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Indoor Air Quality of Kindergarten and Primary School Environment along Dar es Salaam Coast, Tanzania

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Abstract: ***Studies on air quality are limited in Sub-Saharan Africa. Contributions from the sampled kindergarten and primary classrooms dusts and play ground soils in Dar es Salaam city, Tanzania, were assessed for heavy elements. Samples were acid digested and supernatant analyzed using inductively coupled plasma optical emission spectrometer. Mean concentrations (mg/kg) for the identified heavy metals, Cr, Mn, Cu and Ni, were in the range 3.2 - 104 (mg/kg) and 5 - 7200 (mg/kg) respectively. X-ray fluorescence analysises on loaded filters with particulate matter, detected elements Al, Si, S, Cl, K, Ca, Fe and Zn in the range 7.5-26.6 µgm^{-3}. As children spend most of their day time at schools, exposure to heavy elements will lead to health problems. These risks may be reduced by frequent wet mopping in classrooms, planting of grasses and trees on surrounding bare lands.***

Keywords: Health, Heavy metals, Particulate matter, Dar es Salaam.

1. Introduction

Indoor and outdoor air quality is mostly associated with anthropogenic activities. Air pollutants composition are highly variable in space and time and depends upon the relative contribution from diverse sources, e.g., water bodies, soils, dusts which are known to have a major impact on the global biogeochemical cycle of many metallic elements.

African countries are also subject to an increasing burden of air pollutants produced by industries, biomass burning, traffic, waste generations and coal-fired power plant emissions. Heavy metals are believed to be present in water, air, soils, and sediments commonly found in street dusts at trace levels. It is evident that the growth of the population, industries and transportation systems contribute to the increased levels of pollutants especially in urban/city dust and the surroundings (Yongming et al.,2006; Marianne et al., 2008; Yap et al., 2011). This is exemplified by a strong accordance of high levels of heavy metals in street dust with traffic emissions as well as garbage and industrial waste disposal. As reported by Shinggu et al.(2007), street dust is among the major means through which heavy metals get into soils, plants and consequently to human beings. Accordingly, air pollutants in the urban area dusts and soil are among the threats to human health because they can easily enter into their bodies via inhalation, ingestion and dermal contact (Abrahams, 2002; Barnes et al., 2009).

Comprehensive air quality studies in Africa are limited and only a handful of related studies have been published for Sub-Saharan African countries (Jonsson *et al.*, 2004;Bennet *et al.*, 2005,Mkoma,2008, Mkoma et al., 2009a,b., Msafiri; 2009, Mmari,2011., Mkenga, 2013). This may probably be due to the lack of funding, knowledge and/or availability of modern analytical techniques.

This paper, therefore reports the identified heavy metals and their levels in dusts and playing grounds soils in kindergarten and primary schools classrooms respectively.

2. Materials and Methods

2.1 Study Area and Sampling

Dar es Salaam region is a commercial capital of Tanzania and comprises three districts, namely, Ilala, Kinondoni, and Temeke. The selected schools were from Ilala and Kinondoni districts as these districts comprises a wide range of activities. Eleven primary schools were selected from Kinondoni with five within the city, One primary school from Ilala district was selected near the city. Bulk collection of particulate matter was away and within the city, sites, S1 and S2 (Figure 1).

Figure 1.0: Geographical location of sampling sites (red dots) and boundaries of Dar es Salaam region.

Climatic conditions (precipitation, temperature, relative humidity and wind velocity) were continuously recorded and provided by the Tanzanian Meteorological Agency.

2.2 Sample Collection

Two dust samples were collected from each, kindergarten and primary classrooms. Two samples from kindergarten and primary classroom were combined together to form a composite dust sample for kindergarten and primary school classroom. The deposited dust in the classrooms were collected by sweeping the floor using a clean plastic brush into a clean plastic pan as per literature (Abrahams 2002,Adekola and Dosumu 2001,Fairus et al.,2011). Soil samples were taken from the topsoil after removing the top layer using plastic pan as per literature (Norhayati et al., 2007 and Biasioli et al., 2006).

For particulate matter (PM), sampling campaigns in each climatic season (two dry and two wet seasons per year) per site were conducted. The PM was collected on Nuclepore membrane filters (47 mm diameter, pore size 0.4 μm, Nuclepore, Whatman International Ltd., England) using a stack filter unit (SFU) operated at an air flow rate of 20 *l* min^{-1} for 6 h at a height of 2.0 m above the ground.

2.3 Sample preparation and analysis

About 1 g of dust was weighed using Tettler Toledo EL204 analytical balance with the accuracy of ± 0.0001 g and then transferred into a digestion tube. About 6 mL of concentrated hydrochloric acid was added, followed by about 3 ml of concentrated nitric acid. The mixture was pre-digested at room temperature for 16 hours, and then digested at 140 °C using a heating block until brown fumes ceased to come out. Thereafter the temperature was raised to 180 °C and the temperature was maintained until no further brown fumes were given out (Yap CK et al., 2011, Shinggu et al., 2007, ISO 11466., 1995).

The digested sample solutions were analyzed using inductively coupled plasma optical emission spectrophotometer/ inductively coupled plasma atomic emission spectrometer (ICP-OES) at the Government Chemistry Laboratory Agency.

Control sample of about 1 ppm was prepared for the elements under study. The results obtained were between 99% and 110% whereby manganese showed high concentration greater than the prepared concentration above 100 % but the rest of the elements cadmium, chromium, copper, nickel and lead concentration were about 100%.

Average recovery range of heavy metals concentrations from the spiked samples of dust were 1.2034 to 2.1990 ppm equivalent to percentage range of 60.18 to 109.95 and for the soil samples, were 1.0694 to 1.8254 ppm equivalent to percentage range of 53.48 to 93.52. In both soil and dust spiked samples percentage recovery shown that the least recovered heavy metals were chromium and lead.

A Model Epsilon 5 (PANalytical, Almelo, The Netherlands) high-energy EDXRF unit using a polarizing beam was applied for elemental identification in PM. It is equipped with a 600 W Gd-anode with an accelerating voltage ranging from 25 to 100 kV and a current from 0.5 to 24 mA. The EDXRF is fitted with 13 secondary fluorescers (Al, CaF_2, Ti, Fe, Co, Ge, KBr, Zr, Mo, Ag, CsI, CeO_2 and W) and two Barkla scatterers (Al_2O_3 and B_4C). The LOD values for the measured elements (Al, Si, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Se, Br, Rb, and Sr) ranged from 3.8 to 12.6 ngm^{-3} for air samples.

3. Results and Discussion

Calculated concentrations of each heavy metal in mg/kg of dust or soil sample using Equation 1 are presented in Tables 1 to 4.

$$\text{Concentration of a heavy metal in mg/kg of dust or soil} = \frac{x\ (\text{mg/L})}{y\ (\text{kg/L})} \quad (1)$$

Table 1: Concentrations of Heavy Metals (mg/kg) in Dust Samples from Kindergarten Classrooms

Code	Cd	Cr	Cu	Mn	Ni
S1	0.60	37.45	225.30	257,748	52.26
S2	0.04	22.16	21.52	200,200	9.67
S3	0.15	24.16	33.73	300,850	13.03
S4	Bdl	14.46	11.43	75,899	5.84
S5	Bdl	14.33	7.77	139,716	7.19
S6	2.97	25.94	7.89	9,062	7.49
S7	2.92	21.09	6.72	6,055	6.73
S8	2.77	21.98	4.76	10,672	6.88
S9	Bdl	30.73	19.97	212,042	7.19
S10	2.82	20.95	8.83	8,084	9.13
S11	2.89	24.99	7.17	5,852	8.45
S12	3.36	31.67	13.18	11,119	11.22

bdl–below detection limit

Table 2: Concentrations of Heavy Metals (mg/kg) in Dust Samples from Standard one Classrooms in Dar es Salaam Primary Schools

Code	Cd	Cr	Cu	Mn	Ni
S1	Bdl	19.76	19.27	105600	8.33
S2	Bdl	23.60	16.44	146656	8.69
S3	Bdl	18.58	15.32	254700	10.54
S4	Bdl	16.10	16.61	124125	8.06
S5	Bdl	14.97	13.62	146597	7.88
S6	2.92	23.26	6.43	8672	7.39
S7	2.83	21.71	6.71	6024	7.74
S8	2.80	27.66	5.60	18837	7.04
S9	Bdl	20.99	11.36	160152	7.07
S10	2.91	21.21	7.78	9775	7.57
S11	3.14	29.29	9.47	7551	9.40
S12	3.09	28.61	9.91	7049	9.09

bdl–below detection limit

Table 3: Concentrations of Metals (mg/kg) in Soil Samples from Kindergarten Playing Grounds in Dar es Salaam Primary Schools

	Cd	Cr	Cu	Mn	Ni
S1	bdl	34.300	16.110	91561	7.037
S2	bdl	12.220	4.400	160843	4.220
S3	0.017	8.933	9.403	113659	4.683
S4	bdl	7.077	7.243	58728	4.517
S5	bdl	6.410	3.527	250325	2.947
S6	1.463	18.120	6.670	11918	4.957
S7	1.627	193.400	9.020	8951	69.967
S8	1.597	39.500	6.763	15706	14.590
S9	bdl	12.420	1.630	118108	0.963
S10	0.950	8.830	2.297	8336	2.363
S11	1.043	11.220	3.323	7337	3.557
S12	1.820	20.030	10.660	9330	8.057

bdl–below detection limit

Table 4: Concentrations of Heavy Metals in Soil Samples from Standard one Playing Grounds in Dar es Salaam Primary Schools

Code	Cd	Cr	Cu	Mn	Ni
S1	bdl	8.977	6.900	55898	3.523
S2	bdl	7.280	3.607	157984	2.890
S3	bdl	9.040	9.707	61169	3.387
S4	bdl	8.427	8.730	81963	3.977
S5	bdl	5.253	2.967	133233	2.917
S6	1.690	19.870	7.547	15226	6.670
S7	1.487	16.870	7.050	9009	5.110
S8	1.480	28.680	6.763	13155	14.590
S9	0.077	13.630	1.647	127196	1.263
S10	0.927	8.437	2.330	7902	2.417
S11	1.037	10.920	3.343	7016	3.313
S12	1.900	21.040	12.080	9353	8.083

bdl–below detection limit

Analyses of particulate matter identified seventeen elements (Si, K, Ca, Ti, Fe, Se, Sr, Cr, Ni, Mn, Cu, Zn, As, Pb, Al, S and Cl), whose total average elemental concentrations were higher in dry than wet seasons.

and in the range 7.5 - 26.6 μgm^{-3}. Meteorological information shows Dar es Salaam city during dry seasons (wet seasons) had an average daily temperatures in the range of 24 and 30°C (25 and 29°C) and average daily RH of 65-82 % (66-88 %), respectively.

4. Conclusion

The result obtained from this study has shown that heavy elements Mn, Ni, Cu, Cr and Cd were detected in the classrooms dusts and playing grounds soil samples in a significant amount. The only exceptions are for Cd which was generally detected in low levels and in some sites it was not detect at all. The levels of heavy metals, Cd, Cr, Cu, Ni, Pb and Mn in classrooms dust and playing ground soils determined were higher in dust than those in the soil as calculated in mg/kg of the digested dust and soil samples.

Higher mean manganese concentrations recorded in the dust and soil collected may be due to natural sources as manganese being the twelfth abundant element in the earth's crust and fourth important element in the industries. Also it may be pointed out that the heavy metals present in classroom dusts and playing ground soils may significantly contribute to the heavy metals pollution threat to the school children since the classrooms and playing grounds are an immediate environment to children who spend most of their time during their study hours in school classrooms and school playing grounds.

Neighbourhood and surrounding automobile garages, a breweries factory, welding workshops, burning of wastes tyres, municipal wastes, metal works, mining and rocks wearing, may be responsible for the heavy metals accumulation in the classrooms dusts, playing grounds soils, and along the highways.

The results obtained from this research may provide important reference value for the future studies of these heavy metals in the dusts at schools of Tanzania especially in big cities such as Dar es Salaam, Arusha, Mwanza and Mbeya. It may also provide awareness and important information for authorities to take measures against pollution through dusts and soil to young children.

The results obtained contributed a new data set in an area of Africa where limited information was collected previously and therefore extends current knowledge of this phenomenon.

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