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RESEARCH ARTICLE

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Selected Heavy Metal (Zn, Pb and Cd) Pollution in Soil and Water from Marakwet East and Marakwet West, Elgeyo Marakwet County, Kenya

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Abstract

Heavy metal pollution has become a global public health issue, aggravated by human activities in the world leading to food and drinking water quality challenges. The present study aimed at assessing selected heavy metal (Zn, Pb and Cd) pollution in soil and water from Marakwet East and Marakwet West, Elgeyo Marakwet County, Kenya. The sampling sites namely the Chepkaitit, Moiben, Embobut, Arror, Mon, and Mosongu Rivers, were purposively selected. Water samples were collected from three sites of each River during rainy and dry season. Three composites consisting of three subsets of soils were also collected from the Marakwet East and Marakwet West during the rainy and dry seasons. The soil samples came from the same areas as the water samples. Collected samples were transported to the University of Eldoret laboratory where analysis was done using Atomic Absorption Spectrophotometry (AAS). Data was analysed using Analysis of Variance and Correlation analysis and results were presented using graphs, figures and distribution tables. In water samples, Zn concentrations were higher during wet season than dry season ($p>0.05$). Zn levels in water samples increased significantly from 0.212 ppm upstream to 0.225 ppm midstream. There was significant increase in Cd levels from 0.066 ppm upstream to 0.068 ppm midstream. Soil samples collected during wet season from R. Chepkaitit recorded Cd levels of 0.071, 0.078 and 0.053 ppm at upstream, midstream and downstream respectively. Similarly, Pb levels increased from 0.470 ppm to 0.720 ppm to 0.791 ppm in water samples collected from upstream, midstream and downstream of R. Mon respectively. The concentration of pb and Cd in some water and soil samples exceeded the WHO standards. The study recommends that the health personnel from the ministry of Agriculture and health from Elgeyo Marakwet County should train and screen the local residents on the sources and health effects of heavy metals poisoning.

Keywords: Water Downstream, Upstream, Heavy Metal, Soil, River

Introduction

There is growing public concern worldwide, particularly in developing countries, over the possible accumulation of heavy metals in soil, water, and plants as a result of rapid industrial expansion (Ali et al., 2019). Increased anthropogenic activities in Kenya over the past few years have led to massive pollution of the environment (Plessl et al., 2017; Akenga et al., 2019). These activities involve use of chemicals, metals, machines, fertilizers, pesticides, fuels such as petroleum and many others (Hertwich, 2010). Heavy metals can be released into the environment as a by-product, including soils and surface waters as well as ground water where they persist for a long time (Mahurpawar, 2015).

Buzea & Pacheco (2020), Adal & Tarabar (2013), Morais et al. (2012) defined heavy metals based on their high atomic weights and relative toxicity. It is also classified as having a density of over 5 g/cm^3 (Konuk et al., 2010; Issazadeh et al., 2012). The term "heavy metal" refers to a group of elements that includes metalloids, transition metals, actinides, and lanthanides (Khan & Parvez, 2015). This include metals such as lead, cadmium, copper, zinc, chromium and mercury which are major environmental pollutants (Asati et al., 2016; Gill, 2014; Ogunkunle et al., 2014). While most heavy metals are found in rocks, development has augmented human caused heavy metal contributions to the biosphere. Heavy metals are found in trace amounts in the atmosphere as particulates or vapors (Bohra et al., 2015).

The use of agricultural inputs, waste, industrial emission, and spilled petroleum products have led to increase of heavy metals in the soil (Sankhla et al., 2016; Subhashini & Swamy, 2013; Maurya et al., 2018). Exacerbated agricultural practices in Kenya over the last few years have led to an increased and continuous use of fertilizers, pesticides, manure, and machinery to increase crop yields for economic development and to achieve Vision 2030 goals (Akenga et al., 2020). Fertilizers are applied in large quantities to soils in intensive farming systems on a regular basis to ensure adequate potassium, phosphate, and nitrate levels for plant growth (Tein et al., 2014). Herbicides, pesticides, and inorganic fertilizers may contain varying levels of heavy metals; when used in maize farming for the purpose of providing nutrients to plants and controlling weeds, pests, and diseases. These products may result in heavy metal deposition to the soil environment (Akenga et al., 2016). Heavy metals can enter human and animal food chains through plant absorption (Kumar, et al., 2019). Surface waters contain colloidal, particulate, and dissolved heavy metals. The oxidation state of minerals and the redox environment of the system control trace metal solubility in surface waters (Tribovillard et al., 2006).

Heavy metals such as Hg, Pb, As, and Cd have been linked with cognitive disorders, neurological system disorder, kidneys damage, reproductive abnormalities, skin lesions, endocrine damage, and vascular diseases and various types of cancers (Oyugi et al., 2021; Jain & Gauba, 2017; Balali-Mood et al., 2021). Contamination with heavy metals is connected with deficiency of some important nutrients in the human body (Khan et al., 2015). This can eventually result in weakened immune defences, malnutrition-related problems, intrauterine development retardation, poor psychological abilities, and a high prevalence of upper gastrointestinal cancer (Khan et al., 2015; Oves et al., 2016).

Numerous scholars have documented high levels of heavy metals in Kenya, particularly as a result of agricultural pollution and from natural sources (Ndungu et al., 2019; Tomno et al., 2020; Muiruri et al., 2013; Githaiga et al., 2021; Kemboi et al., 2018). There is a paucity of data on the levels of heavy metals in some of the rivers in Elgeyo Marakwet County that inhabitants use. Therefore, the present study aimed at assessing the levels of selected heavy metals (Zn, Pb and Cd) pollution in soil and water from Marakwet East and Marakwet West, Elgeyo Marakwet County, Kenya.The data is useful in informing the county government of Elgeyo Marakwet about the status of heavy metal hence enabling them to come up with mitigation measures to ensure reduced effects of heavy metal toxicity in soil and water. The study results would also be used to inform the communities living around the study area about the potential risk they face on consumption of water containing high heavy metal levels. The local population would also be advised on how to reduce heavy metal uptake through monitoring their levels.

METHODOLOGY

Description of the Study Area

The study area covered the Marakwet East and Marakwet West Sub counties with a latitude of 1° 6'27.25"N and longitude of 35°34'1.81"E (Figure 1) which are found in the Rift valley region. Elgeyo Marakwet County is divided into four administrative sub-counties: Marakwet East, Marakwet West, Keiyo South, and Keiyo North (Misoi et al., 2019). The rainfall is approximately 30% reliable, ranging from 400 to 1000 mm annually with a significant degree of unpredictability, with an average of 600mm per year. The annual average temperature ranges between 14 and 24 degrees Celsius (Murkomen, 2019). The Kerio River runs through the county and the topography rises from the alluvial plain towards the west. The Elgeyo escarpment is notable for its 1500m relief differential. The County's geography is mountainous in the north and south, giving way to more gentle relief changes in the west and the underlying geology is mostly basement gneiss. The county's total population is 454,480 (Kenya National Bureau of Statistics, 2019). Grazing, pastoralism, agricultural and dairy farming are the principal human economic activities in the study areas. Its principal crops are maize, beans, cabbage, kales, and mangoes (*Mangifera indica*).

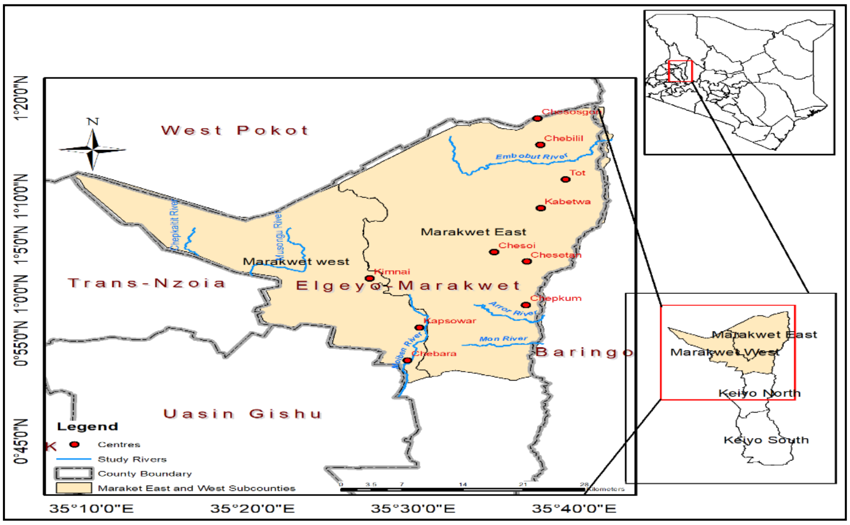

Figure 1: Map of Elgeyo Marakwet County showing the Sampling Points.

Collection, Preparation and Analysis of Water Samples

In Marakwet East water samples were purposively collected from Embobut, Arror and Mon Rivers. The three rivers were opted for because they are permanent rivers and therefore capable of serving the residents all year round. A geospatial location of the three rivers was taken during sampling. Water samples were taken from the three sites of the three rivers (source, middle and end) during rainy (March and April) and dry season of the year (December). A total of 18 samples of water was therefore collected during the period of study. The same water sampling procedures was followed while collecting water from Marakwet West from the Chepkaitit, Moiben and Mosongu Rivers.

At the University of Eldoret laboratory, water samples were filtered using man No.40 and 50 mL were digested in a 15 mL tri acid combination (5:1:2) at 150°C for 20 minutes. A 250 mL volumetric flask was filled to the mark with de-ionized water after cooling the samples (Tomno et al., 2020). Heavy metals were determined using an Atomic Absorption Spectrophotometer (Thermoelectric S-Series).

Collection, Preparation and Analysis of Soil Samples

Three composites consisting of three subsets of soils were collected from the Marakwet East and Marakwet West during the rainy and dry seasons after every 4 km from 0-15 cm and 15 – 30 cm, respectively. The soil samples came from the same areas as the water samples. Soil samples were collected from three grid locations and mixed properly in a plastic bucket and transported to University of Eldoret Laboratory for preparation and analysis. The samples were then air-dried, crushed, and passed through a 2-mm-mesh screen before being stored at room temperature for laboratory examination. The EDTA method was used to extract potentially accessible heavy metals; the digestion (aqua regia) method was used to extract total heavy metals; and the concentrations were determined using an atomic absorption spectrophotometer (Kipruto & Mweu, 2019).

Statistical Analysis

Minitab Statistical Software, version 19, was used to analyse the data. The significance of the difference in heavy metal concentrations in soil and water across sampling locations was determined using one-way analysis of variance (ANOVA). Pearson correlation analysis was also performed on heavy metals in water and soil. The amounts of heavy metals in the samples were compared to the World Health Organization's (WHO) established limits.

RESULTS

Concentration of Zn in Water and Soil Samples from Selected Rivers in Marakwet East during Dry and wet Seasons

River Mon water samples recorded the highest concentration of Zn during the wet season downstream while River Embobut and River Arror recorded the lowest concentration of Zn during the same season. During the dry season River Embobut recorded the highest level of Zn concentration in downstream while River Arror recorded low levels of Zn Concentration midstream as presented in Table 1.

The soil samples in River Mon recorded the highest concentration of Zn upstream while the same time recorded the lowest concentration during the dry season. In the wet season, River Mon recorded the highest concentration of Zn among the three rivers upstream and River Embobut recorded the lowest concentration of Zn during the same season as indicated in Table 1.

Table 1: Concentration of Zn in water and soil samples from selected rivers in Marakwet East during dry and wet seasons

		Water		Soil	
	Section	**Wet**	**Dry**	**Wet**	**Dry**
R. Embobut	upstream	0.207±0.004a*	0.072±0.001b	0.358±0.005a*	0.583±0.015c
	midstream	0.225±0.007b*	0.076±0.001c	0.428±0.011b*	0.618±0.008e
	downstream	0.245±0.007c*	0.083±0.002c	0.537±0.008d*	0.659±0.007f
R. Arror	upstream	0.207±0.003a*	0.080±0.002c	0.566±0.007e*	0.608±0.002d
	midstream	0.226±0.007b*	0.068±0.001a	0.475±0.006c*	0.710±0.021g
	downstream	0.205±0.019a*	0.082±0.001c	0.705±0.004h*	0.457±0.001b
R. Mon	upstream	0.257±0.007d*	0.070±0.01b	0.763±0.003i*	0.840±0.025h
	midstream	0.267±0.002e*	0.078±0.009bc	0.672±0.001g*	0.828±0.019h
	downstream	0.432±0.001f*	0.067±0.001a	0.654±0.003f*	0.436±0.002a

*Means followed by different letters within a column are significantly different at p<0.05, * denote significance between dry and wet season*

Concentration of Zn in Water and Soil Samples from Selected Rivers in Marakwet West during Dry and Wet Seasons

Concentrations of Zn in river water (Chepkaitit, Moiben and Mosongu) within Marakwet west during dry seasons was determined and River Moiben recorded the highest values downstream while River Chepkaitit recorded the lowest concentration. River Mosongu recorded the highest values downstream during the wet season while River Chepkaitit and Moiben recorded the lowest values as presented in Table 2.

The soil samples in River Mosongu recorded the highest concentration of Zn downstream during the dry season while River Chepkaitit recorded the lowest values of Zn upstream. In the wet season, River Chepkaitit recorded the highest concentration of Zn among the three rivers upstream and River Mosongu recorded the lowest concentration of Zn during the same season as indicated in Table 2.

Table 2: Concentration of Zn in water and soil samples from selected rivers in Marakwet West during dry and wet seasons

		Water		**Soil**	
	Section	**Wet**	**Dry**	**Wet**	**Dry**
R. Chepkaitit	Upstream	0.204±0.005a*	0.062±0.011cd	0.757±0.003d*	0.474±0.016a
	Midstream	0.227±0.014ab*	0.055±0.002c	0.662±0.003c*	0.682±0.004e
	Downstream	0.299±0.006c*	0.145±0.025	0.844±0.002g*	0.503±0.002a
R. Moiben	Upstream	0.218±0.024a*	0.064±0.004d	0.543±0.242a*	0.504±0.031a
	Midstream	0.204±0.013a*	0.091±0.003f	0.778±0.001f*	0.607±0.017b
	Downstream	0.208±0.011a*	0.098±0.001g	0.882±0.006h*	0.628±0.006c
R. Mosongu	Upstream	0.212±0.001a*	0.043±0.001a	0.440±0.014a*	0.634±0.029c
	Midstream	0.225±0.006b*	0.049±0.001b	0.456±0.011a*	0.651±0.002d
	Downstream	0.345±0.007d*	0.079±0.011e	0.776±0.001e*	0.822±0.000f

*Means followed by different letters within a column are significantly different at $p<0.05$, * denote significance between dry and wet season*

Concentration of Cd (ppm) in Water and Soil Samples from Selected Rivers in Marakwet East during Dry and Wet Seasons

During the dry season, Cd levels in River water was recorded highest in River Embobut upstream, while River Arror recorded the lowest levels in midstream. During the wet season River Arror recorded the highest level of Cd concentration in upstream while River Mon recorded low levels of Cd concentration midstream as presented in Table 3.

The soil samples in River Mon recorded the highest concentration of Cd midstream during the dry season while River Embobut recorded the lowest concentration of Cd upstream during the same season. In the wet season, River Embobut recorded the highest concentration of Cd among the three rivers downstream and River Arror recorded the lowest concentration of Cd upstream during the same season as shown in Table 3.

Table 3: Concentration of Cd (ppm) in water and soil samples from selected rivers in Marakwet East during dry and wet seasons

		Water		Soil	
	Section	**Wet**	**Dry**	**Wet**	**Dry**
R. Embobut	Upstream	0.100±0.014b*	0.146±0.176e	0.439±0.006a*	0.088±0.001a
	Midstream	0.105±0.021b*	0.031±0.001c	0.475±0.001b*	0.092±0.001b
	Downstream	0.105±0.007b*	0.033±0.001c	0.518±0.006c*	0.106±0.009d
R. Arror	Upstream	0.132±0.019d*	0.025±0.002b	0.046±0.002b*	0.093±0.001b
	Midstream	0.118±0.004c*	0.019±0.003a	0.055±0.001c*	0.095±0.001c
	Downstream	0.116±0.011c*	0.035±0.001c	0.071±0.001d*	0.109±0.001e
R. Mon	Upstream	0.099±0.007b*	0.028±0.001b	0.076±0.001e*	0.091±0.001b
	Midstream	0.060±0.005a*	0.034±0.001c	0.047±0.015ab*	0.112±0.001f
	Downstream	0.082±0.017b*	0.044±0.001d	0.088±0.007f*	0.096±0.001c

*Means followed by different letters within a column are significantly different at p<0.05, * denote significance between dry and wet season*

Concentration of Cd (ppm) in Water and Soil Samples from Selected Rivers in Marakwet West during Dry and Wet Seasons

The water samples in River Mosongu recorded the highest concentration of Cd downstream during the dry season while River Moiben recorded the lowest values of Cd upstream. In the wet season, River Chepkaitit recorded the highest concentration of Cd among the three rivers downstream and River Mosongu recorded the lowest concentration of Cd upstream during the same season as presented in Table 4.

The Soil samples in River Mosongu recorded the highest concentration of Cd downstream during the dry season and the lowest values of Cd upstream in the same season. In the wet season, River Moiben recorded the highest concentration of Cd among the three rivers upstream and River Chepkaitit recorded the lowest concentration of Cd upstream during the same season as presented in Table 4.

Table 4: Concentration of Cd (ppm) in water and soil samples from selected rivers in Marakwet West during dry and wet seasons

		Water		Soil	
R. Chepkaitit	**Section**	**Wet**	**Dry**	**Wet**	**Dry**
	upstream	0.102±0.001e*	0.033±0.001c	0.071±0.008c*	0.099±0.002a
	midstream	0.093±0.004d	0.032±0.001c	0.078±0.011c*	0.102±0.000b
	downstream	0.108±0.001f*	0.024±0.001a	0.053±0.004a*	0.098±0.002a
R. Moiben	upstream	0.098±0.006d*	0.022±0.001a	0.088±0.006d*	0.103±0.001b
	midstream	0.082±0.001c*	0.029±0.001b	0.091±0.001d*	0.099±0.001a
	downstream	0.095±0.004d*	0.032±0.001	0.100±0.002*	0.095±0.007a
R. Mosongu	upstream	0.066±0.001a*	0.034±0.001c	0.066±0.001b	0.069±0.041a
	midstream	0.068±0.002b*	0.034±0.001c	0.057±0.006a*	0.104±0.001b
	downstream	0.081±0.006c*	0.039±0.001d	0.054±0.001a*	0.108±0.001c

*Means followed by different letters within a column are significantly different at p<0.05, * denote significance between dry and wet season*

Concentration of Pb (ppm) in Water and Soil Samples from Selected Rivers in Marakwet East during Dry and Wet Seasons

During the dry season in water samples, highest and the lowest concentrations of Pb was recorded in River Arror upstream and midstream respectively. During the wet season River Mon recorded the highest level of Pb concentration in downstream while River Arror recorded low levels of Pb concentration midstream as presented in Table 5.

The soil samples in River Mon recorded the highest concentration of Pb midstream during the dry season while River Embobut recorded the lowest concentration of Pb upstream during the same season. In the wet season, River Mon recorded the highest concentration of Pb among the three rivers downstream and River Embobut recorded the lowest concentration of Pb upstream during the same season as indicated in Table 5.

Table 5: Concentration of Pb (ppm) in water and soil samples from selected rivers in Marakwet East during dry and wet seasons

		Water		**Soil**	
	Section	**Wet**	**Dry**	**Wet**	**Dry**
River Embobut	Upstream	0.210±0.028a*	0.465±0.021b	0.648±0.004a*	1.031±0.443a
	Midstream	0.421±0.014d*	0.521±0.014c	0.716±0.007b*	1.501±0.453f
	Downstream	0.461±0.014*	0.565±0.007c	0.739±0.008c*	1.560±0.014f
R.Arror	Upstream	0.191±0.042a*	0.581±0.056d	0.715±0.021b*	1.455±0.021e
	Midstream	0.205±0.063b*	0.395±0.021a	0.805±0.063d*	1.420±0.014d
	Downstream	0.355±0.021c*	0.685±0.007e	0.900±0.014e*	1.685±0.078g
R. Mon	Upstream	0.470±0.028d*	0.580±0.042d	1.041±0.084f*	1.235±0.007b
	Midstream	0.720±0.084e*	0.042±0.014a	1.141±0.014g*	1.721±0.042g
	Downstream	0.791±0.057f*	0.555±0.063c	1.190±0.014h*	1.400±0.028c

*Means followed by different letters within a column are significantly different at $p<0.05$, * denote significance between dry and wet season*

Concentration of Pb (ppm) in Water and Soil Samples from Selected Rivers in Marakwet West during Dry and Wet Seasons

The water samples in River Moiben recorded the highest (midstream) and the lowest (upstream) concentration of Pb during the dry season. In the wet season, River Moiben recorded the highest concentration of Pb among the three rivers downstream and River Mosongu recorded the lowest concentration of Pb upstream during the same season as presented in Table 6.

The Soil samples in River Mosongu recorded the highest concentration of Pb downstream during the dry season and the lowest values of Pb River Chepkaitit downstream in the same season. In the wet season, River Moiben recorded the highest (downstream) and the lowest (midstream) concentration of Pb among the three rivers upstream during the same season as presented in Table 6.

Table 6: Concentration of Pb (ppm) in water and soil samples from selected rivers in Marakwet West during dry and wet seasons

		Water		**Soil**	
	Section	**Wet**	**Dry**	**Wet**	**Dry**
R.Chepkaitit	upstream	0.510±0.113c	0.531±0.014c	1.015±0.035b	1.461±0.042
	midstream	0.580±0.028c	0.481±0.028b	1.065±0.007b	1.471±0.000
	downstream	0.170±0.001a	0.565±0.035d	0.910±0.056a	1.385±0.063
R. Moiben	upstream	0.470±0.028b	0.415±0.021a	1.015±0.063b	1.460±0.014
	midstream	0.175±0.035a	0.635±0.035e	0.875±0.007a	1.451±0.014
	downstream	0.945±0.007f	0.605±0.021e	1.595±0.021d	1.435±0.007
R. Mosongu	upstream	0.761±0.014e	0.605±0.007e	1.225±0.007c	1.441±0.014
	midstream	0.715±0.049e	0.470±0.014b	1.215±0.007c	1.450±0.028
	downstream	0.651±0.014d	0.540±0.042c	1.075±0.021b	1.515±0.049

*Means followed by different letters within a column are significantly different at p<0.05, * denote significance between dry and wet season*

DISCUSSION

Results indicated that Zn concentrations in water were higher during season than dry season. In addition, Zn levels increased significantly from upstream to downstream in all the three rivers this could be attributed to geographical differencee, the parent rock and different agricultural activities practices in the region. Furthermore, significant higher Zn levels were recorded in soil samples. Water samples from River Embobut, River Arror, River Moiben and River Mosongu recorded the highest level of Zn during the dry and wet season. The soil samples in River Mon, River Mosongu and River Chepkaitit recorded the highest concentration of Zn during dry and wet season. The mean concentration of Zn from the six rivers that is River Mon, Embobut, Arror Chepkaitit, Moiben and Mosongu were all below the WHO maximum permissible limits for water and soil. This study was similar studies done by Jepkoech (2013) who recorded Zn concentration of 0.70 ± 0.22 ppm in water samples from Sosiani River, Uasin Gishu County, Kenya. Akenga et al., (2020) recorded 0.071-0.054 ppm of Zn from water collected along River Moiben, Uasin-Gishu County, Kenya.

River Embobut, Mosongu, River Chepkaitit and River Arror recorded the highest level of Cd concentration in water during the dry and wet season respectively. The soil samples in River Mon, River Embobut, Mosongu and River Moiben recorded the highest concentration of Cd during the dry and wet season. The mean concentration of Cd from the six rivers that is River Mon, Embobut, Arror Chepkaitit, Moiben and Mosongu were all above the WHO maximum permissible limits for water and soil. Elevated Cd level in water could be attributed to differences in Cd levels in parent rocks and agricultural practices in the region. The high levels in the area may be due to heavy phosphate fertilizer use in potato and tomatoe fields. Natural contaminants in phosphate fertilizers include Cd (Sodhi, 2009). Ethiopian farms had Cd levels ranging from 0.73 to 1.23 g/g (Atlabachew et al., 2011), showing farmers use similar soil management strategies. The detected soil cadmium levels are well below the 3 g/g acceptable limit for agricultural land (FAO/WHO, 2001).

Results from River Arror, River Mon River Moiben recorded the highest level of Pb concentration in water samples during the dry and wet season. The soil samples from River Mon, Mosongu, River Moiben and River Mon recorded the highest concentration of Pb during the dry and wet season. The mean concentration of Pb from the six rivers that is River Mon, Embobut, Arror Chepkaitit, Moiben and Mosongu were above the WHO maximum permissible limits for water and soil except for some few samples. The increase in Pb levels in agricultural soil is due to the use of artificial fertilizers and pesticides (Onder et al., 2007). The low amounts of lead in upper samples may be attributed to the soil type and physical qualities, as lead mobility is greater in sandy soils with less organic matter than in organic soils (Kirmani et al., 2011). They were under the allowed limits, 50 g/g for agricultural land (FAO/WHO, 2001), and well below the Pb levels in uncontaminated soil (10 to 70 g/g 54).

CONCLUSION

This study showed that water and soils samples from Marakwet East and Marakwet West, Elgeyo Marakwet County, Kenya are contaminated with heavy metals. The mean concentration of Zn from the six rivers that is River Mon, Embobut, Arror Chepkaitit, Moiben and Mosongu were all below the WHO maximum permissible limits for water and soil. Also, the mean concentration of Cd from the six rivers that is River Mon, Embobut, Arror Chepkaitit, Moiben and Mosongu were all above the WHO maximum permissible limits for water and soil. Further, the mean concentration of Pb from the six rivers that is River Mon, Embobut, Arror Chepkaitit, Moiben and Mosongu were above the WHO maximum permissible limits for water and soil except for some few samples.

RECOMMENDATIONS

Based on the findings, the study made the following recommendations.

1. The levels of lead and Cd in the water should be constantly monitored. Lead levels in both surface and ground water were beyond WHO guidelines.
2. The study recommends that the health personnel from the ministry of Agriculture and health from Elgeyo Marakwet County should train the local residents on the sources and health effects of heavy metals poisoning.
3. The Government through the Ministry of Health should periodically conduct health screening on the residents to check for some symptoms of heavy metals poisoning.

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