



Impact of Mining and Farming activities on Water and Sediment Quality of the Mara river basin, Tanzania

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Abstract

The effects of mining and agriculture activities on the accumulation of heavy metals and nutrients in water and sediments of rivers in the Mara river basin were examined. The study aimed at evaluation of the environmental quality of aquatic system in order to ascertain its suitability for human consumption, recreation and other purpose. Heavy metals Cd, Pb, Cu, Zn and Cr concentrations ranged from 0.01 to 0.72 mg/l and 0.01 to 90.58 mg/kg dw were detected in surface water and sediments samples, respectively. Plant nutrients NO₃⁻ and PO₄³⁻ concentrations ranged from 0.63 to 127.60 mg/l were detected in surface water samples. In most sites, heavy metals and nutrients concentrations detected were above the recommended WHO and national limits for drinking water. Mining wastes were considered to be major sources of heavy metals, while nutrients were considered to originate from agricultural runoff and weathered agricultural soils. All the parameters were measured by standard methods.

Keywords: Mining, agriculture, heavy metals, nutrients, sediments, surface water

Introduction

Sustainable mining and agriculture is one of the greatest challenges in Tanzania and other developing countries. Sustainability implies that mining and agriculture not only increase country economy and secure a sustained food supply, but their environmental, socio-economic and human health impacts are recognized and accounted for within national development plans¹. FAO's 1990, defined sustainable development as the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and future generations². Such development conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable³. In recent decades there has been remarkable growth of mining sector in many part of Tanzania. Likewise agricultural systems in the country have also increased the use of agrochemicals for enhancement of productivity. These growths have raised public concern about the condition of fresh water in the country due to expansion of mining and agricultural activities in the vicinity of water resource catchments. One of the serious problems is the contamination of water resources by toxic chemicals like mercury, cyanide, pesticides, fertilizers, livestock chemicals and the byproducts that originate from mining and agriculture sites. These have resulted into conservative water pollution and reduction of river in such a way that pollution can no longer be remedied by dilution in many countries⁴. The principal environmental and public health dimensions of the global freshwater quality problems include ecosystem dysfunction and loss of

biodiversity, contamination of marine ecosystems from land-based activities, contamination of groundwater resources, global contamination by persistent organic pollutants and death of millions of people annually from water-borne diseases⁵.

Mining by its nature involves the removal, processing and disposal of vast volumes of rocks and wastes. A typical metal mine uses more water by weight in production of the metal concentrate than the weight of the ore grade material itself. Water contamination at a typical metal mine shows that the main source of metals is from tailings, polishing ponds, discharged mine effluents, leaching, seepage from tailings and waste rock impounded⁶. For large scale commercial mining operations, tools to predict and prevent environmental impact are available. However, mining operations involving a large number of small scale (informal, individual) activities are difficult to control. They usually involve rudimentary mining and processing methods, resulting in unreliable environmental controls. The contaminations of aquatic and terrestrial ecosystems with heavy metals and other mining chemicals have therefore been major environmental problems in many mining areas of the world. Such metals like mercury, cadmium, chromium, lead and zinc are responsible for kidney and brain damages, cancer and high blood pressure in human⁷.

Agriculture is also significant impacts freshwater, estuarine and coastal environments, leading to sedimentation, eutrophication and ecosystem damage. The impacts are due to the increased use of agrochemicals inputs in order to meet agriculture production demand¹. Pollution from fertilizers occurs when they are applied more heavily than crops can absorb or when they are

washed or blown off the soil surface before they can be incorporated. Excess nitrogen and phosphates can leach into groundwater or run off into waterways. The nutrient overload can cause eutrophication of lakes, reservoirs and ponds, leading to an explosion of algae which suppress other aquatic plants and animals⁸. Insecticides, herbicides and fungicides are also applied heavily in many developed and developing countries, polluting fresh water with carcinogens and other poisons that affect humans and many forms of wildlife.

Studies already conducted in Tanzania and other parts of the world have revealed significant level of agriculture and mining contaminants in water, sediments and biota, associated with decreased water quality and productivity, as well as increased exposure of human, wildlife and other organism to harmful chemicals^{9,10}. In some locations water pollution problems due to pesticide and trace metals have become increasingly evident, and have led to serious ecological and environmental problems^{9,10}. The investigation of trace metals and nutrients in water and sediments has thus proved to be an important approach in assessing their fate in aquatic environments and remediation strategies. The results presented in this study therefore form part of the worldwide effort to control the environment against anthropogenic pollution. The objective was to ascertain pollutant levels in the selected areas of Mara river basin. These baseline data are important in designing the management and conservation programmes in the Mara river basin.

Material and Methods

Study area: The Mara River Basin is a trans-boundary basin shared between Kenya and Tanzania. The Basin can be divided into four distinct physical and/or land-use sections, mainly on the basis of location along the river. The upper catchment comprises two sections: first, the forested Mau Escarpment and second, by large-scale agricultural farms. The River then runs through the third section, which is open savannah grassland protected by the Masai Mara Reserve on the Kenyan side and the Serengeti National Park on the Tanzanian side¹¹. The flood plains comprise the fourth section and are located in Tanzania where the Mara River discharges into Lake Victoria. The Mara River is 395 km long to its mouth at Lake Victoria, part of its 295 km being in Kenya. From its main source the river descend over 1000 metres in a distance of around 200 km before it reaches the Old Mara Bride at the start of the Masai Mara plains. The river then flows in a series of meanders a further 150 km to Lake Victoria. Within Tanzania the main tributaries are the rivers Semoche, Tighite and Tabora. The upper zone of the river supports small scale farmers, mid zone large scale farmers and lower zone supports the activities of pastoralists, tourism (wildlife and lodges), mining industry, fishing and finally feeding into the Lake Victoria. Environmental threats associated with human activities include loss of native forest cover in the catchment and along rivers, soil erosion due to cultivation in steep slopes, water pollution and abstractions by industries, mining and urban settlements¹¹.

Sample collection: Water and sediments samples were concurrently collected from 9 pre-selected sampling sites during the dry (September to October 2009) and rainy (March to May 2010) seasons. The sites are those which periodically monitored by the Musoma Water Quality Laboratory and the Lake Victoria Basin Water Office, an organizations responsible for managing the basin environment. The sampling sites are described in table 1 and indicated in the basin map in figure 1. The indication of sampling sites in the basin map was enabled by Global Position System (GPS) points that were measured during sampling.

Water and sediments samples were collected by grabbing and scooping techniques, respectively. Water samples were collected in 500 mL plastic bottles, while sediments were collected at a depth of 0 - 6 cm by using a stainless steel scoop and stored in polyethylene bags. Before water samples collection, the sampling bottles which were previously soaked overnight with 10% HCl and rinsed with distilled water, were rinsed with water samples. Both water and sediments samples were stored in cold boxes and transported to the School of Environmental Science and Technology, Ardhi University. Water samples were filtered and preserved with concentrated HNO₃ (heavy metals) and H₂SO₄ (nutrients), and analysed immediately upon arrival to the laboratory. Hand-held water quality portable monitor was used on site to measure temperature, pH, and EC. Three measurements were made for each parameter at each sampling location during sampling expeditions, and mean values were calculated. The instrument was calibrated at the beginning of every sampling day.

Chemical analysis: Heavy metals determination was carried out by Perkin Elmer Analyst 100 AAS with Perkin Elmer HGA 850 Graphite Furnace and Perkin Elmer AS 800 Auto-sampler made in Germany. For analytical quality assurance, after every five sample readings, standards were run to make sure that the margin of error is within 5%. In every analytical batch, 10% samples of all were analyzed repeatedly to ensure the precision and accuracy of analysis. Standard reagents and blanks were also used in the process of analysis to ensure the precision. A 10 cm long slot-burner head, a lamp and a standard air-acetylene flame were used. The detection limit was 0.01 ppm (0.01 mg/kg), slit width 0.70 nm and elements wavelength were 228.8, 357.9, 324.8, 283.3 and 213.9 nm for Cd, Cr, Cu, Pb and Zn, respectively. Water samples, previous filtered and preserved with HNO₃ were analysed directly into AAS, without any further treatment. The sediment samples were oven dried at 105°C for 24 h, followed by grinding and sieving using 0.18 mm sieve. 0.5 g of dry sediment sample was poured into a graduated test tube and mixed with 2 ml of aqua regia 1:3 (1 conc. HCl: 3 conc. HNO₃). The mixture was digested on a hot plate at 95°C for 1 h and allowed to cool to room temperature. The sample was then diluted to 10 ml using distilled water and left to settle overnight. The supernatant was filtered and analysed into AAS.

Nutrients concentrations were determined as described by APHA/AWWA/WEF¹². For phosphate determination, water samples previous filtered and preserved with H₂SO₄ were treated with phos ver[®]3 phosphate pillow in 25 ml of water sample, followed by vigorous shaking to obtain a uniform mixture which was allowed to settle for 5 min for reaction to take place. A DR-5000 spectrophotometer was set and run at a wavelength of 890 nm and blanks were used for calibration and quality check. The same procedure was done for nitrate determination, using nitra ver[®]5 nitrate reagent at a wavelength of 890 nm.

Results and Discussion

Physicochemical characteristics of the water: The results of the physicochemical parameters measured at 9 sites within Mara River Basin are presented in figure 2. The pH ranges in the dry and rainy seasons show that the river waters were near neutral to alkaline (7.21 - 10.18). The highest and lowest pH values for both seasons were recorded at S3 and S2, respectively. The pH values were lower during the rainy season than the dry season (pH_{rainy} < pH_{dry}). The pH ranges during rainy season was 7.21 – 9.68 and during the dry season was 7.75 – 10.18. The near neutral pH levels observed could be due to the dilution factor as water flows downstream. Mine drainage and spoil heap leachates usually show high acidic conditions, which are easily neutralized when they reach stream or rivers with enough flow

to produce dilution of pollutants¹³. Furthermore not all mine water are characterised by low pH, some may contain elevated concentrations of metals at near neutral or alkaline pH values. The decrease in pH during the rainy season can be attributed to increase in organic matter brought about by rains which result in decrease in dissolved oxygen through utilization of organic dehydration. Also can be caused by aquatic vegetation when they respire or breakdown of organic matter by microorganism in water producing high level of CO₂ that dissolve and equilibrate with the water forming carbonic acid (H₂CO₃)¹⁴. The pH values in some areas were higher than permissible values recommended by WHO for potable water (6.5 – 9.2) and FAO for irrigation water (6.5 – 8.4)^{15,16}. The upper limits in both seasons were above the range for natural river water 6.5-8.5¹⁷, and also beyond the WHO and FAO limits for potable and irrigation water^{15,16}. High pH levels can occur when algae and aquatic vegetation use CO₂ for photosynthesis, as well as when there is presence of alkaline earth metals the carbonate and bicarbonate formed from the solubilisation of CO₂ interact with alkaline earth metals thus increase the alkalinity shifting the pH up over 7. The pH state of surface water is also important for aquatic organisms because their metabolic activities are pH dependent. A pH value of higher or lower than 6 to 8 range for river water can decrease survival of aquatic organisms and can lead to loss of stream ecosystem diversity¹⁴.

Table-1
Description of the sampling sites

Site	Sampling site	Coordinates	Site characteristics
S1	Somoche	S 01 29 75.7 E033 48 48.3	Human settlements, farming activities (tomatoes, green vegetables and livestock), mining (slates) and domestic activities (washing and bathing). Feeds Mara River.
S2	Tabora	S01 36 54.7 E034 36 37.8	Human settlements, farming activities (Tobacco), domestic activities (washing and bathing). Feeds Mara River.
S3	Tarime/Serengeti bridge	S01 36 02.3 E034 35 31.1	At the border of Tarime and Serengeti districts. Small scale farming activities, human settlements and domestic activities.
S4	Mara Mine gauging station	S01 32 91.0 E034 33 24.6	Small scale farming activities, human settlements and domestic activities.
S5	Upper Tigithe	S01 25 13.0 E034 34 08.6	4 km from Nyamongo Mining surrounded by mining hips and human settlements. Small scale farming, gold mining activities and domestic activities.
S6	Nyamwage	S01 25 04.7 E034 33 39.1	3 km from North Mara gold Mining station and about 1 km from upper Tigithe river. Mining hips, human settlements, small scale farming and domestic activities.
S7	Lower Tigithe	S01 26 47.8 E034 31 55.6	2 km from Nyamongo Mining (North Mara Gold Mining) close to the mine waste discharge pipe. Small scale farming, gold mining activities and domestic activities.
S8	Tigithe downstream	S01 26 52.2 E034 31 42.9	1 km from North Mara Gold Mining and about 1km from the Mine waste discharge point to Tigithe River surrounded by mining hips and human settlements. Small scale farming, gold mining activities and domestic activities.
S9	Kirumi bridge	S01 31 30.8 E033 58 28.3	11.6 km from the Makutano junction on the Makutano – Sirali Road along the East coast of the Lake Victoria. Small scale fishing and farming activities (livestock and poultry) and domestic activities (washing and bathing).

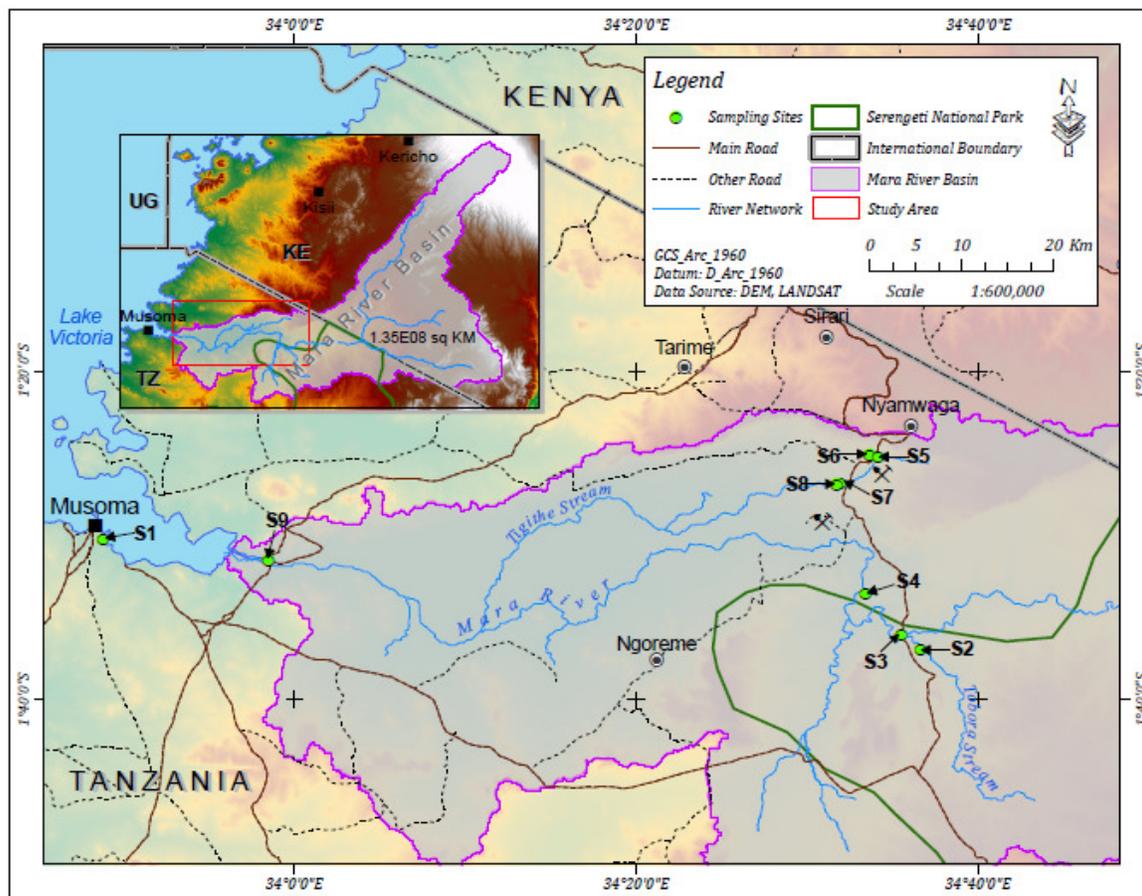


Figure-1
 Site descriptions and sampling points' allocation

Water temperatures reflected the climatic conditions of the MRB whereby for both seasons temperatures ranged from 21.0 to 30.5°C, and were lower during the rainy season ($T_{dry} > T_{rainy}$) for all 9 sites. The spatial variations of temperatures also reflected weather condition of the sites, the coolest part of the basin S4 which is at the highest elevation recorded lowest temperatures, while the highest temperatures were recorded at S3, which is a lower level where air temperatures are higher. The conductivity levels were within the maximum acceptable limits in drinking waters (200-600 $\mu\text{S}/\text{cm}$)¹⁵. The conductivity for a given water body is related to the concentrations of total dissolved solids and major ions. Results of the study indicate high conductivity during the rainy season for S1, S2, S3, S7 and S8. Reason for the trend may be due to increase in concentration of salts, organic and inorganic materials as a result of discharges by feeder streams, effluents from mining areas and runoff from agricultural, domestic and other human activities into the river during rainy season. The lower conductivity values during dry season for S4, S5, S6 and S9 may be due to the utilization of salts, organic and inorganic materials by phytoplankton and other organic organisms.

Heavy metals: Concentration ranges and means of heavy metals Pb, Cd, Fe, Zn, Hg, Cr, Cu measured in water and sediment samples from 9 sites of MRB are summarised in table 2 and table 3 as well as figure 3 and figure 4, respectively. The results from the tables show that the heavy metals varied over distinguishable range of concentrations. This spatial variability reflect the impact of varying settings, lithogenic characteristics and land use practices spread over different sub-catchments in the basin. Sources of these metals may therefore be attributed to the nature of the catchment areas, mining waste discharge, agrochemicals, geological weathering of parent rocks and atmospheric sources. For instance Cd, Cu and Zn are reported to be a component of pesticides and fertilizers which attach to organic materials that can be released through surface runoff during the rainy season. Air from mining activities is reported to be a source of Pb, which is attached into dust particles that eventually settled in surface water¹⁸. Hg has been reported to be part of the components of reagents used in mineral processing. Mining also result in loss of vegetation and topsoil which causes flooding, and the water emerging from the debris contains toxic solutes which include metals. Generally, mining water is complex in nature and of widely varying metallic composition.

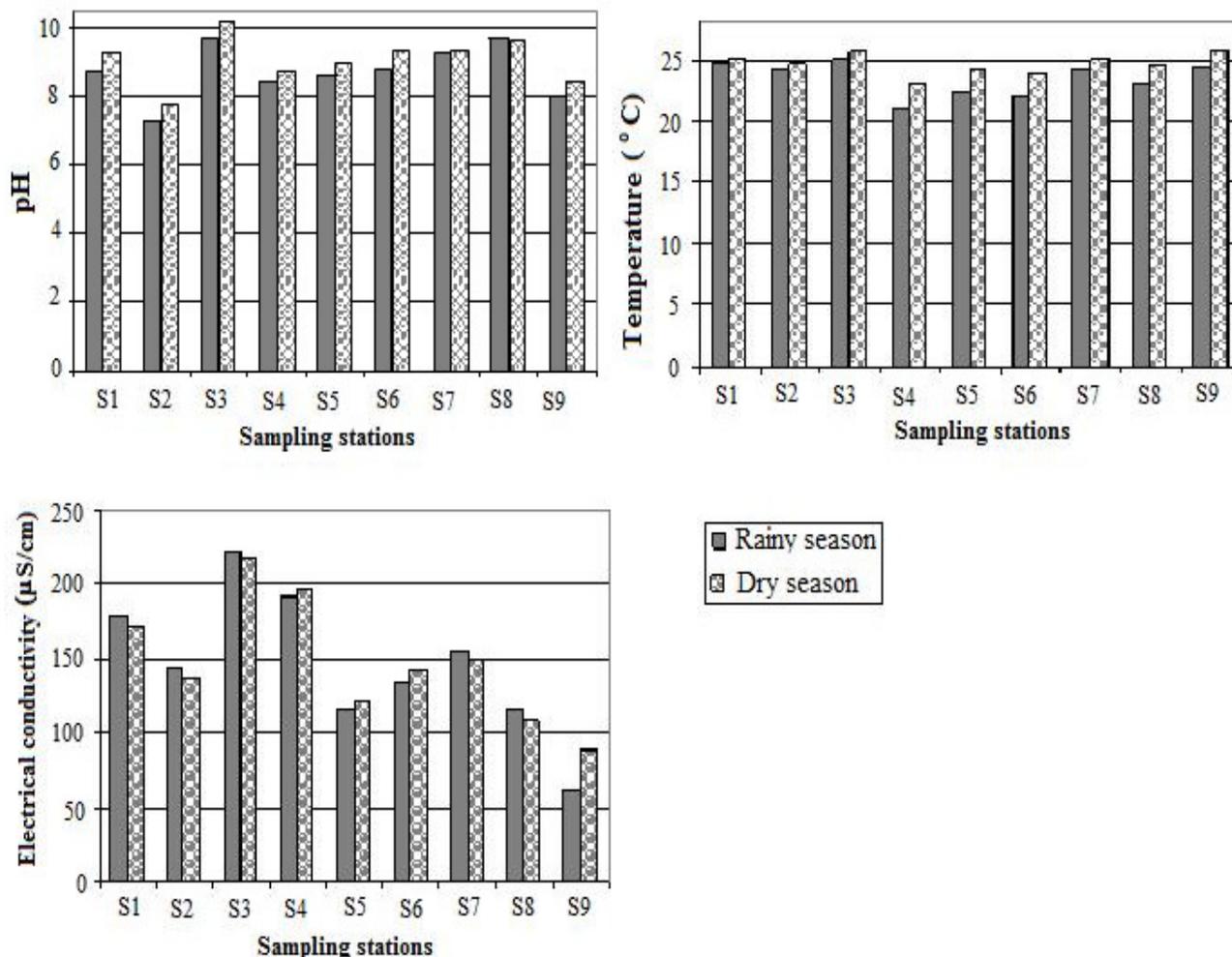


Figure-2
 Levels of the physicochemical parameters measured in water samples from some areas of MRB

Heavy metals distribution in water samples was dominated by Pb which was found in 100% of the samples analysed (table 2 and figure 3). The least found heavy metal in water samples was Cu which was found in less than 17% of the water samples studied. There were no significance differences and uniform patterns for the concentrations of heavy metals in water between dry and rainy season. With exception to Zn and Cu which had concentrations within the acceptable limits, concentrations in water for all other metals were higher than the maximum permissible limits for drinking water quality standards propagated by Tanzania Bureau of Standard TZS 789:2003¹⁹ and WHO¹⁵. High concentrations of heavy metals Fe, Hg, Pb, Cd and Cr compared to maximum limits for drinking water quality infer the possible hazard to human health. Recent data indicate that adverse health effects of cadmium may occur at lower exposure levels than previously anticipated, primarily in the form of kidney damage, bone effects and fractures, hypertension, carcinogenic, tetragenic, mutagenic, liver and

kidney dysfunction²⁰. The impacts to aquatic life may range from their immediate kills to impacts affecting growth, behavior or ability to reproduce. Pb is reported to be responsible for chronic neurological disorders in fetus and children. Hg is reported to be responsible for developmental disabilities¹⁸. The most serious publicised mercury pollution is contamination of fish by methyl Hg in Mina Mata Bay, Japan that caused birth to infants with severe developmental disabilities.

Figure 3 shows variation of heavy metals concentrations in river water at different sites for the dry and rainy seasons. The abundance in individual sites were generally in the order Pb>Cd>Fe>Zn>Hg>Cr>Cu. Copper was below instrumental detection limits in most of the sites. The average total heavy metal concentrations in water samples (\sum Fe + Cu + Hg + Pb + Zn + Cd + Cr) for the two seasons ranged from 14.14 – 16.12 mg/l.

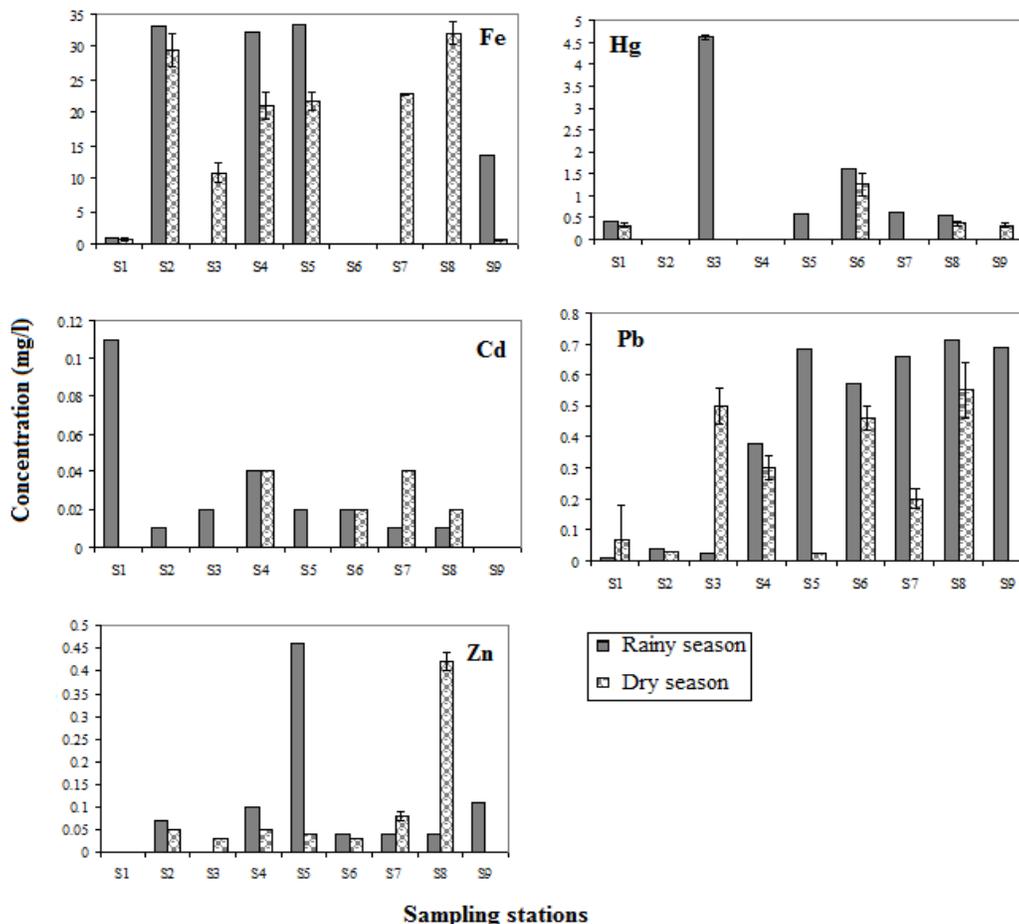


Figure-3
Concentrations (Mean ± SD) of the heavy metals in MRB water samples measured at the 9 sampling sites

Table-2
Concentrations (mg/l) of heavy metals in water samples

Heavy metal	Rainy season		Dry season	
	Concentration range	Mean ± SD (n=9)	Concentration range	Mean ± SD (n=9)
Fe	bdl – 33.49	12.60 ± 15.90	0.01 - 32.16	15.51 ± 12.75
Hg	bdl – 1.62	0.94 ± 1.47	bdl – 1.26	0.25 ± 0.41
Cd	bdl – 0.11	0.03 ± 0.03	bdl – 0.04	0.01 ± 0.02
Pb	0.01 – 0.71	0.42 ± 0.31	0.02 – 0.69	0.24 ± 0.22
Cu	bdl – 0.02	0.002 ± 0.006	bdl – 0.02	0.004 ± 0.009
Zn	bdl – 0.46	0.1 ± 0.14	bdl - 0.42	0.08 ± 0.13
Cr	bdl – 0.31	0.06 ± 0.11	bdl – 0.15	0.03 ± 0.05

Table 3 and figure 4 show heavy metals concentrations and spatial distribution in sediments at different sites. The contents of the heavy metals in sediments unlikely related to the corresponding contents in the aquatic phase. In general there were higher concentrations in sediments than in water samples. This has to be expected because metals are slow to degrade, in water are adsorbed onto suspended particles and eventually settle to the sediments which are particular ‘sinks’ where chemicals tend to concentrate. The heavy metals distribution on

sediment samples was dominated by Cd, Zn and Hg which were found in 100% of the samples analysed. The accumulation effects are greatly dependent on the sediment composition and structure. The accumulation in sediments may therefore be the source of water pollution in case of environmental condition change²¹. For instance low pH levels (< 7) can increase the availability of the metals ions in water as the metals would be released from substrate and complexes where they were attached²².

Table-3
Concentrations (mg/l) of heavy metals in river sediment samples

Heavy metal	Rainy season		Dry season	
	Concentration range	Mean \pm SD (n=9)	Concentration range	Mean \pm SD (n=9)
Fe	bdl – 532.05	204.52 \pm 250.35	bdl – 169.7	64.99 \pm 76.82
Hg	0.23 – 76.97	16.07 \pm 23.61	0.1 – 33.72	6.93 \pm 10.49
Cd	0.17 – 0.97	0.67 \pm 0.26	0.36 – 0.54	0.42 \pm 0.12
Pb	bdl – 61.46	18.78 \pm 19.93	bdl – 24.13	8.95 \pm 8.05
Cu	bdl – 2.48	0.81 \pm 0.83	bdl – 0.92	0.46 \pm 0.43
Zn	43.47 – 90.58	62.16 \pm 15.56	15.75 – 48.08	28.06 \pm 10.26
Cr	bdl – 22.53	13.98 \pm 7.41	bdl – 13.85	8.04 \pm 4.62

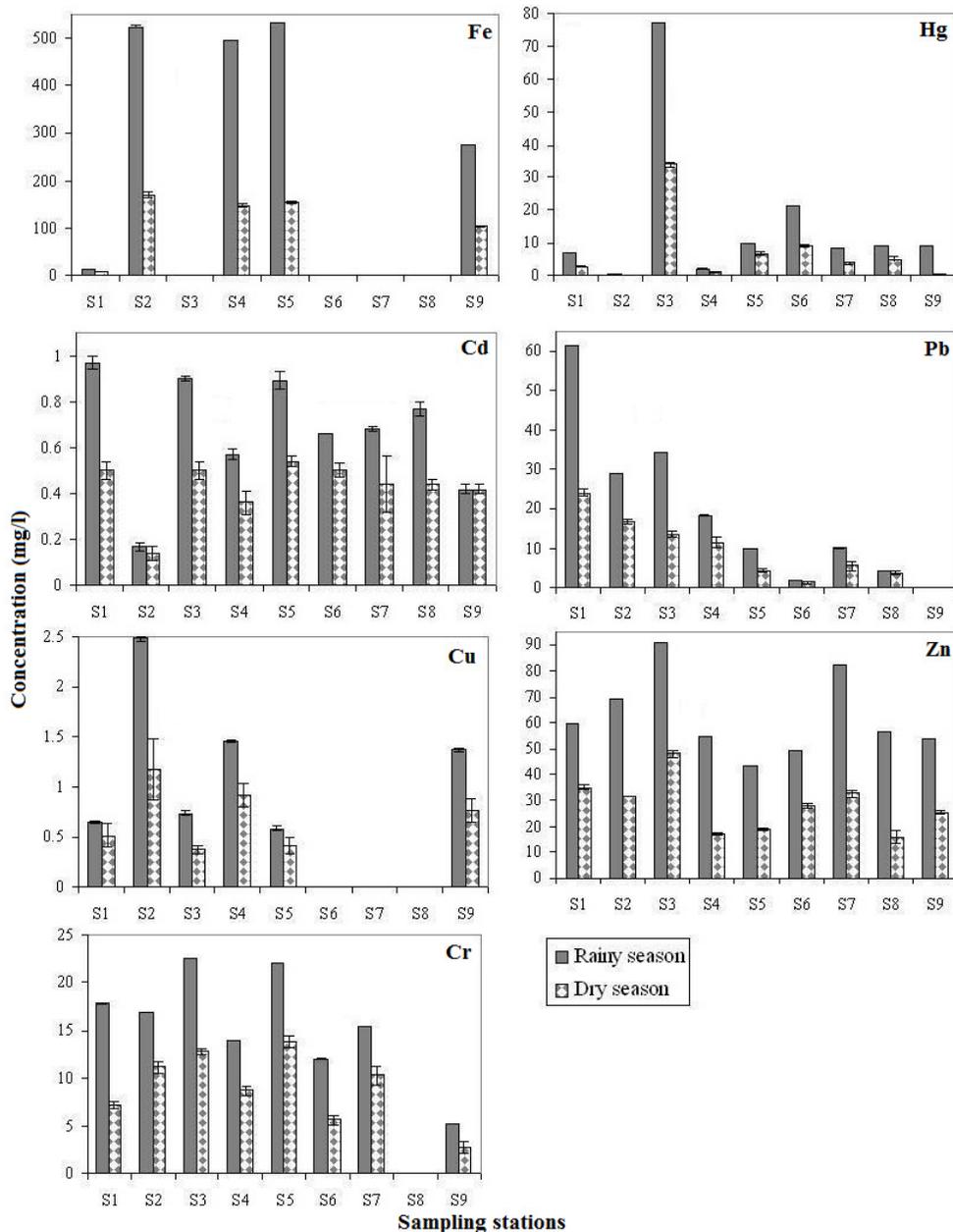


Figure-4
 Mean Fe, Hg, Cd, Pb, Cu, Zn and Cr concentrations of river sediments at different sites

Nutrients: Table 4 presents mean concentrations of nitrate-nitrogen (NO_3^- -N) and phosphorus (PO_4^{3-} -P) determined in river water samples at 9 sites of MRB during the rainy and dry seasons. The table shows that concentrations of NO_3^- -N were the highest than that of PO_4^{3-} -P in all the 9 sites, an indication that NO_3^- -N was the major components. This can be attributed by the nature of nitrate-nitrogen being the most oxidized chemical form of nitrogen found in the natural systems and in living organism²³. The highest concentration of NO_3^- -N was detected at S9 during the rainy season, while for PO_4^{3-} -P highest concentration was during dry season at S2. Nitrate is a form of nitrogen that is an essential plant nutrient, but in excess amounts they can cause significant water quality problems. Despite of natural source of nitrate like igneous rock, plant decay and animal debris, in most cases the nitrate pollutions in water are the results of human activities. The normal range of nitrate concentration in natural waters is normally below 5 mg/l, any value above this level is an indication of manmade nitrate pollution. The WHO potable water guidelines sets concentration limits of 50 mg/L for NO_3^- -N¹⁵. This limit has been exceeded at S1, S2, S3 and S9, indicating potential contamination of the river waters. Both sites are surrounded by agricultural activities (tomatoes, green vegetables and livestock), thus possible sources of NO_3^- -N contamination are agricultural runoffs containing fertilizers. Generally, the main contamination sources of surface waters by nitrate are potassium nitrate (KNO_3) and ammonium nitrate (NH_4NO_3), both salts commonly used as fertilizers²⁴. Apart from nitrate, nitrogen in terrestrial and aquatic ecosystems can also be found in the form of NO_2^- -N and NH_3 -N. Nitrates at higher concentrations in surface and groundwater used for human consumption are especially toxic to young children. Nitrates become more toxic when reduced to nitrite otherwise at reasonable concentrations, nitrates are rapidly excreted in the urine. Nitrite is reported to interact with haemoglobin forming methaemoglobin by oxidation of ferrous iron (Fe^{2+}) to ferric state (Fe^{3+}) preventing or reducing the ability of blood to transport oxygen, a condition described as methaemoglobinaemia, a reaction which is more hazardous to infants under 3 months of age²⁵.

Phosphorous is a limiting plant nutrient and rarely found in high concentrations in fresh waters. It is actively taken up by plants

and any excess amounts that are not used by a crop combine with the soil constituents and can be used by later crops. The concentrations of phosphorus (PO_4^{3-} -P) under this study ranged from 0.87 to 17.37 mg/L. These concentrations are significantly higher than those of natural background levels 0.005 to 0.05 mg/L²⁶, indicating possible enrichment from anthropogenic sources. Potential sources of the PO_4^{3-} -P in this area is excessively used inorganic fertilizers, farmland manure and animal waste, particularly because livestock grazing by allowing them into the water source is a common practice. High concentration of phosphorous in streams and surface waters can cause accelerated plant growth and algae blooms which can then cause rapid oxygen depletion or eutrophication in the water. The end product is water with low dissolved oxygen which cannot support aquatic life including certain fish, invertebrates, and other aquatic animals. Regarding health effects, phosphorous in water is not considered to be directly toxic to humans and animals²⁷. Any toxic effect caused by phosphorous in freshwater is indirect, such as toxic algal bloom. Because of this, no drinking water standards have been established for phosphorous²⁸.

Conclusion

The results of this study revealed that surface water and sediments in the studied area of Mara river basin are grossly contaminated with heavy metals and nutrients contaminants. The concentrations of contaminants in most of the sites were above the recommended international and national limits for drinking and irrigation waters. The discharge of mining and agricultural effluents appears to be the potential source of the heavy metals and nutrients pollution in surface water and sediments of MRB. The strong binding affinity of heavy metals to sediments results in low concentrations in water and high in sediments. Sediments of the studied rivers therefore represent a sink for heavy metals. As more land in the area is converted into mining and agricultural activities, heavy metals and nutrients monitoring is an imperative means in accessing, locating and mitigating man made sources of these chemical pollutants. Future studies should aim at determining the concentration of the heavy metals and nutrients in various aquatic organisms in order to ascertain the ecological risks.

Table-4
Mean concentration of nutrients in river water of Mara River Basin

Sample code	Metal concentration + SD (mg/l), n=3, CL = 95%			
	Rainy season		Dry season	
	NO_3^- -N	PO_4^{3-} -P	NO_3^- -N	PO_4^{3-} -P
S1	118.94 ± 0.42	14.35 ± 0.02	40.49 ± 4.60	11.37 ± 1.36
S2	81.1 ± 0.66	8.58 ± 0.04	25.58 ± 3.34	17.85 ± 1.11
S3	74.17 ± 0.02	6.96 ± 0.03	32.85 ± 3.42	12.87 ± 1.43
S4	11.03 ± 0.26	1.06 ± 0.02	17.71 ± 1.4	10.7 ± 1.8
S5	23.17 ± 0.21	2.58 ± 0.02	29.58 ± 5.28	8.98 ± 1.13
S6	19.50 ± 0.34	3.78 ± 0.02	23.45 ± 3.65	3.34 ± 0.65
S7	16.81 ± 0.32	3.81 ± 0.01	38.05 ± 2.17	0.87 ± 0.23
S8	37.91 ± 0.02	5.33 ± 0.03	19.97 ± 1.76	1.90 ± 0.36
S9	127.59 ± 0.01	16.95 ± 0.06	92.93 ± 3.07	12.28 ± 1.28

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