dust sample contained only 20% of Bacillus cereus and other bacilli. The presence of Staphylococcus was present in all the samples, which constituted 100%. The fungal isolates are aspergillums and cladoporiun; yeast was not found in the Harmattan dust in December, January, and February.

Table 6: Comparison of Heavy metal Concentration (mg/kg) with Previous Studies

Authors	Sample matrix	Ni	Cd	Cu	Cr	Pb	Zn	Study area
Current studies	Harmattan dust	106.1	80.86	228.91	225.9	250.66	283.44	Federal polytechnic Kaura Namoda
Francis *et al.*,2023	Harmattan dust	Nil	Nil	293.2	198.0	Nil	747.4	Across some station in Nigeria
Mfonobong *et al.*,2023	Dust	0.44	1.66	3.03	-	3.75	20.81	Kaduna metropolis

Anegbe *et al.*,2018	auto work shop soil	-	1.11	31.08	-	4.21	36.15	Delta state, Nigeria
Falaiye&Awad,2018	Harmattan dust	217	-	193	270	260	875	Ilorin city
Jimoh,2012	Harmattan dust	350	41.5	695	220	698	947	Kano and Zaria cities
WHO limit		5-500	0.01-0.7	2-100	-	2-200	50-300	

Key**:** WHO – word health organization

Comparative Studies

The results of these current studies as compared with reported studies in the literature and the WHO permissible limit are shown in Table 5. Cd, Cu, Cr, and Pb concentrations are above the permissible limit set by the WHO. The higher value observed in this study can be attributed to the dominant mining and agricultural activities in Zamfara State. The concentrations of Cu and Cr were higher than the concentration values obtained in studies (Falaiye & Awad, 2018) but the concentration of Zn was higher than the value in the present studies. The reason can be a result of city activities such as industrialization, which may not be found in the area of the current studies.

Generally, the concentration of present studies is higher than reported studies in the literature (Mfonobong *et a*l., 2023) in the dust of the Kaduna metropolis and (Anegbe *et al.*, 2018) in auto workshop soil. But Zn and Pb concentrations, as reported by (Falaiye & Awad, 2018) in Ilorin and Kano city, are higher than in the present studies. The reasons can be attributed to the fact that the two cities of reported studies are more commercially and economically busy than Zamfara State, where the current studies are reported. The Zamfara state of Nigeria is known for agricultural activities that involve the use of agro-pesticides and illegal mining.

Discussion

The heavy metals of interest in these studies are Ni, Cd, Pb, Cu, Cr, and Zn. The heavy metals were selected because they are among the elements listed by the Environmental Protection Agency (EPA) that have potential health risks when exposed to both children and adult (Khoder *et al*.,2010). In this present study, the results of heavy metals in the Harmattan dust samples collected in December, January, and February 2024 are summarized in Tables 2–4. The sequential extraction procedure was carried out in five different phases, namely: exchangeable fraction, bound with carbonate by ion exchange, metals bound with manganese oxide, metals bound with organic matter and sulfide, and residual extraction (Ichu & Emeagi, 2019), (Brokhartold *et al.*, 2012).

All the extraction processes were calculated in percentages concerning the sum of the five phases of extraction, as shown in Tables 2–4 above. The variation in heavy metals in the Harmattan dust samples may be the result of a variation in the pH of the dust. Because it was reported by Ajai *et al*., 2022 and Barbieri *et al*., 2014 the pH of the soil intensified the displacement of the hydrogen ion H+ accumulated on the exchange surface of the absorbing composite toward the soil solution. This indicates that pH is among the factors that influence the bioavailability and transportation of heavy metals in the soil. Metals in the residue phase of extraction can be considered moderately immovable to ecological variation, considering metals in all other phases of extraction (Ariapak & Honarjo, 2022).

Therefore, the results of speciation studies of Harmattan dust samples revealed that the highest levels of heavy metals were found in December and January dust samples. This implies that the metals are mainly immovable phases, which may not easily bioaccumulation (Allen *et al*., 2008), (Alswadi *et al.*, 2022).

The microorganisms isolated and identified in this present study were forms of bacteria in the three composite samples, namely, December, January, and February. The results are summarized in Table 5 above, which shows Bacillus cereus, Staphylococcus, and Gram-positive and Gram-negative bacteria were present in the three composite dust samples. The majority of the bacterial types identified are gram-positive after being subjected to staining procedures. The dominant group among the bacteria is Bacillus, which may be responsible for respiratory disease. Aspergillus and Cladosporium are the fungal species found in the Harmattan dust samples in these present studies (Angui Li *et al*., 2016).

Microorganisms cause infectious diseases such as flu and measles. There is also strong evidence that some microorganisms may contribute to many non-infectious chronic diseases, such as cancer and coronary heart disease. Therefore, some bacterial infections are caused by the inhalation of contaminated dust, such as coughing, meningococcal diseases, and strep throat. Fungal spores can reproduce on their own, so they thrive in the dust because they don't need a host. Only viruses need a host body to reproduce (Angui Li *et al*., 2016).

In the environment, which may have a strong association with health effects, the various types of dust may act as airborne attributed to the dispersion of microorganisms in more stable conditions with pathway viability at microorganisms to cause great health effects such as allergy, asthma, and respiratory infection (Yaghi &Abdulwahb, 2004)

CONCLUSION

In this present study, the physicochemical, speciation of heavy metals, and microorganism contaminate in Harmattan dust samples obtained from Kaura Namoda, Nigeria was determined after sequential five phases of extraction was carried out in each composite samples of December, January and February Harmattan dust. The result for the heavy metals shows Cr (13.6%) and Zn (25.5%) are more abundant in the exchangeable phases of extraction for December and January. Metals bound to Fe and MnO extraction phases have Zn (25.50%) abundance in December and January, respectively. The residual phase of extraction shows the highest percentage of pb (95.3%) and nickel (85.40%) for December and January. Some of the heavy metals were not detected in February, such as Cd, Cu, and Cr, both in the metal-bound carbonate and manganese oxide extraction phases. The microorganisms identified are bacterial and fungi; the bacteria are Bacillus cereus, Staphylococcus, and Gram-negative and positive, while the fungal are Aspergillums and Clodosporium. Using statistical analysis (ANOVA), it shows that there is no significant difference in physicochemical parameters between the Harmattan dust samples collected in December, January, and February and a significant difference in the percentage of heavy metals. In conclusion, the research reveals that the percentages of heavy metals in the Harmattan dust are high in the immobility phase of extraction, and both bacterial and fungal levels are high in December and January. Therefore, the use of protective measures such as nose masks for both children and adults may prevent direct exposure to Harmattan dust during the period.

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