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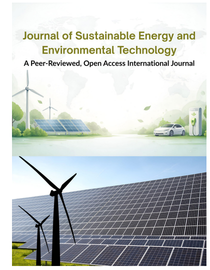

Research Article

Heavy Metal Determination of Surface and Ground Water in a University Community, SouthEast Nigeria

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Abstract: The pollution of drinking water with heavy metals has always presented serious public and environmental health challenges. The World Health Organization provides regulatory standards of permissible limits for heavy metal concentrations in water meant for consumption purposes. The present study assessed the concentrations of cadmium , lead , manganese , copper , zinc , iron , arsenic , and mercury in groundwater and surface water sources at Alvan Ikoku Federal University of Education, Owerri, using a Varian AA240 Atomic Absorption Spectrophotometer according to APHA (1995) methods. The findings of the study were compared with World Health Organization (WHO) permissible limits, which revealed that that cadmium, lead, and mercury exceeded WHO standards in most of the sampling points, while zinc and iron were above acceptable limits in a few locations. The concentrations of manganese and copper were within safe limits with the exception of B Hostel and Nworie midstream (manganese), and English/1000 capacity building for zinc. Statistical analysis by t-test indicated that there was no significant difference ($p > 0.05$) between heavy metal levels in surface and groundwater sources, with the exception of As ($p = 0.0287$), which suggests equivalent contamination route, likely to come from infiltration of polluted drainage or percolated liquid into groundwater reservoir The overall pollution levels indicate that most water samples in the study area are unsafe for direct consumption and may pose long-term health risks including neurological, renal, and carcinogenic effects. There should be continuous monitoring and proper treatment of water sources to protect public health.

Keywords: *Heavy metals, determination, contamination, ground water, surface water, university community*

1. Introduction

The presence of heavy metals in drinking water produces toxic effects , even at low concentrations. They are not easily removed from the body, thereby accumulating in body

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organs and posing serious health problems. Heavy metals find their way into water bodies through various means which include effluents from industries, agricultural run-offs into rivers, and lakes, leachates into ground water from waste dumps, among others. Concentrations of heavy metals in small amounts could lead to damage of liver, kidney, skins and lungs. The literature reflect quite a number of researchers that have determined heavy metals in ground and surface water sources.

(Rajkumar et al., 2019) detected chromium and iron as contaminants in more than 70% of the samples collected from water sources around chromium mining sites in Odisha region of India. (Okafor et al., 2023) evaluated surface and ground water in Ifitte, Ogwari of Anambra state for heavy metal contaminants using AAS technique, and discovered that the metals Cr, Cu, Mn, and Pb were not detected in all samples. The study also showed that there were no health risks associated with drinking water from the studied region. (AbdulGaniyu et al., 2022) identified Cd, Hg, Pb, As, and Co heavy metals to be above the WHO maximum permissible limits in the assessment of all the water samples collected around refuse dumpsites in Olubunku, Ede North, Southwestern Nigeria. (Ahmed et al., 2022) detected heavy metals such as Ni2+, Cu2+, Cr3+, Cr6+, Fe^{2+}, and Fe^{3+}in water samples and also degraded them using synthesized ZnO nanoparticles doped with zinc, as catalyst. (Abadi et al., 2024) assessed the contaminant levels of some heavy metals and their associated health risks, for surface and ground water sources in mountainous region of Irob, Tigray, and discovered that about 94.4% of the water samples exceeded the threshold limits for heavy metal pollution index, degree of contamination and heavy metal evaluation index. (Kumara et al., 2025) developed a sensor for the detection of heavy metal ions in water samples up to the level of 0.03 nM. (Zhou et al., 2024) detected 10 heavy metals in surface and ground water samples collected from a lead-zinc mine area of Daxin, Chongzuo. Fifteen groundwater and surface water samples were collected in a karst lead–zinc mine in Daxin, Chongzuo, which posed carcinogenic health risks in adults and children. (Haidery et al., 2024) detected uranium for the first time in water sample, which might be associated with interaction with the granite aquifer, within the urban and peri-urban region of Ranchi, India. (Ewusi et al., 2022) evaluated surface and groundwater samples collected around Nsuta manganese mining area in western Ghana , and discovered that the carcinogenic risk level is low for the surface water and extremely high in the mine pit water. (Aryal et al., 2024) developed a sensor for detection of heavy metals in environmental water samples, and discovered that six out of seven limits of detection values fell well below EPA regulatory standards for drinking water.

There is no evidence from literature on heavy metal determinations of surface and ground water samples in Alvan University. Hence the present research work sought to assess the concentration of heavy metals in selected locations of ground and surface water in Alvan Ikoku Federal University of Education, and compare them with World Health Organization standards, to ensure that they are safe for human consumption.

2. Materials and Methods

Heavy metal analysis was carried out by making use of Varian AA240 Atomic Absorption Spectrophometer in accordance with the APHA 1995 method (American Public Health Association). The sample to be analyzed is aspirated into the flame, whichis atomized when the AAS's light beam is directed through the flame into the monochromator, and onto the detector which measures the amount of light absorbed by the atomized element in the flame. Metals have their own characteristic absorption wavelength, so a source lamp which is composed of the sample element is used. This way, there is freedom from spectral or radiational interferences. The amount of energy absorbed in the flame, having a characteristic wavelength, is proportional to the concentration of the element in the sample.

Table 1: Results of Heavy Metal Analysis for Ground Water

Sample	Cadmium (ppm)	Lead (ppm)	Manganese (ppm)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Arsenic (ppm)	Mercury (ppm)
WHO Max. Limit	0.003	0.01	0.1	2.0	3.0	0.3	0.01	0.003
D Hostel	0.0078	0.0179	0.0341	0.0000	0.0155	0.0765	0.023	0.030
B Hostel	0.00	0.0292	0.676	0.0032	0.0068	0.0596	0.009	0.018
English/1000 Capacity	0.00	0.0433	0.0527	0.0033	3.898	0.1890	0.016	0.022
Agric. Dept	0.0347	0.0213	0.0672	0.0062	0.0058	0.0696	0.014	0.017
Alvan Nursery	0.0287	0.0158	0.0073	0.0033	0.0599	0.0597	0.019	0.028
Future Hope Shell Camp	0.2175	0.0784	0.0399	0.0598	0.3499	0.6753	0.015	0.017
NAS/Biology Laboratory	0.0240	0.0354	0.0139	0.0174	0.0419	0.1282	0.016	0.019
Safari Club Shell Camp	0.0306	0.0350	0.0632	0.0148	0.0247	0.4572	0.011	0.029

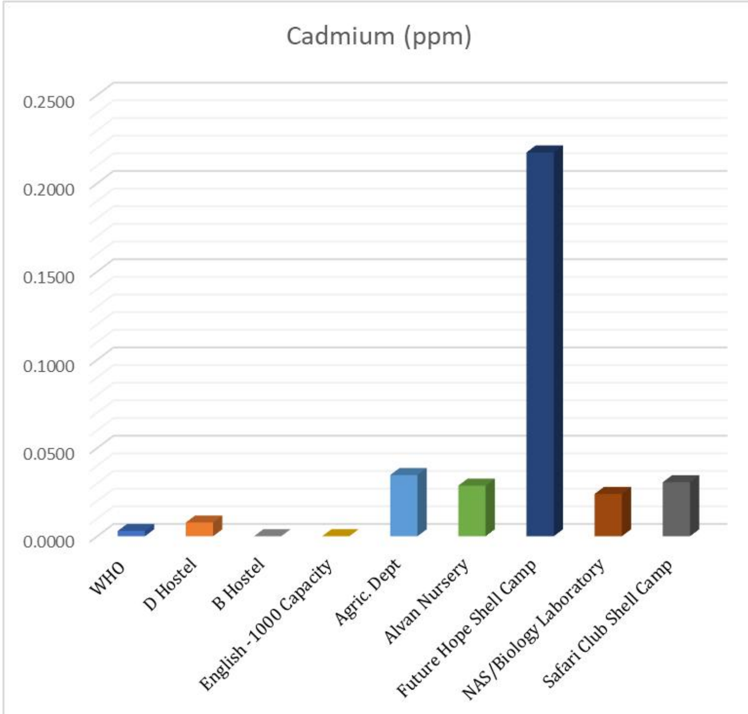

Figure 1: Cadmium ion concentration in ground water in comparison with WHO standard for portable water

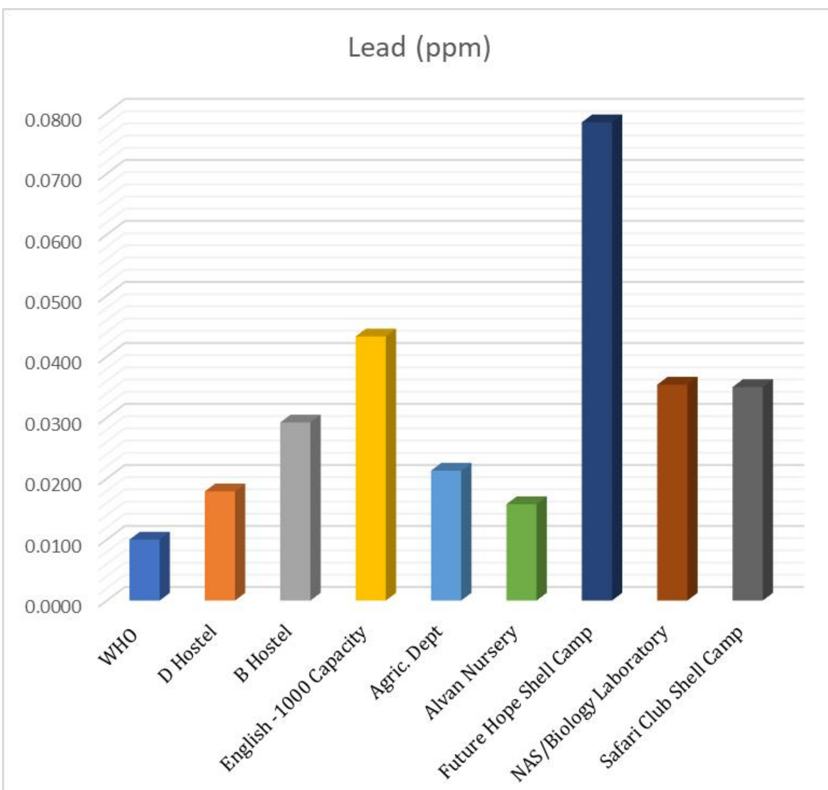

Figure 2: Lead ion concentration in ground water in comparison with WHO standard for portable water

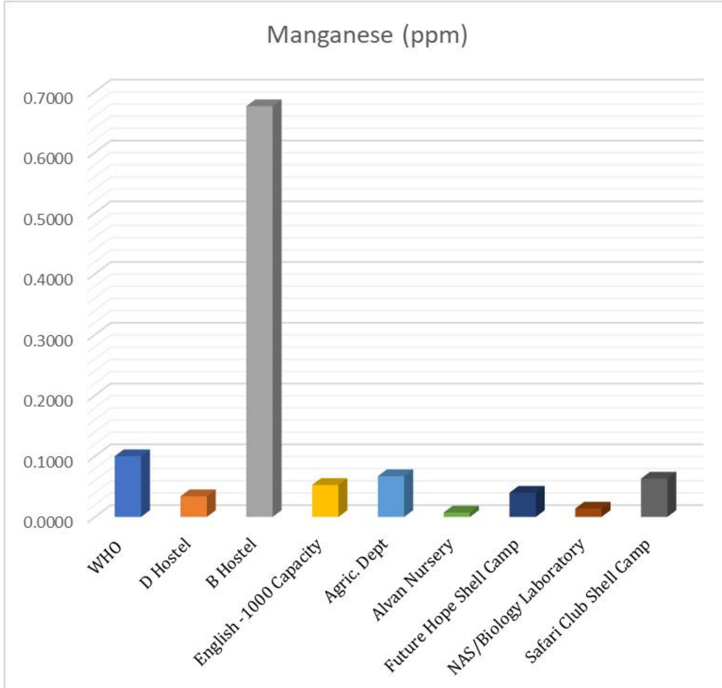

Figure 3: Manganese ion concentration in ground water in comparison with WHO standard for portable water

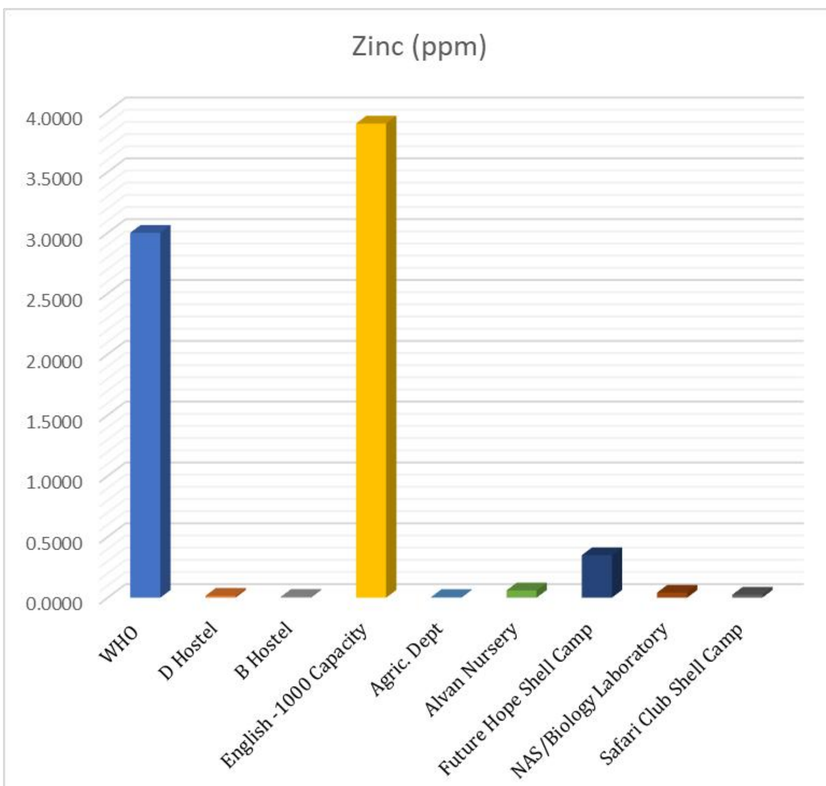

Figure 4: Zinc ion concentration in ground water in comparison with WHO standard for portable water

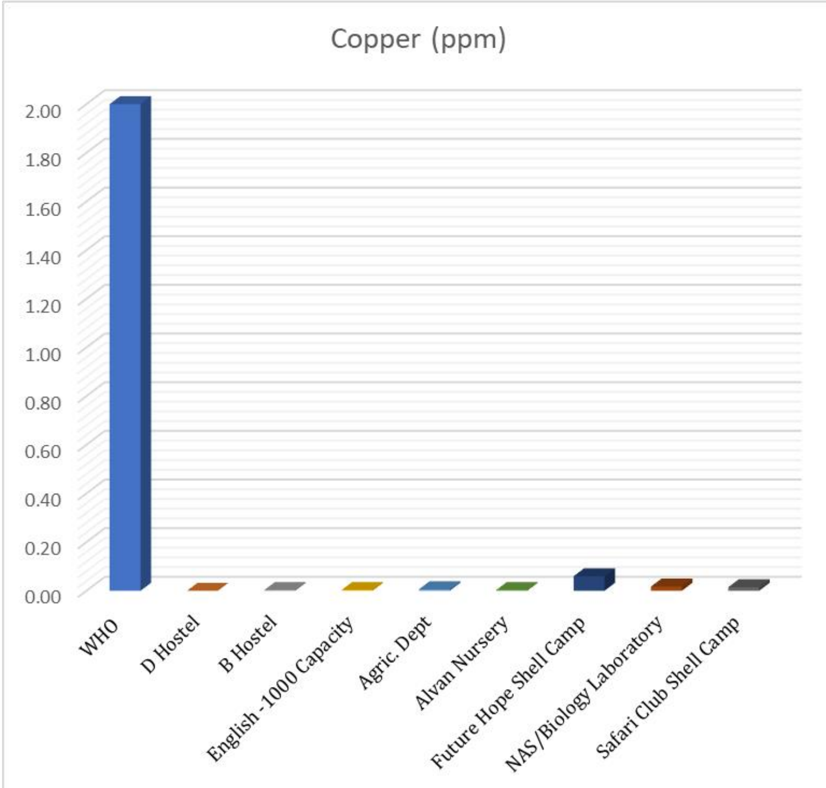

Figure 5: Copper ion concentration in ground water in comparison with WHO standard for portable water

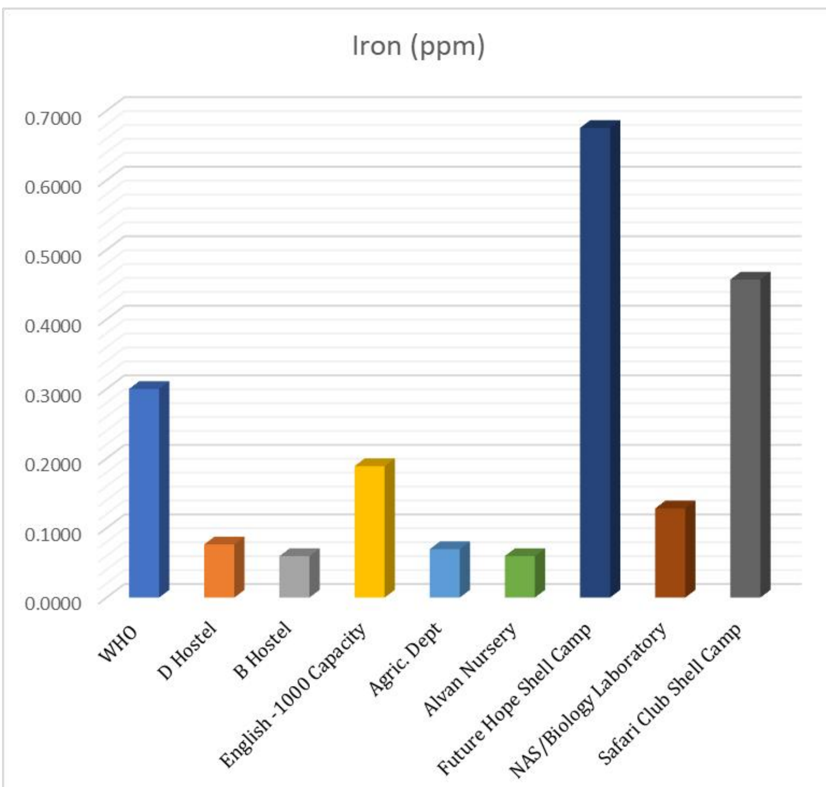

Figure 6: Iron ion concentration in ground water in comparison with WHO standard for portable water

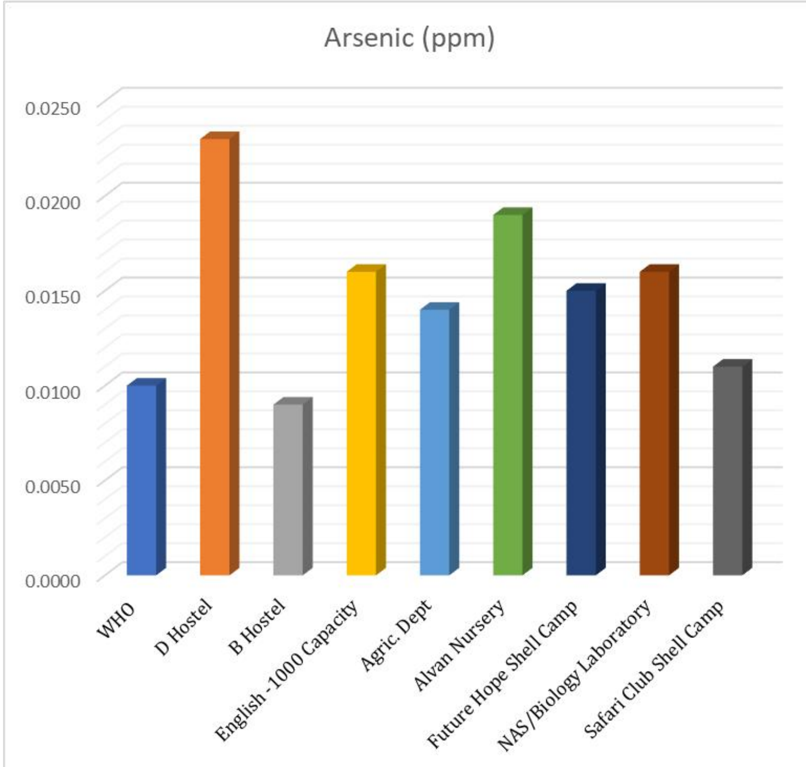

Figure 7: Arsenic ion concentration in ground water in comparison with WHO standard for portable water

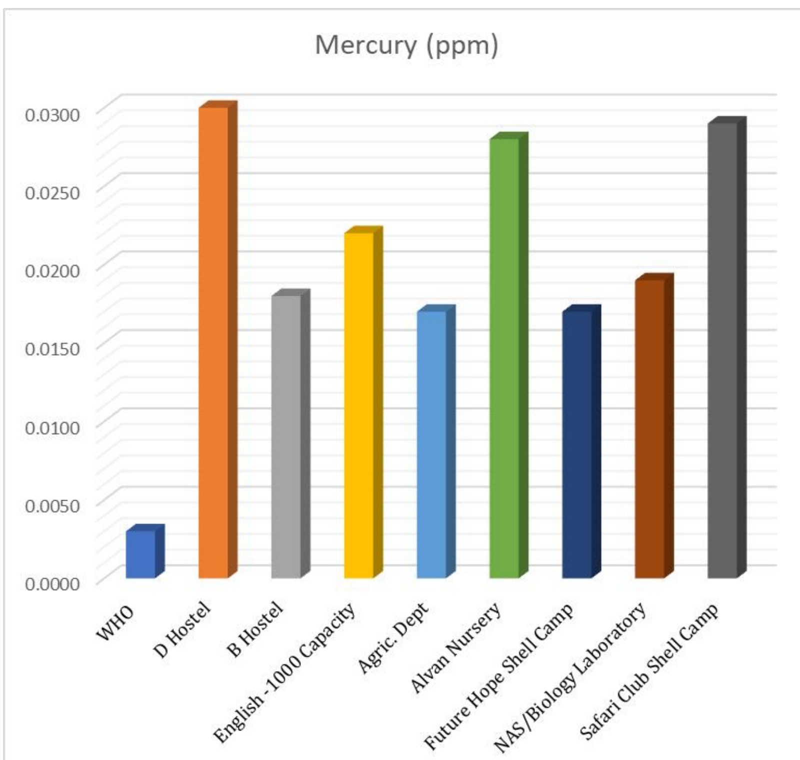

Figure 8: Mercury ion concentration in ground water in comparison with WHO standard for portable water

Table 2: Results of Heavy Metal Analysis for Surface Water

Sample	Cadmium	Lead	Manganese	Copper	Zinc	Iron	Arsenic	Mercury
WHO Max. Limit	0.003	0.01	0.1	2.0	3.0	0.3	0.01	0.001
Nworie Midstream	0.0041	0.0322	0.1648	0.0064	0.2064	0.8960	0.007	0.019
Nworie Downstream	0.00	0.0269	0.0175	0.0041	0.0474	0.0478	0.010	0.032
Nworie Upstream	0.000	0.0269	0.0175	0.0034	0.0016	0.0849	0.014	0.034

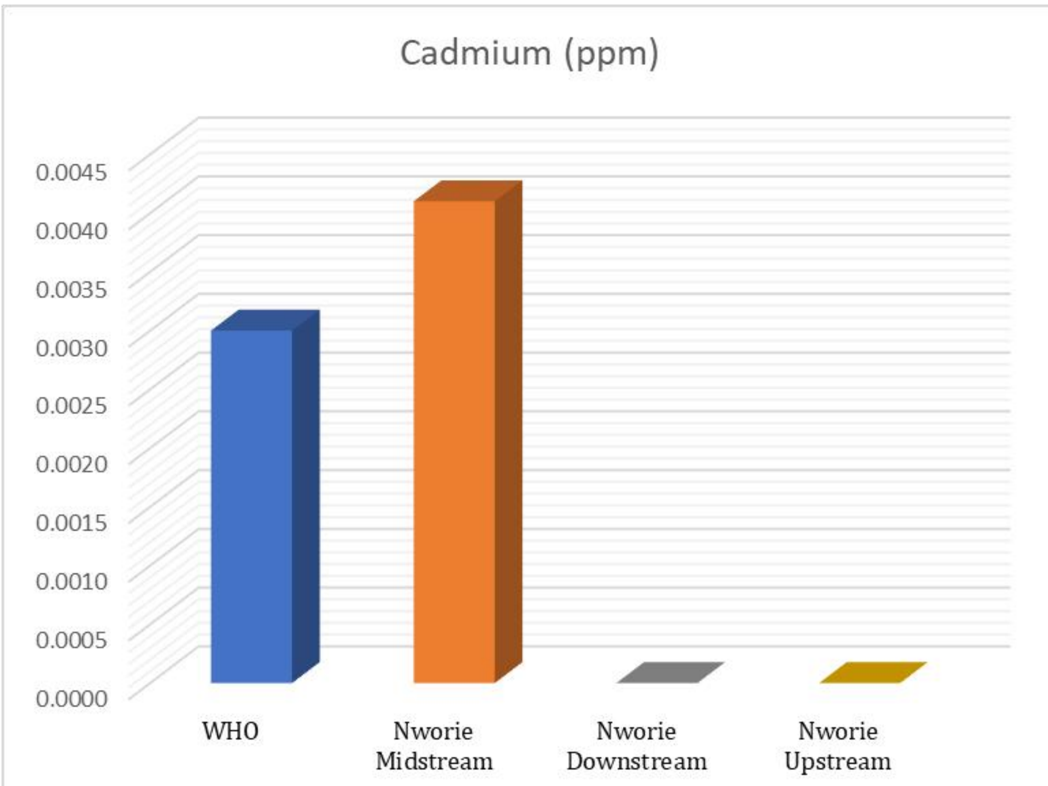

Figure 9: Cadmium ion concentration in surface water in comparison with WHO standard for portable water

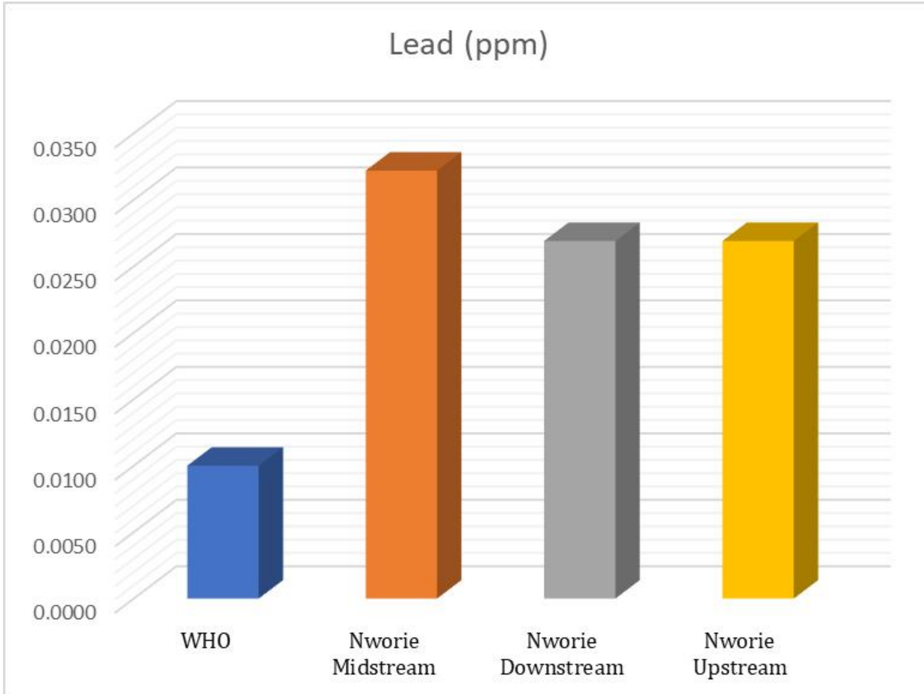

Figure 10: Lead ion concentration in surface water in comparison with WHO standard for portable water

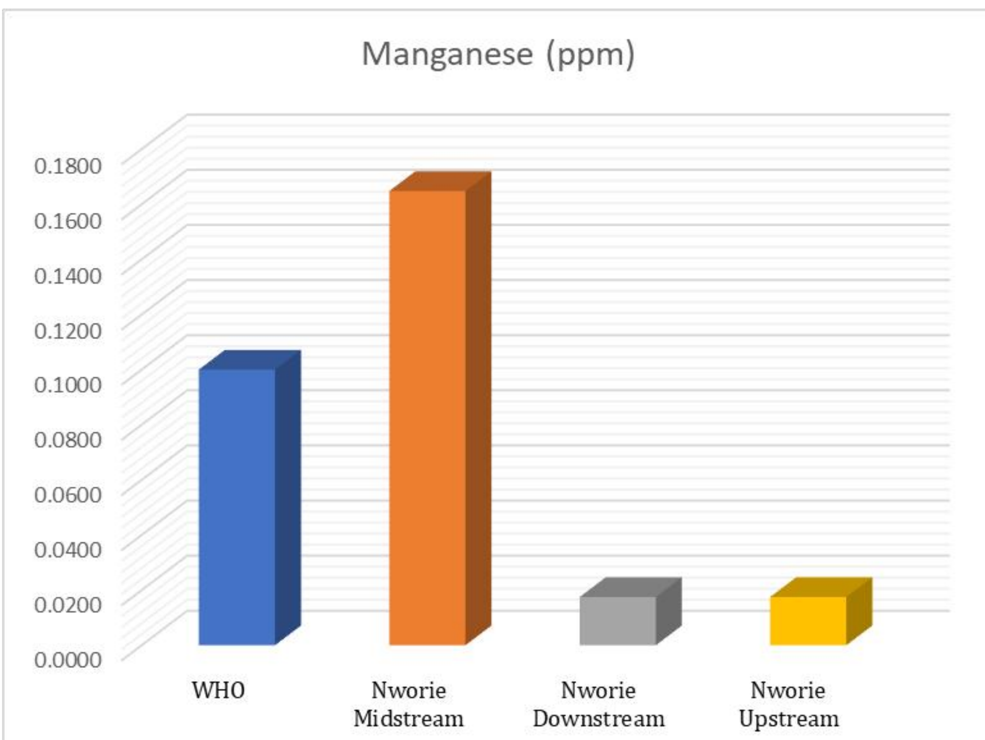

Figure 11: Manganese ion concentration in surface water in comparison with WHO standard for portable water

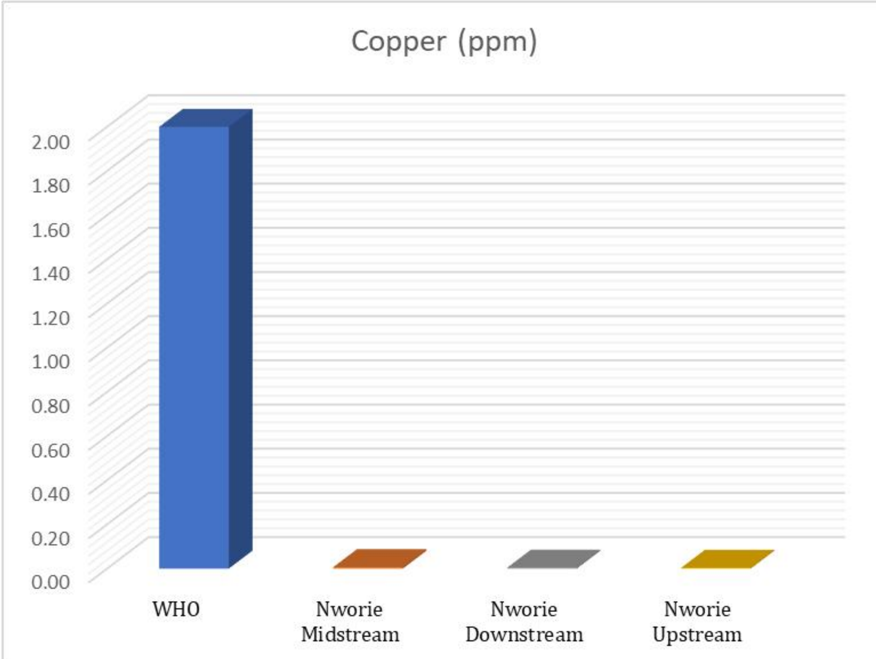

Figure 12: Copper ion concentration in surface water in comparison with WHO standard for portable water

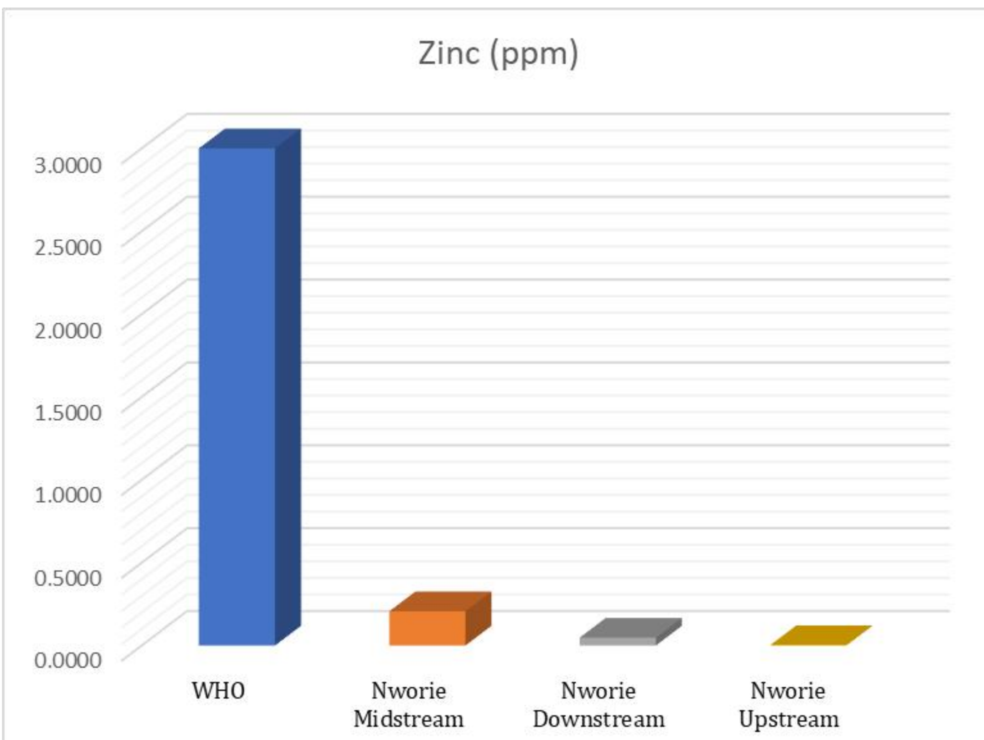

Figure 13: Zinc ion concentration in surface water in comparison with WHO standard for portable water

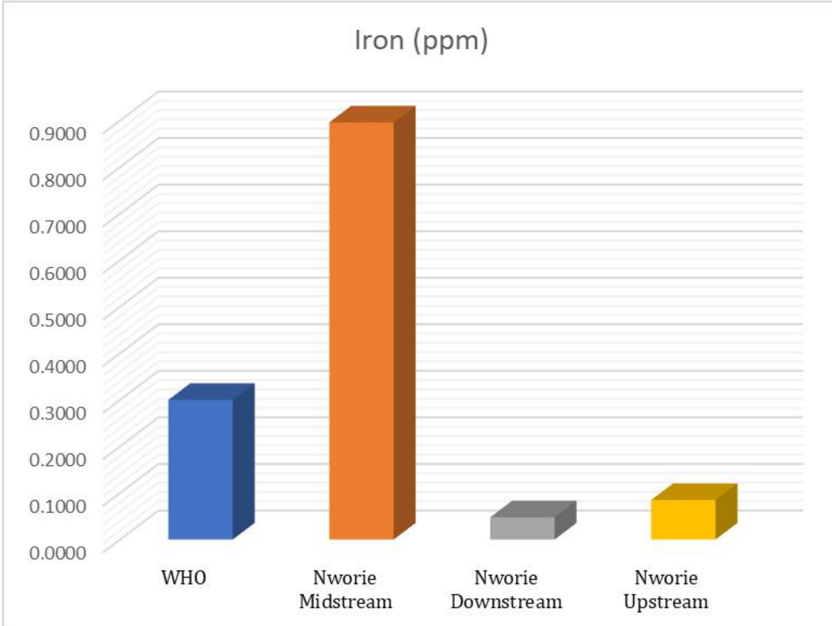

Figure 14: Iron ion concentration in surface water in comparison with WHO standard for portable water

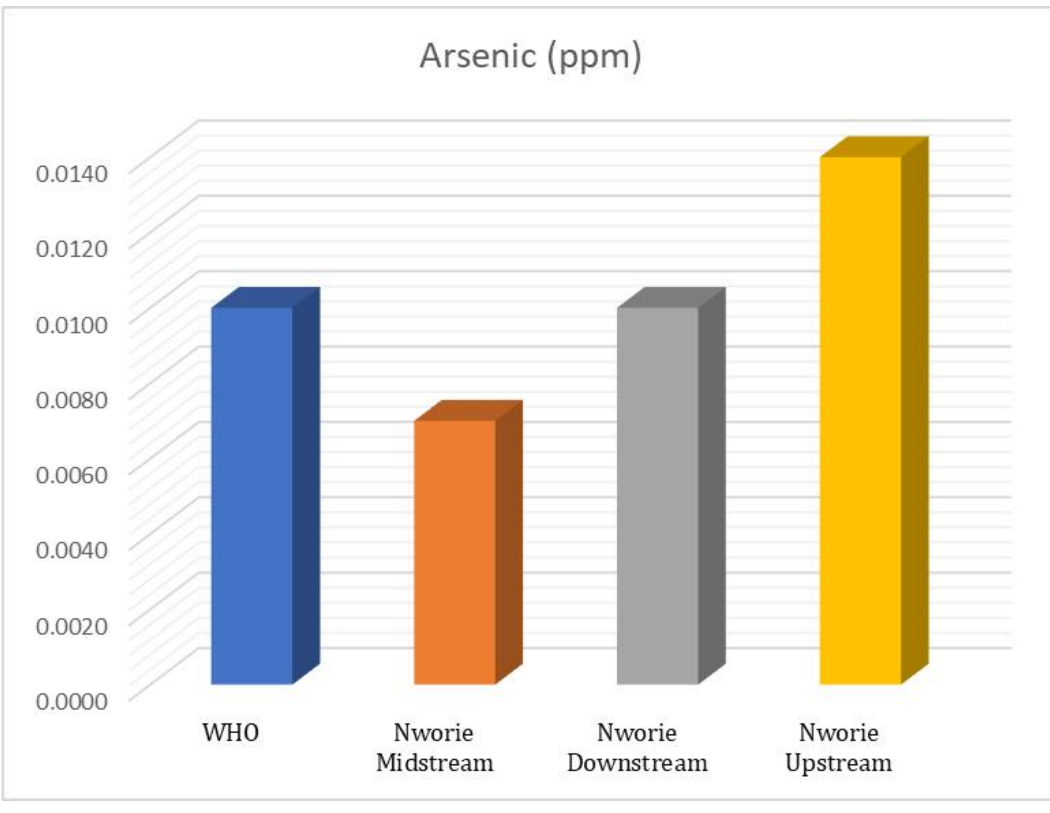

Figure 15: Arsenic ion concentration in ground water in comparison with WHO standard for portable water

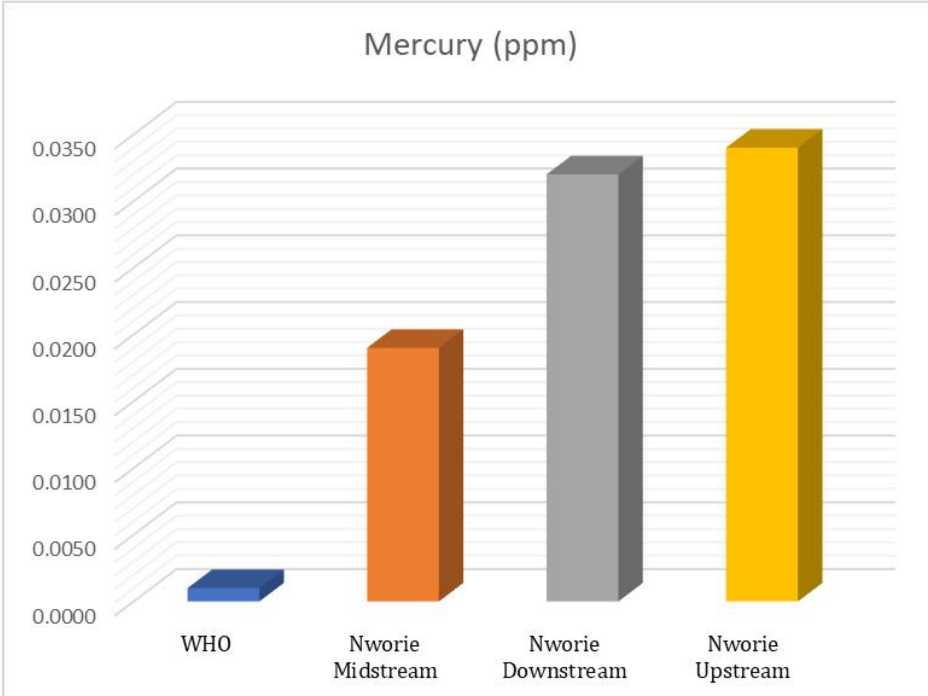

Figure 16: Mercury ion concentration in ground water in comparison with WHO standard for portable water

The results of heavy metal analysis of the tested ground water samples are presented in Table 1 and Figures 1-8, while Table 2 and Figures 9-16 show the concentrations of heavy metals found in the surface water samples. The WHO maximum permissible level for cadmium in portable is 0.003 ppm. Samples from Nworie midstream (0.0041 ppm), D hostel (0.0078 ppm), Agricultural department (0.0347 ppm), Alvan nursery (0.0287 ppm), Future Hope school 0.2175 ppm), NAS/Biology department (0.0240 ppm), and Safari club (0.0306 ppm), all exceeded the WHO limits for cadmium in water. This could be as a result of waste discharge or rusting of plumbing pipes (Ahmed et al., 2021). Future Hope School (0.2175 ppm) has the highest cadmium concentration, which suggests localized pollution index, and requires urgent attention. Cadmium is carcinogenic, and exposure to cadmium , even at low concentrations, affects the kidney and bones. All the tested samples exceeded the WHO maximum limit of 0.01 ppm for lead in portable water. Lead contamination in water could impair the nervous system including the brain, nerves and spinal cord, leading to seizure, memory loss among others (Haidery et al., 2023). This poses a serious health challenge, seeing the university population is largely made up of young adults.

The WHO maximum limit for manganese is 0.1 ppm. All the studied samples have safe values with regards to manganese, excepting Nworie midstream and B hostel with cadmium level of 0.676 ppm and 0.1648 ppm respectively. High manganese levels in drinking water could have neurological effects in humans. Manganese remained within permissible limits except in B Hostel and Nworie Midstream. Increase of manganese in waterbodies could be linked to geochemical procedures (AbdulGaniyu et al., 2022).

All the studied samples have concentrations of copper that are lower than the WHO permissible limit for portable water. All the tested samples had concentrations of zinc lower than the WHO maximum limit of 3.0 ppm for drinking water, with the exception of the sample from English department/1000 capacity building, at 3.898 ppm. This could be caused by seeping of plumbing materials (Ewusi et al., 2020).

Samples from Nworie midstream, Future Hope school and Safari club exceeded the WHO maximum limit of 0.3 ppm for iron in portable water as 0.8960 ppm, 0.6753 ppm and 0.4572 ppm respectively. It might not be out-rightly toxic, but may impair water taste, and stain cloths in laundry. Arsenic limit for drinking values according to WHO is 0.01 ppm. This value was exceeded in D hostel (0.023 ppm), Alvan nursery (0.019 ppm), NAS/Biology department (0.016 ppm) and Future Hope school (0.015 ppm). High arsenic levels in drinking water could lead to cancer of ladder, lungs and skin. The WHO maximum level for mercury is 0.001 ppm, which was exceeded in all the studied samples. High mercury levels in drinking water could cause neurological damages.

The above results show widespread heavy metal contamination within the university, reverberating findings from studies in Nigeria, India, and Ethiopia where water quality is deteriorated as a result of urbanization and poor waste water management. (Khan et al., 2023;Wang et al., 2025). developed an instrument for detection of Cr, Cu and Pb in water up to 1.02, 1.23 and 3.26 ng mL^{-1} limits respectively. (Vetrimurugan et al., 2017) obtained similar results for Tamil, Nadu in India, as chromium and zinc were within permissible limits of the Bureau of Indian Standards for drinking water quality, and silver, lead and nickel exceeded limits of Indian standards for portable water. (Zheng et al., 2024) carried out a review on detection and removal of heavy metals from waste water using carbon, and titanium nanotubes. (Singh et al., 2024) carried out a review on the methodology utilized for the detection and removal of heavy metals in waste water.Similar work of (Eid et al., 2024) found some samples of surface and ground water from rock-dominated area of Irob, Tigray, unfit for drinking as a result of heavy metal concentrations present in excess of WHO and USEPA standards for drinking water. (Almawgani et al., 2023) developed a simple and accurate sensor for detecting heavy metals in aqueous solutions. (Taha et al., 2022) developed a simple and effective tool for the detection of heavy metals in water. (Khan et al., 2023) obtained similar results whereby chromium, cadmium, lead, nickel and iron concentrations in surface water exceeded the WHO standard for drinking water. (Nayak et al., 2022) reviewed the methods that could be used to detect heavy metals in contaminated samples in the environment. The study of (George et al., 2023), on the surface and ground water samples obtained in the automobile workshop region in Kerala India showed similar results to the present study as concentrations of lead, copper and zinc were either equal to or above the control values for drinking water. (Shang et al., 2023) proposed a method for detection of heavy metals in environmental samples.

3. Test of Hypothesis

Null hypothesis (H_0): There no significant difference between the concentration of heavy metals in ground water and surface water in Alvan Ikoku Federal University of Education, Owerri, Imo State, Nigeria.

Alternate hypothesis (H_1): There is significant difference between the concentration of heavy metals in ground water and surface water in Alvan Ikoku Federal University of Education, Owerri, Imo State, Nigeria.

Table 3: Mean and standard deviations for ground and surface water with regards to physicochemical parameters

Parameter	Mean for ground water	Standard deviation for ground water	Mean for surface water	Standard deviation for surface water	t-value	P-value
Cadmium	0.0527	0.0747	0.0040	0.0029	-2.0736	0.0662
Lead	0.0300	0.0174	0.0286	0.0025	-0.1960	0.8493
Manganese	0.0372	0.0214	0.1800	0.3071	1.1643	0.2768
Copper	0.0129	0.0179	0.0043	0.0014	-1.2181	0.2493
Zinc	0.4964	1.1471	0.0615	0.0893	-1.1918	0.2605
Iron	0.1808	0.2327	0.2333	0.3950	0.2948	0.7742
Arsenic	0.0161	0.0035	0.0110	0.0029	-2.6273	0.0287
Mercury	0.0220	0.0052	0.0260	0.0073	1.0067	0.3396

From Table 3, the t-values and p-values show that there is no significant difference between the ground water and surface water values for all the concentration of heavy metals except arsenic (at p: 0.0287<0.05)). This suggests equivalent contamination route, likely to come from infiltration of polluted drainage or percolated liquid into groundwater reservoir (Vetrimurugan et al., 2020).

4. Conclusion

The study has shown contamination of surface and groundwater sources within the university community by heavy metals exceeding the WHO permissible limits, especially cadmium, lead, arsenic, and mercury. Heavy metals, even at low concentrations, can bioaccumulate in body tissues and produce dangerous health problems like neurotoxicity and cancer, even at low concentrations.. Elements like manganese, copper, and zinc were within acceptable levels in most samples, but the presence of many of these toxic metals shows pollution of the environment, which could be connected to waste disposal, industrial discharge from surrounding areas, and corrosion of water supply materials. In addition, the test of hypothesis supports comparable pollution affects for surface and ground water sources, and emphasizes the necessity for prompt corrective measure. The present quality of the examined water sources within the university community does not meet international standard for portable water. Hence there is the need for proper treatment before consumption.

Recommendations

Based on the findings, the following actions are proposed:

1. Water from these sources should be properly treated through reverse osmosis, ion exchange and activated carbon fitration before consumption.
2. There should be enactment of laws to control waste disposal into Nworie river.
3. There should be periodic and routine check of water sources in the institution.
4. Staff and students of the university community should be educated on the implications of drinking water from these sources, and encouraged to use alternative sources.
5. Corroded pipes and tanks should be replaced to avoid leakage of metals into water reservoir.

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