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Heavy Metal Assessment in Abandoned Mine Ponds at Koroshi, Jos South, Plateau State, Nigeria

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Abstract: Abandoned mine ponds in Jos Plateau have become persistent water bodies following decades of artisanal and industrial tin-mining activities. In Koroshi, Jos South Local Government Area, Plateau State, Nigeria, these ponds are used for irrigation, domestic activities, and other livelihood purposes, creating potential pathways for human and ecological exposure to heavy metals. This study assesses the concentrations of cadmium, mercury, lead, and arsenic in selected abandoned mine ponds and artisanal wells within the Koroshi area. Water samples from Dams and abandoned mine wells dung by artisanal miners were collected and transported to the laboratory and analyzed using Atomic Absorption Spectrophotometry. The measured concentrations were compared with national and international water-quality standards to determine the suitability of the ponds for domestic and agricultural use. Statistical techniques were used for better visualization and presentation. The result shows that cadmium and mercury were above the recommendations of national and international base ratings. The research provides recommendation for better remediation and community awareness to the locals about the dangers of using these water bodies for irrigation purposes.

Keywords: *Abandoned Mine Ponds; Heavy Metals; Koroshi; Jos South; Water Quality; Atomic Absorption Spectrophotometry; Irrigation Water.*

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I. INTRODUCTION

The historical prevalence of artisanal and industrial tin mining in the Jos Plateau has left behind numerous unreclaimed excavations that now persist as abandoned ponds (Komolafe et al., 2023). While these sites frequently serve as secondary water sources for local communities, the unchecked expansion of mining operations has raised significant concerns regarding the migration of toxic trace elements into the hydrologic cycle (Sayyadi et al., 2025; Zitta, 2024). These persistent pollutants, including lead, cadmium, and mercury, pose severe ecotoxicological risks to both the aquatic ecosystem and the human populations reliant upon these reservoirs for domestic and agricultural use (Akpa, 2026; Mbet et al., 2025). Given that heavy metal accumulation in these aquatic environments can facilitate bioaccumulation within the food chain, there is a critical need to evaluate the concentration levels of these hazardous contaminants (Akpa, 2026; Bello et al., 2025). This investigation specifically analyzes the concentrations of metals such as cadmium, mercury, Arsenic and lead within selected unreclaimed mine ponds in Koroshi Jos South, plateau State, Nigeria. Furthermore, assessing these specific analytes is essential to determine whether current concentrations exceed established safety thresholds for water quality, as similar mining environments in Nigeria have shown seasonal fluctuations in contaminant trends (Okonofua et al., 2024).

Previous investigations in Jos Plateau State have demonstrated that trace metal concentrations, particularly lead, cadmium, and arsenic, often exhibit marked differences between dry and wet seasons due to dilution and runoff factors (Gungshik et al., 2021). Consequently, the chronic consumption of contaminated water and the usage of these abandoned ponds for irrigation purposes represents a direct pathway for human exposure, potentially disrupting essential biological processes such as calcium and phosphorus

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homeostasis. This study looks to address the knowledge gap regarding the spatial and temporal distribution of these contaminants within the Koroshi area, providing a baseline for assessing potential health risks associated with long-term exposure. This research employs standardized analytical techniques to quantify metal concentrations via Atomic Absorption Spectrophotometry, ensuring findings remain consistent with established protocols for assessing water suitability (Annuri et al., 2026; Awogbami et al., 2023). By integrating these quantitative assessments with comparative analysis of regulatory safety benchmarks, this study aims to clarify the extent of environmental degradation necessitated by abandoned mining infrastructure. Ultimately, the data derived from this evaluation will facilitate the development of targeted remediation strategies to mitigate the ongoing threat of heavy metal ingestion through local agricultural and domestic water sources (Acheampong et al., 2025; Gwira et al., 2024). Furthermore, this research contributes to the broader understanding of contamination dynamics by evaluating the contamination factor and ecological risk indices inherent in these aquatic systems (Adewumi & Laniyan, 2023). This is particularly vital given the extensive reliance on irrigation farming across the Jos Plateau, where agricultural produce grown with potentially contaminated pond water enters the food supply (Okonofua et al., 2024). In the absence of rigorous assessment and actionable recommendations to inform regulatory authorities, the consumption of crops cultivated in these environments presents a persistent health threat to the wider populace (Bello et al., 2025; Komolafe et al., 2023). the research aims to bring to knowledge the existing status of the heavy metal presence in abandoned mine ponds in Koroshi of Du District Plateau State, Nigeria.

➢ *Location of the Study Area*

The study area is geographically situated within the Jos South Local Government Area, characterized by a topography heavily modified by historical mining activities. This encompasses the settlement, where numerous stagnant water bodies serve as the primary nexus for dry-season irrigation and domestic activities for the local populace (Samuel & Ochube, 2021). The area can be access from the popular Kugiya Market in Bukuru town via the road leading to Shen roundabout. The map of the study area along site the GPS points using Arc GIS software have been meticulously demarcated to ensure precise spatial representation of the sampling stations within the Koroshi mining cluster. figure 1 below shows the detailed map.

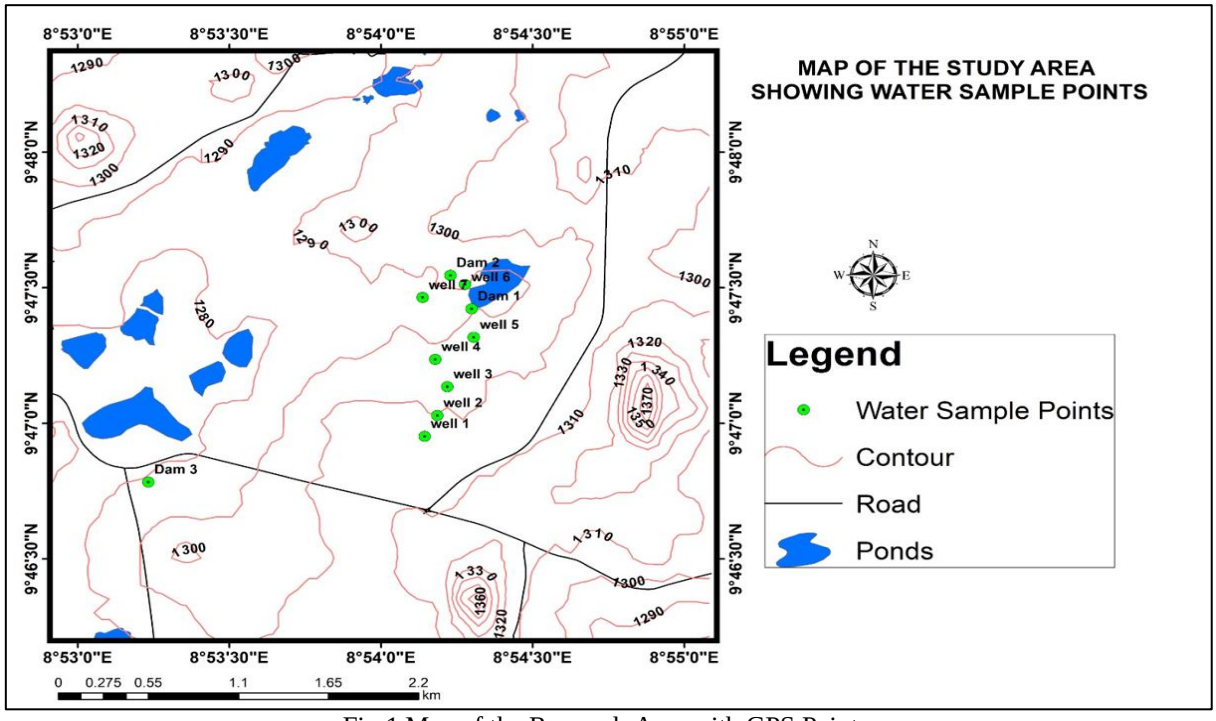

Fig 1 Map of the Research Area with GPS Points.

II. LITERATURE REVIEW

Extensive scholarly discourse has consistently highlighted that the legacy of mining activities creates persistent environmental hazards, as geochemical mobilization of trace elements often leads to significant degradation of water quality in abandoned excavation sites (Adekiya et al., 2024). These hydro-geochemical transformations are frequently exacerbated by the influx of industrial discharge and artisanal ore processing, which alter the physicochemical equilibrium of surrounding aquatic ecosystems. Such activities significantly influence the chemical speciation and mobility of persistent toxic metals, particularly arsenic, cadmium, mercury, and lead, within the pond environment (Gungshik et al., 2021; Mbet et al., 2025). The sustained release of these elements into the water column enhances their bioavailability, creating complex pathways for bioaccumulation in aquatic organisms and ultimately impacting human health through the consumption of contaminated water or agricultural products (Akpa, 2026; Okonofua et al., 2024). Additionally, global studies confirm that tailings and mine wastes represent primary

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anthropogenic sources of heavy metals, which lead to severe ecological degradation and the contamination of regional water resources (Onwuka et al., 2024). Jos Plateau state has face decade of mining activities which the land is degraded with several abandoned mined ponds. These excavated pits, often repurposed for dry-season irrigation, serve as focal points for the accumulation of metallic ions that exceed standard safety thresholds (Nenman, 2025). Such anthropogenic inputs often result in total dissolved solids and turbidity levels that significantly surpass the critical limits established by the World Health Organization and the Federal Environmental Protection Agency. Furthermore, evidence from the Bukuru study area indicates that while certain metallic concentrations may fluctuate, the persistent elevation of physicochemical parameters necessitates a continuous assessment to prevent long-term ecological risks (Kwaghe et al., 2021). Moreover, the presence of these abandoned mining cavities creates stagnant conditions that promote the proliferation of water-borne pathogens, further complicating the management of water safety in these communities (Ogunro & Owolabi, 2022). Consequently, rigorous monitoring of these sites is imperative to mitigate the health risks posed by heavy metal mobilization and to prevent the degradation of groundwater aquifers adjacent to these contaminated pits (Umeh, 2025).

- *Sources of Heavy Metals*

The accumulation of heavy metals in the environment originates from both natural geological weathering and varied anthropogenic activities, such as mining, ore processing, and the application of agrochemicals (Mensah et al., 2023; Okorie et al., 2024). In particular, mining operations discharge effluents rich in cadmium, lead, and arsenic directly into local hydrological systems, while the subsequent use of pesticides and fertilizers in nearby agricultural plots introduces additional non-point source contaminants (Olalekan et al., 2022). Furthermore, local artisanal activities, including traditional blacksmithing and the operation of small-scale metal foundries, contribute to the heavy metal load through the release of untreated industrial run-off into these aquatic basins (Okafor et al., 2023). Additionally, the leaching of heavy metals from abandoned mine tailings and discarded geologic waste serves as a significant non-point source of pollution, often exacerbated by atmospheric deposition and surface runoff that transports concentrated toxins into stagnant pond systems (Kana, 2022).

- *Turbidity of Water*

Turbidity of water represents an optical property indicative of suspended particulate matter, which restricts light penetration and disrupts photosynthetic activity within the pond ecosystem (Umoru et al., 2024). In mining-impacted regions, elevated turbidity levels are frequently linked to sediment loading from ore washing and soil leaching, often reaching concentrations that double established international safety standards (Ojo et al., 2023). Moreover, high turbidity levels often correlate with increased adsorption sites for heavy metal ions, further facilitating the transport and long-term retention of hazardous contaminants within the water column (Bhat & Janaszek, 2024; Singh et al., 2024). Furthermore, the presence of these suspended particles can impede the efficacy of standard water treatment processes, thereby increasing the difficulty of providing safe water for domestic consumption in the surrounding communities. The turbidity usually indicates that the presence of suspended inorganic solids and organic debris that reduce light penetration, thereby altering the thermal stratification and dissolved oxygen dynamics of the pond. In the same context, excessive turbidity often serves as a proxy for localized mining contamination, where sediment loading directly correlates with the physical impairment of water quality and the degradation of aquatic habitats (Ewuga et al., 2025).

- *Water pH*

pH of water represents the measure of hydrogen ion concentration, serving as a critical indicator of the acidity or alkalinity of the pond environment. The acceptable range for values of pH for irrigation purposes typically falls between 6.5 and 8.5 to ensure optimal crop health, as extreme shifts in acidity can mobilize toxic metals or impair nutrient uptake. It is imperative to examine the pH of water because it dictates the solubility and subsequent chemical speciation of heavy metals, directly influencing their toxicity and mobility within the aquatic medium (Chepkoech et al., 2025). Specifically, low pH environments promote the dissolution of mineral-bound metals, thereby increasing their bioavailability to local aquatic biota (Duncan et al., 2023). Acidic range is not the only condition that impacts water quality, as fluctuations outside the standard physiological range can indirectly compromise the health of aquatic organisms by disrupting essential biological processes (Kallon et al., 2024). The pH range of mining ponds in and around Bukuru and environs has been studied to be within the range of 6.5 to 8.5, which aligns with international standards for aquatic productivity and irrigation safety (Faiza et al., 2022). However, despite these acceptable pH levels, other indices such as total alkalinity and dissolved oxygen in similar tin mining ponds often exhibit significant variability that can influence the chemical equilibrium of the water body (Mafuyai et al., 2021). Such conditions may be further complicated by the emergence of incipient acid mine drainage, which, despite near-neutral pH readings, can introduce chemical stressors that negatively impact the solubility and dispersal patterns of heavy metals (Nwachukwu et al., 2021). Post-tin mining environments are frequently characterized by nutritional deficiencies and diminished ion exchange capacity, which further destabilize the chemical integrity of these stagnant water bodies (Kurniawan et al., 2023).

- *Cadmium Cd*

As a highly toxic non-essential trace element, cadmium is frequently identified in mine-impacted waters where its concentration often surpasses the established safety thresholds for drinking and irrigation purposes (George et al., 2023), (Eid et al., 2024). Due to its lack of metabolic function, cadmium remains a potent threat to human health, capable of inducing mutagenicity, genotoxicity, and neurotoxicity upon long-term ingestion (Oyetibo et al., 2021). The environmental persistence and non-biodegradable nature of this metal facilitate its continuous accumulation within aquatic ecosystems, leading to significant bioaccumulation and biomagnification (Olawade et al., 2024). Moreover, its

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mobility within aquatic systems is highly sensitive to fluctuations in pH and the presence of organic matter, which can accelerate the translocation of cadmium into the edible tissues of crops irrigated with these pond waters (Albou et al., 2023; Aziz & Hussain, 2023). Given its high solubility in the acidic conditions often characteristic of mine-impacted environments, cadmium readily enters the food chain via root uptake (Singh & Pant, 2023; Xu et al., 2024). Once absorbed by vegetation, cadmium translocate from the root system to the aerial parts of the plant, increasing the risk of dietary exposure for local populations consuming these contaminated harvests (Al-Khayri et al., 2023; Bargah, 2024). Beyond these direct exposure pathways, the synergistic effect of other heavy metals such as lead and arsenic in stagnant pond water complicates remediation efforts and heightens the potential for chronic systemic toxicity (Madjar & Scăeţeanu, 2025; Paredes-Vilca et al., 2024).

- *Lead Pb*

Lead is a pervasive environmental contaminant that often exhibits elevated concentrations in stagnant mining ponds due to its non-degradability and long-term retention in sediments (Berhanu et al., 2024; Swain, 2024). Due to its strong affinity for organic matter and mineral surfaces, lead readily adsorbs onto pond substrate, where it may be re-released into the water column under fluctuating redox conditions or pH shifts (Cairns et al., 2021). This continuous cycling between the sediment and the water column poses a grave risk to aquatic biota, as lead can interfere with essential metabolic processes even at trace levels (Karadeniz et al., 2024). The resulting accumulation of lead in the human body can subsequently disrupt nervous system function and lead to profound intellectual disabilities, particularly in developing populations (Du et al., 2022). Furthermore, chronic exposure to lead is strongly associated with cardiovascular failure, kidney damage, and the impairment of endocrine functions (Khan et al., 2022; Kumar et al., 2024). The neurological degradation associated with lead toxicity is particularly critical in pediatric cohorts, where it frequently manifests as behavioral deficits and impaired cognitive development (Vajargah & Azar, 2023; Yüksel et al., 2021). Moreover, the ingestion of contaminated crops or aquatic organisms from these sites introduces lead into the human food chain, where it can cause severe ecotoxic stress and long-term health complications (Aziz et al., 2023).

Similarly, the irrigation of crops with metal-laden pond water promotes the sequestration of lead within plant tissues, creating a primary pathway for bio-accumulation in local dietary staples (Chiyangi et al., 2023; Liu et al., 2023). This process is further compounded by the biomagnification of these toxic elements within the food web, which presents an escalating health hazard for communities that rely on livestock and aquatic products derived from these contaminated environments (Imran et al., 2024).

- *Arsenic As*

As a potent metalloid, arsenic is recognized for its chronic toxicity and propensity to induce complex health disorders, including cardiovascular dysfunction, hormonal deregulation, and various neoplastic conditions (Fernández-López et al., 2024). Exposure to this element primarily occurs through the ingestion of groundwater or crops irrigated with contaminated pond water, where it acts as a systemic toxin capable of inducing skin lesions, hyperkeratosis, and increased mortality rates in extreme cases (Gupta et al., 2021). Chronic ingestion of arsenic is further linked to the development of lung, liver, and bladder cancers, as the metalloid disrupts fundamental biochemical pathways and induces oxidative damage (El-Nemr et al., 2023). Furthermore, the bioaccumulation of arsenic within the local food supply, particularly in crops and fish, exacerbates the risk of systemic inflammation and immune modulation among the surrounding populace (Aradhi et al., 2023; Tabassum et al., 2024). Beyond these physiological impacts, prenatal exposure to arsenic increases the risk of developmental delays and neurotoxicity in infants, often resulting in lower IQ and compromised immune function (Rahman et al., 2023). Concurrent with these systemic effects, long-term arsenic intake is strongly correlated with the manifestation of severe dermal diseases and respiratory complications, highlighting the critical nature of monitoring water quality in proximity to artisanal mining zones (Balali-Mood et al., 2021; Saini, 2023).

In addition to direct physiological harm, the environmental presence of these heavy metals disrupts soil microbiota, thereby altering the essential microbial processes that support local agricultural productivity (Sani et al., 2023). The degradation of these microbial communities, which are vital for nutrient cycling, further diminishes soil fertility and complicates the implementation of effective bioremediation strategies (Munyai et al., 2021).

- *Mercury Hg*

Mercury is a highly hazardous, non-essential trace element primarily introduced into the aquatic environment through artisanal gold mining activities that utilize mercury for metal amalgamation (Thiombane et al., 2023). it is frequently discharged directly into tailings and nearby river channels, where it undergoes transformation into the highly toxic methylmercury (Ondayo et al., 2023). Exposure to mercury will lead to severe neurological and gastrointestinal disorders, as the compound readily crosses the blood-brain barrier and the placental barrier, posing significant risks to both the central nervous system and fetal development (Zaib et al., 2023). It has been reported in Nigeria particularly Jos that Mercury has exceeded the maximum permissible limits established by global health organizations, exacerbating the risks of memory impairment, muscle weakness, and permanent neuromuscular damage among local inhabitants (Laoye et al., 2025; Ondayo et al., 2023). it was reported to be found in elevated concentrations within local fish populations and stagnant pond sediment, serving as a primary vector for human exposure via the dietary chain (Laoye et al., 2025). Beyond these neurological concerns, inorganic mercury salts exhibit high corrosivity, causing direct damage to the gastrointestinal tract, ocular surfaces, and dermal integrity upon direct contact (Monroy-Licht et al., 2025). Furthermore, the lack of adequate containment facilities for mining tailings in the region facilitates the atmospheric deposition of mercury, which eventually leaches into surface

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water reservoirs during seasonal rainfall events (Gumbo et al., 2025). Within the Jos-Bukuru metropolis, the concentration of mercury has been found to be around 1.5 mg/kg in certain sediment samples, significantly surpassing the international safety thresholds for environmental remediation and public health safety (Oyetibo et al., 2023). Given the persistence of these toxic elements, the absence of robust containment and remediation frameworks in abandoned mining zones ensures the continued leaching of contaminants into groundwater and agricultural fields (Doku & Belford, 2022; Laoye et al., 2025). Consequently, the implementation of advanced physico-chemical and biological mitigation strategies is essential to reduce these toxic ion concentrations and safeguard the ecological integrity of the Plateau State basin (JEYAKUMAR et al., 2022; Laoye et al., 2025).

III. METHODS

The method employed in this study follows the direct collection of water samples from three (3) abandoned mine ponds and seven wells dung by artisanal miners distributed across the Koroshi Jos South Plateau state, Nigeria ensuring a comprehensive spatial representation of the contamination levels. These samples were systematically collected using standardized polyethylene containers to prevent trace metal contamination and preserved in accordance with established hydrogeochemical assessment protocols (Banso et al., 2023). The samples were taken for physiochemical analysis in the laboratory, where parameters such as the water pH, turbidity, heavy metals such as Lead, Cadmium, Arsenic and Mercury were analyzed. The analysis was done using Atomic Absorption Spectrophotometry. Following these laboratory procedures, the result was compared with World Health Organization and the National Environmental Standards and Regulation Enforcement Agency (NESREA) for drinking water and agriculture. The results were plotted using a statistical software in order to give a better visualization and statistical analysis was performed to identify significant variations in heavy metal concentrations across the sampled pond sites.

IV. RESULTS AND DISCUSSIONS

➢ *pH of Water Sample*

Table 1 pH Values for the Water Samples.

SAMPLES	pH
Dam 1	5.55
Dam 2	5.37
Dam 3	5.67
Well 1	6.77
well 2	7.33
well 3	7.52
well 4	6.82
well 5	7.27
well 6	6.63
well 7	7.83

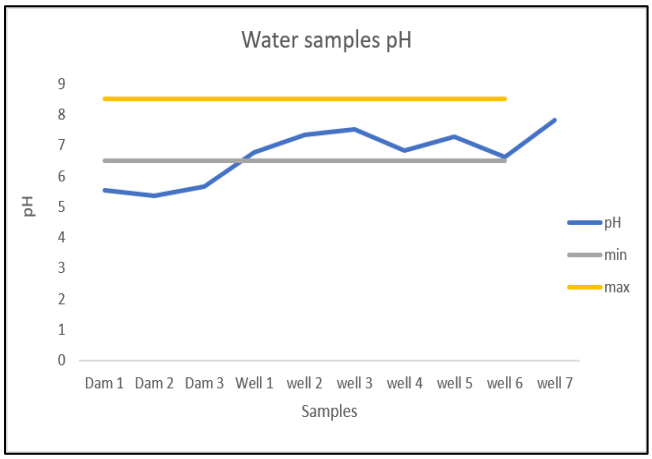

Fig 1 pH Values for the Sampled Waters.

pH of the water sample ranges from 5.37 to 7.83 as shown in table 1 and figure 1. The pH values recorded across the ten sampling sites demonstrated considerable spatial heterogeneity, ranging from a minimum of 5.37 at Dam 2 to a maximum of 7.83 at Well 7, and producing an arithmetic mean of 6.68 over the entire dataset. When compared against the regulatory thresholds for irrigation and potable use (NESREA and WHO permissible range of 6.5–8.5), a clear bimodal structure emerges rather than a continuous distribution of values (Faiza et al., 2022). The three Dam samples (Dam 1 = 5.55, Dam 2 = 5.37, Dam 3 = 5.67) all fall below the lower limit of 6.5 and are therefore classified as non-compliant and mildly acidic, while all seven Well samples (6.63 to 7.83) lie within the acceptable range and are classified as compliant. Notably, the most acidic reading in the entire survey (Dam 2, pH 5.37) is more than 1.0 unit below the most acidic but still compliant reading (Well 6, pH 6.63), and none of the samples exceeded the upper alkalinity threshold of 8.5.

Sampling site appears to be a strong determinant of pH. The mean pH of the three Dam samples (≈5.53) differs from the mean pH of the seven Well samples (≈7.17) by approximately 1.64 units, a substantial separation on the logarithmic pH scale that translates to a roughly 40-fold difference in hydrogen ion activity between the two sub-groups. The internal variability within each sub-group is also informative: the Dam samples span only 0.30 pH units (5.37–5.67), indicating a coherent and consistently acidic micro-environment, whereas the Well samples span 1.20 pH units (6.63–7.83), reflecting more diverse groundwater chemistries that nevertheless remain within the safe envelope. This bimodal pattern stands in contrast with the prior report of tin-mining ponds in Bukuru and environs, whose pH values largely conformed to the 6.5–8.5 standard (Faiza et al., 2022), suggesting that the Dam sites examined in the present study represent a particularly acid-impacted subset of abandoned mining water bodies in the region (Mafuyai et al., 2021).

The physicochemical implications of this pattern are considerable. Because pH governs the solubility, speciation, and bioavailability of metal cations in aquatic systems, depressed pH conditions favour the desorption and dissolution of mineral-bound heavy metals — notably

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cadmium, lead, mercury, and arsenic — from residual mine tailings into the water column (Chepkoech et al., 2025; Duncan et al., 2023). The moderately acidic regime observed in the Dam samples is therefore expected to coincide with elevated dissolved metal loads and enhanced bioavailability to aquatic biota, whereas the near-neutral pH of the Well sites would tend to suppress metal mobilization through precipitation as oxyhydroxides and carbonates, or through enhanced adsorption onto particulate matter. In the context of irrigation, the documented pathway by which low-pH water facilitates root uptake and translocation of metals into edible crop tissues carries direct relevance for food-chain transfer and human exposure, particularly for the Dam sites whose pH lies outside the FAO/WHO-recommended irrigation window (Faiza et al., 2022; Mafuyai et al., 2021). Fluctuations of this magnitude may additionally compromise general aquatic health by disrupting physiological processes in fish and invertebrate communities, even where individual values remain only mildly acidic (Kallon et al., 2024).

The observed Dam–Well dichotomy can plausibly be explained by differences in hydrological setting and geochemical exposure. The Dam samples represent surface water retained in stagnant, excavated pond basins in direct contact with sulphide-bearing ore residues and weathered overburden, conditions that are classically associated with incipient acid mine drainage through the oxidation of pyrite and related sulphide minerals and the generation of proton-rich, metal-laden runoff (Nwachukwu et al., 2021). Such ponds are typically poorly buffered because of limited replenishment of alkalinity and the absence of carbonate-rich geological contact, allowing pH to drift below circum-neutral levels. The Well samples, by contrast, are presumed to draw from groundwater that has equilibrated with different host lithologies or has undergone longer residence times, imparting a higher buffering capacity and more stable near-neutral pH (Nwachukwu et al., 2021). The fact that some of these wells nevertheless approach the upper end of the acceptable range (Well 7 = 7.83) hints at variable mineral equilibration rather than a single homogeneous groundwater signature.

Taken together, these findings indicate that the three Dam sites at Koroshi pose the greatest environmental and public-health risk in terms of heavy metal leaching and bioaccumulation, and are unsuitable without prior treatment or neutralization for the irrigation of edible crops or for domestic uses given their sub-standard pH. The Well sites, while compliant with the pH criterion, should not be presumed entirely safe, since neutral pH alone does not preclude metal contamination, and other physicochemical indices previously documented to vary markedly in Plateau-State tin-mining ponds (e.g., total alkalinity and dissolved oxygen) require concurrent evaluation to characterize true irrigation suitability (Mafuyai et al., 2021). The clear separation between acidic Dam water and near-neutral Well water nevertheless reinforces pH as a useful first-pass screening parameter in prioritizing sampling locations for detailed heavy-metal assay in this and similar abandoned-mining landscapes.

➢ *Water Turbidity*

Table 2 Turbidity of the Water Samples

Samples	Turbidity, mg/L
Dam 1	22
Dam 2	71
Dam 3	33
Well 1	30
well 2	22
well 3	21
well 4	19
well 5	42
well 6	47
well 7	32

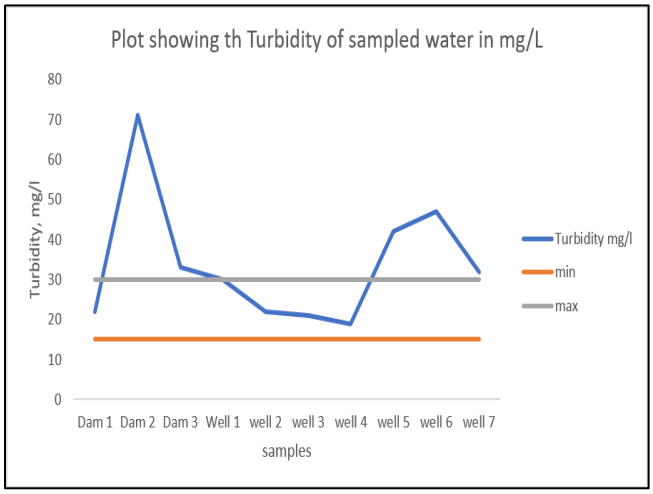

Fig 2 Graph Showing the Turbidity of Water Samples in mg/l

The turbidity values range from 21 to 71 as shown in table 2, with the peak measurement observed at Dam 2 indicating a significantly higher suspended solid load compared to the other sampling sites. This elevated turbidity likely reflects an increased concentration of fine mining wastes and suspended particulate matter, which often serve as primary transport vectors for heavy metals within stagnant pond environments (Gomes & Valente, 2024). The result shows there was an elevated levels of turbidity above the NESREA standards for Dam 2, Dam 3, well 5, well 6 and well 7 respectively. The turbidity which represents the clarity of the water column, is influenced by the presence of suspended particles that can attenuate sunlight penetration, thereby inhibiting photosynthesis and reducing the dissolved oxygen concentration necessary for aquatic life (Patrick et al., 2023).

➢ *Arsenic, As.*

Table 3 Arsenic Concentrations in mg/L

Samples	Conc. mg/l
Dam 1	0.021
Dam 2	0.013
Dam 3	0.012
Well 1	0.026
well 2	0.01

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well 3	0.022
well 4	0.003
well 5	0.024
well 6	0.009
well 7	0.011

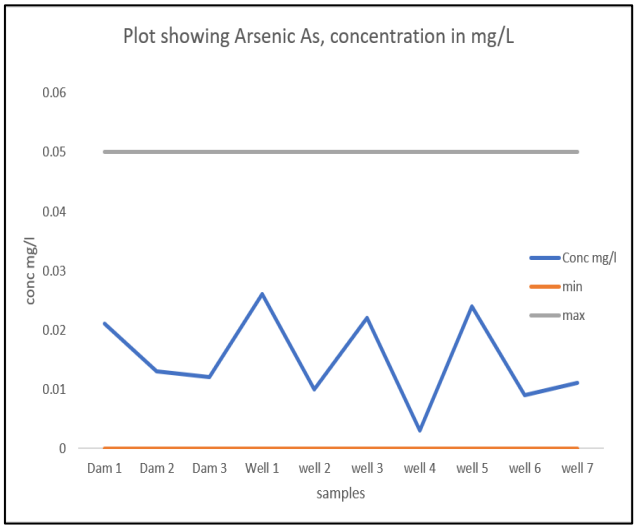

Fig 3 Graphical representation of the concentration of Arsenic

The arsenic concentrations presented in Table 3 range from 0.003 mg/L to 0.026 mg/L. When evaluated against the NESREA standard of 0.05 mg/L, all recorded values across the Dam and Well sites fall significantly below the maximum allowable concentration, indicating compliance with this regulatory safety limit. Despite these findings, the frequent interaction between stagnant mine pond water and local groundwater systems warrants continued vigilance, as geochemical leaching remains a long-term threat to potability (Tse et al., 2026). Beyond regulatory compliance, it is critical to investigate the potential for cumulative toxic effects, as persistent exposure to sub-threshold concentrations of metalloids can lead to bioaccumulation in locally irrigated crops (Obasi et al., 2021). Furthermore, the solubility and mobility of arsenic are often modulated by redox conditions and the presence of competing ions, which may fluctuate seasonally during the rainy period (Moubchir et al., 2023).

➢ *Lead Pb*

Table 4 Lead Concentration

Samples	Conc. mg/l
Dam 1	0.026
Dam 2	0.016
Dam 3	0.027
Well 1	0.09
well 2	0.027
well 3	0.012
well 4	0.014
well 5	0.043
well 6	0.03
well 7	0.003

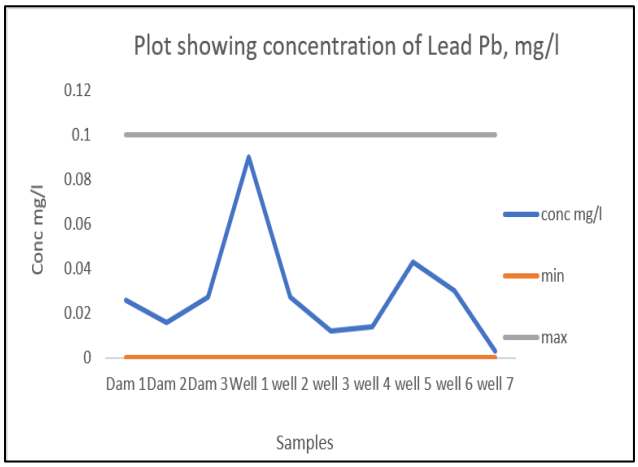

Fig 4 Graph Showing the Concentration of Lead in Relation to NESREA Limits.

The concentrations of Lead across the surveyed sites ranged from 0.012 mg/L to 0.09 mg/L, as presented in Table 4 and figure 4. When evaluated against the NESREA maximum permissible limit of 0.1 mg/L, all samples fall within the regulatory safety standards. However, the relatively higher concentration observed in Well 1 (0.09 mg/L) warrants cautious monitoring to ensure the water remains within safe limits for domestic and irrigation use, preventing potential long-term heavy metal toxicity. Furthermore, the observed spatial variation in lead levels suggests that localized geological characteristics and varying degrees of historical anthropogenic disturbance continue to influence heavy metal mobility within the aquifer (Owusu et al., 2024). Elevated lead concentrations in similar abandoned mining contexts have elsewhere been linked to localized ecosystem poisoning and adverse impacts on the food chain, necessitating longitudinal assessment of potential bioaccumulation (Akpa, 2026).

➢ *Mercury Hg*

Table 5 Mercury Concentration in mg/L

Samples	Conc. mg/l
Dam 1	0.018
Dam 2	0.011
Dam 3	0.013
Well 1	0.017
well 2	0.02
well 3	0.037
well 4	0.018
well 5	0.006
well 6	0.013
well 7	0.008

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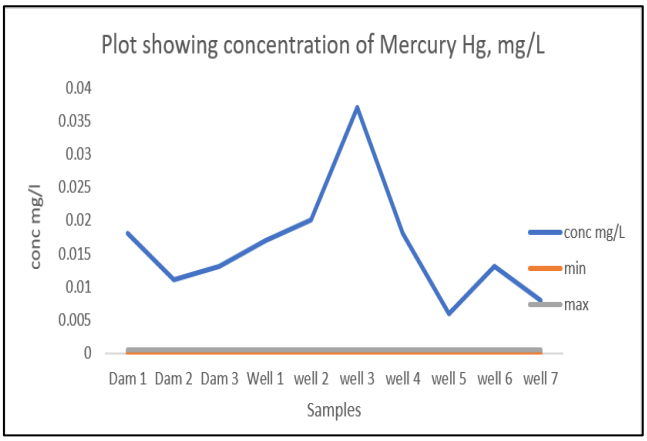

Fig 5 Graph showing Mercury Concentration in Relation to NESREA Limits.

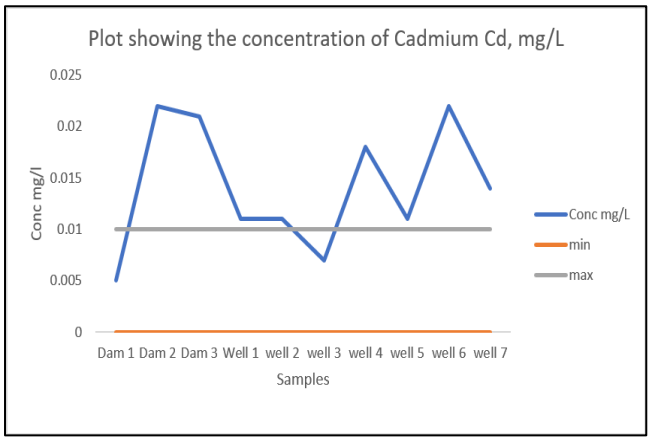

Fig 6 Graphical Representation of Cadmium Concentration.

The mercury concentrations presented in Table 5 range from 0.006 mg/L to 0.037 mg/L. When evaluated against the NESREA permissible limit of 0.0005 mg/L, all recorded values across the Dam and Well sites significantly exceed this standard. This widespread non-compliance indicates a substantial environmental concern regarding mercury contamination in these water bodies. this disparity and non-compliance to NESREA standard will greatly affects the health of local residents who rely on these sources for domestic purposes, as long-term exposure to mercury is strongly linked to adverse neurotoxic and developmental outcomes (Alao et al., 2024). This high levels of mercury in the Koroshi Jos region necessitates immediate mitigation strategies, as such elevated concentrations present significant noncarcinogenic health risks through chronic ingestion (Gwira et al., 2024). Persistent mercury contamination in groundwater is especially hazardous due to the potential for bioaccumulation within aquatic food chains and the subsequent risk of biomagnification in local subsistence diets (Aruf et al., 2024; Ogueh & Aladin, 2024). Given these findings, the prevalence of mercury levels far exceeding safety thresholds underscores the urgent need for comprehensive remediation, as similar legacies of mining-induced pollution have been correlated with severe systemic health impairments such as tremors, gingivitis, and compromised renal function (Arthur et al., 2023; Muhammad et al., 2024).

➢ *Cadmium Cd*

Table 6 Cadmium Concentration in mg/L

Samples	Conc. mg/l
Dam 1	0.005
Dam 2	0.022
Dam 3	0.021
Well 1	0.011
well 2	0.011
well 3	0.007
well 4	0.018
well 5	0.011
well 6	0.022
well 7	0.014

The cadmium concentrations presented in table 6 range from 0.005 mg/L to 0.022 mg/L. When evaluated against the NESREA permissible limit of 0.01 mg/L, several recorded values across the Dam and Well sites exceed this standard, indicating potential environmental concern regarding cadmium contamination in these water bodies. Notably, Dam 2 (0.022 mg/L), Dam 3 (0.021 mg/L), Well 1 (0.011 mg/L), Well 2 (0.011 mg/L), Well 4 (0.018 mg/L), Well 5 (0.011 mg/L), Well 6 (0.022 mg/L), and Well 7 (0.014 mg/L) are above the regulatory threshold. This non-compliance is significant, as long-term exposure to cadmium is linked to adverse health effects such as kidney damage, bone demineralization, and an increased risk of various cancers (Alao et al., 2024). The presence of elevated cadmium levels necessitates urgent monitoring and mitigation strategies to protect public health, especially given its potential for bioaccumulation in the food chain (Ogueh & Aladin, 2024). Furthermore, chronic ingestion of water containing cadmium at these concentrations poses a significant risk for systemic toxicity, including potential damage to renal tubules and hypertension (Jelili et al., 2021). Such findings align with documented trends in other Nigerian mining districts, where cadmium levels frequently surpass health-based guidelines, exacerbating risks of respiratory impairment and skeletal disorders (Chris-Onoh et al., 2026; Oiganji et al., 2023). The widespread contamination reported across these sampling sites mirrors patterns identified in other artisanal mining environments, where mineral processing activities serve as primary drivers for heavy metal loading into surface and groundwater resources (Mbet et al., 2025).

V. CONCLUSION

This research confirms that abandoned mining sites at Koroshi Jos represent significant reservoirs of hazardous heavy metals, with concentrations of mercury and cadmium consistently exceeding established environmental safety thresholds. The persistent leaching of these toxic elements into local water sources necessitates the immediate implementation of rigorous remediation strategies and stringent regulatory oversight to mitigate long-term neurotoxic and systemic health risks for surrounding communities (Acheampong et al., 2025; Garkida et al., 2025). Future policy interventions should prioritize the geochemical monitoring of water resources and the enforcement of waste

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management practices to curb the unchecked expansion of mining-induced environmental degradation (Sayyadi et al., 2025; Umeh, 2025). Moreover, integrating community-based surveillance programs will be essential to track the longitudinal health outcomes of residents exposed to these contaminated water sources (Akpa, 2026). Establishing interdisciplinary frameworks that combine geochemical remediation with toxicological risk assessment remains vital for curtailing the broader carcinogenic and renal impacts often associated with prolonged heavy metal exposure in mining-affected regions (Adekiya et al., 2024; Raimi et al., 2021).

Ultimately, these findings serve as a critical baseline for developing sustainable water quality restoration plans, ensuring that the legacy of mining does not compromise future ecological integrity or public safety (Olalekan et al., 2022). Continuous monitoring of these hydrologic systems is essential to track the efficacy of future detoxification efforts and prevent further migration of toxic plumes into adjacent agricultural zones, thereby safeguarding both local food security and broader environmental health (Odukoya et al., 2021), (Igelle et al., 2024).

RECOMMENDATIONS

Based on the empirical evidence regarding the persistent mercury and cadmium concentrations exceeding regulatory limits in the Koroshi Jos mining area, the following measures are proposed to mitigate environmental and public health risks:

- Strengthen Regulatory Oversight and Enforcement**:** Environmental protection agencies must intensify the enforcement of waste management protocols for mining operations to prevent the discharge of toxic tailings into water bodies (Umeh, 2025). This includes mandating the installation of effective treatment systems for mining effluents before release.
- Implement Targeted Remediation Strategies**:** Given the high concentrations of heavy metals, immediate remediation of contaminated water sources is required. This involves exploring site-specific technologies, such as chemical precipitation or bio-remediation, to reduce metal loads in both surface and groundwater to safe levels (Garkida et al., 2025; Olalekan et al., 2022).
- Enhance Public Health Surveillance: Local health authorities should establish continuous monitoring programs for populations residing near mining sites. Systematic screening for indicators of heavy metal exposure—such as renal impairment, neurological deficits, and bone demineralization—is critical for early clinical intervention (Akpa, 2026; Raimi et al., 2021).
- Public Awareness and Alternative Water Sources: It is essential to educate local communities about the dangers of consuming water from contaminated sources. Providing access to alternative safe water supplies and promoting household-level filtration techniques can significantly reduce immediate exposure risks (Chris-Onoh et al., 2026; Gwira et al., 2024).
- Long-term Environmental Monitoring: Future policy interventions should prioritize longitudinal geochemical surveys to track the migration of toxic plumes. Continued research into the bioaccumulation of metals in the local food chain is necessary to safeguard the long-term food security and ecological health of the region (Odukoya et al., 2021; Sayyadi et al., 2025).

Furthermore, collaborative efforts between government agencies and agricultural stakeholders should focus on developing standardized guidelines to restrict the use of these mining affected water sources for irrigation, as such practices directly facilitate the transfer of heavy metals into the local food supply (A et al., 2024; Samuel & Ochube, 2021).

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