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HEAVY METALS AND CYANIDE DISTRIBUTION IN THE VILLAGES SURROUNDING BUZWAGI GOLD MINE IN TANZANIA

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ABSTRACT

The study aimed at assessing the levels of heavy metals and cyanide in water and sediments in villages surrounding Buzwagi gold mine, both during wet and dry seasons. A total of 56 samples of water (28 from each season) and 44 samples of sediments (22 from each season) were collected from the wells in the area and were analyzed for total cyanide and heavy metals. The total cyanide was analyzed spectrophotometrically whilst the heavy metals were analyzed by an Inductively Coupled Plasma (ICP). The Pb and Fe levels in water were found to exceed 10 µg/L and 2000 µg/L respectively, the World Health Organization (WHO) limits for drinking water in some wells. It was therefore concluded that the water is not safe for drinking. The concentrations of cyanide and most of the heavy metals in sediments (except Cd and Hg which were below the detection limit) were higher in the wells closest to the Tailing Storage Facility (TSF) than the wells which are far from the TSF showing that the contamination to the water is due to mining activities. Furthermore concentrations of most of the parameters in sediments were higher in dry than in wet season. It was recommended that the water contamination should be prevented by having a regular inspection of the TSF liner so as to ensure zero discharge and that the alternative source of water should be provided to the mining communities.

Key Words: Heavy metals pollution, Total cyanide, ground water pollution and mining.

INTRODUCTION

Mining activities contribute a lot to economy of any given country; however, pollution in water bodies in areas where mining activities are taking place has been reported (Thomas and Darimani 2001, Bitala 2008, Nkuli 2008, Armah et al. 2010, Chen et al. 2013). Elevated levels of heavy metals in water, soils and sediments have been reported in China; the largest gold producer in the world (Chen et al.2013), in south Africa; the largest gold producer in Africa (Ochienget al.2010) and in Ghana; the second largest gold producer in Africa (Thomas and Darimani 2001, Armahet al.2010).

Tanzania is one of the largest gold producing countries; it is the fourth in Africa after South Africa, Ghana and Mali. In many areas where gold is mined in Tanzania, elevated levels of heavy metals and cyanide have been reported (Bitala 2008, Nkuli 2008). In such case water resources in areas where gold is mined are affected by pollution from mining activities.

Mwendakulima and Mwime, the villages surrounding Buzwagi gold mine (BGM)

depend on ground water as the only source of water for domestic use. Being close to the mine, the water is vulnerable to pollution from mining activities, especially heavy metals and cyanide.

Cyanide and some heavy metals are very toxic. The toxicity of cyanide is due to the fact that it binds to the active Fe atom in cytochrome oxidase and inactivates oxidative respiration (Basile 2008).Toxicological studies show that, short term exposure to high concentrations of cyanide can harm the nervous, respiratory and cardiovascular systems of animals (Korte and Coulston 1998). Some heavy metals are carcinogenic and neurotoxin (Jomova and Valko 2011, Tokar et al. 2011).

BGM is about eight years old and that limited studies on water quality have been undertaken on the area. The case that groundwater is the only source of water in the area and that limited information is available on the quality of water, were the motives for carrying out this study.

MATERIALS AND METHODS

Description of the study area

The study took place in Tanzania, Shinyanga Region in villages surrounding Buzwagi gold mine. The villages are Mwime, Mwendakulima and Nyihogo (Fig. 1). Nyihogo village is far from the mine, approximately 11 km from the mining area and therefore it was used as a control. The mining site is located 6 km west of Kahama town. Mwendakulima is the nearest ward to the Buzwagi gold mine and it is where Mwime and Mwendakulima villages are.

Collection of samples

A total of fifty six (56) samples of water and forty four (44) samples of sediments were collected as single data samples from wells approximately half a metre from the wells` water level both during dry season (early September 2014) and wet season (end of January 2015), whereby, twenty eight (28) samples of water (12 from Mwendakulima, 10 from Mwime and 6 from Nyihogo) were collected in each season. The number of wells in which samples were collected was selected based on the fact that it is at least 50 % of all the wells in the site. Of the 28 samples of water, 14 samples were specific for heavy metals analyses and were collected in 1 Litre capacity plastic bottles and the other 14 samples were specific for cyanide analyses and were collected in 1 litre capacity brown bottles which do not allow light to pass through. For sediments, 22 samples (12 from Mwendakulima and 10 from Mwime) were collected in each season. Of the 22 samples of sediments, 11 samples were specific for heavy metals analyses and were collected by sediment sampler in half a litre plastic containers and the other 11 sediments samples were specific for cyanide analyses and were collected by sediment sampler in half a litre plastic containers which were covered in black materials. The location of each well was taken by a GPS. The samples for heavy metals analysis were preserved by adding nitric acid to pH below 2 and those for cyanide analysis were preserved by adding sodium hydroxide pellets to pH above 12 according to APHA (1999).

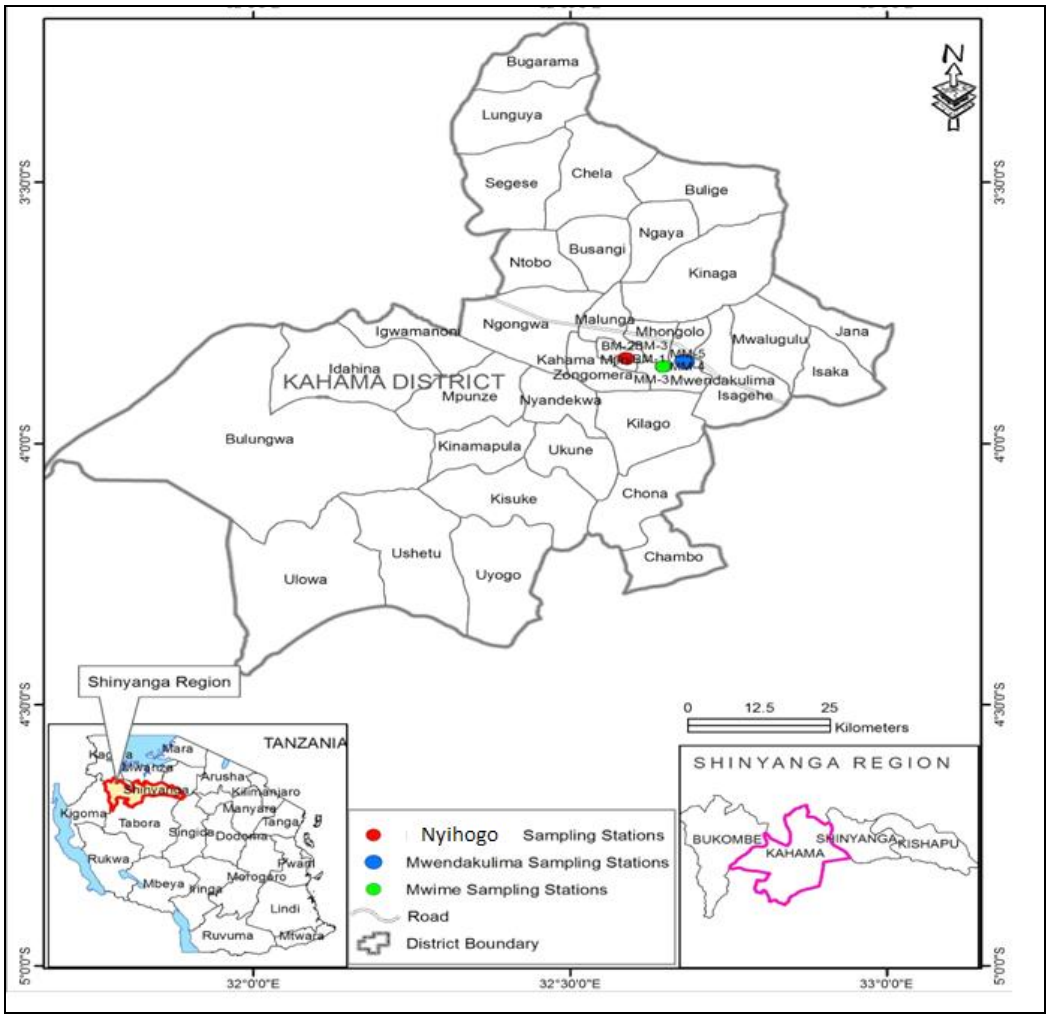

Figure 1: The study area showing sampling villages

Cyanide samples were analysed at the University of Dar es Salaam, Botany Department Laboratory in Tanzania within 5 days after sampling and the heavy metals were analysed at the Tanzania Chief Government Chemist Laboratory within 2 weeks after sampling.

Preparation and analysis of water and sediments samples

The samples for heavy metals and total cyanide were digested and analysed according to APHA (1999). The cyanide samples were analysed by Atomic Absorption Spectrophotometer JENWAY 6305 Model (PerkinElmer Inc., United States).

The heavy metals were analysed using an Inductively Coupled Plasma Optical Emission Spectrometer, ICAP 6000 model (PerkinElmer Inc., United States). The heavy metals that were analyzed are

cadmium, mercury, nickel, lead, manganese and iron.

RESULTS AND DISCUSSION

Total Cyanide

The levels of total CN in water were low and were all within the WHO and TBS limits for drinking water which is 0.07 mg/L (70 µg/L) and 0.2 mg/L (200 µg/L) respectively both in wet and in dry seasons. The CN levels ranged between 0.33 and 0.77 µg/L during dry season (Table 1). During wet season, total CN ranged between 0.23 and 1.1 µg/L (Table 2). Total CN was detected in Mwendakulima and Mwime wells which are the villages surrounding Buzwagi mine and it was not detected in Nyihogo which is the village which is far from the mining area (Tables 1 and 2). The fact that CN was detected in the wells near the mining area and was not detected in the wells far from the mining area is an indication that the contamination of ground water by CN is due to mining activities.

Table 1: The concentrations of different parameters in water (in µg/L) during dry season

Well Id	Location		Total CN	Pb	Fe	Mn	Ni
NY-1	3.83658S	32.68322E	BDL	360.00	190.00	BDL	BDL
NY-2	3.88288S	32.68345E	BDL	40.00	50.00	BDL	20.00
NY-3	3.84298S	32.6803E	BDL	20.00	50.00	BDL	50.00
MK-1	3.84279S	32.67937E	0.63	BDL	160.00	BDL	BDL
MK-2	3.84228S	32.67904E	0.60	20.00	BDL	BDL	BDL
MK-3	3.4434S	32.67958E	BDL	BDL	250.00	BDL	BDL
MK-4	3.85188S	32.65011E	BDL	BDL	BDL	BDL	BDL
MK-5	3.85247S	32.64621E	0.33	BDL	210.00	BDL	BDL
MK-6	3.85284S	32.64592E	BDL	BDL	190.00	BDL	BDL
MM-1	3.85248 S	32.64622E	0.40	BDL	6,920.00	BDL	BDL
MM-2	3.85231S	32.64708E	0.77	BDL	2,100.00	BDL	BDL
MM-3	3.83658S	32.58771E	BDL	BDL	BDL	BDL	BDL
MM-4	3.8377S	32.59053E	BDL	BDL	1,790.00	BDL	BDL
MM-5	3.83702S	32.59088E	0.60	BDL	BDL	BDL	BDL

BDL means Below Detection Limit

In sediments the total CN concentrations were between 2.3 and 25.2 µg/g during dry season and between 0.1 and 10.3 µg/g during wet season. In wet season the concentration of CN was lower than in dry season (Figs. 2 and 3). This is probably due to dilution during wet season as the more the dilution the less the concentration.

Heavy metals

Lead

The detected Pb levels in water ranged between 20 and 360 µg/L in dry season which is above 10 µg/L; the WHO level for drinking water (Table 1). During wet season the levels in water were below the detection limit (Table 2).

Table 2: The concentrations of different parameters in water (in µg/L) during wet season.

Well Id	Location		Total CN	Pb	Fe	Mn	Ni
NY-1	3.83658S	32.68322E	BDL	BDL	50.00	BDL	BDL
NY-2	3.88288S	32.68345E	BDL	BDL	180.00	BDL	BDL
NY-3	3.84298S	32.6803E	BDL	BDL	BDL	BDL	BDL
MK-1	3.84279S	32.67937E	0.27	BDL	20.00	BDL	BDL
MK-2	3.84228S	32.67904E	1.07	BDL	30.00	BDL	BDL
MK-3	3.4434S	32.67958E	BDL	BDL	110.00	BDL	BDL
MK-4	3.85188S	32.65011E	BDL	BDL	BDL	BDL	BDL
MK-5	3.85247S	32.64621E	0.23	BDL	100.00	BDL	BDL
MK-6	3.85284S	32.64592E	BDL	BDL	50.00	BDL	BDL
MM-1	3.85248	32.64622E	BDL	BDL	3380.00	BDL	BDL
MM-2	3.85231S	32.64708E	BDL	BDL	820.00	BDL	BDL
MM-3	3.83658S	32.58771E	1.10	BDL	1930.00	BDL	BDL
MM-4	3.8377S	32.59053E	BDL	BDL	1270.00	BDL	BDL
MM-5	3.83702S	32.59088E	BDL	BDL	780.00	BDL	BDL

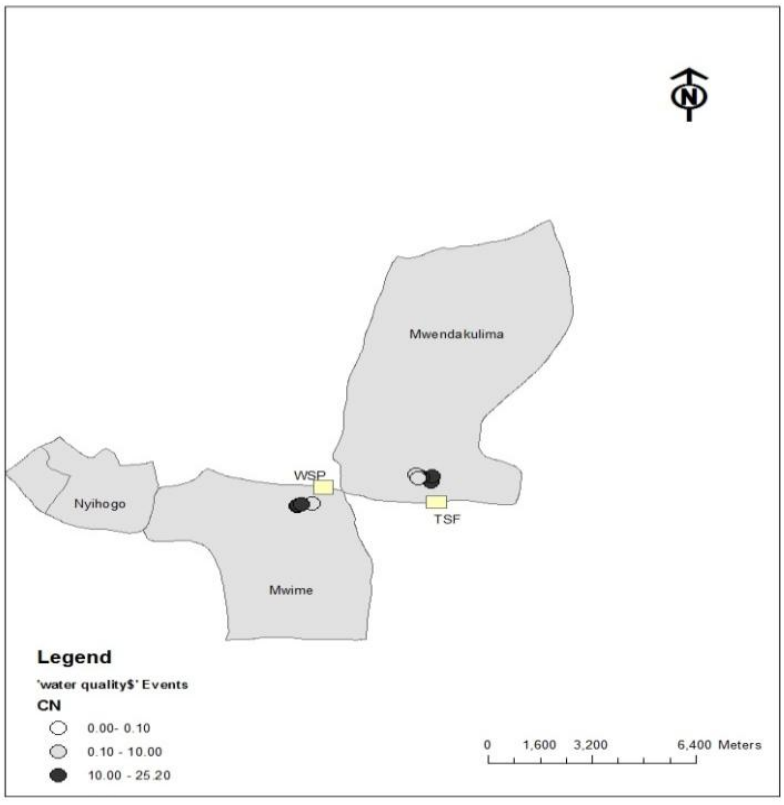

Figure 2: The level of total CN (in µg/g) in sediments during dry season.

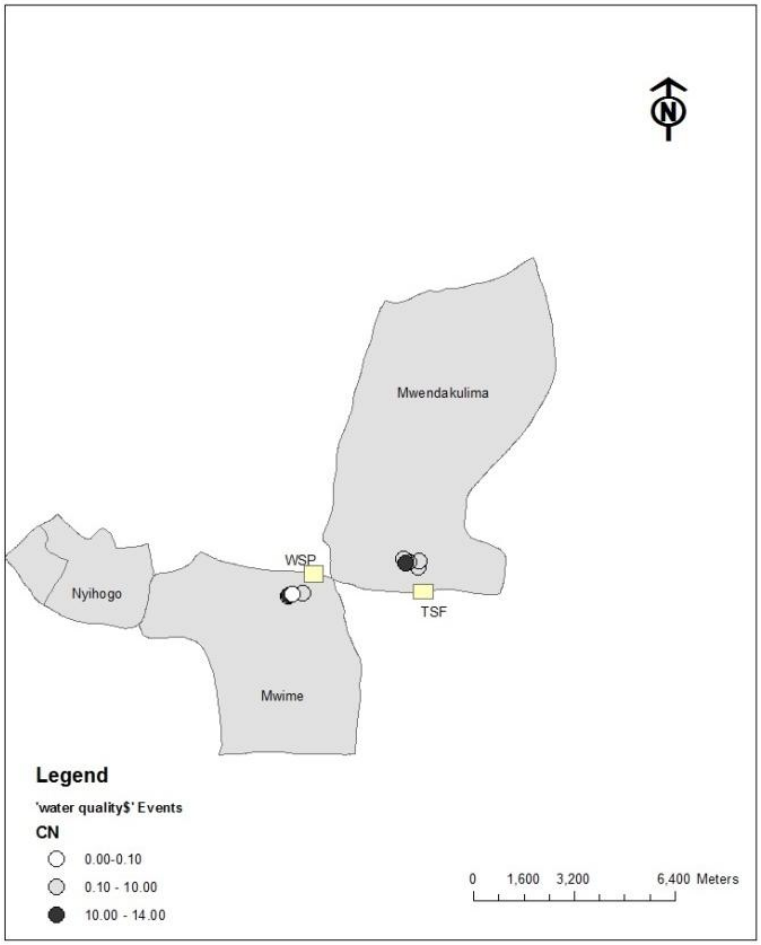

Figure 3: The level of total CN (in µg/g) in sediments during wet season.

The level of Pb in sediments during dry season which ranged between 30 and 1100 µg/g was higher than during wet season which ranged between 30 and 810 µg/g (Fig. 4). In either case the levels in most of the wells exceeded 100 µg/g, which is recommended by WHO. Higher Pb level during dry than during wet season was also found by Yahaya et al. (2009). High dilution during wet season could be the reason for low Pb levels as compared to dry season in which high levels were observed. In either season the Pb content in Mwendakulima (the closest wells from the TSF) was higher than in Mwime (Figs. 4 and 5), although statistically the case was true during wet season (unpaired t test, $P=0.008< 0.05$) at 95 % confidence level but not true during dry season (Mann Whitney, $P= 0.7922>0.05$) at the same confidence level. High Pb level in Mwendakulima could probably be due to contamination from the TSF into which tailings are discharged. Ingesting high Pb level is a health hazard to communities as it may cause neurological effect (Rosin 2009).

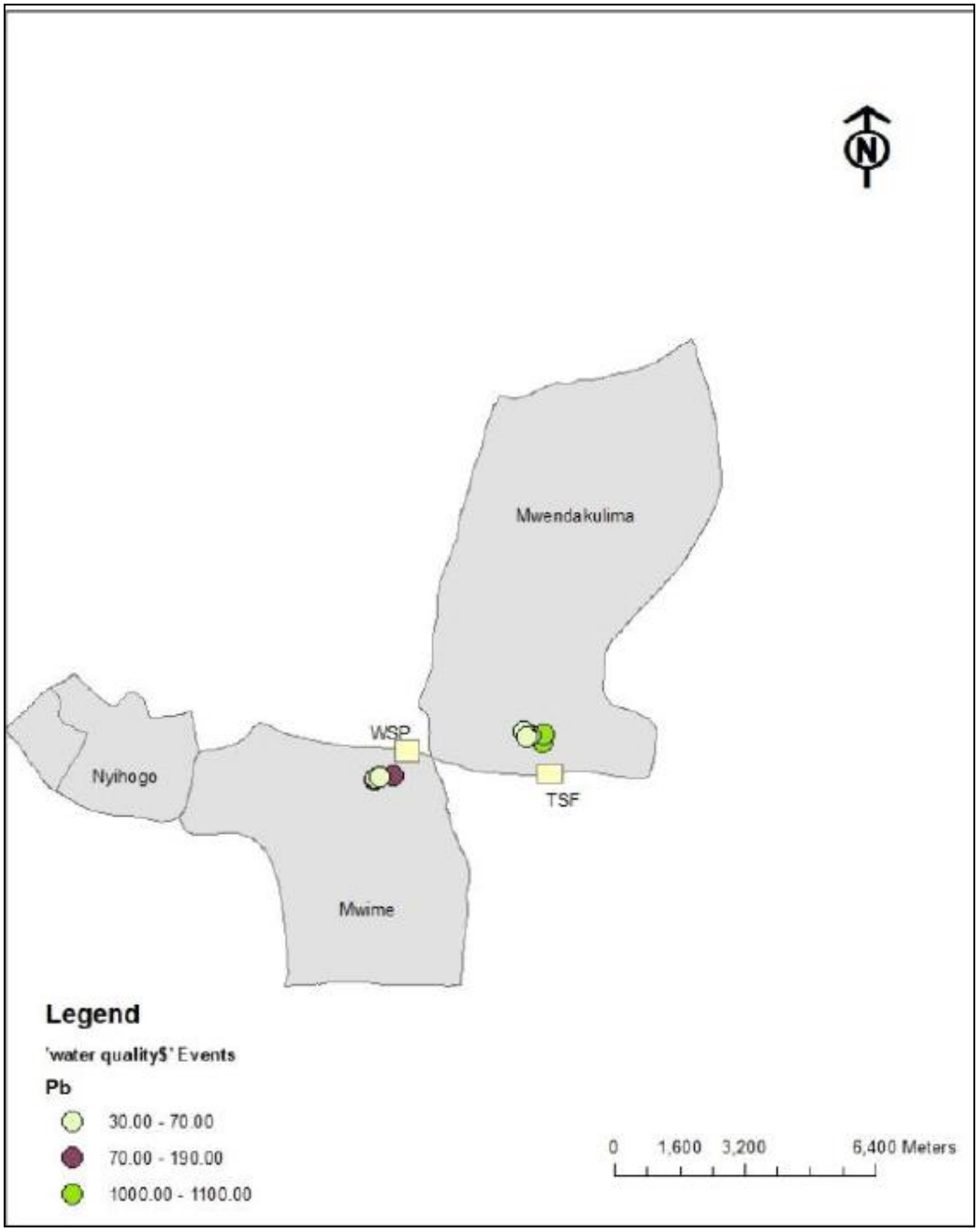

Figure 4: The level of Pb (in µg/g) in sediments during dry season.

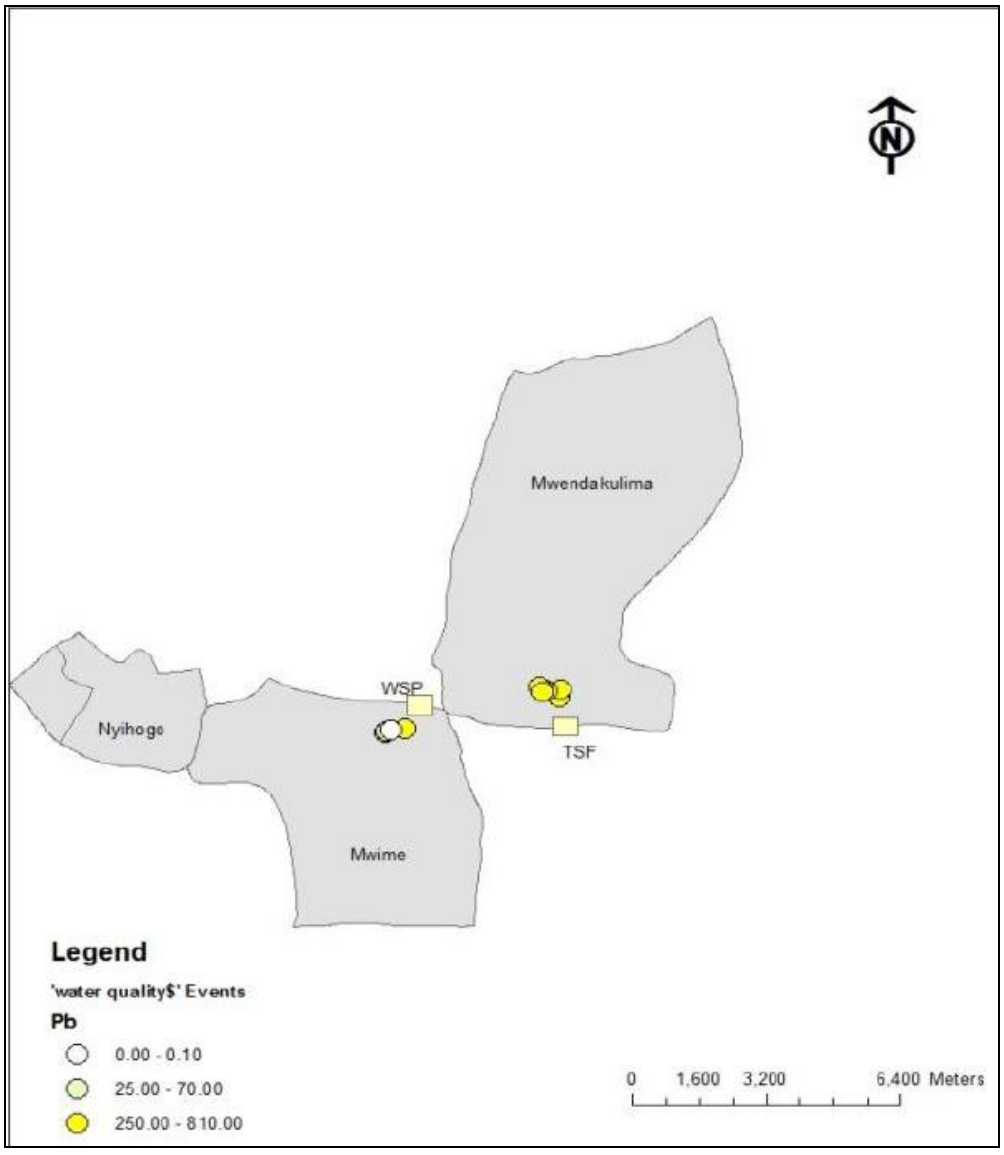

Figure 5: The level of Pb (in µg/g) in sediments during wet season.

Manganese

The levels of Mn in water were below the detection limit in both seasons (Tables 2 and 3). In sediments high Mn levels were observed. As compared to 2000 µg/g which is recommended by WHO, the Mn levels during dry season ranged between 70 and 10,520 µg/g and between 40 and 2,840 µg/g during wet season (Figs. 6 and 7). Statistically the mean Mn level in sediments

was significantly higher in dry than during wet season (Paired t test, P = 0.0172< 0.05) at 95 % confidence level, these findings conform to other similar studies (Yahaya et al. 2009, Nwadinigwe et al. 2014). Low levels of Mn during wet season could be due to high dilution, which reduces the concentration.

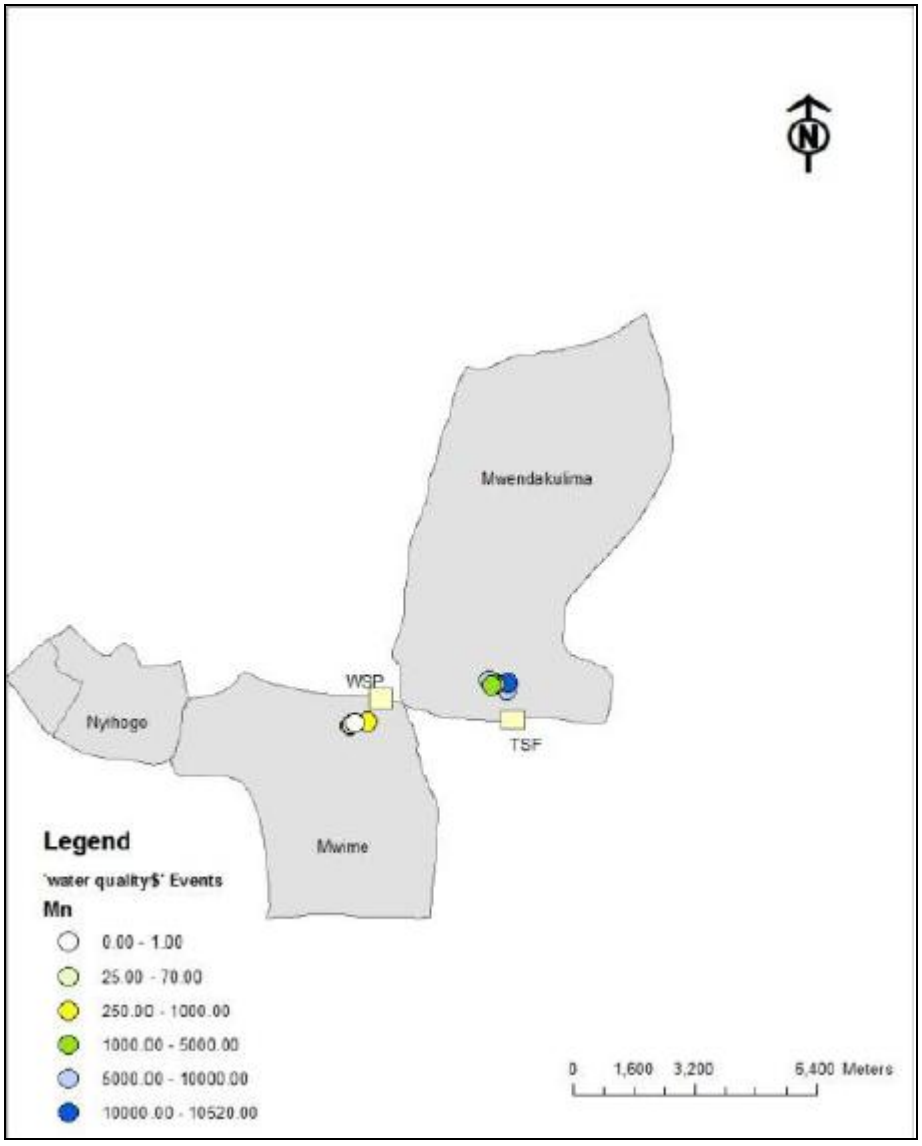

Figure 6: The level of Mn (in µg/g)in sediments during dry season

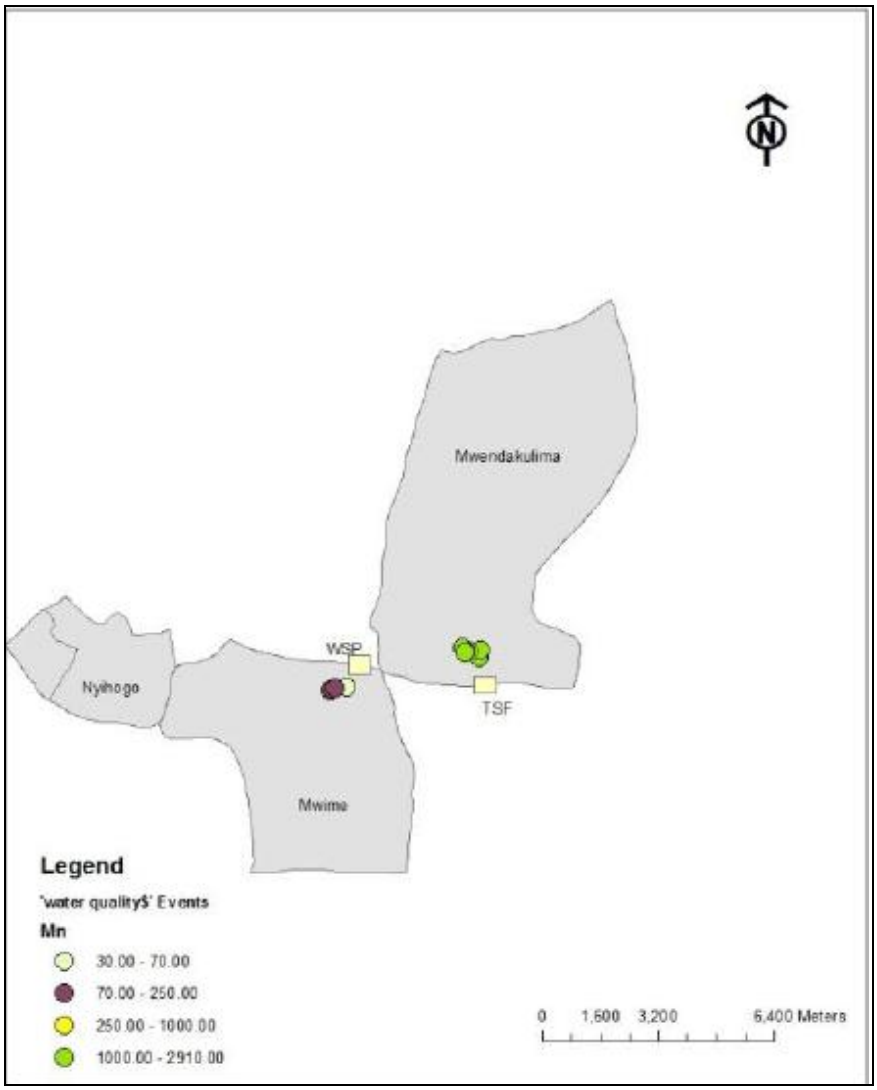

Figure 7: The level of Mn (in µg/g) in sediments during wet season

Mwendakulima samples showed significantly higher Mn content than Mwime in both seasons (Figs 6 and 7), the case was also true statistically (Unpaired t test, P=0.0096 and 0.0264 in dry and wet seasons respectively which are both <0.05) at 95 % confidence level. High level of Mn in Mwendakulima wells could be due to its location which is close to the TSF.

Mn is essential for human and other organisms and is required for growth, development and maintenance of health, however chronic inhalation of high levels of Mn is associated with a neurodegenerative disorder characterized by both central nervous system abnormalities and neuropsychiatric disturbances (Santamaria 2008).

Iron

The concentration of Fe in water ranged between 50 and 6,920 µg/L during wet season and between 20 and 3,380 µg/L during dry season (Tables 2 and 3). Two wells MM-1 and MM-2 showed the levels that were above the WHO and TBS limits for drinking water which is 2000 µg/l during dry season probably due to low dilution. The concentrations of Fe in sediments were extremely high as compared to other heavy metals (Figs. 8 and 9); this finding is similar to that observed by Nwadinigwe et al. (2014). Although most of the wells showed Fe levels within the limit accepted by WHO and TBS, high concentrations were observed in sediments in both seasons (Figs. 8 and 9).

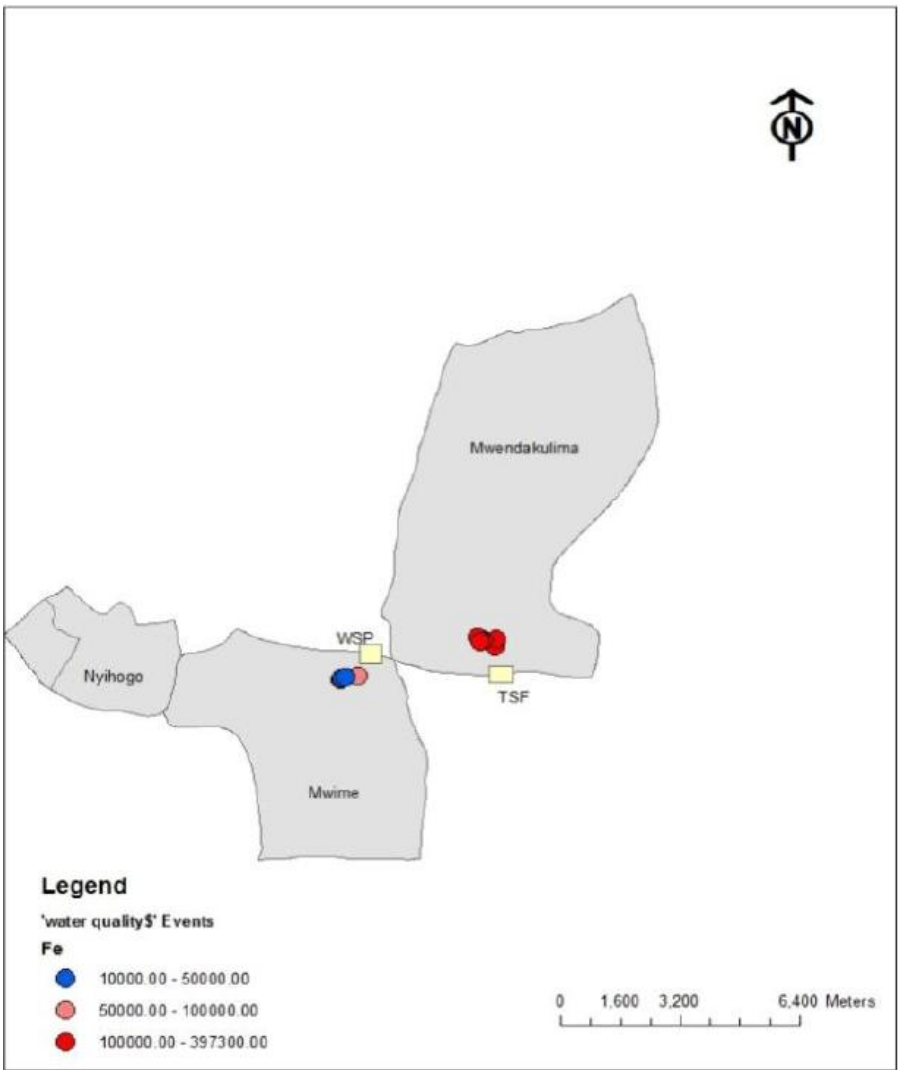

Figure 8: The level of Fe (in µg/g) in sediments during dry season

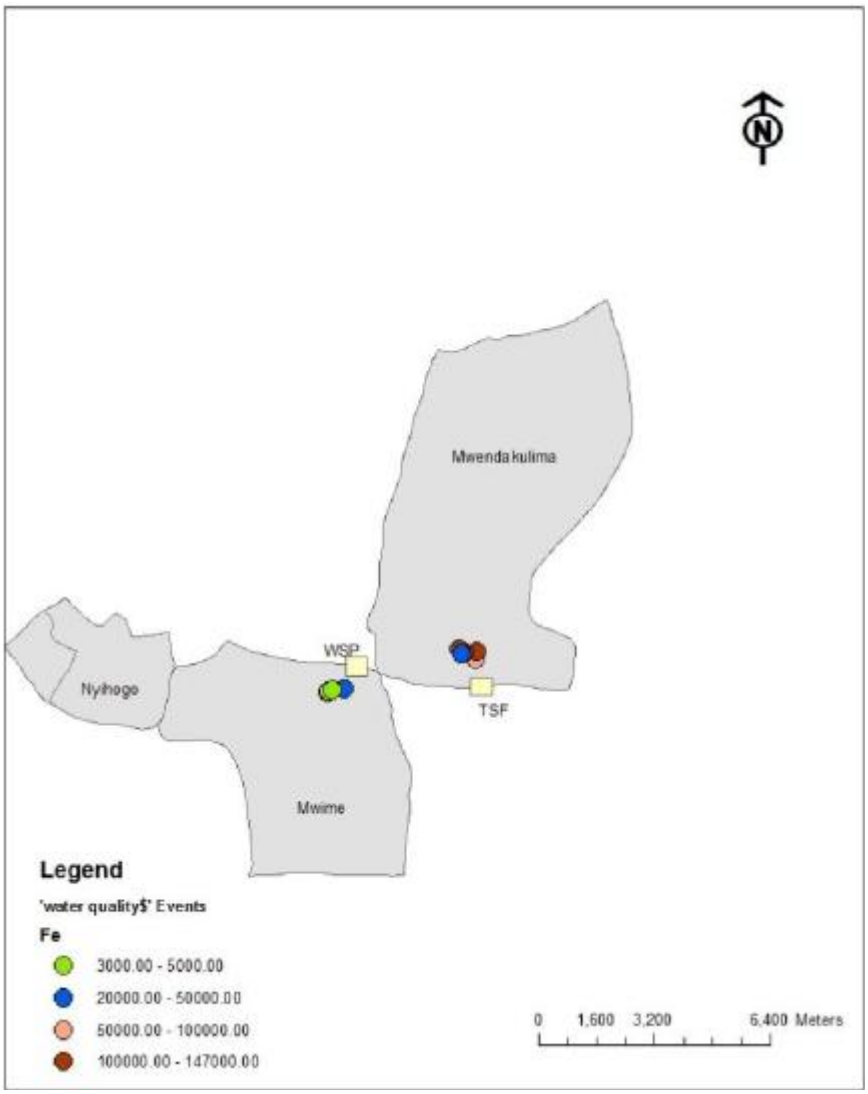

Figure 9: The levels of Fe (in µg/g) in sediments during wet season

Mwendakulima wells showed significantly higher Fe level than Mwime in both seasons (Mann whiteney test, P = 0.0043 and 0.0076 in dry and in wet seasons respectively) at 95 % confidence level. There was also significantly higher concentration in dry than in wet season (paired t test, P=0.0029< 0.05) at 95 % confidence level, which is probably due to dilution during wet season which reduces concentration of Fe. Studies show that long term consumption of drinking water with high concentration of Fe can lead to liver disease (Hem 1970). Furthermore Fe can cause colour in water which may cause staining of cloth and utensils

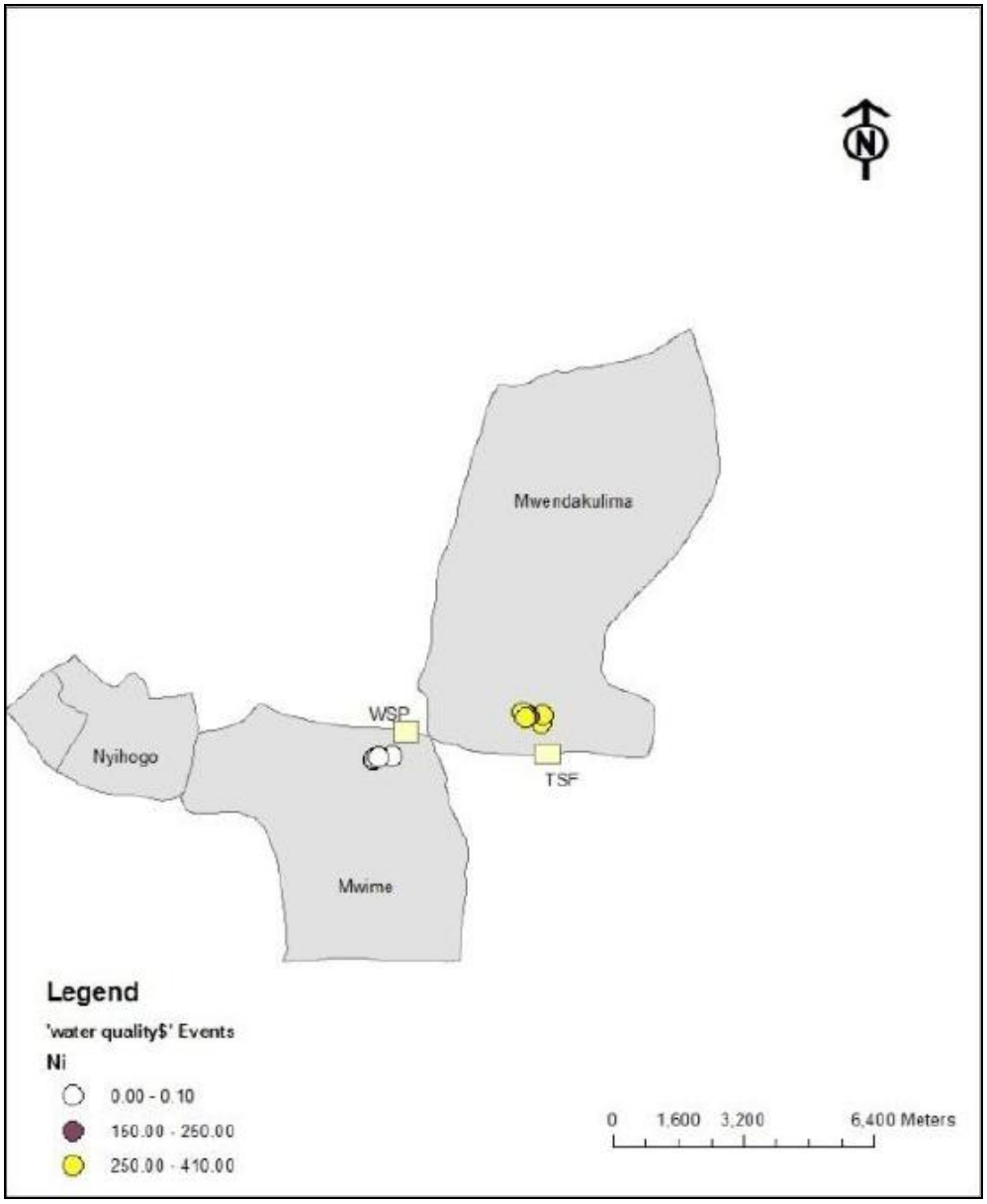

Figure 10: The levels of Ni (in µg/g) in sediments during dry season.

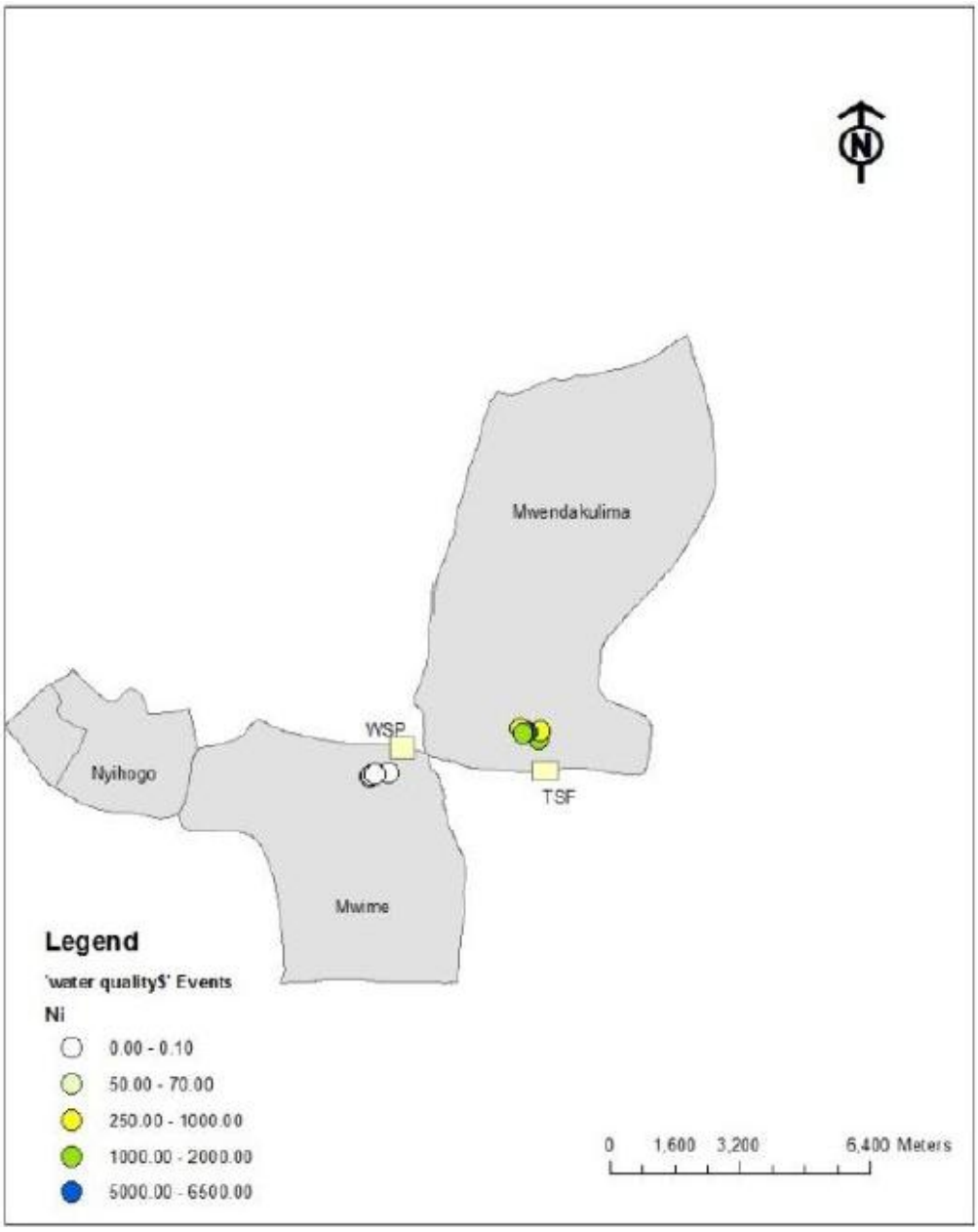

Figure 11: The level of Ni (in µg/g) in sediments during wet season.

Nickel

Nickel was below the detection limit in majority of the water samples, it was detected in only two wells from the control village (Tables 1 and 2), the detected concentrations were within the WHO and TBS limits.

Contrary to other similar studies in which Ni was found to be higher in dry than in wet season (Nwadinigwe et al. 2014), Ni levels in sediments were higher in wet than in dry season although statistically the difference was not significant (Paired t test, P= 0.2080< 0.5) at 95 % confidence level. The level was between 0 and 410 µg/g during dry season and between 0 and 6500 µg/g during wet season. Similar to other heavy metals, Ni in sediments was significantly higher in Mwendakulima than in Mwime (Figs 10 and 11) probably due to contamination from the TSF which is close to Mwendakulima wells. In drinking water Ni is a known neurotoxin (Santamaria 2008).

Cadmium and mercury

Cadmium and mercury levels were below the detection limit in all the wells and in both seasons. The major source of Hg in mining areas is small scale mining whereby Hg is used in extracting gold from its ore. Low level of mercury could be due to the fact that small scale mining is taking place far from the area (more than 7 km) and therefore low possibility of detecting Hg in water and sediments in the study area.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Since some heavy metals parameters such as Pb and Fe exceed the WHO and TBS recommended limits for drinking water, the water is therefore not suitable for drinking purpose.

The concentrations of cyanide and most of the heavy metals in sediments are higher in wells which are closer to the TSF than the wells which are far from the TSF showing that contamination of the parameters to the groundwater is due to mining activities. Furthermore the concentrations of most of the parameters in sediments are higher during dry than wet season.

Recommendations

Due to groundwater contamination by cyanide, heavy metals and probably other hazardous substances, leakage of contaminants from the mining should be prevented; this can be done by having a regular inspection of the TSF liner so as to ensure zero discharge.

There should be an alternative source of water for the mining communities as the water is not safe for drinking, this can be water from the Lake Victoria which is not far from the area.

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