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Playground Soil Contamination with Heavy Metals and Associated Health Risks of Children in Schools Located in the Sunyani-East Municipality of Ghana

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Abstract

Children are exposed to the adverse health impacts of heavy metals found in playground soils where they conduct socio-physical activities in schools. This study focuses on heavy metals pollution of school playgrounds and their associated health risks in children within the Sunyani-East Municipality of Ghana. The concentrations of heavy metals including As, Cd, Cu, Fe, Mn, Pb, Zn in playground soil of schools were analyzed using atomic absorption spectrophotometer. Principal component analysis and Pearson's correlation were applied to discover explanatory variables and associations between heavy metals. The enrichment factor, contamination factor, geo-accumulation index and pollution load index were computed to assess the extent of heavy metal pollution. The hazard quotient and hazard index were used to evaluate children's associated health risks of ingested playground soil. The results show high levels of Fe (12,093.33 – 40,026.67 mg/kg), Cd (0.60 – 11.43 mg/kg) and Cu (31.92 – 85.00 mg/kg) in playground soils of most schools above the world soil average. Strong correlations between Cd, As and Pb were observed, forming one principal component attributed to anthropogenic sources. Contamination and enrichment factors showed severe pollution of playgrounds with Cd, Fe, As, and Cu. The hazard index of playground soils in a few schools indicated potential health risks in children. Possible adverse health effects in children were attributed to levels of Cd, Fe and As thus revealing unsuitable playground environment in these schools. Consequently, proactive measures such as covering bare playground surfaces with natural or synthetic materials could mitigate the adverse impact of heavy metal contamination in school children.

Keywords: Heavy metals; Children; Playgrounds; Health risks; Pollution

1. Introduction

Playgrounds are spaces provided within settlements for recreational purposes to improve physical activity, social interaction and general well-being of individuals (Kang *et al.,* 2021; Donado *et al.,* 2020). School playgrounds are areas where children conduct physical exercises to improve team skills, communication and intellectual abilities (Panteado *et al.,* 2021; Wang *et al.,* 2018; Gredilla *et al.,* 2017). However, in developing countries, spaces allocated for recreational purposes are usually converted to other land-use forms limiting areas for public recreation (Rozanski *et al.,* 2021). Consequently, school playgrounds have come under enormous pressure as they host various social activities ranging from funerals to sporting events. Therefore, these playgrounds receive large amounts of contaminants on their surfaces, including plastic and food waste, and run-off from surrounding areas. (Tume *et al.,* 2021; Rozanski *et al.,* 2018).

School playgrounds in Ghana's urban settlements have bare surfaces or are partially covered with grasses (lawn). As a result, children are directly exposed to contaminants such as harmful microbes, chemicals and heavy metals in playground soil (Glorennec *et al.,* 2012). In addition, children inadvertently ingest soil by picking items from the bare ground, directly touching the earth, and introducing soiled fingers into their mouths without washing (Zupančič *et al.,* 2021; Rodríguez-Oroz *et al.,* 2018). Children have under-developed body systems and higher absorption rate of heavy metals in the gut compared to adults. As a result, they risk suffering from long-term adverse impacts of these heavy metals later in life (Tume *et al.,* 2014). Many studies have focused on the exposure of children to heavy metal contamination in playgrounds and their associated potential health risks in cities around the world, but this is lacking in the Sunyani-East municipality of Ghana (Gredilla *et al.,* 2017; González-Grijalva *et al.,* 20019; Davidson *et al.,* 2019).

Heavy metals such as iron (Fe), copper (Cu), lead (Pb), arsenic (As), cadmium (Cd), zinc (Zn) and manganese (Mn) naturally occur in low quantities in non-mineralized soils from lithogenic sources (Alloway, 2013). However, anthropogenic activities such as vehicular emissions, pesticide application and metallurgical extraction wastes contribute to increased heavy metals in urban soils (Chaiyaraksa and Phumcharoen 2021; Guo *et al.,* 2018). Toxic heavy metals such as Cd, Pb and As elicit adverse effects such as mental retardation in children, kidney dysfunction, bronchitis, nervous system disorders and immune system damage at relatively low concentrations (Yang and Massey, 2019; Singh *et al.,* 2011).

In Ghana, the topsoil in communities near major mining establishments like Obuasi, Tarkwa and Damang have been shown to contain high concentrations of heavy metals (Mensah *et al.,* 2021; Antwi-Agyei *et al.,* 2009). Sunyani is the capital town of the Bono region of Ghana and is situated near two large mining communities at Kenyasi and Afrisipa. The city is a commercial center for foodstuffs and boasts of thriving food commodities markets which attract traders from all over the country. Most public schools in Sunyani are owned mainly by mission establishments such as the Presbyterian, Catholic, Methodist (Wesleyans) and Anglican churches. They are built in clusters from kindergarten to junior high School, housing over 300 children (pupils). Due to the high number of children in these schools, the impact of potential morbidity caused by heavy metal ingestion could be alarming. This study, therefore, evaluates the extent of heavy metal contamination and health risks associated with their presence in playground soils of selected public schools in the Sunyani-East Municipality of Ghana.

2. Materials and Methods

2.1 Study area

The sampling area was the Sunyani municipality located in the Bono Region of Ghana, between coordinates 7° 20’ – 7° 25’ N and 2° 30’ – 2° 10’ W (Figure 1). The municipality lies within the wet semi-equatorial zone of Ghana, with mean temperature ranges between 23 °C – 33 °C and a mean annual rainfall of 62 mm.

The predominant soil type is ochrosol which supports agricultural products ranging from staples to cash crops. The Precambrian formation (Birimian group), which is rich in gold deposits, underlays the area however, no mining activities occur within the confines of the municipality. The estimated number of school children is about 18,000 pupils based on the 2010 census (GSS, 2014). The top seven schools with population sizes above 300 children, including RAPID school, Sunyani Secondary school (SUSEC) Primary school, Anglican Cluster of schools, Catholic Cluster of schools, Presbyterian Cluster of schools, Methodist Cluster of schools and Nyamaa school, were included in the study.

2.2 Collection of samples

Playgrounds were divided into zones and sampled within 1 × 1 m units. Sterile sampling bottles (500 ml) were used to collect triplicate 100 g of topsoil (1 – 10 cm). Triplicates of each sampling unit were pooled to obtain a composite for each school.

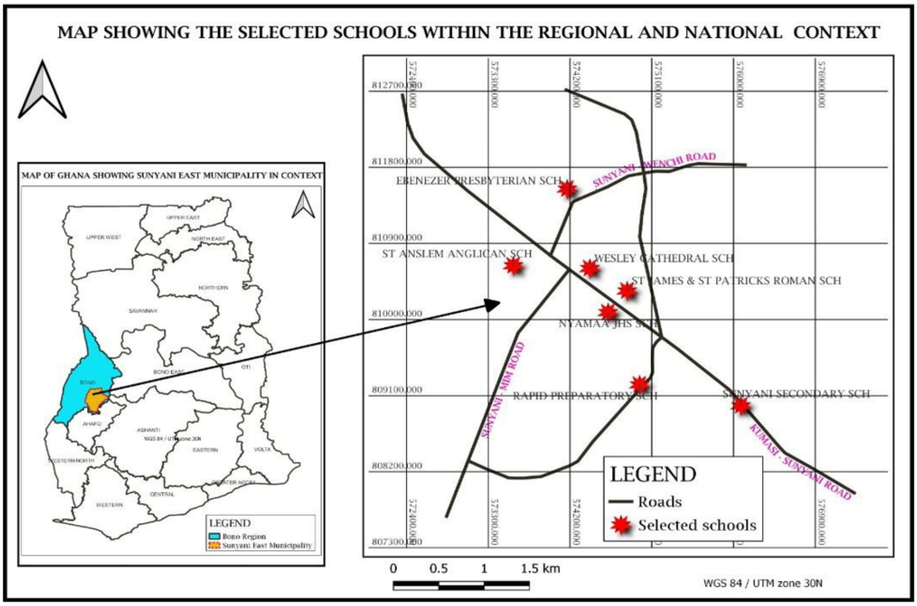

Figure 1. Map of the Ghana showing Bono region and selected schools

Soil samples were dried in an oven at 60 °C until stable weight was obtained and sifted through a 2 mm sieve. Heavy metals in pooled soil samples from playgrounds were analyzed using Buck Scientific 210 VGP (Model 210) atomic absorption spectrophotometer (AAS). Digestion of soil prior to heavy metals analysis was conducted using the US EPA Method 3050B (1996). Briefly, one gram (1g) of the sample was introduced into the Khedjahl digestion tube, digested with perchloric, nitric and hydrochloric acid mixture (1:2:3), and heated (100 °C) to complete digestion. Detection wavelengths of heavy metals are as follows; As at 193.7 nm, Cu at 324.8 nm, Cd at 228.3 nm, Fe at 248.3 nm, Pb at 217 nm, Mn at 279.5 nm and Zn at 213.9 nm.

2.3 Assessment of contamination levels

The extent of heavy metal contamination in playground soils was assessed using the contamination factor, pollution load index, enrichment factor, and geo-accumulation index.

2.3.1 Contamination factor (C_f)

The contamination factor compares heavy metal concentrations in sediment to unpolluted background samples (Hakanson, 1980). Recent computations of this index have used continental shale to represent an uncontaminated sample (Turekian and Wedepohl, 1961). The contamination factor was calculated using the following equation;

$$C_f = M_x / M_b \quad (1)$$

Where: C_f is the contamination factor, M_x refers to the concentration of heavy metals in playground soil, M_b refers to the baseline (continental shale) heavy metal concentration.

2.3.2 Pollution load index (PLI)

The pollution load index is an integrated index that describes the overall pollution status of a site and allows for comparison between different locations (Yahaya *et al.,* 2021; Weissmannova *et al.,* 2019). It is estimated as the geometric mean of the contamination factors of heavy metals (Tomlinson *et al.,* 1980). The following equation was used to estimate the PLI for playgrounds;

$$PLI = (Cf_1 \times Cf_2 \times Cf_3 \times Cf_4 \times Cf_n)^{1/n} \quad (2)$$

Where: C_f refers to the contamination factor of heavy metals in playground soil and n refers to the number of heavy metals being studied

2.3.3 Geo-accumulation index (I_{geo})

The geo-accumulation index estimates metal contamination in sediments compared to that heavy metal's background or pre-industrial concentration (Müller, 1969). The following equation was used to calculate the geo-accumulation index of heavy metals in playground soil;

$$I_{geo} = \log_2[(Cs/1.5Bn)] \quad (3)$$

Where: Cs and Bn refer to heavy metal concentration in sediments and baseline or pre-industrial concentration.

2.3.4 Enrichment factor (EF)

The enrichment factor estimates the extent of natural or anthropogenic enrichment of contaminants compared to unpolluted sediments (Salomons and Förstner, 1984). The comparison for enrichment is made with reference to the concentration of Fe as a normalizing factor and calculated using the following equation;

$$EF = \frac{Cs \times Fn}{Fs \times Cn} \quad (4)$$

Where: *Cs* and *Fs* represent heavy metal and Fe concentration in sediment, and *Cn* and *Fn* represent the concentration of heavy metals and Fe in continental shale, respectively (Turekian and Wedepohl, 1961).

2.3.5 Assessment of risks in children

Non-carcinogenic risk from the exposure of children to heavy metals in playground soil through ingestion was estimated using the US EPA (1986) health risk assessment model. The average daily dose (ADD) in children (mg/kg day) via this route was calculated as follows;

$$ADD_{ingestion} = C \times ([IR \times EF \times ED] \times 10^{-6}) / (BW \times AT) \quad (5)$$

Where: $ADD_{ingestion}$ refers to the average daily dose of heavy metal via ingestion; the concentration of heavy metals in playground soil, C; ingestion rate, IR (200 mg/day); exposure frequency, EF (350 days/year); exposure duration, ED (6 years); bodyweight, BW (15 kg); averaging time, AT (6 years = 2190 days); unit conversion is 1×10^{-6} (Mensah *et al.,* 2021; Shaheen *et al.,* 2020).

The hazard quotients of heavy metals were also estimated as follows

$$HQ = ADD / RD \quad (6)$$

Where: reference dose of heavy metal, RD (mg/kg day) given as follows; arsenic (0.0003); cadmium (0.001); copper (0.04); iron (0.7); lead (0.0035); manganese (0.046) and zinc (0.3) as indicated in earlier reports (Rinkeble *et al.,* 2019; Antonaidis *et al.,* 2019; Li *et al.,* 2015). Assessment of the hazard index, which is the sum of hazard quotients for heavy metals at a playground, was computed using the following formula;

$$HI = \sum HQ \quad (7)$$

The likelihood of adverse impacts is minimal when the hazard quotient (HQ) or hazard index is less or equal to 1. Conversely, the possibility for adverse effects to occur is high when HQ or HI is greater than unity (HQ, HI > 1) (USEPA, 1989; Li *et al.,* 2015).

2.4 Data analysis

Analysis of variance (ANOVA) of heavy metals in playground soil and principal component analysis for source attribution were performed using SPSS (version 20, IBM Inc.). Origin Pro (2019) was used to plot graphs of heavy metals levels in playgrounds. Pearson's correlation explored associations between heavy metals using paleontological tatistics software (PAST 4.0).

3. Results and Discussion

3.1 Concentration of heavy metal levels in playground soil

The mean concentrations of heavy metals in playground soils of schools in the Sunyani Municipality varied significantly ($p < 0.05$), with Fe recording the highest mean concentration with 40,026.67 ± 8.72 mg/kg, followed by Mn, Zn, Cu, As, Cd and Pb in descending order respectively.

Nyamaa school had the highest concentration of Fe in playground soil followed by Methodist, Anglican, Rapid, Catholic and Presbyterian schools in descending order (Figure 2). The concentrations of heavy metals in majority of school playgrounds (71%) recorded values above world average in soil (Kabatas-Pendias, 2011). Specifically, levels of Fe in playground soils at all schools except Presbyterian and SUSEC schools were above the world average levels in soil (20,000 mg/kg) (Shaheen *et al.,* 2020). Mensah *et al.* (2021) indicated that increasing levels of Fe in playground soil is due to scorodite and arsenopyrite found in the Birimian rocks in Ghana (Mensah *et al.,* 2021).

Moreover, the high levels of Fe in playgrounds could be attributed to the accentuated impact of precipitation in accelerating the reduction of these heavy metals in soil characteristic of nutrient-rich forest ochrosols (Bempah *et al.,* 2013). The Presbyterian school cluster had the highest concentrations of Cu, Pb, As and Cd in playground soils which ranged from 31.92 – 85.0 mg/kg, 1.31 – 10.93 mg/kg, 3.05 – 15.77 mg/kg, and 0.59 – 11.43 mg/kg respectively (Figures 3 – 6). Levels of Cu in playground soils exceeded thresholds at all selected schools in the Sunyani Municipality (Kabatas-Pendias, 2011). A common geogenic source of Cu in Ghanaian soils is chalcopyrite found in most gold-bearing rock formations in Ghana (Dzigbodi-Adjimah and Asamoah, 2009). Again, other activities/objects that release Cu into the environment include painting of artifacts, pesticide spraying and metal pipes are not uncommon in artisan shops within the school's vicinity. These could cause anemia, stomachache and intestinal irritation in children since they are fond of ingesting playground soil (Singh *et al.,* 2011).

Nyamaa school recorded the highest concentrations of Mn and Zn in playground soils with 260.57 ± 2.5 mg/kg and 96.71 ± 1.53 mg/kg respectively (Figures 7 and 8). Levels of Pb and Mn were below reference thresholds however, the presence of Pb in urban playground soil has been shown to constitute a potent threat of poisoning in children (Akinwumi *et al.,* 2016). Levels of As, Cd and Zn at the Presbyterian school playground were higher than world average in soilsuggesting multiple sources of heavy metal pollution (Kabatas-Pendias, 2011).

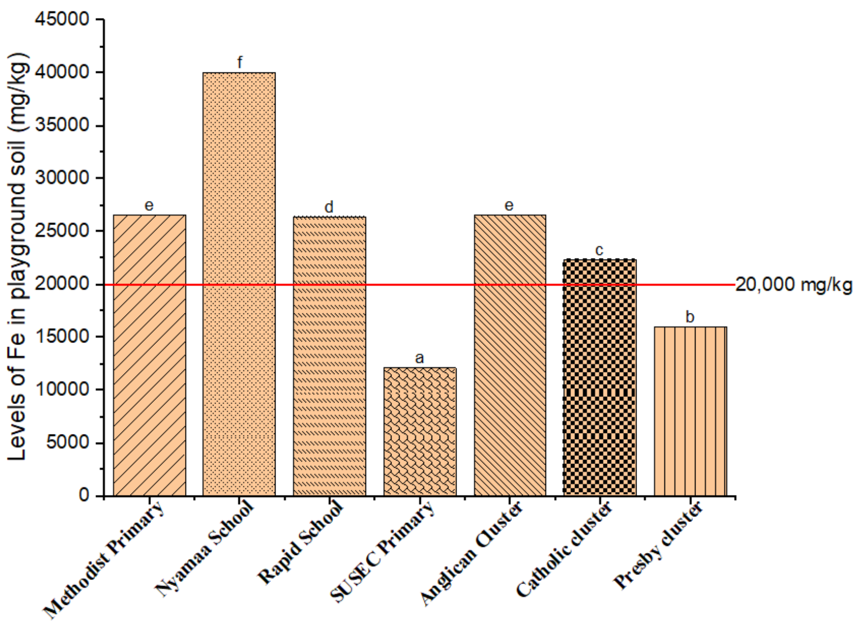

Figure 2. Levels of iron (Fe) in playground soils of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

This occurrence could be attributed to mechanic workshops, hosting of social activities and proximity to vehicular traffic close to the School.

Levels of Zn, As and Cd observed in playground soil at the Presbyterian cluster of schools are higher than those found in major cities such as Los Angeles, Madrid and Sao Paolo, indicating significant pollution (Tume *et al.,* 2021; Rodríguez-Oroz *et al.,* 2018; De Miguel *et al.,* 2007).

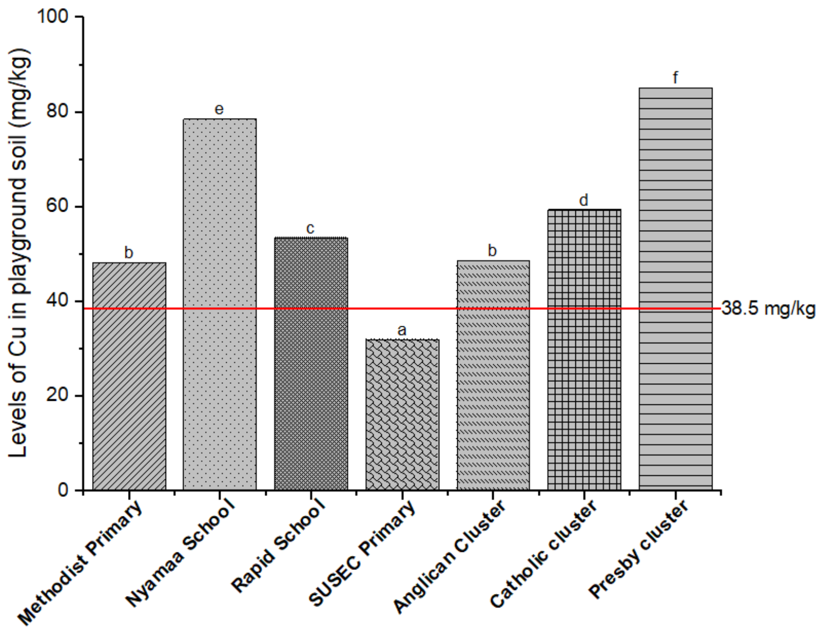

Figure 3. Levels of copper (Cu) in playground soils of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

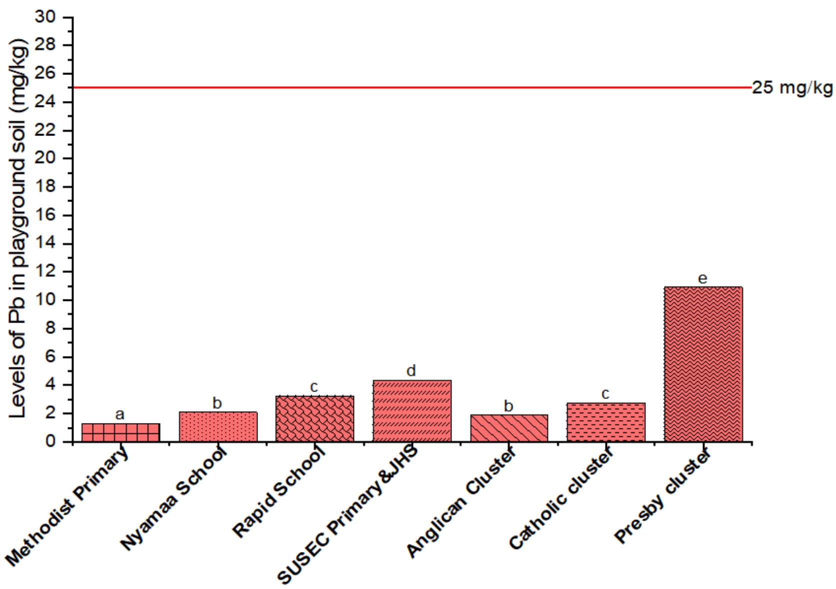

Figure 4. Levels of lead (Pb) in playground soil of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

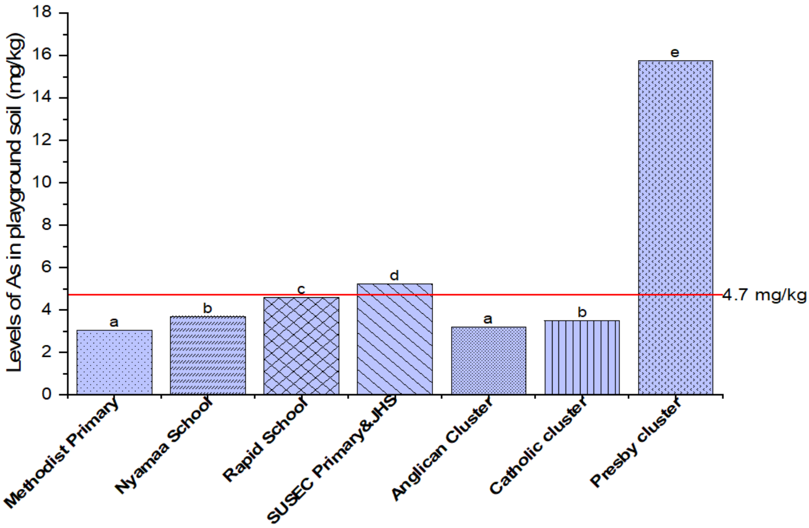

Figure 5. Levels of arsenic in playground soil of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

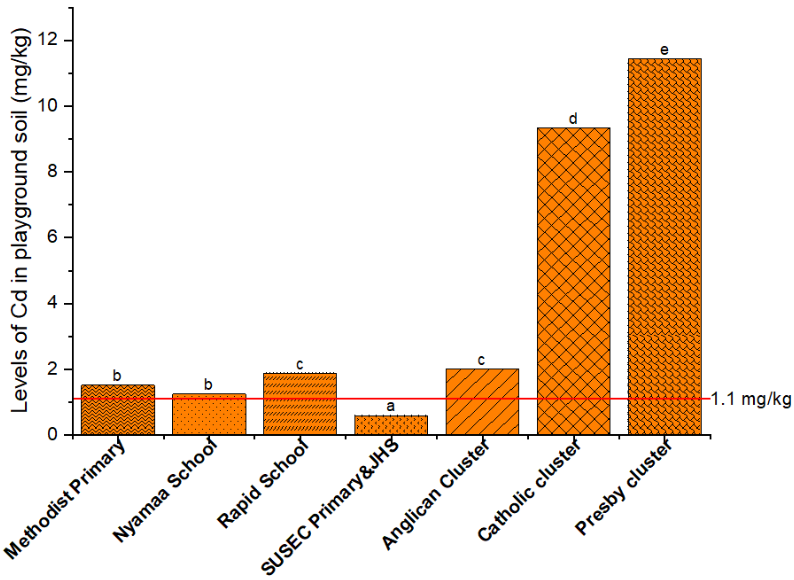

Figure 6. Levels of cadmium in playground soil of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

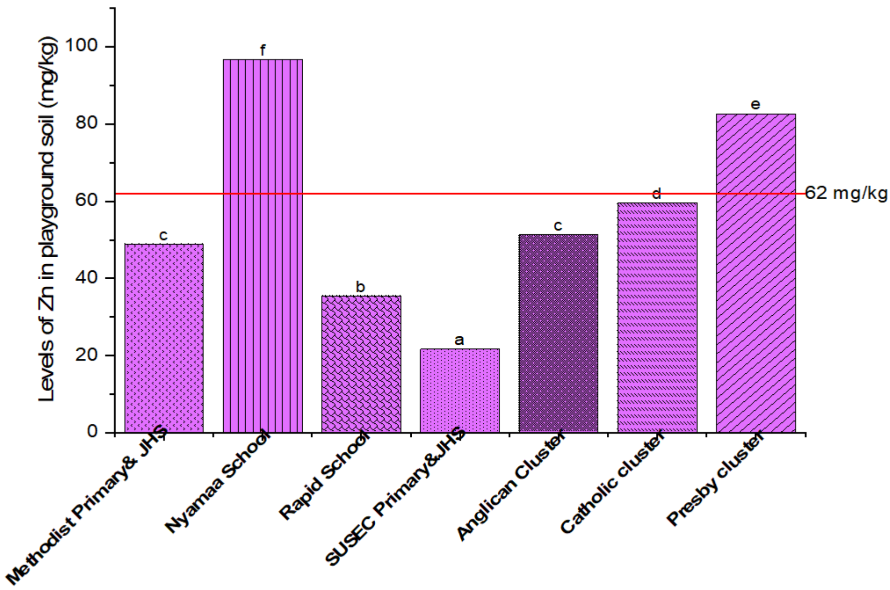

Figure 7. Levels of Zinc in playground soil of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

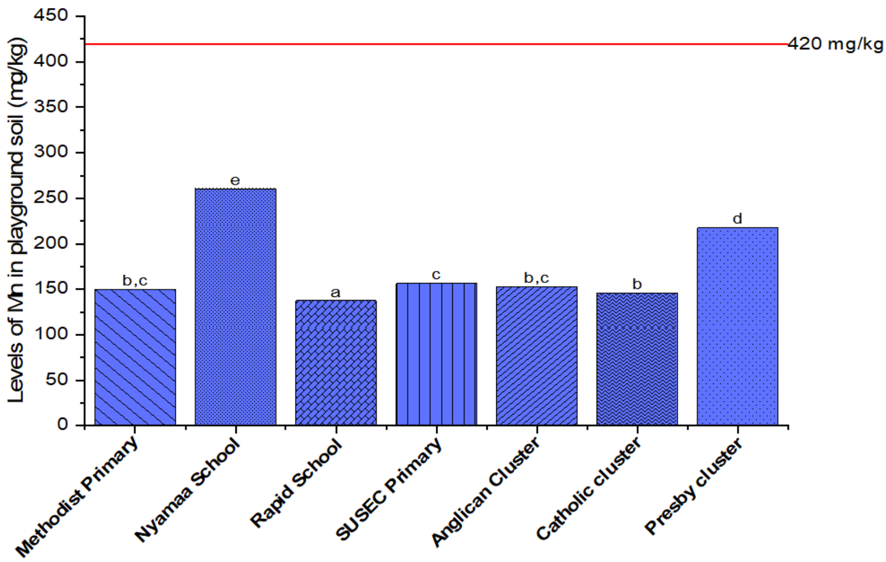

Figure 8. Levels of manganese in playground soils of schools. Red horizontal line represents the world average levels in soil and bars with different alphabets vary significantly ($p < 0.05$)

3.2 Multivariate analysis of heavy metals in playground soil

Pearson correlation indicated strong and significant associations of Cu with Mn and Zn (Table 1). Zinc levels were strongly correlated with Mn, whereas As levels were associated with Pb. Toxic elements such as As, Cd and Pb were also strongly correlated.

Principal component analysis of heavy metals metals in playgrounds indicated two explanatory variables (components) with toxic heavy metals (Pb, As and Cd) constituting the first component. This observed correlation is consistent with the output of factor analysis, which extracted two principal components: to micro-nutrients (Cu, Zn, Fe, Mn) and toxic heavy metals (Pb, Cd, As). Micro-nutrients in soils are attributed to geogenic sources since they build up through biogeochemical cycling, biological activities and weathering (Liu *et al.,* 2018). Hierarchical clustering of playgrounds using Ward's method indicated close associations between SUSEC and Presbyterian school; RAPID school and Catholic school; Methodist and Anglican school clusters; Nyamaa School was an out-group.

3.3 Assessment of heavy metal pollution of playgrounds

The contamination factor showed that Cd is the main contaminant in playground soils, followed by Cu, Fe, As, Zn, Mn and Pb in descending order (Table 3). More so, extreme cadmium contamination was observed at the Presbyterian and Catholic schools (Yahaya *et al.,* 2019). Minimal contamination levels were observed at playgrounds for Mn and Pb but severe contamination of Fe and Cu were observed at playgrounds of all schools. The extreme contamination of Cu, Fe and Cd suggests anthropogenic impacts, especially at the Catholic and Presbyterian school clusters. Heavy metal contamination could be attributed to mechanical workshops which engage in welding car parts, changing lubricants and proximity to vehicular traffic emissions, accentuating the extent of contamination in playgrounds.

The pollution load index indicated extreme pollution of heavy metals at the Presbyterian school cluster, with other heavy metals recording minimal pollution (Fural *et al.,* 2020). Consequently, the Presbyterian cluster of schools is highly polluted with heavy metals requiring decontamination or remediation (Yahaya *et al.,* 2021).

Enrichment factor of heavy metals using Fe levels as normalizing element showed the following trend; Cd > As > Zn > Cu > Mn > Pb. Extremely high cadmium enrichment was observed at the Catholic school cluster, with Anglican and Presbyterian clusters having very high cadmium enrichment (Table 4). Based on the enrichment factor of toxic heavy metals, school playgrounds are more polluted than in the Kumasi Metropolis of Ghana (Darko *et al.,* 2017).

Table 1. Correlation between heavy metals in playground soils

	Fe	Cu	Mn	Zn	Pb	As	Cd
Fe	1						
Cu	0.363	1					
Mn	0.437	**0.777**	1				
Zn	0.544	**0.927**	**0.860**	1			
Pb	-0.575	0.332	0.331	0.262	1		
As	-0.485	0.585	0.391	0.350	**0.988**	1	
Cd	-0.371	0.599	0.142	0.425	0.699	0.695	1

Bold font represents significant correlation ($p < 0.05$).

Table 2. Principal component analysis of heavy metals in playground soils

Component	**Initial Eigen-values**			**Metal**	**Component**	
	Total	**Percentage of Variance**	**Cumulative Percentage**		**1**	**2**
1	3.862	55.171	55.171	Fe	-0.695	0.685
2	2.418	34.541	89.712	Cu	0.411	0.889
3	0.548	7.824	97.536	Mn	0.144	0.890
4	0.141	2.014	99.551	Zn	0.161	0.970
5	0.023	0.328	99.879	Pb	0.963	0.145
6	0.005	0.075	99.953	As	0.938	0.235
7	0.003	0.047	100.00	Cd	0.806	0.233

Table 3. Contamination factors and pollution load index (PLI) of heavy metals

School	Contamination factors of heavy metals							PLI
	Fe	Cu	Mn	Zn	Pb	As	Cd	
Methodist Primary& JHS	1.33	1.25	0.31	0.70	0.05	0.45	7.58	0.01
Nyamaa School	2.00	2.04	0.53	1.38	0.08	0.54	6.23	0.11
Rapid School	1.32	1.39	0.28	0.51	0.12	0.67	9.43	0.03
SUSEC Primary & JHS	0.60	0.83	0.32	0.31	0.16	0.77	2.98	0.00
Anglican Cluster	1.33	1.26	0.31	0.73	0.07	0.47	10.07	0.02
Catholic cluster	1.12	1.54	0.30	0.85	0.10	0.51	46.67	0.15
Presbyterian Cluster	0.80	2.21	0.45	1.18	0.40	2.31	42.17	5.23

Table 4. Enrichment factor of heavy metals in playground soils of public schools

Schools	Heavy metals in playground soils					
	Cu	Mn	Zn	Pb	As	Cd
Methodist Pri., & JHS	0.94	0.25	2.28	0.07	9.24	16.96
Nyamaa School	1.02	0.26	2.59	0.06	7.04	11.52
Rapid School	1.05	0.20	1.80	0.24	5.60	14.08
SUSEC Primary & JHS	1.37	0.39	0.97	0.52	4.74	3.89
Anglican Cluster	0.95	0.25	2.34	0.10	6.68	21.60
Catholic cluster	1.38	0.19	2.86	0.12	5.06	91.07
Presbyterian cluster	2.76	0.20	2.65	0.34	5.70	24.76

Table 5. Geo-accumulation index of heavy metals in playground soils

School	Heavy metals in playground soils						
	Fe	Cu	Mn	Zn	Pb	As	Cd
Methodist Primary& JHS	-0.18	-0.26	-2.29	-1.10	-4.95	-1.75	2.34
Nyamaa School	0.42	0.44	-1.49	-0.12	-4.29	-1.47	2.06
Rapid School	-0.19	-0.11	-2.41	-1.57	-3.65	-1.16	2.65
SUSEC Primary & JHS	-1.31	-0.86	-2.23	-2.28	-3.21	-0.97	0.99
Anglican Cluster	-0.18	-0.25	-2.26	-1.03	-4.43	-1.69	2.75
Catholic cluster	-0.42	0.04	-2.33	-0.82	-3.89	-1.55	4.96
Presbyterian cluster	-0.91	0.56	-1.75	-0.35	-1.89	0.62	5.25

Geo-accumulation index of heavy metals in playground soils indicated moderate to extreme contamination of playgrounds with cadmium, and more so, the Presbyterian school cluster recorded a value (5.25) higher than the threshold for classification (Table 5). Conversely, the other heavy metals apart from cadmium showed uncontaminated levels in the playground soil of schools. Accordingly, the geo-accumulation specifically pointed to the contribution of cadmium as the primary source of heavy metal pollution at the Presbyterian school playgrounds.

3.4 Non-carcinogenic risks of ingested heavy metals in children

The non-carcinogenic hazard quotient of heavy metals in playground soils for children followed the trend; Fe > As > Cd > Mn > Cu > Pb > Zn (Table 6). The hazard index of heavy metals in playground soils ranged from

Table 6. Hazard quotient of heavy metals in playgrounds of schools

School	Hazard quotient of heavy metals						
	Fe	Cu	Mn	Zn	Pb	As	Cd
Methodist Primary& JHS	0.485	0.015	0.042	0.002	0.005	0.130	0.019
Nyamaa School	0.731	0.025	0.072	0.004	0.008	0.158	0.016
Rapid School	0.482	0.017	0.038	0.002	0.012	0.195	0.024
SUSEC Primary & JHS	0.221	0.010	0.043	0.001	0.016	0.223	0.008
Anglican Cluster	0.485	0.016	0.042	0.002	0.007	0.136	0.026
Catholic Cluster	0.408	0.019	0.040	0.003	0.010	0.149	0.119
Presbyterian Cluster	0.292	0.027	0.060	0.004	0.040	0.672	0.146

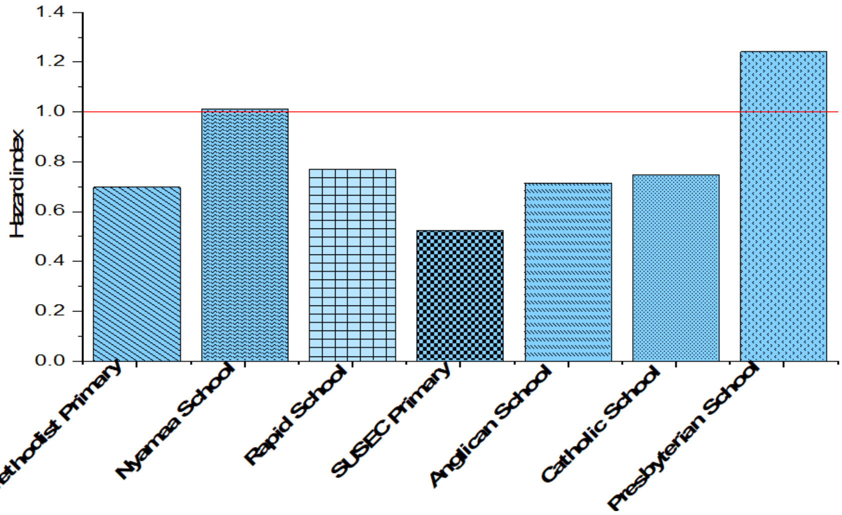

Figure 9. Hazard index of heavy metals in playground soil of schools

0.522 – 1.241 (Figure 9). The non-carcinogenic risks of heavy metals in children via the oral route (ingested) for Presbyterian and Nyamaa schools were greater than unity (HI > 1). This shows that Nyamaa and Presbyterian school playgrounds could pose significant health threats to children (Li *et al.,* 2015). More so, the hazard quotient points to contributions of Fe and As at Nyamaa School, whereas As, Fe and Cd are implicated at the Presbyterian School. Possible health risks that children could accrue from ingestion of playground soils owing to the presence of high concentrations of cadmium and arsenic include bronchitis, dermatitis, kidney damage and osteoporosis (Singh *et al.,* 2011). Therefore, the hazard posed by Fe, As and Cd contamination at playgrounds should be mitigated by ecologically friendly interventions.

Covering the playground surface with grass reduces direct contact with soil while improving aesthetic value and safety (Rozanski *et al.,* 2021). Furthermore, application of biomaterials such as biochar, green manure and compost tailored towards improving bioavailability of heavy metals in playground soil for uptake by plants (grass) could reduce potential hazard posed by presence of heavy metals (Dhaliwal *et al.,* 2020).

4. Conclusion

Assessment of heavy metals pollution in playground soil of selected schools in the Sunyani Municipality of Ghana showed that majority of the schools (> 70%) had levels of Fe, Cu and Cd above world soil average, indicating anthropogenic enrichment. Specifically, toxic heavy metals such as Cd, As and Pb constituted a principal component attributed to activities of mechanic shops and vehicular emissions close to schools. Furthermore, contamination and enrichment factors revealed severe pollution of playgrounds with Cd, Fe and As. In contrast, the pollution load index showed that the Presbyterian cluster of schools was the most impacted. Consequently, the high concentrations of Fe, As and Cd at Nyamaa and Presbyterian school playgrounds could elicit adverse health effects if no intervention(s) are instituted. Therefore, eco-friendly mitigation strategies such as covering the bare soil with grass and application of organic chelating agents could reduce potential hazard posed by heavy metal pollution.

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