Academic Journal of Chemistry
ISSN(e): 2519-7045, ISSN(p): 2521-0211
Vol. 9, Issue. 1, pp: 1-10, 2024
URL: https://arpgweb.com/journal/journal/20
DOI: https://doi.org/10.32861/ajc.91.1.10

Academic Research Publishing Group

Original Research
Open Access

Elemental and Ecological Health Risk Assessment of Wastewater and Soils Collected During the Wet Season at Selected Industrial Sites in Kano Nigeria

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Article History
Received: 10 October, 2023
Revised: 27 December, 2023
Accepted: 18 January, 2024
Published: 24 January, 2024

Abstract

In this study, the elemental analysis of soils and effluents collected from selected manufacturing industries in Kano metropolis of Nigeria West Africa for the wet season of 2020 has been carried out using standard analytical methods, Analar grade reagents and approved calibrated equipment. All samples were analyzed in triplicates and the outcome values are presented as mean concentration in mg/kg. The mean concentration of heavy metals evaluated such as Co, Cd, Cr, Zn, Mn, Fe, Ni and Pb show mixed levels (excessive, moderate and normal levels) when compared to the recommended levels by NESREA. Contamination factor (CF) and contamination degree (C_d) was determined for investigated elements in all 58 samples. CF for Ni, Pb, Fe, Mn and Zn were all < 1, implying no potential ecological risk contamination. Enrichment factor (EF) was calculated to determine anthropogenic input of metals in all the samples investigated. High enrichment factor for samples MW, MS, ADS, FS, PPS, MW, DW, PPW, MyW, DFS, DS, AS, LZS, 7upW, and DFW (67.2 % of the samples), The mean concentration of the metals is an indication of pollution was tested with a high implication outcome most likely, when samples are continuously emptied into the environment untreated. Safe to remind us that heavy metals are toxic with excessive human health risks.

Keywords: Industrial pollution; Environment; Elemental analysis; Soils; Effluents and ecological risk contamination.

How to Cite: 1Author Name, 2Author Name, 2022. "Article Title." *Journal of Agriculture and Crops*, vol. 9, pp. xx-xx.

1. Introduction

Pollution has been documented as one of the most important problems in the world today; with millions suffering industry and atmospheric pollutants related health problems. Recent years have witnessed amplification of heavy metals in our environment, determined to be both from natural and anthropogenic factors; leading to their accumulating in both agricultural products and seafood products via water, air and soil pollution [1, 2].

The release of large quantities of heavy metals into natural environment through mining, tanneries, metal plating facilities, refining of ores, combustion of fossil fuels, agricultural runoff, industrial and domestic effluents has not only intensified environmental pollution problems but also the deterioration of several aquatic ecosystems with the accumulation of metals in biota and flora. Although these metals are essential to life at low concentration but may become hazardous at high concentration [2, 3]; while some have proven to be essential minerals for all aerobic and most anaerobic organisms, as much as when in large amounts some of them, such as copper, lead, cadmium, or mercury, seriously affect human health. The human body cannot process and dispose the metals. As a result, they are deposited in various internal organs and may cause adverse reactions and serious damage to the body [4] [5].

Studies have related metal distribution between soil and vegetation as a key issue in assessing environmental effect of metals in the environment. Heavy metal toxicity has been documented to have an inhibitory influence on the growth of plants, enzymatic activity, photosynthetic activity and accumulation of other nutrient elements, and also damages the root system [6, 7].

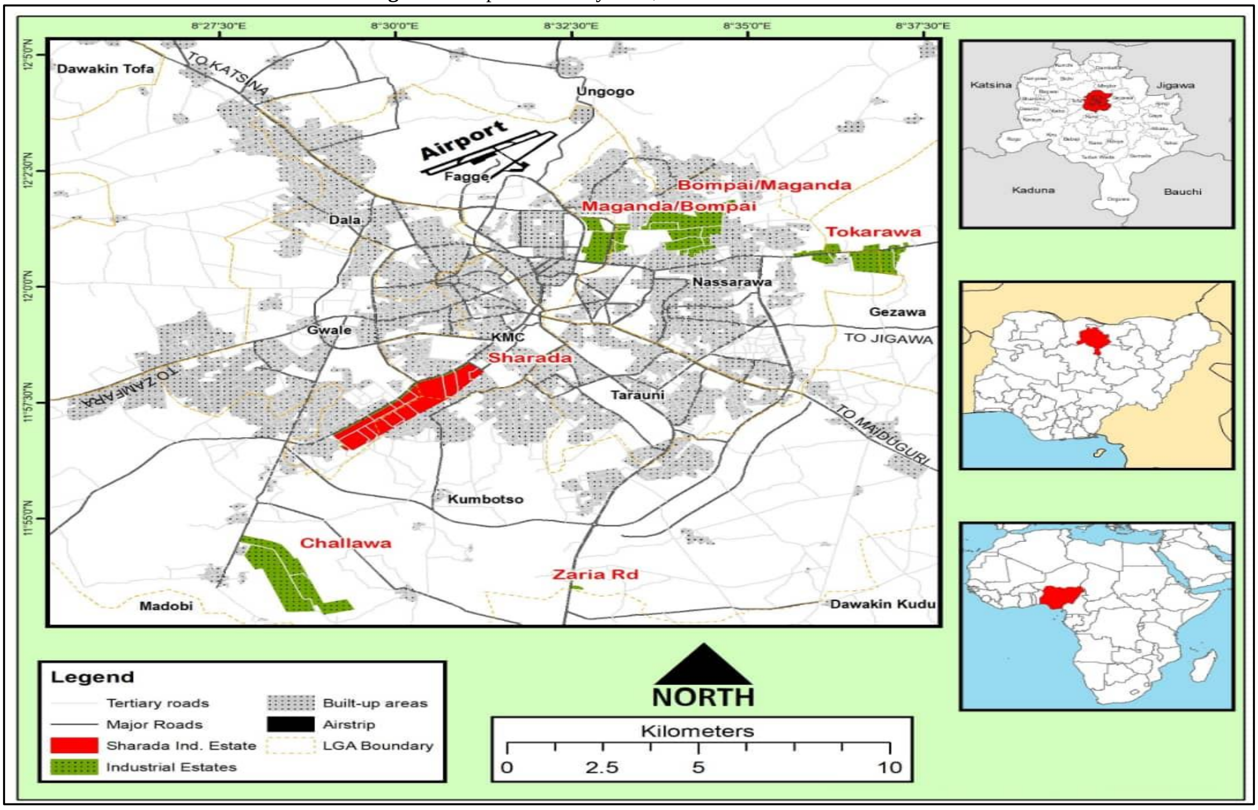
Every contaminant has a source, when the source is defined in terms of a calculated value, it is termed ‘’quantification of contamination’’ (QoC); this is the index of contamination that categorizes the origin of a contaminant either as lithogenic or anthropogenic [8-11].

Effluents from various food industries around Kano metropolis eventually find their ways to agricultural soils and plants, aquatic organisms, and eventually humans. This is as a result of none-treatment of these effluents and uncontrolled disposal, which if left unchecked, in the long run, bioaccumulation and concentration of these contaminants may lead to a health epidemic. Therefore, this study is intending to investigate the metal contamination status of soils, waters and plants resulting from food industries around Kano metropolis, thereby establish the potential pollution risk confronting inhabitants of the study site [12].

2. Study Area

Manufacturing industries and industrial estates in Kano metropolis Very little, if anything, is mentioned of pre-colonial Kano industries. But much of the commodities taken away from Kano city included leather (the renowned Moroccan leather), dyed cloths (yan Kura) and plain-woven cloths and are sufficient proof of the traditional industries that existed particularly in leather, textiles and dyeing. Modern industrial activities came with colonial administration. Just as the traditional dyeing industry was harmful in many ways and so the activity was concentrated in one place and usually at the outskirts of the city or the ward ("Karofi" in Hausa) so is the modern industrial set-up of the time polluting to the environment by way of its discharge or noise and so had to be secluded in estates. Economic reasons, in the form of benefits of agglomeration and economies of scale, also dictate the formation of industrial estates. Although industries don‟t has to be concentrated in one place any more, Kano metropolis already has the Bompai, Challawa, Sharada, and Tokarawa industrial estates which in design could be home to 1,200 industries. In terms of organization, the Manufacturers‟ Association of Nigeria (MAN) is, so far, the voice of industrialists in Nigeria. In Kano MAN has an Executive Secretary and two chairmen managing the two industrial zones. The Bompai Industrial Zone (BIZ) is made up of the Bompai and Tokarawa (Gunduwawa) industrial estates, including all industries located outside the estates in the northern parts of Kano metropolis (Dala, Fagge, Nassarawa, and Tarauni LGAs). The Challawa / Sharada Industrial Zone (CIZ) comprises the Challawa and Sharada industrial estates, including all industries located outside the estates in the southern parts of Kano metropolis (Gwale, Kumbotso and Municipal LGAs). Being the oldest industrial estate in Kano metropolis, it is home to some of the oldest industries in Kano. The estate is bordered in the south by the northern edge of the CBD, in the west by Sabon Gari and the Bompai G.R.A in the east. It was so successful that the Dakata industrial area was planned. However, Dakata industrial estate was only partially implemented. Thus, the newly established industries were considered extensions of the Bompai industrial area [12].

Figure-1. Map of the Study Area, Kano State industrial area



3. Soil and Water samples

Random samples of soils and wastewater samples were collected from the waste effluent in the industrial site listed above. Wastewater samples (500 mL) was collected in HDPE bottles and stored at 4 ^{0}C in a refrigerator till usage [13, 14].

4. Sample Preparation

4.1. Determination of Heavy Metals by MPAES

This study was carried out at the Center for Dry Land Agriculture, Bayero University, Kano-Nigeria. All measurements were performed using Agilent 4210 MP-AES. The sample introduction system consisted of PVC peristaltic pump tubing (white/white and blue/blue), a single pass cyclonic spray chamber, and the oneNeb nebulizer. The Agilent MP Expert software was used to automatically subtract the background signal from the analytical signal. A background spectrum from a blank solution was recorded and automatically subtracted from each standard and sample solution that was analyzed. The software was also used to optimize the nebulization pressure and the viewing position for each wavelength selected to maximize sensitivity. -, each analyte was determined under optimized conditions. A standard reference solution was used to quickly and easily optimize the parameters. The samples were collected in triplicates for analysis [14-17]

Sample	Code
PAL Pharmaceuticals	PP
Ugo Lab	UL
ASAD Pharmaceuticals	AP
Chizy Foods	CH
Myer Foods	MY
FECCOX Pharmaceuticals	F
Gerawa Oil Mills	GE
Aminu Dawaki Industries	AD
Dala Foods	DF
Dangote Foods	D
L and Z Foods	LZ
Seven up Bottling Company	7up
Santex industries	SA
Marley Sheley Pharmaceuticals	M

5. Results

Table-1. Mean Concentration of Heavy Metals in Rainy Season

sample ID	Mean Elemental Concentration (mg/kg)							
	Ni	Pb	Fe	Mn	Zn	Cd	Co	Cr
MW	0.260±0.0007	0.065±0.0003	2.429±0.001	0.040±0.0002	0.119±0.002	0.241±0.0010	0.100±0.0013	0.162±0.0004
MS	0.327±0.0013	0.217±0.001	5.878±0.0072	0.179±0.0011	0.106±0.002	0.242±0.001	0.128±0.0007	5.596±0.0027
ADS	0.258±0.0005	0.131±0.0003	3.562±0.002	0.076±0.002	0.187±0.001	0.299±0.003	0.023±0.0004	0.087±0.0005
FS	0.162±0.0012	0.504±0.0002	12.774±0.003	0.256±0.001	0.260±0.0003	0.294±0.001	0.045±0.0013	0.218±0.0007
GES	0.128±0.0003	0.340±0.001	9.248±0.006	0.219±0.003	0.121±0.0020	0.108±0.002	0.203±0.0005	0.075±0.0004
GEW	0.070±0.001	0.003±0.001	1.725±0.001	0.100±0.001	0.066±0.0013	0.110±0.002	0.011±0.0014	0.110±0.0003
PPS	0.130±.0014	0.121±0.001	1.525±0.0014	0.035±0.001	0.074±0.002	0.291±0.001	0.173±0.0004	0.162±0.0001
DW	0.003±0.002	0.268±0.0010	7.506±0.006	0.095±0.0002	0.098±0.002	0.281±0.001	0.086±0.0005	0.040±0.0001
PPW	0.022±0.001	0.307±0.0004	1.918±0.0012	0.194±0.0011	0.069±0.012	0.298±0.0020	0.062±0.0006	0.198±0.0006
MyW	0.027±0.001	0.081±0.001	1.078±0.0003	0.011±0.0003	0.044±0.0014	0.288±0.0002	0.027±0.0010	0.260±0.0001
FW	0.044±0.001	0.171±0.001	6.978±0.005	0.201±0.0011	0.191±0.001	0.268±0.001	0.032±0.0012	0.071±0.0006
DFS	0.170±0.001	0.103±0.001	2.725±0.001	0.200±0.001	0.096±0.0013	0.3210±0.002	0.021±0.0014	0.100±0.0003
DS	0.168±0.0003	0.440±0.001	11.248±0.006	0.319±0.003	0.221±0.0020	0.308±0.002	0.103±0.0005	0.085±0.0004
ULS	0.233±0.001	0.403±0.001	27.505±0.008	0.717±0.0021	1.870±0.005	0.261±0.0011	0.066±0.0009	0.018±0.0002
AW	0.020±0.001	0.025±0.0001	19.171±0.009	0.3719±0.0003	0.543±0.0030	0.279±0.0022	0.068±0.0008	0.037±0.0006
AS	0.042±0.002	0.111±0.0002	3.103±0.0020	0.193±0.001	0.158±0.0002	0.261±0.0011	0.058±0.0005	0.128±0.0003
ULW	0.306±0.0003	0.604±0.001	39.311±0.007	1.163±0.0031	3.091±0.0062	0.263±0.001	0.011±0.0005	0.131±0.001
LZS	0.222±0.0013	0.687±0.001	9.701±0.0041	0.251±0.001	0.249±0.0024	0.299±0.001	0.026±0.0010	0.002±0.002
MyS	0.241±0.0002	0.094±0.0002	4.793±0.002	0.142±0.001	0.149±0.0014	0.289±0.001	0.066±0.0011	13.343±0.0052
7upW	0.089±0.0014	0.168±0.001	2.196±0.0002	0.051±0.0003	0.143±0.0014	0.299±0.002	0.093±0.0009	0.066±0.0004
CS	0.230±0.0013	0.162±0.0003	7.973±0.0052	0.205±0.001	0.199±0.0011	0.281±0.0011	0.029±0.0017	0.603±0.001
CW	0.251±0.001	0.015±0.0004	4.466±0.0021	0.160±0.001	0.100±0.0014	0.309±0.0013	0.015±0.0013	0.476±0.0001
7upS	0.195±0.0010	0.012±0.001	2.944±0.002	0.064±0.002	0.153±0.0021	0.308±0.0021	0.013±0.0014	0.270±0.001
ADW	0.122±0.0011	0.035±0.001	2.418±0.0032	0.027±0.001	0.120±0.002	0.284±0.0012	0.118±0.0008	0.130±0.0001
LZW	0.162±0.001	0.057±0.0003	7.804±0.009	0.273±0.0010	0.160±0.002	0.284±0.0010	0.037±0.0014	0.291±0.001
SS	0.035±0.0020	0.142±001	1.020±0.0013	0.015±0.0002	0.207±0.001	0.291±0.001	0.025±0.0001	0.230±0.0001
DFW	0.065±0.0021	0.142±0.0000	1.326±0.0020	0.031±0.0003	0.087±0.001	0.295±0.0022	0.091±0.0012	0.164±0.0002
SW	0.013±0.0013	0.150±0.0010	9.103±0.005	0.353±0.0014	0.328±0.001	0.303±0.0002	0.036±0.0008	0.010±0.001

Table-2. Ecological Risk Index for Ni Contamination

Sample Code	Ni					
	CF	E	RI	C_d	QoC	EF
MW	0.011453744	0.057269			-8630.769231	150.5033
MS	0.014405286	0.072026			-6841.896024	78.22012
ADS	0.011365639	0.056828			-8698.449612	101.8418
FS	0.007136564	0.035683			-13912.34568	17.83152
PPS	0.005726872	0.028634			-17361.53846	119.8599
GEW	0.006784141	0.033921			-14640.25974	103.7525
GES	0.008898678	0.044493			-11137.62376	79.62484
DW	0.000132159	0.000661			-756566.6667	0.56197
PPW	0.000969163	0.004846			-103081.8182	16.12777
MyW	0.001189427	0.005947			-83974.07407	35.21643
FW	0.001938326	0.009692			-51490.90909	8.865883

DFS	0.007488987	0.037445			-13252.94118	87.71678
DS	0.007400881	0.037004			-13411.90476	21.00072
ULS	0.010264317	0.051322			-9642.49	11.9109
AW	0.000881057	0.004405			-113400.00	1.466849
AS	0.00185022	0.009251			-53947.62	19.03127
ULW	0.013480176	0.067401			-7318.30	10.94479
LZS	0.009779736	0.048899			-10125.23	32.17635
MyS	0.01061674	0.053084			-9319.087137	70.69845
7upW	0.003920705	0.019604			-25405.61798	56.98466
CS	0.010132159	0.050661			-9769.565217	40.56079
CW	0.011057269	0.055286			-8943.824701	79.02332
7upS	0.008590308	0.042952			-11541.02564	93.13161
ADW	0.005374449	0.026872			-18506.55738	70.94206
LZW	0.007136564	0.035683			-13912.34568	29.18758
SS	0.00154185	0.007709			-64757.14286	48.24676
DFW	0.002863436	0.014317			-34823.07692	68.92394
SW	0.000572687	0.002863			-174515.3846	2.007979

Table-3. Ecological Risk Index for Pb Contamination

	Pb					
SampleCode	**CF**	**E**	**RI**	C_d	**QoC**	**EF**
MW	0.00325	0.01625			-30669.2	42.70532112
MS	0.01085	0.05425			-9116.59	58.91505699
ADS	0.00655	0.03275			-15167.2	58.69127316
FS	0.0252	0.126			-3868.25	62.9650822
PPS	0.00605	0.03025			-16428.9	126.6227311
GEW	0.0063	0.0315			-15773	96.34834212
GES	0.00115	0.00575			-86856.5	10.29013036
DW	0.0134	0.067			-7362.69	56.97999201
PPW	0.01535	0.07675			-6414.66	255.4382456
MyW	0.00405	0.02025			-24591.4	119.9119341
FW	0.00855	0.04275			-11595.9	39.10761178
DFS	0.00515	0.02575			-19317.5	60.32076881
DS	0.022	0.11			-4445.45	62.42715149
ULS	0.02015	0.10075			-4862.78	23.38242483
AW	0.00125	0.00625			-79900	2.081092536
AS	0.00555	0.02775			-17918	57.0870174
ULW	0.0302	0.151			-3211.26	24.51991707
LZS	0.03435	0.17175			-2811.21	113.0150763
MyS	0.0047	0.0235			-21176.6	31.29799917
7upW	0.0084	0.042			-11804.8	122.0880328
CS	0.0081	0.0405			-12245.7	32.425703
CW	0.00075	0.00375			-133233	5.360048142
7upS	0.0006	0.003			-166567	6.504884511
ADW	0.00175	0.00875			-57042.9	23.09978288
LZW	0.00285	0.01425			-34987.7	11.65611289
SS	0.0071	0.0355			-13984.5	222.1694412
DFW	0.0071	0.0355			-13984.5	170.8995701
SW	0.0075	0.0375			-13233.3	26.29679776

Table-4. Ecological Risk Index for Fe Contamination

	Fe			
Sample Code	**CF**	C_d	**QoC**	**EF**
MW	7.61029E-05		-1313910	1
MS	0.000184163		-542896	1
ADS	0.000111601		-895950	1
FS	0.000400222		-249761	1
PPS	4.77797E-05		-2092838	1
GEW	6.53877E-05		-1529239	1
GES	0.000111758		-894694	1
DW	0.00023517		-425124	1

PPW	6.00928E-05		-1663993	1
MyW	3.37748E-05		-2960688	1
FW	0.000218628		-457299	1
DFS	8.53769E-05		-1171177	1
DS	0.000352411		-283660	1
ULS	0.000861758		-115942	1
AW	0.000600646		-166387	1
AS	9.722E-05		-1028495	1
ULW	0.001231652		-81091.8	1
LZS	0.000303942		-328910	1
MyS	0.000150169		-665815	1
7upW	6.88028E-05		-1453329	1
CS	0.000249802		-400217	1
CW	0.000139924		-714573	1
7upS	9.22384E-05		-1084047	1
ADW	7.57583E-05		-1319888	1
LZW	0.000244507		-408886	1
SS	3.19576E-05		-3129047	1
DFW	4.15449E-05		-2406936	1
SW	0.000285206		-350524	1

Table-5. Ecological Risk Index for Mn Contamination

Sample Code	Mn					
	CF	**E**	**RI**	C_d	**QoC**	**EF**
MW	0.003174603	315			-31400	41.7146
MS	0.014206349	70.39106			-6939.11	77.1399
ADS	0.006031746	165.7895			-16478.9	54.04746
FS	0.02031746	49.21875			-4821.88	50.7655
PPS	0.002777778	360			-35900	58.13716
GEW	0.002936508	340.5405			-33954.1	44.90915
GES	0.001349206	741.1765			-74017.6	12.07262
DW	0.007539683	132.6316			-13163.2	32.06053
PPW	0.015396825	64.94845			-6394.85	256.2175
MyW	0.000873016	1145.455			-114445.00	25.84815
FW	0.015952381	62.68657			-6168.66	72.96603
DFS	0.015873016	63.00			-620000	185.917
DS	0.02531746	39.49843			-3849.84	71.84077
ULS	0.056904762	17.57322			-1657.32	66.03332
AW	0.029515873	33.88008			-3288.01	49.14021
AS	0.01531746	65.28497			-6428.5	157.5546
ULW	0.092301587	10.83405			-983.405	74.9413
LZS	0.019920635	50.1992			-4919.92	65.54096
MyS	0.011269841	88.73239			-8773.24	75.04755
7upW	0.004047619	247.0588			-24605.9	58.82927
CS	0.016269841	61.46341			-6046.34	65.13099
CW	0.012698413	78.75			-7775	90.75214
7upS	0.005079365	196.875			-19587.5	55.06781
ADW	0.002142857	466.6667			-46566.7	28.28545
LZW	0.021666667	46.15385			-4515.38	88.61372
SS	0.001190476	840			-83900	37.25175
DFW	0.002460317	406.4516			-40545.2	59.22073
SW	0.028015873	35.69405			-3469.41	98.23037

Table-6. Ecological Risk Index for Zn Contamination

Sample Code	Zn					
	CF	**E**	**RI**	C_d	**QoC**	**EF**
MW	0.000983	0.000983			-101581	0.106801
MS	0.000876	0.000876			-114051	0.039313
ADS	0.001545	0.001545			-64605.9	0.114447
FS	0.002149	0.002149			-46438.5	0.044371
PPS	0.000612	0.000612			-163414	0.105783
GEW	0.000554	0.000554			-180497	0.069985
GES	0.000942	0.000942			-106040	0.069672
DW	0.00081	0.00081			-123369	0.028462
PPW	0.00057	0.00057			-175262	0.078425
MyW	0.000364	0.000364			-274900	0.088979
FW	0.001579	0.001579			-63250.8	0.05967
DFS	0.000793	0.000793			-125942	0.0768
DS	0.001826	0.001826			-54651.1	0.042832
ULS	0.015455	0.015455			-6370.59	0.148213
AW	0.004488	0.004488			-22183.6	0.061746
AS	0.001306	0.001306			-76482.3	0.111002
ULW	0.025545	0.025545			-3814.59	0.171412
LZS	0.002058	0.002058			-48494.4	0.055955
MyS	0.001231	0.001231			-81108.1	0.067769
7upW	0.001182	0.001182			-84515.4	0.141958
CS	0.001645	0.001645			-60704	0.054411
CW	0.000826	0.000826			-120900	0.048813
7upS	0.001264	0.001264			-78985	0.113295
ADW	0.000992	0.000992			-100733	0.108188
LZW	0.001322	0.001322			-75525	0.044695
SS	0.001711	0.001711			-58354.1	0.442411
DFW	0.000719	0.000719			-138980	0.143031
SW	0.002711	0.002711			-36790.2	0.07855

Table-7. Ecological Risk Index for Cd Contamination

Sample Code	Cd					
	CF	**E**	**RI**	C_d	**QoC**	**EF**
MW	0.808725	24.26174			-23.6515	10626.72
MS	0.812081	24.36242			-23.1405	4409.564
ADS	1.003356	30.10067			0.334448	8990.569
FS	0.986577	29.59732			-1.36054	2465.076
PPS	0.97651	29.2953			-2.4055	20437.75
GEW	0.956376	28.69128			-4.5614	14626.23
GES	0.973154	29.19463			-2.75862	8707.726
DW	0.942953	28.28859			-6.04982	4009.661
PPW	1.00	30.00			0.00	16640.93
MyW	0.966443	28.99329			-3.47222	28614.33
FW	0.899329	26.97987			-11.194	4113.521
DFS	1.077181	32.31544			7.165109	12616.78
DS	1.033557	31.00671			3.246753	2932.819
ULS	0.875839	26.27517			-14.1762	1016.339
AW	0.936242	28.08725			-6.81004	1558.724
AS	0.875839	26.27517			-14.1762	9008.835
ULW	0.88255	26.47651			-13.308	716.5583
LZS	1.003356	30.10067			0.334448	3301.145
MyS	0.969799	29.09396			-3.11419	6458.034
7upW	1.003356	30.10067			0.334448	14583.06
CS	0.942953	28.28859			-6.04982	3774.804
CW	1.036913	31.10738			3.559871	7410.536
7upS	1.033557	31.00671			3.246753	11205.28
ADW	0.95302	28.5906			-4.92958	12579.75
LZW	0.95302	28.5906			-4.92958	3897.723
SS	0.97651	29.2953			-2.4055	30556.44
DFW	0.989933	29.69799			-1.01695	23828.04
SW	1.016779	30.50336			1.650165	3565.069

Table-8. Ecological Risk Index for Cr Contamination

Sample Code	Cr						
	CF	E	RI	C_d	QoC	EF	PLI
MW	0.003059	0.006118			-32591.4	40.19441	0
MS	0.105665	0.211329			-846.39	573.7547	0
ADS	0.001643	0.003285			-60773.6	14.71985	0
FS	0.004116	0.008233			-24193.6	10.28508	0
PPS	0.003059	0.006118			-32591.4	64.02113	0
GEW	0.002436	0.004872			-40954.3	37.25164	0
GES	0.000736	0.001473			-135695	6.589306	0
DW	0.000755	0.001511			-132300	3.21166	0
PPW	0.003739	0.007477			-26647.5	62.21495	0
MyW	0.004909	0.009819			-20269.2	145.3559	0
FW	0.001341	0.002681			-74491.5	6.132048	0
DFS	0.001888	0.003776			-52860	22.11626	0
DS	0.001605	0.00321			-62205.9	4.554302	0
ULS	0.00034	0.00068			-294122	0.394402	0
AW	0.000699	0.001397			-143035	1.163148	0
AS	0.002417	0.004834			-41275	24.8603	0
ULW	0.002474	0.004947			-40327.5	2.008331	0
LZS	3.78E-05	7.55E-05			-2647900	0.124249	0
MyS	0.251945	0.50389			-296.912	1677.738	0
7upW	0.001246	0.002492			-80142.4	18.11297	0
CS	0.011386	0.022772			-8682.75	45.57994	0
CW	0.008988	0.017976			-11026.1	64.23421	0
7upS	0.005098	0.010196			-19514.8	55.27187	0
ADW	0.002455	0.004909			-40638.5	32.40151	0
LZW	0.005495	0.010989			-18099.3	22.47263	0
SS	0.004343	0.008686			-22926.1	135.8957	0
DFW	0.003097	0.006193			-32192.7	74.53813	0
SW	0.000189	0.000378			-529500	0.662054	0

Table-9. Ecological Risk Index for Co Contamination

Sample Code	Co					
	CF	E	RI	C_d	QoC	EF
MW						0.088979
MS						1.709425
ADS						0.014813
FS						0.535127
PPS						0.042832
GEW						0.204574
GES						0.066502
DW						0.061746
PPW						0.111002
MyW						0.176915
FW						0.171412
DFS						0.100441
DS						0.34549
ULS						0.076281
AW						0.080671
AS						0.03539
ULW						0.142587
LZS						0.068044
MyS						0
7upW						0
CS						0
CW						0
7upS						0
ADW						0
LZW						0
SS						0
DFW						0
SW						0

6. Contamination Levels of Heavy Metals

All samples were analysed in triplicates and the outcome values are presented as "mean concentration" (Table 1) in mg/kg; generally, the most available metal in any of the sample is Fe, recorded in sample ULW, with a concentration of 39.311±0.007 mg/kg, while lowest metal concentration (0.003±0.002 mg/kg) was recorded by Ni in sample DW. The concentration of Ni raged between 0.327±0.0013mg/kg (sample MS) to 0.003±0.002 mg/kg (sample DW). Concentration for Pb ranged from 0.687±0.001 in sample LZS to 0.012±0.001 mg/kg in sample 7upS. Fe concentration ranged between 39.311±0.007to 1.020±0.0013mg/kg in samples ULS and SS respectively [18-21]. Mn has concentration ranging between 1.163±0.0031 mg/kg (sample ULW) to 0.011±0.0003 mg/kg in sample MyW. Values recorded for Zn ranged between 3.323±0.0041 mg/kg and 0.044±0.0014 mg/kg. Cd has concentration range between 0.3210±0.002 and 0.241±0.0010 mg/kg (samples DFS and MW). For Co, concentration recorded ranged between 0.173±0.0004 mg/kg in sample PPS and 0.011±0.0005 mg/kg in sample ULW. Concentration of Cr range between 5.596±0.0027and 0.002±0.002 mg/kg (samples MS and LZS).

Samples MW recorded highest metal concentrations for Fe. Cr appeared highest in sample MS (62.232±0.004) and Ni lowest (0.010±0.0014). The highest concentrations of metals in samples PPS-MyW was recorded by Fe as 1.525±0.0014, 2.087±0.0004, 3.567±0.002, 3.365±0.008, 4.795±0.003, 7.506±0.006, 1.918±0.0012 and 1.078±0.0003 mg/kg, while the lowest values recorded following same order was documented for the elements Mn, Co, Mn, Pb, Pb, Ni, Ni and Mn with their corresponding values of 0.035±0.001, 0.016±0.0013, 0.017±0.001, 0.058±0.0004, 0.108±0.0004, 0.003±0.002, 0.022±0.001 and 0.011±0.0003 mg/kg. Again, Fe was estimated highest in samples FW-LZS with concentrations of 6.978±0.005, 2.725±0.001, 11.248±0.006, 27.505±0.008, 19.171±0.009, 3.103±0.0020, 39.311±0.007 and 9.701±0.0041 mg/kg; their corresponding least concentrations were validated in this order; 0.032±0.0012, 0.021±0.0014, 0.085±0.0004, 0.018±0.0002, 0.020±0.001, 0.042±0.002, 0.011±0.0005 and 0.002±0.002 for Co, Pb, Co, Cr, Co, Cr, Mn, Co, Co, Cr, Ni, Ni, Co, Co, Co, Cr, Co, Mn, Mn, Co, Co and Pb. MyS recorded the highest concentration of Cr (13.343±0.0052 mg/kg) while the least concentration (0.066±0.0011 mg/kg) was documented for Co [19, 20, 22].

From the result, Fe appeared as element having highest concentration in all samples, Co appears as the element with lowest concentration in 10 samples, Mn 8, Pb 2, Ni and Cr 4each, while Zn recorded lowest in 1 sample. On the whole, the concentration of investigated heavy metals varied in different sampling sites and type (i.e. wastewater and soil) ([19, 22, 23]

To determine environmental pollution compliance, concentration levels of metals were compared to the [24]. Ni concentration in samples DW, PPW, MyW, FW, AW, AS, SS and SW were below the set limit. Samples AW, 7upS, CW and ADW reported values lower than the limit for Pb. No limit was set for Fe; FW, FS, DS, ULS, AW, ULW, LZS, CS, LZW and SW recorded concentrations above the set limit. Zn concentrations in all samples were within the guidelines except in sample ULW. All samples were well within the set limit for Cd, while samples MW, MS, PPS, DW, PPW, DS, ULS, AW, AS, MyS, 7upW and DFW exceeded the acceptable amount of Co in soils and effluents. Availability of Cr as evaluated showed all samples were contaminated beyond the recommended level except in samples DW, ULS, AW, LZS and SW [19, 22, 23, 25].

7. Evaluation of Ecological Risk Index

Every contaminant has a source, when the source is defined in terms of a calculated value, it is termed ''quantification of contamination'' (QoC) as revealed in Table 2; this is the index of contamination that categorizes the origin of a contaminant either as lithogenic or anthropogenic [11]. Analysis of the QoC computed outcomes have been presented in Tables 2, 3, 4, 5, 6, 7, 8 following the order: Ni, Pb, Fe, Mn, Zn, Cd and Cr in each of samples MW to SW. Result indicate the concentrations reported for Ni were mainly derived from lithogenic inputs. Similar results were obtained in tables 3, 4, 5, and 6 for elements Pb, Fe, Mn, Zn and Cr for all samples investigated. However, Cd concentration (Table 7) were shown to be both from lithogenic and anthropogenic sources; Samples Mw and MS, FS, DW, MyW, ULS- AS, CS, ADW- DFW are all mainly due to lithogenic origin, while samples ADS, PPS-13, PPW, 22-DS, 31 and 32, LZS-36, 48 and 7upW, CW, 7upS and 58 are mainly due to anthropogenic inputs [18, 19, 22, 25].

Contamination factor (CF) and contamination degree (C_d) was determined for investigated elements in all 58 samples and displayed Tables 2, 3, 4, 5, 6, 7, 8. CF for Ni, Pb, Fe, Mn and Zn were all < 1, implying no potential ecological risk contamination. The corresponding C_d value for the elements mentioned were all < 8, indicating a low contamination, which is consistent with the CF. there was variations in the CF result computed for Cd (Table 7); majority of the samples recorded values < 1, except for ADS (1.003356), PPW (1), DFS (1.077181), DS (1.033557), LZS (1.003356), 7upW (1.003356), CW (1.036913), 7upS (1.033557), these values indicates light contamination, but the overall C_d (54.5936) implies very high degree of contamination for the element Cd. Table 8 displays CF and C_d for Cr. None of the samples reported CF value > 1 implying a light contamination, while the C_d reported was low. No CF or C_d was calculated for Co. Potentially individual risks of metals (E) were calculated and also presented in Tables 2, 3, 4, 5, 6, 7, 8. E <40 portends Low risk, 40 ≤ E <80 Moderate risk, 80 ≤ E <160 Considerable risk, 160 ≤ E <320 High risk, and E ≥ 320 Very high risk. In Tables 2, 3, 6, F reported values that indicate low risk of contamination, although values recorded for Cd (Table 7) were much closer to the moderate than the low risk level. Table 5 (Mn) reported values for samples PPS (360), MW (340.5405), MyW (1145.455), ADW (466.6667), SS (840), and DFW (406.4516), as being at very high-risk contamination level; samples 1, MW, ADS, 7upW, and 7upS reported values at high risk of contamination level, while samples DWand MyS are at a considerable risk level [19, 22, 23, 25]. Samples MS, FS, PPW, FW, DFS, AS, LZS, CS, CW, and LZW reported moderate risk level of contamination, while samples ULS and SW are at a low risk level of contamination.

The Potential Ecological Risk Index (RI) is the summation of potential ecological risk factor of multiple metals. [26]. Calculated values revealed there exist a very strong risk index for Mn (13087.93) and Cd (1637.808), but low for Cr (5.226171), Zn (0.189769), Pb (3.08325) and Ni (2.331). This index was not computed for Fe and Co [19, 22, 23, 25].

Enrichment factor (EF) was calculated to determine anthropogenic input of metals in all the samples investigated. The EF values can further clarify if metal accumulation was either by anthropogenic sources or natural or mixed sources. EF for every metal was calculated and exhibited in Tables 2, 3, 4, 5, 6, 7, 8, 9, the numerical results are indicative of different pollution levels. Table 2 showed EF values for Ni measured in all samples. Values reported for samples DW and AW showed deficiency to minimal enrichment in Ni, while samples 9 and SW showed moderate enrichment. There was significantly enrichment of Ni in samples PPW, FW, ULS, AS, and ULW. Very high Ni enrichment was recorded in samples MyW, LZS and LZW. Sample ADS, PPS, DFS, then SS and DFW have values indicating extremely high enrichment of Ni. EF of Pb (table 3) revealed extremely high enrichment factor for samples MW, MS, ADS, FS, PPS, MW, DW, PPW, MyW, DFS, DS, AS, LZS, 7upW, and DFW (67.2 % of the samples), samples ULW, MyS, CS, ADW and SW showed concentration of Pb at a very high enrichment level. Significant enrichment of Pb was exposed in samples MS, CW, 7upS and LZW. No moderate enrichment was reported for any sample [19, 22, 23, 25]. All samples recorded a 100 % deficiency to minimal enrichment of Fe (table 4), with result showing exact values. Table 5 showed EF for Mn in all samples. Mn in all samples were above deficiency to minimal, as well as moderate enrichment levels. Only sample 12 recorded a significant enrichment level. Samples DW, MyW, and ADW recorded very high enrichment. Largest percentage of the samples reported extremely high enrichment by Mn (samples MW, MS, ADS, FS, PPS, MW, PPW, FW, DFS, DS, ULS, AW, ULW, LZS, MyS, 7upW, CS, CW, 7upS, LZW, DFW and SW) [19, 22, 23, 25].

Result for EF for Zn (table 6) showed deficiency to minimal enrichment, similar values were recorded for Fe; while in table 7, extremely high enrichment was reported for Cd in all samples.

Samples MW, MS, PPS, PPW, MyW, MyS, CS, CW, 7upS, SSand DFW reported extremely high enrichment of Cr, while lesser values at very high enrichment levels were reported for samples MW, DFS, ADW and LZW. Significant enrichment was noted in samples ADS, FS, MS, FW, and 7upW. Samples DWand DS showed moderate enrichment. A 6.90 % of the samples (ULS, AW, LZS,) showed there was a deficiency or minimal enrichment of Cr. Similar to results for Fe and Zn, Co reported values at deficiency and or minimal enrichment level [1, 19, 22, 23, 25].

8. Conclusion

Elemental analysis of soils and effluents collected from manufacturing industries and industrial estates in Kano metropolis for the wet season of 2020 has been carried out successfully. Mean concentration of heavy metals evaluated such as Co, Cd, Cr, Zn, Mn, Fe, Ni and Pb show mixed levels (excessive, moderate and normal levels) when compared to the recommended levels by NESREA. An indication of pollution was tested with a high implication outcome most likely, if samples are continuously emptied into the environment untreated. Safe to remind us that heavy metals are toxic with excessive human health risks.

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