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Heavy Metal Contamination of Urban Slum Groundwater: A Case Study of Ijora, Badia, Lagos

[*1]Ojo, O. I., [2]Coker, A.O., [1]Omotosho, O. A., [1]Atta, A. T. and Yahaya A. I.

[1]Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, Nigeria.
[2]Department of Civil Engineering, Faculty of Technology, University of Ibadan, Nigeria

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Corresponding Author:
oluwaropoojo2017@gmail.com

ABSTRACT

This study assessed groundwater sources within the urban slum settlement of Ijora Badia, Lagos, to evaluate heavy metal contamination levels in relation to the attainment of Sustainable Development Goal (SDG) 6, which emphasizes access to safe and clean water. Groundwater samples were collected from six representative sources comprising three wells and three boreholes: Badia East Well (BEW), Badia Central Well (BCW), Badia West Well (BWW), Badia East Borehole (BEB), Badia Central Borehole (BCB), and Badia West Borehole (BWB). The concentrations of selected heavy metals: Lead (Pb), Cadmium (Cd), and Iron (Fe), were determinedusing atomic absorption spectrometry and compared with thepermissible limits recommended by the World Health Organization(2022). Results showed that Pb concentrations ranged from 0.00 to 0.66 mg/L, Cd from 0.00 to 0.021 mg/L, and Fe from 0.00 to 12.50 mg/L. The highest concentrations of Pb (0.66 mg/L), Cd (0.021 mg/L), and Fe (12.50 mg/L) were recorded in the Badia Central Borehole (BCB). Most groundwater samples exceeded the WHO permissible limits for the analyzed heavy metals, except samples from Badia West Well (BWW) and Badia Central Well (BCW), which complied with the guideline values. These findings indicate the presence of heavy metal contamination in groundwater sources within the study area. The contamination may be attributed to anthropogenic activities such as leachate infiltration from waste disposal sites and industrial effluent discharges, although natural geogenic sources cannot be ruled out. Consequently, further investigations are recommended to identify the specific sources, pathways, and extent of heavy metal pollution in the area and to develop appropriate mitigation measures for safeguarding public health and groundwater quality.

INTRODUCTION

Water is the most vital source of life on Earth. Access to safe drinking water is a fundamental human right and a marker of good health. (CDC, 2017). Groundwater is a major source of water supply, which is derived from boreholes and wells. At a minimum, groundwater accounts for 50% of the water supply worldwide (Afolabi *et al.,* 2012). However, water pollution is increasing globally, causing over 1.8 million deaths each year. (Philip *et al.,* 2018). Children are the most affected by contaminated water, with at least 525,000 children worldwide dying annually from diarrheal diseases, most of which result from contaminated water, inadequate sanitation, and poor personal hygiene (CDC, 2017; WHO, 2017). Key factors contributing to high water contamination are mostly due to poor management of waste, though it could also be naturally occurring.

Worldwide, approximately 41.8 million metric tons of waste are generated annually, and this figure is projected to soar to 3.4 billion tons by 2050, given current pollution trends and increased urbanization (World Bank, 2022). The issue of waste generation is of such magnitude that it ranks as a top-priority health concern in Europe (Waste and Human Health, 2022). In addition to generation, poor

handling and disposal also remain a significant challenge, especially in developing nations of the world. This is more serious in slum settlements around urban centres where inadequate facilities and poor hygiene are prevalent. Waste significantly contributes to soil, food, and groundwater contamination, resulting in various diseases. Solid waste, in particular, is a breeding ground for vector-borne diseases and zoonotic diseases, including gastrointestinal, dermatological, respiratory, and genetic diseases, among others (Krystosik *et al*., 2020). In addition, the lack of proper treatment of industrial wastes before discharging into the environment also results in water contamination, especially of heavy metal origin. Globally, over 8000 people die daily from diseases related to waste accumulation (Addo *et al*., 2017). The threat posed by waste accumulation is more pronounced in slum settlements due to poverty, inadequate infrastructure, and limited planning (Boateng and Agyei, 2024). Seepage of leachate and effluent from waste sites find their way into groundwater, thereby leading to contamination (IDR Environmental Service, 2022). These leachates and effluents from waste contain heavy metals, microorganisms, and other toxic compounds (Parvin and Tareq, 2021).

Heavy metals are notable water contaminants, which are generally toxic metals with a density greater than 5 g/cm^3 (Jarup, 2003). Heavy metals that concern public health regarding water pollution include arsenic (As), cadmium (Cd), nickel (Ni), mercury (Hg), chromium (Cr), zinc (Zn), copper (Cu), Iron (Fe), and lead (Pb) (Rehman *et al*., 2018). The main sources of these metals in water are soil erosion, weathering, mining, industrial wastewater, urban runoff, sewage discharge, municipal waste, and agrochemicals (Morais *et al.,* 2012). Heavy metals generate reactive oxygen species in living organisms, leading to oxidative damage. Notably, heavy metals, particularly Cu, Ni, Cr, and Zn, are naturally present in trace amounts ranging from 70 - 140, 75 - 140, 0.1 - 0.3, and 0.14 - 1.0 µg/dL, respectively,in biological systems and are essential for normal body functions (Medscape, 2025; MCL, 2025; Templeton and Sunderman, 1994). They only become harmful at high doses or due to environmental factors, such as contaminated water. Therefore, continuous monitoring of the levels of these heavy metals in various water sources in every area is crucial for preventing disease.

In Lagos, which is located in the southwest of Nigeria, groundwater is the primary source of water for drinking and domestic purposes (Popoola *et al*., 2019) due to the inadequacy of pipe-borne water in some regions of the state, especially its slum settlements, similar to many other developing countries. Leachate, debris from inadequate waste management, and industrial effluent in the area can contaminate surrounding groundwater. Since groundwater serves as the primary water source in the area, periodic groundwater quality assessments, particularly for heavy metal contamination, are therefore a necessity. Considering the cosmopolitan nature of this state, periodic monitoring of groundwater is essential for preventing diseases and disease outbreaks through the groundwater supply, especially for poor urban slum dwellers like the Ijora Badia who are provided with a few boreholes by politicians (Ojo *et al*., 2026).

The poor waste management practices in Ijora-Badia, a notable urban slum located in the Apapa area, and the enormous industrial waste generated by surrounding industries are often poorly managed; therefore, this study was necessitated to evaluate the levels and risks of selected heavy metals in boreholes and wells in the area. This will help to provide a basis for developing effective groundwater quality management and pollution mitigation strategies.

Study Area

Ijora–Badia is one of the suburbs in the Apapa Local Government Area of Lagos State, and it is located in the Southern area of the Lagos Metropolis. It is situated at the geographical coordinates: latitude 6.453056° N and longitude 3.395833° E. It is surrounded in the Northern area by the Lagos-Badagry expressway link bridge to the National Theatre. On its Eastern boundary is the railroad to Apapa, while to the South, it is bounded by Ajegunle, another slummy residential suburb.

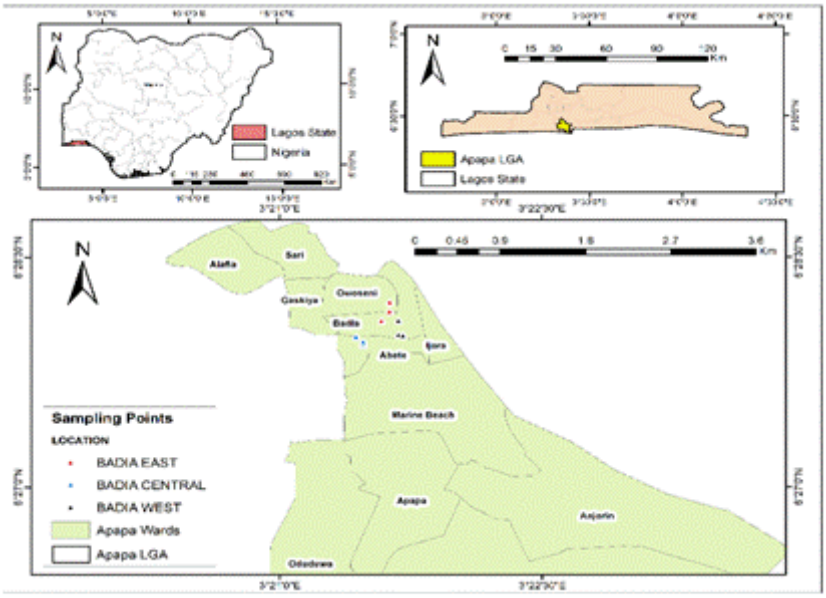


Figure 1: Map showing water sampling location at Ijora Badia in Apapa Local Government Area of Lagos, Nigeria.

MATERIALS AND METHODS

Water sampling technique and collection

A random sampling method was used after dividing Ijora Badia into three districts: Badia East, Badia West, and Badia Central (Lukeman *et al.,* 2014). Water samples were collected from boreholes and wells, groundwater sources in each of the three districts. The sources were carefully chosen to get samples that accurately reflect the drinking water quality in the area. The selection was based on oral interviews with residents and careful observation of the most commonly used water sources.

Six (6) water samples were randomly collected in 1L polyethylene plastic bottles, three samples for each borehole and well designated as Badia East Well (BEW), Badia Central Well (BCW), Badia West Well (BWW), Badia East Borehole (BEB), Badia Central Borehole (BCB), and Badia West Borehole (BWB), as shown in Table 1. To ensure the integrity of the samples, the sampling bottles were pre-cleaned. Before actual sampling, the bottles were properly rinsed with each borehole and well water source to prevent dilution and then appropriately labelled.

Table 1: Coordinates of Sampled Water Sources

Sampled Sources	Latitude (°N)	Longitude (°E)
Badia East Borehole (BEB)	6.463	3.407
Badia West Borehole (BWB)	6.453	3.395
Badia Central Borehole (BCB)	6.455	3.355
Badia East Well (BEW)	6.463	3.585
Badia West Well (BWW)	6.456	3.355
Badia Central Well (BCW)	6.455	3.352

Heavy metal analysis

The collected samples were temporarily preserved in the refrigerator at 4°Cfor 2 hours before being analysed for heavy metal parameters, specifically lead (Pb), cadmium (Cd), and iron (Fe), following the procedures described by Yahaya *et al*., 2022. Each water sample was thoroughly mixed and then digested by transferring 100 mL of it into a previously cleaned 50-ml beaker, which contained 5 mL of concentrated HNO_3. The beaker was heated until the contents dried completely, then allowed to cool before an additional 5 mL of concentrated HNO_3 was added. It was heated again until a light-colored residue appeared. To dissolve the residue, 1 mL of HNO_3 was added, and the heating was done at a low temperature. The beaker was rinsed and filled with distilled water up to the meniscus. Subsequently, the digest was analyzed for the presence of Cd, Fe, and Pb using the UNICAM 969 atomic absorption spectrophotometer. To ensure the accuracy of the analysis, reagents used were formulated from chemicals of analytical grade. Non-metallic materials were used throughout, and they were thoroughly washed with distilled water and rinsed with reagent for each container. Blank samples were analyzed concurrently with the water samples to detect any background contamination. Each sample was evaluated three times, and the reproducibility of nearly identical values exceeded 95%.

RESULTS AND DISCUSSIONS

Sampled Water Sources

Measured values showed that only the BWW water source was free of heavy metal contamination in the present study. The sampled water sources and parameter values are as presented in Figures 2, 3 and 4. All other sampled sources had the presence of heavy metal contamination.It was observed that Iron (Fe) concentration was more prevalent in water samples in the area.

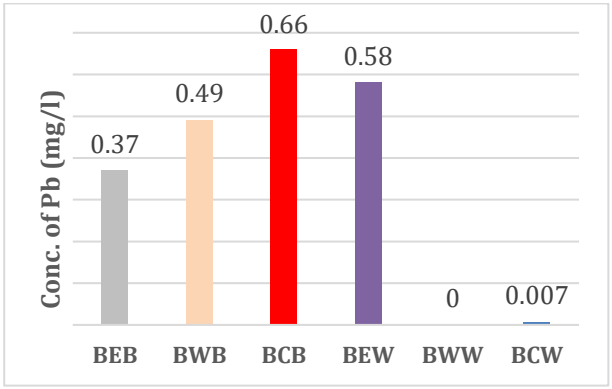


Figure 2: Pb concentration in sampled boreholes and wells

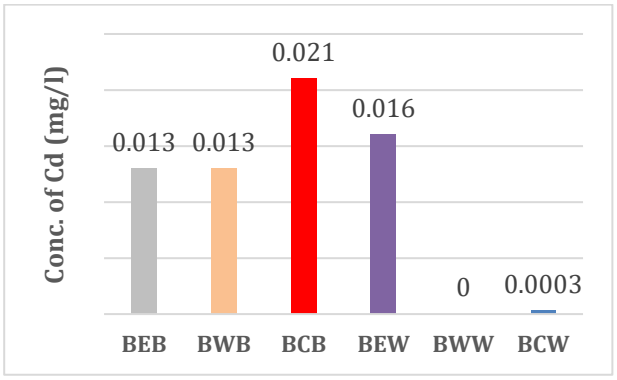


Figure 3: Cd concentration in sampled boreholes and wells

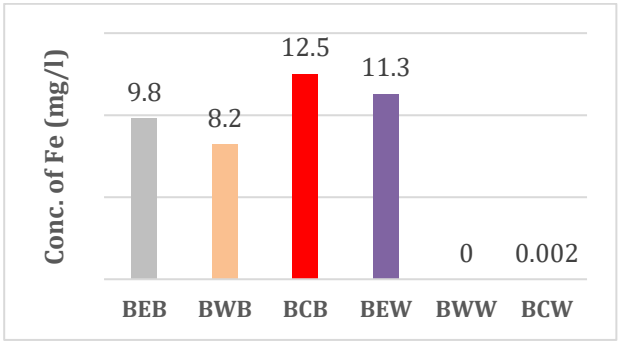


Figure 4: Fe concentration in sampled boreholes and wells

Heavy Metals Concentration

A high degree of variation in heavy metal concentration was observed for water samples in the area. Results showed that measured lead (Pb) values ranged from 0.37 – 0.66mg/l for wells, while boreholes ranged from 0.00 – 0.58 mg/l. The measured levels of Cadmium ranged from 0.013 –

0.021mg/l for boreholes, while wells ranged from 0.00 – 0.016mg/l. Iron levels ranged from 8.20–12.5mg/l for boreholes, and wells ranged from 0.002 – 11.30mg/l. The highest measured values were recorded in the BCB sample (Pb: 0.66, Cd: 0.021, Fe: 12.5mg/l), while the lowest was recorded in the BWW sample with 0.00mg/l for all parameters.

The results imply that borehole sources have higher contamination levels than well water generally in the area. These findings are consistent with those of Kayode *et al*., (2018) and Yahaya *et al*., (2022), all of whom detected non-permissible levels of heavy metals in groundwater near unsanitary sites in Lagos, Nigeria. Heavy metal contamination of borehole water sources may be naturally occurring in the area. The results showed a potential health risk to the slum dwellers whose drinking water sources in the area are boreholes. The high levels of Iron recorded corroborate the rusty appearance and frequent breakdown of borehole water facilities often experienced by slum dwellers in the area. This is because the oxidation of Fe^{2+} into Fe^{3+} results in rusting of metallic pipes and plumbing fittings.

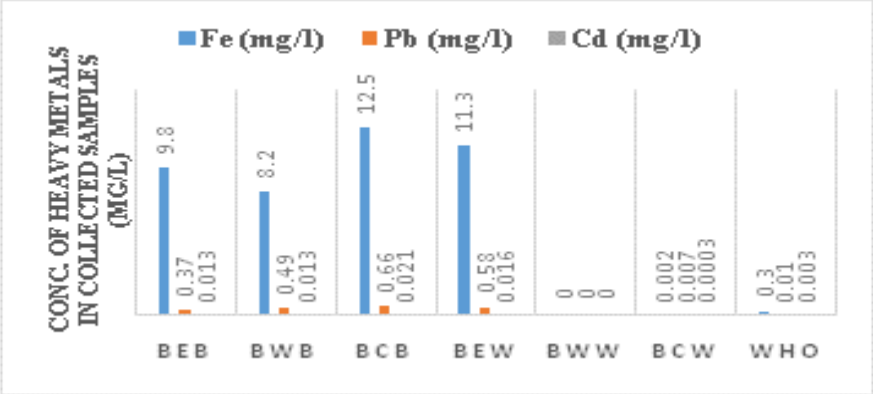


Figure 5: Pb, Cd, and Fe concentration in sampled boreholes and wells compared with the WHO permissible limits

Results when compared with the WHO permissible limits showed that only the BWW and BCW samples were within the limits. All measured values for the BEB sample (Pb: 0.37, Cd: 0.013, Fe: 9.8mg/l), BWB (Pb: 0.49, Cd: 0.013, Fe: 8.2mg/l), BCB (Pb: 0.6, Cd: 0.021, Fe: 12.5 mg/l) and BEW (Pb: 0.58, Cd: 0.016, Fe: 11.3mg/l) exceeded the WHO limits. Heavy metal contamination of the borehole and well water sources might be naturally occurring or as a result of pollution from industrial discharges and poor waste management in the area. The most probable sources of Cd in the water are wastes from phosphate fertilizers, sewage sludge from homes and industries that produce Ni-Cd batteries, iron and steel, pigments, and plastics (ATSRD, 2025). Pb is naturally occurring, but high concentrations may suggest waste from homes and industrial products such as paint, ceramics, pipes, cosmetics, plumbing materials, solders, gasoline, and batteries, among others (USEPA, 2025).

These findings suggest that the water may pose heavy metal-related toxicities. Specifically, exposure to high levels of Pb can result in anaemia, fatigue, foetal developmental errors, infertility, and damage to the kidney and brain (CDC, 2017). Short-term exposure to high levels of Cd can cause flu-like symptoms and lung injury, while chronic exposure can lead to organ damage (OSHA, 2025).

CONCLUSION

The results indicate that the sampled boreholes and wells in Ijora Badia contain concentrations of

heavy metals, particularly Lead (Pb), Cadmium (Cd), and Iron (Fe), that exceed permissible drinking water limits. However, heavy metal concentrations in the Badia West Well (BWW) and Badia Central Well (BCW) were found to be within the acceptable guideline values. Overall, the findings suggest that borehole water in the study area is unsuitable for human consumption without appropriate treatment.

RECOMMENDATIONS

Given the elevated concentrations of Iron (Fe) detected in the borehole samples, the use of PVC pipes, fittings, and storage tanks is recommended for borehole installations to minimize corrosion and prevent the deterioration associated with metallic components. Furthermore, detailed hydrogeochemical investigations should be undertaken to determine whether the observed heavy metal contamination is of natural (geogenic) origin or results from anthropogenic activities within the area. Such studies will provide a basis for developing effective groundwater quality management and pollution mitigation strategies in Ijora Badia, Lagos.

REFERENCES

Addo, H.O., Dun-Dery, E.J., and Afoakwa, E. (2017). Correlates of domestic waste management and related health outcomes in Sunyani, Ghana: a protocol towards enhancing policy. BMC Public Health, 17, 615. https://doi.org/10.1186/s12889-017-4537-8.

Afolabi T.A., Ogbuneke C.C., Ogunkunle, O.A and Bamiro F.O. (2012) Comparative assessment of the potable quality of water from industrial, urban and rural parts of Lagos, Nigeria. Ife J Sci; 14(2): 221-32.

ATSDR Agency for Toxic Substances and Disease Registry. Where is Cadmium Found? (Accessed on August 4, 2025) Available online: https://www.atsdr.cdc.gov/csem/cadmium/Where-Cadmium-Found.html#.

Boateng, K., and Agyei, M. O. (2024). Solid waste management in informal settlements in Harare, Soweto, Egypt, Accra, Kinshasa, and Lagos: A review of challenges, impacts, and measures for improvement. *Journal of Environmental Health and Sustainable Development*, 9(2), 245–259.

Centers for Disease Control. Global WASH Health Burden. 2017. Available at https://www.cdc.gov/healthywater/global/healthburden.html#one.

IDR Environmental Services. How Does Leachate Contaminate Our Water Supply? Available online: https://blog.idrenvironmental.com/how-does-leachate-contaminate-our-water-supply.

Järup L. Hazards of heavy metal contamination. Br Med Bull 2003; 68: 167-82.

Kayode, O.T., Okagbue, H.I., and Achuka, A.J. (2018). Water quality assessment for groundwater around a municipal waste dumpsite. Data Brief, 17, 579-587. https://doi.org/10.1016/j.dib.2018.01.072.

Krystosik, A., Njoroge, G., Odhiambo, L., Forsyth, J.E., Mutuku, F., and LaBeaud, A.D. (2020). Solid Wastes Provide Breeding Sites, Burrows, and Food for Biological Disease Vectors, and Urban Zoonotic Reservoirs: A Call to Action for Solutions-Based Research. Frontiers in Public Health, 7, 405. https://doi.org/10.3389/fpubh.2019.00405.

Lukeman, Y., Bako, A.I., Omole, F.K., and Nwokoro, I.I.C. (2014). Survival in the Midst Of Challenges: Tale from Ijora-Badia Slum Dwellers of Lagos State, Nigeria. Journal of Educational and Social Research, MCSER Publishing, Rome, Italy, 4(3). 131.

Mayo Clinic Laboratories. (2025). *Chromium, serum overview*. Mayo Foundation for Medical

Education and Research. https://www.mayocliniclabs.com/test-catalog/overview/8638

Medscape. (2025). *Lab values, normal adult laboratory reference ranges in healthy adults*. Medscape Reference. https://emedicine.medscape.com/article/2172316-reference

Morais S., Costa F.G., and Pereira, M.L. (2012). Heavy metals and human health. Environmental Health: Emerging Issues and Practice, Jacques Oosthuizen (Ed), Intech Open, Chapter 10, 2-23. DOI: 10.5772/29869

Occupational Safety and Health Administration (OSHA). Cadmium. (Accessed on August 4, 2025) Available online: https://www.osha.gov/cadmium/health-effects#.

Ojo, O. I, Coker, A. O, Omotosho, O. A, Atta, A. T and Yahaya, A. I (2026): Assessment of Physicochemical and Microbial Quality of Water Sources in Lagos Urban Slum: Implications for Public Health and Environmental Engineering. In *FUOYE Journal of Engineering and Technology (FUOYEJET)*, 11(1), 28-33. https://dx.doi.org/10.4314/fuoyejet.v11i1.6

Philip, J. L., Richard, F., Nereus, J.R. A., Olusoji, A., Robert, A., and Niladri, B. (2018). The Lancet Commission on pollution and health. Lancet Comm 2017; 391 (10119): 462-512. 10.1016/S0140-6736(17)32345-0.

Parvin, F. and Tareq, S.M. (2021). Impact of landfill leachate contamination on surface and groundwater of Bangladesh: a systematic review and possible public health risks assessment. Applied Water Science, 11, 100. https://doi.org/10.1007/s13201-021-01431-3.

Popoola L.T., Yusuff A.S. and Aderibigbe T.A. (2019). Assessment of natural groundwater physico-chemical properties in major industrial and residential locations of Lagos metropolis. Appl Water Sci; 9: 191.

Rehman K, Fatima F, Waheed I and Akash M.S.H. (2018). Prevalence of exposure to heavy metals and their impact on health consequences. J Cell Biochem; 119(1): 157-84.

Templeton, D. M., and Sunderman, F. W. (1994). Tentative reference values for nickel concentrations in human blood, serum, and urine. *Pure and Applied Chemistry*, 66(5), 1141–1144. https://pubmed.ncbi.nlm.nih.gov/8029699/

The World Bank. Solid Waste Management. Available online: https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management

United States Environmental Protection Agency (USEPA). Learn about Lead. (Accessed on August 4, 2025) Available online: https://www.epa.gov/lead/learn-about-lead#.

Waste and human health: evidence and needs. Available online: https://www.euro.who.int/__data/assets/pdf_file/0003/317226/Waste-human-health Evidence-needs-mtg-report.pdf.

World Health Organization, "International Drinking Water Standards," 3rd Edition, Geneva, WHO, 2007. 315– 400.

World Health Organization. Diarrheal disease. (2017). Available at https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease.

Yahaya, T. Abdulganiyu, Y. Gulumbe, B.H. Oladele, E. Anyebe, D. and Shemishere, U. (2022). Heavy Metals and Microorganisms in Borehole Water Around the Olusosun Dumpsite in Lagos, Nigeria: Occurrence and Health Risk Assessment. Avicenna Journal of Environmental Health Engineering, 9(2), 69-74.http://dx.doi.org/10.34172/ajehe.2022.4213.

Yahaya, T. Muhammad, A. Onyeziri, J. Abdulazeez, A. Shemshere, U. and Bakare, T. (2022). Health Risks of Ecosystem Services in Ologe Lagoon, Lagos, Southwest, Nigeria. Pollution, 8(2), 681-692. https://doi.org/10.22059/poll.2022.334605.1265.