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Assessment of Heavy Metal Contamination and their Pollution Index in Settled Dust from Kaduna Polytechnic Campuses, Kaduna State, Nigeria

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Abstract **Original Research Article**

The concentration, distribution, and ecological risk associated of selected heavy metals (Zn, Cd, Pb, Ni, and Cr) in indoor dust samples across the four colleges at Kaduna Polytechnic which includes College of Administration and Social Science (CASSS), College of Environmental Studies (CES), College of Science and Technology (CST), and College of Business and Management Studies (CBMS). Low to moderate concentrations of heavy metals were observed in CASSS, CES, and CBMS confirming their mostly non-industrial and administrative activities. Higher concentrations were observed in CST, this may likely be attributed to laboratory based and technical operations involving reagents, equipments, and experimental procedures. However, Zn and Pb indicated notable variability, while Cd concentration remain consistently low whereas approached limits in some cases. The comparative analysis of the heavy metals with WHO/FAO and US EPA standards indicated that all measured concentrations were within acceptable limits, though cadmium requires continuous monitoring due to its toxicity. Statistical analysis demonstrated significant anthropogenic contributions to metal accumulation in selected sites. The Contamination factor (Cf) and pollution load index (PLI) assessment have shown localized hotspots, particularly at DAP, DAB, and DA, with different levels of ecological risk varying from moderate to very high contamination. Overall, while current pollution levels suggest low immediate health risk, the presence of anthropogenic influences and potential for long-term accumulation highlight the need for periodic monitoring and improved environmental management practices.

Keywords: Heavy metals, Indoor dust, Contamination factor (CF), Pollution load index (PLI).

Background of the Study

Heavy metals occur naturally in the environment and are vertically aligned and defined because of the atomic weights, and densities at least five times greater than that of water. These metals obtain elements, such as Lead (Pb), Cadmium (Cd), Mercury (Hg), Chromium (Cr), and Arsenic (As), that are persistent environmental pollutants, and are toxic to human health (Ali et al., 2021). In living organisms, the metal is essential in trace amounts, and in large amounts, they are poisonous to humans, animals, and plants.

These metals are used in urban areas, and in university and polytechnic campuses, from human activities. Some of these activities are;

vehicular movement, mechanical wearing, incineration of wastes, construction of buildings and burning of fossil fuels. These pollutants keep adding to surface dust on walls, floors, furniture, and plants (Yusuf et al, 2020). In such environments, the risk of exposure is very high especially to students and staff. In such environments, the risk of exposure is very high especially to students and staff.

Both indoor and outdoor dust act as reservoirs for various contaminants, including heavy metals. Human exposure typically occurs through ingestion, inhalation, or dermal contact. Furthermore, settled dust can be re-suspended into the atmosphere, creating a cycle of inhalation risk. This is particularly concerning at educational establishments like Kaduna Polytechnic, where the academic community may be unknowingly exposed to environmental contamination (Nwachukwu & Uzoije, 2019).

Studies from Nigeria and other developing countries show that schools situated in busy urban areas often have dust with heavy metal concentrations that surpass the safety limits issued by the US Environmental Protection Agency (USEPA) and the World Health Organization (WHO) (Ihedioha et al., 2017; WHO, 2021). As a result, cumulative health risks have become a serious issue for at-risk populations such as young adults.

Being one of the largest polytechnics in Sub-Saharan Africa and the most commercially integrated in Nigeria, dust pollution risks are high for Kaduna Polytechnic, as the institution is located around commercial hubs, motor parks, roadside traders, and busy roads. Despite these risks, there is a lack of localized studies determining the level of dust pollution on the campuses of the institution.

Public health and environmental management measures to ensure the safety of the academic community on campuses of higher learning need to include the dust of the campuses. The objective of this study is to provide a basis for estimating the status of pollution and dust pollution levels on the various campuses of Kaduna Polytechnic.

The principle issue this study attempts to address is the lack of data on the concentration of heavy metals and the associated health risks to the population in the institution. Without this data, any attempts to mitigate these risks and develop environmental health management strategies will remain hypothetical. This study is one of the first to be conducted in Northern Nigeria to consider specific pollution levels (Concentration Factor, Pollution Level Index) in the assessment of dust in academic institutions, thereby providing a reference for the study of anthropogenic pollution in the dust of educational institutions.

Materials and Methods

Description of the Study Area

College of Administrative Studies & Social Sciences (CASSS)

The CASSS, also known as the "College of Administration," is located in Sabon Tasha, Chikun LGA, Kaduna at 0.4404°N, 7.4704°E (approximately 10°26′26″N, 7°28′13″E)(Geoview, 2023; Maps Coordinates, 2022). This college offers courses in Public Administration, Local Government Studies, Social Sciences, and related fields. It also provides career training in governance, policy and administration in the public and private sectors. The college is located at the southern end of the Kaduna metropolis at the Sabon Tasha campus (Kadpoly, 2024).

College of Environmental Studies (CES)

The College of Environmental Studies is situated at Barnawa, Kaduna South LGA, with broad national and global coordinates of 10.4702° N, 7.4295° E (approx. 10°28′13″N, 7°25′46″E) (Geoview, 2023). It is the academic center for the disciplines of the building environment and sustainable development at Kaduna Polytechnic. The College runs diploma and higher national diploma programmes in Architecture, Building Technology, Quantity Surveying, Urban and Regional Planning, Estate Management, and related disciplines. The College is pivotal to Kaduna Polytechnic's promise of producing skilled personnel with the requisite professional and technical expertise to address the challenges Nigeria is facing in the areas of infrastructure, housing and environmental management (Kadpoly, 2024).

College of Business and Management Studies (CBMS)

Situated in Unguwan Rimi Campus, Kaduna North LGA, with coordinates 10.521365° N, 7.44249° E, the College of Business and Management Studies is the main hub for the training of Business Management professionals, Accountancy, Banking and Finance, Business Administration, Marketing, and Office Technology Management.

College of Science and Technology (CST)

The College of Science and Technology is located at the Tudun Wada Main Campus, Kaduna South LGA, with approximate coordinates of 10.511° N, 7.425° E. It has the College of Pure and Applied Sciences, Computing agriculture and Technology-related programme. The College is dedicated to high-impact technology-oriented teaching and offers Applied Biology, Applied Chemistry, Computer Science, Food Technology, and Statistics. It strives to prepare technicians and scientists who will foster innovation and address the region's industrial research requirements.

Study Area and Sample Collection

Map of the Study Area

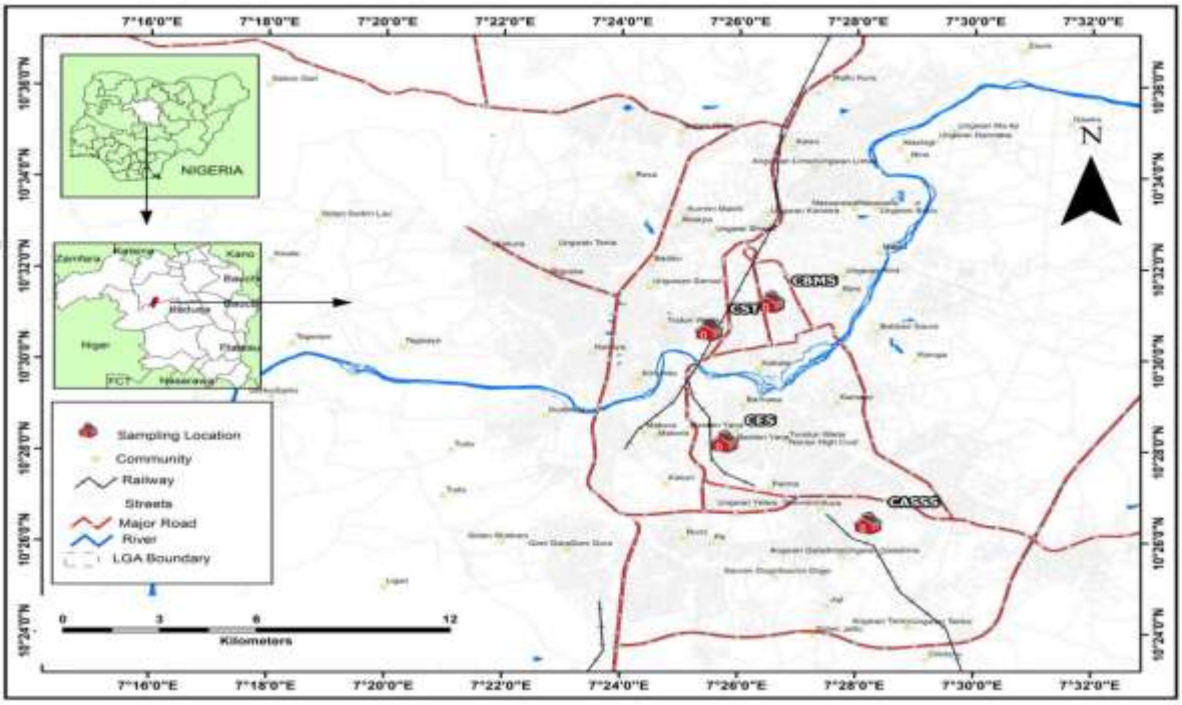

Figure 1: Map Showing Sample Collection Points across Kaduna Polytechnic Colleges

Sample Collection

The study will take place at the various campuses of Kaduna Polytechnic across the Kaduna metropolis, Northwestern Nigeria. Sample sites included the classrooms and laboratories of the College of Administrative Studies and Social Sciences (CASSS), the College of Environmental Studies (CES), College of Business and Management Studies (CBMS), and the College of Science and Technology (CST).

To comply with the procedures as presented by (Skorbiloicz et al. 2020), Indoor and outdoor dust will be collected with a clean broom and plastic dust collection bags. Samples will be placed in clean paper envelopes and sealed for labeling, allowing them to be tracked and identified easily. Face masks and gloves will be worn by the personnel to eliminate contamination and to ensure the safety of the personnel.

In the Control Sampling, the area to be sampled will be away from the institution and will be characterized by low commercial and human activities (Okoro et al. 2025). This study is aimed at the dry season, i.e. November 2025 to April 2025, since rainfall during the study will lead to leaching/redistribution of heavy metals (Ogunbanjo et al. 2023). The samples will be transported to Kaduna Polytechnic laboratory for preparation and subsequent physico-chemical analysis, in well labeled improvised polythene bags.

Sample Preparation and Digestion

Dust samples were first dried at 100-110 °C to remove moisture. After drying, samples were cooled and sieved through a 2 mm nylon mesh to obtain a uniform particle size, following the method described by Molnar (2016).

A precisely weighed 1.0 g portion of each dried and sieved dust sample was placed into a 100 cm^3 Pyrex beaker. Then, they were digested with a mixture of 3 cm^3 of concentrated nitric acid (HNO_3) and 2 cm^3 of perchloric acid ($HClO_4$) for 1 hour at 100 °C in a fume cupboard. After the mixture cooled, the digest was filtered and the volume was adjusted to 50 cm^3 with deionized water.

Statistical Analysis

The IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA) will be used to conduct all statistical analyses. Data will be represented as mean ± SD. The Shapiro–Wilk and Levene's tests will be used to evaluate the normality and homogeneity of variance for the datasets prior to analysis.

One-way analysis of variance (ANOVA) will be used to assess the differences in concentration of heavy metals in the sampling departments and the control site. Where there were differences, Tukey's Honestly Significant Difference (HSD) post hoc test will be used for pairwise comparisons. A significance level of $p < 0.05$ will be used.

Evaluation of Pollution Indices

Using pollution indices is intended for the first time in this study for the dust samples to measure heavy metal contamination, in order to provide a comprehensive measure of the degree of contamination and the degree of human impact for the different dust sample collection points. In this study, contamination will be measured using the CF and PLI methods (Habib et al., 2021; Oboshenure & Airen, 2021).

Contamination Factor (CF)

Individual heavy metals in street dust will be evaluated using the contamination factor (CF). CF is defined as a metal's measured concentration (Cn) divided by the metal's background concentration (Cb) (Ouchir et al., 2016; Chandrasekaran et al., 2016).

$$CF=\frac{Cn}{Cbn}$$

where:
C_n = measured concentration of the metal in the dust sample
C_{b_n} = background concentration of the metal

The degree of contamination was classified as follows: $CF < 1$ (low contamination); $1 \leq CF \leq 3$ (moderate contamination); $3 \leq CF < 6$ (considerable contamination); $CF \geq 6$ (very high contamination).

Pollution Load Index (PLI)

The Pollution Load Index (PLI) was determined to show the extent of heavy metal pollution at each sampling site. The PLI was calculated as the geometric mean of the contamination factors (CF) for the metals analyzed:

$$PLI = \sqrt[n]{CF_1 \times \ldots \times CF_n}$$

A value of zero shows that there is nothing wrong at the site, and everything is perfect. A value of one shows that there is some level of baseline pollutants present, and any value higher than one shows that there is worsening pollution at the site (Harikumar and Jisha, 2010).

where *n* represents the number of metals assessed.

PLI values were interpreted as follows:
PLI = 1 indicates baseline levels of pollutants;
PLI < 1 indicates no pollution (perfection);
PLI > 1 indicates progressive deterioration of site quality.

Results

Table 1: Mean Concentrations of Heavy Metals (mg/kg) in Indoor Dust from the College of Administration Studies and Social Sciences, Kaduna Polytechnic

Department	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cr (mg/kg)
Public Administration	0.749 ± 0.026	0.015 ± 0.000	0.227 ± 0.003	ND	0.281 ± 0.003
Local Government	0.948 ± 0.017	0.011 ± 0.000	0.223 ± 0.001	ND	0.313 ± 0.001
Mass Communication	1.605 ± 0.011	0.017 ± 0.000	0.472 ± 0.002	0.054 ± 0.001	0.363 ± 0.001
Social Development	0.989 ± 0.009	0.011 ± 0.001	0.184 ± 0.003	0.004 ± 0.000	0.329 ± 0.001
Languages	1.088 ± 0.012	0.014 ± 0.001	0.294 ± 0.004	0.009 ± 0.004	0.836 ± 0.007
Control	**6.973 ± 0.021**	**0.014 ± 0.001**	**10.620 ± 0.008**	**0.140 ± 0.002**	**0.836 ± 0.007**

Table 2: Mean Concentrations of Heavy Metals (mg/kg) in Indoor Dust from the College of Environmental Studies, Kaduna Polytechnic

Department	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cr (mg/kg)
Environmental	1.944 ± 0.004	0.016 ± 0.001	0.640 ± 0.011	0.072 ± 0.002	0.338 ± 0.001
Estate Management	1.264 ± 0.003	0.013 ± 0.000	0.267 ± 0.001	ND	0.340 ± 0.002
Building	1.002 ± 0.004	0.010 ± 0.001	0.200 ± 0.001	0.003 ± 0.003	0.317 ± 0.001

Department	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cr (mg/kg)
Quantity Surveying	1.194 ± 0.014	0.012 ± 0.001	0.624 ± 0.001	ND	0.283 ± 0.002
Architecture	1.478 ± 0.007	0.012 ± 0.000	0.455 ± 0.002	0.013 ± 0.001	0.294 ± 0.000
Control	**1.522 ± 0.007**	**0.012 ± 0.000**	**0.465 ± 0.001**	**0.013 ± 0.001**	**0.270 ± 0.001**

Table 3: Mean Concentrations of Heavy Metals (mg/kg) in Indoor Dust from the College of Science and Technology, Kaduna Polytechnic

Department	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cr (mg/kg)
Applied Chemistry	1.440 ± 0.020	ND	ND	0.070 ± 0.002	0.920 ± 0.010
Applied Biology	9.380 ± 0.030	0.130 ± 0.010	0.830 ± 0.010	ND	0.570 ± 0.010
Applied Physics	7.260 ± 0.020	0.110 ± 0.001	0.890 ± 0.020	0.500 ± 0.010	0.520 ± 0.020
Computer Science	3.190 ± 0.020	0.030 ± 0.002	0.220 ± 0.001	ND	0.280 ± 0.001
Printing	1.480 ± 0.020	0.010 ± 0.001	0.450 ± 0.010	0.810 ± 0.020	0.290 ± 0.002
Control	**2.100 ± 0.010**	**0.060 ± 0.002**	**0.130 ± 0.001**	**ND**	**0.270 ± 0.001**

Table 4: Mean Concentrations of Heavy Metals (mg/kg) in Indoor Dust from the College of Business and Management Studies, Kaduna Polytechnic

Department	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cr (mg/kg)
Accountancy	1.940 ± 0.020	0.020 ± 0.002	0.640 ± 0.010	1.070 ± 0.020	2.340 ± 0.020
Banking and Finance	ND	ND	0.270 ± 0.010	ND	0.340 ± 0.010
Management Studies	1.260 ± 0.020	ND	ND	0.220 ± 0.010	0.320 ± 0.020
Procurement	1.190 ± 0.020	0.030 ± 0.002	0.620 ± 0.010	ND	1.280 ± 0.020
Marketing	1.480 ± 0.020	0.010 ± 0.001	ND	0.010 ± 0.001	0.290 ± 0.002

Department	**Zn (mg/kg)**	**Cd (mg/kg)**	**Pb (mg/kg)**	**Ni (mg/kg)**	**Cr (mg/kg)**
Control	**1.230 ± 0.010**	**0.070 ± 0.003**	**ND**	**0.190 ± 0.010**	**2.070 ± 0.020**

Table 5: Heavy Metal Concentrations Compared with Standard Limits

Heavy Metal	**Highest Value (mg/kg)**	**WHO/FAO (mg/kg)**	**US EPA (mg/kg)**	**Status**
Zn	9.38	50	300	Within Limits
Cd	0.70	0.80	3	Borderline
Pb	0.89	35	150	Within Limits
Ni	1.07	35	75	Within Limits
Cr	2.34	100	400	Within Limits

Table 6: Statistical Significance of Heavy Metal Concentrations Compared to Control

Heavy Metal	**Site**	**Mean**	**Control**	**p-value**	**Significance**
Zn	DAB	9.38	2.10	0.002	**
Cd	CST	4.55	2.88	0.034	*
Pb	DA	0.70	0.07	0.001	**
Ni	DAP	0.89	0.13	0.008	**
Cr	DA	1.07	0.19	0.012	*
Zn	DA	2.34	2.07	0.410	NS

Keys: *$p < 0.05$ = Significant (*)*, $p < 0.01$ = Highly Significant (**), $p > 0.05$ = Not Significant (NS), DAB = Applied Biology; CST = College of Science &Technology; DAP = Applied Physics; DA = Accountancy

Table 7: Contamination Factor (CF)

Heavy Metal	**Site**	**CF Value**	**Interpretation**
Cd	DA	10.00	Very High Contamination
Pb	DAP	6.85	Very High Contamination
Pb	DAB	6.38	Very High Contamination
Ni	DA	5.63	Considerable Contamination
Zn	DAB	4.47	Considerable Contamination

Heavy Metal	Site	CF Value	Interpretation
Zn	CST	1.58	Moderate Contamination
Cr	DA	1.13	Moderate Contamination

Table 8: Pollution Load Index (PLI)

Rank	Sampling Site	PLI	Environmental Status
1	DAP (Set 3)	5.30	Extremely Deteriorated
2	DAB (Set 3)	3.38	Severely Deteriorated
3	DA (Set 4)	2.84	Moderately Deteriorated
4	CST	1.22	Baseline/Slightly Deteriorated

Discussion

Heavy Metals in CASSS (Table 1)

Córdoba et al. (2025) suggest the following factors regarding the presence of zinc in mass communication department (1.605 mg/kg): vehicular emissions, tire wear, galvanization, and paint residue. The elevated concentrations (10.620 mg/kg) noted from control samples suggest outdoor to indoor transfer mechanisms are taking place, including air infiltration, resuspension of contaminated dust, or foot traffic (Rasmussen et al., 2013). This suggests there are more significant sources of heavy metal contamination from the outside environment than from activities inside the CASSS.

Cadmium (Cd) was found to have very low concentrations (0.011 - 0.017 mg/kg) in the various departments which show that there was low anthropogenic input (Yuan et al., 2019). The mass communications department had the highest Pb concentration which was 0.017 mg/kg. However, the Pb levels in the departments are still lower than the control samples which can show that there are not many sources present including decaying paint, or legacy emissions from gasoline with lead (Unsal, (2025).

Some departments did not have Nickel (Ni) inclusive of the Public Administration and Local Government department whereas others had very low (0.004 - 0.054 mg/kg) which indicates that the contamination was low. The Languages department however, had the highest concentration of Chromium (Cr) which ranged from 0.281 to 0.836 mg/kg. The low concentration and low range of Ni and Cr indicates that the study area limited industrial, laboratory or specialised educational activities (Lwin et al., 2022).

In general, a reflection of the non-industrial nature of CASSS and the lack of substantial sources of pollution in the indoor environment is evident, especially in the levels and variability of heavy metals across all the departments. Less heavy metal accumulation in administrative and non-technical academic environments has been documented in previous studies and is in line with our findings (Li et al., 2022; Wei et al., 2021).

Heavy Metals in CES (Table 2)

Analysis of heavy metals in indoor dust at the College of Environmental Studies (CES) at Kaduna Polytechnic have shown low concentrations to moderate, with small variances due to departmental activities (Akinpelu et al, 2026). For example, concentrations of dust zinc (Zn) ranged from 1.002 to 1.944 mg/kg, with the highest in the Environmental Department. Sample control was at 1.522 mg/kg, which is comparable to departmental dust, indicating that indoor dust and outdoor dust are also at CES (Wu et al., 2023).

The concentrations of Cadmium (Cd) are low and were consistent across Environmental (the highest at 0.016 mg/kg) and the other departments (0.010 to 0.016 mg/kg) indicating little deviation to that due to human activity (anthropogenic). The low concentrations show that there is little risk of Cd contamination across CES (Yuan et al, 2019).

Concentration of Lead (Pb) is highest at 0.640 mg/kg in the Environmental Department, followed by Quantity Surveying at 0.624 mg/kg. The two departments record Pb concentration from 0.200 mg/kg to 0.640 mg/kg level and may be due to dust from construction activities and renovation, as well as old contamination from leaded paints (Cook et al, 2022).

Nickel (Ni) was absent at the two departments, Estate Management and Quantity Surveying, and the other departments had traces (0.003–0.072 mg/kg) with Environmental having the highest as well. The presence of Ni is believed to be as a result of low localized activity, due to manipulation of sample materials or environmental-sampling devices at the sample collection areas (Genchi et al, 2020).

The concentration of Chromium (Cr) in Estate Management and Environmental Cr was slightly higher than other departments, ranging from Cr 0.283 to 0.340 mg/kg. Andrade et al. (2026) noted that the Cr presence may be due to construction materials used by the departments: cement, paints, and metal fittings.

The slightly higher concentration of Pb and Zn in the Environmental and Construction related departments suggests that, while they engage in some academic work that may involve building materials, field samples, and design work, the contributions from such work are likely very small. These findings are consistent with other research that has documented higher levels of indoor dust metal loads in construction and environmental science related departments due to the dust created during the construction and renovation process (Isley et al., 2022; Kameda & Ishii, 2012).

Heavy Metals in CST (Table 3)

Dust samples were taken from the College of Science and Technology (CST), Kaduna Polytechnic (Table 3), and as compared to the other colleges, the concentrations of heavy metals found were highest. This might mean that there is more interaction from hands-on and technical activities at this location. For laboratory-grade Zinc (Zn) reagents, a normal concentration range is 1.44 to 9.38 mg/kg. Here, the highest concentration of Zinc (Zn) is recorded at 9.38 mg/kg for Applied Biology and 7.26 mg/kg for Applied Physics. Elevated levels of Zinc (Zn) are attributed to the reagents, metals, and/or residues from experimental procedures (Huang et al., 2021). The control sample at 2.10 mg/kg is much lower than peak values of the other samples, and this also suggests the increased indoor academic activities of the college.

As for Cadmium (Cd), there were concentrations detected (ND) in Applied Chemistry, and the highest in Applied Biology (0.13 mg/kg) and is relatively lower in Applied Physics (0.11 mg/kg). Here, the contaminants are most likely experimental remnants and laboratory-grade reagents. The tech departements have much more of it than other colleges therefore this demonstrates localized human activities at a high degree.

Lead (Pb) concentrations were also noted to be absent (ND) in Applied Chemistry and are the highest in Applied Physics at 0.89 mg/kg, and also high in Applied Biology at 0.83 mg/kg which contributes to the highest Pb concentrations across the sampled colleges. The likely sources for these mean laboratory-grade chemicals, laboratory electronic, solder, and metal equipment used in the science departments (Leung et al., 2008).

Nickel (Ni) showed high variability with concentration ranging from ND to 0.81 mg/kg. The highest concentration level of 0.81 mg/kg was found in the Printing department. Other notable cases include 0.50 mg/kg in Applied Physics and 0.07 mg/kg in Applied Chemistry. High concentrations in the Printing department may be due to printing inks while those found in Applied Physics and Applied Chemistry may be due to presence of metal alloys, components, and laboratory equipment. The absence of Ni in some departments indicates an uneven distribution of activities in the laboratory.

In the Applied Chemistry department, Chromium (Cr) had the highest concentration of 0.92 mg/kg, while the other departments had a moderate level of concentration. The concentration of Cr in Applied Chemistry may be due to the presence of chemical reagents, metals, and laboratory work that involved chromium.

The presence of laboratory activities, equipment, and technical work in CST is the likely reason for the pollution from laboratory dust. The higher concentration of Zn, Pb, Cr, and Ni is consistent with previous research which states that science and technology environments have higher pollution due to heavy metals (Huang et al., 2023; Leung et al., 2008).

Heavy Metals in CBMS (Table 4)

Table 4 shows the heavy metals concentrations found in indoor dust at the College of Business and Management Studies (CBMS), Kaduna Polytechnic, and indicate that even though there are low levels of heavy metals in every department, they are still low somewhat consistently due to the low technical and administrative history of the college. However, there are some localized increases, specifically for Chromium (Cr) and Nickel (Ni). This matches the findings of Shah (2026).

For the Department of Banking and Finance, Zinc (Zn) concentration was (ND) (not detected), and in Accountancy, it was 1.94 mg/kg. Most departments evidenced levels of Zn in the range between Banking and Finance Department to Accountancy Department, whose levels were considered moderate. The relatively high concentration of Zn in Accountancy may be due to indoor sources (office equipment, coated furniture and construction) and to a small extent, dust that comes from outdoors (Lei et al., 2025).

Cadmium (Cd) was detected at low concentrations (0.01-0.03 mg/kg) in all departments, except for the control sample that had 0.07 mg/kg). This tells us that the levels of Cd within CBMS (College of Business and Management Studies) are minimum, and thus supports the findings of Olowojuni et al. (2025).

Lead (Pb) concentrations ranged between ND and 0.64 mg/kg. The Accountancy department had the highest value, followed by Management Studies (0.62 mg/kg). Ageing paint, office supplies, or contaminated outdoor dust that infiltrates the office may be the reasons for these levels (Sowers et al., 2024).

With Nickel (Ni), the most variability was present: the highest concentration was in Accountancy (1.07 mg/kg), while it was absent in some departments such as Banking and Finance and one of the samples from the Management Studies. The source of Ni in Accountancy could be from the metallic office furniture or electronic devices and equipment, which are common indoor sources of nickel (Roy et al. 2024).

of the analyzed metals the highest range of concentration for Chromium (Cr) was present from 0.29 to 2.34 mg/kg: the greatest being in Accountancy. One of the control samples also contained a high value (2.07 mg/kg) which suggests that both indoor (like metal furniture and coated equipment) and outdoor stuff, also, are contributing to the presence of Cr in CBMS (Lei et al. 2025).

It seems that the low concentration of heavy metals in CBMS is due to occupational materials and the infrequent presence of heavy metals due to the refinement of industrial and laboratory activities. These findings are in agreement with other studies which examine the low presence of heavy metals in a non-laboratory and non-administrative setting in the educational environment (Rahman, et al., 2021).

Comparative Analysis with Permissible Limits (Table 5)

Pollution Load Index (PLI) (Table 8)

The cumulative data on heavy metals and their loading indices show progressive gradients of environmental decline at the various sampled sites. Tomlinson et al. (1980) positively associate a PLI value of greater than 1.0 with a progressive decline in the site's geochemical quality.

Contamination site DAP (Set 3) is the most contaminated site with the highest PLI rating of 5.3. This value is a direct result of the previously found "Very High" levels of Lead. Such a score implies the site is critically a "hotspot" with regards to cumulative metals and their concentrations, for it is far beyond the natural environmental carrying capacity and is extremely detrimental to the surrounding living organisms (Angulo, 1996).

DAB (3.38) and DA (2.84) PLI scores are well above the 1.0 threshold, and are, thus, classified as "Severely" and "Moderately" deteriorated. The DAB site suffers most from the combined effect of Lead and Zinc. Site DA has the highest individual Cf, which happens to be 10 (Cadmium), and it is ranked 3rd in terms of PLI. This means that even though DA has a specific pollutant that is in high concentration, Site DAP is the one that has a higher concentration on multiple metals more consistently than DA.

Out of all the sampled sites, Site CST (College) has the PLI value of 1.22, which is a reflection of 1.22 and the closest to a baseline condition. The site is "slightly deteriorated" (as PLI > 1), it has a case of minimal human interference. Future remediation standards could use this site as a control benchmark (Usero et al., 2000).

Conclusion

The study demonstrates that indoor dust across the colleges of Kaduna Polytechnic contains measurable levels of heavy metals, with variations largely influenced by the nature of activities within each college. Non-technical environments such as CASSS and CBMS exhibited relatively low contamination levels, primarily influenced by outdoor dust infiltration and minor indoor sources. CES showed slightly elevated levels linked to construction-related activities, while CST recorded the highest concentrations due to intensive laboratory and technical operations. Although all measured heavy metals were within international permissible limits, the detection of elevated contamination factors and pollution load indices at specific sites indicates localized anthropogenic impacts. Cadmium and lead, in particular, pose potential ecological and health concerns due to their toxicity and persistence, despite their current concentrations being within safe limits. Statistical analysis further confirmed that several metal concentrations are significantly influenced by human activities rather than natural background levels. The findings suggest that, while the overall non-carcinogenic risk is low, there is a need for continuous environmental monitoring, especially in high-activity areas such as CST and identified hotspot sites. Preventive measures such as improved ventilation, dust management, regular cleaning, and control of indoor sources of contamination should be implemented. Additionally, future studies should focus on long-term exposure risks and include bioavailability assessments to better understand potential health implications.

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