Original Research Article

Analysis of Fecal Coliform Levels at Watering Points along the Upper Reaches of River Isiukhu in Kakamega County, Kenya

Abstract

Diarrheal diseases often attributable to poor sanitary conditions and fecal contamination of drinking water remain a leading cause of mortality for children younger than five years. Water contaminated with human faeces, for example from municipal sewage, septic tanks and latrines, is of particular concern. Animal faeces also contain microorganisms that can cause diarrhea. Kakamega County in Kenya has a diarrhea prevalence rate of 20.2%, which is the highest in the country; a good proportion of these cases are believed to be water borne. This study was designed to determine faecal coliform levels in water samples collected from watering points along the upper reaches of River Isiukhu in Kakamega County, Kenya. Fifty-four samples were collected between August and October 2015 from nine sampling points, comprising springs and watering points along the river. Water samples were filtered on nitrocellulose filters by vacuum filtration; faecal coliform counts were conducted using membrane filters cultured on mFC agar to establish contamination levels. The results indicated that counts ranged from 200cfu/100ml - 1450cfu/100ml in river sampling points and ranged from 0cfu/100ml - 44cfu/100ml in springs sampling points. The faecal coliform counts for River Isiukhu and most springs surrounding it exceeded the WHO recommended drinking water coliform(or *E.coli*) count value of 0cfu/100ml indicating that water from the upper reaches of River Isiukhu and springs is not fit for drinking before treatment, especially during the wet seasons, based on WHO drinking water standards.

Keywords: Faecal-coliform, Contamination, River-water, Spring-water, Season

Introduction

Water has been classified as a natural resource and is important in sustaining life. Ashbolt *et al*., (2001) reported that the accessibility and availability of clean drinking water not only plays a vital role in economic development and social welfare, but is also an important component in health, food production and poverty alleviation. Despite its significance, WHO (2006) revealed that safe potable water is not accessible by about 1.1 billion people in the world, and the hourly toll from biological contamination of drinking water is 400 deaths of children below the age of five. In most developing countries, Kenya being one of them, the demand for clean drinking water supply is growing rapidly (Gelover *et al.,* 2006). In addition, a small percentage of people in these countries access piped water. Therefore, those who do not have access to safe drinking water, as well as those who have access but cannot afford it; rely on other sources of water of questionable quality (Gadgil, 1998). It is often assumed that spring water emerges from the ground clean and free of contaminants, especially in rural areas where industrial contamination is not present (Wampler *et al.,* 2010). Many rural Kenyans know that drinking untreated water from surface streams and rivers is not safe but, they often assume that water emerging from the ground at a spring is clean and safe to drink.

Although not absolute, several pathogenic microorganisms have been recommended as indices of faecal pollution and act as indicators of microbiological quality of domestic water (WHO, 2003; Kabler and Clark, 1960; Abera *et al.*, 2011). According to WHO (2006), drinking water should contain zero fecal coliform and coliform organisms per 100 ml. However, human activities, particularly urbanization, and waste disposal and agricultural practices have greatly increased inputs of microbial and other pollutants to terrestrial and aquatic habitats (Smol, 2009). Therefore, the present study sought to establish the level of faecal coliform in sampling points in the upper reaches of River Isiukhu.

Materials and Methods

Study area

The study was carried out along River Isiukhu, Kakamega County, Kenya. The average annual rainfall of Kakamega County is 1800mm per annum and is bimodally distributed with peaks in April-May and August-September. Temperatures range from a minimum of 10.3°C to a maximum of 30.8°C with an average of 20.5°C. Anthropogenic activities are done along the river such as agriculture, livestock watering, laundry and bathing and sewage disposal.

Sample collection

The sampling sites were River Isiukhu and springs along it. The sites were randomly chosen and they represented the upper reaches of the river as shown in Table 1. In the study, samples were collected in three successive months (August, September and October). Approximately 250ml of water samples were aseptically collected in duplicates from watering points using sterile containers and immediately stored in an ice box before being transported to the laboratory for analysis. Water samples were collected from a depth of about 10-20 cm below the water surface at each site to avoid potential contamination from surface water.

Table 1: River and spring sampling sites

Site	**Label**
Forest	S1
Confluence of Lianila stream and Isiukhu River	S2
Savona resort area	S3
Amalemba	S4
Waste water entry point	S5
Spring 1	SP1
Spring 2	SP2
Spring 3	SP3
Spring 4	SP4

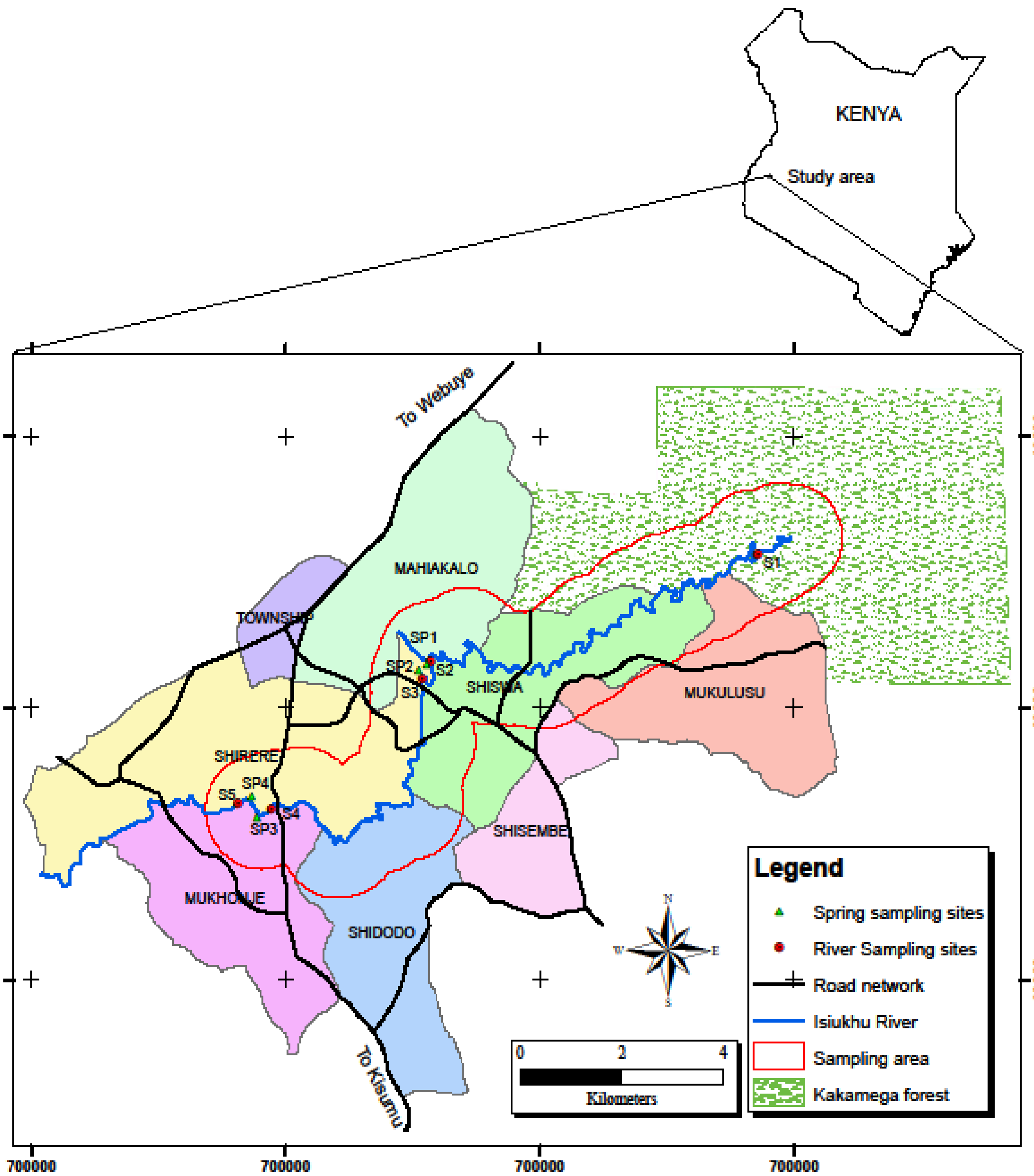

Figure 1

Sampling sites (S1-S5) and (SP1-SP4) in the upper reaches of River Isiukhu Kakamega County, Kenya. Map drawn to scale using Arc GIS software (units in UTM).

Research Design

The present study adopted randomized sampling design, where Fifty four duplicate samples were collected between the month of August and October 2015 from nine sampling points along the river and springs that represented the upper reaches of River Isiukhu.

Determination of faecal coliform levels at watering points and springs along the upper reaches of River Isiukhu.

Faecal coliform levels in water samples were determined by the membrane filter procedure using mFC agar (Hi Media, India).The samples collected from the river were diluted to 1:100. The biomass from both spring and the diluted river-water samples (100ml) was concentrated via subsequent filtration on nitrocellulose filters, 47mm diameter with pore size of 0.45µm by vacuum filtration. The vacuum pressure for filtration was between 50mm to 70mm Hg in order to avoid rupture of bacterial cells that has been observed at pressures above 80 mm Hg (Kepner and Pratt 1994). Following the method recommended by the American Public Health Association in 2006 (Wehr *et al.*, 2004; Britton and Greeson 1987) filters were then aseptically placed with grid side up onto the surface of the plates of mFC. All plates were incubated inverted in watertight plastic bags submerged in a 44.5^{o}C water bath for 22-24 hours. Fecal coliform colonies that were observed in any shade of blue color were counted using a Quebec colony counter and recorded as colony-forming units per 100ml. The formula used was:

$$CFU/100mL = \frac{Colonies\ counted}{mL\ filtered} \text{X } 100$$

Data analysis

Data obtained on coliform counts was subjected to one-way ANOVA followed by Turkey's post hoc test at 95% confidence level using Winks software version 7.

Results

Table 2 shows the mean counts of faecal coliforms from five different sampling points in River Isiukhu for three successive months. There was a significantly high (p<0.05) faecal coliform concentration between sampling point, S5 and all other sampling points in the river in the month of August. Sampling point, S2 also recorded significantly higher (p<0.05) coliform counts when compared to S1 in the month of October. In the month of September, S2 and S5 had visibly higher coliform counts per 100ml, though they were not significantly different from the rest of the samples. Generally, fecal coliform counts were lowest at S1 and highest at S5in all the three month of the study.

Table 2: Means of Faecal coliform count given in colony forming units /100mls for five sampling points from River Isiukhu for three consecutive months

Sample code	Environment	Aug.	Sept.	Oct.
S1	Forest (site 1)	200±0.00[a]	600±141.42[a]	600±424.26[a]
S2	Confluence of Lianila stream and River Isiukhu	300±141.42[ab]	1050±1343.50[a]	1700±424.26[b]
S3	Savona resort area	550±494.97[ab]	750±636.40[a]	950±353.55[ab]
S4	Amalemba area	450±353.55[ab]	900±848.53[a]	1050±636.40[ab]
S5	Waste water entry point	1450±212.13[c]	1050±353.55[a]	950±212.13[ab]

*Means followed by the same letter within the same column are not significantly different at *P <0.05*

Faecal coliform count for four sampling points from springs along River Isiukhu

Table 3 shows the mean counts for fecal coliform from four different springs for three consecutive months. Generally, the month of October recorded higher coliform count compared to September and August. The month of August recorded few counts across all the springs, in the three months studied. However, it is important to note that there was no significant difference in the counts for all the months studied. In the month of August, spring SP1 recorded no coliform counts, however, increasing counts were recorded in the month of september and October.

Table 3: Means of Faecal coliform count given in colony forming units /100mlfor four sampling points from spring for six sessions

Sample code	Environment	Aug.	Sept.	Oct.
SP1	Confluence of Lianila stream and River Isiukhu	0±0.00[a]	5±7.07[a]	6.5±4.95[a]
SP2	Savona resort area	3±1.41[a]	3±2.83[a]	44±46.67[a]
SP3	Amalemba area	2.5±3.54[a]	6.5±4.95[a]	6.5±4.95[a]
SP4	Waste water entry point	5.5±4.95[a]	6.5±2.12[a]	36.5±43.13[a]

*Means followed by the same letter within the same column are not significantly different at P <0.05

Discussion

Generally, coliforms are the most common group of indicator organisms used in water quality monitoring (Sibanda *et al.*, 2013). Furthermore Alotaibi (2009) elaborated that the presence of fecal coliform indicates the presence of potential fecal contamination and the presence of possible pathogenic microorganisms and to determine the health risk to the consumers. In the present study, significant variation of fecal coliform counts in River Isiukhu was reported during the three months of the study. This difference is attributed to rainfall variation within the three months. Lower rainfalls are normally experienced in the month of August than in the month of October. Similar observations have been made elsewhere, for instance, Wolf (1999) reported that in the dry season, there were fewer incidences of faecal pollution in the water supply system but high fecal contamination of drinking water increases during wet season.

Results in the present study further indicated significant differences in means for fecal coliforms in samples taken from the different sampling points in River Isiukhu. This finding agrees with a previous study carried out on River Danube which showed lower bacterial pollution on upstream of the River and higher levels of fecal pollution in the middle part and downstream of the River (Kavka *et al*., 2002). However, the finding in this study disagrees with that of Uwimpuhwe (2014) where total and fecal coliform from different sampling points in River Nyabarongo showed insignificant differences. This difference could be attributed to the fact that the current study of River Isiukhu included survey of sampling points with different anthropogenic activities taking place at every point.

According to the WHO guideline values for bacteriological parameters, the total and fecal coliform bacteria should be 0 cfu/100ml in water intended for drinking. However, in this study the fecal coliform counts for River Isiukhu, exceeded the WHO recommended drinking water guideline value. These results are supported by previous studies conducted in rural areas (Abera *et al.,* 2011; Chigor *et al.,* 2011). The studies found that microbiological parameters counts for river water in rural areas were above the permissible limits and were a potential hazard to public health (Chigor, 2011). Even though, WHO recognizes that these targets would be difficult to achieve in some cases, especially in rural communities with untreated water provisions, and recommends that in these settings, the guidelines values would be seen as goals for the future, but not an immediate prerequisite (WHO/UNICEF**,** 2008)

Although findings from the study reported insignificant difference in fecal coliform counts from different springs during the three months studied, the water was unsafe to drink based on the World Health Organization (WHO) drinking water standard. Both protected and unprotected springs had bacterial counts in excess of the WHO standard, suggesting that water treatment from all sources is necessary to ensure clean and safe drinking water. The spring water contamination could be due to what Narain Rai and Sharma (1995) termed as lack of sanitation or improper waste disposal. The researchers further explained that 40% or more of the disease out breaks were attributed to consumption of polluted ground water. Furthermore, presence of coliforms in drinking water sources indicates need for treatment and proper sanitation which is necessary for drinking (Christine *et al.,* 2006). Further the destruction of microbial ecosystems through deforestation, high spring water temperatures, averaging 24.4^0C, may be contributing to the observed bacterial abundance.

Findings from the study indicate that springs have more fecal coliform contaminants during wet season. This finding is not different from that of Ofoma *et al.,* 2005) where spring water was highly contaminated with fecal coliform during wet seasons compared to dry seasons. They suggested that the contamination was due to pollution; most likely from sewage as well as solid waste discharge during run-offs. This is non-point sources typically wet-weather where they diffuse in nature, in that they do not enter water bodies from any single point (e.g. urban litter, contaminated refuse, domestic pet/wildlife excrement and failing sewer lines).This suggests that emphasis on points of use (POU) treatment methods, decontamination of protected and unprotected springs, and behavioral interventions to improve sanitation practices are needed.

Conclusion

Results obtained from the study indicated significant contamination of River and spring water at different sites. The levels of faecal coliforms were higher than the accepted levels. In addition, higher faecal coliform levels were recorded during wet than dry seasons, concluding that water from the upper reaches of River Isiukhu and spring is not fit for drinking before treatment especially during wet seasons based on the WHO drinking water standard and the water quality. It is therefore recommended that water from both the stream and springs in the upper reaches of River Isiukhu should be treated before use.

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