World Journal of Environmental Research

Volume 13, Issue 2, (2023) 23-32

www.wjer.eu

Detection of environmental pollutants from cobwebs found in selected lecture rooms at the Faculty of Science, Federal University Dutse, Nigeria

Adeniyi O. Adeleye *, Department of Environmental Sciences, Federal University Dutse, Jigawa State, Dutse, Nigeria
Nurudeen Jibrin, Department of Environmental Sciences, Federal University Dutse, Jigawa State, Dutse, Nigeria
Peter G. Shiaka, Department of Microbiology and Biotechnology, Federal University Dutse, Dutse, Jigawa State, Nigeria
Mohammed B. Yerima, Department of Microbiology, Sokoto State University, Sokoto, Sokoto State, Nigeria

Suggested Citation:
Adeleye, A.O., Jibrin, N., Shiaka, P.G. & Yerima, M.B. (2023). Detection of environmental pollutants from cobwebs found in selected lecture rooms at the Faculty of Science, Federal University Dutse, Nigeria. *World Journal of Environmental Research. 13*(2), 23-32. https://doi.org/10.18844/wjer.v13i2.9284

Received from April 11, 2023; revised from June 12, 2023; accepted from December 12, 2023
Selection and peer review under the responsibility of Prof. Dr. Haluk Soran, Near East University, Cyprus

Abstract

The aim of this study was to assess the environmental pollutants present in the cobwebs found in selected lecture rooms; Mathematics lecture room (MTH), Chemistry lecture room (CHM), Biology lecture room (BIO) and Environmental Science lecture room (EMT) in the Faculty of Science, Federal University Dutse. Bacterial pollutants coupled with Arsenic (As) Lead (Pb) in the sampled cobwebs were isolated and identified using standard procedures. One-way Analysis of variance was used to determine the variation in the concentrations of Pb and As in the sampled cobwebs. *Staphylococcus aureus* (28.1%), *Bacillus* sp. (37.5%), *Streptococcus* sp. (18.8%), and *Streptobacillus* sp. (15.6%) were detected in all the cobwebs samples. MTH 4 had the highest Pb concentration (1.2800 mg/kg) while CHM 3 had the lowest (0.470 mg/kg) Pb concentration. CHM 3 and BIO 3 had very low concentrations of Pb, which were significantly different from each other ($p<0.05$). This study has revealed that spider cobwebs can be an effective bio-indicator in determining indoor air quality.

Keywords: Indoor air, Cobwebs, Lecture rooms, Bacterial contaminants, Lead, Arsenic

* ADDRESS FOR CORRESPONDENCE: Adeniyi O. Adeleye , Department of Environmental Sciences, Federal University Dutse, Jigawa State, Dutse, Nigeria
E-mail address: adeniyi.adeleye@fud.edu.ng or adeniyiadeleye80@gmail.com

1. Introduction

Coupled with being a delinquent in countless technologically advanced and developing nations, air pollution is one of the key environmental snags that developing cities encounter (Komolafe *et al*., 2016). Chemicals, particle matter, or biological materials are released into the atmosphere, harming or upsetting people or other living things as well as wreaking havoc on the built environment or the natural environment (Tawari and Abowei, 2012). It might occur as a result of a natural event. The amount of some natural pollutants has either risen or new pollutants have been added to the atmosphere as a result of various anthropogenic activities. As a result, both the air quality and the overall pollution of the environment have greatly declined (Chandna, 2018). Since it causes illness and can result in chronic illness, it has significant negative effects on human existence. Aside from its negative effects on health, air pollution also worsens our climatic circumstances, which can endanger local and global communities (Komolafe *et al*., 2016). For instance, the rise in high-level industrialization and technical advancement has led to an increase in greenhouse gases (GHGs), which has led to an increase in world temperatures. (Abaje *et al*., 2016; Abaje and Oladipo, 2019).

Both in the natural world and in industrialized metropolitan environments, cobwebs are prevalent (Stojanowska *et al*., 2020). In addition, these authors further reported that because cowebs effectively collect contaminants, they are a great way to learn about the state of the ecosystem. Despite being present practically everywhere, cobwebs are a relatively new technique and are not as frequently employed as other bio-indicators (Rutkowski *et al*., 2019). According to Stojanowska *et al*. (2020), the main benefits of using cobwebs as a viable bio-indicator are their wide availability, their convenient location (they are typically woven in remote areas), their inexpensive cost, the ease with which samples may be collected, and the fact that studies don't require intrusive procedures. Due to the lack of preparation required prior to sampling, cobwebs are also a non-specific and general instrument.

Despite being frequently found in nature and essential for life, heavy metals can become dangerous when they accumulate in the built environment [United Nations Environment Programme (UNEP), 2023]. According to UNEP (2023), the most prevalent heavy metals that might harm the environment are mercury (Hg), cadmium (Cd), copper (Cu), nickel (Ni), chromium (Cr), lead (Pb), and arsenic (As). Even little concentrations of Pb exposure, according to UNEP (2008), may have an effect on a child's neurodevelopment. Generally, Pb and As can have detrimental consequences on the heart, kidneys, gastrointestinal tract, hematological, and reproductive systems (UNEP, 2008).

1.1.Purpose of Study

In spite of the massive presence of cobwebs in virtually all the lecture rooms on the campus of Federal University Dutse, no study has been conducted to document its capacity to accumulate environmental pollutants. Consequently, the aim of our study was to assess the presence of Pb, As and bacteria in the cobwebs present in selected lecture rooms of the University with a view to establishing the usage of these cobwebs as a viable bio-indicator of environmental pollution.

2. Materials and Methods

2.1. Study Area

The research was carried out in Faculty of Science, Federal University Dutse, Nigeria which is located on latitude 11.7333N and longitude 9.2875E (Adeleye *et al*., 2022a).

2.2. Media Preparation

All the media were gotten from the Biotechnology Laboratory, Federal University Dutse. The specific media (Nutrient and Trypticase soy agar) for bacterial isolation and growth were measured, produced, and reconstituted with distilled water. According to the makers' directions, the agar was made by suspending 4 g of peptone water in 240 mL of distilled water. The agar combination was dissolved in water by boiling at 100 °C, and the agar was then autoclaved for 15 minutes at 121 °C and 15 Pascals of pressure to sterilize it. The medium was then divided across thirty-two (32) petri dishes and given time to set. In order to make nutrient broth, which contained the same components but no agar, 3.6 g of nutrient agar were suspended in 240 mL of distilled water, cooked until completely dissolved, and then sterilized as before. The mixture was subjected to heat and stirred often to wholly liquefy the medium in water. In order to collect samples, it was then chilled to a temperature of 50 °C, thoroughly mixed, and poured into sixteen (16) sterile bottles.

2.3. Method of Sample Collection

Four (4) lecture rooms were purposively selected and in each Departmental classroom. Four (4) cobweb samples were collected from the four (4) corners (ceiling level) in the classrooms, making sixteen (16) different cobweb samples, using sterile rods into the nutrient broth prepared. Having collected a cobweb sample, the sterile rod was sterilized using fire flame and spirit as reported by Viveka (2017).

2.4. Isolation of Bacterial Pollutants

Each sample was inoculated into Nutrient agar and Trypticase soy agar plates using a wire loop. Here, a primary streak was created with the help of the wire, and secondary and tertiary streaks were created from the primary streak in a parallel pattern using a sterilized wire loop to create a four-way streak plate. All the plates underwent a 24-hour, 37 °C incubation period while being inverted. Having incubated the plates overnight, it was taken out and ostensibly examined for colony features. For proper preliminary identification, isolated colonies were then sub-cultured onto new nutrition agar and Trypticase soy agar plates (Cheng *et al*., 2000).

2.5. Macroscopic Identification of Bacteria Isolates

The procedures reported by Tawfeeq (2018) were used to identify the bacterial isolates macroscopically. Shape (circular, irregular, spreading), elevation (flat, slightly raised or noticeably raised), colouring (red, white, pink, colourless), size (pinpoint, small, medium, large), and texture are among the traits that have been noted.

2.6. Gram Staining and Microscopy

For the microscopic identification of bacterial contaminants, a Gram staining method reported by Aryal (2022) was employed. Gram iodine, Safranine (a biological stain), crystal violet solution, and 100% analytical-grade ethanol were the chemicals utilized. Using masking tape, the code for the unidentified bacteria was written on a clean microscope slide. On the slide, an inoculating loop was used to apply a drop of an unidentified bacterial culture. By holding the smear over the flame of a Bunsen burner, the smear was then heated and adhered to the slide (Bittencourt *et al*., 2007). Using a sterile cloth peg and a staining basin, the slide containing the bacterial smear was held at the edge. Crystal violet, the main stain during the following 40 seconds, was then flooded on the surface. Before applying Gram's iodine for additional 20 seconds, the stain was cleaned with sterile tap water. In order to make the alcohol clear, 95% ethyl alcohol was gradually added after the iodine was removed with tap water. Safranine was used as a counterstain for 40 seconds, after which sterile tap water was used to carefully remove it. The smear was blotted dry after that, and the oil immersion objective lens was used to visualize it under a microscope. Following that, it was noted how the bacteria appeared and how they stained the sample.

2.7. Biochemical Characterization Tests

Using the methodology outlined by Nworie *et al*. (2012), biochemical characterization tests; Voges-proskauer, coagulase, indole, citrate utilization, methyl red, and catalase tests were conducted to identify the bacterial isolates.

2.8. Heavy Metal Estimation from the Cobwebs

The procedure reported by Upasana *et al*. (2018), was employed for the estimation of Pb and As from the sampled cob webs. From the buffered peptone water, 1 mL of the supernatant in each initial test tube was taken and introduced into a new test tube containing distilled water wherein samples meant for heavy metal estimation were collected. The estimation of heavy metals was done using Atomic Absorption Spectrophotometer (AAS) in Center for Dry Land Agriculture Bayero University, Kano State.

2.9. Experimental Design

Randomized completely blocked design (RCBD) was adopted in this study. There were 16 treatments and replicated thrice giving a total of 48 experimental units. The treatments are listed below:

MTH 1	**CHM 1**	**BIO 1**	**EMT 1**
MTH 2	**CHM 2**	**BIO 2**	**EMT 2**
MTH 3	**CHM 3**	**BIO 3**	**EMT 3**
MTH 4	**CHM 4**	**BIO 4**	**EMT 4**

Note: MTH = Mathematics lecture room one; CHM= Chemistry lecture room one; BIO= Biology lecture room one; EMT= EMT lecture room one.
1= sample 1; 2= sample 2; 3= sample 3; 4= sample 4.

2.10. Data Analysis

The analysis of variance (ANOVA) was performed on all data generated using procedure of general linear model via GenStat version 17, and significant means that emanated were separated using the Duncan's multiple range test.

3. Results and Discussion

The results of the biochemical characterization tests conducted to identify the bacteria isolated from the sampled cob webs are presented in Table 1. Out of the eight (8) bacterial isolates that were cultured, three (3) were Gram-negative and five (5) were Gram-positive (Table 1). Gram-positive bacteria that were identified after the conduct of various biochemical characterization tests range from *Bacillus* sp., *Streptococcus* sp., *Streptobacillus* sp. to *Staphylococcus aureus* (Table 1).

Table 1
Biochemical characterization tests conducted for the identification of the isolated bacteria

Colony on NA	**Gram Reaction**	**Catalase**	**Citrate Utilization**	**Coagulase**	**Indole**	**Methyl Red**	**Voges Proskauer**	**Isolate Identity**
White, smooth, creamy and round	+ coccus in cluster	+	-	+	-	+	+	*Staphylococcus aureus*
Green, glossy pigmented and thin	+ Bacillus	+	-	-	-	+	-	*Streptobacillus* sp.
Short rods, singles and clustard	+Cocci	-	+	+	-	+	-	*Streptococcus* sp.
White glossy membranous	+ Bacillus	+	-	+	-	+	-	*Bacillus* sp.
Greyish, granular with limited growth	+ Bacillus	+	-	-	-	+	-	*Bacillus* sp.
Straight paired rods	+ Bacillus	+	-	+	-	+	-	*Streptobacillus* sp.
Clear, small, round and irregular	- Bacillus	+	-	+	-	-	-	*Bacillus* sp.

Note: + = Positive; - = Negative; NA= Nutrient Agar

The frequency of the isolated bacteria in the sampled cob webs is depicted in Table 2. The rate of occurrence of bacterial isolates differed as shown in Table 2. Bacteria isolated from the selected lecture rooms ranged between *Staphylococcus aureus* (28.1%), *Bacillus* sp. (37.5%), *Streptococcus* sp. (18.8%), and *Streptobacillus* sp. (15.6%). When compared to the other bacterial species discovered in the sampled cobwebs, *Bacillus* sp. was the one that was present most frequently. The study's findings revealed that there was a substantial number of bacteria in the classrooms. Unventilated rooms may facilitate the movement of microorganisms among people and may operate as a reservoir for bacterial contamination, according to Baadhaim *et al.* (2011). The findings indicated that highly dangerous microorganisms with the ability to cause diseases are present in the lecture halls.

Table 2

Relative frequency of the bacterial isolates

Bacterial isolate	Frequency	Relative frequency (%)
Staphylococcus aureus	9	28.1
Bacillus sp.	12	37.5
Streptococcus sp.	6	18.8
Streptobacillus sp.	5	15.6
Total	32	100

These findings make it very evident that bacteria play a significant role in every ecosystem and that they can accumulate on cobwebs. Microorganisms spread from person to person and from place to place through the air (Baadhaim *et al*., 2011). The discovered bacterial population was found to be very high in the chosen lecture halls, according to the results. This may be explained by the fact that more individuals than necessary enter the lecture halls. According to Mitsuko *et al*. (2005), bacteria levels may increase in a crowded building since their presence in a room implies the presence of people. According to Dropulic and Lederman (2016), two of the bacteria found in the sampled cobwebs in this study, *Streptococcus* sp. and *Staphylococcus aureus* are opportunistic pathogens linked to lung infections in immunosuppressed patients. Numerous studies (such as those by Ayedun *et al*., 2017; Upasana *et al*., 2018; Justyna *et al*., 2021) have equally demonstrated the efficiency of lichens and cobwebs as bio-indicators.

The variation in the concentrations of Pb and As detected in the cobweb samples are presented in Tables 3 and 4 respectively. Specifically, EMT 3 recorded the highest concentration of As (0.16367 mg/kg) and BIO 3 recorded the lowest concentration (-0.10000 mg/kg) of As (Table 3). Moreover, MTH 4 recorded the highest Pb concentration (1.2800 mg/kg) while CHM 3 recorded the lowest (0.470 mg/kg) Pb concentration (Table 4). However, despite the fact that CHM 3 and BIO 3 had very low concentrations of Pb, they are significantly different from each other ($p<0.05$). MTH 1, MTH 2 and MTH 3 As concentrations are not significantly different from each other ($p>0.05$) but are significantly different from MTH 4 ($p<0.05$). CHM 1, CHM 2, CHM 3 and CHM 4 As concentrations are significantly different from each other ($p<0.05$). BIO 1 and BIO 2 As concentrations are not significantly different from each other ($p>0.05$) but are significantly different from BIO 3 and BIO 4 ($p<0.05$). Furthermore, EMT 1, EMT 2 As concentrations are not significantly different from each other ($p>0.05$) but are significantly different from its concentrations in EMT 3 and EMT 4 ($p<0.05$).

Moreover, MTH 1, MTH 2 and MTH 3 Pb concentrations are not significantly different from each other ($p>0.05$) but are significantly different from its concentration in MTH 4. CHM 1, CHM 2 Pb concentrations are not significantly different from each other ($p>0.05$) but are significantly different from its concentrations in CHM 3 and CHM 4 ($p<0.05$), while CHM 3 and CHM 4 are not significantly different from each other ($p>0.05$). BIO 1 and BIO 3 Pb concentrations are not significantly different from each other ($p>0.05$) and also, BIO 2, BIO 3 and BIO 4 are not significantly different from each other ($p>0.05$). The concentrations of Pb in EMT 1, EMT 3 and EMT 4 are not significantly different from each other ($p>0.05$) but its concentration is significantly different from the one obtained in EMT 2 ($p>0.05$). The results obtained in this study are in agreement with the other reports on the viable heavy metal contaminants obtained on cobwebs in their respective study areas (Ibrahim, 2012; Upasana *et al*., 2018).

Table 3

Effect of location on Arsenic content in the sampled cobweb

Location	As (mg/kg)
MTH 1	0.09000c
MTH 2	0.11333bc
MTH 3	0.10000c
MTH 4	0.00000e
CHM 1	0.08333cd
CHM 2	0.02333e
CHM 3	-0.04700f
CHM 4	0.15000ab
BIO 1	0.04000de
BIO 2	0.01700e
BIO 3	-0.10000g
BIO 4	0.09333c
EMT 1	0.03000e
EMT 2	0.01033e
EMT 3	0.16367a
EMT 4	0.07700cd

Means with the same letter (s) in the same column are not significantly different from each other at p >0.05 using Duncan's multiple range test

Table 4

Effect of location on Lead content in the sampled cobweb

Locations	Pb (mg/kg)
MTH 1	0.6000def
MTH 2	0.5600def
MTH 3	0.6400de
MTH 4	1.2800a
CHM 1	0.9133b
CHM 2	0.7933bc
CHM 3	0.4700f
CHM 4	0.5067ef
BIO 1	0.6770cd
BIO 2	0.8400b
BIO 3	0.8033bc
BIO 4	0.8230b
EMT 1	0.5700def
EMT 2	0.8500b
EMT 3	0.5600def
EMT 4	0.6400de

Means with the same letter (s) are not significantly different from each other at p >0.05 using Duncan's multiple range test

The outcomes of this investigation, where a copper smelter and refinery are located in Western Poland, are distinct from those of other reports on the identification of heavy metal contamination (Stojanowska *et al*., 2020). The discrepancy could result from the use of different bio-indicators. However, Stojanowska *et al*. (2020) found that in their research, cob webs were more vulnerable to pollution emissions than lichens. Pb and As are ominously present in the environment as a result of human undertakings such as the burning of waste and the products derived from fossil fuels (UNEP, 2023). Another important source of Pb exposure in people is cigarette smoke. Pb exposure has declined in recent years in many nations (Ritchie, 2022). However, because Pb has a relatively long biological half-life (10–30 years), human activities using Pb should be kept to a minimum or at no dangerous level (Wani *et al*., 2015).

According to Wong *et al*. (2007), young children are especially susceptible to the harmful effects of Pb and may have severe, long-lasting health problems, particularly with regard to the development of the brain and nervous system. Pb also harms adults over the long term, increasing their risk of high blood pressure and kidney damage (Wong *et al*., 2007). These authors reported further that high Pb exposure during pregnancy can result in low birth weight, early birth, stillbirth, and miscarriage. Cardiovascular issues, cardiovascular disease, gastrointestinal conditions like colon, pancreatic, stomach, and rectal cancer, liver and kidney damage, respiratory system problems like respiratory tract cancers, and asthmatic conditions are just a few of the health issues linked to As poisoning (Joan, 2013). An indispensable element of a hale and hearty interior environment is good indoor air quality (Adeleye *et al*., 2022b). Students and employees who spend the most time in lecture halls may have more immediate and long-term health issues as a result of a failure to avoid or swiftly address indoor air quality issues.

According to Joan (2013), being exposed to an atmosphere that is polluted with air pollution can cause coughing, eye irritation, headaches, allergic reactions, carbon monoxide poisoning, asthma, and other respiratory ailments. There is strong evidence that allergen exposure in the indoor environment, including exposure to dust mites, pests, and moulds, contributes to the onset of asthma symptoms (Louisias *et al*., 2019). These authors emphasized once more how widespread allergies are in school environments with huge populations of students and staff. According to a research by Liu and Grigg (2018), children's exposure to diesel exhaust from school buses and other vehicles aggravates asthma and allergies. These issues can inevitably affect student performance, comfort, and attendance, as well as negatively affect teachers' and students' work.

4. Conclusion and Recommendations

This study has revealed that spider cobwebs can be an effective bio-indicator in determining indoor air quality as the selected lecture rooms in Federal University Dutse were polluted with a wide variety of potentially pathogenic bacteria (*Staphylococcus aureus*, *Bacillus* sp, *Streptococcus* sp. and *Streptobacillus* sp. coupled with harmful heavy metals (Pb and As). Hence the null hypothesis which stated that there is no bacterial, As and Pb pollutant in the selected University lecture rooms is rejected. In light of the findings of this study, it is advised that lecture hall overcrowding be avoided, lecturers and school staff be informed that poor indoor air quality has an adverse effect on both students' health and academic performance. Students' personal hygiene should be encouraged in order to prevent them from bringing potential sources of pollutants (animal hair on students' clothes, mould or other unclean materials under the shoes, and so on).

Acknowledgments

The authors thank all the laboratory staff of the Department of Microbiology and Biotechnology, Federal University Dutse, Nigeria for their support during the bench work of this study.

Conflict of interest
We declare that there is no conflict of interest regarding this study

Adeleye, A.O., Jibrin, N., Shiaka, P.G. & Yerima, M.B. (2023). Detection of environmental pollutants from cobwebs found in selected lecture rooms at the Faculty of Science, Federal University Dutse, Nigeria. *World Journal of Environmental Research. 13*(2), 23-32. https://doi.org/10.18844/wjer.v13i2.9284

References

Abaje, I. B and Oladipo, E. O. (2019). Recent Changes in the Temperature and Rainfall Conditions Over Kaduna State, Nigeria. *Ghana Journal of Geography*, 11(2): 127-157.

Abaje, I. B., Abdullahi, N. and Jeje, O. G. (2016). Climate Change and Infectious Diseases in Funtua Local Government Area of Katsina State, Nigeria. *International Journal of Science and Technology*, 5(1): 47-58.

Adeleye, A. O., Sim, K. M. and Yerima, M. B. (2022b). Bacteriological Quality Assessment of Ready-to-Eat Hawked Suya in Dutse Urban, Northwest Nigeria. *Stamford Journal of Microbiology,* 12(1): 25-30.

Adeleye, A. O., Godwin, A. O., Amoo, A. O., Ijanu, E. M., Amoo, F. K. and Yerima, M. B. (2022a). Assessing the State of Drinking Water from Storage Tanks in Federal University Dutse Nigeria. *World Journal of Environmental Research*, 12(1): 01-10.

Aryal S. (2022). Gram Staining: Principle, Procedure, Interpretation, Examples and Animation. Retrieved from https://microbiologyinfo.com/gram-staining-principle-procedure-interpretation-examples-and-animation/

Ayedun, H., Adewole, A., Osinfade, B. G., Umar, B. F., Rabiu, S. A., Ogunlusi, R. O. and Osinfade, B. G. (2017). The use of spider webs for environmental determination of suspended trace metals in industrial and residential areas. *Journal of Environmental Chemistry and Ecotoxicology*, 5(2): 21-25.

Baadhaim, M., Kusner, D. and Ahmed, H. (2011). Distribution and Prevalence of Bacteria Found on the Door Handles of Olin Hall, Drake University. Conference Poster. Retrieved from https://escholarshare.drake.edu/bitstream/handle/2092/1572/Poster%20%2337.pdf?sequence=1&is Allowed=y.

Bittencourt, C., Astolfi-Filho, S., Chartone-Souza, E., Santos, F. and Nascimento, A. (2007). Analysis of *Chromobacterium* sp. Natural Isolates from Different Brazilian Ecosystems. *BMC Microbio*logy, **7**(58). Retrieved from https://doi.org/10.1186/1471-2180-7-58.

Chandna, R. C. (2018). *Environmental Geography*, 4th Enlarged Edition. New Delhi: Kalyani Publishers.

Cheng, C., Sun, J., Zheng, F., Wu, K. and Rui, Y. (2014). Molecular identification of clinical "difficult to identify" microbes from sequencing *16S* ribosomal DNA and internal transcribed spacer 2. *Journal of Clinical Microbiology*, 13:1-7.

Dropulic, L. K. and Lederman, H. M. (2016). Overview of Infections in the Immunocompromised Host. *Microbiology Spectrum*, 4(4). Retrieved from https://doi.org /10.1128/ micro biolspec.DMIH2-0026-2016.

Ibrahim, R. (2012). Spider Webs as Indicators of Cobalt and Lead Pollution in Kano Municipality. *Chemsearch Journal,* 3(2): 46-52.

Joan, M. N. (2013). Assessment of Heavy Metal Concentration in the Environment and Perceived Health Risks by the Community around Kadhodeki Dumpsite, Nairobi County. Unpublished MSc thesis, School of Public Health of Kenyatta University.

Justyna, R., Izabela, S., Anna, Z., Magdalena, F. and Krystyna, T. (2021). Evaluation of the Usefulness of Spider Webs as an Air Quality Monitoring Tool for Heavy Metals. *Ecol Chem Eng S.,* 22(3): 389-400.

Komolafe, A. A., Adegboyega, S. A., Anifowose, A. Y. B., Akinluyi, F. O. and Awoniran, D. R. (2016). Air Pollution and Climate Change in Lagos, Nigeria: Needs for Proactive Approaches to Risk Management and Adaptation. *American Journal of Environmental Sciences*, 10(4): 412-423.

Liu, N. M. and Grigg, J. (2018). Diesel, children and respiratory disease. *BMJ Paediatrics Open*, 2(1). Retrieved from https://doi.org/10.1136/bmjpo-2017-000210.

Louisias, M., Ramadan, A., Naja, A. S. and Phipatanakul, W. (2019). The Effects of the Environment on Asthma Disease Activity. *Immunology and Allergy Clinics of North America*, 39(2): 163. Retrieved from https://doi.org/10.1016/j.iac.2018.12.005.

Nworie, A., Ayeni, J. A., Eze, U. A. and Azi, S. O. (2012). Bacterial Contamination of Door Handles/Knobs in Selected Public Conveniences in Abuja Metropolis, Nigeria; A Public Health Threat. *Continental J Med Res*., 6(1): 7-11.

Ritchie, H. (2022). Many countries have achieved an impressive reduction in lead poisoning. Retrieved from https://ourworldindata.org/decline-lead-poisoning.

Rutkowski, R., Rybak, J., Rogula-Kozłowska, W., Bełcik, M., Piekarska, K,. Jureczko, I. (2019). Mutagenicity of Indoor Air Pollutants Adsorbed on Spider Webs. *Ecotoxicol. Environ. Saf.*, 171: 549-557.

Stojanowska, A., Rybak, J., Bożym, M., Olszowski, T. and Bihałowicz, J. S. (2020). Spider Webs and Lichens as Bioindicators of Heavy Metals: A Comparison Study in the Vicinity of a Copper Smelter (Poland). *Sustainability*, 12(19): 8066. https://doi.org/ 10.3390/su1219806 6

Tawari, C. C. and Abowei, J. F. (2012). Air pollution in the Niger Delta Area of Nigeria. *International Journal of Fisheries and Aquatic Sciences*, 1(2): 94-117.

Tawfeeq, M. (2018). Macroscopic Appearance of Culture. Retrieved from http://vet.mu.edu.iq/ wp-content/uploads/2018/12/colony-1.pdf.

United Nations Environment Programme (UNEP) (2008). Interim Review of Scientific Information on Lead. Retrieved from http://www.chem.unep.ch/PbandCd/SR/Files/ 2008/UNEP_Lead_review Interim-mar102008.doc

United Nations Environment Programme (UNEP) (2023). Heavy Metals. Retrieved from https://www.unep.org/cep/heavy-metals

Upasana, B., Sanjay, K. D., Pramod, K., Naresh, C. G., Neetu, R. and Khem, S. (2018). Heavy Metals Assessment in Urban Air of National Capital Region of Delhi Using Spider Webs as Bioindicator. *Journal of Environmental Science and Technology,* 11(1): 49-55.

Viveka, V. A. (2017). Isolation and Identification of Common Bacterial Contaminant in Mobile Phones. *Journal of Heath, Medicine and Nursing*, 10(4): 92-95.

Wani, A. L., Ara, A. and Usmani, J. A. (2015) Lead Toxicity: A Review. *Interdisciplinary Toxicology*, 8(2): 55-64. Retrieved from https://doi.org/10.1515/intox-2015-0009.

Wong, L. T., Mui, K. W., Hui, P. S. and Chan, W. Y. (2007). Bayesian Assessment for Acceptable Airborne Bacterial Levels in Air-conditioned Spaces. *Journal of Aerosol Science*, 17(1): 80-6.