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LEVELS OF HEAVY METALS IN DEPOSITED DUST AND SOIL FROM SELECTED PRIMARY SCHOOLS IN DAR ES SALAAM

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ABSTRACT

The objective of this study was to examine the levels of heavy metals, lead, manganese, nickel, copper, chromium and cadmium in standard one and kindergarten classroom dusts and playing ground soils from selected primary schools along Morogoro road highway (Kimara, Mbezi, Kibamba and Kiluvya primary schools) and away from Morogoro road highway (Makabe, Msumi and Mbopo primary schools) as well as in the Dar es Salaam city center (Uhuru, Mzimuni, Dr. Omari Ali Juma, Manzese and Ubungo National House primary schools), Tanzania. The samples were acid digested and the supernatant analyzed using inductively coupled plasma optical emission spectrometer (ICP-OES). The mean concentrations (mg/kg) range of heavy metals in kindergarten and standard one classroom dust samples were bdl – 3.2 ± 0.2 (Cd), 14.7 ± 0.5 – 30.1 ± 2.2 (Cr), 6701 ± 1201– 277775 ± 32632 (Mn), 5.18 ± 0.59 – 122 ± 145 (Cu), 6.95 ± 1.57 – 30.3 ± 31.1 (Ni) and 17.67 ± 3.56 – 104.9 ± 94.7 (Pb). Similarly, the mean concentrations (mg/kg) range of heavy metals in kindergarten and standard one playing ground soil samples were bdl – 1.86 ± 0.06 (Cd), 5.8 ± 0.8 – 105 ± 124 (Cr), 7176 ± 226 – 191779 ± 82776 (Mn), 1.64 ± 0.01 – 11.51 ± 6.5 (Cu), 1.11 ± 0.2 – 37.5 ± 45.9 (Ni) and 8.9 ± 2.4 – 34.04 ± 1.9 (Pb). The present results, which indicate significantly high levels of heavy metals in school classroom dusts and playing ground soils, signify an important advancement towards shedding light on the alarming threat to school children's health since classrooms and playing grounds are their immediate environments where they spend significant amount of their early life time.

Keywords: Heavy metals, lead, manganese, nickel, copper, chromium, cadmium, classrooms dusts, Tanzania

INTRODUCTION

Heavy metals are present in water, air, soil, sediments and commonly found in street dusts at trace levels (Bhattacharya et al. 2011). It is evident that the growth of the population, industry and transportation system contribute to the increased levels of heavy metals in urban dust and the surroundings, which, as it has been established (Yongming et al. 2006, Yap et al. 2011), are a significant sign of pollution. Basically, all anthropogenic activities are known to have a major impact on the global biogeochemical cycle of many metallic elements such as lead, manganese, cadmium, nickel and chromium (Handt and Fernandez 2008), especially due to emissions and waste generations. Thus, a typical non-sustainable economic growth is usually accompanied by environmental pollution. This is exemplified by the strong accordance of high levels of heavy metals in street dusts with traffic emissions as well as garbage and industrial waste disposal (Yap et al. 2011). As reported by Shinggu et al. (2007), street dust is the major means through which heavy metals get into soils, plants and consequently to human beings. Accordingly, heavy metals 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).

According to Adekola and Dosumu (2001), dust is a particulate matter in the form of fine powder that settles on the ground or on the surface of objects or blown about by the wind. WHO (1999) and TBS (2005) define dust as small solid particles, conventionally taken as those particles below 75 μm in diameter, which settle under their own weight but which may remain suspended for some time. A number of studies have shown that urban soils receive a greater load of heavy metals than the surrounding rural areas due to the presence of more anthropogenic activities in urban settlements (Mielke et al. 1999, Abrahams 2002, Biasioli et al. 2006, Norhayati et al. 2007, Fairus et al. 2011). Children are the most exposed to dust, since despite of inhalation, as they play on floors and on the ground, they pick up dust and soil on their fingers and then to their mouths. Adults are exposed to a similar threat since inhalation is one of the ways for toxic heavy metals to enter the human body. Currently there is an increased concern and awareness over heavy metal contaminations in indoor environments since many people spend most of their time indoors such as in offices, schools, and at their homes (Norhayati et al. 2007). Yap et al. (2011) reported that concentrations of cadmium, copper, nickel, lead, and zinc from ceiling fan dusts samples in Serdang Selangor-Malaysia were high indicating the presence of anthropogenic sources. It is certain that heavy metals at trace levels easily get into the environment through natural and anthropogenic activities. As a consequence, human beings get into contact with heavy metals. As levels of heavy metals rise in air, dust, water and topsoil, they also rise within human bodies, thus contributing to chronic diseases.

It is worth studying the levels of heavy metals in deposited dust and soil because literature reports health effects associated with heavy metals. For example, manganese is associated with increased intellectual impairment and reduced intelligence quotients in school-age children (Bouechard et al. 2010). Chromium is associated with lung cancer and asthma (OSHA 2006). Nickel is said to be carcinogenic and mutagenic (Cempel et al. 2006). Health effects associated with cadmium include growth impairment, as well as brain, renal and liver diseases (Ganeshamurthy et al. 2008). Copper is said to cause liver disorder known as Wilson's disease (Stern et al. 2007). Moreover, exposure to lead may result in birth defects, mental retardation and paralysis (Kosnett 2009).

Scanty scientific literature on levels of heavy metals in street dusts in Tanzania typifies a meager research effort on this issue, even though it is well known that children put dust contaminated hands, toys and other playing materials into their mouths. Therefore, it is deemed necessary to instigate a tendency of determining the levels of heavy metals in street dusts in Tanzania. The present study reports the levels of heavy metals (lead, chromium, cadmium, copper, nickel and manganese) in dust and soil samples obtained from classrooms and playing grounds of selected primary schools in Dar es Salaam.

MATERIALS AND METHODS

Reagents

Concentrated hydrochloric acid analytical reagent grade (37%) with specific gravity of 1.18 was supplied by J. T. Taker, USA and concentrated nitric acid analytical reagent grade 70% with specific gravity of 1.42 was supplied by Fisher Scientific Company, from United Kingdom. Standard solutions used were prepared from standard stock solutions of manganese, cadmium, lead, nickel, copper and chromium, each with concentration of 1000 ppm purchased from Assurance Spex CertiPrep. Q (1-800-

lab.spex), USA. Argon (99.999%) was bought from Nairobi gas Company, and nitrogen (99.995%) was obtained from Mwanza Oxygen Company.

Materials

Plastic containers were used for storing polyethylene sampling bags and other sampling materials. Plastic pans and brushes were used for sampling dusts and soils. Polyethylene bags were used for storing samples. Plastic sieves were used for sieving powdery samples to remove unwanted debris. Plastic spatulas were used to transfer dust and soil samples from polyethylene bag during measuring. Polyethylene bottles (500 mL) were used to store sample solutions. All glassware and apparatus used in this study were cleaned with liquid soap and rinsed with tap water followed by distilled water. Thereafter they were soaked in 10% analytical reagent grade nitric acid for overnight, rinsed with distilled water and then left to dry.

Equipment

Heating block - Gerhardt SMA 20 type with temperature ranging from 0 to 400 °C purchased from Germany was used for dust and soil sample digestion processes carried out in a fume hood - AFA 1000 (TEL) air flow monitor type purchased from England. Weight measurements were carried using analytical balance - Tettler Toledo EL 204 type purchased from China. All elemental analyses were carried out using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) of the model iCAP 6000 series from Thermo Fisher Scientific UK.

Study Sites

The study was conducted in Ilala and Kinondoni Districts in Dar es Salaam, Tanzania. Eleven primary schools were selected from Kinondoni District and one primary school was selected from Ilala District. The choice of the sampling sites was based on the presence of anthropogenic activities. Five schools namely Uhuru primary schools, Mzimuni primary schools, Dr. Omari Ali Juma primary school, Manzese primary schools and Ubungo National House primary school were assumed to be located at the city centre. Four schools namely Kimara Baruti primary school, Mbezi primary school, Kibamba primary school and Kiluvya primary school are located along the highway (Morogoro Road) but away from the city centre. Three schools, which are Mbopo, Msumi, and Makabe primary schools are located away from the Morogoro Road highway.

Sampling

Dust samples were collected from lower classes, *i.e*., kindergarten and standard one, in the selected primary schools along the highways and away from the highways as well as in the Dar es Salaam city center. Soil samples were collected from playing grounds in two sampling points in each school, *i.e*., grounds where kindergarten and standard one pupils play. For dusts, two samples were collected from kindergarten classroom and the other two samples were collected from standard one classroom. Two samples from kindergarten and standard one classroom were combined together to form a composite dust sample for kindergarten and standard one classroom. The deposited dust in the classrooms were collected by sweeping the floor using a clean plastic brush into a clean plastic pan. For soils, samples were taken from the topsoil after removing the top layer using plastic pan. Portions of soil were collected from four points of the corners of one square meter, and then combined to form one composite sample. The second sample was obtained in the same way but at a different sampling point. The collected dust and soil samples were then transferred into polyethylene bags, sealed and taken to the laboratory for treatment and analysis.

Sample Preparation
About 1 g of dust was weighed 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 until brown fumes ceased. Thereafter, the temperature was raised to 180 °C and maintained until no further brown fumes were given out. The obtained solution was left to cool to room temperature and then filtered through an ashless Whatman 41 filter paper, diluted to 100 mL with 0.5 M nitric acid, and stored in polyethylene bottles at room temperature. Preparation of soil samples was performed in the same way as for dust samples except that 3 g of the soil sample was used. Reagent blanks were prepared by treating 11 mL of distilled water in the same way as for preparing dust and soil samples. For the method blank, 6 mL of hydrochloric acid and 3 mL of nitric acid plus 3 mL of distilled water were poured into a digestion tube and digestion process carried as for the preparation of dust and soil samples. For the method recovery, 2 mL of each element standard from 100 ppm solution equivalent to 2 ppm was added to 1 g of dust sample and 3 g of soil sample in a digestion tube. The rest of the digestion process was performed as for dust and soil sample preparations.

Standard solutions of the desired metals were freshly prepared from stock solutions. A pipette was used to transfer 10 mL of 1000 ppm stock solution of each metal into 100 mL volumetric flask to prepare 100 ppm solution. To prepare 50 ppm solution, 25 mL of the prepared 100 ppm solution was transferred into 50 mL volumetric flask and filled with distilled water to the mark. From there 0.5 ppm, 1 ppm and 2 ppm of each element was prepared by diluting with distilled water 0.5, 1, and 2 mL, respectively of 50 ppm solution into 50 mL volumetric flask. These solutions were used to generate calibration curves. A 1 ppm solution was also used as the control sample solution.

Statistical Analysis
t -Test was used to find out if there are significant differences between the concentration of heavy metals (mg/kg) in soil samples collected from school playing grounds and value of each element from TBS (2007) soil standard. *t* -Test was also used to find out if there are significant differences in concentration of heavy metals (mg/kg) of dust and soil samples at city center and away from city center, as well as along highway and away from highway. ANOVA together with line charts were used to find if there is significant differences in heavy metal concentrations (mg/kg) within the studied sites (city center, along highway and away from highway).

RESULTS
In order to harmonize ICP-OES reading (x mg/L) and the amount of dust or soil which was digested and made up to 100 mL (0.1 L) of solution, the mass of dust or soil (y kg) that would have been used to make 1 L of the sample solution was calculated, i.e., y kg/L. Thus, the concentrations of each metal in mg/kg of dust or soil sample was calculated using Equation 1 and the results presented in Tables 1 to 4. With the help of Microsoft excel, concentrations of heavy metals presented in Tables 1 to 4 were then used to calculate the mean concentrations of heavy metals in kindergarten and standard one classrooms dust and playing ground soil samples, which are presented in Tables 5 and 6.

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

Table 1: Concentrations of Heavy Metals (mg/kg) in Dust Samples from Kindergarten Classrooms in Dar es Salaam Primary Schools

Primary School	Concentrations of Metals in mg/kg					
	Cd	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**
Uhuru Girls	0.60	37.45	225.30	257,748	52.26	171.90
Mzimuni	0.04	22.16	21.52	200,200	9.67	39.21
Dr. Omari Ali Juma	0.15	24.16	33.73	300,850	13.03	105.50
Manzese	bdl	14.46	11.43	75,899	5.84	24.92
Ubungo National House	bdl	14.33	7.77	139,716	7.19	15.15
Kimara Baruti	2.97	25.94	7.89	9,062	7.49	102.30
Mbezi	2.92	21.09	6.72	6,055	6.73	20.80
Makabe	2.77	21.98	4.76	10,672	6.88	19.03
Msumi	bdl	30.73	19.97	212,042	7.19	33.80
Mbopo	2.82	20.95	8.83	8,084	9.13	35.99
Kibamba	2.89	24.99	7.17	5,852	8.45	29.00
Kiluvya	3.36	31.67	13.18	11,119	11.22	35.83

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

Primary School	Concentrations of Metals in mg/kg					
	Cd	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**
Uhuru Girls	bdl	19.76	19.27	105600	8.33	38.03
Mzimuni	bdl	23.60	16.44	146656	8.69	30.56
Dr. Omari Ali Juma	bdl	18.58	15.32	254700	10.54	27.11
Manzese	bdl	16.10	16.61	124125	8.06	52.71
Ubungo National House	bdl	14.97	13.62	146597	7.88	20.18
Kimara Baruti	2.92	23.26	6.43	8672	7.39	23.52
Mbezi	2.83	21.71	6.71	6024	7.74	20.06
Makabe	2.80	27.66	5.60	18837	7.04	22.27
Msumi	bdl	20.99	11.36	160152	7.07	32.35
Mbopo	2.91	21.21	7.78	9775	7.57	30.51
Kibamba	3.14	29.29	9.47	7551	9.40	35.30
Kiluvya	3.09	28.61	9.91	7049	9.09	30.03

bdl–below detection limit

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

Primary School	**Concentrations of Metals in mg/kg**					
	Cd	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**
Uhuru Girls	bdl	34.300	16.110	91561	7.037	52.200
Mzimuni	bdl	12.220	4.400	160843	4.220	16.163
Dr. Omari Ali Juma	0.017	8.933	9.403	113659	4.683	20.500
Manzese	bdl	7.077	7.243	58728	4.517	14.160
Ubungo National House	bdl	6.410	3.527	250325	2.947	10.610
Kimara Baruti	1.463	18.120	6.670	11918	4.957	19.347
Mbezi	1.627	193.400	9.020	8951	69.967	22.943
Makabe	1.597	39.500	6.763	15706	14.590	22.663
Msumi	bdl	12.420	1.630	118108	0.963	13.967
Mbopo	0.950	8.830	2.297	8336	2.363	11.413
Kibamba	1.043	11.220	3.323	7337	3.557	13.067
Kiluvya	1.820	20.030	10.660	9330	8.057	32.717

bdl–below detection limit

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

Primary School	**Concentrations of Metals in mg/kg**					
	Cd	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**
Uhuru Girls	bdl	8.977	6.900	55898	3.523	15.423
Mzimuni	bdl	7.280	3.607	157984	2.890	8.090
Dr. Omari Ali Juma	bdl	9.040	9.707	61169	3.387	19.883
Manzese	bdl	8.427	8.730	81963	3.977	22.770
Ubungo National House	bdl	5.253	2.967	133233	2.917	7.193
Kimara Baruti	1.690	19.870	7.547	15226	6.670	24.573
Mbezi	1.487	16.870	7.050	9009	5.110	19.393
Makabe	1.480	28.680	6.763	13155	14.590	22.663
Msumi	0.077	13.630	1.647	127196	1.263	15.953
Mbopo	0.927	8.437	2.330	7902	2.417	10.120
Kibamba	1.037	10.920	3.343	7016	3.313	12.853
Kiluvya	1.900	21.040	12.080	9353	8.083	35.367

bdl–below detection limit

Table 5: Mean Concentrations (μ ± S.D, mg/kg) of Heavy Metals in Dust Samples from Kindergarten and Standard One Classrooms

Primary School	Mean Concentrations of Metals μ ± S.D, mg/kg					
	Cd	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**
Uhuru Girls	0.3±0.4	28.6±135	122±145	181674±107584	30±31	104.9±95
Mzimuni	0.02±0.03	22.9±1	19.0±3.6	173428±37861	9.18±1	34.88±6
Dr. Omari Ali Juma	0.08±0.11	21.4±3.9	24.5±13	277775±32632	11.8±2	66.3±55
Manzese	bdl	15.3±1.2	14.02±4	100011±34100	6.95±2	38.8±20
Ubungo National House	bdl	14.7±0.5	10.7±4.1	143156±4865	7.54±1	17.67±4
Kimara Baruti	2.9±0.04	24.6±1.9	7.16±1.0	8866±276	7.44±0.	62.9±56
Mbezi	2.88±0.06	21.4±0.4	6.72±0.0	6039±22	7.24±1	20.43±1
Makabe	2.79±0.02	24.8±4.0	5.18±0.6	14754±5773	6.96±0.	20.65±2
Msumi	bdl	25.9±6.9	15.7±6.1	186097±36691	7.13±0.	33.08±1
Mbopo	2.9±0.1	21.1±0.2	8.31±0.7	8929±1195	8.35±1.	33.25±4
Kibamba	3.0±0.2	27.1±3.0	8.32±1.6	6701±1201	8.93±1	32.15±5
Kiluvya	3.2±0.2	30.1±2.2	11.6±2.3	9083±2878	10.2±2	32.93±4

bdl–below detection limit, μ-mean, and S.D-standard deviation

Table 6: Mean Concentrations (μ ± S.D, mg/kg) of Heavy Metals in Soil Samples from Kindergarten and Standard one Playing Grounds in Dar es Salaam

Primary School	Mean Concentrations of Metals μ ± S.D, mg/kg					
	Cd	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**
Uhuru Girls	bdl	21.6±189	11.51±6.5	73729±25217	5.28±2.5	33.8±26
Mzimuni	bdl	9.75±3.5	4.00±0.56	159413±2021	3.6±0.94	12.13±6
Dr. Omari Ali	0.01±0.01	8.99±0.1	9.56±0.21	87413±37116	4.0±0.9	20.2±0.4
Manzese	bdl	7.8±0.95	7.99±1.05	70345±16430	4.2±0.4	18.5±6.1
Ubungo National	bdl	5.8±0.8	3.2±0.4	191779±82796	2.9±0.02	8.9±2.4
Kimara Baruti	1.58±0.16	19±1.24	7.11±0.62	13572±2338	5.8±1.21	21.96±4
Mbezi	1.6±0.1	105±124	8.0±1.4	8980±41	37.5±46	21.2±2.5
Makabe	1.54±0.08	34±7.65	6.763±0	14430±1804	14.59±0	22.663±0
Msumi	0.04±0.05	13±0.86	1.64±0.01	122651±6426	1.11±0.2	15±1.4
Mbopo	0.94±0.02	8.63±0.3	2.31±0.02	8119±306	2.4±0.04	10.77±1
Kibamba	1.04±0.00	11.1±0.2	3.33±0.01	7176±226	3.44±0.2	13±0.2
Kiluvya	1.86±0.06	21±0.71	11.37±1.0	9341±16	8.1±0.02	34±1.9

dl–below detection limit, μ-Mean, S.D-standard deviation

Mean Concentrations of the Heavy Metals (mg/kg) in Dust Samples

Mean concentrations of heavy metals in the classrooms dust samples showed significant mean values. While cadmium was found to have minimum mean concentrations, manganese had the highest mean concentrations (Table 5). Each heavy metal studied is discussed hereunder.

Cadmium. Results have shown that classroom dusts in which children stay for considerable period of time are contaminated with cadmium. The mean concentrations of cadmium in kindergarten and standard one classrooms range from bdl mg/kg to 3.2 mg/kg (Table 5). The highest mean concentrations value was obtained from samples collected from Kiluvya Primary School, while samples from Uhuru Girls, Mzimuni and Ubungo National House Primary Schools registered values which were below detection limit. Although the mean concentrations of cadmium obtained in this study are within the range reported by Yap et al. (2011), the mean concentrations of cadmium reported elsewhere (Handt and Fernandez 2008) is much higher. Mean cadmium concentrations from dust samples collected from Uhuru Girls, Mzimuni, Dr. Omari Ali Juma, Manzese and Ubungo National House Primary Schools (city center) showed significant difference (p-value = $1.8665 \times 10^{-07} < 0.05$) from dust samples obtained from Kimara Baruti, Mbezi, Kibamba and Kiluvya Primary Schools (away from city center). Likewise mean cadmium concentrations from dust samples obtained along highway sites (Kimara Baruti, Mbezi, Kibamba and Kiluvya Primary Schools) showed no significant difference (p = 0.16904) from dust samples collected away from the highway sites (Makabe, Msumi and Mbopo Primary Schools). It is clear that dust polluted more than the soil as the heavy metals concentrations in the dust is higher than in the soil.

Chromium. The mean concentrations of chromium from classroom dust samples ranged from 14.65 to 30.14 mg/kg. The highest chromium concentration of 30.14 mg/kg was found from Kiluvya Primary School and lowest chromium concentrations of 14.65 mg/kg at Ubungo National House Primary School. However, mean chromium concentrations did not vary very much from site to site. Moreover, chromium mean concentrations from classroom dust samples obtained from city center sites showed no significant difference (p-value = 0.2503 > 0.05) from the dust samples collected away from city center and along Morogoro highway. The mean chromium concentrations from classrooms dust samples collected along Morogoro highway sites showed no significant difference (p-value = 0.3682 > 0.05) from the dust samples obtained away from Morogoro highway. Equally, the mean chromium concentrations from dust samples collected at the city center, away from city center and along highway and away from the highway showed no significant differences (p-value = 0.7826 > 0.05) among the sites. From this trend it is clearly that chromium is widely dispersed in the studied area in Dar es Salaam city.

Copper. Mean concentrations of copper from classroom dust samples were found to be between 5.18 and 122.285 mg/kg. The lowest concentration of 5.18 mg/kg is obtained at Makabe Primary school and highest concentration of 122.285 mg/kg at Uhuru primary school. It is indicating that copper concentration is higher at the city center than away from city center with the exception of Msumi primary school where its copper level is comparable to that of the city center. The mean copper concentrations from dust samples collected from city center showed no significant difference (p-value = 0.1429 > 0.05) from the dust obtained away from city center sites. The mean copper concentrations from dust obtained along Morogoro highway sites showed no significant difference (*p*-value = 0.3301 > 0.05) from dust samples collected from sites away from the Morogoro highway. Mean copper concentrations from dust samples collected from city center, away from city center and along Morogoro highway and away from Morogoro highway showed no significant differences (*p*-value = 0.4216 > 0.05). These results are in line with findings reported elsewhere (Bhattacharya et al. 2011), which suggested that high copper concentrations are found at sites with high traffic density. High copper concentrations in street dust can therefore be related to corrosion of metallic vehicles parts, wear and tear of the car engine, bearing metals and spillage of lubricants.

Manganese. Manganese compounds are emitted from automobile exhausts, certainly polluting the air at ground level and consequently deposited together with dusts. It has been reported that during internal combustion of petroleum products, the engine antiknock, methyl cyclopentadienyl manganese tricarbonyl (MMT) produce inorganic manganese compounds some of which are considered to be toxic manganese oxides (Dobson et al. 2004). As can be seen from Table 5, manganese mean concentrations in classroom dust samples ranged from 6039.3 mg/kg to 277775 mg/kg. The lowest mean concentration was reported at Mbezi primary school while the highest level was obtained at Dr. Omari Ali Juma primary school. The highest manganese mean concentration from dust samples from Dr. Omari Ali Juma Primary School may be attributed to the location of the school, which is in the vicinity of Mwembechai fuel filling station, welding and garage activities. Manganese mean concentrations from dust samples obtained from the city center sites showed significant variation (*p*-value = 0.0049 < 0.05) from the dust samples obtained away from city center and along the Morogoro highway. Manganese mean concentrations from dust samples obtained along Morogoro highway showed no significant difference (*p*-value = 0.2075 > 0.05) from dust samples collected away from Morogoro highway. Similarly, manganese mean concentrations from dust samples obtained from the city center, away from city center and along Morogoro highway and away from Morogoro highway sites showed significant difference (*p*-value = 0.0217 < 0.05) among the sites indicating that the concentrations are decreasing away from the city center, with an exception of Msumi primary school. These results are in agreement with the report by Joselow et al. (1978), in which the researchers found that at a distance 0 and 70 meters from the edge of the roadside manganese concentrations were 330 mg/kg and 290 mg/kg respectively, indicated that introduction of MMT as antiknock is responsible for the elevation of manganese concentrations along highways.

Nickel. The mean concentrations of nickel from classroom dust samples ranged from 6.95 – 30.295 mg/kg. The highest value of 30.295 mg/kg was achieved at Uhuru Primary School, while the lowest value of 6.95 mg/kg was obtained from Manzese and Makabe Primary Schools. The mean nickel concentrations collected from the city center sites showed no significant difference (*p*-value = 0.1793 > 0.05) from dust gathered away from city center and along Morogoro highway. Likewise, mean nickel concentrations from classrooms dust samples collected along Morogoro highway sites showed no significant difference (*p*-value = 0.2836 > 0.05) from dust samples obtained away from Morogoro highway sites. Furthermore, mean nickel concentrations from classrooms dust samples collected at city center sites, away from city center and along Morogoro highway and away from the Morogoro highway showed no significant difference (*p*-value = 0.4957 > 0.05). As proposed in the literature (Biasioli et al. 2006, Fairus et al. 2011), sources of nickel element can be diesel fuel and gasoline and emission from automobiles.

Lead. Mean lead concentrations in the classrooms dusts ranged from 17.665 – 104.965 mg/kg, which, except at Uhuru Primary School, were significantly lower than the maximum acceptable limit of lead in normal soil which is 100 mg/kg (TBS 2007). The highest mean concentration was reported at Uhuru primary school and lowest was reported at Ubungo National House primary school. From these results it is evident that the studied schools were contaminated with lead. Lead is among toxic heavy metals which were previously used as antiknock agent. Since lead is not removed instantly *via* bio-activities, it will continue to be found in our environments. On the other hand, the current car batteries are made from lead cells which are not handled properly. The mean lead concentrations obtained from city center school samples showed no significant difference (*p*-value = 0.4018 > 0.05) from dust samples collected from schools away from the city center. Similarly, the mean lead concentrations from dust samples obtained from schools along Morogoro highway showed no significant difference (*p*-value = 0.1386 > 0.05) from the dust collected from schools away from Morogoro highway. Equally, the mean lead concentrations from dust samples obtained from schools at city center, away from city center and along Morogoro highway and away from Morogoro highway showed no significant difference among them (*p*-value = 0.5603 > 0.05). As reported elsewhere (Shakya et al. 2006, Hu 2002), dominant sources of lead are paints, tires and automobile emissions.

Mean Concentration of Heavy Metals (mg/kg) in Playing Grounds Soil Samples

Cadmium. It is evident from Table 6 that the concentrations of cadmium in playing ground soils are contaminated with cadmium except at sites Uhuru Girls, Mzimuni, Manzese, and Ubungo National House Primary Schools whose Cd concentrations were below detection limit. The mean concentrations of cadmium are between bdl and 1.86 mg/kg. The highest mean value was obtained from soil samples from Kiluvya Primary School while soil samples from Mbopo Primary School the lowest mean value was obtained. Samples from Dr. Omari Ali Juma, Msumi, and Mbopo Primary Schools had Cd concentrations less than that of TBS-standard (1 mg/kg) for soil quality. Samples from Kimara Baruti, Mbezi, Makabe, and Kibamba Primary Schools had Cd concentrations greater than that of TBS-soil standard (*p*-value = 0.0089). The reason for samples obtained from Dr. Omari Ali Juma, Msumi, and Mbopo Primary Schools to have cadmium concentration values below detection limit is not known since the sites were fully of traffic and anthropogenic activities. However, according to Luilo (2001) amounts of heavy metal depositions along roadsides may depend on the speed and direction of the wind as well as age, size and speed of the vehicles. Mean cadmium concentrations from soil samples collected in the city center primary schools (Uhuru, Mzimuni, Dr.Omar Ali Juma, Manzese, and Ubungo National House) showed significant variation (*p*-value = 0.0018) from playing ground soil samples collected away from city center (Kimara, Mbezi, Kiluvya, and Kibamba Primary Schools). These results have shown that cadmium concentrations in the playing ground soil samples were high in schools away from the city center as well as along the Morogoro road highway.

Mean cadmium concentrations from soil samples collected along Morogoro Road highway (Kimara, Mbezi, Kiluvya and Kibamba Primary Schools) showed no significant difference (*p*-value = 0.1078) from samples collected away from Morogoro Road highway (Makabe, Msumi, and Mbopo Primary Schools). The likely sources of cadmium in soil are commonly anthropogenic activities such as metal works (welding), burning of fuels, burning of tires and tires wear through bad roads or braking.

Manganese. Manganese had the highest concentrations of all the heavy metals in the soil samples from playing ground in Dar es Salaam primary schools. The concentration of manganese ranged from 7176.7 – 191779.15 mg/kg. The lowest mean concentration was reported at Kibamba Primary School while the highest level was obtained at Ubungo National House Primary School. The manganese concentrations reported in this study is greater than the TBS maximum allowable value (1800 mg/kg) for soil standard for all the studied sites (P-value = 0.0036). This may be due to the use of methylcyclopentadienyl manganese tricarbonyl (MMT) as an antiknock agent in motor engines after the ban of organic lead. High traffic in the Morogoro road, Mandela road, Shekilango road and Ubungo bus terminal may have also contributed to the high levels of manganese in the soil sampled at Ubungo National House Primary School. Some other literature report manganese concentrations ranging from 178.8 – 2338 mg/L equivalent to 2235 – 29225 mg/kg in Dar es Salaam roadside soil (Luilo 2001).

Concentrations of manganese from playing ground soil samples at city center Primary Schools (Uhuru Girls, Mzimuni, Dr. Omari Ali Juma, Manzese and Ubungo National House) showed significant difference (*t*-test: P-value = 0.0098<0.05) from soil samples collected away from city center Primary Schools (Kimara Baruti, Makabe, Kibamba, Kiluvya). Concentrations of manganese from soil obtained from schools playing ground along highway showed no significant differences (*t*-test: P-value = 0.1979 > 0.05) from soil collected from schools away from highway. In comparing the three groups of sites together, the mean manganese concentrations from soils collected at the city center, away from city center, along highway and away from highway showed significant variation (Anova: P-value = 0.0255 < 0.05) between them. This fact indicates that the mean manganese concentrations are decreasing away from city center and away from highway except at Msumi where the level is high. Traffic emissions and natural processes (Luilo 2001, Ayodele and Ali 2007) may contribute to the elevation of manganese at Msumi because there was a station for buses and lorries nearby and wind may blow dusts from across Morogoro and Bagamoyo roads toward the site which may contain manganese compounds. Furthermore, the site was close to Msumi-Mbopo road where a number of lories go to and fro. Sources of manganese in the residential areas may be associated with automobile exhaust emissions, re-suspension of soil derived dust and windblown dusts.

Chromium. The mean concentrations of chromium ranged from 5.8315 mg/kg to 105.135 mg/kg. The are lower than TBS maximum allowable soil standard (200 mg/kg, P-value = 4.24×10^{-7}) in all the studied sites. Luilo (2001) reported the mean chromium concentrations from roadside soil in Dar es Salaam as ranging from 11 – 65.625 mg/kg, which is comparable to the mean concentrations of chromium obtained from this study, with some exceptions.

The mean chromium concentrations from the city center schools playing ground soil showed that there is no significant variation (*t*-Test: P-value = 0.2064>0.05) from the playing ground soil samples collected away from city center. Similarly chromium concentrations from playing ground soil samples collected along highway showed no significant difference (P-value = 0.1438>0.05) from the one collected away from highway schools. Comparison of chromium concentrations from playing ground soil samples collected from city center, away from city center, along highway and away from highway showed no significant differences (Anova:- P-value = 0.3145>0.05) between the groups. This result indicates that heavy metals pollution at the city center, away from city center, along highway and away from highway is similar except at Mbezi Primary School which had elevated concentrations. The reason behind this elevation is not clearly known. The highest value reported at Mbezi Primary School may be due to the closeness of the school to the bus stand and the presence of auto garages and painting activities.

Copper. Mean concentrations of copper ranged from 1.6385 mg/kg (Msumi Primary School) – 11.505 mg/kg (Uhuru Primary School). The copper concentrations reported in this study are less than maximum allowable by TBS-soil standard (200 mg/kg) (P-value = 4.2×10^{-21}) in all the studied sites. Copper concentrations in a range of 2.50 – 14.75 mg/L equivalent to 31.25 – 184.375 mg/kg was reported in soil collected along roadside in Dar es Salaam (Luilo 2001), about 16 to 19 higher than the value reported in this study.

In comparing mean copper concentrations in the playing ground soil samples collected from city center did not show significant variation (P-value= 0.4009>0.05) from the soil obtained away from city center. Similarly mean copper concentrations from soil samples obtained along highway showed no significance difference (p-value = 0.0748>0.05) from playing ground soil samples collected from schools away from highway sites. Comparing the mean copper concentrations from the playing ground soil samples obtained at schools in the city center, away from city center, along highway and away from highways showed no significant difference (Anova: P-value = 0.3242>0.05) among the sites. Copper concentrations varied inconsistently at the city center, away from city center, along highway and away from highway.

Copper in the environment mainly originates from traffic which is associated with brakes consumption (Mielke et al. 1999). Other sources of copper element in the environment include those related with incinerators, water pipes, cables, paints and from application of fertilizers, pesticides, manures and sewage sludge in farms (Biasioli et al. 2006).

Nickel. The mean concentrations of nickel in the soil samples were between 1.1133 mg/kg (Msumi Primary School) and 37.5385 mg/kg (Mbezi Primary School). The nickel concentrations reported in this study are less than the maximum allowable by TBS- value for soil standard (200 mg/kg) (P-value = 5.49×10^{-16}) in all the studied sites. Luilo (2001) reported nickel concentrations from roadside soil ranging from 0.78 – 36.25 mg/kg almost similar to the one reported in this study. Concentrations of nickel in the road soil samples reported elsewhere (Addo *et al*. 2012) ranged from 12.30 – 492.30 mg/kg which are higher than in this study.

Comparison of the nickel concentrations from the city center sites (schools) playing grounds, soil samples showed no significant difference (P-value = 0.1855 >0.05) from the soil samples obtained away from city center sites/schools. Likewise nickel concentration from playing ground soil samples obtained along highway sites showed no significant difference (P-value= 0.2089 > 0.05) from the soil samples collected away from highway. Nickel concentrations from playing ground soil samples obtained from city center, away from city center and along highway and away from highway sites showed no significant difference (p-value 0.513 > 0.05) between them. The mean nickel concentrations divert erratically from the city center, away from city center, along highway and away from highway.

Lead. The mean concentrations of lead are between 8.90165 mg/kg (Ubungo National House Primary School) and 34.042 mg/kg Kiluvya Primary School. The lead concentrations reported in this study (P-value = 8.509×10^{-13}) were less than the maximum allowable by TBS-soil standard (100 mg/kg) and also less than what was reported in the literature (Luilo and Othman 2006.

Mean lead concentrations from the playing ground soil samples obtained from city center sites showed no meaningful difference (*t*-test: P-value= 0.4685 >0.05) from the soil samples collected from sites away from city center. Similarly mean lead concentrations from the playing ground soil samples obtained along highway showed no significance difference (*t*-test: p-value = 0.1558) in lead content from playing ground soil samples obtained away from highway sites. Mean lead concentrations from the playing ground soil samples obtained from city center, away from city center and along highway and away from highway sites showed no significant differences (Anova: p-value= 0.7496 >0.05) among the sites. Lead concentrations among sites at city center, away city center and along highway and away from highway varied inconsistently, but maximum concentrations being reported at Uhuru and Kiluvya Primary Schools.

CONCLUSION

The results obtained from this study have shown that classrooms dust and playing grounds soil contain a significant amount Pb, Mn, Ni, Cu, Cr with low levels of Cd. The levels of heavy metals are generally higher in classrooms dust than in playing grounds and no significant variation of heavy metals (Cr, Cu, Ni and Pb) concentrations with respect to the distance from the highways and from the city center. The presence of significant levels of heavy metals in classrooms dust and playing grounds soil may be attributed to both natural and anthropogenic sources such as automobile emissions, municipal wastes and metal works

The results that have been obtained from this research may provide important reference value for future studies of these heavy metals in the dusts at schools in Tanzania especially in big cities such as Dar es Salaam, Tanga, Arusha, Mwanza and Mbeya.

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