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An Assessment of Water Quality Variation On Human Health in the River Sosiani Catchment, Kenya

George Ontumbi
Graduate Student(Msc. Hydrology and Water Resources) Kenyatta University, Kenya.
email: ontumbigeorge@yahoo.com

Charles Nyabero
Lecturer University of Eldoret School Education,
Kenya.

Catherine C. Sang
Lecturer University of Eldoret School of Environmental studies,
Kenya

Abstract: **The aim of the study was to assess the water quality variation on human health in the river Sosiani catchment in Kenya. The research objectives for the study were; to analyze the spatial-temporal variation of Feacal coliforms in water samples in River Sosiani, identify the waterborne diseases occurring in the River Sosiani catchment and recommend and mitigate on the spread of waterborne diseases. The study adopted experimental research design where samples of river water were collected for laboratory testing. The water samples were later subjected to standard test procedures for Feacal Coliforms concentration during the wet and dry seasons. One way ANOVA and paired t-tests analysis were used to determine statistical significant variations in Feacal Coliforms along the river. During the dry season FC ranged from 28cfu/100 ml at Flax to 396 cfu/100 ml at the Kipkaren Bridge with a mean value of 161.94 ± 19.46. On the other hand during the wet season the Feacal coliforms had mean concentrations ranging from 26 cfu/100 ml at Flax to 430cfu/100 ml at the Kipkaren Bridge with a mean value of 181.60 ± 21.16. The study recommends further research on tracking the sources and quantities of Feacal pollution in Sosiani River.**

***Keywords*: Feacal Coliforms, Human Health, River Sosiani, Water Pollution and Water Samples**

1. Introduction

Water is a key priority issue for economic growth, employment, social development and environmental sustainability. Water is a resource that is vital to communities both for their own survival and their contribution to the society needs. Access to clean water is therefore the foundation of any sustainable community. Water resources management and development can also serve to protect societies from the destructive impacts of water and meet basic human needs. Rivers play a major role as sources of water for both domestic and industrial use in many parts around the world (Masese *et al*., 2012).

A major challenge for developing countries in achieving the Millennium Development Goals (MDG) and in particular the target with respect to safe drinking water and basic sanitation is finding ways to provide sustainable water supply and basic sanitation in small towns and rural areas. According to the World Health Organization (2008) 1.1 billion people have no access to safe drinking water. Water bodies have long been considered limitless dumping ground for wastes such as industrial effluents, raw sewage, eroded sediments and chemicals used for agricultural activities hence water quality is closely linked to water use and the state of economic development in countries. The world is on record to meet the Millennium Development Goals (Goal 7 Target 10 of the MDGs: Safe water and basic sanitation) adopted by the UN General assembly in 2000 and revised after the world summit on sustainable development in Johannesburg (WHO/UNICEF 2004).

Faecal pollution to water sources is a serious threat to the quality of water with a negative impact on the integrity of aquatic ecosystems and therefore is a risk to the health of the community consuming water from such sources. It is believed that 80% of all diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water (WHO/UNICEF 2004). Rop (2012) eludes that in areas where water for domestic purposes is unreliable in quality the child mortality rate is high causing more than three million deaths from diseases caused by unsafe water. A Ministerial statement from the World Water Forum (2000) at the Hague-Netherland called for efforts to guarantee that every person has access to enough safe water at an affordable cost to lead a healthy and productive life and emphasized that the vulnerable people are protected from the risks of water related health hazards.

Pollution of river waters with deleterious microbes, including bacteria, viruses, parasites and fungi, has been on steady increase in the recent past (Abraham *et al.*, 2007). For surface waters, total coliforms, Feacal coliforms and *E. coli* are used to indicate the possible presence of harmful pathogens derived from human or animal waste. Entry of pathogens into rivers can occur either from a point source, non- point sources or both. According to Petersen *et al*., (2005) and Donovan *et al*., (2008) Non- point source microbial pollution of rivers occurs from rainwater surface run-offs, storm sewer spillages or overflow, while point-source pollution comes from discharge of untreated or partially treated effluents from wastewater treatment plants.

2. Research Design and Methodology

2.1 Research Design

This study adopted experimental research design where the natural environment is exposed to an intervention in its own environment and the researcher observes a phenomenon and attempts to establish what caused it (Kumar 2011). The sampling sites were selected in anticipation that the samples varied in water quality in the vicinity and upstream of the sampling points. Once the

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water samples were collected they were subjected to standard procedures for testing of the biological indicators (feacal coliforms) of water quality.

2.2 Sampling procedure

According to Kumar (2011) the researcher knows that the environment is being exposed or has been exposed to an intervention and wishes to study its impact on the environment. The variation in water quality and hence occurrence of water borne diseases would be attributed to the various human activities within the River Sosiani. Based on the occurrence of water borne diseases four sites identified for water sampling namely; Flax Bridge, Plateau Bridge, Nairobi Road Bridge and the Kipkaren Bridge points.

2.3 Study area

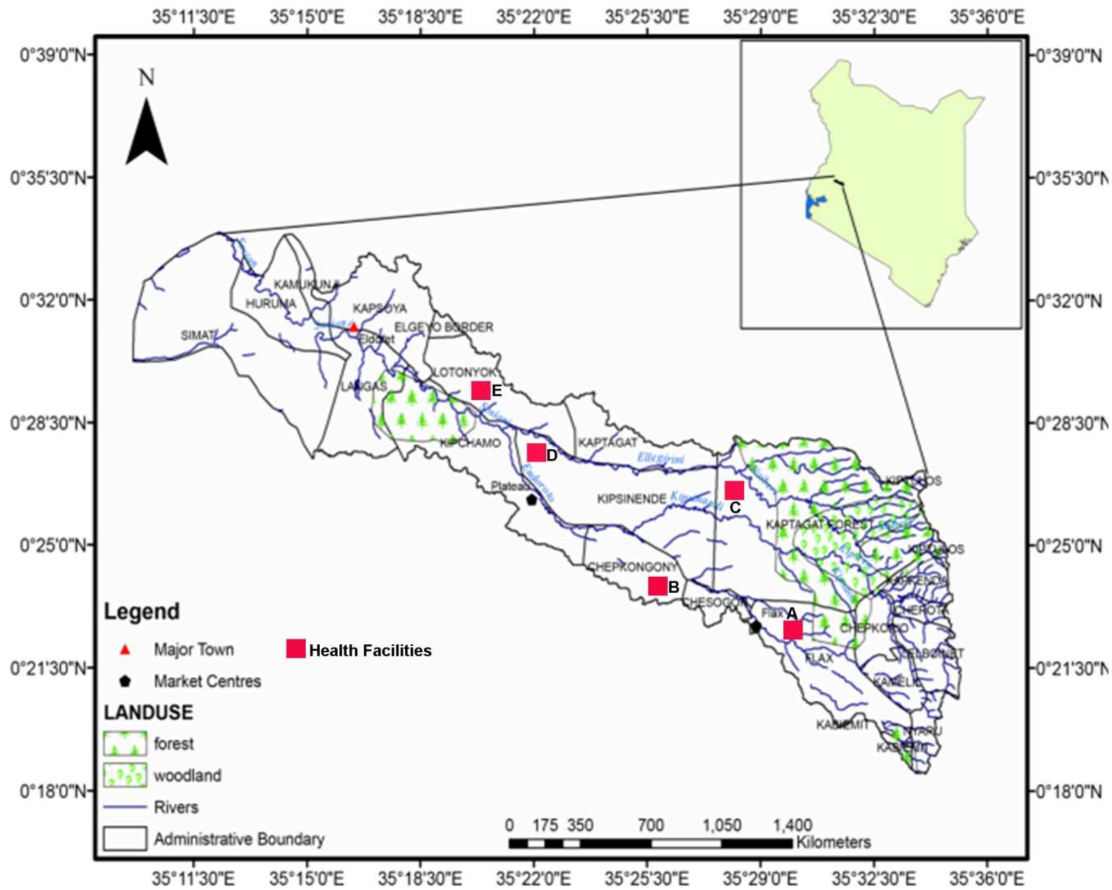

Figure 1: River Sosiani catchment area showing the location of the health facilities.

The health facilities in the study area are labeled A, B, C, D and E in figure 1. These facilities included A: Chepkero, B: Katuiyo, C: Cheptigit, D: Plateau and E denoted Ngelel Tarit. The Chepkero, Katuiyo and Cheptigit were located upstream while Plateau and Ngelel Tarit health facilities were located downstream of the Sosiani River catchment. The areas around Chepkero, Katuiyo and Cheptigit health facilities have Forestry, crop cultivation and livestock keeping as the main activities while the areas around Plateau and Ngelel Tarit have settlement and intensive agriculture.

2.3 Data collection

Both primary and secondary data was used. The primary data was obtained by collecting water samples from the river during the dry and wet season and subjected them to laboratory testing to establish the status of biological qualities. The secondary Data on the occurrence of water borne diseases within the river Sosiani catchment were obtained from the Uasin Gishu county public health officer.

2.4 Data collection procedure

The water samples were collected from four sites a long river Sosiani during both the dry and wet seasons where the distance from one sampling station to the next one was approximately 6 kilometers for a fair comparison of the biological parameters that were analyzed. Before water sampling the water sample bottles were cleaned by soaking in a detergent for 24 hours, followed by rinsing with tap water until they were free of the detergent and rinsed with distilled water. The water samples were collected from the deepest and mid-section of the river channel using Sterilized sample bottles in triplicate.

2.5 Data Analysis

Data was coded and inferences made (Kombo and Tromp, 2006), collected data on water samples was analyzed using inferential statistical techniques. Data on biological water quality parameters were analyzed using a Statistical Package for Social Sciences (SPSS version 20) where the seasonal and site variations for feacal concentration for the wet and dry seasons and amongst the four sampling sites were performed using ANOVA. In comparing the variance ANOVA was used for Flax and Kipkaren sites due to the anticipated apparent changes in water quality. In all the analysis, 95% level of significance was used as the critical point ($P < 0.05$).

Variations in sampling sites for the biological water quality parameter was performed using t-test for paired variables were specifically used to compute the statistical significance of the parameters concentration in each sampling station along the River Sosiani. In all the analysis, 95% level of significance was used as the critical point ($P < 0.05$).

3 Results and Discussion

3.1 Variation of Feacal Coliforms

Table 1: Mean values and Ranges of Feacal Coliforms in River Sosiani January to June 2014

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
	Flax	12	35.00	5.62	1.62	28.00	42.00
FCD	Plateau	12	44.50	10.38	2.10	34.00	60.00
	Nairobi	12	232.75	69.19	19.97	120.00	290.00
	Kipkaren	12	335.50	43.12	12.45	286.00	396.00
	Flax	12	32.00	4.67	1.35	26.00	38.00
FCW	Plateau	12	53.25	15.09	4.36	42.00	78.00
	Nairobi	12	299.67	55.84	16.12	230.00	360.00
	Kipkaren	12	341.50	54.84	15.83	294.00	430.00

Where: FCD- Feacal coliforms dry season and FCW- Feacal coliforms wet season

Feacal coliforms differed in all the four sampling sites during both the dry and wet seasons as shown in table 1. During the dry season Kipkaren recorded 396.00 Cfu/100ml which were the highest quantities of Feacal coliforms while Flax recorded the lowest maximum of 42.00 Cfu/100ml. On the other hand also during the wet season the Kipkaren Bridge sampling point recorded the highest quantities of coliforms at 430.00 Cfu/100ml while the Flax point recorded lowest at 38.00 Cfu/100ml. The apparent increase of Feacal coliforms in both the dry and wet season upstream and downstream was attributed to the increased surface runoff during the wet season as compared to the dry season.

3.2 Feacal coliforms

Feacal coliform get into the water through untreated sewage, poorly maintained septic systems, un-scooped pet waste, and farm animals with access to streams can cause high levels of feacal coliform bacteria to appear in a water body (Wakuli *et al.*, 2011). Feacal coliforms were measured to assess possible locations where microbial contamination was entering the Sosiani River and generally the Concentrations tended to vary by site and seasons.

According to UNICEF (2008) Feacal coliform bacteria are living organisms, unlike the other conventional water quality Parameters and multiply rapidly when conditions are good for growth and die in large quantities when they are not. When the Feacal coliform counts are high (over 200 colonies/100 ml of a water sample) in a body of water, there is a greater chance that disease causing organisms are also present.

Table 2: ANOVA Analysis of Feacal coliforms during the January to June 2014

ANOVA						
		Sum of Squares	Df	Mean Square	F	Sig.
FCD	Between Groups	28308.563	3	9436.188	.502	.683
	Within Groups	826862.250	44	18792.324		
	Total	855170.813	47			
FCW	Between Groups	28780.563	3	9593.521	.430	.733
	Within Groups	981678.917	44	22310.884		
	Total	1010459.479	47			

Where: FCD is the Feacal coliform concentration during the dry season FCW is the Feacal coliform concentration during the wet season

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During the dry season Feacal coliform ranged between 28 cfu/100 ml at Flax to 396 cfu/100 ml at the Kipkaren Bridge with a mean value of 161.94 ± 19.46. The concentrations of Feacal coliforms during the dry season did not differ significantly (ANOVA f = 0.502, d.f =3 and $p > 0.05$) between the wet and dry season.

During the wet season the Feacal coliforms had mean concentrations ranging from 26 cfu/100 ml at Flax to 430 cfu/100 ml at the Kipkaren Bridge with a mean value of 181.60 ± 21.16. The concentrations of Feacal coliforms did not differ significantly during the dry and wet seasons (ANOVA f= 0.430, d.f =3 and $p > 0.05$).

3.5 Feacal concentration between the sites.

Table 3: ANOVA Analysis of Feacal coliforms in different sites (January to June 2014)

		Sum of Squares	d.f	Mean Square	F	Sig
FCD	Between Groups	780516.56	3	260172.19	153.34	.00
	Within Groups	74654.25	44	1696.67		
	Total	855170.81	47			
FCW	Between Groups	940339.56	3	313446.52	196.69	.00
	Within Groups	70119.92	44	1593.63		
	Total	1010459.48	47			

Where: FCD is the Feacal coliform concentration during the dry season
FCW is the Feacal coliform concentration during the wet season

The concentration of Feacal coliform differed significantly between the sampling sites during the dry season (ANOVA d.f = 3, F= 153.34 and $p < 0.05$). Similarly also the concentration of Feacal coliform differed significantly between the sampling sites during the wet season (ANOVA d.f = 3, F= 196.69 and $p < 0.05$).

3.6 Feacal concentrations along different sampling sites

The levels of Feacal coliforms concentrations during the dry and wet seasons in the River Sosiani are shown in Figure 2. The Feacal coliforms differed between the wet and dry seasons; however the concentrations were higher throughout the wet season. There were negligible changes in the levels of Feacal coliforms between Flax and Plateau sampling points during both the dry and wet seasons. However the levels of Feacal coliforms increased rapidly between the Plateau and the Kipkaren sampling in both the dry and wet seasons with the highest quantities recorded at Kipkaren Bridge. The concentration of Feacal coliforms had higher mean values in samples collected during the rainy season than samples from dry season. This would have been attributed to the contribution of surface run off which increased the load of Feacal contamination indicators. The high quantities of Feacal coliforms between the Nairobi road and the Kipkaren sampling points was attributed to the disposal of wastes washed to the river from the settlement estates and streets of Eldoret town.

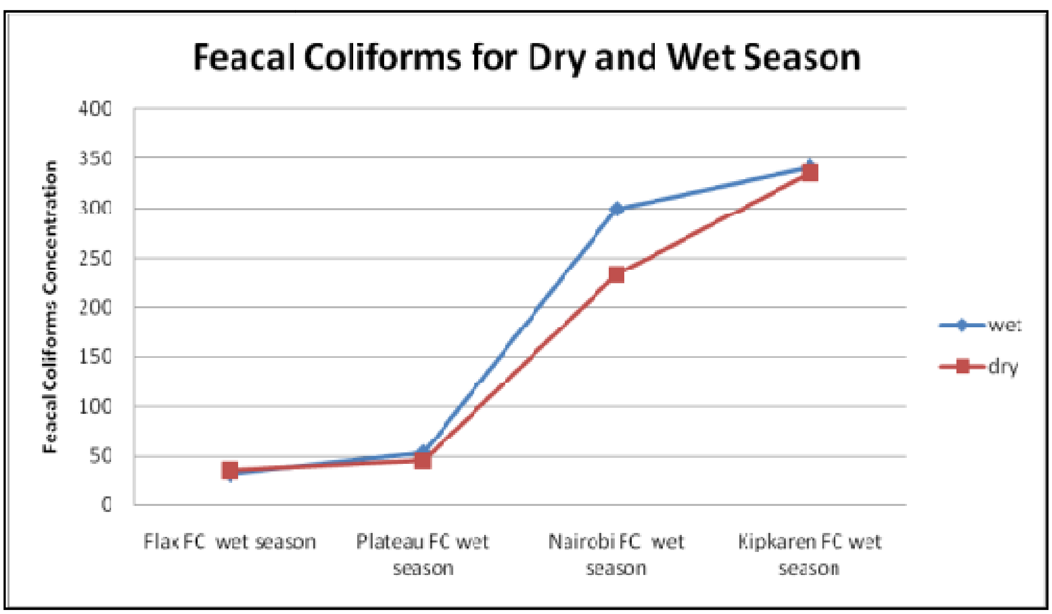

Figure 2: Feacal concentrations in different sampling sites in River Sosiani during the Dry and Wet seasons (January to June 2014)

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3.7 Waterborne Diseases

According to UNICEF (2008) waterborne diseases include Diarrhea disease, cholera, dysentery, typhoid and infectious hepatitis. The health facilities were picked depending on where they are located relative to the water sampling sites as indicated in figure 2. The Chepkero health facility is located upstream around Flax area while Chepkero health facility is located upstream of the Kipsinende River a tributary of river Sosiani. The Chepkero health facility recorded 3% of the total number of treated cases in the period February to June 2014. The highest cases of waterborne diseases reported in Chepkero during the period of study were Diarrhea.

Table 4: Treated cases of waterborne diseases within the River Sosiani catchment (Jan to June 2014)

HEALTH FACILITY	DISEASES	NUMBER OF CASES					
Ngelel Tarit		JAN	FEB	MAR	APR	MAY	JUN
	Diarrhea	59	71	102	63	101	96
	Typhoid	19	0	13	12	12	15
	Cholera	0	0	0	0	0	0
Chepkero	Amoebiosis	8	0	0	4	6	2
	Diarrhea	50	38	36	12	53	35
	Typhoid	0	0	0	0	1	0
	Cholera	0	0	0	0	0	0
Katuiyo	Amoebiosis	2	0	0	3	1	1
	Diarrhea	7	14	32	14	32	21
	Typhoid	7	2	13	8	9	5
	Cholera	0	0	00	0	0	0
Plateau Mission	Amoebiosis	0	2	0	0	0	0
	Diarrhea	49	113	85	22	51	30
	Typhoid	10	44	32	39	46	43
	Cholera	0	0	0	0	0	0
Cheptigit	Amoebiosis	2	12	4	0	0	0
	Diarrhea	43	54	69	25	41	38
	Typhoid	0	0	0	0	0	1
	Cholera	0	0	0	0	0	0
	Amoebiosis	2	0	0	0	1	0

Source: Uasin Gishu county public health office (2014)

Cheptigit and Katuiyo health facilities are located in the upper courses of the Nondoroto and Naiberi tributaries. The cases of waterborne diseases treated in the Katuiyo health facility represented 6.4% while 13.1% of waterborne diseases were treated in the Cheptigit health facility. The Plateau Mission recorded 27.9% of the treated cases while the Ngelel Tarit recorded 41.7 % of the waterborne diseases treated. Fecal coliforms were statistically different by site when the Feacal coliform concentrations were statistically analyzed. The health facilities were picked depending on where they are located relative to the down slope flow of River Sosiani. The Chepkero health facility located in Flax area around the source River Sosiani recorded the least number of waterborne diseases treated which was attributed to the lower levels of Feacal contamination in the river. Other than the protected land upstream at Flax and Plateau all other locations had relatively high fecal coliform hence possibility of water contamination problems.

In all the sampling sites the levels of E.coli exceeded the WHO/NEMA recommended levels of Nil/100ml (GoK 2006). According to Ogutu (2008) one of the major factors for the inadequate human resource development in the Nyando basin is lack of access to safe drinking water leading to an upsurge of water borne diseases. Ogutu (2008) further asserts that with the rapid population growth in the Nyando basin more pressure is being placed on the land and water resources this has made the land to be more degraded leading to further water quality degradation.

3.8 Conclusions

Microbiological contamination in the Sosiani River seems to be a result of land use activities and development in the catchment but no specific source could be identified from this study. Other than the protected land upstream at Flax and Plateau all other locations had relatively high fecal coliform hence possibility of water contamination problems. In all the sampling sites the levels of E.coli exceeded the WHO/NEMA recommended levels of Nil/100ml (GoK 2006).

Similar findings are supported by Rop (2012) whose research work concluded that there existed Feacal pollution in Nyangores River which was indicated by positive correlation between E. coli and C. perfringens which are disease causing vectors and further according to the Public Health Office in Ruiru District, where Githurai is located, in year 2010 the majority of cases with diarrheal diseases (typhoid, Amoebiasis, etc) which are waterborne diseases were between 30 and 40% of all the patients seeking medical care (*Kaluli et al., 2011).*

3.9 Recommendations

Water from Sosiani River is not safe for human consumption hence there is a need for further research on water treatment and sensitize the community using the water on its quality and its potential danger to their health. Finally further research on tracking the sources and quantities of Feacal pollution in Sosiani River is recommended.

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Author's Profile

Mr George Morara Ontumbi
Contact: 0721314191
email: ontumbigeorge@yahoo.com
Moi university B.Ed Geography (Major) and Economics
Currently Undertaking M.sc in Hydrology and water Resources (Kenyatta University).
Current position: Lecturer Ollessos Technical Training Institute, Kenya

Dr Charles Nyabero
PhD (moi University) M.Ed (moi University), B.Ed (Kenyatta university), Dip Ed(Siriba Teachers college), Dip HR (Baraton University)
Lecturer School of Education, University of Eldoret, Kenya.

Mrs. Catherine Chebet Sang
M.Phil Environmental Studies (Moi University), B.Ed Arts (Kenyatta University)
Lecturer School of Environmental studies, University of Eldoret, Kenya.