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Human Health Risk of Toxic Elements (TEs) in Trapped AC Filter Dusts from Workplace Environments

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ABSTRACT

Background: Excessive toxic element (TE) level in our environment is a great concern with large amount of emerging research.
Objective: The study evaluates the level of TEs in air conditioner (AC) filter dust and the potential human health risk of exposure in work (offices) environment in the State Secretariat, Oke- Mosan, Abeokuta, Ogun State, Nigeria.
Methods: Twelve (12) composite AC filter dust samples were collected from offices into sample bags, then sent to the Lagos State Environmental Protection Agency (LASEPA) for analysis. Exactly, 1g of the processed dust was digested using *Aqua regia* method while TE analysis was carried using Atomic Absorption Spectrometer (AAS). Geo-accumulation index and enrichment factor were employed to determine the degree of pollution using the US EPA model while pearson correlation was performed to determine possible source using SPSS vs 21. Human health risk assessment model was computed to estimate the non-cancer and cancer risks of exposure.
Results: The level of TEs in the AC filter dust were within the permissible limit state by the UK, Canada and Dutch guideline values. Cadmium in the dust was labeled as the stated chief contaminant in the dust by the pollution indices. Furthermore, the relationship between the TEs shows that the TEs emerged from sources grouped in two such as mixed geogenic and anthropogenic sources (Fe, Cr and Zn) and strict anthropogenic sources (Pb and Mn; Cr and Zn) which are primarily linked to the components of the air conditioners. Human health risks assessment revealed a negligible non-cancer and cancer risk to the human group on exposure.
Conclusion: The AC filter dust is moderately polluted with Cd but showed no human health risk.

Keywords. Human Health Risk, Toxic Elements, Filter Dusts, Workplace Environments

1. Introduction

Exposure to toxic element (TE) polluted dust have been reported to affect human health, since people in urban areas spend most of their time indoors (workplaces, homes, schools, worship centres etc.), where airborne particles can accumulate and be re-suspended or ingested inadvertently (Iwegbue *et al*., 2019; Famuyiwa *et al*., 2022; 2024; Umoren *et al*., 2024; 2025a). Global syntheses and local studies show that indoor dust routinely contains metals and metalloids such as lead (Pb), cadmium (Cd), arsenic (As), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), and manganese (Mn), with concentrations varying by local emissions, building materials, occupant activities, and outdoor/traffic inputs (Iwegbue *et al*., 2020; Bamidele *et al*., 2020; Umoren et al., 2025b). Air-conditioning (A/C) systems act as both sinks and secondary sources of indoor particulate matter (Umoren *et al*., 2024), their filters trap airborne particles from outdoor infiltration, indoor activities and building materials, concentrating TEs in filter dust which can then be analyzed as an integrated, time-averaged proxy of indoor air contamination (i.e., filter dust integrates pollutant inputs over the filter service period). Recent works using AC filter dusts has demonstrated substantial levels of some elements (AlMulla *et al*., 2022; Umoren *et al*., 2024).

Office buildings and government complexes are critical microenvironments for exposure assessment: they host dense populations and often contain complex mixtures of indoor

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sources (electronic equipment, furnishing, renovation residues) and are frequently located near busy roads or industrial activities that influence outdoor–indoor pollutant transfer. Studies using settled indoor dust from classrooms, living rooms, and offices in southern Nigeria have reported elevated levels of toxic elements (Olujimi *et al*., 2015).

Human health risk assessment methods applied to dust and filter matrices allow quantification of non-carcinogenic risk (hazard quotients, hazard index) and carcinogenic risks (incremental lifetime cancer risk) via ingestion, inhalation, and dermal contact, enabling prioritization of contaminants and identification of at-risk subpopulations (e.g., office cleaners, maintenance staff, children visiting offices). In Nigeria, health risk assessments of indoor dust have sometimes shown hazard index values above threshold in certain age groups (e.g., workplace environments, homes and classroom), which implicates non-negligible exposure (Olujimi, 2015; Iwegbue *et al*., 2020; Umoren et al., 2025b).

Despite growing literature on indoor dust and settled particles, few studies have specifically characterized the concentration, spatial distribution and human health risks of toxic elements in A/C filter dust from government office complexes in Nigeria. The Secretariat Complex, Oke-Mosan (Governor's Office), Ogun State, is a high-occupancy administrative facility, potentially exposed to both outdoor urban emissions and building-specific sources. Generating site-specific data from A/C filter dusts will therefore provide an integrated measure of indoor metal loading over filter service periods, allow comparison with local and international benchmarks and dust studies, and enable a human health risk assessment tailored to office occupants and maintenance workers.

2. Materials and Methods

2.2 Site Area

Abeokuta is the largest city and state capital of Ogun State in Southwest Nigeria. It is situated on the cast bank of the Ogun River, near a group of rocky outcrops in a wooded savanna; 77 kilometers north of Lagos by railway, or 130 kilometres by water. According to the National Population (2006) Abeokuta Metropolis had a total population of 449, 088. Abeokuta lies below the Olumo Rock, home to several caves and shrines. New Secretariat, Oke-Mosan, Abeokuta, is the location that houses the Office of the Governor of Ogun State and other Ministries Department and Agencies (Figure 1). To assess the level of elements in the dust form Air conditioners (ACs) filter used in the State New Secretariat, Oke-Mosan, Abeokuta, Ogun State, AC filter dust samples were randomly collected from twelve (12) Offices for the purpose of the study.

2.2 Sample Collection

Twelve (12) composite dust samples were collected from ACs (1.5–2 tonne units) situated on the walls at a height of 6–25ft above ground level for a period ranging from 2 to 3 years. Samples were collected from one AC unit per location with 5–6 g of sample collected; samples were collected by tapping the AC filters onto a sterile polythene sheet as well as using a plastic brush to remove the dust. Samples were stored in clean labeled polyethylene bags and transported to the laboratory. The coordinate for the sampled AC filter is presented in Table 1.

2.4 Sample preparation, digestion and Metal analysis

Dust samples were sieved with 1 mm mesh size then stored for digestion. Digestion and metal analysis was carried out at the laboratory of the Lagos State Environmental Protection Agency (LASEPA), Lagos State, Nigeria. Exactly, 1g of each sample was transferred into a 20 mL concentrated nitric acid (HNO_3) and hydrochloric acid (HCl) in the ratio 1:3 respectively. The mixture was gently stirred to make a homogenous mixture and was heated subsequently in a fume

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Figure 1: The Map of the study area generated from google earth

Table 1: Sampling points and geo-coordinate

Sample code	Location	Geo-coordinate
OF01	Block A	7.117063, 3.368448
OF02	Block A	7.117206, 3.368139
OF03	Block A	7.117484, 3.368198
OF04	Block A	7.117583, 3.368202
OF05	Block B	7.118028, 3.368948
OF06	Block B	7.118112, 3,369058
OF07	Block B	7.118224, 3.369058
OF08	Block B	7.118757, 3.368724
OF09	Block C	7.119149, 3.369393
OF10	Block C	7.119449, 3.369416
OF11	Block C	7.119558, 3.369034
OF12	Block C	7.119208, 3.368641

cupboard until a clear solution was obtained. The samples was later cooled off, filtered and diluted with distilled water to a volume of 50ml in a standard volumetric flask. The diluted samples were analyzed using Atomic Absorption Spectrophotometer (AAS) for metal determination.

Pollution Indices

The pollution assessment of geologic samples such as soil and dust can be carried out in various ways, although, the most common ones are the index of geo-accumulation, pollution load, enrichment and contamination factors (Umoren *et al.,* 2024). In this investigation, the index of geo-accumulation (Igeo) and enrichment Factor (EF) was employed assess the level of TEs in the trapped dust from air conditioner filter

2.4.1 Geo-accumulation index (I-geo)

A quantitative measure of the extent of metal pollution in the studied dust was calculated using the geo-accumulation index proposed by Muller (1969). This index (Igeo) of toxic element is calculated by computing the base 2 logarithm of the measured total concentration of the elements over its background concentration using the following mathematical expression.

$$Geo-accumulation\,(Igeo) = \text{Log}\,2\; x \left({}^{Cn}/_{1.5\,x\,Bn} \right) \qquad Equation\ 1$$

Where Cn denotes the TE level in the dust, Bn denotes the TE level in shale (background), and 1.5 denotes the factor compensating for the background data due to geogenic impact. The following interpretation is used for the geo-accumulation index; Igeo<0=practically unpolluted, 0<Igeo<1=unpolluted to moderated polluted, 1<Igeo<2= moderately polluted, 2<Igeo<3= moderately to strongly polluted, 3<Igeo<4=strongly polluted, 4<Igeo<5 = strongly to extremely polluted and Igeo >5=extremely polluted.

2.4.2 Enrichment factor (EF)

The enrichment factor (EF) is another index that determines the degree of anthropogenic contribution and TE pollution in dust, as well as to differentiate between anthropogenic and natural sources of TEs (Yuen *et al.,* 2012; Famuyiwa *et al.,* 2024). It was calculated using mathematical expressing in equation 2.

$$Enrichment\ factor\ (EF) = \frac{Cn\,(TE)\,/C\,(TE\,crust)}{Bn\,(reference\,TE)\,/B(reference\,crust)} \qquad Equation\ 2$$

Where Cn (TE) is the level of the measured element, C (TE crust) is the level of the TE in the crustal region, Bn (reference TE) is the level of the reference TE (Fe in this case) in the measured sample, B is the level of reference TE (Fe) in the crustal region. A toxic element is regarded as a reference element, if it is of low occurrence variability and is present in trace amounts (Turekian and Wedephol, 1961; Iwegbue *et al.* 2019; Umoren *et al*., 2024). According to Famuyiwa *et al.* (2022), there are five categories of degree of pollution based on enrichment factor index: EF<2 is regarded as no or minimal enrichment, EF=2- 5 is regarded as moderate enrichment, EF=5–20 is regarded as significant enrichment, EF=20–40 is regarded as very high enrichment, EF>40 is regarded as extremely high enrichments.

2.5 Health Risk Assessment

The potential human health risk of exposure to TEs from the dust through ingestion, inhalation, and dermal (skin) contact pathways was calculated using the mathematical expression presented in equation 3-5.

$$MDD_{ingest} = C\ x \left({}^{IngR\ x\ EF\ x\ ED}/_{MBW\ x\ AT} \right) x\ 10^{-6} \qquad \text{Equation 3}$$

$$MDD_{inhale} = C\ x \left({}^{InhR\ x\ EF\ x\ ED}/_{PET\ x\ MBWx\ AT} \right) \qquad \text{Equation 4}$$

$$MDD_{dermal} = C\ x \left({}^{SA\ x\ DAF\ x\ SAF\ x\ EF\ x\ ED}/_{MBW\ x\ AT} \right) x\ 10^{-6} \qquad \text{Equation 5}$$

where MDD ($mgkg^{-1}day^{-1}$) is the mean daily dose on exposure via ingestion (MDD_{ingest}), inhalation (MDD_{inhale}) and dermal contact (MDD_{dermal}). C is the level of TE in the dust (mg/kg), IngR (ingestion rate) is 200 mg/day for children and 100 mg/day for adults and IhR (inhalation rate) is 7.63 mg/day for children and 12.8 mg/day for adult of TE in dust respectively (USEPA 2011). ED (exposure duration) is 6 years for children and 30 years for adults, and EF (exposure frequency) is 350 days/year for children and adults. MBW and AT are the mean body weight (15 kg for children and 70 kg for adults) and the mean exposure period (6 years for children and 30 years for adults) respectively (Chen *et al.,* 2014; Umoren *et al*., 2024). CF is the conversion factor (1 x 10^{-6} kg/mg), SA is the exposed skin surface area (2800 cm^2 for children and 4340 cm^2 for adults), SAF is the skin adherence factor (0.2 $mg/cm^2/d^1$ for children and 0.7$mg/cm^2/d^1$ for adult), DAF is the dermal absorption factor used in this study is 0.001 for both children and adult, and PEF is the particle emission factor (1.36 x 10^9 m^3/kg) for both children and adult.

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The reference dose is used according to Famuyiwa *et al.* (2022) is a measure of non-cancer chronic hazards. Toxic effects are likely to ensue when the exposure dose of the target contaminant exceeds the reference dose, which is generally articulated as HQ and HI. Hazard index (HI) and cancer risk method were used to assess the human health risk due to dust exposure, before calculating the HI, a hazard quotient (HQ) based on non-cancer toxic risk was calculated for individual TE according to equation 6.

$$\text{Hazard quotient (HQ)} = {MDD}/_{RfD} \qquad \textit{Equation 6}$$

RfD (mg/kg/day) is the daily maximum allowable dose of TE without posing a non-carcinogenic risk to humans during their lifespan. Three different types of RfDs are used for three different exposure pathways: reference dose RfD_{ingest} (mg/kg/day) for ingestion, RfD_{dermal}, (mg/kg/day) for dermal contact and RfD_{inhale} (mg/m^3) for inhalation. The hazard index measures the cumulative risk of specific chemicals from multiple exposures (HI). Equation 7, can be used to measure the cumulative risk of TEs in ACFD from multiple exposures.

$$\sum HQi = Hazard\ index\ (HI) \qquad \text{Equation 7}$$

where i = different exposure pathways. The value of HI less than 1 shows that there is no significant risk of non-carcinogenic effects. However, when the HI value is greater than 1, significant non-carcinogenic effects are probable (USEPA, 2011). The carcinogenic risks to humans are estimated using the reference dose (RfD) multiplied by the respective cancer slope factor (CSF, 1 mg/kg). A cancer slope factor is an upper bound probability of an individual developing cancer as a result of lifetime exposure to dust by ingestion, inhalation and dermal contact using equation 8 (Olujimi *et al.,* 2015).

$$Total\ Cancer\ Risk\ (TCR) = RfD\ x\ CSF \qquad \textit{Equation 8}$$

Cancer risk (CR) is the probability of an individual developing any type of cancer from lifetime exposure to carcinogenic hazards. Total cancer risk (TCR) less than $1x10^{-6}$ specifies negligible cancer risk, while TCR greater than $1x10^{-4}$ recommends high cancer risk to humans on dust exposure (Wu *et al.,* 2015).

2.6 Data Analysis

Data was analyzed using statistical package for social sciences 21.0 for descriptive statistics. Microsoft Excel 2010 was also used for graphical presentations, relationships between toxic elements for source determination was carried out using Pearson correlation at $p<0.05$ and 95% confidence level.

3. Results and Discussions

3.1 Level of TEs in Dusts

Generally, the study recorded the presence of toxic elements (Fe, Pb, Ni, Cr, Cd, Zn and Mn) in the AC filter dusts from the secretariat offices. The level of TEs in the dust is presented in Table 2. This showed that the level of Fe ranges from 28500 -63100 mg/kg with a mean of 43900±16500 mg/kg. The mean level of Fe in the dust was higher than the report from other similar indoor dust studies such as Jeddah, Saudi Arabia (8,751 mg/kg) by Mansour *et al.* (2019), Southern-Nigeria (23,499 mg/kg) by Iwegbue *et al.* (2019) and Adodo-Ota, Nigeria (6780 mg/kg) by Umoren *et al.* (2024). Increased iron (Fe) levels in AC ducts are mainly attributed to corrosion of metallic ducting and internal components, resuspension of outdoor soil and road dust, and gradual wear of AC casings, especially under humid conditions and poor maintenance practices (WHO, 2010; ATSDR, 2019). While Fe is an essential micronutrient, chronic inhalation of Fe-containing dust can cause respiratory irritation, promote oxidative stress in lung tissues, and may worsen pre-existing respiratory conditions when exposure is prolonged (WHO, 2010).

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Table 2: Level of toxic elements in filter dusts

Sample	Toxic Elements (mg/kg)						
	Fe	Pb	Ni	Cr	Cd	Zn	Mn
OF01	37700	3.59	0.92	2.16	0.016	25.8	23.7
OF02	63100	7.19	3.66	4.28	0.088	53.6	39.6
OF03	49400	3.21	2.86	2.03	0.071	33.3	24.4
OF04	53500	7.17	2.68	3.37	0.076	50.5	30.8
OF05	60500	3.64	3.19	3.65	0.141	44.9	33.2
OF06	43400	4.86	1.76	2.58	0.036	34.7	28.4
OF07	46600	6.86	3.68	1.44	0.112	55.5	39.8
OF08	60900	3.34	2.35	2.91	0.187	49.9	15.3
OF09	28500	2.69	3.60	1.06	0.125	21.9	28.7
OF10	48700	4.55	2.13	1.30	0.217	29.6	29.7
OF11	33300	2.02	1.68	0.94	0.155	28.3	15.5
OF12	45700	7.01	4.22	1.92	0.148	27.7	26.4
Mean±SD	43900± 16500	4.67 ± 1.90	2.73±0.99	2.30±2 .30	0.114±0. 059	37.9±12.1	27.9±7.77
UK (2013)	-	450	200	200	150	-	-
CSGV (2009)	-	140	-	64	22	360	-
Dutch (Qing *et al.*, 2015)	-	530	210	380	12	750	-

Lead (Pb) level in the dust ranges from 2.69 - 7.19 mg/kg with a mean of 4.67 ± 1.90 mg/kg. The level of Pb were much lower than the permissible limit by the UK (450 mg/kg), Canada (140 mg/kg) and Dutch (530 mg/kg) guideline value. Furthermore, the value were also lower to the values reported for studies in Sri Serdang, Malaysia (89.05 mg/kg) by Sarva *et al.* (2015), Sydney, Australia (199 mg/kg) Israel *et al.* (2019) and Abeokuta, Nigeria (10.9 mg/kg) by Umoren *et al.* (2025).

The level of Nickel (Ni) in the dust ranges from 0.92 -4.22 mg/kg with a mean of 2.73±0.99 mg/kg. The values recorded were within the permissible limit by the UK (200 mg/kg) and Dutch (210 mg/kg). The level of Ni reported were low compared to various report from other studies from Abeokuta, Nigeria (12.7 mg/kg) by Olujimi *et al.* (2015) and Jeddah, Saudi Arabia (35.7 mg/kg) by Mansour *et al.* (2019) but higher than that of indoor dust in Abeokuta, Nigeria (0.516 mg/kg) by Famuyiwa *et al.* (2024a).

The level of Chromium (Cr) in the dust ranges from 0.94 - 4.28 kg/mg with the mean of 2.30±2.30 mg/kg. The recorded mean value was lower than the permissible limit given by the UK (200 mg/kg), Canada (64 mg/kg) and Dutch (380 mg/kg). The reported level of Cr were low compared to various report from other studies in Abeokuta, Nigeria reported (41.8 mg/kg) by Olujimi *et al.* (2015), Adodo-Ota, Nigeria (20.4 mg/kg) by Famuyiwa *et al.* (2022) and Adodo-Ota,

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Nigeria (198 mg/kg) by Umoren *et al.* (2024).

The level of Cadmium (Cd) ranges 0.016 - 0.217 mg/kg with a mean of 0.114±0.059 mg/kg. The level of Cd was lower than the permissible limit by the UK (150 mg/kg), Canada (22 mg/kg) and Dutch (12 mg/kg). The reported level of Cd were also lower compared to various studies such as Abeokuta, Nigeria (8.55mg/kg) by Olujimi *et al.* (2015), Adodo-Ota, Nigeria (2.53 mg/kg) by Umoren *et al.* (2024) and Abeokuta, Nigeria (0.076 mg/kg) by Famuyiwa *et al.* (2024).

The level of Zinc ranges from 21.9 -55.5 mg/kg with a mean of 37.9±12.1 mg/kg. The recorded values were lower than the permissible limit by Canada (360 mg/kg) and Dutch (750 mg/kg). However, the recorded value for Zn was lower than other studies reported from Adodo-Ota, Nigeria (254 mg/kg) by Umoren *et al.* (2024), Abeokuta, Nigeria (81.6 mg/kg) by Famuyiwa *et al.* (2024) and Abeokuta, Nigeria (29.4 mg/kg) by Umoren *et al.* (2025).

The level of Manganese (Mn) in the dust ranges from 15.3 - 39.8 mg/kg with a mean of 27.9±7.77 mg/kg. The level of Mn in the dust was lower than the report made by other authors from various studied such as Sydney, Australia (220 mg/kg) (Israel *et al.,* 2019), Jeddah, Saudi Arabia (391 mg/kg) (Mansour *et al.,* 2019) and Adodo-Ota, Nigeria (229 mg/kg) by Umoren *et al.* (2024).

3.2 Pollution indices of TEs in filter dusts

Geo-accumulation index (I-geo) of TEs in the dust is presented in Table 3. This shows that Cd (0.71) has the highest I-geo value appearing to moderately contaminate the dust. However, the dusts showed no contamination from Fe (-0.21), Pb (-0.81), Ni (-1.57), Cr (-2.79), Zn (-1.53), and Mn (-0.71). The TEs appear in a downtrend pattern of Cd>Fe>Mn>Pb>Zn>Ni>Cr.

Enrichment factor (EF) of TEs in the dust is presented in Table 4. This shows that Cd (8.23) had the highest EF value indicating a severe enrichment in the dust while Fe (1), Pb (0.25), Ni (0.043), Cr (0.0013), Zn (0.048) and Mn (0.315) indicating minimal enrichment. The TEs appear in a downward trend mirroring that of the I-geo index.

3.3 Correlation Coefficient of TEs in filter dust

Elemental relationship gives unique insight into their sources and routes in the environment (Famuyiwa *et al.,* 2024). Pearson's correlation conducted between the elements presented in Table 5 indicated that iron (Fe) had a positively

Table 3: I-geo index of TEs in filter dust

TEs	Mean±SD	I-geo value	I-geo grade	Pollution Intensity
Fe	43900±16500	-0.21	0	Uncontaminated
Pb	4.67±1.90	-0.81	0	Uncontaminated
Ni	2.73±0.99	-1.57	0	Uncontaminated
Cd	2.30±2.30	0.71	0-1	Moderately contaminated
Cr	0.11±0.06	-2.79	0	Uncontaminated
Zn	37.9±12.1	-1.53	0	Uncontaminated
Mn	27.9±7.77	-0.71	0	Uncontaminated

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Table 4: EF of TEs in filter dust

TEs	Mean ±SD	EF Value	EF Scale	EF Grade
Fe	43950.0± 16454.6	1	EF<2	Minimal enrichment
Pb	4.67 ± 1.90	0.251	EF<2	Minimal enrichment
Ni	2.73±0.99	0.043	EF<2	Minimal enrichment
Cd	2.30±2.30	8.23	EF=5-20	Severe enrichment
Cr	0.11±0.06	0.0013	EF<2	Minimal enrichment
Zn	37.9±12.1	0.048	EF<2	Minimal enrichment
Mn	27.9±7.77	0.315	EF<2	Minimal enrichment

Table 5: Correlation matrix of TEs in filter dust

	Fe	Pb	Ni	Cr	Cd	Zn	Mn
Fe	1						
Pb	0.302	1					
Ni	0.319	0.507	1				
Cr	**0.771****	0.418	0.145	1			
Cd	-0.310	-0.159	0.249	-0.273	1		
Zn	**0.683***	0.550	0.300	**0.653***	0.001	1	
Mn	0.152	**0.682***	0.551	0.348	-0.206	0.473	1

***. Correlation is significant at p<0.01 *. Correlation is significant at p<0.05*

strongly relationship was observed between Cr and Zn (r= 0.653, p<0.05). The observed relationship between the elements can be grouped into two: mixed geogenic and anthropogenic sources (Fe, Cr and Zn) and strict anthropogenic sources (Pb and Mn; Cr and Zn). The anthropogenic sources could be linked to the casing and the accompanying components of the air conditioners.

3.4 Human Health Risk Assessment of TEs in filter dust

The non-cancer and cancer risks of exposure to the TEs were estimated for adult (18 -70 years) and children (1 -17 years) through three different exposure pathways (i.e. ingestion, dermal contact and inhalation) to the filter dust.

The mean daily dose of TEs in filter dusts is presented in Table 6. This shows that ingestion was the major pathway of exposure with Fe as the most dosed TE for adult (3.10E-01) and children (2.89E+00) respectively. This is in good support with previous studies reported by Mehr *et al.* (2017) and Yadav *et al.* (2019). Furthermore, the study shows that the children group was vulnerable to TE exposure through ingestion which is explainable due to their hand -mouth behaviour (Famuyiwa *et al.*, 2022) while the adults were more exposed through dermal contact.

The hazard index (HI) value for individual TE presented in Table 7 and visualized in Figures 2a & b; revealed that all studied TEs were <1 indicating a non-cancer effect on human. Furthermore, the HI value for the TEs showed a downward pattern of Pb (1.10E-01) > Cd (3.12E-02) > Ni (2.75E-03) > Cr (5.40E-03) > Mn (1.44E-03) Zn (9.11E-04) for adult group while Cd (5.03E-02) > Mn (1.31E-02) > Cr (5.03E-02) > Pb (1.27E-03) > Ni (2.78E-03) > Zn (1.31E-02) for children group, this is not in agreement with the work of Yadav *et al.* (2019) who recorded HI value for Pb and Cr in human group >1, indicating a significant non-cancer risk for the group.

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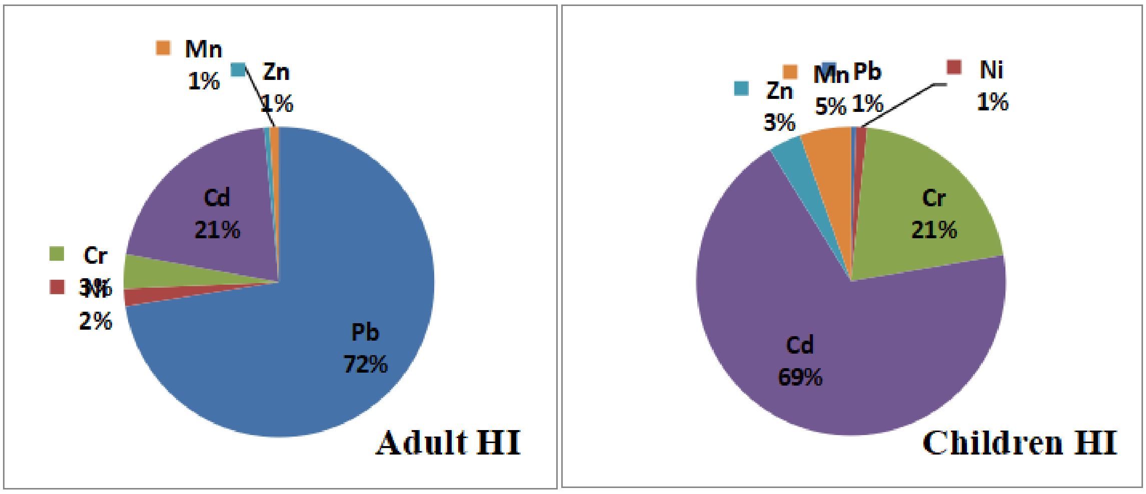
Table 6: Mean daily dose (MDD) of TEs in filter dust

Human Receptors	Exposure Routes	Toxic Elements						
		Fe	**Pb**	**Ni**	**Cr**	**Cd**	**Zn**	**Mn**
Adult	**MDD$_{ing}$**	3.10E-01	3.29E-05	1.92E-05	1.62E-05	7.75E-07	2.67E-04	1.97E-04
	MDD$_{inh}$	6.19E-08	6.58E-12	3.85E-12	3.24E-12	1.55E-13	5.34E-11	3.93E-11
	MDD$_{dermal}$	7.15E-03	7.60E-07	4.44E-07	3.74E-07	1.79E-08	6.17E-06	4.54E-06
Children	**MDD$_{ing}$**	2.89E+00	3.07E-04	1.80E-04	1.51E-04	7.23E-06	2.49E-03	1.83E-03
	MDD$_{inh}$	1.10E-07	1.17E-11	6.82E-12	5.75E-12	2.75E-13	9.47E-11	6.97E-11
	MDD$_{dermal}$	8.09E-03	8.60E-07	5.03E-07	4.23E-07	2.03E-08	6.98E-06	5.14E-06

Table 7: Non cancer risk of TEs in filter dust

Human	Exposure	Toxic Elements					
		Pb	**Ni**	**Cr**	**Cd**	**Zn**	**Mn**
Adult	**HQ$_{ing}$**	1.10E-01	1.75E-03	5.40E-03	1.62E-02	8.90E-04	1.41E-03
	HQ$_{inh}$	-	6.51E-08	1.08E-07	3.24E-09	-	7.86E-10
	HQ$_{dermal}$	2.17E-04	1.01E-03	-	1.50E-02	2.06E-05	3.24E-05
	HI	**1.10E-01**	**2.75E-03**	**5.40E-03**	**3.12E-02**	**9.11E-04**	**1.44E-03**
Children	**HQ$_{ing}$**	1.02E-03	1.64E-03	5.03E-02	1.51E-01	8.30E-03	1.31E-02
	HQ$_{inh}$	-	1.15E-07	1.92E-07	5.75E-09		1.39E-09
	HQ$_{dermal}$	2.46E-04	1.14E-03		1.69E-02	2.33E-05	3.67E-05
	HI	**1.27E-03**	**2.78E-03**	**5.03E-02**	**1.68E-01**	**8.32E-03**	**1.31E-02**



Figures 2a & b: Percentage HI of each TEs for adult and children group in filter dust

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The cancer risk (CR) value for the TEs in the dust is presented in Table 8. This shows that TEs such as Pb (9.61E-08, 2.24E-07), Ni (4.09E -12, 1.81E-12), Cr (4.55E-11, 2.02E-11) and Cd (3.35E-13, 1.49E-13) for both adult and children respectively, were less than the acceptable range ($1x10^{-6}$ - $1x10^{-4}$) suggesting a negligible cancer risk for human group on exposure (Wu *et al*., 2015). This is in contrast to the work of Israel *et al.* (2019) and Umoren *et al*., (2024) who reported Cr in dust to be higher than $1x10^{-6}$ but less than $1x10^{-4}$ in dust from Australia and Nigeria. Furthermore, the CR value for the TEs appear in a downward trend of Pb>Ni>Cr>Cd for the human groups.

Table 8: Cancer Risk of TEs in filter dust

Human Receptors	**Exposure route**	**Toxic Elements**			
		Pb	**Ni**	**Cr**	**Cd**
Adult	CR_{ingest}	9.61E-08	-	2.78E-06	-
	CR_{inhale}	9.49E-14	4.09E-12	4.55E-11	3.35E-13
	CR_{dermal}	-	-	-	-
	Total CR	9.61E-08	4.09E-12	4.55E-11	3.35E-13
Children	CR_{ingest}	2.24E-07	-	6.50E-06	-
	CR_{inhale}	4.20E-14	1.81E-12	2.02E-11	1.49E-13
	CR_{dermal}	-	-	-	-
	Total CR	2.24E-07	1.81E-12	2.02E-11	1.49E-13

Conclusion

A study investigated level of TEs in AC filter dust from selected offices at the New Secretariat in Abeokuta, Ogun State. The dusts were collected, digested and the TEs analyzed using Atomic Absorption spectroscopy (AAS). The result showed that the TEs were with permissible limits. The pollution indices revealed that the AC dust was moderately polluted and severely enriched with Cd. The observed relationship between the TEs can be grouped into mixed geogenic and anthropogenic sources (Fe, Cr and Zn) and strict anthropogenic sources (Pb and Mn; Cr and Zn) linked to the casing and the accompanying components of the air conditioners. Furthermore, human health risks assess revealed a negligible non-cancer and cancer risk to the human group. Therefore, it is recommended that despite trace elements being within permissible limits and posing negligible health risks, the moderate pollution and severe Cd enrichment observed call for regular AC filter cleaning, routine indoor dust monitoring, and improved ventilation to minimize potential long-term exposure.

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