Bima Journal of Science and Technology, Vol. 8(2) June, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i2.667

Chemometric Analysis for Distribution of Physicochemical Parameters and Heavy Metals of Soil

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ABSTRACT

This research work was carried out on distribution of physicochemical parameters and heavy metals in soil in the vicinity of Ashaka cement industry, Gombe state. The objective of this study was to determine the concentration of heavy metal in soil sample of the study area and compare the results with standard value by WHO/FAO. 12 soil samples were collected from four (4) sampling sites, following APHA procedures for physicochemical parameters while XRF was used for heavy metals of soil samples. Samples were collected using a composite sampling method during the rainy season of 2023. Soils were sampled using clean plastic bags. Analysis was done for heavy metal concentrations such as Pb, Cr, Cd, As, Co, Ni, Cu and Zn. Chemometric analytical statistical analysis such as Hierarchical Cluster Analysis (HCA), Principal Component Analysis (PCA) and Correlation Analysis (CA) were carried. Unlike the rest of the heavy metal concentrations, the result showed the highest levels for Pb, i.e., 94.2 mg/kg for soil sample in JGS which is ≤ 2Km from the cement factory. On the other hand, the mean concentration of heavy metals in the soil sample showed a strong positive correlation between Cd to Cd, Co, and Pb at +1, +0.572 and +0.68 respectively which shows they are all from the same source of pollutant. The study also revealed that most of the heavy metal concentration recorded increased in content during the month of August/September over the month of July/October, due to the surface run off from storm water. The research therefore recommended that although it is indispensable to monitor constantly the quality of soil to avoid the penetration of heavy metals, the government should provide rules and regulations that hinder the dumping of industrial effluent on farmlands to avoid further enrichment of the soil with heavy metals.

Keywords: Cement industry, Environmental, Farmlands, Heavy metals, Industrial effluent, and Mining.

INTRODUCTION

The amount of pollution in the environment is rising as a result of human activities like mining and the careless disposal of sewage and industrial waste. Because heavy metals are persistent, poisonous, and non-degradable, they pose a substantial threat to the ecosystem and have a considerable impact on the local ecology and geology. In Nigeria, the prospecting, extraction, and exploitation of minerals can lead to contamination of the soil, water, and air. The scale of the deposit, the host-rock lithology, the wall-rock alteration, the kind of ore, the geochemistry of trace elements, the mineralogy and zonation of the ore and gangue, the topography, physiography, and climate, as well as the mining and milling techniques used, all have an impact on limestone deposits.

Large volumes of physical and chemical data from the impacted environmental compartments—such as the air, water, soil, sediments, biota, and other elements—must be gathered for environmental monitoring studies. According to Amadi, (2009), mining is an integral part of development of civilization and early mining operations have left a historical legacy of negative environmental impacts that affect our perception on mining and this is occasioned by the crude mining equipment. The exploration and processing of limestone have adversely affected the environment (Singh *et al*., 2008; Sundaray, 2009). Chemometric methods, such as Hierarchical Agglomerative Cluster Analysis (HACA or CA), Discriminant Analysis (DA), and Factor/Principal Components Analysis (PCA), are used to reveal relevant patterns and variation sources in environmental databases.

In Funakaye Local Government Area of Gombe State, heavy metal pollution enrichment in soil is primarily due to bedrock dissolution, weathering, and application of fertilizers on farmlands. However, research has not covered the effect of these mining activities on surrounding soil and farmlands, nor the role played by chemometric analytical tools and interrelationships between water quality and health risk parameters.

This research aims to determine the distribution and source identification of physicochemical parameters and heavy metals in soil near the Ashaka cement industry in Gombe state using chemometric analysis. The study will benefit the academic sector by understanding the distribution patterns of heavy metals and physicochemical parameters in industrial areas and

For this study, the concentration of heavy metals in soil and vegetables after irrigation practices with wastewater emanating from industrial parks were analyze and 24 samples were collected from 8 sampling stations for vegetable, soil and water samples separately, following APHA procedures. Samples were collected using a composite sampling method in May and June 2021. Water samples were collected using clean polyethylene plastic bottles while soil and vegetables were sampled using clean plastic bags. Analysis was done for heavy metal concentrations such as Pb, Cr, Cd, and Zn for each sample using descriptive statistics of changes in concentrations, one-way analysis of variance (ANOVA), Principal Component Analysis and Pearson Correlation Coefficient. The mean concentration of heavy metals in soil, vegetables, and water samples was analyzed.

MATERIALS AND METHODS

Measurement of pH for Soil Samples

For measuring the pH of the soil sample, Kebir and Bouhadjera, (2019) method was adopted with a slight modification. The pH of the soil samples were measured in a 1:5 soil-water ratio (w/v). Then 10.00g of the sieved and dried soil were weighed into beaker and 50.00 cm^3 of distilled water added. The mixtures were stirred several times for 30 minutes. Then the soil suspensions were allowed undisturbed or more 30 minutes. The electrode pH meter was then inserted into the settled suspension and the pH of the soil samples were measured.

Heavy Metal Experimental Procedure for Soil Samples

The heavy metals (As, Co, Zn, Pb, Cd, Cu, Ni, and Cr) for soil samples were analysed using the X-Ray Fluorescene (XRF) Spectrometer. Tiago et al., (2019) method was adopted with slight modification, the samples were-dried in a clean place, then grounded to break down aggregates. Preliminary ground sample were then subdivided by using quartering. The samples obtained after quartering were grounded again into fine powder to yield an acceptable number of particles of each component of the heterogeneous material. The samples were sieved through a sieve of 60 µm size and the oversized were ground again until no grains larger than 60 µm were left. Sieves made of nylon were used to avoid contamination by metals. 10g of soil samples were taken from the laboratory sample for measurement, to evaluate their homogeneity. The samples were then mixed with or without binder and pressed to make the pellets. The pellets were visually inspected, evaluating their homogeneity aspect and integrity as shown in Figure 1 below

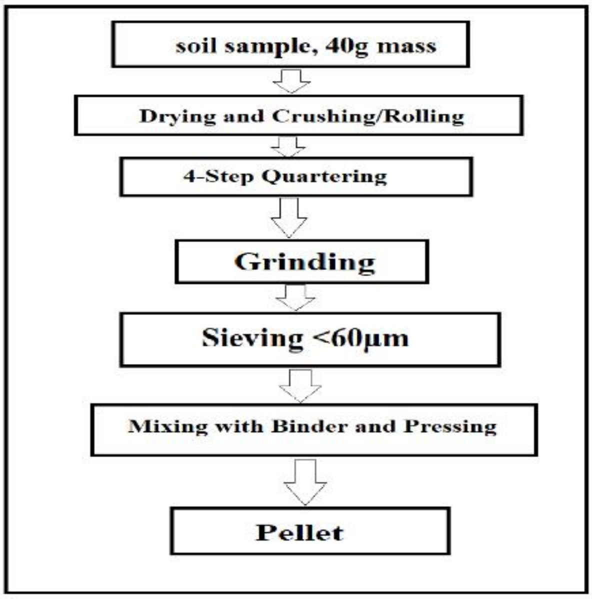

Figure 1: Sample Pelleting Prior to Analysis

Chemometric Statistical Analysis

Chemometric Statistical Analysis for Hierarchical Cluster Analysis (HCA), Correlation Analysis (CA), Factor/Principal Component Analysis (PCA) and Discriminant analysis (DA) were performed accordingly;

Correlation analysis (CA)

The analyzed water quality and health risk parameters were subjected to Pearson's correlation analysis using the IBM SPSS software (v. 29.0.2.0). This was done to establish the interrelationships between the analyzed parameters (contaminants/pollutants) and their possible sources in the vicinity of Ashaka Cement Industry. Parameters with association (correlation) coefficients (r) > 0.7, 0.7 >r > 0.5, and r < 0.5 were considered as strong, moderate, and weak, respectively (Barzegar*et al.* 2018; Mgbenu and Egbueri 2019). Strong and moderate coefficients also indicate pairs with significant risk factors, while those with weak coefficients indicate low risk factor.

Principal component analysis (PCA)

The PCA was also used to study the interrelationships between analyzed parameters and their factor loadings (Egbueri 2018, 2019). The degree of the impact of heavy metals on non-carcinogenic and carcinogenic health risk parameters and WQI was also analyzed using the PCA. The PCA was used to show the parameters (components) with low, medium, and high factor loadings. In addition, it was used to identify the most significant health risk factor (parameter) loadings. Varimax rotation (with Kaiser normalization) was used in extracting the factor components. The exact number of factors was chosen by Kaiser (1958, 1960) criterion in which factors with eigen values < 1 are not considered. In this study, factor loadings above 0.75 were classed as high, those between 0.50 and 0.75 as medium, and those below 0.50 as weak (Tziritis*et al.* 2017). This was based on the fact that the higher a factor loading of a parameter, the greater its participation to the examined factor group.

Hierarchical cluster analysis (HCA)

This statistical tool (HCA) is commonly used in water quality evaluation to group, into the same cluster/class, samples with similar quality, and risk characteristics (Egbueri 2018, 2019, Egbueri and Unigwe 2019). In other words, HCA successfully classifies water samples based on their qualities. The Ward's linkage method (with squared Euclidean distance and z-score standardization) was used in this analysis. A dendrogram was produced to show the quality groups of the water samples.Table 1 shows the results of heavy metals from the 4 locations of the river.

DOI: 10.56892/bima.v8i2.667

RESULTS AND DISCUSSION

Table 1: Cr, Co, Ni, Cu, Zn As, Pb, Cd in (mg/kg) result obtained from soil samples

S/N	Sample Code	Cr (mg/kg)	Co (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	As (mg/kg)	Pb (mg/kg)	Cd (mg/kg)
1	FSS	ND	8.01±0.03	22.20±2.41	81.50±2.48	13.6±2.34	ND	75.90±2.31	9.92±0.72
2	JGS	12.80±0.01	10.20±0.00	17.50±0.14	51.50±0.055	47.20±1.82	14.50±1.46	94.20±2.94	15.20±0.841
3	ASS	59.20±1.32	9.38±0.03	23.10±2.59	54.10±2.37	40.00±1.65	ND	82.10±2.59	ND
4	KTS	ND	5.49±0.012	11.20±2.02	38.30±1.89	12.70±1.14	11.10±1.11	71.20±2.24	ND
5	Min.	12.80±0.01	5.49±0.012	11.2±2.02	38.3±1.89	12.7±1.14	11.1±1.11	71.20±2.24	9.92±0.72
6	Max.	59.20±1.32	10.20±0.00	23.10±2.59	81.50±2.48	47.20±1.82	14.50±1.46	94.20±2.94	15.20±0.841
7	Mean	36	8.27	18.5	56.35	28.38	12.8	80.85	12.56
8	WHO/FAO	0.05	0.01	0.01	1.5	5.0	0.05	0.05	0.05

The Value are the mean ± SD of four (4) soil samples analyzed individually in triplicate and mean value

Table 1 above describes the results of heavy metals of soil samples by comparing it with the WHO/FAO permissible limit

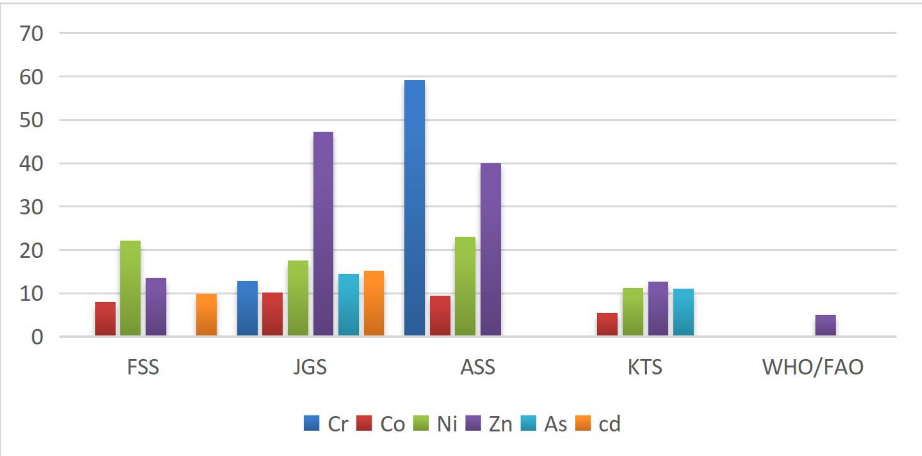

Figure 2: The above figure shows the chart of heavy metals from different locations by comparing it the WHO/FAO permissible limit of heavy metals in river water**.** Cr, Co, Ni, Zn As, Cd in (mg/kg) result obtained from soil samples.

The highest mean value concentration recorded in table 1 for the soil sample was in Pb (80.5 mg/kg) while the least concentration recorded was in Co (8.27 mg/kg) and the trend of the concentration of the target elements in the soil samples are in the order Pb > Cr > Ni > As > Cd> Cu > Zn > Co respectively. This result is in line with Yaylal-Abanuz, (2011) who evaluated the heavy metal contamination of surface soil and Lemessa*et al.*, (2022) they conducted a research on the analysis of the concentration of heavy metals in soil around the Bole Lemi industrial Park, Ethiopia, It is also in line with the study examined the levels of heavy metals in soil, water, and vegetables around the industrial area Bauchi, Northeastern Nigeria, (Maigari *et al.,* 2021***).***

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Table 2: Soil physical properties

S/N	Sample Code	EC (μScm^{-1})	P^H	Salinity (%)	Cl (mg/kg)
1	FSS	1150±255.35	6.36±0.07	2.80±0.003	396±5.32
2	JGS	1310±223.15	8.17±1.30	1.60±0.004	535±7.84
3	ASS	1176.5±246.20	6.73±0.51	2.60±0.02	535±4.61
4	KTS	2395±562.05	6.45±0.03	3.70±0.09	486±11.52
5	Min.	1150±225.35	6.36±0.007	1.6±0.004	396±5.32
6	Max.	2395±562.05	8.17±1.30	3.7±0.09	535±4.61
7	Mean	1507.88	6.9275	2.675	488
8	WHO/FAO	110-570	6.5-8.5	3.6	250

The Value are the mean ± SD of four (4) soil samples analyzed individually in triplicate and mean value.

Table 2 above shows some of the physical properties of the soil that were used for the analysis by comparing it with the World Health Standards.

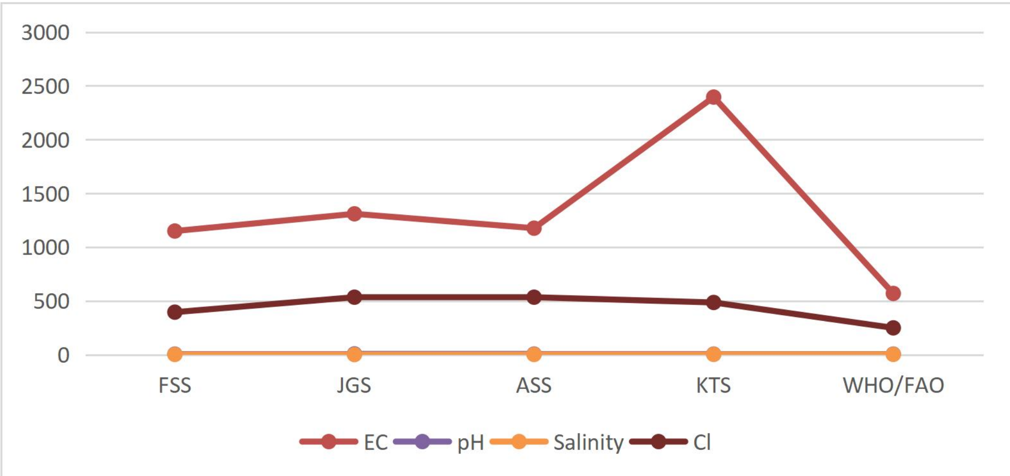

Figure 3: Chemometric Statistical Analysis

The figure 3 above describes the Chemometric Statistical Analytical Data Analysis Result for Soil Samples of Hierarchical Cluster Analysis (HCA), Correlations Analysis (CA), Factor/Principal Component Analysis (PCA) and Discriminant Analysis (DA).

pH, Electrical Conductivity (EC), Salinity and Chloride (Cl) Result for soil sample.

The evaluation of the distribution of physicochemical parameters (pH, EC, Salinity and Chloride) in the vicinity of Ashaka Cement Inductry Gombe state, Table 2 shows that the values of EC and Chloride obtained in the research are both above the desirable threshold standard permissible limits of WHO and FAO in all the sampling sites. While pH and Salinity were observed to be within acceptable limits in all sampling sites with the exception of pH whose Value ranges between (6.36 to 8.17), the minimum values of 6.36 and 6.45 obtained from FSS and KTS respectively are below the standard permissible limit, also, the value Salinity (3.70) obtained from KTS is above the standard permissible limit of WHO and FAO. This result is in line with Dandwate (2020) the study focused on analysis of soil samples for its physicochemical parameters from Sangamner city, India.

Cluster Analysis Result of Physicochemical Parameters Result for SoilSamples (EC, pH, Salinity and Cl-)

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Table 3: Case Processing Summary

Cases Valid		Cases Missing		Total	
N	Percent	N	Percent	N	Percent
4	100.0	0	.0	4	100.0

a. Squared Euclidean Distance used

Figure 4: Dendrogram for EC, Salinity, Chloride and pH.

The figure 4 above is a dendrogram produced to show the quality groups of soil samples based on their pH, Salinity, Chloride and EC using Average Linkage Method. Salinity and pH are members of the same cluster which were then attached to Chloride to formed a cluster/class due to their significant relationship and similarities, as Salinity increases, pH too must be affected. Also, Chloride and EC form the same cluster which were formed cluster/class with pH, due to their significant relationship, this shows they all share common source of pollution that originated from their sample sites. Hence the result is in line with Olukoya *et al.,* (2019) in Chemometric evaluation of heavy metals pollution patterns of soil in the vicinity of some dumpsites in Lokoja, Nigeria. Cluster Analysis Result of Heavy Metal Result for Soil Samples (Cd, Ni, As, Co, Pb, Cr, Zn and Cu).

The dendrogram above shows the quality of soil samples based on their Cd, Co, As, Pb, Zn, Ni, Cr and Cu using Average Linkage Method. the cluster analysis gives pattern recognition based on the similarity and closeness is the soil sites and the nature of the contaminants. With reference to figure 6 Cd and As are members of the same cluster which were formed a large cluster/class with Ni, Co and Pb due to their significant relationship within the group. Cr and Co formed another cluster, while Cu and Cr formed a cluster which were formed cluster/class with Co, due to their significant relationship. Finally, Zn formed a large cluster/class with Cr and Co due to their significant relationship within the groups, this shows Cd, As and Ni, Co, Pb share common source of pollution and different pollution source from Cr, Cu and Zn at their sample sites. The result is in line with Olukoya *et al.,* (2019) in Chemometric evaluation of heavy metals pollution patterns of soil in the vicinity of some dumpsites in Lokoja, Nigeria.

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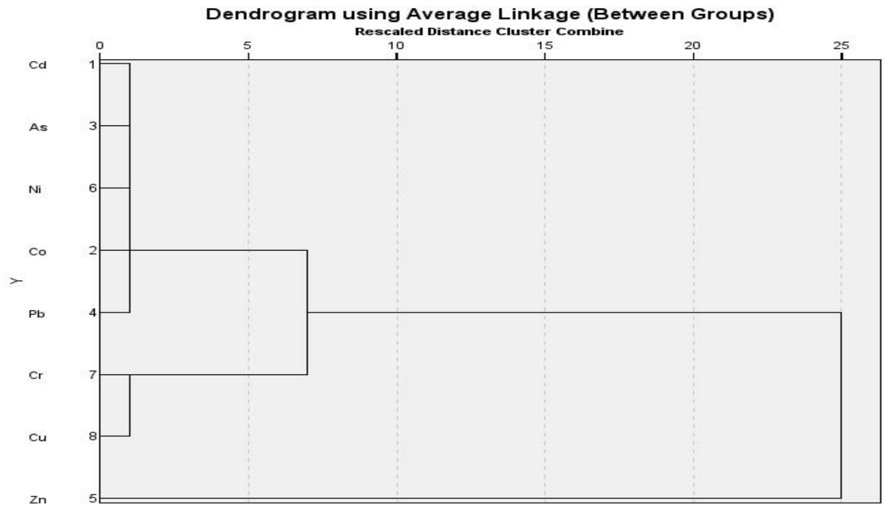

Figure 5: Above is describes the dendrogram results of the heavy metal analysis. Dendrogram Result for Soil Samples (Cd, Ni, As, Co, Pb, Cr, Zn and Cu)

The table 4 showed the correlation between the physicochemical parameters of soil samples (pH, EC, Salinity, Chloride) correlated using Pearson correlation, the result shows a strong positive correlation between EC to EC and Salinity at +1 and +0.71 this shows they share common source of pollution that originated from their sample sites., weak positive correlation between EC to Chloride at +0.054 r also, a weak negative correlation were obtained between EC to pH at -0.266. There is also a strong positive correlation between pH to pH and Chloride at +1 and +0.617, a strong negative correlation were obtained between pH to Salinity at -0.863, there is also a weak negative correlation between pH to EC at -0.266. The result shows a strong positive correlation between Salinity to Salinity and EC at +1 and 0.716 respectively, also, a strong negative correlation were obtained between Salinity to pH at -0.863. a weak negative correlation were obtained between Salinity to Chloride at -0.399. The result shows a strong positive correlation between Chloride to Chloride and pH at +1, +0.617, weak positive correlation between Chloride to EC at +0.054 also, a weak negative correlation were obtained between Chloride to Salinity at -0.399. Any score from +0.5 to +1 indicates a very strong positive correlation, which means that they both increase at the same time. Any score from -0.5 to -1 indicate a strong negative correlation, which means that as one variable increases, the other decreases proportionally.

Table 4: Correlation Table for (EC, pH, Salinity and Cl-)

EC	Pearson Correlation	1	-.266	.716	.054
	Sig. (2-tailed)		.734	.284	.946
	N	4	4	4	4
pH	Pearson Correlation	-.266	1	-.863	.617
	Sig. (2-tailed)	.734		.137	.383
	N	4	4	4	4
Salinity	Pearson Correlation	.716	-.863	1	-.399
	Sig. (2-tailed)	.284	.137		.601
	N	4	4	4	4
Chloride	Pearson Correlation	.054	.617	-.399	1
	Sig. (2-tailed)	.946	.383	.601	
	N	4	4	4	4

Table 5 is the results of heavy metal concentration of soil Samples (Cd, Ni, As, Co, Pb, Cr, Zn and Cu) correlated using Pearson correlation, the result shows a strong positive correlation between Cd to Cd, Co, and Pb at +1, +0.572 and +0.681 this shows they share common source of pollution that originated from their sample sites., a weak positive correlation between Cd to Ni, As, Zn and Cu at +0.174, +0.349, +0.482 and +0.427 respectively, also, a weak negative correlation were obtained between Cd to Cr at -0.404. There is also a strong positive correlation between Ni to Ni, Co, Cr, Zn, and Cu at +1, +0.668, +0.564, +0.626 and +0.739, weak positive correlation between Ni to Cd and Pb at +0.174 and +0.273 respectively, also, a strong negative correlation were obtained between Ni to As, at -0.777. The result shows a strong positive correlation between As to As at +1, weak positive correlation between As to Cd and Pb at +0.349 and +0.385 respectively. also, a strong negative correlation were obtained between As to Ni, Zn and Cu at -0.777, -0.568 and -0.662 respectively, weak negative correlations were obtained between As to Co and Cr at -0.062 and -0.434 respectively. The result shows a strong positive correlation between Co to Co, Cd, Ni, Pb and Cr at +1, +0.572, +0.668, +0.897 and +0.520 respectively. weak positive correlation between Co to Zn and Cu at +0.196 and +0.283 respectively also, a weak negative correlation was obtained between Co to As at -0.062. The result shows a strong positive correlation between Pb to Pb, Cd and Co at +1, +0.681 and +0.897, weak positive correlation between Pb to Ni, As and Cr at +0.273, +0.385 and +0.292 respectively also, a weak negative correlation were obtained between Pb to Zn and Cu at -0.072 and -0.033. The result shows a strong positive correlation between Cr to Cr, Ni, and Co at +1, +0.564 and +0.520, weak positive correlation between Cr to Pb at +0.292, also, a weak negative correlation were obtained between Pb to Cd, As, Zn and Cu at -0.404, -0.434, -0.282 and -0.128 respectively.

Table 5: Correlation Table for soil (Cd, Ni, As, Co, Pb, Cr, Zn and Cu)

Cd	Pearson Correlation	1	.174	.349	.572	.681	-.404	.482	.427
	Sig. (2-tailed)		.826	.651	.428	.319	.596	.518	.573
	N	4	4	4	4	4	4	4	4
Ni	Pearson Correlation	.174	1	-.777	.668	.273	.564	.626	.739
	Sig. (2-tailed)	.826		.223	.332	.727	.436	.374	.261
	N	4	4	4	4	4	4	4	4
As	Pearson Correlation	.349	-.777	1	-.062	.385	-.434	-.568	-.662
	Sig. (2-tailed)	.651	.223		.938	.615	.566	.432	.338
	N	4	4	4	4	4	4	4	4
Co	Pearson Correlation	.572	.668	-.062	1	.897	.520	.196	.283
	Sig. (2-tailed)	.428	.332	.938		.103	.480	.804	.717
	N	4	4	4	4	4	4	4	4
Pb	Pearson Correlation	.681	.273	.385	.897	1	.292	-.072	-.033
	Sig. (2-tailed)	.319	.727	.615	.103		.708	.928	.967
	N	4	4	4	4	4	4	4	4
Cr	Pearson Correlation	-.404	.564	-.434	.520	.292	1	-.282	-.128
	Sig. (2-tailed)	.596	.436	.566	.480	.708		.718	.872
	N	4	4	4	4	4	4	4	4
Zn	Pearson Correlation	.482	.626	-.568	.196	-.072	-.282	1	.987*
	Sig. (2-tailed)	.518	.374	.432	.804	.928	.718		.013
	N	4	4	4	4	4	4	4	4
Cu	Pearson Correlation	.427	.739	-.662	.283	-.033	-.128	.987*	1
	Sig. (2-tailed)	.573	.261	.338	.717	.967	.872	.013	
	N	4	4	4	4	4	4	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

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The result shows a strong positive correlation between Zn to Zn, Ni, and Cu at +1, +0.626 and +0.987, weak positive correlation between Zn to Cd and Co at +0.482 and +0.196, a strong negative correlation were obtained between Zn to As at -0.568, also, there is a weak negative correlation were obtained between Zn to Pb and Cr at -0.072 and -0.282 respectively.

The result shows a strong positive correlation between Cu to Cu, Ni and Zn, at +1 +0.739 and +0.987, there are weak positive correlations between Cu to Cd and Co at +0.427 and +0.283, also, a strong negative correlation was obtained between Cu to As at -0.662, a weak negative correlation were obtained between Cu to Pb and Cr at -0.033 and -0.128 respectively. Any score from +0.5 to +1 indicates a very strong positive correlation, which means that they both increase at the same time. Any score from -0.5 to -1 indicate a strong negative correlation, which means that as one variable increases, the other decreases proportionally. This result is in line with Lemessa (2022) in analysis of the concentration of heavy metal in soil, vegetable and water. The result is also in line with Olukoya *et al.,* (2019) in Chemometric evaluation of heavy metals pollution patterns of soil in the vicinity of some dumpsites in Lokoja, Nigeria.

Factor/Principal Component Result of Physicochemical Parameters Result for

Soil Samples (EC, pH, Salinity and Cl-)

Component Matrix[a]

a. 2 components extracted.

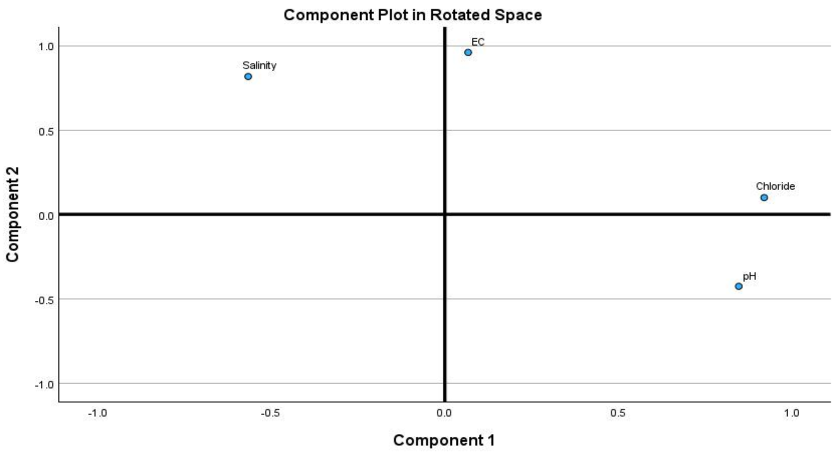

Figure 7: The figure above is a Principal Component Plot for Soil Samples (EC, pH, Salinity and Cl-). The first principal component is the one that explains the most variance, the second one is the one that explains the most variance after removing the effect of the first one, and so on, two (2) components were extracted from the PCA plot above which shows the similarities and dissimilarities between the parameters, in component one (1) EC and Chloride detects a strong significant relationship followed by pH, which shows they originate from the same source and distribution pattern of contaminants, while in Component two (2), Salinity detects a strong similarity after removing the effect by component one (1), which shows they originate from the same source and distribution pattern of contaminants. Parameters similarities and dissimilarities are easily and visually detected using PCA plot. PCA is more suitable for exploratory data analysis, where we want to discover the main patterns and sources of variation in the data.

Bima Journal of Science and Technology, Vol. 8(2) June, 2024 ISSN: 2536-6041

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Factor/Principal Component Result of Heavy Metal Result for Soil Samples (Cd,Ni, As, Co, Pb, Cr, Zn and Cu)

Component Matrix[a]

a. 3 components extracted.

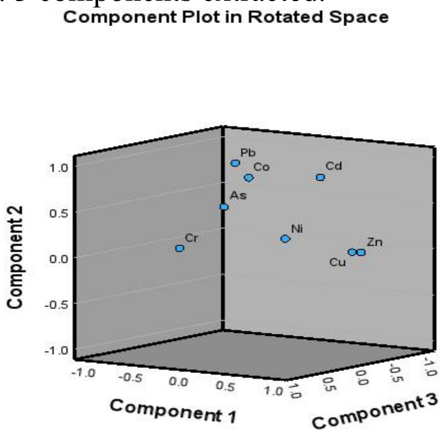

Figure 8: This figure describes the principal component plot for soil Samples (Cd, Ni,As, Co, Pb, Cr, Zn and Cu)

The first principal component is the one that explains the most variance, the second one is the one that explains the most variance after removing the effect of the first one, and so on, two (2) components were extracted from the PCA plot above which shows the similarities and dissimilarities between the parameters, in component one (1) Pb, Cd, Co, As and Ni detects a strong significant relationship which shows they originate from the same source and distribution pattern of contaminants, followed by Component two (2), Cr detect a strong similarity after removing the effect of the first one followed, which shows they originate from the same source and distribution pattern of contaminants, by Component three (3) which Zn and Cu detects a strong similarity after removing the effect of the second component and so on which shows they originate from the same source and distribution pattern of contaminants. Parameters similarities and dissimilarities are easily and visually detected using PCA plot. PCA is more suitable for exploratory data analysis, where we want to discover the main patterns and sources of variation in the data. This research is in line with Juahir et al., (2010). Spatial assessment of Langat river water quality using chemometrics. The result is also in line with Olukoya *et al.,* (2019) in Chemometric evaluation of heavy metals pollution patterns of soil in the vicinity of some dumpsites in Lokoja, Nigeria.

This research was conducted on chemometric analysis for distribution of physicochemical parameters and heavy metals in soil in the vicinity of Ashaka Cement Industry, Gombe State. 12 soil samples were obtained from four (4) sampling station (FSS, JGS, ASS and KTS) which are both sediment and surface soil sample. The study was caried out in rainy reason for the month of July, August, September and October, 2023. The analysis caried out on soil physicochemical parameters and heavy metal concentration include low and high tech instrumental method of analysis, X-ray Florescence (XRF) Spectrometry was used for determination of heavy metal concentration in soil, chemometric statistical analysis performed were include Hierarchical Cluster Analysis (HCA), Correlation Analysis (CA), Factor/Principal Component Analysis (PCA) respectively.

The highest mean value concentration recorded in table 4.5 for the soil sample was in Pb (80.5 mg/kg) while the least concentration recorded was in Co (8.27 mg/kg) and the trend of the concentration of the target elements in the soil samples are in the order Pb > Cr > Ni > As > Cd> Cu > Zn > Co respectively. This result is in line with Yaylal-Abanuz, (2011) who evaluated the heavy metal contamination of surface soil and Lemessa*et al*., (2022) they conducted a research on the analysis of the concentration of heavy metals in soil around the Bole Lemi industrial Park, Ethiopia, It is also in line with the study examined the levels of heavy metals in soil, water, and vegetables around the industrial area Bauchi, Northeastern Nigeria,Maigari *et al., (2021).* While the evaluation of the distribution of physicochemical parameters (pH, EC, Salinity and Chloride) in the vicinity of Ashaka Cement Inductry Gombe state, Table 4.1 shows that the values of EC and Chloride obtained in the research are both above the desirable threshold standard permissible limits of WHO and FAO in all the sampling sites. While pH and Salinity were observed to be within acceptable limits in all sampling sites with the exception of pH whose Value ranges between (6.36 to 8.17), the minimum values of 6.36 and 6.45 obtained from FSS and KTS respectively are below the standard permissible limit, also, the value Salinity (3.70) obtained from KTS is above the standard permissible limit of WHO and FAO. This result is in line with Dandwate (2020) the study focused on analysis of soil samples for its physicochemical parameters from Sangamner city, India.

CONCLUSION

The concentrations of Chromium (Cr) and Nikel (Ni) were predominantly higher in the sediment samples indicating downward movement of the metals, while Lead (Pb), Asenic (As), Cadmium (Cd), Copper (Cu), Zinc (Zn) and Cobalt (Co) were higher in the surface soils than the sediment. In general, the highest concentrations for metals analyzed occurred at JGS which is ≤ 2Km from the factory, as a result, the distribution pattern showed that the metal concentrations decreased with increasing distance from the factory. The alkaline nature of cement dust may have an impact on the mobility of metals in the soil, and this pattern indicates that emissions from factories may enrich the environment with heavy metals and cause them to associate with dust., and this may in turn affect plant available forms of the metals, which here may be potential health implications as a result of cement emissions. In conclusion, all the mean concentration of heavy metals recorded in soil are above the standard permissible limit by WHO/AFO.

Recommendations

i. Although the Ashaka Cement Industry Management is putting in commendable efforts to curtail the effluent, more effort should be enhanced, also, the community farmers should endeavor to seek the advice of environmental chemists for application of fertilizer, chloride-rich fertilizers would only cause more harm.

ii. Government should ensure that industrial wastes or residues are properly checked and regulated for heavy metals and must not be discharged on soil surfaces without significant treatment, tests and approval.

REFERENCES

Amadi, A. N. (2009). Bacteriological and Physio-chemical Characteristics of different Water Sources in Bida Town, Niger State. Journal of Environmental Science, l(l),72-82.

Dandwate, S. C. (2020). Analysis of soil samples for its physicochemical parameters from

Egbueri JC (2018) Assessment of the quality of groundwaters proximal to dumpsites in Awka and Nnewi metropolises: a comparative approach. Int J Energ Water Res. https :/ /doi.org/10. 1007/ s4210 8-018-0004-1

Egbueri JC, Mgbenu CN, Chukwu CN (2019) Investigating the hydrogeochemical processes and quality of water resources in Ojoto and environs using integrated classical methods. Model Earth Syst Environ. https ://doi.org/10.1007/s4080 8-019-00613 -y

Iwegbue, C. M. A., Bassey, F. I., Tesi, G. O., Nwajei, G. E., & Tsafe, A. I. (2013). Assessment

of heavy metal contamination in soils around cassava processing mills in sub-urban areas of Delta State, Southern

Nigeria. *Nigerian Journal of Basic and Applied Sciences*, *21*(2), 96-104.

Juahir, H., Zain, S. M., Aris, A. Z., Yusoff, M. K., &Mokhtar, M. B. (2010) Spatial assessment of Langat river water quality using chemometrics. *Journal of Environmental Monitoring*, *12*(1), 287-295.

Lemessa, F., Simane, B., Seyoum, A., & Gebresenbet, G. (2022). Analysis of the concentration of heavy metals in soil, vegetables and water around the bole Lemi industry park, Ethiopia. *Heliyon*, *8*(12).

Liu, C. W., Lin, K. H., & Kuo, Y. M. (2003). Application of factor analysis in the assessment of groundwater quality in a blackfoot disease area in Taiwan. *Science of the total environment*, *313*(1-3), 77-89.

Mgbenu, C. N., &Egbueri, J. C. (2019). The hydrogeochemical signatures, quality indices and health risk assessment of water resources in Umunya district, southeast Nigeria. *Applied water science*, *9*(1), 1-19.

Olasehinde, P. I., Amadi, A. N., Enwedo, E. O., Dan-Hassan, M. A., & Okunlola, I. A. (2016). Assessing the Groundwater Potential in Wuye District, Federal Capital Territory, Abuja, Nigeria.

Olukoya, A. B., Yisa, J., & Jacob, J. O. Chemometric Evaluation of Heavy Metals Pollution Patterns of Soil in the Vicinity of Some Dumpsites in Lokoja, Nigeria.

Orisakwe, O. E., Nduka, J. K., Amadi, C. N., Dike, D. O., & Bede, O. (2012). Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South Eastern, Nigeria. *Chemistry central journal*, *6*(1), 1-7.

Rai PK. (2009) Technology, Heavy metal phytoremediation from aquatic ecosystems with special reference to macrophytes. Critical Reviews in Environmental Science and Technology. 39(9):697-753

Sangamner city. *GSC Biological and Pharmaceutical Sciences*, *12*(2), 123-128.

Saudi, A. S. M., Ridzuan, I. S. D., Balakrishnan, A., Azid, A., Shukor, D. M. A., &Rizman, Z. I. (2017). New flood risk index in tropical area generated by using SPC technique. *Journal of Fundamental and Applied Sciences*, *9*(4S), 828-850.

Sekabira, K., Origa, H. O., Basamba, T. A., Mutumba, G., & Kakudidi, E. (2010). Assessment of heavy metal pollution in the urban stream sediments and its tributaries. *International journal of environmental science & technology*, *7*, 435-446.

Singh KP et al. (2008) Impact assessment of treated/untreated wastewater toxicants discharged by sewage treatment plants on health, agricultural, and environmental quality in the wastewater disposal area. Chemosphere. 55(2):227-255

Singh, K. P., Malik, A., Mohan, D., &Sinha, S. (2004). Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)—a case study. *Water research*, *38*(18), 3980-3992.

Sonone SS et al. (2020) Water contamination by heavy metals and their toxic effect on aquaculture and human health through food Chain. Letters in Applied NanoBioScience.;10(2):2148-2166

Sundaray, S. K., Nayak, B. B., & Bhatta, D. (2009). Environmental studies on river water quality with reference to suitability for agricultural purposes: Mahanadi river estuarine system, India–a case study. *Environmental monitoring and assessment*, *155*, 227-243.

DOI: 10.56892/bima.v8i2.667

Tavakoli-Hosseinabady B et al. (2018) Detoxification of heavy metals from leafy edible vegetables by agricultural waste: Apricot pit shell. Journal of Environmental & Analytical Toxicology. 8(1):548

Tziritis EP, Datta PS, Barzegar R (2017) Characterization and assessment of groundwater resources in a complex hydrological basin of central Greece (Kopaida basin) with the joint use of hydrogeochemical analysis, multivariate statistics and stable isotopes. Aquat Geochem. https ://doi.org/10.1007/s1049 8-017-9322-x

Unigwe, C. O., & Egbueri, J. C. (2023). Drinking water quality assessment

based on statistical analysis and three water quality indices (MWQI, IWQI and EWQI): a case study. *Environment, Development and Sustainability*, *25*(1), 686-707.