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Assessment of Indoor Dust in the Chemistry Laboratory of a Tertiary Institute in Zaria, Nigeria

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ABSTRACT

This study assessed trace metal levels, organic compounds, bacteria and fungi isolate in indoor dust in a Chemistry laboratory of a Nigerian tertiary institute. Dust samples, collected by following standard procedures, were digested using a mixture of nitric acid and perchloric acid prior to atomic absorption spectroscopy for trace metal analysis. FTIR spectrometry was employed for functional groups determination while standard microbial methods were employed for bacteria assessment. The trace metal analysis revealed cadmium level of 0.014 mg/kg, 0.002 mg/kg and 0.007 mg/kg in the floor, window and bench top respectively. The copper levels of 0.417 mg/kg, 0.034 mg/kg and 0.055 mg/kg in the floor, window and bench top respectively. The chromium level of 0.216 mg/kg in the floor sample was above permissible limit while 0.038 mg/kg and 0.018 mg/kg for window and bench top respectively. Lead in the floor, window and bench top at 1.214 mg/kg, 0.723 mg/kg and 0.113 mg/kg respectively. The FTIR analysis showed the functional groups in the various samples as OH, N=C=S, C=C, NH_2 C-F, C=C OH, C=C, and CO-O-CO. The bacteriological properties of indoor dust revealed eight bacteria species. This study recommends measures to keep the laboratory environment safe for users.

Keywords: Indoor dust, chemistry laboratory, trace metals, organic compounds, bacteria, fungi

INTRODUCTION

Scientific laboratory in schools, industries, government and military facilities provides controlled conditions for scientific, technological experiment and measurement [1]. However, the laboratory becomes unsafe with settlement of dust particles on floors, benches, windows.

Dust particles is a widely recognized significant reservoir and transporter of diverse environmental pollutant. It contains inorganic, organic and energy indoor chemical contaminant. Among harmful environmental pollutants, metals are most harmful due to their widespread use [2]. Most often, common metals such as copper, zinc, and lead present in indoor dust due to

persistence and resistance to degradation have posed significant toxicity and detrimental impact to human health [3]. Common effect of indoor dust pollution includes allergies, skin irritation and respiratory diseases [4]. According to a report by Ugwu and Ofomatah [5], metals linked to cardiovascular injuries as well as cancer might be contained in indoor dust. Exposure through oral, inhalation, skin contact affect productivity and health status making it a great concern due to the toxic constituent of the dust [5]. Scientifically, it has been validated that indoor environment have two five times pollutant than outdoor environment [6].

This research focuses on assessing the indoor dust composition of chemistry laboratory by investigating the trace metal level, various organic compounds, bacteria and fungi isolates with a view to raise awareness to users which will help improve on sanitation and precautionary measures.

MATERIALS AND METHODS

Sample collection

The dust samples were collected on windows, bench tops and floors in the chemistry laboratory at a Nigerian tertiary institute in Zaria, Kaduna State, northwest Nigeria, using standard procedure [7]. Collected dust was cleaned from hair, debris and sieved through a 100-mesh (150 µm) and placed in clean bags with label.

Sample digestion

The dust sample was dried in an oven at 105 ^{o}C for 24 h. Thereafter, 1.0 g of the fine portion of the dust was weighed and digested with a mixture of nitric acid (HNO_3) and per chloric acid ($HClO_4$) at a ratio of 4:1 on a hot plate at 50 ^{o}C for 21 hours inside a fume hood. The solution was allowed to cool before filtration through filter paper into a 100 ml volumetric flask. The filtrate was made to mark with distilled water. It was then analyzed for (Cu, Cd, Cr and Pb) using an atomic absorption spectrometer (BUK Model 210 VGP) [8].

FTIR spectroscopy

The FTIR spectroscopy (FTIR NICOLET IS10) was performed in the Multiuser Laboratory, Chemistry Department, Ahmadu Bello University Zaria, Kaduna State, Nigeria. The samples were mixed with potassium bromide (KBr) at a ratio of 1:30. Pellets were then prepared and the spectra were captured in the frequency range of 4000 cm^{-1} to 400 cm^{-1} [9].

Bacteria assessment

The bacterial isolates from indoor dust of the Chemistry Laboratory, were characterized using microscopic and biochemical tests.

Biochemical test

Biochemical test was carried out to identify bacteria. Investigations include catalase test, coagulase test, reactions on triple sugar, iron agar, indole, gram staining, oxidase, citrate, methyl red and Voges-proskaur test.

Catalase test

A drop of 3% hydrogen peroxide was placed on a glass slide. A bit of growth from the solid medium was removed with a wire loop and placed in a drop of hydrogen peroxide on the glass slide. A positive test was indicated by bubbling whereas a negative one showed no bubbling and or frothing [10-11].

Coagulase test

Two drops of physiological saline were poured into 2 cm clean glass slide that has been divided into two. One colony was carefully emulsified in each drop of saline. A loopful of citrated human plasma was added to the bacterial suspension on one side and mixed with wire loop. The slide was held up and tilted back and forth for 1 min. clumping of cells was positive [10-11].

Triple sugar iron test

Using a sterilized needle, a cultured material was obtained from a broth culture. The surface of the slant was streaked and the butt stabbed 2 or 3 times. Cap was let loose and incubated at 37 ^{o}C for 48 hours. Formation of hydrogen sulfide was determined by the blackening of the whole butt/streak/ ring of blackening at the slant junction. Glucose fermentation was indicated by the butt becoming yellow. When no other sugar was fermented, the slant appears red while the butt is yellow referred to as Alkaline/Acid or K/AG .Where the lactose, sucrose or both was fermented ,in addition to the glucose, and both the top and bottom of the slant changes to yellow, it indicated acid/ acid or A/A reaction . Where no sugar was fermented, either at the butt or slant portions, the reaction was referred to as K/K [10-11].

Methyl Red Test

A volume of 10 ml of MRVP was inoculated with the test organism and incubated at 35-37 ^{o}C for 24 hours. It was then divided into two equal halves. To the first half, 3 drops of methyl red indicator

was added and allowed to act for 3-5 minutes. The presence of red or pink coloration indicates positive while negative remain unchanged [10-11].

Voges-Proskaur test

Two to three drops of 5% naphthol solution was added followed by 3 drops by 1 ml of 40% potassium hydroxide solution. The mixture was shaken and allowed to stand for some minutes and then observed. A red cooler within 5 minutes indicate a positive reaction, while no colour formation indicates a negative reaction [10-11].

Isolation and identification of fungi

Various fungi were isolated from indoor dust using direct plating technique. The indoor dust was surface sterilized by soaking for 1 minute in sodium hypochlorite (2.5%) and rinsed with sterile distilled water. It was blotted with sterile filter paper and plated on potato dextrose agar containing 7.5% sodium chloride and 1.0 g of streptomycin sulphate in 1 litre of media. The plates were incubated at 25 ^{o}C and monitored for fungi growth daily for seven days. The resulting cultures were identified based on cultural and morphological characteristics using taxonomic keys. Target moulds were sub-cultured to obtain pure single spore cultures. A small amount of the growth colonies were taken and smeared on a glass slide, covered with a slip and heated slightly to remove air bubbles before being viewed under microscope. The organism identified was compared with standard structure [10-11].

RESULTS AND DISCUSSION

Table 1 shows the result of the trace metal analysis for floor, window and bench top samples in mg/kg which was compared with world health organization standard. Tables 2-4 are results of the FTIR analysis for floor, window and bench top samples respectively. While Tables 5 and 6 are results of biochemical test and cultural characteristics of fungi isolates respectively.

Table 1: Metal concentrations (mg/kg) in indoor dust of a chemistry laboratory

Sample	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)
Floor	0.014	0.216	0.417	1.214
Window	0.002	0.038	0.034	0.723
Bench top	0.007	0.018	0.055	0.113
W.H.O. (2006)	0.030	0.050	2.00	0.01

In Table 1, the trace metal analysis compared with the World Health Organization standard revealed cadmium level of 0.014 mg/kg, 0.002 mg/kg and 0.007 mg/kg in the floor, window and bench top respectively were below the permissible limit. Likewise, the copper levels of 0.417 mg/kg, 0.034 mg/kg and 0.055 mg/kg in the floor, window and bench top respectively were below the permissible limit. Chromium level of 0.216 mg/kg in the floor sample was above permissible limit while 0.038 mg/kg and 0.018 mg/kg for window and bench top respectively were below permissible limit. Lead in the floor, window and bench top at 1.214 mg/kg, 0.723 mg/kg and 0.113 mg/kg respectively were above the permissible limit.

Chromium level in the dust sample poses a serious hazard such as allergic dermatitis. Copper in dust plays an essential role in coenzymes [12]. However, above permissible limit is responsible for liver damage. Lead decrease cognitive development, increases blood pressure, cardiovascular disease risk for adults, formation of renal tumor in high amount. Cadmium is responsible for kidney dysfunction, prosthetic and breast cancer, osteomalacea and reproductive deficiencies [13].

Table 2: FTIR analysis for some functional groups present in indoor dust of floor sample in a chemistry laboratory.

Frequency. (cm^{-1}).	Range of Wave number	Nature of bond.	Assignment	
3693.8	4000-3000	Medium sharp.	OH	Stretching alcohol
3623.0	4000-3000	Medium sharp.	OH	Stretching alcohol
2098.5	2140-1990	Strong.	N=C=S.	Stretching isothiocyanate
1625.1	1648-1610	Medium.	C=C	Stretching alkene
1420.1	1440-1395	Medium.	NH_2	Stretching amine
1002.7	1400-1000	Strong.	C-F.	Stretching fluorocarbon
909.5	915-905	Strong.	C=C.	Stretching alkene

Table 3: FTIR analysis of indoor dust in bench top at a chemistry laboratory

Frequency (cm^{-1})	Range of. Wave number	Nature of bond.	Assignment	
3693.8	4000-3000	Medium sharp.	OH.	Stretching alcohol
3619.2	4000-3000	Medium sharp.	OH	Stretching alcohol
1621.4	1650-1600	Medium	C=C.	Stretching alkene
1416.4	1420-1330	Medium.	OH	Stretching alcohol

1002.7	1400-1000	Strong.	CO-O-CO.	Stretching anhydride
909.5.	915-905	Strong.	C=C.	Stretching alkene

Table 4: FTIR analysis of indoor dust on the window in a chemistry laboratory

Frequency (cm^{-1})	Range of. Wave number	Nature of bond.	Assignment	
3692.8	3700-3584	Medium sharp.	OH	Stretching alcohol
3619.2	3584-3700	Medium sharp.	OH	Stretching alcohol
1636.3	1650-1600	Medium.	C=C.	Stretching alkene
1420.1	1440-1395	Medium.	NH_2	Stretching amine
1002.7	1400-1000	Strong.	CO-O-CO.	Stretching anhydride
909.5	915-905	Strong.	C=C.	Stretching alkene

On the basis of peak position and frequency, the quality, nature and identification of functional groups of samples were predicted. Identified functional groups on Table (2.0 -4.0) shares similarities. Functional groups identified in Table 2.0 are OH, N=C=S, C=C, NH_2 C-F and C=C in the floor sample. OH, C=C, CO-O-CO are functional groups identified in bench top sample in Table 3.0 While OH, C=C, NH_2 and CO-O-CO were identified in Table 4.0 in window sample. Presence of crusted elements and chemical spills occurring in the sample could be responsible for the presence of C-F, NH in the sample as suggested [14]. C=C, OH C-H could be attributed to the presence of organic compound in various activities

Table 5: The isolation, microscopic and biochemical characterization of bacteria isolates from indoor dust in a chemistry laboratory.

Bacteria isolates	Microscopic Characteristics			Biochemical characteristics					Suspected Bacteria
	Gram Reaction	Cell type	Cell arrangement	Ca	Mr	Vp	Tsi	Ci	
B1	+ve	rod	single	+ve	+ve	-ve	-ve	-ve	*Lactobacillus sp*
B2	+ve	rod	single	+ve	-ve	+ve	-ve	+ve	*Bacillus cereus*
B3	-ve	cocci	chains	-ve	+ve	-ve	+ve	-ve	*Streptococcus sp*

B4	+ve	cocci	cluster	+ve	+ve	+ve	-ve	+ve	*Staphylococcus aureus*
B5	+ve	cocci	cluster	+ve	+ve	-ve	-ve	-ve	*Micrococcus sp*
B6	-ve	rod	single	+ve	-ve	-ve	-ve	+ve	*Pseudomonas sp*
B7	+ve	rod	single	+ve	-ve	-ve	-ve	-ve	*Lactobacillus sp*
B8	+ve	cocci	cluster	+ve	-ve	+ve	-ve	-ve	*Staphylococcus sp*

Keys: B1-B8=Bacteria isolates 1-8, Ca = Catalase test, Mi = Methyl Red test, Vp = Voges proskauer test, C = Citrate test, TSI = Triple sugar Iron test, + - Positive, - Negative, Spp - Species.

Isolates from the three samples (floor, window and bench top) were observed. Most of the organisms present in the window isolates and floor are present in the bench top isolates. The bacterial isolates obtained from the indoor dust samples of the chemistry laboratory were identified as *staphylococcus aureus, micrococcus sp, bacillus sp, streptococcus sp,* and *pseudomonas sp*. These bacteria are commonly found in indoor environments, particularly in areas with higher level places. The bacterial Isolates were Gram- positive or Gram-negative Gram-positive bacteria*: staphylococcus aureus, micrococcus sp, bacillus sp* while gram-negative bacteria*: Streptococcus sp, Pseudomonas sp* [15].

Staphylococcus aureus

This bacterium is commonly found on human skin and mucous membranes. It can cause a range of illnesses, from minor skin infections to life-threatening diseases such as pneumonia and sepsis.

Micrococcus sp

This bacterium is commonly found in soil, water, and indoor environments. It can cause infections in people with compromised immune systems. *Bacillus sp:* This bacterium is commonly found in soil, water, and indoor environments. It can cause food poisoning, respiratory infections, and infections in people with compromised immune systems. *Streptococcus sp:* This bacterium is commonly found in human throat and respiratory tract. It can cause a range of illnesses, from minor throat infections to life-threatening diseases such as pneumonia and sepsis. *Pseudomonas sp:* This bacterium is commonly found in water, soil, and indoor environments. It can cause respiratory infections, skin infections, and infections in people with compromised immune systems [16].

The presence of these bacteria in the indoor dust samples can be attributed to several human activities in the chemistry laboratory area, students and staff movement, and faculty members frequently entering and exiting the laboratory. This human activity can lead to the transfer of bacteria from human skin and clothing to the indoor environment. Poor ventilation may lead to settle down of microorganisms in the laboratory, and also lead to the accumulation of bacteria and other microorganisms in the indoor air. Contaminated surfaces of the laboratory including workbenches, floors, and equipment, may lead to assimilation of contaminated bacteria, which then become airborne and settle on other surfaces [17].

When in contact with these bacteria, individuals may experience a range of health effects, including: Respiratory problems: Inhaling bacteria can cause respiratory problems, such as coughing, sneezing, and shortness of breath. Skin infections: Coming into contact with bacteria can cause skin infections, such as acne, boils, and impetigo. Food poisoning: Ingesting bacteria can cause food poisoning, which can lead to symptoms such as nausea, vomiting, and diarrhea. Infections: In people with compromised immune systems, these bacteria can cause serious infections such as pneumonia, sepsis, and meningitis [18].

Table 6 shows the four fungi isolates (F1, F2, F3, and F4) obtained from indoor dust samples. The fungi isolates identified based on their cultural and microscopic characteristics are *Aspergillus niger*, *Alternaria sp*, *Rhizopus sp*, and *Fusarium sp*.These fungi are commonly found in soil, water, and indoor environments, and can cause a range of health problems.

Table 6: The microscopic and cultural characteristics of fungi isolates from indoor dust in a chemistry laboratory

Fungi isolate	Cultural characteristics	Microscopic characteristics	Identified fungi
F1	The colony was noted with black colour and also dark brown reverse colour	Has septate hyphae with dark large globose conidial heads that are biseriate.	*Aspergillus niger*
F2	The colony was observed with a notable fast growing rate, having a black to greyish brown colour	Has septate hyphae with ellipsoid or ovoid shape conidia brown in colour	*Alternaria sp*
F3	The colony was noted with a white colour, later turned yellowish brown colour.	Has a septate hyphae with sporangiophores that are spherical in shape.	*Rhizopus sp*
F4	The colony was noted with white to pink colony	The hyphae are septate, with microconidia ovoid to cylindrical in shape that are arranged in chains.	*Fusarium sp*

Aspergillus niger can cause allergic reactions, infections, and toxin production, leading to respiratory problems. It can produce spores that become airborne and trigger allergic reactions in sensitive individuals. In rare cases, it can cause infections in people with compromised immune systems, leading to serious health problems.

Alternaria sp can also cause allergic reactions, infections, and toxin production, resulting in respiratory problems. It can produce spores that become airborne and trigger allergic reactions in sensitive individuals. In rare cases, it can cause infections in people with compromised immune systems, leading to serious health problems.

Rhizopus sp can cause mucormycosis, a rare but serious fungal infection that can affect the sinuses, brain, and lungs. It can also cause infections in people with compromised immune systems, leading to serious health problems. Additionally, it can produce mycotoxins, which are toxic compounds that can cause a range of health problems.

Fusarium sp can cause infections, toxin production, and respiratory problems, with potential cancer risk. It can produce mycotoxins, which are toxic compounds that can cause a range of health problems. Exposure to *Fusarium sp* can exacerbate existing respiratory problems, such as asthma and chronic obstructive pulmonary disease [19].

The presence of these fungi in the indoor dust samples are attributed to many reasons which includes poor ventilation of the laboratory, contamination of surfaces in the laboratory such as workbenches, floors, and equipment, which may be contaminated. These can then become airborne and settle on other surfaces. Human activity is also one of the major element of dust Occurrence in chemistry laboratory may be due to students, staff, and faculty members frequently entering and exiting the laboratory [20].

These microorganisms have certain effect when inhaled, contacted or assimilated. Individuals may experience a range of health effects due to respiratory problems of inhaling fungi which cause respiratory problems, such as coughing, sneezing, and shortness of breath. It also leads to allergic reactions which are caused by coming into contact with fungi such as skin irritation and itching. It is also responsible for several Infections which comprises several systems including the immune systems [21].

CONCLUSION

This research assessed the trace metal level, organic compounds, bacteria and fungi isolate in indoor dust of chemistry laboratory of a research institute. The findings revealed chromium and lead being above the permissible limit, while cadmium and copper were below permissible limit. Alcohol, alkene, alkane, amine, fluorocarbon, isothiocyanate are some functional groups present. *Lactobacillus sp, Bacillus cereus, Streptococcus sp, Staphylococcus aureus, Micrococcus sp Pseudomonas sp and Staphylococcus sp* were bacteria isolated while fungi isolated were *Aspergillus niger, Alternaria sp,Rhizopus sp and Fusarium sp*. Findings from this study recommends a more strict measures to be implemented in keeping the laboratory environment clean and the need to observe precautionary measures. There is need to further investigate other trace metals which were not captured in this study. Similar routine studies are necessary in other laboratories.

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