Chuka University
info@chuka.ac.ke | 020 231 0512 / 020 231 0518

ASSESSMENT OF HEAVY METALS CONTAMINANTS IN NKENYE STREAM IN MERU SOUTH, KENYA

Samson Chabari Kithaka[1], Eric C. Njagi[2] and Joachim Njagi[3]
[1]Department of Environmental Studies and Resources Development, [2]Department of Physical Sciences, [3]Faculty of Science, Engineering and Technology, Chuka University, P. O. Box 109-60400, Chuka, Kenya
Email: chabarisam@gmail.com or schabari@chuka.ac.ke
, echomba@chuka.ac.ke, joachim.njagi70@gmail.com or jnjagi@chuka.ac.ke

How to cite:

Kithaka, S. C., Njagi, E. C. and Njagi, J. (2022). Assessment of heavy metals contaminants in Nkenye stream in Meru South, - Kenya. *In: Isutsa, D. K. (Ed.). Proceedings of the 8th International Research Conference held in Chuka University from 7th to 8th October, 2021, Chuka, Kenya, p. 87-100*

ABSTRACT

Access to portable water remains major global concern due to increased rate of water pollution contributed for by human pressure such as accelerated urbanization, high population, industrialization and intense agricultural activities that destroys riparian zones thus exposing the rivers and streams to toxic and pathogenic pollutants released from untreated organic and inorganic waste. Exposure of river and stream used for drinking water to pollution is detrimental to aquatic plants, human consumers and animals inhabiting water bodies. Nkenye stream in Meru South is depended upon for the use of its water in supplying fish ponds constructed along it, supplying water used for irrigation and provision of water for domestic use to the neighboring homestead. Nonetheless, little attention has been accorded to ascertain the quality of its water despite of the stream being located in an urban area with high exposure to pollutants. Pressure on Nkenye wetlands ecosystem that habour Nkenye stream has seen major destruction of riparian leaving just few plant communities such as *Commelina banghalensis* whose water purification potential is not well known. Based on the above fact a study was conducted to determine water quality of Nkenye stream based on the presence of heavy metals. Samples were collected at designated locations using ecological survey method and taken to Chuka University for evaluation. Macrophyte roots were cleaned and dried then powdered and digested using nitric acid. The sediment samples were dried, ground to pas a 2 mm non-metal sieve, digested samples were diluted and analyzed using atomic absorption spectrometry model PG990 at Chuka University. The concentration of anions was determined by ion chromatography at Chuka University Chemistry laboratory. The results obtained from the field and laboratory were analyzed by General linear model (GLM) on Statistical analysis system (SAS) version 9.4 and significance means separated by Least significance difference (LSD) [alpha = 0.05]. The results showed that Nkenye stream is polluted with iron, copper and lead. However, the concentration of iron and copper were within the set standards by the World Health Organization while lead was slightly higher by 0.02 ppm. The results obtained were analyzed by General linear model (GLM) on Statistical analysis system (SAS) version 9.4 and significance means separated by Least significance difference (LSD) [alpha = 0.05]. The metals contaminants observed in the Nkenye stream water, sediments and root samples may be associated with discharge of wastes from Chuka town particularly wastes from car wash, garages and from farms that surround the stream and the wetland. Considerable amount of lead, copper and iron was observed in the root samples of *Commelina banghalensis.* This shows that the plant can be utilized in the removal of the above cations in the Nkenye stream. Considerable amount of chemical was observed in the root samples of *Commelina banghalensis* this shows that the plant can be utilized in removal of chemicals in the stream. Local authorities should provide waste management disposal systems and policies that prohibit direct discharge of untreated effluents into the stream.

Keywords: Water quality, Heavy metals, Nkenye Stream, Meru South, Kenya

INTRODUCTION

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life, occurring where the water table is at or near the surface of the land, or where the land is covered by shallow water (Yilma and Kim, 2003). Features like Rivers, lakes, marshes, rice fields, and coastal areas are examples of wetland ecosystems and are generally among the most fertile and productive ecosystems of the world. Wetlands can be classified as artificial (constructed wetlands) and naturally occurring in any regions of world

(Yilma and Kim, 2003; Odum, 2016). These wetlands support highly diverse biological communities and provide extensive ecosystem services like heavy metal stabilization and phytoextraction (Bouchard *et al.*, 2007; Bassi *et al*., 2014). Wetlands are the key in ecosystem processes such as, water purification due to its richness and in plant cover (Vymazal and Březinová, 2015; Odum, 2016).

Functions played by macrophytes communities in wetlands ecosystems are complex and interconnected, they include carbon and nutrient cyclization, sediment and riparian sectors stabilization, as well as provision of food and habitats for a variety of animal species (Engelhardt and Ritchie 2001; Dee and Ahn, 2014; O'Hare *et al*., 2017). They are important natural harvesters of rainwater, acting as sinks into which surface water and groundwater flows from the surrounding catchment (Kinzig *et al*., 2006; Odum, 2016). This is because their effect on stream water quality should be monitored. The wetlands are also important in addressing issues of food security by providing fertile soils and water for irrigation and provisioning of clean water (Jones *et al*., 2010; Tamire and Mengistou 2012; Cgiar, 2014). These ecological features are being altered, degraded and destroyed around the world, with both liquid and solid wastes (Mitsch and Gosselink, 2015; Michael *et al.,* 2018). In addition, aquatic plants have been unrecognized in broad-scale investigations, a condition that can lead to wrong or to conflicting evaluations in analyzing their current spatial patterns and rarity (Sossey-Alaoui and Rosillon, 2013; Alahuhta *et al.*, 2017).

A distinctive characteristic of wetland is high species diversity and vegetation complexity (Mitsch and Gosselink, 2015). Species richness is a quantified function of species composition reflecting much on wetland ecosystem structure and accounting to ecosystem functionality (Lou *et al.,* 2016). Vegetation community influences the maturation of biogeochemical functions in wetlands such as primary productivity, soil development, and nutrient accumulation thus influencing water quality function (Dee and Ahn 2014). Macrophyte diversity may increase diversity in algal species by creating a wider variety of niches, by so doing, the resilience of these communities is improved (Engelhardt and Ritchie 2001; Kinzig *et al*. 2006). Nonetheless, biodiversity in wetlands is an expression of human activity in their surrounding (Mitsch and Gosselink, 2015). This depends mostly on human impact to environment.

Water contamination with heavy metals such as cadmium, chromium and copper at higher concentrations can lead to oxidative stress and growth inhibition in plants (Gill, 2014), Mercury , lead , cobalt, iron and nickel whose high concentration in the vegetative organs of most plants reaches toxicity at around 10e15 mg/kg (Leguizamo *et al.,* 2017), While manganese and zinc which at high concentrations can cause muscular stiffness, loss of appetite, nausea and irritation (Meittei and Prasad, 2014) and arsenic pose a serious threat to humans due to their persistence, toxicity, non-destructible nature in the environment and their bioaccumulation in the food web (Fang *et al.,* 2014; Bortey-Sam *et al*., 2015; Chopra and Pathak, 2015). The concentrations of chemical pollutants of Nkenye stream have been studied by (Ombaka *et al.,* 2013). Though chemical pollutants concentration was reported to be low (Ombaka *et al.,* 2013), However, little research has been done to evaluate the amount of chemicals load absorbed by macrophytes as a mean of improving water quality in this study area.

Waste water discharged into surface waters limits the availability of portable water for household and agricultural use. Sewage treatment systems such as activated sludge process, membrane bioreactors, and membrane separation have been used successfully for domestic waste water treatment in large cities (Li *et al.,* 2014). However, the installation and use of these treatment technologies is expensive complicating their use in rural set up (Chen *et al.,* 2014). Phytoremediation through Phytoextration and Phytostabilization is an effective, affordable and environmentally sustainable alternatives that can be used for sustainable sanitation and wastewater purification compared to conventional technologies (Sehar *et al.,* 2013; Ribadiya and Metha, 2014),Macrophytes; such as *Typha latifolia, Phragmites australis*, *Cyperus papyrus*, *Echinochloa pyramida*lis and *Typha dominguensis* have been reported to be key player and efficient in reducing water pathogen loads of wastewaters in wetlands (Boutilier *et al.,* 2010; Martin *et al.,* 2012; Abdel-Shafy and El-Khateeb, 2013; Giacoman-Vallejos *et al.,* 2015).

The mechanism of macrophytes functioning in wastewater purification involves provisioning of surface area for attached microorganisms, pollutant uptake, enhancing filtration, and releasing oxygen; however, the role of the vegetation still requires quantification (Zhang *et al.,* 2009). The pathogenic microbial values recorded in Nkenye stream gave high bacteria load compared to recommended standards for drinking water based on WHO (Ombaka *et al.,* 2013). Wastes that are brought into the Nkenye stream from upstream comprises different organic and inorganic substances may settle at streambed and contaminate streams sediment (Ali *et al.,* 2019). Settling of pollutants as accumulated sediments chemicals that are toxic to biota and often contribute to aquatic biodiversity loss and ecosystem decline (Jeppe *et al.,* 2017). The continued contamination of sediments with heavy metals is an environmentally significant issue of concern with consequences on aquatic organisms and human health (Fernandes and Nayak, 2012; Staley *et al*., 2015). Sediments act as main pool of metals in aquatic environment (Zahra, 2014). Their quality indicate the status of water pollution. Due to the change in the aquatic environment it can pose serious ecological risks (Martin *et al*., 2015).

The level of contamination in the sediments of any surface water strongly reflects water ecosystem health that might be a reflection of kind of wastes and effluent that are channeled in such water resources (Zhang *et al*., 2011). Many previous studies have also confirmed an increased contamination level of sediments in rivers and streams that provide water for the domestic use (Abuduwaili *et al.,* 2015; Chen *et al.,* 2016; Zhang *et al.,* 2016). These pollutants are stored in fine-grained sediments and complexed to organic matter and oxides (Bartoli *et al.,* 2012; Chen *et al*., 2016). Therefore, there is a need to evaluate many water bodies used for domestic water especially in areas surrounding emerging towns to determine their purity and find ways to purify polluted waters (Chen *et al*., 2016)

METHODOLOGY

Study Area

The study was conducted in Nkenye stream which is found in Chuka Municipality, Meru South within Tharaka Nithi County. The stream is approximately two and half kilometres and it is permanent. Macrophytes are sparsely distributed with *Commelina banghalensis* Tharaka Nithi county borders the Embu County to the South and South West, Meru County to the North and North East, Kirinyaga and Nyeri to the West and Kitui to the East and South East. The County lies between latitude 000 07’ and 000 26’ South and between longitudes 37° 19’ and 37° 46’ East. The highest altitude of the County is 5,200 m while the lowest is 600 m, Eastwards in Tharaka. The average annual rainfall is 717 mm. The high-altitude areas have reliable rainfall. The lower regions receive low, unreliable and poorly distributed rainfall. Temperatures in the highland areas range between 14°C to 30°C while those of the lowland area range between 22°C to 36°C. Major towns in Tharaka Nithi County include Chuka which is highly populated with 45,882 residents and Chogoria with a lower population of 33,378 residents (KNBS, 2010). The area accommodates diverse industries, hospitals, hotels, garages, schools and markets. Other major activities involve crops and livestock farming (GoK, 2018). A map of the study area is shown in Figure 3.

Research Design and Sample Collection

The study used ecological survey design both for water, sediments and macrophytes roots collection. Using belt transect of 1000 meters long, 20 sampling points were laid along the belt using quadrant (1x1m) where Macrophytes roots , sediments and water were collected for study to compare the pollutants reduction down Nkenye stream. During the study, data collected included: colour of water at each sampling point, nature of vegetation (floating, submerged and emerged, macrophyte diversity, water velocity (slow, medium and high speed), point pollution areas and their key sources. Samples collected include water, plants and sediments. These samples were carried to the laboratory for further study.

Figure 4: Map of Study Area- Source: Google Map (Modified)

Water Collection

Water samples from the stream were collected in 1000 ml plastic bottles using grab method along the selected points established as per section 3.2 within Nkenye stream. The water samples were collected during the dry season in the month of January, February and March in 2019. A total of 20 water samples were collected for this study in triplicate totaling to 60 water samples. All the samples were appropriately labeled, stored in cool box for transport to the laboratory at Chuka University. Samples were stored at 4^{o}C prior to laboratory analysis.

Macrophytes Collection

At every sample collection point established in section 3.2, different plant species that form masses on the stream and on the wetlands that drains into the stream were collected in triplicate. Collected plants were packed in different zip lock bags, marked appropriately, packed in cool box for transport to Chuka university where the samples were kept at 4^{o}C prior to laboratory analysis which was carried out one day after collection.

Sediment Collection

At every sampling point established in section 3.2, approximately 220 g of soil sediments was scooped using sterile shovel. The sediment were packed in sterile ziplockbags, labeled, placed in a cool box, transported to the chemistry laboratory of Chuka University and stored at 4^{o}C prior to analysis.

Determination of Cations and Digestion of Samples

Macrophyte roots were cleaned and dried in an oven (Model Memmert UNB400; Chuka University) at 65 ^{o}C for 48 h, reduced in size and then powdered to pass through a 2 mm on-metal sieve. The powdered samples were further re-dried in an oven to obtain constant weight.1 g of the powdered sample was digested at 125^{o}C for 4 h using 10 ml concentrated nitric acid (HNO_3; trace metal grade). The mixture was then cooled to ambient temperature, filtered and diluted to 50 ml. The sediment samples were dried in an oven (Model Memmert UNB400; Chuka University) at 65 ^{o}C for 48 h then ground to pass a 2 mm on-metal sieve. The powdered samples were further re-dried in an oven to obtain constant weight.1 g of the powdered sample were digested at 125^{o}C for 4 h using 10 ml concentrated nitric acid (HNO_3; trace metal grade). The mixture was then cooled to ambient temperature, filtered and diluted to 50 ml.5 g of each water sample was acidified with 1 ml of concentrated nitric acid (HNO_3; trace metal grade$_)$. The acidified sample was then heated at 70^{o}C for 3 min, filtered with a 0.45µm filter syringe, diluted to a final volume of 100 ml and stored at 4^{o}C prior to analysis.

Preparation of Standard Solution

Standard solutions of the selected metal cations were prepared using respective analytical grade metal nitrates. The amount of the metal salt required was weighed accurately, dissolved and diluted with ultrapure water in a 1000 ml volumetric flask to prepare a 1000 ppm stock solution. The stock solution was serially diluted to prepare 1, 2, 3, 4 and 5 ppm working standards.

Elemental Analysis

The concentration of the selected metal cations in the water, macrophyte roots and sediments water was determined by atomic absorption spectrometry using a PG 990 Atomic Absorption Spectrophotometer, located at Chuka University. Samples were analyzed using the standard calibration method.

Pretreatment of Samples for Anions Analysis

Water samples was filtered using a 0.45 µm filter syringe and diluted with ultrapure water to a final volume of 1000 ml. Macrophyte root samples were dried in an oven at 65oC for 4 h. Then 2 g of the dried sample were placed in 200 ml of boiling ultrapure water for 5 min. The mixture was then cooled to ambient temperature, filtered; the filtrate was transferred into a 250 ml volumetric flask and diluted to the mark with ultrapure water. Sediment samples were dried in an oven (Model Memmert UNB400; Chuka University) at 65oC overnight and ground into powder using an agar pestle and mortar. The 2 g of the powdered sample was placed in 200 ml of boiling ultrapure water for 5 min then cooled to ambient temperature. The sample was filtered and the filtrate transferred into a 250 ml volumetric flask. The sample was further diluted to the mark with ultrapure water as per Balcerzak and Janiszewska (2015).

Preparation of Standard Solutions

Standard solutions of the nitrate and phosphate anions were prepared using analytical grade sodium salts. The required amount of the respective sodium salt was dissolved in ultrapure water to prepare 1000 ppm stock solutions. The stock solutions were then serial diluted to prepare working standards which was then mixed to prepare a multi-anionic standard solution. A certified multi-ion standard solution was also purchased from Sigma-Aldrich for comparative analysis.

Analysis of Anions

The concentration was determined by ion chromatography using UV 1800 model located at Chuka University

Chemistry laboratory, after all the samples had been prepared 20 µl injection volume was used for all analyses. Each peak was manually identified and labeled as a specific anion and the concentration was computer generated.

Reagents for Anion and Cations

All reagents for use were of analytical grade acquired from sigma. Water purified in a Millipore Simplicity UV system prepared at Chuka University was used in all experiments. Standard solutions of fluoride, chloride, Nitrate (V), phosphate, and Sulphate anions (from Sigma) prepared from high purity sodium salts were used. Multi-anionic working solutions were prepared by mixing up single anion standards with appropriate dilution. Certified Multi-anion Standard Solution dedicated to IC (from Sigma) containing an aqueous mixture of, Cl^{-}, $NO_3{}^{-}$, $PO_4{}^{3-}$, and $SO_4{}^{2-}$ (10 mg l–1 each of anions) was used for the evaluation of the accuracy of the chromatographic procedure applied. Sodium carbonate (Na_2CO_3) and sodium hydrogen carbonate ($NaHCO_3$) from Sigma was used for the preparation of the eluent (3.2 mmol l–1 Na_2CO_3 +1.0 mmol l^{-1} $NaHCO_3$).

Data Aanalysis

The data obtained were subjected to analysis of variance (ANOVA) using General linear model in scientific analysis system (SAS) software version 9.4 and Mean comparison achieved through least significance difference (LSD).

RESULTS

Concentration of Nutrients in Water, Plant Root and in Sediment

Concentration of Lead in Water, Plant Root and in Sediment

The concentration of lead in water samples were significantly different ($p<0.05$; Appendix 5). The highest mean was at location 20 with mean of 2.87 ppm while the lowest mean for lead in water was location 5 and 10 with mean of 0.02 ppm. The difference between the highest mean and the lowest concentration of lead in water was 2.85 ppm. The overall mean of lead in water was 0.77 ppm. Seven out of the twenty water sample location sampled had means of lead in water higher than the overall mean (Table 1).

Table 13: Concentration of lead in plant roots, sediments and in water samples in ppm

Location	Lead root	Lead sediment	Lead water
20	11.63^{a}	93.50^{ba}	2.87^{a}
19	11.13^{a}	93.00^{ba}	1.74^{b}
18	8.00^{b}	65.0^{ebdacf}	1.53^{cb}
16	7.68^{cb}	79.43^{bdac}	1.68^{b}
14	7.23^{cb}	71.33^{ebdac}	0.57^{ed}
15	6.82^{cbd}	95.33^{a}	1.78^{b}
17	6.733^{cd}	80.47^{bac}	1.73^{b}
3	5.60^{ed}	34.53^{egf}	0.27^{ed}
13	$4.90f^{e}$	47.33^{edgcf}	0.40^{ed}
2	$4.17f^{g}$	20.33^{g}	0.23^{ed}
11	3.57^{g}	49.33^{ebdgcf}	0.71^{ced}
12	2.27^{h}	36.0^{edgf}	1.12^{ebd}
6	2.05^{h}	20.0^{g}	0.12^{e}
10	1.93^{ih}	47.0^{edgcf}	0.02^{e}
5	1.83^{ih}	23.0^{gf}	0.02^{e}
9	1.68^{ih}	47.67^{edgcf}	0.06^{e}
8	1.68^{ih}	35.33^{edgf}	0.14^{e}
4	1.18^{ihj}	17.47^{g}	0.17^{e}
1	0.76^{ij}	6.11^{g}	0.04^{e}
7	0.28^{j}	29.67^{egf}	0.17^{ed}
Mean	4.55	49.59	0.77
LSD(p<0.05)	0.67	23.58	0.51
CV	8.95	28.76	39.78

[a]Means followed by the same letters in columns are not significantly different at 5% probability level.

The concentration of lead in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 5). The highest mean was at location 15 with mean of 95.33 ppm, while the lowest mean for lead in water was location 1 with mean of 6.11 ppm. The difference between the highest mean and the lowest mean of lead concentration in sediment was 89.22 ppm. The overall mean of lead in water was 49.59 ppm. Seven out of the twenty sediment location sampled had means of lead higher than the overall mean (Table 1).

The concentration of lead in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 5). The highest mean of lead concentration in plant root was at location 15 which had the mean of 11.63 ppm followed by location 19 which had a mean concentration of 11.13 ppm. The lowest mean for lead in plant root was location 7 with concentration mean of 0.28 ppm. The difference between the highest mean and the lowest lead concentration in plant root was 11.35 ppm. The overall mean of lead in water was 4.55 ppm. Nine locations out of the twenty locations sampled for determination of concentration of lead in plant root had means higher than the overall mean (Table 1).

Concentration of Iron in Water, Plant Root and in Sediment

The concentration of iron in water samples from different locations in Nkenye stream was significantly different ($p < 0.05$; Appendix 7). The highest mean of iron concentration was at location 19 which was followed by location 20 and location 16 with means of 14.44 ppm, 13.97 ppm and 12.82 ppm respectively. The lowest mean for iron in water was observed from samples collected at location 1, location 4 and location 2 with means of 0.03 ppm, 0.07 ppm and 0.14 ppm respectively. The difference between the highest mean and the lowest concentration of iron in water was 14.30 ppm. The overall mean of iron in water was 5.11 ppm. Eight out of the twenty water sample location sampled had means of iron in water higher than the overall mean (Table 2).

Table 14: Concentration of Iron in Plant Root, Sediment, and in Water samples in ppm

Location	Iron water	Iron Root	Iron Sediment
19	14.44^{a}	44552^{b}	372827^{a}
20	13.97^{ba}	43513^{cbd}	366063^{a}
16	12.82^{bac}	27233^{fe}	289961^{b}
17	12.82^{bc}	30829^{e}	209913^{c}
18	11.85^{bc}	42593^{cbd}	353047^{b}
15	11.77^{c}	14437^{hg}	286733^{b}
14	8.80^{d}	16960^{g}	357830^{b}
13	6.72^{d}	20332^{fg}	325407^{b}
9	1.71^{e}	3483.33^{i}	36863^{d}
10	1.33^{e}	18587^{fg}	70390^{d}
12	1.33^{e}	11210^{hi}	259073^{b}
7	1.27^{e}	32482^{e}	27310^{d}
11	1.22^{e}	16910^{g}	74823^{d}
6	1.03^{e}	47467^{a}	58550^{d}
8	0.95^{e}	5936.67^{h}	52339^{d}
3	0.30^{e}	35197^{ced}	59697^{d}
5	0.27^{e}	14437^{hg}	52267^{d}
2	0.14^{e}	42972^{cbd}	61897^{d}
4	0.07^{e}	34253^{ed}	65500^{d}
1	0.03^{e}	8415^{hg}	106223^{d}
Mean	5.113	16.62	174335.7
LSD($p<0.05$)	1.137	4.41	99192
CV	13.46	16.07	34.42

[a] Means followed by the same letters in columns are not significantly different at 5% probability level.

The concentration of iron in sediment for different sampling location within Nkenye stream was significantly different ($p=0.05$). The highest mean of iron in sediment was recorded at location 19 with mean of 372827 ppm followed by location 20, location 14 and location 13 with means of 366063 ppm, 357830 ppm and 325407 ppm respectively. The locations which recorded the lowest mean for iron in sediment was location 7 followed by location 9 and location 5 in that order with means of 27310 ppm, 36368 ppm and 52267 ppm respectively. The difference between the highest mean and the lowest mean of iron in sediment at Nkenye stream was 345517 ppm. Iron in sediment was 174335.70 ppm. Nine out of the twenty sediment location sampled had means of iron higher than the overall mean (Table 2).

The concentration of iron in plant root for sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 7). The highest mean of iron concentration in plant root was at location 6 which had the mean 47467 ppm followed by location 19 which had a mean concentration of 44552 ppm and location 20 with mean iron concentration of 43513 ppm. The lowest mean for iron in plant root was location 9 which had mean concentration of 3483.33 ppm and was followed with plant sample from location 8 with mean of 5936.67 ppm and location 1 with mean of 8415.00 ppm. The difference between the highest mean and the lowest iron concentration in plant root was 44836.67 ppm. The overall mean of iron in water was 25590.72 ppm. Ten locations out of the twenty locations sampled for determination of concentration of iron in plant root had means higher than the overall mean (Table 2).

Concentration of Copper in Water, Plant Root and in Sediment

The copper concentration in water samples from different locations in Nkenye stream was significantly different ($p < 0.05$; Appendix 9). The highest mean of copper concentration was at location 20 which was followed by sample from location 19 and location 16 with means of 2.97 ppm, 2.90 ppm and 2.53 ppm respectively. The lowest mean for copper in water was observed from samples collected at location 9, location 10 and location 3 which recorded means of 0.00 ppm. The overall mean of copper in water was 0.99 ppm. Seven locations out of the twenty water sample locations sampled had means of copper in water higher than the overall mean (Table 3).

Table 15: Concentration of Iron in Plant Root, Sediment, and in Water in ppm

Location	Copper water	Copper Root	Copper Sediment
20	2.967^{a}	15.167^{a}	137.00^{a}
19	2.900^{a}	11.962^{abc}	117.00^{b}
16	2.533^{ba}	10.180^{bcd}	85.333^{cd}
18	2.133^{bc}	13.200^{ab}	96.667^{bc}
15	1.750^{c}	10.920^{abcd}	90.333^{bc}
17	1.667^{cd}	11.233^{abcd}	62.333^{de}
13	1.00^{de}	8.433^{g}	54.667^{fe}
14	0.977^{deh}	9.700^{bdec}	325407^{b}
12	0.800^{feh}	11.233^{abcd}	57.00^{ef}
7	0.700^{fgeh}	4.100^{ijh}	34.33^{fg}
8	0.633^{fgeh}	5.533^{efghij}	42.00^{efg}
5	0.500^{fgeh}	5.196^{efghij}	39.667^{efg}
1	0.290^{fgeh}	2.300^{j}	31.00^{fg}
2	0.283^{fgeh}	47467^{a}	21.333^{g}
6	0.267^{fgh}	4.933^{fghij}	55.333^{fe}
4	0.240^{fg}	3.780^{ijh}	49.333^{ef}
11	0.200^{fg}	9.033^{bcdef}	52.33^{ef}
3	0.00^{g}	2.800^{ij}	33.667^{fg}
10	0.00^{g}	6.967^{defghi}	45.00^{efg}
9	0.00^{g}	7.600^{defgh}	52.00^{ef}
Mean	0.992	7.986	60.900
LSD($p<0.05$)	0.7312	2.3124	27.136
CV	44.597	17.286	26.957

[a]Means followed by the same letters in columns are not significantly different at 5% probability level.

The concentration of copper in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 9). The highest mean of copper in sediment was recorded at location 20 with mean of 137 ppm followed by location 19, location 18 and location 15 with means of 117.00 ppm, 96.67 ppm and 90.33 ppm respectively. The locations which recorded the lowest mean for copper in sediment was location 2 followed by location 1 and location 3 in that order with means of 21.33 ppm, 31.00 ppm and 33.67 ppm respectively. The difference between the highest and lowest mean of copper at Nkenye stream was 115.67 ppm. The overall mean of copper was 60.90 ppm. Seven locations out of the twenty sediment locations sampled had means of copper higher than the overall mean (Table 3).

The concentration of copper in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 9). The highest mean of copper concentration in plant root was recorded at location 20 which had the mean 15.17 ppm followed by location 18 which had a mean concentration of 13.20 ppm and location 19 with mean copper concentration of 11.92 ppm. The lowest mean for copper in plant root was location 1 which had mean concentration of 2.30 ppm and was followed with plant sample from location 3 with mean of 2.80 ppm and location 4 with mean of 3.78 ppm. The difference between the highest mean and the lowest copper concentration in plant root was 12.96 ppm. The overall mean of copper in water was 7.99 ppm with a coefficient variance (CV) of 17.28 ppm. Ten locations out of the twenty locations sampled for determination of concentration of copper in plant root had means higher than the overall mean (Table 3).

Concentration of Phosphate in Water, Plant Root and in Sediment

The phosphate concentrations in water samples from different locations in Nkenye stream were significantly different ($p < 0.05$; Appendix 11). The highest mean of phosphate concentration was at location 19 which was followed by sample from location 20 and location 17 with means of 24.80 g/L, 21.03g/L and 12.58 g/L respectively. The lowest mean for phosphate in water was observed from samples collected at location 12, location 7 and location 4 which recorded means of 0.15 g/L, 0.20 g/L, 0.40 g/L. The overall mean of phosphate in water was 5.34 g/L. Seven locations out of the twenty water samples location sampled had means of phosphate in water higher than the overall mean (Table 4).

Table 16: Concentration of Phosphate in Plant Roots, Sediments, and in Water samples in g/L

Location	Phosphate water (g/L)	Phosphate Sediment (g/L)	Phosphate Root (g/L)
19	24.8033^{a}	38.47^{a}	8.0^{ba}
20	21.0333^{ab}	48.63^{b}	7.4^{bac}
17	12.5833^{bc}	16.8^{ed}	4.57^{bedc}
18	6.8667^{cd}	29.30^{c}	5.03^{bdc}
10	5.7677^{cd}	15.93^{edf}	2.0^{fed}
14	5.0333^{cd}	13.77^{egdf}	2.60^{fed}
13	5.0000^{cd}	12.0^{hegdfi}	4.0^{edc}
9	4.8000^{cd}	13.67^{hegdf}	1.13^{fe}
6	4.6333^{cd}	8.15^{hgfi}	1.53^{fed}
8	3.6667^{cd}	9.97^{hegdfi}	1.70^{fed}
5	3.4000^{cd}	12.37^{hegdf}	2.93^{fed}
11	3.0000^{cd}	31.43^{cb}	3.43^{fed}
2	2.0833^{cd}	9.00^{hegfi}	8.60^{a}
3	1.3333^{d}	17.57^{d}	1.60^{fed}
15	0.7833^{d}	5.97^{hgi}	1.60^{fed}
1	0.7000^{d}	8.8333^{a}	8.83^{a}
16	0.4667^{d}	3.93^{i}	0.33^{f}
4	0.4000^{d}	15.20^{edf}	2.27^{fed}
7	0.2000d	13.17^{hegdf}	2.67^{fed}
12	0.15^{d}	5.13^{hi}	2.15^{fed}
Mean	5.34	16.62	3.62
LSD(p<0.05)	5.92	4.41	1.87
CV	67.16	16.07	31.28

[a] Means followed by the same letters in columns are not significantly different at 5% probability level.

The concentration of phosphate in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 11). The highest mean of phosphate in sediment was recorded at location 20 with mean of 48.63 g/L followed by location 19, location 11 and location 18 with means of 48.63g/L, 38.47 g/L and 31.43 g/Land 29.30 g/L respectively. The locations which recorded the lowest mean for phosphate in sediment was location 16 followed by location 12 and location 15 in that order with means of 3.93 g/l 5.13 g/L and 5.57g/L respectively. The difference between the highest mean and the lowest mean of phosphate in sediment at Nkenye stream was 44.70 g/L. The overall mean of phosphate in sediment was 16.62 g/L. Six locations out of the twenty sediment locations sampled had means of phosphate higher than the overall mean (Table 4).

The concentration of phosphate in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 11). The highest mean of phosphate concentration in plant root was recorded at location 1 which had the mean 8.83 g/L followed by location 2 which had a mean concentration of 8.60 g/L and location 19 with mean phosphate concentration of 8.00g/L. The lowest mean for phosphate in plant root was location 16 which had mean concentration of 0.33 g/L and was followed with plant sample from location 9 with mean of 1.33g/L and location 6 with mean of 1.53 g/L. The difference between the highest mean and the lowest phosphate concentration in plant root was 8.50g/L. The overall mean of phosphate in root was 3.62 g/L with a coefficient variance (CV) of 31.27 g/L. Seven locations out of the twenty locations sampled for determination of concentration of phosphate in plant root had means higher than the overall mean (Table 4).

Concentration of Nitrate in Water, Plant Root and in Sediment

The concentrations of nitrate in water samples were significantly different ($p < 0.05$; Appendix 11). The highest mean of nitrate concentration was recorded at location 4 with mean of 32.63 g/l followed by location 8 and 7 with means of 29.63 g/L, and 23.53 g/L respectively. The lowest mean for nitrate in water was location 6 and location 1 with mean of 5.27g/L and 5.97 g/L respectively. The difference between the highest mean and the lowest concentration of nitrate in water was 27.39 g/L. The overall mean of nitrate in water was 14.54 ppm. Seven out of the twenty water sample location sampled had means of nitrate in water higher than the overall mean (Table 5).

Table 17: Concentration of Nitrates in Plant Roots, Sediments and in Water samples in ppm

Location	Nitrate Root	Nitrate Sediment	Nitrate Water
20	8.27 ^{a}	96.67^{a}	17.67 ^{abc}
18	8.13 ^{a}	78.33^{cd}	17.47 ^{abc}
17	7.43 ^{ba}	89.33^{ab}	14.20 ^{abc}
19	7.03 ^{bac}	87.00^{abc}	18.00 ^{abc}
10	6.73 ^{bdac}	44.67^{jik}	15.40 ^{abc}
12	5.43 ^{bdec}	45.33^{jik}	14.12^{abc}
07	5.43 ^{bdce}	44.00^{jik}	23.53 ^{abc}
14	4.53 ^{fdec}	79.33^{abc}	13.00 ^{abc}
16	4.40 ^{fdec}	75.67^{ed}	11.83^{abc}
15	4.40 ^{fdec}	67.00^{ef}	11.02^{bc}
04	4.37 ^{fdec}	43.00^{jik}	32.63 ^{a}
09	4.23 ^{fheg}	36.00^{k}	11.97 ^{abc}
13	3.87 ^{fheg}	51.00^{ghi}	11.37 ^{abc}
08	3.10 ^{fheg}	39.33^{jk}	29.68 ^{ab}
02	3.07^{fheg}	51.33^{ghi}	7.33 ^{c}
06	2.47 ^{fhg}	46.67^{jik}	5.27 ^{c}
03	2.40 ^{fhg}	61.33^{gf}	8.17 ^{c}
05	2.10 ^{fhg}	52.67^{ghi}	6.30 ^{c}
01	1.67 ^{hg}	56.67^{fgh}	5.97 ^{c}
11	1.27 ^{h}	39.67^{jk}	15.80 ^{abc}
Mean	4.52	59.40	14.54
LSD($p<0.05$)	0.56	10.36	21.497
CV	19.23	9.97	89.47

^{a}Means followed by the same letters in columns are not significantly different at 5% probability level.

The concentration of nitrate in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 11). The highest mean of nitrate in sediment was at location 20 with mean of 96.67 g/L, followed by location 17 with mean of 89.37 g/L followed by location 19 with mean of 87.00 g/L. location 18had mean of 78.33 g/L, location 16 had mean of 75.67 g/L and location 15 had mean of 67.67 g/L. The lowest mean for nitrate in sediment sample was recorded at location 9 with mean of 36.00g/L followed by sample from location 8 with mean of 39.33 g/L and at location 11 with mean of 39.67 g/L. The difference between the highest mean and the lowest mean of lead concentration in sediment was 42.33g/L. The overall mean of nitrate in water was 59.40g/L. Four out of the 20 sediment location sampled had means of nitrate higher than the overall mean (Table 5).

The concentrations of nitrate in roots were significantly different ($p < 0.05$). The highest mean was at location 20 with mean of 8.267 g/L followed by location 18 and 17 with means of 8.13 g/L, and 7.43 g/L respectively. The lowest mean for nitrate in root was location 11 and location 1 with mean of 1.27 g/L and 1.67 g/L respectively. The difference between the highest mean and the lowest concentration of nitrate in root was 7.00 g/L. The overall mean of nitrate in root was 4.52 g/L. Eight out of the twenty root sample location sampled had means of nitrate in roots higher than the overall mean (Table 5).

DISCUSSION

Metal Contamination of Water, Sediment and Plant Root

The concentrations of metals in water, sediment and plant root were highest for iron than for copper which was second and lead which had the lowest concentration. The result indicated that the contamination was higher at the upstream than on the downstream. Upstream of Nkenye stream borders settlements, *juakali* sheds and garages which drains to Nkenye wetland that is the origin of Nkenye stream. According to Kananke *et al*. (2014) waste water and the sludge from the hotels, kichens,residential houses and septic tanks from Chuka town are key in Nkenye stream pollution (Tasrina *et al*., 2015). Contamination of surface waters such as rivers and streams by the heavy metals such as lead, copper and iron emanates from wastes and road runoff, in addition to atmospheric deposition. Thus, run-off from roads and wastes from Chuka town that originates from jua kali sheds are the potential sources of metal entry to the water at Nkenye stream. This is due to the fact that areas where the heavy metal concentrations were higher were at the source of the stream which was barely 30 meters from Chuka town. Further, the higher concentrations of the metals in water may have been contributed for by use of fertilizers in the farms that border the stream (Kananke *et al*., 2014; Willis and Bishop, 2016; Mosimanegape, 2016; Pope e*t al*., 2016) and sludge from septic tanks of residential house and hotels (Tasrina *et al*., 2015) which find their way into Nkenye stream untreated.

In water, copper, lead and iron concentrations varied significantly from one sampling location to the next. Similar reports of variation of metal pollutant along the stream were reported by Giwa *et al.* (2014).The highest concentration of copper was 3.00 ppm and the lowest was 0.02 ppm with average of 0.99 ppm. The Lead highest concentrations were 2.87 ppm while the lowest concentrations were 0.02 ppm with the average of 0.77 ppm.

The highest concentration for iron was 14.44 ppm and the lowest was 0.03 ppm with the average of 5.11 ppm. In order of priority the highest metal concentration in water was iron followed by copper and lastly leads. According to the order of occurrence of these metal pollutants disagrees with the finding of Wasiu *et al.* (2016) who observed copper to be higher than iron and Lead. Based on overal means of metal pollutants of all water samples collected, the concentration of iron were found to be within the WHO standard (WHO, 2016; WHO, 2018). The mean concentration of copper is within the acceptable limits of 2 ppm. However, the mean concentration of Lead was slighlty higher than the acceptable limit as per the WHO standards of 0.01 ppm as the acceptable limit in drinking water (WHO. 2018). This is because concentration of pollutants are not universal but locational specific due to differnces in pollution sources and type from Chuka town.

The results of high concentration of lead were above the the recommended WHO standards agrees with those of Sekabira *et al.* (2010) who made similar observation in Kampala Nakivubo stream Uganda. Higher concentration of lead in water particularly surface water have also been reported by Mathews-Amune *et al*. (2018). Long term consumtion of water contaminated with pollutants such as lead may lead to metal bioaccumulation in the body cells, tissues and organs which may cause irreversible health complications (Orosun *et al.,* 2016). Drawing of water from sampling points which recorded higher values of copper may expose the users of such resources to live, chromic anemia as well as development of Wilson’s diseases (Asma Iqbal *et al* 2011; Samuel Zerabruk *et al* 2011). Higher copper in the stream may impede the physiology of aquatic dependent plants and animals (Lopez *et al.,* 2019).

Contamination of stream sediments with heavy metals remains a big issue of environmental concern (Deemer *et al*., 2012; Wasiu *et al.,* 2016). In this study the concentrations of assessed metals in the sediment collected from the stream were all higher. In order of priority, the metals in sediment were higher in iron concentration followed by copper and lead. The similar trends of results on sediment had been reported by Areguamen *et al.* (2013). The concentration of iron was the highest with mean of 174335.70 ppm followed with copper with mean of 60.90 while lead was the least. Higher concentrations of pollutant reported by this study correspond to those reported by Abuduwaili *et al.* (2015), Chen *et al.* (2016) and Zhang *et al.* (2016). The reason for high concentration of metals in the sediment may be due to their continuous accumulation over the years since the sediment acts as sink for heavy metals in water body (Zahra, 2014).As the pH of water falls, the metals released from water may be locked up in bottom sediments and remain for many years (Areguamen *et al.,* 2013). The higher concentration of iron may have come from waste water that drains into the stream nearby vehicle garage where rusted metal parts are washed. Such higher metal deposit of pollutants in the stream bed sediment may be released in the flowing water due to turbulence and contributing to consistent water pollution downstream where the stream is depended upon for provision of water for domestic use (Fernandes and Nayak, 2012; Staley *et al*., 2015; Chen *et al*., 2016).

Higher amount of metals where observed from root samples (*Commelina baghalensis)* indicated higher absorption of metal pollutants. The concentrations of the metal measured in plant root samples tend to vary with the amount of chemicals measured in the sediment. This may indicate the efficiency of the plant in the absorption of the pollutants in contaminated river sediment upon sedimentation of the pollutant. The report on the absorption of nutrients (pollutants) by the plants is supported by the report by upta. (2013). There was reduction of pollutants down the stream, which may be attributed to absorption capacities of the plants which includes *Comelina bahgalensis* which is the dominant macrophyte on water surface along Nkenye stream. Absorption and ultimate translocation of metals within the plants may contribute to toxicant reduction in water bodies (Voutsa *et al*., 1996).

Nitrate concentrations in Nkenye stream were higher downstream as compared to samples collected upstream. In water the highest nitrate level was 32.63 gm/L and the lowest was 5.27 gm/L with overall mean of 14.54 gm/l. Phosphate concentration was higher upstream as compared to downstream unlike nitrates. Nonetheless, the concentration of phosphate and nitrate varied along the Nkenye stream. Similar results on the variation of the nutrients such as nitrates along the stream have been reported (Van Metre *et al.,* 2016). The highest phosphate concentration was 24.80 gm/L and the lowest was 0.15 gm/L with mean of 5.34 gm/L. The finding of this study corroborates with those of (Eruola *et al.,* 2015). However, where as Eruola *et al*. (2015) reported higher concentration at the middle of the stream, the current study observed higher concentration upstream.

The means of phosphates and nitrate in water were higher compared to the accepted limits of 0.05 mg/L by the WHO (WHO., 2018). Accumulation of Phosphorus and nitrogen in Nkenye stream might have been contributed for by wastes from animal feed, agricultural fertilizers, manure, garbage and liquid wastes originating from Chuka particularly at the upstream that boarder the Chuka town market. Municipal wastes dumped or drained into the streams have been identified as potential contributors to stream degradation in urban areas (MPCA, 2009; Fissore *et al.,* 2011; Wua *et al.,* 2015; Varanka, 2016). The higher concentration of P in surface of freshwaters can stimulate algal growth deplete oxygen due to algae death which kills fish and impairment of water that is used for recreation, drinking or agricultural uses (McDowell *et al.*, 2019)

SUMMARY OF FINDINGS

Access to portable water remains major global concern due to increased rate of water pollution contributed for by human pressure such as accelerated urbanization, high population, industrialization and intense agricultural activities that destroys riparian zones thus exposing the rivers and streams to toxic and pathogenic pollutants release from untreated organic and inorganic waste. Exposure of river and stream that provide drinking water to pollution is detrimental to both aquatic plants, human consumers and animals inhabiting water bodies.Nkenye stream in Meru South is depended upon for the use of its water in supplying fish ponds constructed along it, suppling water used for irrigation and provision of water for domestic use to the neighboring homestead. Nonetheless, little attention has been accorded to acertain the chemical and biological quality of the flowing water and that of the water bed (sediment) despite of the stream being located in semi urban areas with high exposure to pollutants.

Pressure on Nkenye wetlands ecosystem that habour Nkenye stream has seen major destruction of riparian vegetation (majorly by cultivation of riparian land) leaving just few plant communities such as *Commelina banghalensis* whose water purification potential is not well known. Based on the above fact a study was conducted to determine water quality of Nkenye stream and water purification capacity of *Commelina banghalensis* along this stream. Samples were collected at designated locations and taken to Chuka University for evaluation. However, the water temperature, pH and dissolved oxygen were determined *insitu* using Hanna conductivity meter. The results of metal were significantly different in different sampling locations. The concentration of lead in water samples was significantly different ($p < 0.05$; Appendix 5). The highest mean was at location 20 with mean of 2.87 ppm while the lowest mean for lead in water was location 5 and 10 with mean of 0.02 ppm. The difference between the highest mean and the lowest concentration of lead in water was 2.85 ppm. The mean of lead in water was 0.77 ppm.

The concentration of lead in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 5). The highest mean was at location 15 with mean of 95.33 ppm while the lowest mean for lead in water was location 1 with mean of 6.11 ppm. The difference between the highest mean and the lowest mean of lead concentration in sediment was 89.22 ppm. The overall mean of lead in water was 49.59 ppm. The concentration of lead in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 5). The highest mean of lead concentration in plant root was at location 15 which had the mean 11.63 ppm followed by location 19 which had a mean concentration of 11.13 ppm. The lowest mean for lead in plant root was location 7 with concentration mean of 0.28 ppm. The difference between the highest mean and the lowest lead level in plant root was 11.35 ppm. The overall mean of lead in water was 4.55 ppm (Table 1).

The iron concentration in water samples from different locations in Nkenye stream was significantly different ($p < 0.05$; Appendix 7). The highest mean of iron concentration was at location 19 which was followed with location 20 and location 16 with means of 14.44 ppm, 13.97 ppm and 12.82 respectively. The lowest mean for iron in water was observed from samples collected at location 1, location 4 and location 2 with means of 0.03 ppm, 0.07 ppm and 0.14 respectively. The difference between the highest mean and the lowest concentration of iron in water was 14.30 ppm. The overall mean of iron in water was 5.11 ppm. Eight out of the twenty water sample location sampled had means of iron in water higher than the overall mean (Table 2).

The concentration of iron in sediment for different sampling location within Nkenye stream was significantly different ($p=0.05$). The highest mean of iron in sediment was recorded at location 19 with mean of 372827 ppm followed by location 20, location 14 and location 13 with means of 366063 ppm, 357830 ppm and 325407 ppm respectively. The locations which recorded the lowest mean for iron in sediment was location 7 followed by location 9 and location 5 in that order with means of 27310 ppm, 36368 ppm and 52267 ppm respectively. The difference between the highest mean and the lowest mean of iron in sediment at Nkenye stream was 345517 ppm. The overall mean of iron in sediment was 174335.70 ppm.

The concentration of iron in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 7). The highest mean of iron concentration in plant root was at location 6 which had the mean 47467 ppm followed by location 19 which had a mean concentration of 44552 ppm and location 20 with mean iron concentration of 43513 ppm. The lowest mean for iron in plant root was location 9 which had mean concentration of 3483.33 ppm and was followed with plant sample from location 8 with mean of 5936.67 ppm and location 1 with mean of 8415.00 ppm. The difference between the highest mean and the lowest iron concentration in plant root was 44836.67 ppm. The overall mean of iron in water was 25590.72 ppm (Table 2).

The copper concentration in water samples from different locations in Nkenye stream was significantly different ($p < 0.05$; Appendix 9). The highest mean of copper concentration was at location 20 which was followed by sample from location 19 and location 16 with means of 2.97 ppm, 2.90 ppm and 2.53 respectively. The lowest mean for copper in water was observed from samples collected at location 9, location 10 and location 3 which recorded means of 0.00 ppm. The overall mean of copper in water was 0.99 ppm. The concentration of copper in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 9). The highest mean of copper in sediment was recorded at location 20 with mean of 137 ppm followed by location 19, location 18 and location 15 with means of 117.00 ppm, 96.67 ppm and 90.33 ppm respectively. The locations which recorded the lowest mean for copper in sediment was location 2 followed by location 1 and location 3 in that order with means of 21.33 ppm, 31.00 ppm and 33.67 ppm respectively. The difference between the highest mean and the lowest mean of copper in sediment at Nkenye stream was 115.67 ppm. The overall mean of copper in sediment was 60.90 ppm.

The concentration of copper in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 9). The highest mean of copper concentration in plant root was recorded at location 20 which had the mean 15.17 ppm followed by location 18 which had a mean concentration of 13.20 ppm and location 19 with mean copper concentration of 11.92 ppm. The lowest mean for copper in plant root was location 1 which had mean concentration of 2.30 ppm and was followed with plant sample from location 3 with mean of 2.80 ppm and location 4 with mean of 3.78 ppm. Differences between the highest mean and the lowest copper concentration in plant root were 12.96 ppm. The overall mean of copper in water was 7.99 ppm with a coefficient variance (CV) of 17.28 ppm (Table 3).

The phosphate concentrations in water samples from different locations in Nkenye stream were significantly different ($p < 0.05$; Appendix 11). The highest mean of phosphate concentration was at location 19 which was followed by sample from location 20 and location 17 with means of 24.80 g/L, 21.03 g/L and 12.58 g/L respectively. The lowest mean for phosphate in water was observed from samples collected at location 12, location 7 and location 4 which recorded means of 0.15 g/L, 0.20 g/L, 0.40 g/L. The overall mean of phosphate in water was g/L. Seven locations out of the twenty water samples location sampled had means of phosphate in water higher than the overall mean (Table 4). The concentration of phosphate in sediment for different sampling location within

Nkenye stream was significantly different ($p < 0.05$; Appendix 11). The highest mean of phosphate in sediment was recorded at location 20 with mean of 48.63 g/L followed by location 19, location 11 and location 18 with means of 48.63 g/L, 38.47 g/L and 31.43 g/L and 29.30 g/L respectively. The locations which recorded the lowest mean for phosphate in sediment was location 16 followed by location 12 and location 15 in that order with means of 3.93 ppm, 5.13 g/L and 5.57 g/L.

The differences between highest mean and lowest mean of phosphate in sediment at Nkenye stream was 44.70 g/L. The overall mean of phosphate in sediment was 16.62 g/L. The concentration of phosphate in plant root for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 11). The highest mean of phosphate concentration in plant root was recorded at location 1 which had the mean 8.83 g/L followed by location 2 which had a mean concentration of 8.60 g/L and location 19 with mean phosphate concentration of 8.00 g/L. The lowest mean for phosphate in plant root was location 16 which had mean concentration of 0.33 g/L and was followed with plant sample from location 9 with mean of 1.33 g/L and location 6 with mean of 1.53 g/L. The difference between the highest mean and the lowest phosphate concentration in plant root was 8.50 g/L. The overall mean of phosphate in root was 3.62 g/L with a coefficient variance (CV) of 31.27 g/L (Table 4).

The concentrations of nitrate in water samples were significantly different ($p < 0.05$; Appendix 11). The highest mean of nitrate concentration was recorded at location 4 with mean of 32.63 ppm followed by location 8 and 7 with means of 29.63 g/L, and 23.53 g/L respectively. The lowest mean for nitrate in water was location 6 and location 1 with mean of 5.27 g/L and 5.97 g/L. The differences between highest mean and lowest concentration of nitrate in water was 27.39 g/L. The overall mean of nitrate in water was 14.54 ppm. Seven out of the twenty water sample location sampled had means of nitrate in water higher than the overall mean (Table 5).

The concentration of nitrate in sediment for different sampling location within Nkenye stream was significantly different ($p < 0.05$; Appendix 11). The highest mean of nitrate in sediment was at location 20 with mean of 96.67 g/L, followed by location 17 with mean of 89.37 g/L followed by location 19 with mean of 87.00 g/L. location 18 had mean of 78.33 g/L, location 16 had mean of 75.67 g/L and location 15 had mean of 67.67 g/L. The lowest mean for nitrate in sediment sample was recorded at location 9 with mean of 36.00 g/L followed by sample from location 8 with mean of 39.33 g/L and at location 11 with mean of 39.67 g/L. Differences between the highest mean and lowest mean of lead concentration in sediment was 42.33 g/L. The concentrations of nitrate in root samples were significantly different ($p < 0.05$; Appendix 11). The highest mean was at location 20 with mean of 8.267 g/L followed by location 18 and 17 with means of 8.13 g/L, and 7.43 g/L respectively. The lowest mean for nitrate in root was location 11 and location 1 with mean of 1.27 g/L and 1.67 g/L. The difference between highest mean and lowest concentration of nitrate in root was 7.00 g/L. The overall mean in root was 4.52 g/L (Table 5).

CONCLUSION

Metal pollutants were significantly different from location to location of sampling. However, their concentrations were within the WHO standards for drinking water. The metals contaminants observed in the Nkenye stream water, sediments and macrophytes roots may be associated with discharge of wastes from Chuka town particularly wastes from car wash, garages and from farms (agrochemicals) that surrounds the stream and wet land. Due to fluctuation in the concentration of chemical pollutants observed, there is need for regular and proper monitoring of the stream to safeguard the integrity of Nkenye stream and the lives of people who draw water from it. Nitrates had the highest mean concentrations compared to other phosphates and indication that nitrates pollutants that are drained into Nkenye stream are in high amount. High amount of chemicals observed in the sediment samples from Nkenye is a point of concern, as these chemicals may be dismounted from the streams sediment by turbulence and carried along the river at the point where water is drawn thus a health hazard. The feacal coliforms were higher than the required concentration by the WHO. Considerable amount of lead, copper and iron were observed in the root samples of *Commelina banghalensis* this shows that the plant can be utilized in removal of chemicals in the stream.

RECOMMENDATIONS

The local authorities particularly Tharaka Nithi county government should provide waste management disposal systems and policies that prohibit direct discharge of effluents or any other industrial based wastes at the stream course. The county government should impose policies that outlaw cultivation along the stream or any activity that endangers the riparian zones of Nkenye stream. The macrophyte plants such as *Commelina banghalensis* should be adopted and planted as a buffer zone between the stream and the land bordering upstream of Nkenye stream to trap and retain harmful wastes that otherwise would get their way into the water body. Future research should focus on the following aspects. Macrophyte biodiversity and their individual role in water purification along Nkenye stream in Meru South in Kenya. Effect of seasonal variation of water pollution in Nkenye stream in Meru South. Factors contributing to the water pollution load in Nkenye stream.

REFERENCES

Abdel-Shafy, H., and El-Khateeb, M. (2013). Integration of septic tank and constructed wetland for the treatment of wastewater in Egypt. *Desalin Water Treat*, *51*, 3539–3546.

Abubakar, M., Ahmad, M., and Getso, B. (2014). Rhizofiltration of heavy metals from eutrophic water using *Pistia stratiotes* in a controlled envirronment. *OSR, J Environ Sci Toxicol Food Technol.*, *8*, 1-3.

Abuduwaili, J., Zhang, Z. Y., and Jiang, F. Q. (2015). Assessment of the distribution, sources and potential ecological risk of heavy metals in the dry surface sediment of Aibi Lake in Northwest China. *Plosone10*(3).

Agabiti, N., Ancona, C., and Forastiere, F. (2001). Short term respiratory effects of acute exposure to chlorine due to a swimming pool accident. *Occup. Environ. Med., 58*, 399–404.

Akpor, O., Ogundeji, M., Olaolu, T., and Aderiye, B. (2014). Microbial roles and dynamics in waste water treatment systems: An overview. *Int J Pure Appl Biosci., 2*(1), 156–168.

Al Naggar, Y., Khalil, M. S., and Ghorab, M. A. (2018). Environmental pollution by heavy metals in the aquatic ecosystems of Egypt. *Open Acc J of Toxicol., 3*(1), 1-9.

Alahuhta, J. (2017). Geographic patterns of lake macrophyte communities and species richness at regional scale. *J. Veg. Sci., 26*, 564–575.

Albertoni, E. P, and Palma-Silva, C. (2007). Macroinvertebrate fauna associated with *Pistia stratiotes* and *Nymphoides indica* in subtropical lakes (south Brazil). *B.J.B 7*(3), 499-507.

Alexander, R., Boyer, E., Smith, R., Schwarz, G., and Moore, R. (2007). The role of headwater streams indownstream water quality. *Journal of the American Water Resources Association 43*, 41-59.

Ali, H., Khan, E., and Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals:environmental persistence, toxicity, and bioaccumulation. *Journal of Chemistry* -14.

Andersson, I, and Fenger, B. (2003). Environment and human health. *European Environment Agency* 250-271.

Andrews, K. W., Savitz, D. A., and Hertz-Picciotto, I. (1994). Prenatal lead exposure in relation to gestational ageand birth weight: a review of epidemiologic studies. *American Journal of Industrial Medicine 26*(1), 13-32.

Ani, K., and Eugenia, P. L. (2017). Waste water purification potential of *Eichhornia crassipes* (water hyacinth). *International Journal of Current Microbiology and Applied Sciences, 6*(12), 3723-3731.

Annabi, B. A., Nehdi, A., and Hajjaji, N. (2007). Antioxidant enzymes activities and bilirubin level in adult rattreated with lead. *Comptes Rendus Biologies, 330*(8), 581-588.

Aoi, T., and Hayashi, T. (1996). Nutrient removal by water lettuce (Pistia stratiotes). *Water Sci Technol, 34*:07–412. Aoi, T., and Ohba, E. (1995). Rates of nutrient removal and growth of the water lettuce (*Pistia stratiotes*) . *6th International conference (book) on the conservation and management of lakes Kasumigaura' 95.*

APHA, (2012). *Standard methods for the examination of water and wastewater.* (22nd Ed.) Washington D.C:American Public Health Association.

Areguamen, I. O., Oluwasesan, B. M., and Ekwumengbo, P. (2013). Heavy metals evaluation of Madna Stream'sediment in Kubokun village of Abuja Metropolis . *Adv. Appl. Sci. Res., 4*(6), 237-241.

Arroyo-Rodríguez, V., Pineda, E., Escobar, F., and Benítez-Malvido, J. (2009). Value of small patches in theconservation of plant-species diversity in highly fragmented rainforest. *Conservation Biology, 23*, 729-739.

O'Hare, M. T., Aguiar, F. C., Asaeda, T., Bakker, E. S., Chambers, P. A., and Clayton, J. S. (2017). Plants in aquaticecosystems: current trends and future directions. *Hydrobiologia, 153*, 1–11.

Odum, H.T. 2016. *Heavy Metals in the Environment: Using Wetlands for their Removal.* Boca Raton FL. CRC PressOmbaka, O., Gichumbi, J., Mukono, S., and Kibara, D.

(2013). Effect of human activities and seasonal variation onwater quality of Nkenye (Chikuu) stream in Chuka, Kenya. *International Journal of Modern Chemistry, 4*(1), 50-65.

Sehar, S., Aamir, I., and Ali, N. (2013). Sehar, S., Aamir, I. and Ali, N. (2013). Reduction of contaminants indomestic waste wwater through hybrid constructed wetland. Islamabad. Hindawi

Sossey-Alaoui, K., and Rosillon, F. (2013). Macrophytic distributtion and trophic state of some natural and impactedwatercourses – Belgium Wallonia. *Int. J. Water Sci.*, *2*(2), 1-11.