

Original Research Article

**Quality Assessment of Water Bodies in Mining Communities of
Plateau State, Nigeria**

ABSTRACT

The geochemical assessment of water from mine ponds, streams, wells and boreholes of selected cassiterite mine sites in Plateau State of Nigeria had been carried out. These samples were analysed at the Geochemistry Laboratory of the Nigerian Geological Survey Agency (NGSA) in Kaduna, Nigeria. These water bodies in the study area have unenviable concentration of heavy metals as most of the water sources had been affected by the mining activities. They were therefore not suitable for consumption due to low pH of 5.2 - 6.6. The water bodies in the area contain toxic contaminants like Cd, Cr, Pb and As. These may cause diseases when consumed by human beings. It could have serious health effects, including mental retardation in children. This does not only pose threat to humans in that area but to the basic links in the foodweb as well as the environmental niches and the ecosystem.

Keywords: Cassiterite Mine Sites, Mine Ponds, Toxic Contaminants, Environmental Niche

INTRODUCTION

The study area played host to a lot of mining activities by foreign companies which rendered the area derelict with numerous waste dumps and ponds. The impact of the past mining activities on the landscape became very devastating as several mined-out pits ranging from 10 m to about 40 m in depth were left with various hazardous effects. These mined-out pits which are filled with water are generally referred to as mine ponds. Abandoned mine ponds pose serious threat to human and animal lives (Adiukwu-Brown, 1999; Mallo, 2007). The abandoned mine ponds and the numerous mounds of mine dumps and mill tailings resulting from mining activities that were carried out without consideration to the environment has led to soil, water and air pollution and loss of biodiversity. Today, hand methods by a single person or a group of people are used for mining near-surface, high grade deposit in the study area. The area was therefore described as a “disaster area” by the state government because of its devastated landscape as a result of indiscriminate mining activities over the years, (Jaiye, 2013).

Forstner and Salomong (1991) classified elements according to toxicity. Most of the very toxic and relatively accessible elements such as Cd and Cr are associated with the minerals mined in the study area. Opafunso (2010) opined that a number of studies have been undertaken to create a public awareness of the risks of prolonged human exposure to heavy metals. Heavy metals in stream sediments soils and water bodies occur as a result of the constituents of the ore and leachates from waste dumpsites among other sources. Heavy metals such as As, Cd, Pb exhibit extreme toxicity even at trace levels. It was observed during the course of this research that mine wastes (overburden and tailings) in the study area are used for building construction, as foundry sand for steel casting, road fill for road maintenance, for frying groundnuts and as recreational facilities in Jos wild life park for sand bathing by children. Water that accumulates in mine ponds is also used for dry season irrigation farming, for domestic and industrial uses such as drinking, cooking and in the manufacture of soft and alcoholic drinks. It is also used as recreational facilities such as sailing club and for agricultural purposes such as rock water fish farm. Occasionally, the heaps of mine tailings are exposed to weathering and leaching. They thereby constitute a source of pollution to the nearby water bodies. There is therefore the possibility of direct ingestion. It had therefore become necessary to determine qualitatively and quantitatively the toxic elements in the waste in order to be able to assess how safe or unsafe possible direct ingestion of the tailings could be.

MATERIALS AND METHODS

Water samples were collected and the physicochemical parameters of the samples were determined in accordance with the provision of Kegley and Andrew (1998) as well as APHA, AWWA and WEF (1998). Heavy metals concentrations of samples were analysed for using the atomic absorption spectrophotometric (AAS) model AA 6800 in accordance with the provision of ASTM D 856-10 at the Geochemistry Laboratory of the Nigerian Geological Survey Agency (NGSA), Kaduna. The results were compared with the international guidelines for drinking water quality presented by the World Health Organisation, WHO (2011). The suitability of water samples for irrigation was determined by comparing the Electrical Conductivity (EC), Percentage Sodium (% Na) and Sodium Absorption Ratio (SAR) with Table 1.

Table 1: Suitability of Water for Irrigation Based on EC and % Na (Ragunanth, 1987) SAR (Richard, 1954)

Quality Parameter	Range of Values	Description
EC	<250	Excellent
	250 – 750	Good
	750 – 2000	Permissible

	2000 – 3000	Doubtful
SAR	> 3000	Unsuitable
	< 10	Excellent
	10 – 18	Good
	18 – 26	Doubtful
%Na	> 26	Unsuitable
	< 20	Excellent
	20 – 40	Good
	40 – 60	Permissible
	60 – 80	Doubtful
	> 80	Unsuitable

54 RESULTS AND DISCUSSION

55 The results of the physicochemical analysis of water samples from the study area are presented in Table2. EC
56 ranged from 47 – 74 μ S/cm. These water samples can therefore be used for farm irrigation. The % Na ranged
57 between 60 and 87. This made the samples doubtful and unsuitable for farm irrigation. The sodium absorption
58 ratio (SAR) ranged between 2.7 - 6.8. The samples were therefor classified as excellent in the use for farm
59 irrigation.

60 Figures 1 - 8 show boxplots of the pH values, Cu, Fe, Mn, As, Cd, Cr and Pb respectively of water samples
61 collected from the study area. The mean pH values of water samples collected from mine ponds, streams, wells
62 and boreholes were 5.6, 6.5, 6.3 and 6.3 respectively (Fig. 1). These values were lower than the mean pH values
63 of the control samples as well as the recommended and maximum permissible limits of 6.8 and 7.0 set by WHO
64 (2011) for pH of portable water. There were no significant differences between pH values of water samples
65 collected from the study area and the mean control values, recommended limit of 7.0 and maximum permissible
66 limit of 6.8 except for water samples collected from mine ponds.

67 The mean concentrations of copper in water samples collected from mine ponds, streams, wells and boreholes
68 were 0.074 ppm, 0.043 ppm, 0.045 ppm and 0.041 ppm respectively (Fig. 2). Though, these values were higher
69 than the mean copper concentrations of the control samples, they were within the recommended level of 1 ppm
70 set by WHO (2011) for portable water. There were significant differences between the copper concentrations
71 water samples collected from the study area and the mean control value. The mean concentrations of iron in
72 water samples collected from mine ponds, streams, wells and boreholes in the vicinity of the mine sites were
73 0.423 ppm, 0.193 ppm, 0.229 ppm and 0.174 respectively (Fig. 3). These values were higher than the mean iron
74 concentrations of the control samples. They were however within the maximum permissible limits of 1 ppm set

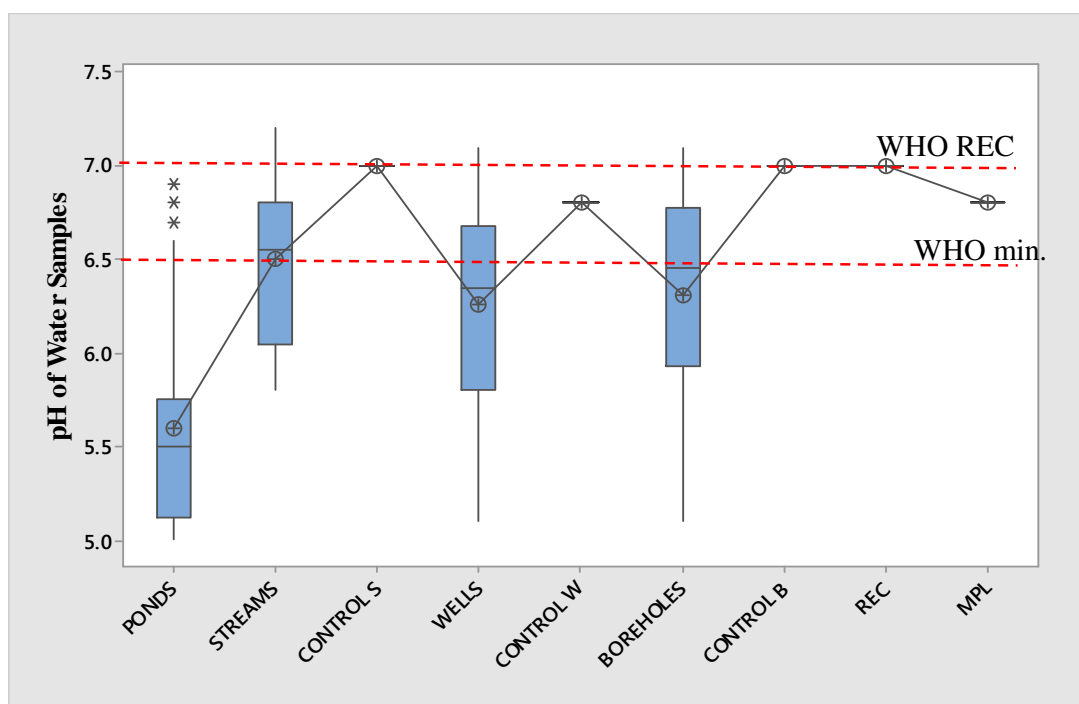
by WHO (2011) for portable water. The mean concentrations of manganese in the water samples collected from mine ponds, streams, wells and boreholes are 0.053 ppm, 0.031 ppm, 0.022 ppm and 0.021 ppm respectively. These values were higher than the mean manganese concentrations of the control samples as well as the recommended level of 0.01 ppm set by WHO (2011) for portable water. The mean concentration of manganese in the water samples collected from the mine ponds was higher than the maximum permissible limit of 0.04 ppm while those of others were within this limit (Fig. 4). There are however no significant difference between the manganese concentrations water samples collected from the study area and the mean control value as well as the maximum permissible limit of 0.01 ppm except for water samples collected from the mine ponds.

The mean concentrations of arsenic of water samples collected from mine ponds, streams, wells and boreholes are 0.027 ppm, 0.013 ppm, 0.013 ppm and 0.013 ppm respectively (Fig. 5). These values were higher than the mean arsenic concentrations of the control samples as well as the maximum permissible limits of 0.01 ppm set by WHO (2011) for portable water. There were however no significant difference between the arsenic concentrations water samples collected from the study area and the mean control value as well as the maximum permissible limit of 0.01 ppm except for water samples collected from the mine ponds. The mean concentrations of cadmium in water samples collected from mine ponds, streams, wells and boreholes were 0.013 ppm, 0.0098 ppm, 0.007 ppm and 0.0079 respectively (Fig. 6). These values were higher than the mean cadmium concentrations of the control samples as well as the maximum permissible limits of 0.003 ppm set by WHO (2011) for portable water. There were no significant differences between the cadmium concentrations water samples collected from the study area and the mean control value as well as the maximum permissible limit of 0.003 ppm except for water samples collected from the mine ponds. The mean concentrations of chromium in water samples collected from mine ponds, streams, wells and boreholes were 0.06 ppm, 0.03 ppm, 0.03 ppm and 0.03 ppm respectively (7). These values were within the maximum permissible limits of 0.05 ppm set by WHO (2011) for portable water except for water samples collected from mine ponds. There were no significant differences between the chromium concentrations water samples collected from the study area and the mean control value as well as the maximum permissible limit of 0.05 ppm. The mean concentrations of lead in water samples collected from mine ponds, streams, wells and boreholes were 0.06 ppm, 0.02 ppm, 0.02 ppm and 0.03 ppm respectively (Fig. 8). These values were higher than the mean lead concentrations of the control samples as well as the maximum permissible limits of 0.01 ppm set by WHO (2011) for portable water. There are no significant differences between the cadmium concentrations water samples collected from the study area and the mean control value as well as the maximum permissible limit of 0.01 ppm.

105 Table 2: Physicochemical Parameters of Water Samples from the Study Area

	EC	K	Na	Ca	Mg	% Na	SAR
Mine ponds	73.8	6.4	6.6	1.8	0.1	87	6.8
Streams	53.8	7.8	5.2	3.8	0.9	73	3.4
Wells	52.9	6.5	4.8	4.2	0.8	69	3
Boreholes	46.8	3.9	4.4	4.6	0.9	60	2.7
Control Stream	31.3	3.8	2.8	4.6	0.3	57	1.8
Control Well	29.9	2.1	1.5	4	0.1	46	1
Control Borehole	28.9	0.7	0.8	2.2	0.9	32	0.6

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Fig. 1: pH of Water Samples Collected from the Study Area

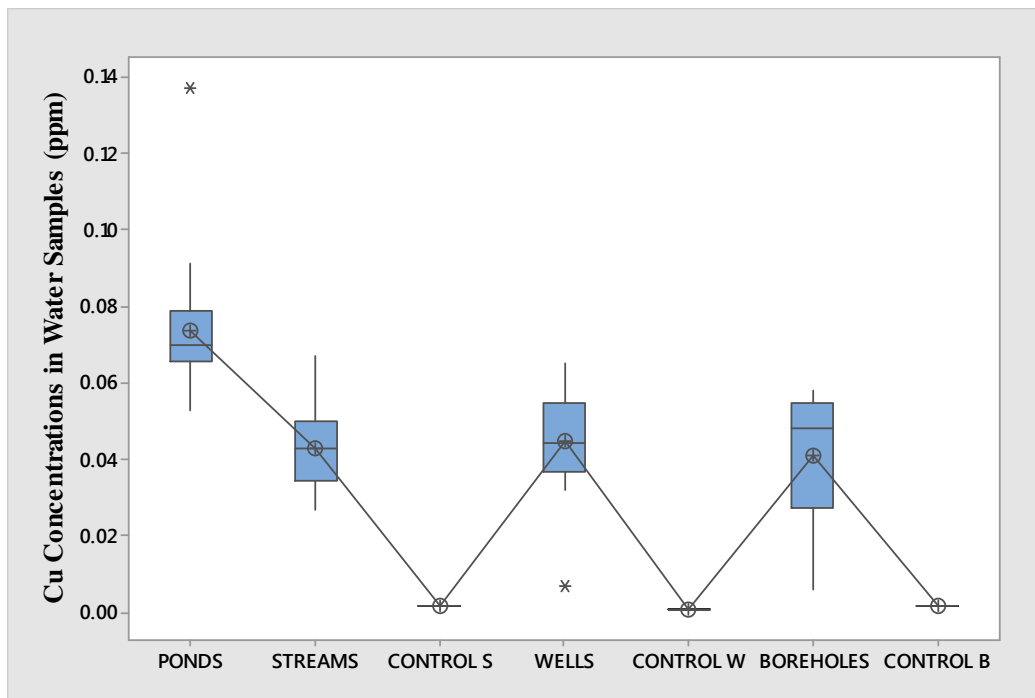


Fig. 2: Copper Concentrations in Water Samples Collected from the Study Area

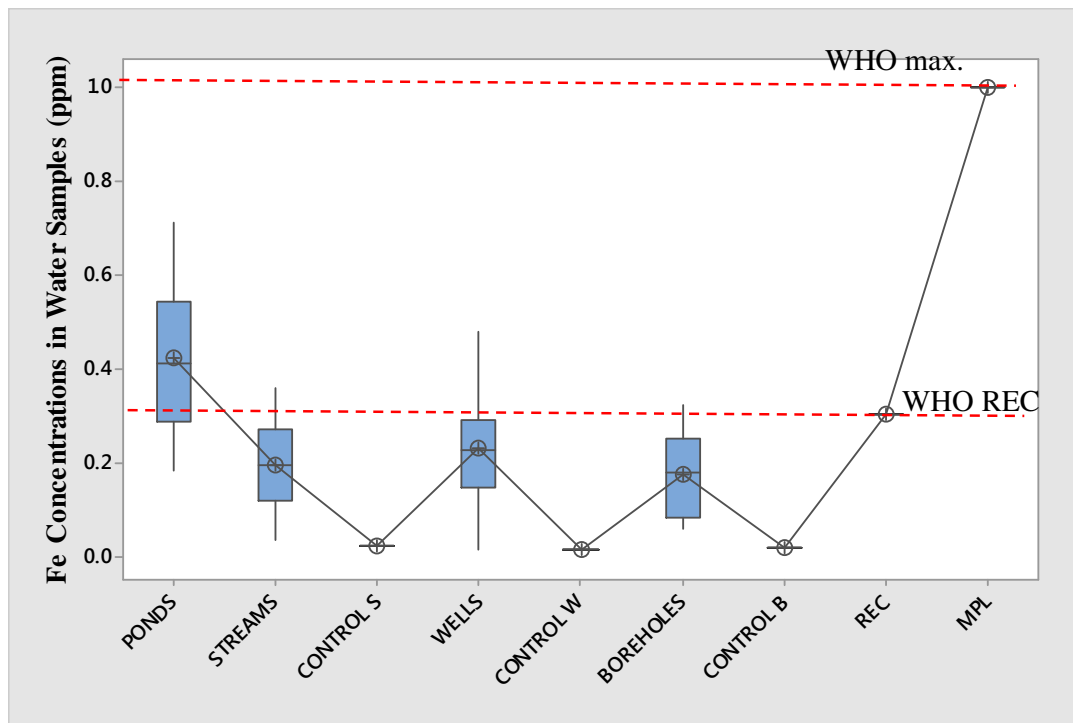


Fig. 3: Iron Concentrations in Water Samples Collected from the Study Area

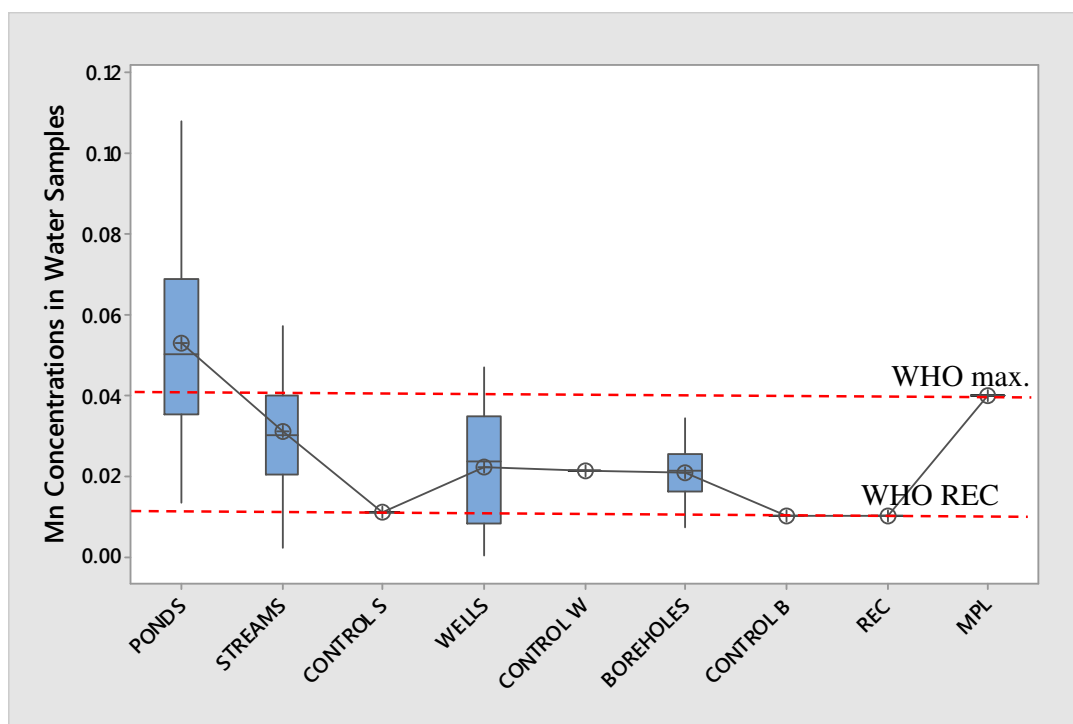


Fig. 4: Manganese Concentrations in Water Samples Collected from the Study Area

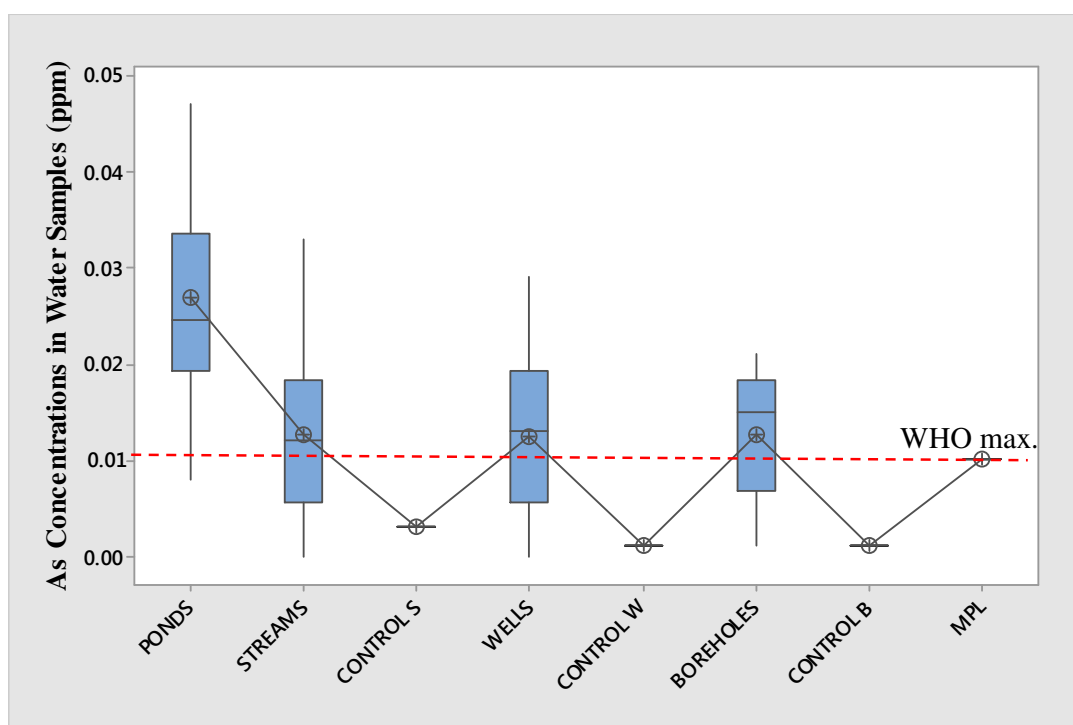


Fig. 5: Arsenic Concentrations in Water Samples Collected from the Study Area

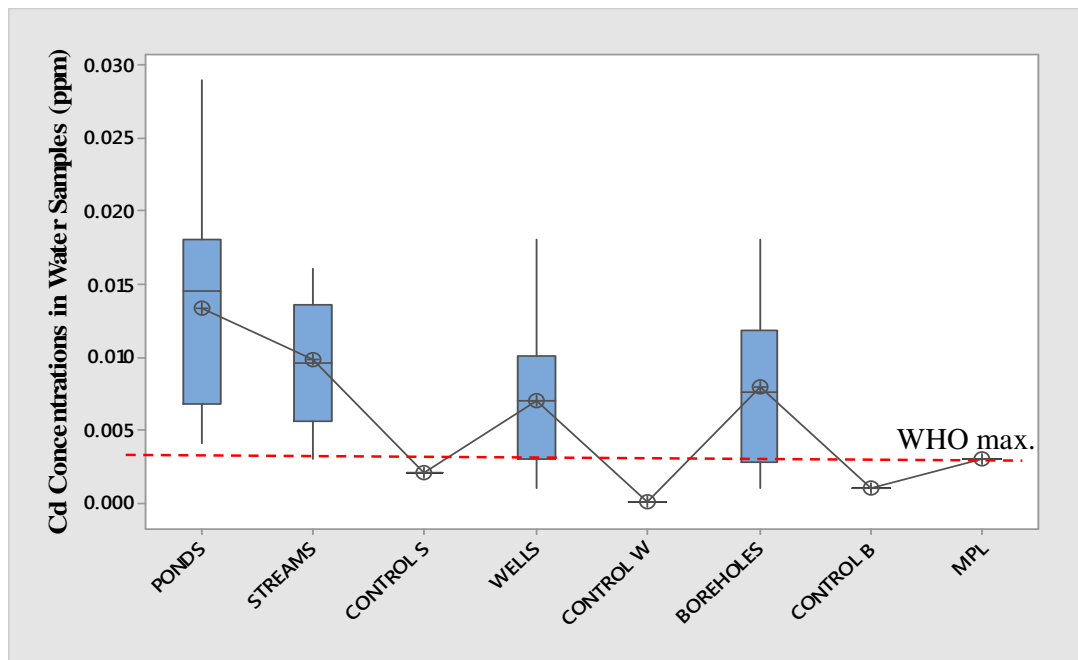


Fig. 6: Cadmium Concentrations in Water Samples Collected from the Study Area

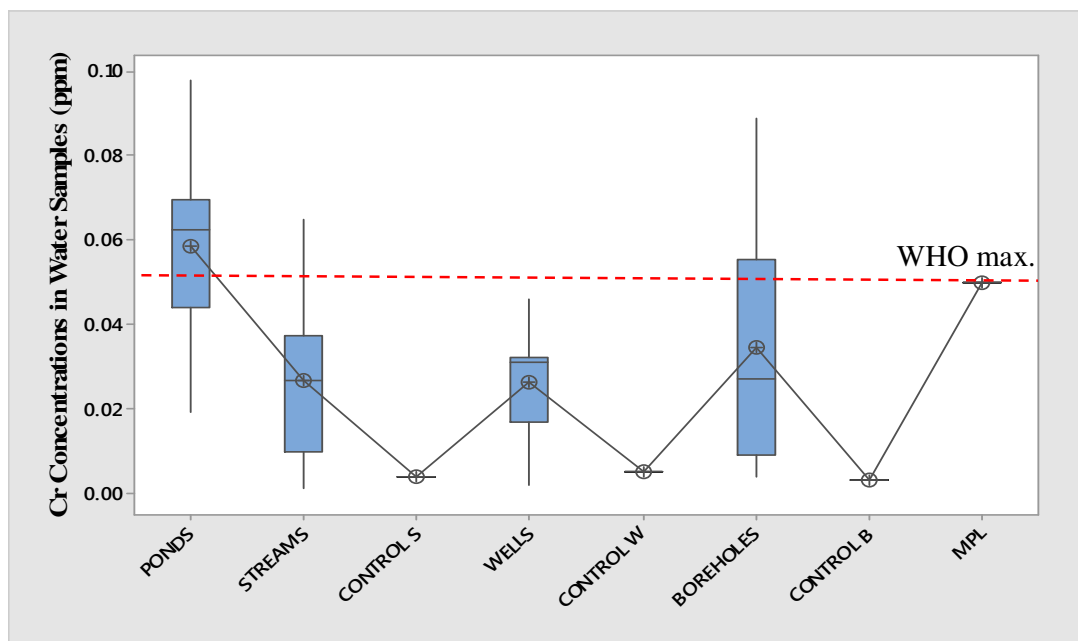


Fig. 7: Chromium Concentrations in Water Samples Collected from the Study Area

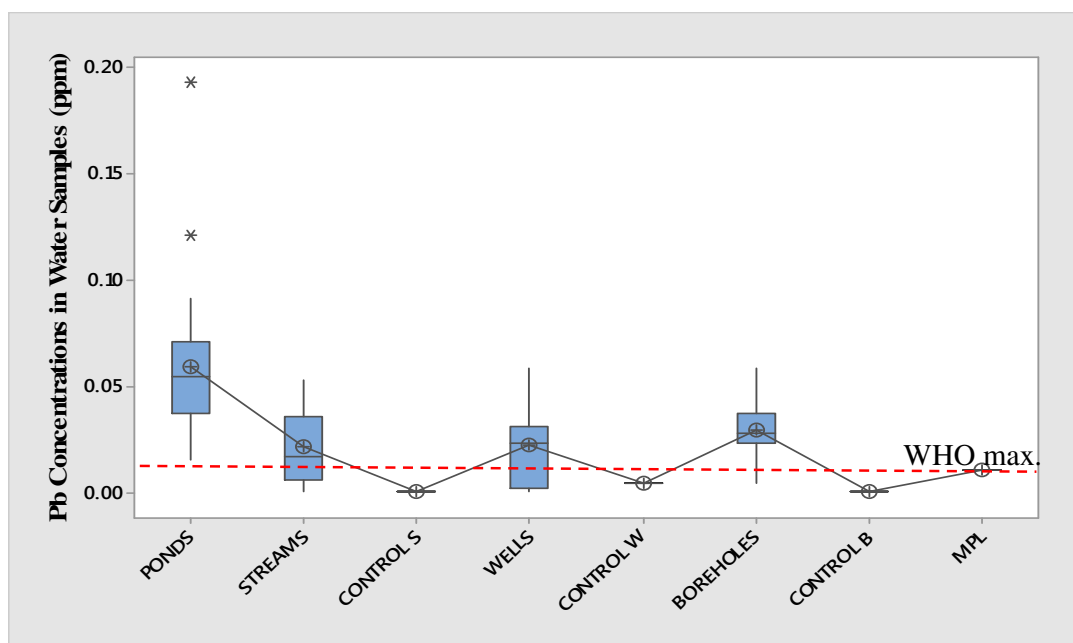


Fig. 8: Lead Concentrations in Water Samples Collected from the Study Area

CONCLUSION

It was discovered that the water bodies in the study area have unenviable concentration of heavy metals as a most of the water sources have been affected by the mining activities. The water bodies in the area contain toxic contaminants that may cause diseases when consumed by human beings. This could have serious health effects, including mental retardation in children. This does not only pose threat to humans in that area but to the basic links in the ecosystem foodweb as well as the environmental niches and the ecosystem they comprise.

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