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Research article

High Incidence of Asthma, Bronchitis, Pneumonia and Sinusitis in Kano State, North West Nigeria during Saharan Dust Events

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Abstract

Among the atmospheric aerosols, mineral dust produced from windblown soils and deserts is one of the largest contributors to the global aerosel loading and has strong impacts on human health. Harmathan dust is considered to be among the most harmful of all air pollutants due to the toxic effect of the dust constituents. Respiratory infections make up more than 20% of the causes of infant mortality and morbidity. The study aims to evaluate particulate concentrations and associated chemical species in Saharan dust and top soil during Saharan dust events and their impact on human health. The results show that apart from the elemental composition; other properties such as pH, organic matter, CEC, and texture were elevated in the dust samples. The EF values indicate that the soil is minimally enriched / contaminated with Pb, Cd, Cu, Ni and Mn by the Saharan dust when Fe was used as a background reference element. The geo – accumulation index values show that the soil was moderately polluted with Pb, Cd, Cu, Fe, Ni and Mn by the Saharan dust. Based on hospitalization data on respiratory diseases collected, the study concludes that the prevalence of respiratory diseases in Kano State is consistent with the Saharan dust events.

Keywords: Saharan Dust, Asthma, Bronchitis, Pneumonia, Sinusitis, Enrichment Factor, Geo – Accumulation Index, Kano, Nigeria.

INTRODUCTION

The dry, dusty wind is one of the predominant atmospheric phenomena in West Africa, known as the Harmathan. It blows from late November to March in the sub – region [1, 2, 3], when the South – Westerly trade winds are replaced by a North – Eastern air flow from the Sahara. The Saharan dust is transported from the Sahara to the Gulf of Guinea by North Easterly trade winds in a South – Westerly direction [4]. During that period, storm activities in the

Bilma and Faya Largeau area (the Bodele depression) in the Chad Basin, raise large amounts of dust into the atmosphere, which is then carried South – West by the predominant winds [5, 6, 7, 8, 3,].
Enormous amounts of dust are carried, deposited, resuspended and redeposited along the transport path. As the Intertropical Convergence Zone (ITCZ) in December to February is located in the Atlantic Ocean but close to the Coast of the Gulf of Guinea [9], the Harmattan wind stops there and most of the dust settles over the land.
The predominatly harmattan winds could be found specifically in Nigeria, Benin, Togo, Ghana and the Cote D'voire [10]. The number of particles, mass distribution, dusty flows, the deposition rate and the mean size of the particles have been estimated in several countries, especially in Ghana [3, 11, 12, 10] Mali [13],and Nigeria [14]. These studies show that the dust quantity which varies from year to year is greater in the Northern parts of these countries and that the dust particles become finer in size as they move further south [14]. However, none investigated on harmathan dust impact on human health. Nine regions contribute to the total global production of harmattan / desert dust. These include: North Africa (Sahara), South Africa, the Arabian Peninsula, Central Asia, Western China, Eastern China, North America, South America and Australia [15, 16] . North Africa (Sahara) is the main source area contributing about 58% of the total global Harmathan dust emission and almost five times as much as the second biggest source, the Arabian Peninsula [16]. Nigeria is one of the countries in west Africa most exposed to desert dust because of its proximity to the main emission source area and its location with regard to the dominant winds [17].

Among the atmospheric aerosols, mineral dust produced from wind blown soils and deserts is one of the largest contributors to the global aerosols loading and has strong impacts on human health, agriculture, micro - climate, visibility and the ecosystems of a large area of West Africa, and even on the global environment [1, 6, 8, 18, 19, 20] and therefore attracts international attention. Kano has about 9.4 Million inhabitants and thus becomes one of the megacities in West Africa who confront severe challenges of air quality management. Along with rapid economic growth and vehicle increase, the features of air pollution in Kano are changing from typical firewood and /or fossil fuel combustion pollution to a complex pollution case [21]. In Harmattan season, dust storms and local re – suspended dust due to traffic and construction work enhance the complexity of particulate matter in Kano [22]. During transport, some of the atmospheric aerosols undergo chemical modifications. For example, oxidation of gaseous material, such as SO_x and NO_x occurs on the surface of mineral dust particles [23]. Also, dust particles can mix internally with sulphate and antropogenic contaminants through coagulation process with the aerosol particles [24, 25]. As a result, dust particles change their size, shape and surface conditions, and these modifications have profound implications on human health. Harmattan dusts therefore, are the reservoir for many harmful constituents, elemental and biological including heavy metals and trace metals [26]. Harmattan dust is considered to be among the most harmful of all air pollutants. When inhaled, particularly those that have antecedents of bronchial asthma, pneumonia and other respiratory diseases, these particles evade natural defenses of the respiratory system and lodge deep in the lungs causing serious health complications [27, 28].

In recent years, it has become common especially in Northern Nigeria, for people to experience nasal congestion, cough, muscular aches and pains, painful watery eyes (Apollo), and unusually high body temperature during the more dusty Harmattan periods. Monteil[29] notes a significant rise in the number of paediatric admissions following major dust events, including chronic obstructive pulmonary disease. Respiratory infections make up more than 20% of the causes of infant mortality and morbidity [30,31]. These conditions may be associated with toxic effect of the dust constituents on human health. While exposure to low levels of some elements may pose no health hazards, cumulative ingestion of relatively large quantity over a duration as long as the period usually spanned by the Harmattan Climate (November – March) in Nigeria, may be dangerous to human health. In the present study, the content of the Harmattan dust and associated top soils from Bayero University demonstration farm and hospitalization data from Aminu Kano Teaching Hospital on respiration related diseases for three years have been investigated. The results confirm a correlation between Harmattan dust impact and human health.

MATERIALS AND METHODS

Location of the research: The study area is Bayero University experimental farm, kano, North-West Nigeria and is within latitude 4^0 and 14^0 North and longitude 3^0 and 15^0 East Nigeria. The study is dominantly educational and agricultural community.

Sample Collection and Analytical Procedure

All the sampling sites were situated at the Bayero University agricultural experimental farm, far from public roads to minimize the amount local dust [(32, 33).]

Harmattern dust samples were collected in plastic basins about 30cm deep and 60cm diameter. The basins were filled with deionized water to trap the dust to within 10cm of the top, and the water level was topped up every week. In order to prevent birds, mice and other animals from drinking and polluting the water, a thin net 1cm mesh was used to cover the mouth of the basins. The plastic basin samplers were installed at a height of 3meters above the dried grass covered ground. Sampling began toward the end of Novermber 2010 and finished at the middle of March 2011. In the laboratory, the water was evaporated in a five liter glass beakers in order to get dry dust sample. The dried dust samples dried at about 75^0c were weighed and stored in a desiccators for analysis. Homogenous samples representative of the top soil sample at the representative sampling sites were previously collected for analysis to enable comparison, with the Saharan dust. The soil samples were air dried under laboratory conditions for two weeks, ground, sieved through a 2mm polyethylene sieve and dried to constant mass in an oven at 75^0C and kept in desiccators for further analysis.

0.25g of the oven dried haramttan dust and soil samples were weighed individually into platinum crucibles. The digestions were conducted with a mixture of $3cm^3$ of conc. HNO_3, $2cm^3$ of con. HF and $1cm^3$ of 40% H_2O_2 solution. The mixture was digested on a sand bath at a temperature of 200-230^oc and the acids were evaporated to dryness. After the dust and soil had been digested and acids evaporated, $20cm^3$ of $0.25MHNO_3$, was added, warmed for 10mins and transferred and filtered into $50cm^3$ plastic container and filled to volume with the 0.25M HNO_3 solution. The digested dust and soil samples , the reagent blanks and standard solutions were analyzed using Atomic Absorption spectrometer model bulk scientific UPG2,10. The metal contents were calculated by using the straight line equation from the calibration curve plotted. Dust and soil pH were measured potentiometrically in IMKCL with dust and soil extractant ratio of 1:5 in three replicates per sample. The organic carbon was determined by Tiurin method. It was oxidized to carbon dioxide with potassium dichromate in the presence of conc. Sulphuric acid. The unreacted potassium dichromate was titrated with ammonium ion(II) sulphate considering that the average content of carbon in soil organic matter was equal to 58%, the conversion factor 1.724 was used to calculate the percentage of organic matter from the content of organic carbon.

The particle size composition (sand, soil and clay) of the dust and soil samples were determined by the hydrometer method. Texture of the dust and soil samples were established by charting the percentages of sand, silt and clay fractions with a textural triangle. The cation exchange capacity (CEC) of the dust and soil, were determined by the direct cation saturation method.

When the enrichment factor (EF) and geo-accumulation index (Igeo) of the dust samples were calculated, ions was used as background reference element. Iron is one of the main components of the earth crust and its concentration in soil is connected mainly with the matrix.

Table 1: pH of Harmattan Dust and Soil

S/N	Dust pH	Soil pH
1	9.71	4.8
2	9.56	6.7
3	9.90	5.6
4.	9.88	6.4

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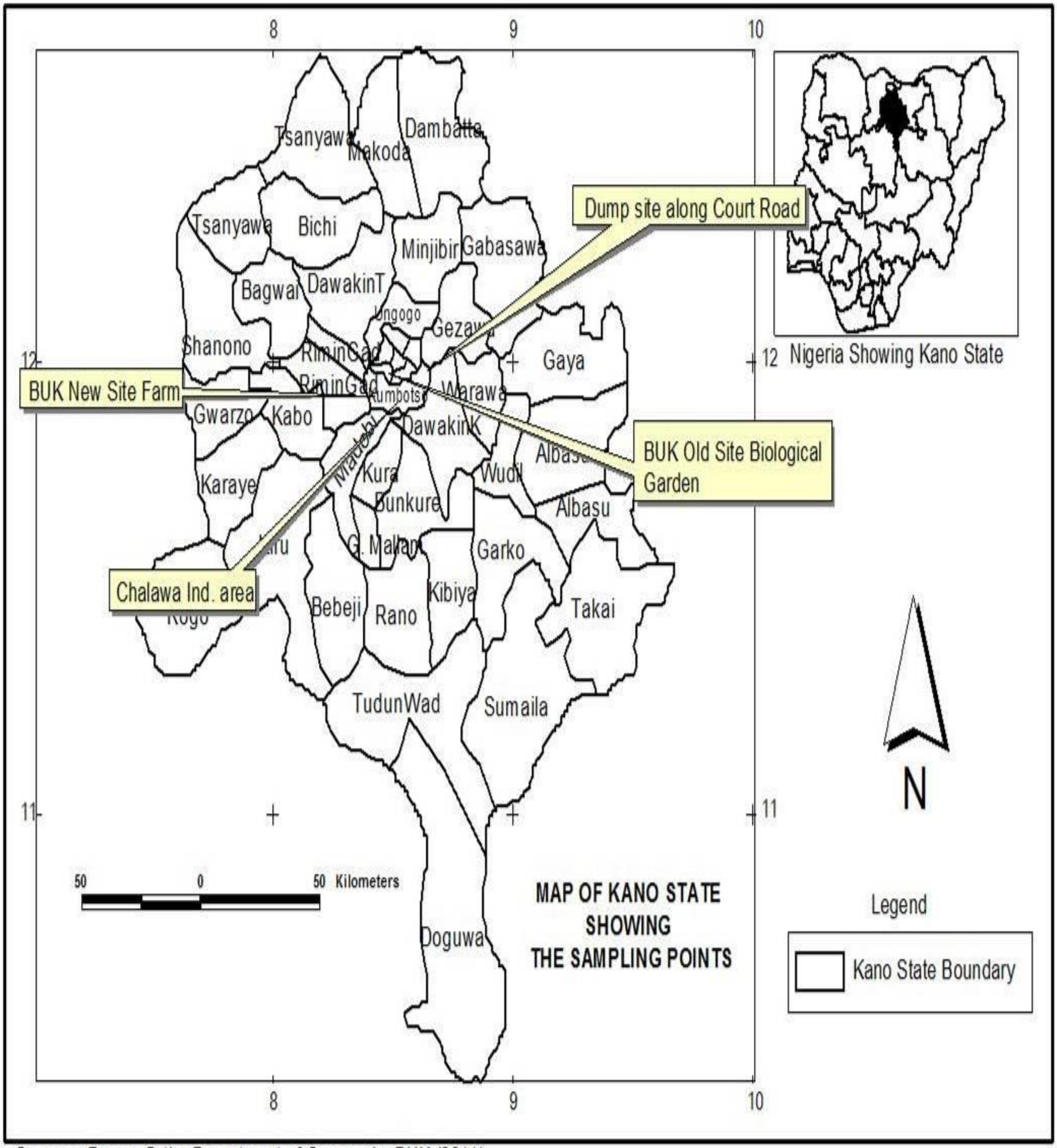

Sources: Drawn @ the Department of Geography BUK (2011)

Figure 1: Map of Kano State Showing the Sampling Points

Table 2: Organic Matter Content of the Harmattan Dust and Soil (%)

S/N	Dust Organic Matter	Soil Organic Matter
1	7.63	1.52
2	7.70	1.24
3	7.58	2.68
4.	7.59	2.36

Table 3: Cation Exchange Capacity of the Harmattan Dust and Soil (mmol/100g)

S/N	CEC Dust	CEC Soil
1	27.22	5.1
2	25.28	6.8
3	23.08	4.9
4.	27.09	5.1

Table 4: Harmattan Dust Texture and Textural Classification

	Percentage Sand, Silt and Clay			
S/N	**Clay**	**Silt**	**Sand**	**Textural Class**
1	26	56	18	Silt loam
2	27	57	16	Silt Loam
3	26	60	14	Silt Loam
4.	23	59	18	Silt Loam

Table 5: Soil Texture and Textural Classification

	Percentage Sand, Silt and Clay			
S/N	**Clay**	**Silt**	**Sand**	**Textural Class**
1	9	33	58	Sandy Loam
2	8	31	61	Sandy Loam

3	7	27	66	Sandy Loam
4.	5	17	78	Sandy Loam

Table 6: Concentration of Metal in the Harmattan Dust Samples (mg/kg)

S/No	Pb	Cu	Fe	Cr	Cd	Zn	Mn	Ni
1	13.8	12.5	127	ND	7.5	ND	4.0	12.5
2	13.8	7	164	ND	5.0	ND	7.5	9.5
3	7	1.5	91	ND	2.5	ND	4.0	12.5
4	7	7	109	ND	5.0	ND	7.5	9.5

Table 7: Concentration of Metal in the Soil Samples (mg/kg)

S/No	Pb	Cu	Fe	Cr	Cd	Zn	Mn	Ni
1	14	7	55	ND	13	78	20	10
2	14	7	109	ND	10	70	16	19
3	21	34	145	ND	5	104	16	9.5
4	21	28	164	ND	5	96	12	1.9

Table 8: Enrichment factor of Heavy Metal in the Harmattan Dust samples Using Fe as a Background Reference Element

S/No	Pb	Cu	Fe	Cr	Cd	Zn	Mn	Ni
1	0.43	0.77	1	-	0.25	-	0.09	0.54
2	0.65	0.67	1	-	0.33	-	0.31	0.33
3	0.53	0.58	1	-	0.78	-	0.40	2.10
4	0.50	0.37	1	-	1.51	-	0.94	0.75

Table 9: geo – Accumulation Index of Heavy Metal in the Harmattan Dust samples on the Basis of Background Samples

S/No	Pb	Cu	Fe	Cr	Cd	Zn	Mn	Ni
1	0.20	0.36	0.46	-	0.12	-	0.04	0.25
2	0.20	0.20	0.30	-	0.10	-	0.04	0.10
3	0.07	0.07	0.13	-	0.10	-	0.05	0.26
4	0.07	0.07	0.13	-	0.20	-	0.13	0.10

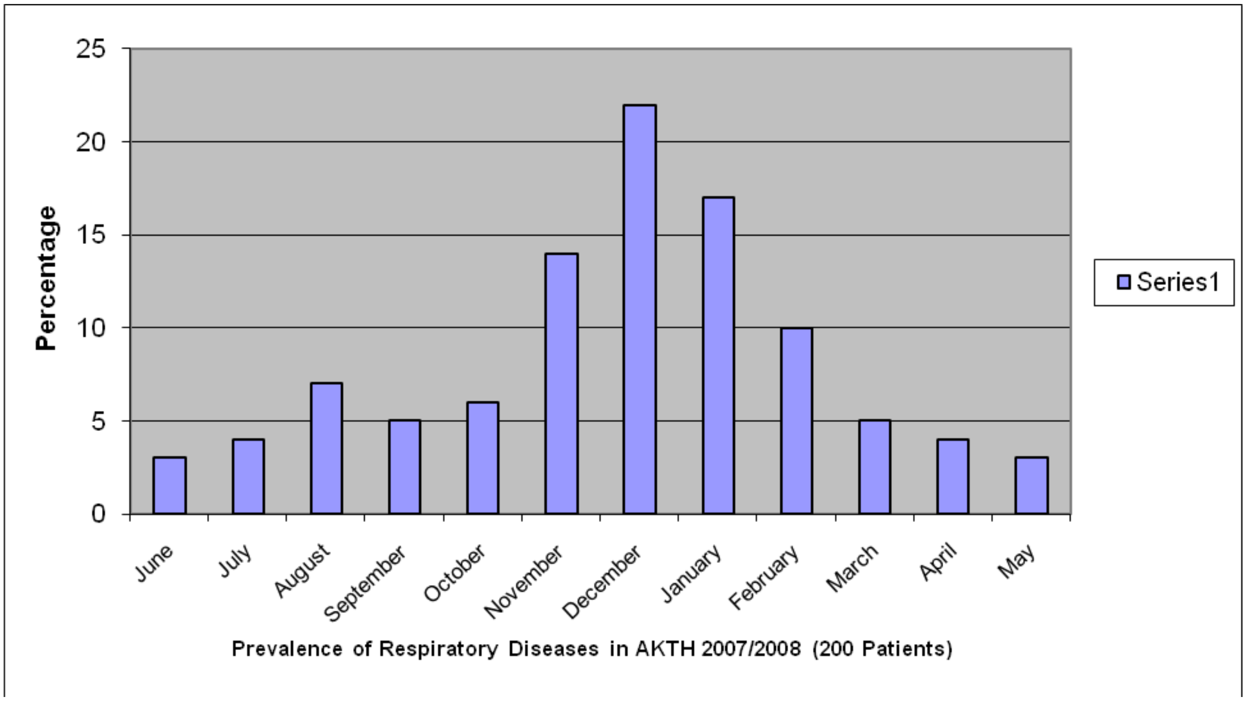

Figure 2: Frequency Distribution Pattern for Prevalence of Respiratory Diseases in AKTH 2007/2008

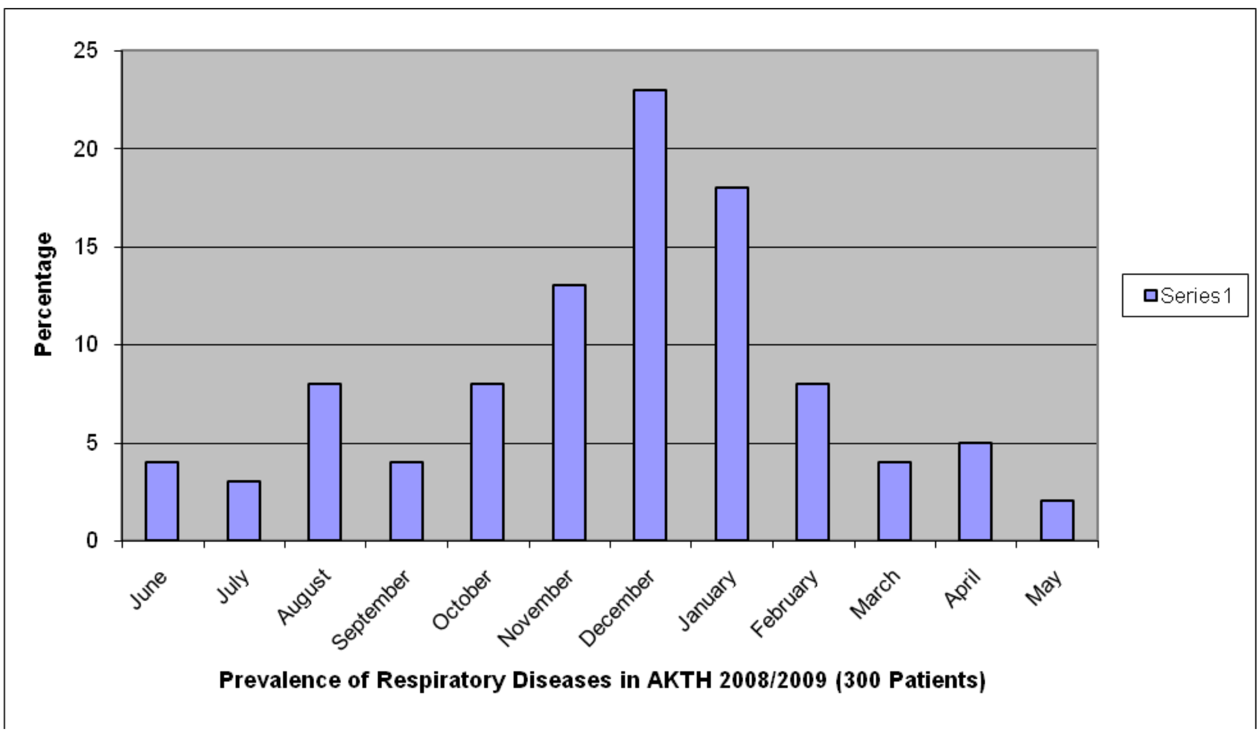

Figure 3: Frequency Distribution Pattern for Prevalence of Respiratory Diseases in AKTH 2008/2009

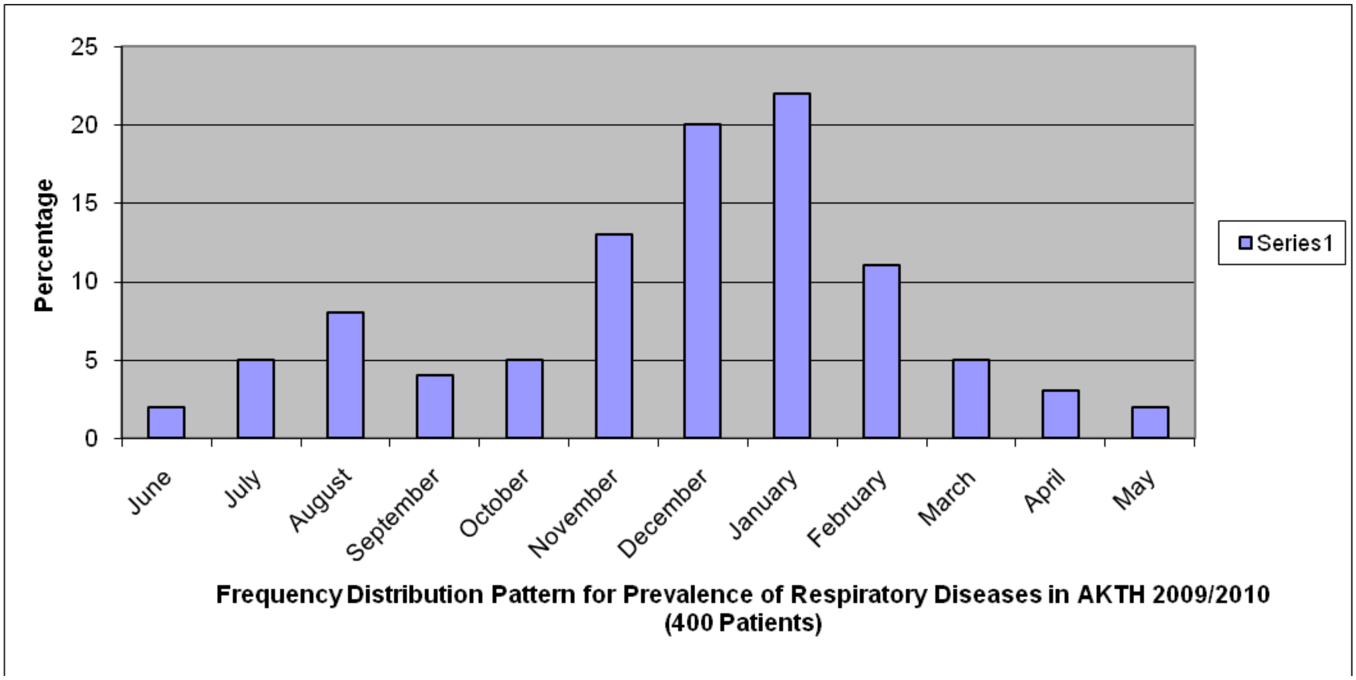

Figure 4: Frequency Distribution Pattern for Prevalence of Respiratory Diseases in AKTH 2009/2010

RESULTS

The studied area is shown in fig.1. the pH of the dust and soil (Table 1), indicates alkaline dust and acidic soil. Table 2, shows the variation of the percentage organic matter of the dust and soil, with the dust showing high organic matter content. The Saharan dust has high CEC when compared with the soil(Table 3) Tables 4 and 5, show the dust and soil texture, and textural classification the textural order of the dust is silt > clay > sand while sand> Silt>clay, is the order of the soil texture. The metal content of the dust and soil is shown in table 6 and 7 .The variations of the enrichment factor of the dust is shown in table 8, using iron as a background reference element. The geoaccumulation index of the dust is shown in Table 9. The variations of the prevalence of respiratory diseases in Kano state, Nigeria, as indicated, by the Aminu Kano Teaching Hospital patients admissions data in 2007/ 2008, 2008/2009 and 2009/2010, harmattan seasons, are shown in figure 2-4 respectively. The data is consistent with the prevalence of asthma, bronchitis, pneumonia and sinusitis in Kano state especially during Saharan dust events.

DISCUSSION

The pH of the dust in the harmattan season 2010/2011(Table1) is higher than in the soil, showing that a substancial part of the dust deposited over Kano is coming from Sahara [11, 18]. The variation in pH is probably due to sodium carbonates and calcites which were brought by the harmattan from the Sahara and the different imputs of local materials to the harmattan dust on its way from the Sahara to the Gulf of Guinea [18]. Table 2 indicates that the harmattan dust has higher organic matter content than the soil samples. Also the CEC in the harmattan dust samples are higher than the CEC in the soil samples (Table 3). These differences in chemical and physical properties and in constituent composition of the harmattan dust may be expected to have an impact on human health. Table 4 and 5, shows the harmattan dust and soil particles size distribution which indicated that clay less than 2µm) constituted an average of 26% and slit (2-50µm) 58% and sand (150-200µm) 16% of the dust. Texturally, the harmattan dust is classified as a slit loam [3, 34]. Tables 6 and 7, show the total metal content in the harmattan dust and soil samples. Generally, the metal concentrations in the dust samples is lower than the soil samples. High elemental concentration in the soil, could be due to enrichment of the farming soils from anthropogenic sources.

Enrichment Factor: A popular technique in order to evaluates the relative importance of contamination sources on the determined trace metals of an environmental sample (air blown particles, soil, sediments, street and / or road dusts etc) is to compare the relative abundance of species in sources material to that found in the background. The result obtained is described as an enrichment factor (EF) and the equation used to calculate it is as follows.

$$EF= C_n / C_{ref} \text{ (Harmattan dust)} / B_n / B_{ref} \text{ (Control soil)}$$

Where,
C_n = Content of the examined element in the harmattan dust
C_{ref} = Content of the reference element iron(Fe) in the hammattan dust.
B_n = Content of the examined element in the control soil
B_{ref} = Content of the reference elements in the control soil

Calculation of enrichment factor (EF) values helps to determine whether a certain element has additional or anthropogenic sources other than its major natural sources [35].

However, Table 8 shows that the soil is minimally enriched/ contaminated with Pb, Cd, Cu, Ni and Mn by the harmattan dust. The traces of the heavy metals in animals are not toxic [36], lead and cadminum are exceptions, they are toxic even in low concentrations [37]. Lead and cadmium can replace essential metals in enzymes disrupting their functions and can cause oxidative stress by the formation of free radicals [38, 39].

Geo- Accumulation index (Igeo): Geo-accumulation index represents a quantitative measurement of metal pollution in an environment [40]. Index of geo accumulation (Igeo) has been used widely, to evaluate the degree of in metal pollution terrestrial, aquatic and marine environment [41]. The Igeo of a metal in a sample can be calculated with the formula[42,40, 43].

$$Igeo= \text{Log } 2 \ (C_n) \text{ Harmattan dust} / (1.5 B_n) \text{ Control soil}$$

Where:
C_n = Concentration of the examined elements in the Harmattan dust
B_n = Concentration of the examined element in the control soil.

The correction factor 1.5, is introduced to minimize the effect of the possible variation in the control values which may be attributed to lithogenic variations, in the sample [43]

Table 9 shows that the soil was moderately polluted with pb, cu, Fe, Cd, Ni and Mn by the Saharan dust. The kidney, liver and central nerve systems are the major target organs of Cd and Pb, accumulation and exposure to Cd and Pb, lead to renal tubular dysfunction, poor bone mineralization and testicular necrosis [44]. Total content of Harmattan dust is useful for many geochemical application i.e. the level of enrichment, depletion or pollution of the environment.

Figure 2-4, show the variation in the hospitalization of patients with respiratory related diseases (asthma, bronchitis, pneumonia and sinusitis) in Aminu Kano Teaching Hospital (AKTH) Kano, during the period under investigation.This survey study, 106 patients were hospitalized during harmattan season, between November to January, out of a total of 200 patients admitted with respiratory cases in 2007-2008. In the same period in 2008/2009, 162 patients, out of 300 respiratory cases for the entire period representing 54% were hospitalized. Similarly in 2009/ 2010, 220 patients out of 400 respiratory cases for the whole year, were hospitalized for respiratory related cases during the harmattan season.

However, there were low cases of hospitalization of patients with reparatory related ailments outside the harmattan season, within the study period. Prevalence of respiratory diseases in Kano State is consistent with Harmattan season. This is so because Nigeria is one of the countries in West Africa most exposed to the Sahara dust because of its proximately to the main emission source area and its location, with regards to the dominant winds [17].

CONCLUSION

The study compared the properties of Saharan dust and local top soil at the Bayero University Experimental farm on one hand and the impacts of the Saharan dust on human health on the other hand. The results show distinctive difference on properties such as pH, organic matter content, CEC, texture and textural classification and metal content, between the dust and soil. The hospitalization data on respiratory related diseases, confirms a positive correlation between harmattan dust impact and human health. Kano state is one of the cities in Nigeria most exposed to the Sahara dust because of its proximity to the main emission source area and its location with regards to the dominant winds.

REFERENCES

[1] Adetunji, J., McGregor, J. and Ong, C. K. The Harmattan Haze. Weather Journal 34:430-436 (1979).

[2] Adedokun, J.A., Emofurieta, W.O and Adedeji, O.A Physica, Mineralogical and Chemical Properties of Harmattan Dust at Ile – Ife, Nigeria. Theor. Appl. Climatol. 40:161 – 169 (1989).

[3] Afeti, G.M. and Resh, F.J. Physical Characteristics of Saharan Dust near the Gulf of Guinea. Atmospheric Environment 34:1273 – 1279 (2000).

[4] Encyclopedia Britannica Harmattan Encyclopedia Inc., Chicago. Pp 56 – 71 (2007).

[5] Kalu, A.E: The African Dust Plume: Its Characteristrics and Propagation Across West Africa in Winters. In: Saharan Dust Mobilization Transport Deposition. Wiley, New York. Pp. 95 – 118 (1979).

[6] McTainsh, G. Harmattan Dust Deposition in Northern Nigeria. Nature 286:587 – 588 (1980).

[7] Mctainsh, G and Walker, P. H. Nature and Distribution of Harmattan Dust. Geomorphic N.F. 26:417 - 435 (1982).

[8] Cox, R.E., Mazurek, M.A and Simoneit, B.R.T. Lipids in Harmattan Aerosols of Nigeria. Nature 296: 848 – 849 (1982).

[9] Prospero, J.M. Dust from the Sahara. Nat. Hist. 88:54 – 61 (1979).

[10] Sunnu, A., Afeti, G., Resh, F.A. A long Term Experimental Study of the Saharan Dust Presence in West Africa. Atmos. Res. 87:13 – 26 (2008).

[11] Breuning – madasan, H. and Awadzin, T.W. Harmattan: Dust Deposition and Particle Sizi in Ghana. Catena 63:23 – 38 (2005).

[12] Resch, F., Sunnu, A., Afeti, G. Saharan Dust Flux and Deposition Rate Near the Gulf of Guinea. Tellub 60:98 – 105 (2007).

[13] McTainsh, G.H., NickLing, W.G., L:ynch, A.W. Dust Deposition and Particle Size in Mali West Africa. Catena, 29:307 – 22 (1997).

[14] Anuforom, A.C. Spatial Distribution and Temporal Variability of Harmattan Dust Haze in Sub – Sahel West African Atmosphere. Environ. 41:9079 – 90 (2007).

[15] Prospero, J.M., Girouse, P. Torres, O., Nicholson, S. E., Gill, T.E. Environmental Characterization of Global Sources of Atmospheric Soil Dust Identified with the Nimbus 7 Total Ozone Mapping Spectrometer Absorbing Aerosol product. Rev. geophysics. 40(1): 1002 (2002).

[16] Tanaka, T.Y and Chiba, M. A numerical study of the contribution of Dust Source Regions of the Dust Budget. Globe Planet Change 52:88 – 104 (2006).

[17] Rutherford, S., Clark, E., McTainsh, G., Simpson, R., Mitchell, C. Characteristics of Rural Severity in Brisbane Australia. Int. J. Biometeoral 42:217 – 25 (1999).

[18] Goudie, A.S. and Middleton, N.J. Saharan Dust Storms: Nature and Consequences. Earth Science reviews 56;179-204 (2001).

[19] Tagen, I., Lacis, A and Fung, I. The influence of Mineral Aerosol from Distribution Source on the Global Radiation Budget. Nature 380: 419 – 422 (1996).

[20] Wu, J., Xu, Y. Y., Fu, C.B., Zhang, R.J, Dai, M and Zhu, Y. Comparison of Simulating Mineral Dust Aerosols in East Asia by two Emission Schemes. China Particulogy 4:293 – 299 (2006).

[21] Zhang, R.J, Xu, Y.F and Han, Z.W. A Comparison Analysis of Chemical Composition of Aerosols in the Dust and Non – Dust Periods in Beijing. Adv. Atmos. Sci. 21:300 – 3005 (2004).

[22] Guo, H., Rahn, K.A and Zhuang, G. A Mechanism for the increase of Pollution Elements in Dust Storms in Beijung. Atmos. Environ. 38:855 – 862 (2004).

[23] Dentener, F.J., Carmichael, G.R., Zhang, Y.g, Lertiveled, J. and Crutzen, P.J. Role of Mineral Aerosols as a Reactive Surface in the Global Troposphere. J. geophys. Res. 101: 22869 – 22889 (1996).

[24] Roth, B. and Okada. On the Modification of Sea salt Particles in the Coastal Atmosphere. Atmos. Environ. 32:1555 -1569. (1998).

[25] Wurzler, S., Reisin, T.G and Levin, 2. Modification of Mineral Dust particles by Cloud Processing and Subsequent Effects on Drop Size Distributions. J. Geophys. Res. 105: 4501 – 4512 (2000).

[26] Jimoh, W.L.O. A Sequential Extraction Method for the Chemical Speciation of Metals in Harmattan Dust Collected from Kano and Zaria Cities in Northern Nigeria. Int. J. Res. Chem. and Environ. 2(2): 76 – 82 (2012).

[27] Krystna, R., Flocchini, G. and Caracho, F. European Aerosol Conference. Salzburg, T19 A 006 (2007).

[28] Yoo, Y., Chuong, J.T., Yu, J.H, Kim, D.K., Koh, Y. A cute Effects of Asian Dust events on Respiratory symtoms and Peak Expiratory Flow in Children, with Mild Asthma. J. Korean Med. Sci. 23:66 – 71 (2008).

[29] Montail, M.A. Saharan Dust Clouds and Human Health in the English Speaking Caribbean: What we know and Don’ts Know. Environ Geochem. And Health 30:339 – 43 (2008).

[30] Morris, S.S., Black, R.E. Tomaskoric3, L. Predicting the Distribution of Under – Five Deaths by cause in Countries Without Adequate Vital Registration System. In. J. Epidemol 32:1041 – 51 (2003).

[31] Bryce, J. Boschi – Pinto, C., Schiobuya, K. Black, R.E. The WHO Estimate of the cause of Death in Children. Lancet 365:1147-52 (2005).

[32] Tiessen, H., Hauffe H.K., Mermut, A.R. Deposition of Harmattan Dust and Its Influence in Ghana. Geodema 49:285 – 299 (1991).

[33] Erell, E and Tsoar, H. Spatial Narrations in the Aedian Deposition of Dust, the Effect on a city: A Case Study in Be’ ershare, Israel. Atmosphere Env. 33:4049 – 4055 (1999).

[34] Adetunji, M.T, Martins, O and Arowolo, T.A. Seasonal Variation in Atmospheric Deposition of Nitrate, Sulphate, Lead, Zinc and Copper in South Western Nigeria. Com. Soil Sci. Pl. Anal 32:65-73 (2001).

[35] Kabata – Pendias, A and Pendias, H. Biochemistry of Trace Element. Naukowe Press, Warsaw, Poland pp 99 – 105 (1999).

[36] Devries, W., Rouyken, P.F and Schultz, G. Critical Soil concentration of Cadonium, lead and mercury in view of Health Effect on Humans and Animals. Review of Environ. Conta. And Toxicology. 191:91 – 30 (2007).

[37] Malayeri , B. E., Chehuegari, F., Golmohammadi, R. Effects of Heavy Metals on the Developmental Stages of Ovule and Embryonic Sac in Euphorbia Chenademia Park. J. Bol. Sc. 8:622 – 625 (2005).

[38]Ghosch, M. and Singh, S.P. A Review on Phytoremediation of Heavy Metals and Utilization of its By – Products. App. Ecol. Env. Res. 73:1-18

[39] Asaah, A.V. and Abimbola, A.F. Heavy Metal Concentration and Distribution in Surface Soil of the Bassa Industrial Zone 1, Doula, Cameroon. The J. for sci and Engineering 31 (2): 147 – 158 (2005).

[40] Tijjani, M. N. and Omodera, S. Chemical Assessment of Metals Contamination in an Urban Drainage by Stem. A case study of Osogbo Township, SW Nigeria. Water Resources and Protection. 3. 164 – 173 (2009).

[41] Muller, G. Index of Geo – accumulation in Sediment of the R Line River. Geol. J. 2: 109 – 118 (1969).

[42] Mediola, L.L., Dominguez, M.C.D. and Sand Oral, M.R.G. Environmental Assessment of an Active Tailings Pile in the State of Alexico. Re. of J. Env. Sci. 2(3): 197 – 208 (2008).

[43] Samara, S and Richard, S. Toxicity, Heavy Metal. Meds Cape. Comm. Article (2008).