Characterization of Topsoil and Groundwater at Leather Industrial Area, Challawa, Kano, Northern Nigeria.

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ABSTRACT

This paper presents the characterization of topsoil and well water at Challawa Leather Industrial Estate, Kano City, northern Nigeria. The investigation was aimed at determining variations in some physicochemical properties of the topsoil and groundwater in the area owing to contamination by total chromium. Sixty-two topsoil samples were evaluated for both spatial and depth variation in concentration of total chromium. Ten well water samples were investigated for seasonal variation of Chromium. Atomic Absorption Spectrophotometry was used to determine the concentration of the chromium in all the samples. Results show that the concentration the total chromium in topsoil and seasonal variation of it in well water were in the ranges of 0.0043 mg/l to 1.86 mg/l and < 0.065 mg/l to 0.118 mg/l, respectively. This suggests that the concentration of total Chromium in the topsoil samples were beyond the tolerance limit. The highest range of the concentration of total chromium was registered by the soil samples between the offset 700 m and the bank of River Challawa (1200 m). At this offset range, the soil's pH and electrical resistivity were also relatively highest whereas the soil's porosity was relatively low. The average spatial increase and attenuation with depth in the concentration of total chromium were estimated to be at the rate of +0.001 ppm/meter and -0.061 ppm/meter, respectively. Results also show significantly, low and high concentration of the total chromium in well water samples during the wet and dry seasons, respectively. This suggests that there sufficiently subsurface dilution effect during the wet season.

(Keywords: topsoil, groundwater, total chromium, concentration seasonal variation, attenuation)

INTRODUCTION

Physicochemical changes in soil and water usually result to variation in both quality and ecology of our environment. The changes usually occur in the pH, color, temperature, alkalinity and turbidity, dissolved oxygen, phosphate, biochemical oxygen demand, chemical oxygen demand, electrolytic conductivity, nitrate, and sulphate in the environment (Ahmed and Tanko, 1994, Kotas and Stasicka, 2000, and, Abdullahi *et. al.,* 2008).

Industrial processes such as steel making, chrome plating dyes and pigments, leather tanning process and wood preservation are common sources of acute environmental pollution if they are not properly controlled. According to Patangay *et al.* (2002), industrial effluents, when released untreated into storage ponds, contaminate groundwater regime. Groundwater is a major source of public water supply because it is assumed to be free from surface pollutants compared to surface water (Voudouris *et al.,* 2007). The movement of pollutants into soil and groundwater through disposals of wastes, discharge of effluent from industries, or releases of chemicals through agricultural activities have led to increased vulnerability of groundwater and soil (Ahmed *et al*., 2009).

Chromium is a heavy metal which has a wide spread usefulness especially in leather and textile industries. However, its inadequate disposal as waste has led to serious environmental contamination in most developing countries of the world (USEPA, 1990; Allen *et al.*, 1998 and Patterson, 1999). In Nigeria, industries generate thousands of tonnes of hazardous wastes per day which are discharged into the environment. For example about 160 Kg of heavy metals are discharged into River Kaduna, northern Nigeria per day (Ajayi and Osibanjo, 1981). According to Ajayi and Osibanjo, there is a wide-scale contamination of Nigeria's surface waters from industrial effluents due to increase in industrialization and urbanization.

Kano City, northern Nigeria is significantly faced with both surface and groundwater pollution due to enormous leather and textile industrial activities. Kano comprises three major clusters of leather and textile industries namely; Challawa Industrial Estate, Sharada Industrial Estate, and Bompai Industrial Estate. Unfortunately, the discharge of untreated industrial wastes from some of the industries in these clusters has resulted in significant pollution of land, surface water and groundwater in the municipality.

It has been observed that untreated and inadequately treated effluents and solid wastes produced by the tannery and textile industrial processes are indiscriminately discharged to the surrounding lands and rivers. Monitoring bodies such as the Kano State Environmental Agency (KASEPA) and United Nations Industrial Development Organization (UNIDO) have to no avail, made several efforts to monitor waste treatments and disposal processes in the areas. Hence, soil and water pollution in the area are progressing daily. Regrettably, most settlers around the industrial areas resort to the use of polluted well water for their domestic activities due to the absence of viable options. Farmers in the areas use the industrial waste water ways for the irrigation of their farm land.

Particularly, settlers around Challawa Industrial site have reported that for most of the times in dry season, they suspend the use of the well water for domestic purposes because of its odor and taste. Farm produce from the site also reported in the recent years to have lost their usual tastes owing to contamination of the land.

Excess chromium in soil results to significant contamination it. Plant's' roots can absorb the contaminant from the soil through capillary action and transport it to various parts of the plant. Therefore, when crops from such plants are consumed, they pose hazardous effect on the consumer ranging from liver damage to cancer of the lungs (WHO, 2009). Although in form of Cr^{3+}, it is an essential nutrient in man because it helps the body in the use of sugar, protein, and fats but at low concentration. However, intake of Cr^{3+} is toxic, mutagenic and potentially carcinogenic. Excess Cr^{3+} can also cause skin rashes and other related diseases whereas the shortage of chromium may cause alteration of heart conditions, disruption of metabolisms and diabetes (USEPA, 2009). As Cr^{6+}, it causes various health effects such as skin rashes, stomach upset, ulcer, respiratory problems, and alteration of genetic materials, weakness of immune system, kidney and liver damage and can even lead to death (Costa, 1997). The World Health Organization posited that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (USEPA, 2009). Most of these environment-related diseases are however not easily detected because they commonly manifest in adulthood though may have been acquired since childhood.

Therefore, there is an urgent need for environmental scientists to embark on concise routine investigative monitoring on the surface and subsurface environment in the area. Routine Environmental Effect and Monitoring (EEM) in the study area using scientific methods will significantly aid the assessments of environmental hazard, human health risks, save time, reduce the cost of unscheduled downtime and provide assurance in the quality of soil for agricultural activities and safe groundwater supply to Kano municipal. An effective management of groundwater resources in the area will integrate hydrogeological and socioeconomic elements hence determine the interactions between land, groundwater systems and their use (Chilton and Alley, 2006; Sartaj and Nasiri, 2008).

This paper therefore presents the characterization of topsoil and groundwater for total chromium concentration in Challawa Industrial Area, Kano, Nigeria. Comparisons of the concentration with standards will be made using the Environmental Protection Agency (EPA, 1988), World Health Organization (WHO, 1971) standards, and the standard for water and soil quality of elements for Agricultural uses in Nigeria (1998).

THE STUDY SITE AND ITS CONTAMINATION

Challawa Industrial Estate Kano, northern Nigeria is bounded by latitude range of $11^{0}52.65^{''}$N–$11^{0}54.29$"N and longitude range of $8^{0}27.52$E$^{'}$–$8^{0}28.853^{'}$E at an average elevation of about 430 m above the mean sea level. The study site (Figure 1) is characterized by a gentle slope trending in N-S direction.

All the industries located in the area discharge their effluents into Challawa River located at about 2.0 km downstream from the cluster of the industries. The area which falls between the industrial site and the river is about 6.0 km^2. It mainly constitutes cultivated portions and few village settlements.

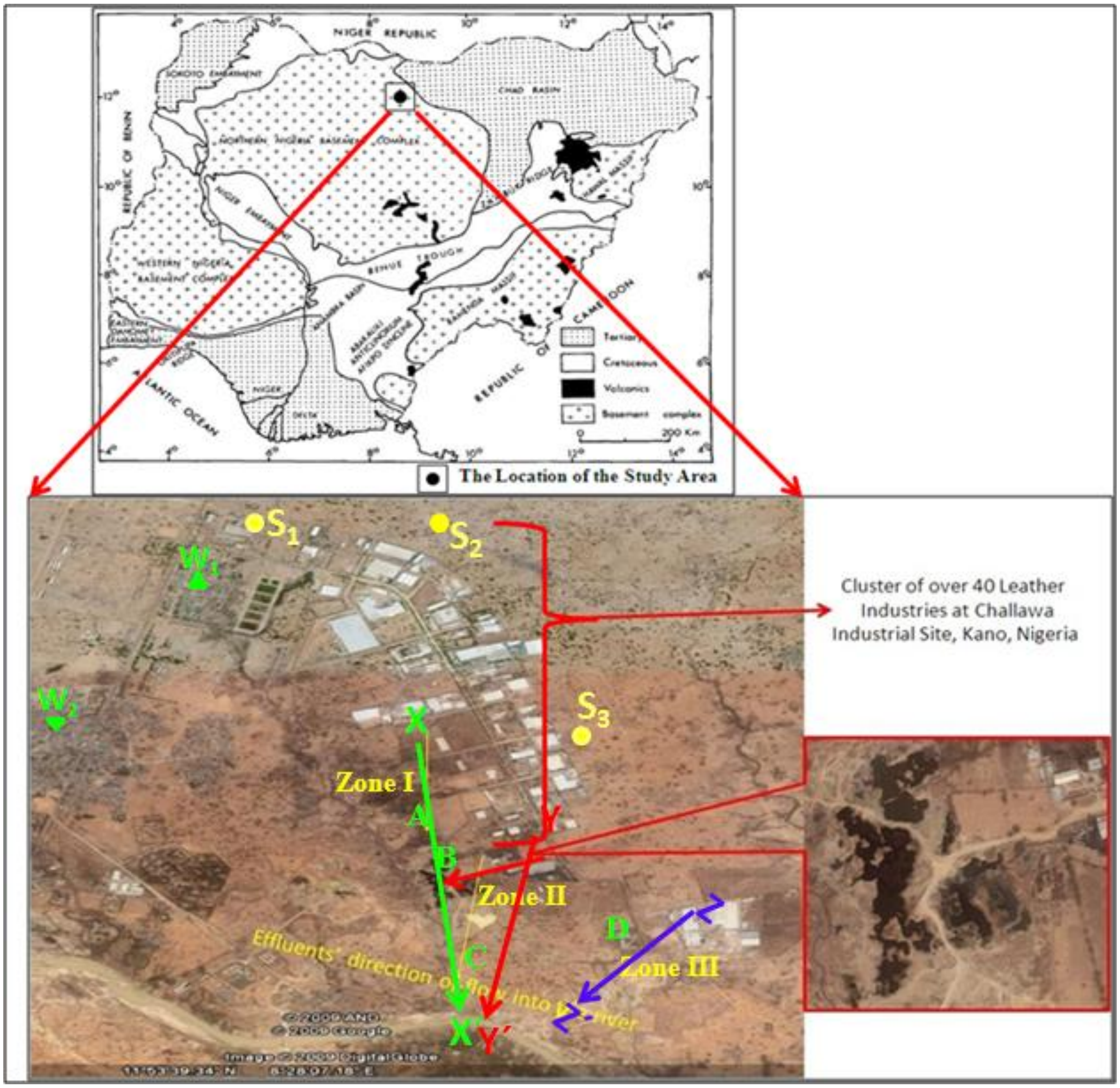

Figure 1: (a.) The Geological Map of Nigeria Showing the Location of the Study Area, **(b)** Study Area Showing the Industrial Estate and the Drainage Patterns Leading to River Challawa (adopted from *Google Earth*).

The topsoil in the site is principally characterized by plain and muddy ground surface. While some parts of the site upslope have gullies which are caused by erosion. The river banks are clayey, swampy, and are cultivated with crops such as rice and vegetables. The industrial effluents are channeled from various tannery discharge points through most farm lands into the river (Figure 2).

Geologically, the study site is located at the southern part of Kano area. It is characterized by two rocks of basement complex of pre-Cambrian age. The Basement Complex rocks are mainly Older Granites and old metamorphic rocks of various descriptions. The rocks are intrusive which were exposed after millions of years of erosion. Subsequently, they were subjected to deep chemical weathering, lateritization and pediplanation which developed on moderately thick regolith derived from them. The rocks were later overlain in many areas by a top layer of windblown material up to 2m thick during a dry phase that occurred about 10,000 years before present (Garba, 2002).

The drainage at the study site is part of the inland drainage of Chad basin consisting of headstreams which includes the Challawa River. The climate, rock and human activities in Kano directly affect the drainage and hydrogeology of the area. Kano River is tributary to the Challawa River end which is situated along human settlements. It serves as the major source of drinking water for the Kano metropolis and its neighbouring communities. Parts of the wetlands are put into intensive irrigated agricultural activities in Kano municipality. The other parts are used by wildlife as a refuge in Kano (Abdullahi *et al.,* 2008).

THE EFFECTS OF CHROMIUM IN SOIL AND WATER

Among the sources of wastes in the area, leather industrial effluent has a high percentage of the composition of Chromium. Although the chrome tanning has come under severe criticism owing to its ecotoxicological objections, about 80-90% of all leather products today are tanned with chromium (Ademoroti, 1996). Activities of the leather industries in Challawa, Kano has resulted to obvious visual environmental degradation due to migration of chrome tannery effluent into the subsoil and groundwater.

Chromium in industrial effluent could either be in trivalent (Cr^{3+}) or hexavalent (Cr^{6+}) form. In large quantity, the Cr^{6+} may be reduced to Cr^{3+} when absorbed on particulate matter. If it is not absorbed, the Cr^{3+} will form large polynucleate complexes that are not soluble.

Figure 2: Photographs Showing Some Effluent Channels and Some Contaminated Farm Lands between the Challawa Industrial Site and the *River Challawa.*

The heavy metal finds its way into the soil as effluents and consequently alters the soils properties (Ademoroti, 1996). In water, it tends to precipitate, but usually accumulate and magnify in down slope cultivated soil. The constant discharge of the effluents makes the soils in the area constantly moist and the presence of chromium easily visible in the upper horizons. In relation to texture, the concentration of chromium is usually high in clay soil than in easily leached sandy soils. In most tropical soils, chromium accumulates in the clayey layers and increases relatively with many soils as the oxide content increases.

The most important deposit of chromium in soil is either in the elemental or the trivalent oxidation state, in the form of chromites. Crops usually uptake Cr^{3+} as low as 0.19mg/Kg, however, this does not cause direct harmful effects. However, when the amount of the chromium II in the soil rises, it could lead to higher concentration in crops which is dangerous. The limits of accumulation of the heavy metals in soil, plants and grazers depend on the soil type and the length of time the land is exposed to the metal. Chromium is unstable and reducible by organic matter on topsoil to Cr^{3+}, It consequently enters the soil and adversely affects the soil properties making it unfavorable for plant's growth and quality of produce.

The toxicity of chromium becomes more significant as the acidity of the soil increases. Under acidic condition, chromium becomes highly soluble and may create problem in vegetation (Patterson 1998).

METHODOLOGY

Atomic Absorption Spectrophotometry (AAS) analysis was used for the determination of the concentration of the elements based on Beer's Law (Dunmoye, 2004). An optimal combination of methods in both spatial and depth investigation was devised at the study site. A pilot survey was first of all carried out at the study site to confirm that most of the industries were operational during the investigation. With the aid of a Global Positioning System (GPS) instrument, ranging rods, tape, meter rule, auger, pig-axe, sterilized sample bottles and polythene bags, sixty-two soil samples and ten water samples were mapped and collected.

The soil sample collection was made along profile lines on the land while water samples were collected from twelve hand dug water wells into sterilized bottles. Soil sample collection was done using two techniques: firstly they were collected at common depth of 10.0 cm at spatial interval of 100 m. Secondly the samples were collected at various horizons of the top soil ranging from 0.0 cm to 25 cm at 5.0 cm interval.

Three control soil samples located at S_1, S_2 and S_3 and two control water sample located at W_1 and W_2 (Figure 1) were collected. For each sample location, three samples were collected to ensure redundancy and reliable representation. The latitude, longitude and elevation above the mean sea level for each sample location were measured with the aid of GPS. An offset of about 0.5 m was allowed for the sample collections that were difficult at the mapped points. Bulk samples of the soil were also collected for density measurement.

The soil samples were air-dried between 25 and 35^0C, grinded and sieved with 2.00 mm sieve, weighed and digested using Aqua-Regia method for determination of total chromium (Vogel, 1989, Johnson, 2004). The extract was then used for the AAS analysis. A model *UNICAN SOLAR 32 Data Station V7.17* at the National Research Institute for Chemical Technology, Zaria, Nigeria, having good working standards, was used for the AAS analysis of the chromium in the soil and water samples. Laboratory resistivity values (Ωm) of the soil samples based on Ohm's law were also measured. The pH, density, particle size and porosity of the samples were also duly carried out. All measurements were replicated for quality assurance such that the mean results were registered in the required standard units.

RESULTS

The result of spatial variation in the concentration of total chromium along XX/, YY/ and ZZ/ and the electrical resistivity of the samples along the longest profiles XX/ (Figure 1) are shown in Table 1. Figures 3 and 4 show the variation of total chromium concentration and, electrical resistivity with offset distance along profile XX/. Table 2 shows the depth variation in pH and concentration of the samples collected from locations A, B, C and D (Figure 1) at layers in the range of 0.0 cm to 15.0 cm.

However, Figures 5a and 5b show the graphs of variation in total chromium concentration in topsoil with depth at the same locations.

Table 3 shows some other physical properties of the soil samples collected from the selected locations A, B, C, D and based on texture triangle, textural classes of the soil samples were derived. Figure 6 shows the graph of the variation of calculated porosity of the samples with total chromium concentration. The summary of the variation in pH and chromium concentration for 10 groundwater samples during the wet season are shown in Table 4. Hence, Figure 7 shows the surface map of chromium concentration in ground water during the dry season.

Based on the results, the spatial and depth variations in the concentration of total chromium and electrical resistivity in topsoil at the study site are in the range of 0.0043- 4.900 mg/l and 29.42-95.4 Ωm, respectively along profile lines X-X/ (Table 1), Y-Y/ and Z-Z/. The pHs of the topsoil samples are in the ranges of 7.85 – 8.87. The pHs of the groundwater samples are in the ranges of 6.10 – 7.15 and 7.09 – 8.76, respectively (Table 4). Results also show that the measured particle sizes of the soil samples are in the ranges of 37-63% sand, 20-36% silt, and 17 - 27% clay, respectively. Hence, the topsoil in the study area based on textural class is predominantly loamy. Particle and bulk densities range are 1.98-2.20 g/cm3 and 1.36-1.48 g/cm^3, respectively while porosity ranges between 39.5% and 53.2%. The insitu moisture contents of the samples are in the range of 0.231-0.400 units (Table 3).

DISCUSSION

The standard of chromium concentration given by WHO, FEPA and USEPA as the tolerance limits for soil and water are 0.10 mg/l and 0.05 mg/l, respectively. However, the concentration of the total chromium for control samples of soil (S1, S2, and S3) and water (W1 and W2) are in the ranges of 0.521-0.095 mg/l) and (0.019-0.045 mg/l), respectively. These values agree within the tolerance limit for soil and groundwater, hence, contrasts distinctly with the results obtained from the study area.

Table 1: Spatial Variation in pH, Total Chromium Concentration and Electrical Resistivity of the Soil Samples along Profile XX/

Offset Range from the Factory Site (m)	pH	Absorbance	Standard Deviation	Concentration of total Cr Along XX, (mg/l)	Concentration of total Cr Along YY, (mg/l)	Concentration of total Cr Along ZZ, (mg/l)	USEPA, WHO; FEPA; (mg/l)	Electrical Resistivity (Ωm)
0-100	8.07	0.003	0.06	0.0043	0.0187	0.5567	0.01	19.42
100-200	8.10	0.005	0.1	0.3889	0.6891	0.5673	"	29.42
200-300	7.85	0.003	0.01	0.4124	0.5932	0.7761	"	39.20
300-400	7.85	0.003	0.03	0.4377	0.7557	0.8338	"	70.11
400-500	8.36	0.011	0.01	0.7107	0.8998	0.9045	"	88.9
500-600	8.16	0.006	0.02	0.7226	0.9276	0.9231	"	94.20
600-700	8.54	0.008	0.02	0.8968	0.9945	_	"	92.75
700-800	8.20	0.010	0.04	0.9835	0.9725	_	"	99.34
800-900	8.27	0.012	0.02	1.3362	_	_	"	161.34
900-1000	8.87	0.006	0.03	1.6120	_	_	"	168.84
1000-1100	8.58	0.006	0.03	1.8563	_	_	"	185.50
1100-1200	8.19	0.012	0.02	1.9316	_	_	"	195.45
S1	7.30	0.007	0.01	0.089	0.089	0.089	"	25.42
S2	7.35	0.003	0.04	0.095	0.095	0.095	"	33.75
S3	7.11	0.009	0.02	0.521	0.521	0.521	"	51.75

(Source: Field Work)

Table 2: Depth Variation in pH and Total Chromium Concentration at Locations A, B, C and D Sample Locations.

Depth (cm)	Sample point A		Sample point B		Sample point C		Sample point D		USEPA, WHO; FEPA; (mg/l)
	pH	Conc. of total Cr (mg/l)	pH	Conc. of total Cr (mg/l)	pH	Conc. of total Cr (mg/l)	pH	Conc. of total Cr (mg/l)	
0.00	8.60	4.9	7.66	0.65	5.46	0.58	7.62	0.67	0.01
5.00	8.11	2.67	7.36	1.28	6.94	0.23	7.77	0.33	"
10.00	7.56	1.79	7.55	1.33	6.98	0.33	7.37	0.23	"
15.00	7.87	2.37	8.04	0.16	7.02	0.39	7.36	-0.07	"

(Source: Field Work)

Table 3: Variation of Some Physical Properties of Soil Samples at Locations A, B, C and D.

Sample Location	Porosity (%)	Moisture content (in/ft)	Soil Particle density (g/cm^3)	Soil Bulk density (g/cm^3)	Particle Size			Texture	Textural Class
					Clay (%)	Silt (%)	Sand (%)		
A	39.5	0.230	2.10	1.48	17	20	63	Moderately coarse	Sandy loam
B	47.9	0.400	2.20	1.42	23	20	57	Medium	Sandy Clay loam
C	53.2	0.334	2.20	1.36	27	36	37	Fine	Clay loam
D	47.0	0.132	2.15	1.46	18	22	60	Moderately coarse	Sandy loam
S1	55.1	0.114	2.01	1.57	10	18	72	Moderately coarse	Sandy loam
S2	44.0	0.250	2.16	1.43	17	46	37	Medium	Loam
S3	48.2	0.168	1.98	1.52	14	22	6	Moderately coarse	Sandy loam

(Source: Field Work)

Table 4: Summary of Spatial Variation of Some Physicochemical Properties of the Groundwater Samples.

Samples' I.D.	Height of Ground-surface above m.s.l. (m)	Latitude (N)	Longitude (E)	Depth of Water Table (m)	pH: Wet Season	pH: Dry Season	Conc. of Chromium in wet season (mg/l)	Conc. of Chromium in wet season (mg/l)	USEPA, WHO; FEPA; (mg/l)
1	459.00	11°53.854'	008°27.925'	3.902	6.96	8.33	0.022	0.077	0.05
2	436.00	11°53.850'	008°27.824'	3.353	7.04	8.76	0.015	0.065	"
3	460.00	11°53.850'	008°27.714'	3.993	6.10	7.91	0.045	0.049	"
4	459.00	11°53.836'	008°27.785'	4.206	6.98	7.78	0.027	0.081	"
5	464.00	11°53.845'	008°27.785'	3.886	7.15	8.35	0.019	0.108	"
6	450.00	11°53.865'	008°27.698'	3.414	7.12	7.89	0.026	0.063	"
7	458.00	11°53.859'	008°27.680'	3.079	7.11	7.09	0.028	0.052	"
8	446.00	11°53.767'	008°27.809'	4.298	7.16	8.26	0.025	0.118	"
9	444.00	11°53.792'	008°27.869'	4.237	7.08	7.43	0.023	0.082	"
10	461.00	11°53.746'	008°27.862'	4.267	6.98	8.56	0.027	0.091	"
W1	459.00	11°53.824'	008°27.880'	4.785	7.02	7.44	0.019	0.023	"
W2	438.00	11°53.823'	008°27.865'	4.191	6.98	7.23	0.027	0.045	"

(Source: Field Work)

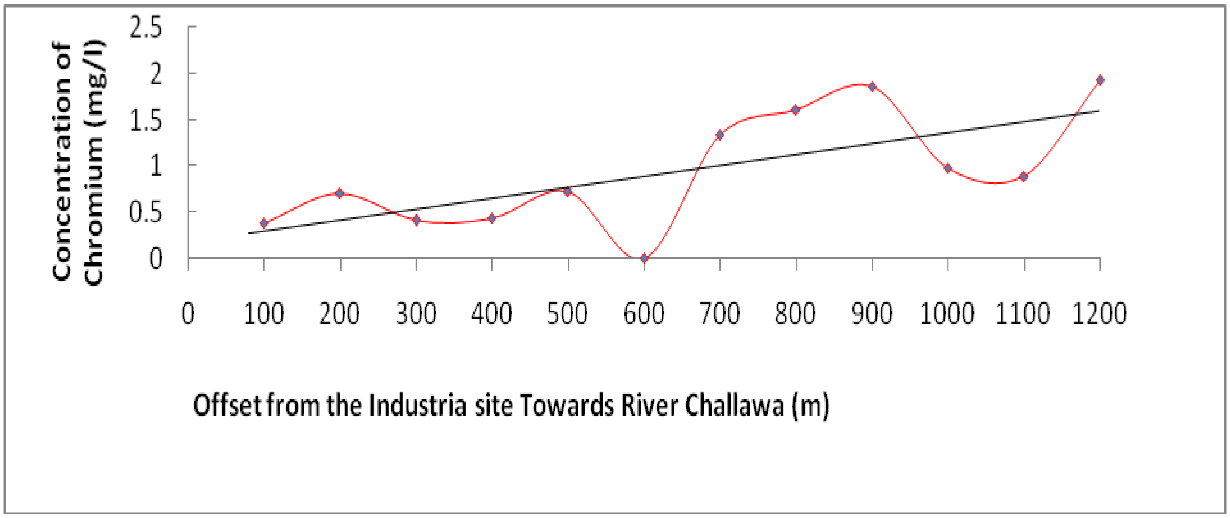

Figure 3: Graph of Total Chromium Concentration against the Lateral Offset of Sample Locations between the Industrial Estate and the Challawa River along Profile X-X$^{/}$.

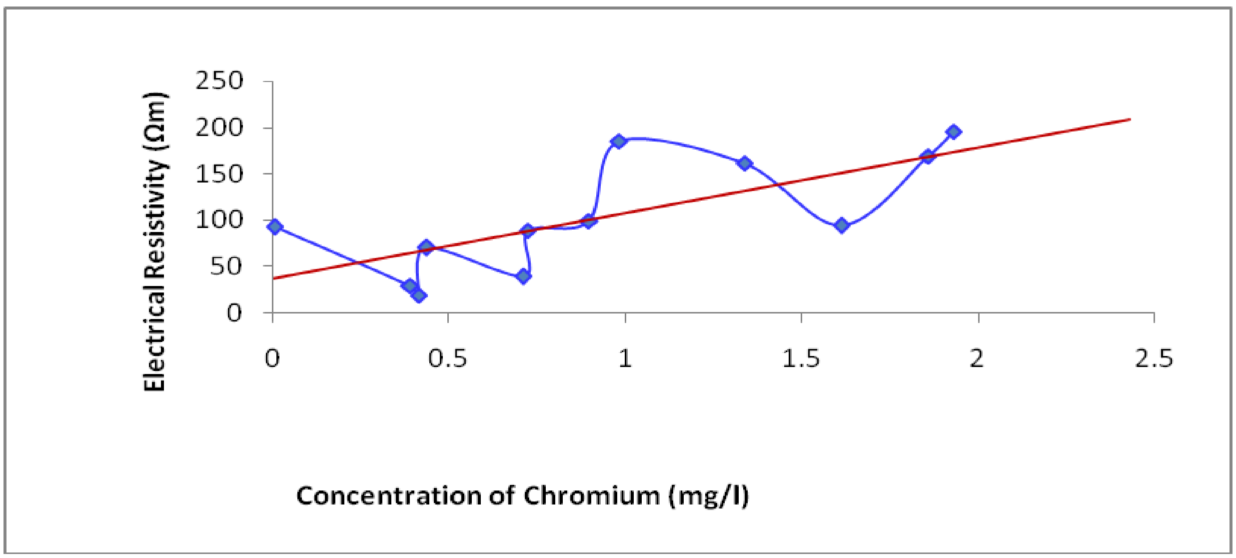

Figure 4: Graph of Electrical Resistivity of the Samples versus the Concentration of their Total Chromium along Profile X-X$^{/}$.

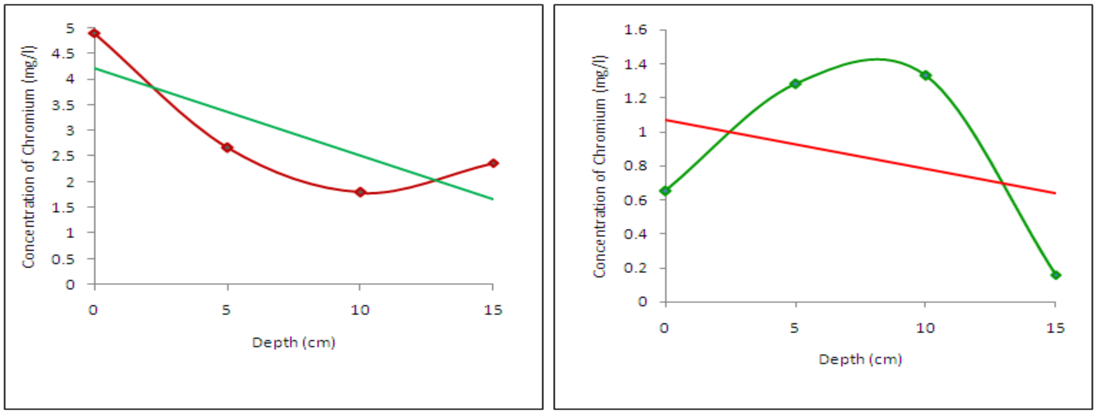

Figure 5a: Total Chromium Concentration Depth Relationship from Sample Locations A and B.

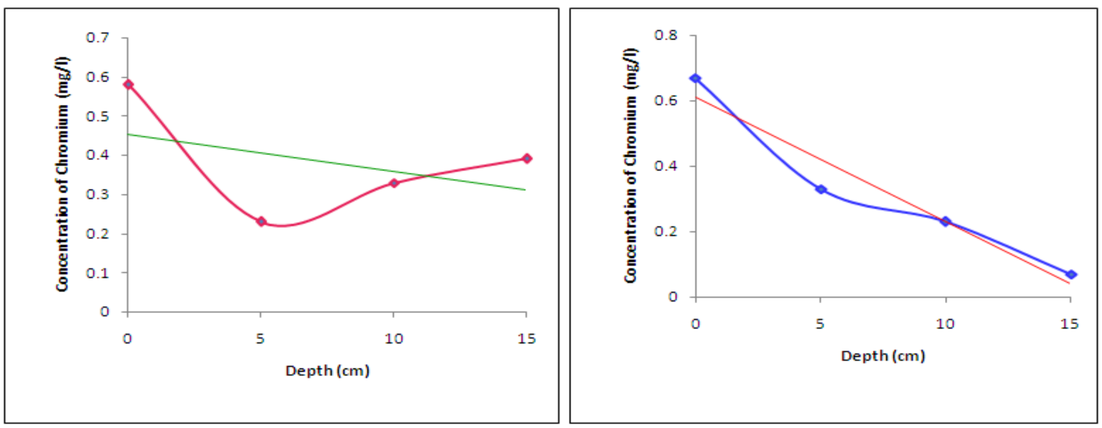

Figure 5b: Total Chromium Concentration Depth Relationship from Sample Locations C and D.

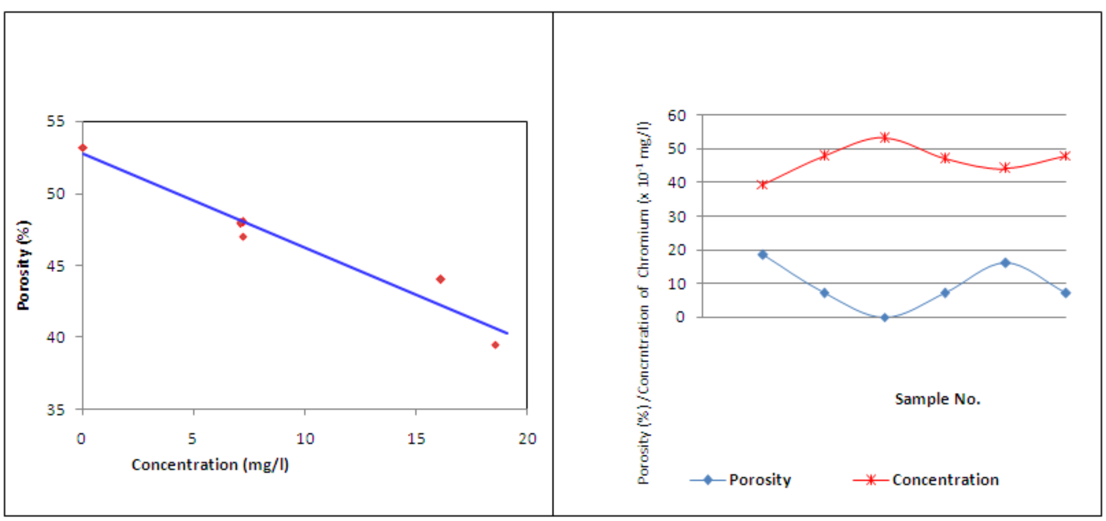

Figure 6: Graph of Porosities and Concentration of Total Chromium of the Samples.

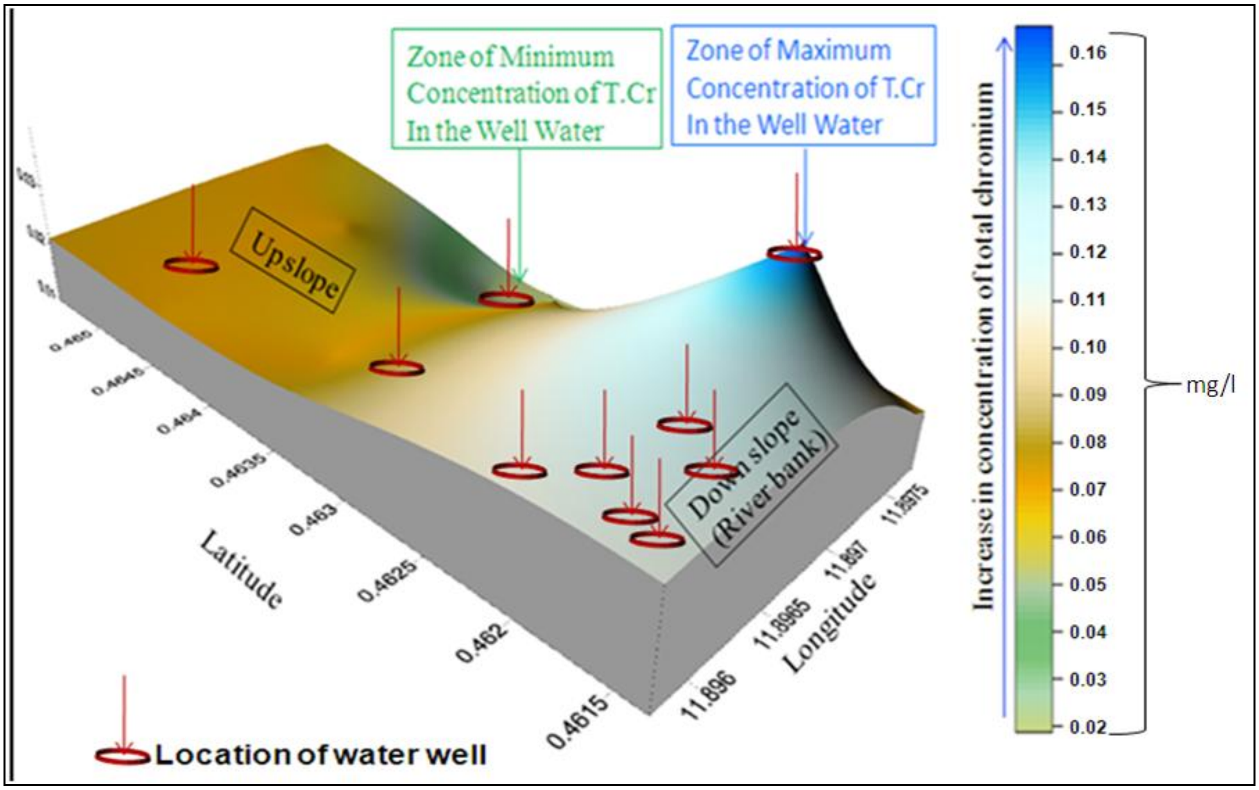

Figure 7: 3D Surface Map of Chromium Concentration in Well Water Sampled from the Settlement in the Study Area During the Dry Season.

The ranges of soil sample's concentration along X-X´, Y-Y/ and Z-Z are 1.79-4.9 mg/l, 0.16-1.33 mg/l, 0.23-0.58 and 0.07-0.67 mg/l, respectively. Based on the standard limits and experimental control values, the concentration of chromium in both topsoil and groundwater in dry season, are predominantly above tolerance limits. The estimated spatial increase in total chromium concentration between the leather industrial site and River Challawa along the profile lines X-X´, Y-Y/ and Z-Z/ at common depth of 10.0 cm are about +0.0011 ppm/meter, +0.0094 ppm/meter and +0.0098 ppm/meter, respectively. The increase may be attributed to accumulation of heavy metal over the years (Congzheng Yu *et. al.*, 2004). It may as well, be attributed to the presence of clay soil which is usually impermeable. Hence infiltration at the clayey zones of the study area is most likely poor. Results also show that concentration of total chromium at the study site is relatively minimum around the leather industrial cluster and relatively maximum at the bank of the River Challawa (Figure 3).

Samples locations A, B, C and D show moderate decay rates of -0.169 ppm/cm, -0.028 ppm/cm, -0.009 ppm/cm and -0.046 ppm/cm, respectively within the depth range of 0-15.0 cm in the topsoil (Figures 6a and b). The variation with depth is probably due to the differences in the size of pore spaces in the soil, the soil's texture, and the density of the soil. Table 4 shows that during the wet season, the concentration of total chromium in groundwater is below the tolerance limit (0.05 mg/l) whereas in dry season it is above the tolerance limit. Hence, while the use of well water is not discouraged during the wet season, the significant pollution in dry season suggests that the settlers around the industrial area stand at a high risk in the use of well water noting that Kano falls within the arid zone of Nigeria. Figure 7 shows that the highest concentration of chromium in groundwater is located at the settlement at the bank of River Challawa.

Results also show that there is a relative increase in the topsoil's electrical resistivity due to increase in the concentration of total chromium in it (Figure

4). The rate of increase in electrical resistivity towards River Challawa along the profile lines X-X´, Y-Y/ and Z-Z/ at common depth of 10.0 cm are about 71.00 Ωm/ppm, 66.00 Ωm/ppm and 84.00 Ωm/ppm, respectively. This suggests that accumulation of total chromium in the topsoil in the area most probably reduces the soils conductivity.

There is a significant decrease in the porosity of the topsoil due to increase in the concentration of total chromium in it at the rate of about 0.653/ppm. Therefore, the results show inverse proportionality of the concentration of chromium in the soil and the soils porosity (Figure 5). Based on the results on soil texture (Table 3), the topsoil in the study area is sandy. Sandy soil is the most porous of the three soil types in the area. Hence in the study area, it most probably has provided the highest rate of infiltration in the soil of the waste water into the subsurface upslope and around the leather industrial cluster. Table 1 results suggest that the soils pH in study area is moderately alkaline, whereas the groundwater is relatively neutral in wet season and moderately alkaline in dry season. Table 5 shows the summary of some findings about the area's topsoil and groundwater.

RECOMMENDATIONS

Based on the foregoing findings, it is obvious that physical and chemical changes take place in the area spatially, with depths and seasonally. Therefore time dependent laboratory calibration, qualitative and quantitative physicochemical data interpretations of topsoil and groundwater in the area should frequently be provided.

Further routine checks on toxicity and spatial migration of contaminants at the site are recommended in order to provide good spectrum of services for environmental support. This would aid future proposal schemes for sustainable development of both soil and groundwater systems. Particularly, integrated hydrogeological and non-intrusive geophysical investigations are recommended at the catchment of the industrial complexes in order to reveal the routes and channels of the contamination of groundwater regime hence, its better management is recommended.

Table 5: Summary of Some Findings about the Topsoil and Groundwater in the Study Area.

Physicochemical Property Investigated	Variation in Study Area	Remarks
Concentration of total chromium in topsoil spatially	Relative increase with offset distance (down-slope) in range of +0.0010 ppm/meter	Concentration of samples predominantly above the standard with Bank of River Challawa contaminated most
Concentration of total chromium in topsoil at depths	Relative decrease with depth with decay range of -0.009 to -0.169 ppm/cm	Infiltration predominantly poor in most parts of the study area particularly at the Bank of River Challawa contaminated
Concentration of total chromium in groundwater	Significant increase from wet to dry season: Sharp contrast between the peaks of the two seasons.	Predominantly below the standard in wet season above it in dry season: Has highest risk at the peak of the dry season
pH of topsoil	6.76-7.16	Predominantly moderate Alkaline
pH of groundwater: Wet Season	7.09-8.76	Relatively neutral
pH of groundwater: Dry Season	7.11-8.87	Moderately Alkaline
Electrical Resistivity of topsoil	Direct proportionality with concentration of total chromium in soil at about 71.00 Ωm/ppm	Conductivity is least at the bank of River Challawa contaminated most
Porosity	39.5 - 53.2%.	Inversely proportional to the concentration of total chromium in topsoil
Textural class	Ranges between fine and moderately coarse	Predominantly loamy soil with admixture of sandy, clayey soil

Routine investigations should be embarked upon in the study area in order to ascertain the extent of uptake of the pollutant from the soil. The electrical resistivity versus chrome concentration data generated in this work can be used as provisional reference standard for future research. Preventive measures should also be adopted through adequate routine enlightenment of the villagers on the health hazard due to farming activities on the land. It is also recommended that hydrophytes such as water hyacinth, vetiver grass, guinea grass, and water lettuces which have high capacity of the uptake of heavy metal from effluents should be planted across the waste water ways in the area in order to drastically reduce the high level of contamination. Industrial laws should be enforced on the leather and textile factories in Kano and other cities in Nigeria which share similar environmental degradation.

CONCLUSIONS

The physicochemical data acquired in this study have aided the assessment of environmental contamination in Challawa industrial area. The investigation shows that spatially, the concentration of the total chromium in topsoil is above the tolerance limit, minimum at the vicinity of the leather industries and has its maximum at the bank of Challawa River. With depths in the topsoil, the concentration of chromium show relative decrease. In the groundwater, the concentration of total chromium was valued to be within the tolerance standard limit in wet season but above the limit in dry season. The study has shown that indiscriminate discharge of untreated or partially treated effluents in the area has resulted to significant changes in some physicochemical properties of the topsoil namely decrease in porosity, increase in density and increase in electrical conductivity all owing to increase in concentration chromium in the topsoil. These imply that presently, an obvious environmental degradation of topsoil quality and seasonal contamination of groundwater in the area has occurred. Hence, if the industrial activities continue at the same rate in the factories without adequate remedy, the contamination may be gross both in the topsoil and groundwater which have paramount agricultural and domestic usefulness.

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