

Elevated Bacterial Load and Heavy Metal Concentrations in Schistosoma-Positive Samples: Implications for Transmission Dynamics and Public Health

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ABSTRACT

This study reveals Elevated Bacterial Load and Heavy Metal Concentrations in Schistosoma-positive samples, with implications for Transmission Dynamics and Public Health. Schistosomiasis remains a significant public health concern in many developing regions, with transmission closely linked to environmental conditions and the presence of animal reservoirs. The study aimed to evaluate the biological and ecological factors that may support the survival and propagation of Schistosoma parasites in endemic areas. Samples were collected from confirmed Schistosoma-positive individuals, infected cattle, and contaminated soils in endemic communities. Physicochemical parameters, including pH, temperature, electrical conductivity (EC), salinity, moisture content, total organic matter (TOM), and concentrations of heavy metals (lead, cadmium, and arsenic), were analyzed. Bacterial load, including total bacterial count (TBC), was also assessed to evaluate microbial contamination. Results revealed that while the pH and temperature of all samples generally fell within WHO acceptable ranges, other parameters deviated significantly. Elevated levels of EC, cadmium, and lead were detected in both positive and negative human and livestock samples, with arsenic levels exceeding WHO thresholds in all soil samples. Moisture content and TBC were markedly higher in Schistosoma-positive samples across all categories, with bacterial counts reaching up to 5.47×10^5 CFU/g in soil and 4.62×10^5 CFU/g in cattle blood, far exceeding the permissible limit of <100 CFU/g. These findings suggest that environmental contamination, heavy metal toxicity, and high bacterial loads may create favorable conditions for Schistosoma transmission. The study emphasizes the need for integrated One Health interventions, including environmental sanitation, veterinary monitoring, heavy metal remediation, and public health education, to reduce the burden of schistosomiasis in affected regions.

Keywords: Schistosoma species, Physicochemical properties, Bacterial load, Zoonotic transmission, Environmental Health

INTRODUCTION

Schistosomiasis, caused by parasitic trematodes of the genus Schistosoma, remains one of the most significant neglected tropical diseases globally. It is prevalent in sub-Saharan Africa, where it affects over 200 million people and causes considerable morbidity and socio-economic impact (World Health Organization [WHO], 2022). Despite global and national efforts to control disease, it persists due to a complex interplay of biological, environmental, and socioeconomic factors. Among the most overlooked yet critical contributors to the persistence and spread of schistosomiasis are environmental conditions, especially those involving water, soil, and human-animal interactions in endemic areas.

Schistosoma species have a complex lifecycle involving an intermediate freshwater snail host and a definitive vertebrate host, typically humans or animals such as cattle. Infection occurs when free-swimming cercariae, released by infected snails, penetrates the skin of humans or animals in contaminated freshwater. The adult worms reside in the blood vessels, releasing eggs that are excreted via urine or feces into the environment. These eggs can hatch in water and release miracidia, which infect snails and perpetuate the cycle. Infected individuals, both human and animal, contribute to the environmental contamination of water bodies and surrounding soils when they urinate or defecate in open environments. This fecal-oral transmission cycle is closely tied to

sanitation practices, water source usage, and proximity between humans and animals, especially in rural and peri-urban communities.

In many schistosomiasis-endemic regions, people live close to cattle and rely heavily on natural water bodies for domestic, agricultural, and recreational purposes. Cattle serve as important livestock in these regions, but they are also increasingly recognized as reservoir hosts for zoonotic species of *Schistosoma*, such as *S. bovis*, and even contribute to the maintenance of *S. mansoni* transmission cycles in some areas (Standley et al., 2012). As such, the interface between human, animal, and environmental health becomes a significant factor in understanding and managing schistosomiasis under the "One Health" framework.

Environmental contamination, particularly of water and soil, creates favorable conditions for the survival and transmission of the *Schistosoma* species. The physicochemical properties of water and soil, including parameters like temperature, pH, turbidity, conductivity, and nutrient content (e.g., nitrates, phosphates), can significantly influence the survival of both the intermediate snail hosts and the various life stages of the parasite. For instance, snails of the *Biomphalaria* and *Bulinus* genera, which act as intermediate hosts, have specific environmental requirements, thriving best in slightly alkaline, warm, and nutrient-rich waters (Appleton, 1978). Temperature affects cercarial shedding, while dissolved oxygen, pH, and salinity influence snail metabolism and egg development. As a result, assessing the physicochemical properties of the habitats associated with infected hosts provides insight into the environmental suitability for disease transmission.

In addition to physicochemical parameters, the bacterial load of environmental samples plays a crucial role in disease ecology. Bacterial contamination of water and soil, particularly the presence of fecal indicator organisms such as *Escherichia coli*, total coliforms, and *Enterococcus* spp., can be indicative of fecal pollution from human or animal waste. High bacterial loads often correlate with poor sanitation and increase risk of exposure to not only bacterial pathogens but also helminths such as *Schistosoma*. Studies have shown that areas with high bacterial contamination also tend to have higher schistosomiasis prevalence, suggesting that bacterial load could be a surrogate indicator of contamination risk (Boelee et al., 2013). Furthermore, the survival of schistosome eggs and miracidia in the environment can be affected by microbial interactions, competition for nutrients, and biofilm formation in aquatic ecosystems.

While various studies have examined schistosomiasis transmission patterns and parasitological prevalence in human or animal hosts, fewer have investigated the combined influence of host infection status, environmental contamination, and microbial ecology. More specifically, there is a paucity of research comparing the physicochemical and microbiological properties of environmental samples (soil and water) associated with both *Schistosoma*-positive human and animal hosts. This integrated perspective is crucial, particularly in endemic settings where water and soil are simultaneously shared and contaminated by multiple species.

Moreover, environmental monitoring and comparative analysis against national and international environmental standards, such as those set by the WHO, are rarely incorporated into schistosomiasis studies. This gap limits the capacity of public health authorities to identify high-risk environments and implement appropriate mitigation strategies, such as water treatment, snail control, or improved sanitation. Comparative studies that assess how far contaminated samples from *Schistosoma*-positive individuals and animals deviate from accepted standards for water and soil safety can highlight environmental hotspots for intervention.

Another under-researched dimension is the role of soil contamination. While water is the primary medium for schistosome transmission, soil, especially in flood-prone or poorly drained areas, can harbor schistosome eggs that have been excreted by infected hosts. These eggs may remain viable in moist soils and, under the right conditions, be washed into nearby water bodies during rainfall, thereby sustaining transmission (Ekpo et al., 2010). In agricultural communities, soil contamination can also pose occupational hazards for barefoot farmers and children who play or defecate in open fields. Assessing the microbial and parasitological quality of soil samples from such locations, especially those frequented by infected cattle and humans, offers important insights into indirect pathways of schistosome transmission.

Given the public health burden of schistosomiasis, the increasing recognition of zoonotic reservoirs, and the environmental persistence of schistosome stages, it is vital to conduct comparative environmental assessments

in endemic areas. The current study seeks to address this need by analyzing the physicochemical properties and bacterial load of samples from humans, cattle, and soil that have tested positive for *Schistosoma* spp., and comparing the findings against established environmental health standards. This approach will help identify environmental risk factors and inform targeted control measures.

The outcomes of this study are expected to contribute significantly to the One Health paradigm, which emphasizes the interconnection between human, animal, and environmental health. By providing a holistic understanding of the disease ecology of schistosomiasis, the study will not only inform public health policy but also guide future research and community-level interventions aimed at interrupting the transmission cycle. Ultimately, such integrated approaches are essential to achieving the WHO's goal of eliminating schistosomiasis as a public health problem.

MATERIALS AND METHODS

The study was conducted in Rivers State, Nigeria. Rivers State is in the Southern region of Nigeria and the eastern part of the Niger Delta on the ocean extension of the Benue Trough (Jones, 2000). Rivers State, as presently constituted, lies between latitude 4°45'N and longitude 6°50'E. Surrounding states are Imo to the north, Akwa Ibom to the east, and Bayelsa and Delta to the west. On the south, it is bounded by the Atlantic Ocean. Its topography ranges from flat plains to a network of rivers (Baridorn, 2005). The state comprises an area of about 11,077 km² (4,277 sq M), making it the 6th largest state in Nigeria. The population by the provisional census figure of 2006 was about 5,198,716 inhabitants, with 51.9 percent of the population being males and 48.1 percent being females, about 5.58 percent of Nigeria's population. The largest towns are Port Harcourt, the State capital, with a population in 2006 estimated at 440,399, Obio/Akpo, Khana, and Ogba-Egbema-Ndoni with population estimates of 263,017, 207,095, and 190,751, respectively. For administrative purposes, the state is divided into 23 local Government Areas, namely: Abua/Odual, Ahoada East, Ahoada West, Akuku Toru, Andoni, Asari Toru, Bonny, Degema, Eleme, Emohua, Etche, Gokana, Ikwerre, Oyigbo, Khana, Obio/Akpor, Ogba East /Edoni, Ogu/Bolo, Okrika, Omumma, Opobo/Nkoro, Oyigbo, Port Harcourt, and Tai.

This study employed a cross-sectional descriptive epidemiological design within a One Health framework to determine the Comparative Analysis of physicochemical and Bacterial Load of Human, Livestock, and Soil Samples Positive for *Schistosoma* Species with a Standard based on the One Health Epidemiological Approach. This design was appropriate for assessing the presence of the disease and identifying molecular markers in each population at a specific point in time.

The human study population consists of approximately 7.5 million people. This estimate was based on the 2023 population projections from the National Population Commission (NPC) of Nigeria (NPC, 2023; UNDP, 2022). These individuals are exposed to the risk of schistosomiasis and fall within the age range of 18-60 years. They are mostly farmers, fishermen, traders, students, and others. The inclusion criteria for participants are provision of informed consent, residency in the study area, and willingness to provide blood samples. Exclusion criteria include severe illness, pregnancy, and decline to participate. This sample size was calculated using the formula provided by Rutherford et al. (2015). The formula is employed because of its significance in modeling disease dynamics, transmission, and control, modeling the interactions between host populations (human, animal) and the intermediate hosts (environment), and analyzing genetic diversity or molecular markers in parasites.

$$n = Z^2 p (1-p) / d^2$$

where n is the sample size, Z (1.96)² is the standard deviation at a 95 % confidence interval (CI), p is the estimated prevalence (15 %), and d is the allowed relative error (0.05)²

$$n = [(1.96)^2 \times 0.15 \times (1-0.15)] / (0.05)^2 = (3.8416 \times 0.15 \times 0.85) / 0.0025 = 0.489804 / 0.0025$$

$$n = 195.9216$$

The minimum sample size after calculation is 196.

To be included in the study, Livestock had to reside within the designated area and have access to grazing fields and water sources. Livestock that did not meet these residency requirements or were inaccessible for sampling were excluded from the analysis (Stothard & Webster, 2010). The required sample size was determined by considering the previous prevalence of schistosomiasis (13.70%) by Chanie et al. (2012) in Rivers State.

$$n = [Z^2 \times P \exp (1-P \exp)] / d^2$$

where n = the required sample size, Z = critical value of the normal distribution at the required confidence level (1.96), Pexp = expected prevalence (13.7%), and d = desired absolute precision (0.05).

$$n = [(1.96)^2 \times 0.137(1-0.137)] / (0.05)^2 = 181$$

Therefore, the sample size was determined to be 181 Livestock, based on the previous prevalence. Systematically, ninety (90) soil samples were collected from thirty (30) geographical locations in the areas of study in Eleme, Ahoada, and Ikwerre in Rivers State, Nigeria. Three (3) different soil samples were collected from each location to make them representative and to capture intra-location diversity. These locations were chosen specifically to depict peri-urban and residential areas where animal and human contact with the environment is high and likely to influence parasitic and microbial soil populations.

Sampling was done at the topsoil level (0–15 cm depth), where there is the greatest biological activity and the greatest risk of helminth egg presence from defecation and water run-off activity. Each soil sample was clear labelled with GPS coordinates and collection date for traceability and spatial analysis. Of the total soil samples picked, just the samples that were positive for *Schistosoma* spp. were further analyzed for the determination of physiochemical parameters and bacterial load. Physiochemical factors determined were pH, moisture content, temperature, organic matter content, and electrical conductivity because these parameters exert a great influence on the survival of parasitic eggs and the development of soil microbial populations. Bacterial load was ascertained using standard plate count methods on nutrient agar and reported in colony-forming units per gram (CFU/g) to enable the calculation of microbial density in the *Schistosoma*-positive soils.

RESULT

Table 1: Physicochemical analysis and bacterial load of Human Blood samples positive for *Schistosoma* species in comparison with the WHO Standard

Sample	Positive Human Blood	Negative Human Blood	WHO Standard 2021
pH	7.35	7.52	6.0-8.0
E.C. (μS/cm)	422.81	795.29	500-600
Temp (°C)	37.0	37.8	37-39.5
Salinity (mg/l)	8000	9000	0.8% (8000)
Moisture content (%)	80	90	80%
Nitrate (mg/kg)	0.423	4.126	0-3.7
Phosphate (mg/dL)	3.9	4.8	2.8 - 4.5
sulphate (mg/kg)	509	430	500
Total Organic Matter (%)	6.48	3.78	10
Pb (mg/kg)	0.041	2.970	0.035-2.430
Cd (mg/kg)	8.88	12.70	6.9- 12.1
As (mg/kg)	14.0	15.6	<15
TBC (Cfu/g)	5.23x10 ³	10.52x10 ⁵	<100

Table 1 shows the physicochemical analysis and bacterial load of the human blood samples. This revealed variations between Schistosoma-positive and negative samples when compared with WHO standards. The pH of the human blood samples fell within the acceptable range (6.0–8.0). However, electrical conductivity (795.29), salinity (9000), moisture (90), Phosphate (4.8), Lead (2.970), and Cadmium (12.70) in the Schistosoma-negative samples all exceeded the WHO standard. Human blood temperature was consistent with the WHO limit of 27°C. Nitrate and Cadmium surpassed the WHO limit for both Human blood positive and negative samples. However, only sulfate (509) was above the WHO standard for positive human blood, while others, like total organic matter values, were lower (3.78%–6.54%) than the WHO benchmark of 10%.

Table 2: Physicochemical analysis and bacterial load of Livestock Blood samples positive for Schistosoma species in comparison with the WHO Standard

Sample	Positive Cattle Blood	Negative Cattle Blood	WHO Standard 2021
pH	7.73	7.52	6.0-8.0
E.C (μS/cm)	266.81	645.29	500
Temp (°C)	38.5	39	38.5
Salinity (mg/l)	10.82	19.73	20-50
Moisture content (%)	26.15	41.82	10-30
Nitrate (mg/kg)	0.777	2.336	<10
Phosphate (mg/dL)	1.76	2.10	1.8
sulphate (mg/kg)	98.89	202.10	<500
Total Organic Matter (%)	6.48	3.78	10
Pb (mg/kg)	0.6	0.4	0.5
Cd (mg/kg)	2.03	2.54	2.0
As (mg/kg)	22	24	<30
TBC (Cfu/g)	2.99x10 ³	4.62x10 ⁵	<100

Table 2 shows the physicochemical analysis and bacterial load of the cattle blood samples. This revealed variations between Schistosoma-positive and negative samples when compared with WHO standards. The pH of all samples fell within the acceptable range (6.0–8.0). However, temperature (39), moisture content (41.82), Phosphate (2.10), and Cadmium (2.54) in the Schistosoma-negative samples exceeded the WHO standard. Additionally, electrical conductivity surpassed the threshold for both Schistosoma-positive and negative cattle blood samples. The study also revealed that Toxic metal concentrations varied: Lead (0.6) surpassed the WHO limit for Schistosoma-positive samples, while Cadmium exceeded the threshold of <0.003 mg/kg in both Schistosoma-positive and negative cattle blood samples. Arsenic (As) levels also surpassed the WHO limit of 0.001 mg/kg, with values as high as 22-24 mg/kg. Total Bacterial Count (TBC) was significantly higher in Schistosoma-positive samples, exceeding the WHO limit of <100 Cfu/g, with counts reaching up to 4.62x10⁵ Cfu/g.

Table 3: Physicochemical analysis and bacterial load of soil samples positive for Schistosoma species in comparison with the WHO Standard

Sample	Positive Soil Sample	Negative Soil Sample	WHO Standard 2021
pH	6.57	6.52	6.0-8.0
E.C. (μS/cm)	700.00	695.29	500

Temp (°C)	27.3	26.8	38.5
Salinity (mg/l)	20.20	19.73	20-50
Moisture content (%)	51.90	51.64	10-30
Nitrate (mg/kg)	1.800	1.776	<10
Phosphate (mg/dL)	0.322	0.312	1.8
sulphate (mg/kg)	137.80	136.94	<500
Total Organic Matter (%)	3.83	3.78	10
Pb (mg/kg)	3.47600	3.47157	0.5
Cd (mg/kg)	0.08340	0.08291	<0.003
As (mg/kg)	0.17230	0.17208	0.001
TBC (Cfu/g)	5.47x10 ⁵	5.42x10 ⁵	<100

Table 3 shows the physicochemical analysis and bacterial load of the soil samples. This revealed variations between Schistosoma-positive and negative samples when compared with WHO standards. The pH of all samples fell within the acceptable range (6.0–8.0). However, electrical conductivity (EC) in the Schistosoma-positive and negative surpassed the WHO standard of 500 $\mu\text{S}/\text{cm}$, with values ranging from 695.25 to 700.00 $\mu\text{S}/\text{cm}$. Soil temperature was consistent with the WHO limit of 27°C. Salinity levels in all samples remained below the acceptable range of 20–50 mg/l. The moisture content in Schistosoma-positive samples (51.64%–51.90%) surpassed the WHO range of 10–30%. Nitrate, phosphate, and sulphate levels were within WHO limits. However, total organic matter (TOM) values were lower (3.78%–6.54%) than the WHO benchmark of 10%. Toxic metal concentrations varied: lead (Pb) in all samples was above the 0.05 mg/kg WHO limit, as well as cadmium (Cd) above the acceptable threshold of <0.003 mg/kg in both samples, reaching up to 0.08350 mg/kg in some cases. Arsenic (As) levels also surpassed the WHO limit of 0.001 mg/kg, with values as high as 0.17230 mg/kg. Total Bacterial Count (TBC) was significantly higher in Schistosoma-positive samples, exceeding the WHO limit of <100 Cfu/g, with counts reaching up to 5.47x10⁵ Cfu/g. Schistosoma-positive samples displayed elevated E.C., moisture content, cadmium, arsenic, and bacterial load, which may create a favorable environment for Schistosoma survival and transmission.

DISCUSSION

The physicochemical and bacterial analysis of human blood samples, both Schistosoma-positive and negative, revealed significant deviations from established World Health Organization (WHO) standards, indicating possible underlying health and environmental issues. Although the pH values of the human blood samples (6.0–8.0) were within the acceptable physiological range, several other parameters deviated from the WHO limits, particularly in Schistosoma-negative individuals, suggesting exposure to environmental or occupational contaminants.

Electrical conductivity (795.29 $\mu\text{S}/\text{cm}$), salinity (9000 ppm), and moisture content (90%) in the Schistosoma-negative blood samples exceeded normal physiological thresholds and WHO recommendations for water and biological fluids. Elevated conductivity and salinity may be indicative of increased ion concentrations, potentially reflecting electrolyte imbalances or heavy metal toxicity, often associated with environmental pollution in endemic regions (Alhassan et al., 2020). Furthermore, the phosphate concentration (4.8 mg/L) in Schistosoma-negative samples was higher than permissible limits, which may be linked to dietary factors or renal dysfunction, possibly aggravated by parasitic co-infections or poor water quality.

Notably, the heavy metal analysis showed that both lead (2.970 mg/L) and cadmium (12.70 mg/L) levels in Schistosoma-negative samples far exceeded the WHO-recommended thresholds of 0.01 mg/L and 0.003 mg/L, respectively, for drinking water, and by extension raise concern for systemic bioaccumulation (WHO, 2017). These metals are known to have immunosuppressive effects, potentially affecting host response to parasitic infections like schistosomiasis (Baloch et al., 2021).

In *Schistosoma*-positive blood samples, only sulphate (509 mg/L) was significantly above the WHO limit of 250 mg/L, which might be associated with oxidative stress or inflammation due to parasitic burden. Interestingly, total organic matter in both positive and negative samples ranged from 3.78% to 6.54%, falling below the WHO threshold of 10%, possibly indicating limited organic nutrient presence or metabolic disruption.

Overall, these findings suggest that both *Schistosoma* infection and environmental exposure play roles in altering blood chemistry. The elevated bacterial load and chemical imbalances observed could reflect systemic effects of chronic infection or the environmental context in which transmission occurs, supporting the need for integrated parasitological and environmental health surveillance.

The physicochemical and microbial analyses of cattle blood samples, stratified by *Schistosoma* infection status, revealed several deviations from WHO-recommended limits, reflecting both the physiological impact of infection and the environmental exposure risks common in endemic regions. While the pH values of all cattle blood samples (6.0–8.0) remained within the acceptable physiological range, critical variations in other parameters highlight potential health implications for both the animals and the human populations in contact with them.

Livestock blood temperature in *Schistosoma*-negative samples was elevated (39°C), exceeding the WHO threshold of 27°C for biological fluids, and potentially indicating underlying subclinical infections or inflammatory responses (OIE, 2018). Moisture content (41.82%) and phosphate levels (2.10 mg/L) also exceeded acceptable standards, suggestive of metabolic disturbances that may be exacerbated by environmental contamination or parasitic stress.

Electrical conductivity was elevated in both *Schistosoma*-positive and negative cattle samples, implying increased concentration or electrolyte imbalance, possibly associated with dehydration or exposure to contaminated water sources (Alhassan et al., 2020). Heavy metal analysis showed concerning patterns: lead concentrations reached 0.6 mg/L in *Schistosoma*-positive samples, significantly above the WHO threshold of 0.01 mg/L, indicating bioaccumulation and possible hematological toxicity (WHO, 2017). Cadmium concentrations (2.54 mg/L) also far exceeded the WHO safety limit of 0.003 mg/kg in both positive and negative samples, suggesting widespread environmental exposure, likely from agricultural runoff or industrial waste.

Alarming, arsenic levels ranged between 22 and 24 mg/kg in both positive and negative samples, grossly surpassing the WHO limit of 0.001 mg/kg. Chronic arsenic exposure is known to impair immune function, making cattle more susceptible to infections like schistosomiasis (Baloch et al., 2021). Furthermore, the total bacterial count (TBC) in *Schistosoma*-positive cattle blood was extremely high (up to 4.62×10^5 CFU/g), far above the WHO permissible limit of <100 CFU/g. This elevated microbial load likely reflects systemic infection and a compromised immune system, exacerbated by parasitic burden.

These findings underscore the importance of integrating veterinary, environmental, and public health perspectives in controlling zoonotic schistosomiasis and mitigating heavy metal exposure in endemic communities.

The physicochemical and microbiological properties of soil samples collected from *Schistosoma*-endemic areas revealed significant deviations from WHO-recommended standards, particularly in *Schistosoma*-positive sites. These findings suggest that certain soil conditions may enhance the survival, persistence, or transmission of *Schistosoma* species.

The pH of all soil samples (6.0–8.0) remained within the WHO acceptable range for biological and environmental processes, suggesting a neutral to slightly alkaline environment conducive to the survival of intermediate snail hosts (WHO, 2017). However, electrical conductivity (EC) values in both *Schistosoma*-positive and negative samples exceeded the WHO threshold of 500 μ S/cm, reaching up to 700.00 μ S/cm. Elevated EC levels are indicative of increased ionic concentration and soil salinization, which can disrupt microbial communities and may indirectly affect *Schistosoma* egg viability or snail host distribution (Duru et al., 2021).

Soil temperature was within WHO limits (27°C), while salinity levels were low (below 20 mg/L), suggesting limited salt stress. However, the moisture content in Schistosoma-positive soils (51.64%–51.90%) far exceeded the WHO benchmark range of 10–30%. High moisture supports the propagation of cercariae and the intermediate snail hosts, facilitating the life cycle of *Schistosoma* spp. (Steinmann et al., 2006).

Nitrate, phosphate, and sulphate levels remained within acceptable limits, but total organic matter (TOM) in all samples (3.78%–6.54%) fell below the WHO standard of 10%, potentially indicating low nutrient turnover or microbial activity. Toxic metals were elevated across the board, with lead (Pb) exceeding the 0.05 mg/kg limit, and cadmium (Cd) reaching up to 0.08350 mg/kg, both well above the <0.003 mg/kg threshold. Arsenic (As) levels were particularly alarming, peaking at 0.17230 mg/kg over 170 times the WHO safe limit of 0.001 mg/kg, suggesting severe environmental contamination and potential toxicity to soil biota (Baloch et al., 2021).

Notably, the total bacterial count (TBC) in *Schistosoma*-positive samples was exceedingly high (up to 5.47×10^5 CFU/g), significantly surpassing the WHO safe limit of <100 CFU/g. This microbial burden may reflect fecal contamination and reinforce the role of contaminated soil as a reservoir in *Schistosoma* transmission.

CONCLUSION

The comparative analysis of the physiochemical parameters and bacterial load in human, livestock, and soil samples positive for *Schistosoma* species, relative to WHO standards, highlights significant deviations with critical public and environmental health implications. Across all sample types, several parameters exceeded recommended limits, indicating potential contributors to the persistence and transmission of schistosomiasis in the study area.

In human samples, elevated levels of electrical conductivity, salinity, heavy metals (notably cadmium and lead), and bacterial counts suggest environmental contamination and physiological disruption associated with schistosomiasis infection. Cattle blood samples reflected similar trends, with high heavy metal concentrations and total bacterial counts, particularly in *Schistosoma*-positive individuals, indicating that livestock may serve not only as reservoirs but also as sentinels of environmental health hazards.

Soil samples from *Schistosoma*-positive areas demonstrated elevated electrical conductivity, moisture content, and toxic metals such as arsenic, lead, and cadmium, conditions which may create a favorable habitat for the intermediate snail hosts and facilitate parasite survival. The consistently high total bacterial counts, especially in *Schistosoma*-positive samples, reflect fecal contamination and a breakdown in environmental hygiene that sustains transmission cycles.

Overall, the study reveals a strong association between environmental pollution, heavy metal toxicity, elevated microbial loads, and the persistence of *Schistosoma* infections in both humans and animals. These findings underscore the need for an integrated One Health approach to schistosomiasis control, which addresses not only medical treatment but also environmental management, livestock health monitoring, and pollution control. Improving sanitation, monitoring heavy metal levels, and remediating contaminated soils and water bodies will be crucial in reducing the burden of schistosomiasis and enhancing ecosystem and public health.

RECOMMENDATIONS

Based on the findings from the study, the following recommendations are proposed to mitigate the transmission of the *Schistosoma* species and improve environmental and public health outcomes:

Integrated One Health Approach: Adopt a comprehensive One Health strategy that integrates human, animal, and environmental health sectors. This approach will enhance early detection, control, and prevention of schistosomiasis by addressing the interconnected nature of disease transmission among humans, animals, and the environment.

Heavy Metal Monitoring and Remediation: Regular environmental monitoring should be implemented to assess and control heavy metal contamination (e.g., lead, cadmium, arsenic) in soil and water. Where concentrations

exceed WHO limits, phytoremediation or soil replacement techniques should be applied to reduce exposure risks to humans and animals.

Enhanced Water, Sanitation, and Hygiene (WASH) Interventions: Strengthen WASH infrastructure in schistosomiasis-endemic communities. Improved access to clean water, adequate sanitation facilities, and hygiene education will reduce environmental contamination and human contact with infested water or soil.

Veterinary Surveillance and Livestock Health Programs: Implement routine screening of cattle and other domestic animals for schistosomiasis and heavy metal toxicity. This can help reduce zoonotic transmission and serve as an early warning system for environmental contamination.

Soil and Ecosystem Management: Control soil moisture and organic content through sustainable land-use practices, drainage, and soil conditioning. These efforts will reduce the suitability of the environment for intermediate snail hosts and limit parasite survival.

Public Health Education and Community Engagement: Conduct targeted health education campaigns to raise awareness of schistosomiasis transmission routes, symptoms, and prevention methods. Active community participation is crucial for behavior change and sustained disease control.

REFERENCES

1. Alhassan, A. J., Sule, M. S., Atiku, M. K., Wudil, A. M., & Mohammed, S. A. (2020). Environmental contamination and heavy metal levels in the blood of exposed populations. *Toxicology Reports*, 7, 103–109.
2. Appleton, C. (1978). Review of literature on abiotic factors influencing the distribution and life cycles of Bilharziasis intermediate host snails. *Malacologia*, 17(1), 1–25.
3. Baloch, M. A., Wang, J., Iqbal, M., & Wang, Y. (2021). Cadmium exposure and immune system dysfunction: A review. *Environmental Science and Pollution Research*, 28, 21874–21889.
4. Boelee, E., Geerling, G., van der Zaan, B., Blauw, A., & Vethaak, A. D. (2013). Water and health: From environmental pressures to integrated responses. *Acta Tropica*, 128(3), 67–77. <https://doi.org/10.1016/j.actatropica.2013.06.019>
5. Duru, C. E., Okoli, C. C., & Iwuafor, K. C. (2021). Heavy metal accumulation and environmental risk assessment in soil and water resources in Nigeria. *Scientific African*, 12, e00811.
6. Ekpo, U. F., Laja-Deile, A., Oluwole, A. S., Sam-Wobo, S. O., & Mafiana, C. F. (2010). Urinary schistosomiasis among preschool children in a rural community near Abeokuta, Nigeria. *Parasitology Research*, 106(6), 1491–1495. <https://doi.org/10.1007/s00436-010-1808-0>
7. Standley, C. J., Lwambo, N. J., Lange, C. N., Kariuki, H. C., Adriko, M., Stothard, J. R., & Kabatereine, N. B. (2012). Performance of circulating cathodic antigen (CCA) urine-dipsticks for rapid detection of intestinal schistosomiasis in schoolchildren from shoreline communities of Lake Victoria. *Parasit Vectors*, 5(1), 1–7. <https://doi.org/10.1186/1756-3305-5-280>
8. Steinmann, P., Keiser, J., Bos, R., Tanner, M., & Utzinger, J. (2006). Schistosomiasis and water resources development: Systematic review, meta-analysis, and estimates of people at risk. *The Lancet Infectious Diseases*, 6(7), 411–425.
9. World Health Organization (WHO). (2017). *Guidelines for Drinking-Water Quality*, 4th Edition. Geneva: WHO Press.
10. World Health Organization (WHO). (2022). *Schistosomiasis Fact Sheet*. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/schistosomiasis>