Effects Of Human Activities On Microbial Water Quality In Nyangores Stream, Mara River Basin

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Abstract: This paper presents an assessment of the effects of human activities on the microbial water quality along Nyangores stream. Seven sampling stations were selected to correspond to different human activities along the stream. Physical and chemical water quality parameters were measured *in situ* using measuring probes and coliform bacteria determined using the membrane filtration technique (MFT). Significant variation ($p<0.05$) of physical chemical parameters were observed downstream. The same trend was observed with total coliforms and *Escherichia coli.* Higher densities of bacteria were recorded during the wet season. We conclude that human activities influenced the quality of water in Nyangores stream.

Key words: Human activities, Total coliforms, E. *coli*, water quality, Nyangores stream

1 INTRODUCTION

Rivers and streams are very important ecosystems for socio-economic development and sustainability of the environment since they provide a variety of valuable functions to the environment, national economies and the communities that depend on them [1], [2]. However, the systems are unable to provide basic functions to the rapidly growing population because they are threatened by pollution from various human activities [2], [3]. Most people in Kenya lack access to potable clean water hence rely on polluted surface water from streams or rivers [2]. During the dry period, people make frequent visits to rivers to either abstract water for domestic needs, water livestock, bath, swim and wash vehicles and clothes because other sources of water such as rainwater or pipe water are lacking [4],[5]. These activities may influence microbial water quality in shallow streams due to littering of faecal matter the surrounding area [2]. Waterborne diseases were not a problem in the Mara river basin in the past. However, an emergence of these diseases in the basin has been reported in the recent past [6]. This has been linked to effluent discharge from untreated or partially treated wastewaters from settlements and upcoming towns. The situation has been exacerbated by an ever increasing population growth rate in both the rural and urban areas. For instance, the volume of wastes in the Mara River is reported to have increased as a result of high population growth rate of 7% [7]. This study provides an assessment of the effects of human activities on the microbial water quality of the Nyangores stream, Mara River.

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2 MATERIALS AND METHODS

2.1 Study area

The Mara River is one of the ten rivers that drain into Lake Victoria. The research was conducted in Nyangores stream, a tributary in the upper catchment of the transboundary Mara River basin between Tanzania and Kenya (Fig. 1). The Nyangores stream is one of the two permanent tributaries of the Mara River, the other being the Amala River. These two rivers are very important for maintaining base flows in the Mara River mainstream and are the only source of water for the Maasai Mara Game Reserve (Kenya) and the Serengeti National Park (Tanzania). The Nyangores stream is located between longitudes 33º 47' E and 35º 47' E and latitudes 0º 28' S and 1º 52' S. It covers an area of 696km^2 and runs approximately 94km before joining Amala stream at Kaboson to form the main Mara River [8]. The area experiences two rainy seasons with the long rains starting in mid-March to June with a peak in April, while short rains occur between September and December [9]. The altitudes range between 2951m around the Mau Escarpment to 1706m downstream. The major land use in the Nyangores stream includes closed forest, and tea in the upper slopes, and agricultural land. Nyangores sub catchment covers Bomet and Nakuru counties with a total population of 225,458 residents. Agriculture is the dominant economic activity to the majority of the population and about 62% of the agricultural area is occupied by small scale farmers [8].

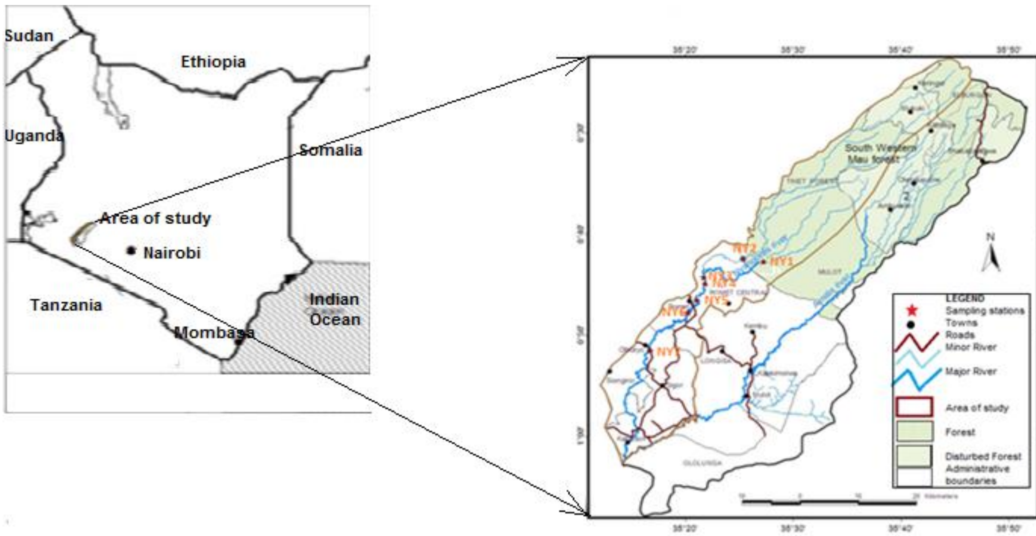

Figure 1: Map of Nyangores stream a tributary of the Mara River, Kenya showing sampling station

2.2 Sampling Design

2.2.1 Sampling stations

Sampling stations in this study were selected longitudinally based on different forms of degradation and prevailing human activities along Nyangores stream. A total of seven stations were selected, two (NY1 and NY2) were located in the forest to act as reference points. Three stations (NY3 NY4, and NY5) were located in sections of the river where small scale farming of tea, maize and potatoes interspersed with agro forestry and animal husbandry. These three stations were used to capture the effects of non-point sources of pollution. The effects of point source pollution were captured by selecting stations NY6 and NY7 downstream of Tenwek Hospital and Bomet Town, respectively, where semi-treated and untreated sewage is discharged into the river. In addition, runoff from Bomet Town during spates contributes non-point sources of pollutants into the river.

2.2.2 Physical chemical parameters

Water samples were collected from the seven sampling stations monthly from February to July 2012 to cover the wet (Mid March - June) and dry (February, Early March and July) seasons. Dissolved oxygen and temperature were measured using a DO meter (Model HACH HQ 4d) while pH and conductivity were measured using a combined meter (Model HACH Eco 40). Water velocity was determined using a Marsh-McBirney portable flow meter (MODEL 2000). Total suspended solids (TSS) were gravimetrically determined and (BOD_5) determined using Winkler's method according to APHA [10].

2.2.3 Coliform bacteria

Water samples for assessment of coliform bacteria were collected in using sterilized 500ml glass bottles 30 cm below the surface of water and transported on ice. The samples were processed within 6 hours of collection to avoid changes of bacterial count due to growth or die off. The Membrane Filtration Technique (MFT) as described in APHA (2002) was used in the analysis of samples for the presence of indicator organisms. Three appropriate dilutions were made for each faecal indicator. Dilutions were duplicated and drained through a 0.45 μm sterile membrane filters with a vacuum pump. Filters for Total Coliforms (TC) and Escherichia *coli* (*E. coli*) were incubated

on *Chromocult Coliform Agar (ISO 6222, OXOID)* at 37^0C for 24 hours. Typical colonies appearing pink to red and dark blue were counted as total coliforms and *E. coli* respectively. For all colonies forming units (CFU) counted, total numbers per 100 ml was expressed as [10];

$$Total\ numbers\ (per\ 100\ ml) = (CFU's \times Dilution/Volume\ filtered \times 100)$$

2.3 Data analysis

Statistical analyses were performed with the aid of Microsoft excel spreadsheet for windows 2007, Minitab™ version 14.0 for windows. Two-way ANOVA test was used to test for variations in physical chemical parameters and post hoc Duncan's Multiple Test was used to compare means among station. Pearson correlation analysis was performed to investigate the relationship between coliform bacteria and physical chemical parameters.

3 RESULTS

3.1 Physical chemical parameters

The results of physical chemical parameters studied are recorded in Table 1. ANOVA analysis showed significant differences of these parameters among stations. The highest temperature recorded during the study period was (22.9 ± 0.66 ºC), station NY1 and NY2 differed significantly ($p<0.001$) with other stations downstream. The dissolved oxygen levels were almost uniform during the study period with stations NY3 and NY6 differing significantly from other stations ($p <0.001$). Significant spatial variations were also recorded in pH and conductivity with highest pH and conductivity levels in station NY3 and NY7 respectively. The highest values of total suspended solids (TSS) and discharge were recorded at station NY7 while the least occurred in station NY1. A seasonal pattern in which higher values of TSS and discharge was observed in the wet season than in the dry season. Station NY6 recorded the highest biological oxygen demand (BOD) levels (2.5 ± 0.04 mg/l) and lowest in station NY1 (1.4 ±0.10 mg/L). Station NY1 was significantly different from the rest of the stations downstream ($p<0.001$).

Table 1: Mean (± SE) physical-chemical parameters of the study stations in Nyangores River, February- July 2012

Physical – chemical parameters	SAMPLING STATIONS						
	NY1	NY2	NY3	NY4	NY5	NY6	NY7
Temperature (ºC)	12.8 ± 0.34	15.1 ± 0.57	22.9 ± 0.66	21.1 ± 0.22	20.8 ± 0.38	19.5 ± 0.10	18.4 ± 0.40
DO(mgl^{-1})	7.6 ± 0.14	7.6 ± 0.03	7.1 ± 0.16	7.2 ±0.07	7.3 ± 0.01	6.2 ± 0.14	7.2 ± 0.18
DO% saturation	95.8 ± 1.44	96.2 ± 0.58	105.5 ± 2.47	103.5 ± 1.67	95.7 ± 6.38	85.5 ± 1.85	99.4 ± 0.73
pH	7.3 ± 0.12	7.5 ± 0.06	7.8 ± 0.14	7.7 ± 0.08	7.4 ± 0.10	7.5 ± 0.10	7.7 ± 0.09
Conductivity ($\mu s.cm^{-1}$)	55.3 ± 1.18	58.3 ± 1.46	74.5 ± 3.49	77.6 ± 4.29	82.0 ± 3.29	85.2 ± 2.77	87.8 ± 2.63
TSS (mgl^{-1})	39.7 ± 8.60	60.1 ± 15.70	78.0 ± 15.7	91.9 ± 15.8	99.3 ± 16.50	109.3 ± 14.6	128.6 ±14.20
BOD(mgl^{-1})	1.4 ± 0.10	1.5 ± 0.05	2.2 ± 0.05	2.4 ± 0.06	2.2 ± 0.09	2.5 ± 0.04	2.5 ± 0.08
Discharge($m^3.s^{-1}$)	0.9 ± 0.13	1.1 ± 0.18	1.3 ± 0.21	1.6 ± 0.20	1.9 ± 0.23	2.1 ± 0.25	2.7 ± 0.31

3.2 Coliform bacteria

The mean total coliform and *Escherichia coli* are presented in Figure 1. The highest mean total coliform and *E. coli* bacteria was recorded in station NY6 (4628.3 ±368.8 and 3469±452.3 cfu/100ml) respectively and lowest in NY1 (500.2 ±20.2 and 200±10.5 cfu/100ml).

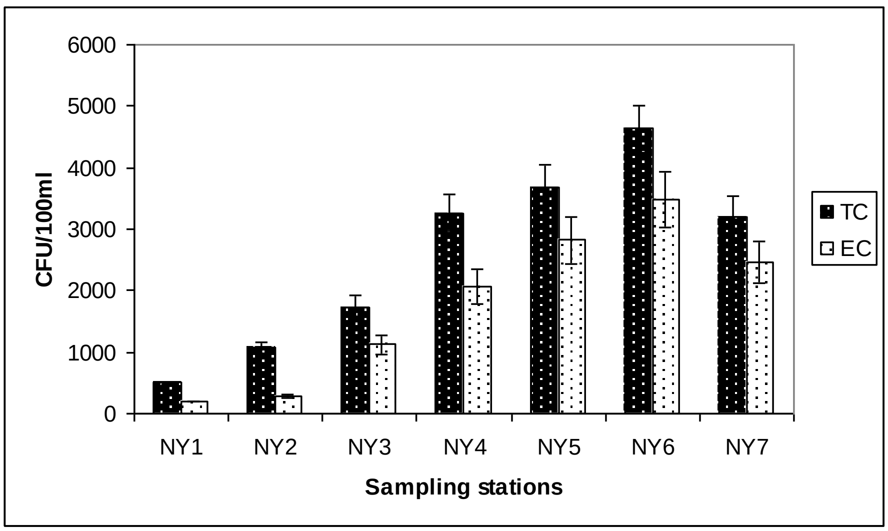

Figure 2: Mean (±SE) coliform bacteria in Nyangores stream during the study period

Table 2: Mean values of Total coliforms (TC) and *Escherichia coli* (EC) in Nyangores stream during the study period. Numbers in brackets are SE of the mean and the letters indicate significant differences

Parameters	NY1	NY2	NY3	NY4	NY5	NY6	NY7
TC	500.2[a] (20.2)	1067.8[b] (100.1)	1721.3[c] (207.2)	3266[d] (300.7)	3667.8[e] (358.4)	4628.3[f] (365.5)	3201[d] (348.7)
EC	200[a] (10.5)	278.2[b] (22.8)	1124.4[c] (145.2)	2065.6[d] (276)	2821.2[d] (366.3)	3469.3[e] (442.3)	2456.3d (334.7)

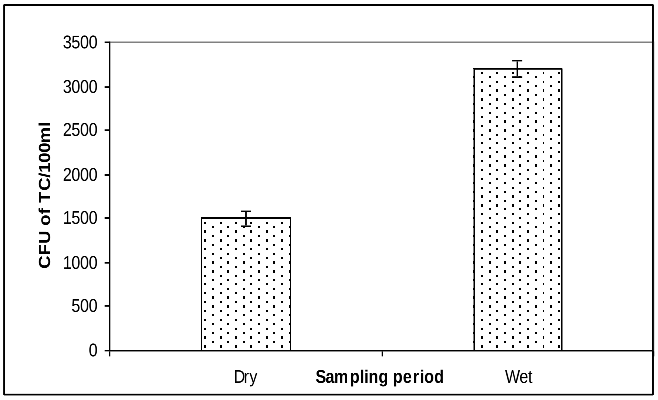

Figure 3: Mean (±SE) Total coliforms in Nyangores stream during wet and dry seasons

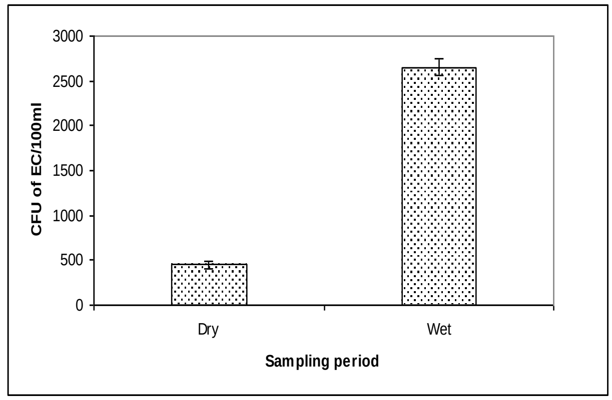

Figure 4: Mean (±SE) E. *coli* in Nyangores stream during wet and dry seasons

There were significant spatial variations in total coliforms and E. *coli* among stations with station NY6 being significantly different from the rest of the stations (Table 2) Higher number of total coliforms and E. *coli* were recorded during the wet season and low values recorded during the dry season Figure 3 and 4.

3.3 Relationship between coliform bacteria and physical chemical parameters

The relationship between *E. coli* and total coliform counts in Nyangores stream were statistically significant ($p < 0.05$) Table 3. *E. coli* was positively related to total suspended solids ($r = 0.23$) and temperature ($r = 0.24$) while total coliforms had a negative relationship with TSS ($r = -0.25$) and a positive relationship with DO ($r = 0.26$) and temperature.

Table 3: Pearson correlation coefficients between physical chemical parameters and coliform bacteria (*designate significant correlation at α=0.05)

Parameter	Discharge	BOD	TSS	DO	Temp	pH	Cond
E. coli	0.18	0.55	0.23*	0.018	-0.24*	0.019	0.09
T. coliforms	0.22	0.51	-0.25*	0.26*	-0.22*	0.016	0.017

4 DISCUSSIONS

4.1 Physical chemical parameters

The physical and chemical parameters in Nyangores stream exhibited significant variations among stations. The upstream stations recorded low temperature, conductivity, TSS and BOD levels but these levels increased downstream. Spatial variation in temperature and DO could have been as a result of modification of riparian vegetation leading to little or no canopy which can lead to increased solar radiation reaching the surface water. Decreased DO downstream was attributed to increased water temperature which decreases solubility of oxygen in water [11]. High organic load could be another factor that contributed to decreased DO concentrations and increased BOD levels in downstream stations. Organic wastes use a lot of dissolved oxygen in water during decomposition [12]. The conductivity levels in the Nyangores stream increased with increase in runoff from agricultural areas and sewage effluents. The high TSS levels in the middle and lower reaches of Nyangores stream was attributed to agricultural activities. During the rainy season, a lot of sediments are carried from the bare farmlands into the stream resulting in high levels of suspended solids [13].

4.2 Coliform bacteria

Bacterial counts in streams tend to increase during high flows and decrease during base flows as a result of runoff [14]. A significant source of pollutants in rivers and streams is storm water runoff which can include sediments and bacteria [15]. During the study period, high levels of both total coliform and *Escherichia coli* (fecal coliform) were recorded during the wet season. This was attributed to sedimentation and storm water discharge which introduces faecal materials from contaminated areas to streams. The microbial water quality of the stream was generally poor with faecal indicator levels higher than the recommended levels. In the Nyangores stream, runoff and discharge influenced the high number of coliform bacteria. This is evident in the lower reaches of the stream which had high counts of bacteria due to increased flows and runoff during the wet season. The high density of bacteria was also linked to high TSS levels. The suspended particles facilitate their survival and growth since the particles protect them from attack by bacteriophage and UV-radiation and provide organic and inorganic nutrient and attachment areas to the bacteria [14]. In general the spatial and temporal variation in coliform bacteria was linked to point and non point sources of pollution in the Nyangores stream.

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