Assessment Of The Physicochemical And Microbial Quality Of Water In Ke-Nya Stream At Babato-Kuma Community In The Kintampo North Municipal Assembly Of Brong Ahafo Region Of Ghana

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ABSTRACT: The study was carried out to evaluate the physicochemical and microbiological quality of the Ke-enya stream which is relied on by the inhabitants of Babato-kuma and its surrounding villages for their domestic and Agricultural activities. A total of twenty eight (28) water samples were collected at upstream, midstream and downstream from November 2012 to January 2013 for analysis. Most of the physicochemical parameters were within WHO guidelines recommended for potable water with the exception of Turbidity and Colour which exceeded the WHO standard of 5 (NTU) and 15 (Hz) respectively. Colour ranged from 100 to 130 (Hz) with a mean of 117±9.45 (Hz), whiles Turbidity ranged from 9 to 36 NTU with a mean of 20.78±10.5 NTU. However, Total Coliform (420-1188 CFU/100ml, 757±261), Faecal Coliform (140-623 CFU/100ml, 305±145) E.coli (46-391 CFU/100ml, 135±102) and Total Heterotrophic bacteria (444-3129 CFU/ml, 1341±778) were higher than WHO standards. Bacterial contamination could be traced to settlements along the stream, livestock production, poor or non-existence sewage system coupled with poor sanitary conditions among others. Alternative sources of water supplies in the form of hand-dug wells or boreholes if possible by the Municipal assembly, NGOs and other philanthropies to the inhabitants whose traditional sources of drinking water is directly from this stream will be beneficial in reducing the health implications associated with this pollution.

Keywords: Babato-Kuma; surface water; Water quality; Coliform bacteria, Membrane filtration

INTRODUCTION

Water is a clear, colourless and tasteless liquid which falls from the sky as rain and can be found at different places on the earth such as the sea, rivers, lakes, streams, dams and is required for human, animal, plant and many different organisms life. It also helps with the metabolism and detoxifying processes in our bodies. Our human system is made up of about 70% of water which makes water and life intricately [1]. Water covers approximately 75% of the earth surface, representing a volume of over one billion cubic kilometres. About 96.7% of earth water is salty, over two-thirds of fresh water is frozen in glacier and polar caps living only 0.9% available for human use [2].

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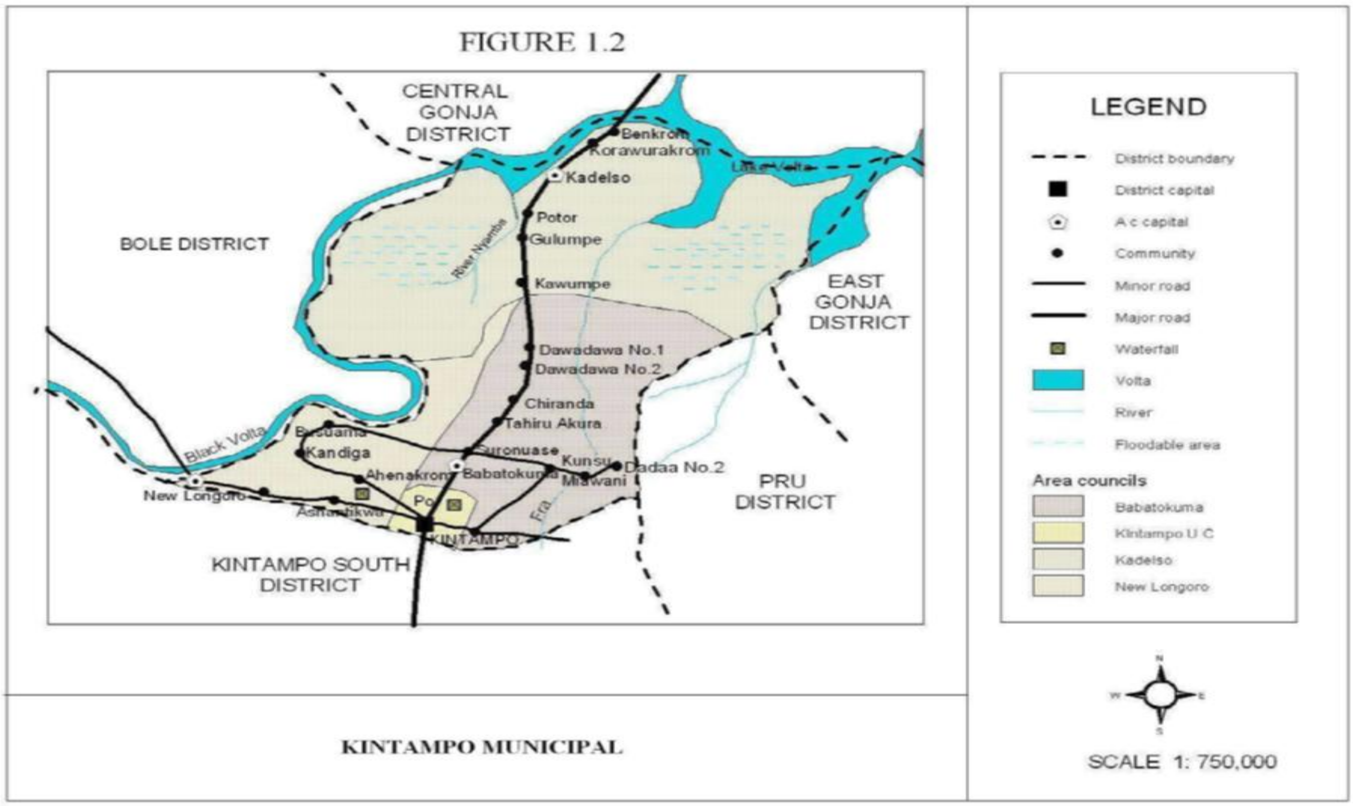
Public and environmental health protection requires safe drinking water, which implies that it must be free of pathogenic bacteria. Among the pathogens disseminated in water sources, enteric pathogens are the ones most frequently encountered [3]. As a consequence, sources of fecal pollution in waters devoted to human activity must be strictly controlled. Entero-pathogens, such as Escherischia coli, are generally present at very low concentrations in environmental waters within a diversified microflora [3]. Most coliforms are present in large numbers among the intestinal flora of humans and other warm-blooded animals, and are thus found in fecal wastes. As a consequence, coliforms, detected in higher concentrations than pathogenic bacteria, are used as an index of the potential presence of entero-pathogens in water environments [4].The quality and quantity of our drinking water has enormous effects on our health, and our way of living rely on having clean water resources. Water quality problems have intensified through the ages in response to the increase growth and concentration of populations and industrial canters. Polluted water is an important vehicle for the spread of diseases. In developing countries, about 1.8 million people, mostly children die every year as a result of water related diseases [5].The Ke-nya stream is the main source of water for various domestic activities such as drinking, cooking and washing for majority members of the Babato-Kuma community and its surrounding villages. The Stream is susceptible to pollution due to but not limited to the following; Site observation revealed signs of open defecation which when it rains in a form of runoff drains into the stream. Most community members of Babato-Kuma are famers, and majority of their farms are located close to the stream which can serve as a source of chemical and nutrient leach as a result of chemical and fertilizer applications. The community refuse damp is also not far from where the stream is which can also be a major source of pollution. The stream is shared by the community members and livestock within the community and these livestock can pollute the stream directly or re-suspend settled pollutants. It is based on these observations that this study was conducted to assess the water quality of the Ke-nya stream since access to safe drinking water is essential to achieve good health in the population [6].The provision of safe drinking water for the world deprived populations has been captured in Millennium Development Goals (MDGs), Goal 7 which aims at ensuring environmental sustainability and quality drinking water [7].

MATERIALS AND METHODS

Study area

The study was carried out at Babatokuma community in the Kintampo North Municipal Assembly in the Brong Ahafo Region of Ghana within the Guinea Savannah Agro-ecological zone. Babato-Kuma and its surrounding village's amount a population of about 10,000 people, the inhabitants are mainly farmers. Babato-Kuma is located along the Kintampo – Tamale main road, the community falls within the Voltain Basin and the Southern Plateau physiographic regions is a plain with rolling and undulating land surface with a general elevation between 60-150m above sea level. The study area is located on latitudes 8º45'N and 7º45'N and Longitudes 1º20'W and 2°1'E, [8]. The study area is limited to the Ke-nya stream in the Babato-Kuma and its surroundings villages that service most of the community members. The municipal which falls within the Voltain basin is endowed with a lot of water resources. The major water bodies include the Fra, Urukwain, and the Nyamba rivers. Others are rivers Oyoko, Nante, Pumpum and Tanfi. These water bodies flow through the west of the district and join the Black Volta at Buipe.



Water sampling and laboratory analysis

Stratified random sampling method was used in collecting water samples from the stream, where by the stream was divided into parts namely upstream, mid-stream and downstream. Water samples were collected monthly from these parts from November 2012 to January 2013 with a total of 28 water samples. Stratified random sampling method was chosen in order to establish the quality of the stream at each point it comes in contact with natural and anthropogenic factors. Upstream was the site before any major activities in the sampling area whiles midstream is where most activities takes place and downstream point was after most of the major activities. At each sampling point plastic bottles were acid washed and well rinsed with deionised water twice before sampling. Samples for bacteriological analysis were collected into sterilized 250 ml screw-capped glass bottles. Collected samples were preserved in ice chest at temperature of 4°C and transported to the laboratory of the Council for Scientific and Industrial Research institute (CSIR)-Water Research Institute, Tamale for analyses. Each sampling bottles had an appropriate labels on them. Coliform bacteria analyses were done immediately on arrival at the laboratory and the samples for other parameters were refrigerated, to avoid chemical transformation and external contamination until the time of the analysis. Physical parameters like conductivity and total dissolved solids of the samples were measured using conductivity meter. pH was recorded using pH meter. A visual comparator and turbidimeter were used to determine colour and turbidity respectively. Orthophosphate, nitrate-nitrogen and sulphate contents of the water sample were analysed using the stannous chloride, hydrazine reduction and turbidimetric methods respectively. A flame photometer (Jenway model PFP 7) was used to determine sodium and potassium whiles EDTA titration was employed for the determination of calcium and total hardness. Chloride contents were determined by argentometric titration and total alkalinity by strong acid titration. Calcium and magnesium hardness, on the other hand, were determined by calculation. Total iron and manganese were determined using a Shimadzu model AA 6300 flame atomic absorption spectrophotometer (AAS).

Statistical analyses

Statistical analyses of data was done using SPSS version 16.0 for Windows. The Pearson‘s rank correlation was used to examine correlation between parameters. All tests were two-tailed.

Microbial analysis of samples water

Microbial analysis was done in accordance with the American Public Health Association [9] standard procedures. Membrane filtration technique was used to determine total coliform, faecal coliform and Escherichia coli in accordance with APHA 9222B, 9222D and 9260F respectively. Filtration unit comprising of an Erlenmeyer flask, suction system and porous support were assembled and with the aid of a flame-sterilized forceps, a sterile membrane filter (0.45µm Millipore) was placed on the porous support. The upper funnel was placed in position and secured with appropriate clamps in a Millipore machine. 100 ml of the water sample was aseptically poured into the upper funnel and suction applied to create a vacuum. After the sample was passed through the membrane filter, the filtration unit was taken apart and with the aid of a sterile forceps the membrane filter was placed in the petri dish containing selective media for various parameters: M-Endo for total coliform, M-FC for faecal coliform and Hi-Chrome agar for Escherichia coli. Clamps, forceps were usually sterile prior to use for the next sample. All plates were incubated in inverted position at 37±2 ºC (total coliform and Escherichia coli) and 44±2 ºC (faecal coliform) for 18-24 hours.Total heterotrophic bacteria count was determined following the heterotrophic plate count method, using pour plate technique in accordance with APHA 9215. 1ml of the sample was pipetted into a sterilized Petri dish and 10-15 ml of nutrient agar added to it. This was uniformly mixed for a minute and allowed to solidify. It was then incubated at 37ºC for 48 hours. Colony growth on the plate after the incubation period was then counted using a colony counter

RESULTS AND DISCUSSION

A summary of the results of physico-chemical and bacteriological quality of the stream have been presented in Tables 1, 2 and 3.

Table1: *Statistical analysis of physico-chemical water quality of Ke-nya stream.*

Parameter	TDS	EC (µS/cm)	Bic	SO4	Cl	NO_3-N	PO_4	F	Total Alkalinity	Mn
Min.	36	59.9	36.6	4	4	0.08	0.044	0.06	30	3.8
Max.	55.5	91.9	48.8	8.5	6.9	3.79	0.534	0.32	43.9	4.9
Mean	47.73	79.5	42.44	5.4	4.99	1.4	0.15	0.23	35.77	4.22
SD	7.09	11.77	4.15	1.46	1.03	1.18	0.17	0.07	4.45	0.42
WHO	1000	1500	-	400	250	10	-	1.5	1000	150

* Concentrations are in mg/L unless otherwise stated.

Table 2: *Statistical analysis of physico-chemical water quality of Ke-nya stream.*

Parameter	Tem	TUB (NTU)	pH (pHunit)	Sod	Total Hard	Cal. Hard	Mn. Hard	SiO4	K	COL (Hz)
Min.	24.7	9	6.69	1.7	28	12	16	19	3.2	100
Max.	27.1	36	7.31	3	40	20	20	31.6	12.2	130
Mean	25.94	20.78	6.96	2.3	33.33	15.56	17.56	23.69	5.99	117
SD	0.83	10.5	0.22	0.45	4.62	3.37	1.57	3.34	3.72	9.45
WHO	-	5	6.5-8.5	200	500	-	-	-	30	15.0

* Concentrations are in mg/L unless otherwise stated

Table 3: *Statistical analysis of microbiological water quality of Ke-nya stream.*

Parameter	TC (CFU/100ml)	FC (CFU/100ml)	E.coli(CFU/100ml)	THB(CFU/ml)
Min.	420	140	46	444
Max.	1188	623	391	3129
Mean	757.22	305	135.78	1341.78
SD	261.7	145.94	102.99	778.64
GHANA	0	0	0	500
WHO	0	0	0	500

PHYSICO-CHEMICAL PARAMETERS

The pH ranged from 6.69 to 7.31 with a mean of 6.96±0.22 (pH-unit), with November downstream sample recording the highest value of 7.31 and the lowest value of 6.69 (pH-unit) recorded in January downstream. The values were within the WHO guideline value of 6.50 - 8.50 (pH-unit). pH is very essential for recreational activities because it has been proven that eye and skin irritation can originate from very low or high pH concentrations [10]. Temperature measured during sampling period ranged between 24.7 and 27.1°C with a mean value of 25.94±0.83°C. **Figure 2** shows the monthly variation in pH and temperature. Turbidity levels ranged from 9 to 36 NTU with a mean value of 20.78±10.5 NTU. November upstream and downstream recorded an equal highest value of 36 NTU, while January upstream recorded the lowest turbidity level of 9 NTU. All mean values recorded in the study exceeded the WHO guidelines for drinking quality water of 5 NTU. The colour of the stream was above WHO standard for safe drinking water (15 Hz), the values recorded ranged from 100 to130 (Hz) with a mean of 117±9.45 (Hz). January and December downstream samples recorded the value 130 (Hz), December downstream had the least value of 100 (Hz). This agreed with an earlier studies conducted by Peavy Howards and D.R. Tehobanoglous, [11], who reported that various farming undertakings around water bodies by the settler farmers contribute microscopic organisms as well as some inorganic and organic materials such as plant debris and leaf fall to surface waters and these materials are often natural contaminants resulting in high levels of turbidity and colour. Rainfall, grazing of ruminants and improper management of solid and liquid waste within the Babato-Kuma Township and its villages could also influence the high turbidity and colour values of the stream. Turbid and much coloured water conditions have the risk of increase the possibility for waterborne infection and costs related to discolouration of the water for human consumption. **Figure 3** shows the monthly variation in colour and turbidity. The rest of the physicochemical parameters measured were within WHO guideline values for drinking water quality (**table 1 and 2**).

BACTERIOLOGICAL QUALITY OF KE-NYA STREAM WATER SAMPLES

Generally, none of the samples analysed for microbiological quality met Ghana and WHO's standardized limits. With the exception of Heterotrophic bacteria that Ghana and WHO guideline permits 500 CFU/ml counts. Faecal coliform numbers in the water samples were comparatively high, about half the number of Total coliforms on the whole. Faecal Coliform ranged between 140 and 623 (CFU/100ml). The highest and lowest Faecal Coliform numbers occurred in January upstream and November midstream respectively with a mean of 305±145.94. E. coli count recorded the lowest values for all the bacteriological analysis carried out during the studies. The values ranged from 391 (CFU/100mL) as the highest count and 46 (CFU/100ml) as the lowest count with a mean of 135.78±102.99 (CFU/100ml). January downstream recorded the lowest count while January upstream had the highest count and were all above Ghana's and WHO guidelines for safe drinking water[12]. The monthly variation in fecal coliform and E. coli count is shown in **figure 4** Total coliform numbers ranged from 420 to 1188 (CFU/100ml) with a mean of 757.22±261.7. The highest count occurred in December at midstream, whilst the lowest count was recorded in November at midstream. Total Heterotrophic Bacteria recorded the highest count, of all the bacteriological analysis conducted, above Ghana standard and WHO guidelines recommendation of 500(CFU/ml) which makes the stream water not safe for drinking. December recorded 3129(CFU/ml) as the highest count while November recorded the lowest count (444 CFU/ml) with a mean value of 1341.78±778.64. **Figure 5** shows the monthly variation of Total coliform and total heterotrophic bacteria counts.The presence of total coliform, faecal coliform, E. coli and total heterotrophic bacteria in a stream or any drinking water is considered as a possible threat or indicative of microbiological water quality deterioration [4]. These high levels could be attributed to open defecation by community members and livestock activities in and around the stream. Also, these coliform bacterial may emanate from several origins some of which could be attributed to poor and non-existent sewage systems or improper sanitary conditions in most of the communities. Livestock reared in Babato-Kuma and its villages is practice on an extensive system, where animals search for their own food and water. This condition is in line with research carried out by Morgan [13], who reported that when livestock are allowed to graze and drink freely around and from these water bodies, they end up indiscriminately contaminating these surface waters with their faeces thus contributing to the high incidence of Total and faecal coliform build up. The high microbial load of the stream indicate significant health risk of infectious disease transmission and implications such as diarrhoea and other gastro-intestinal diseases to those who use it without treatment, since consumption of unwholesome water affect human health in many ways [14].

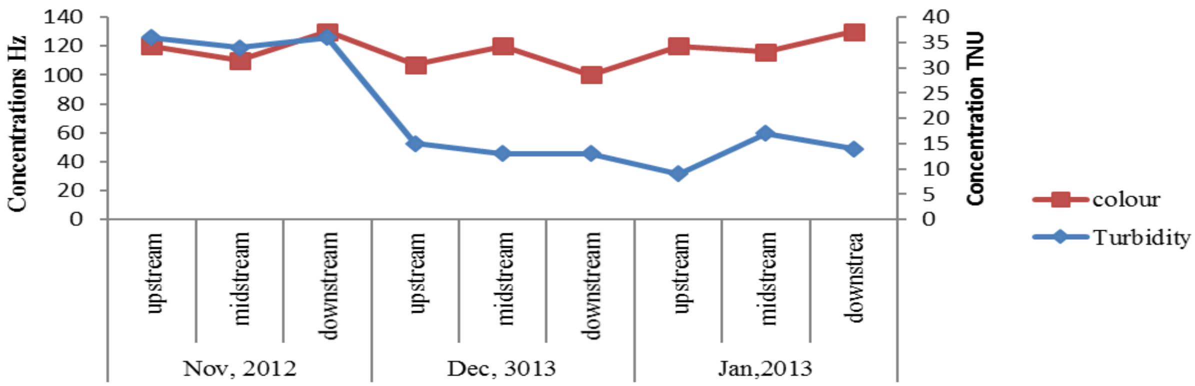


Fig.3: Monthly Levels of Turbidity and Colour Measured

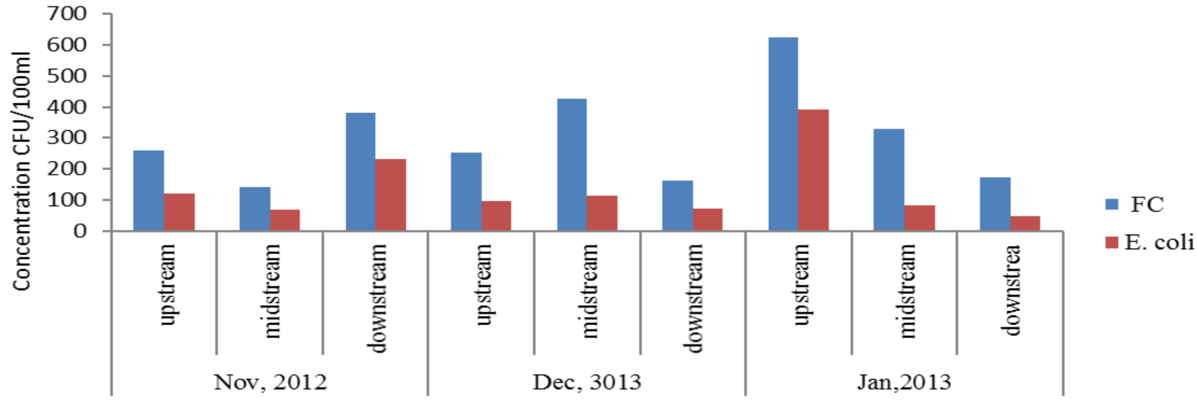


Fig. 4 Monthly Faecal Coliform and E. Coli Counts

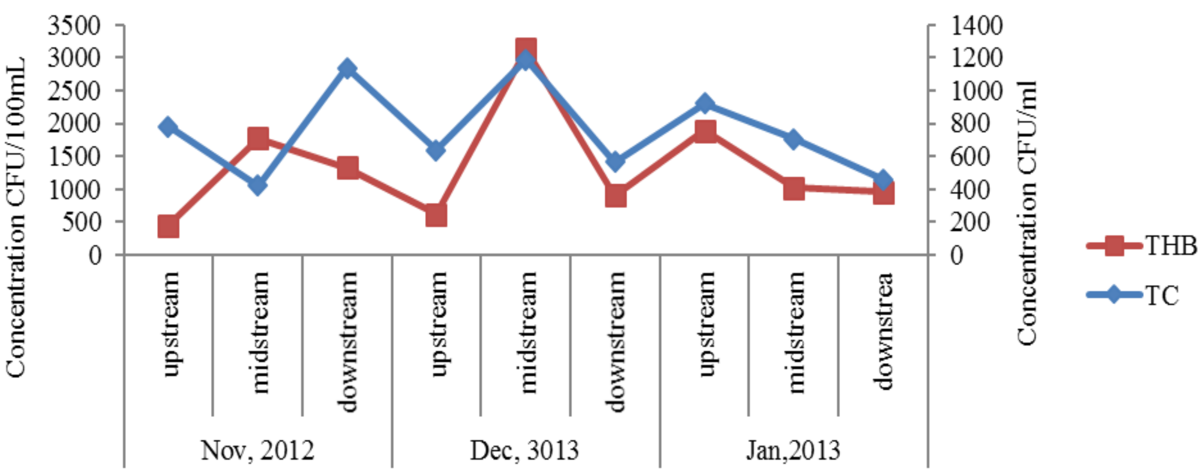


Fig. 5 Monthly Total Coliform and Total Heterotrophic Bacteria Counts

Correlation matrix

Correlation analyses show that there were significant differences between the parameters measured within the period of the research which suggests strongly positive relationships between parameters such as Electrical Conductivity, Total Dissolved Solid, Temperature, pH, Nitrate-nitrogen, Electrical Conductivity, Total Hardness, Turbidity, Nitrate-nitrogen, Chloride Faecal coliform and E. coli as indicated in (**Table 4**). Electrical conductivity strongly correlated with Total dissolved solid ($r=1.00$, $p<0.01$), Temperature also strongly correlated with pH (r=0.803, p<0.01), Total hardness also strongly correlated with turbidity (r=0.850,p<0.01), Faecal coliform strongly correlated with E. coli (r=0.876, p<0.01) etc. as shown in **table 4**. There were also strongly negative relationships between parameters such as Total Hardness and Temperature, pH and Electrical Conductivity, as well as pH and Turbidity indicating that they do not emanate from the source.

Table 4. *Correlation analysis showing the differences between the parameters measured within the time of study.*

	TDS	EC	PH	TUR	TEMP	COL	NO3	CL	Mn	THD	E.CO	FC	TC
TDS													
EC	**1.000****												
PH	-.922**	-.922**											
TUR	0.175	0.183	-0.376										
TEMP	-.722**	-.729**	**.803****	-.74**									
COL	0.229	0.222	-0.383	0.07	-0.285								
NO3	**.879****	**.879****	-.76**	-0.093	-0.547	0.118							
CL	**.804****	.796*	-.77**	-0.208	-0.351	0.554	.752**						
Mn	0.624**	0.628**	-.584*	0.446	-.76**	0.066**	0.657**	0.229					
THD	0.4	0.408	-0.448	**.850****	**.811****	-0.095	0.255	-0.085	.755**				
E.CO	0.284	0.289	-0.156	-0.1	-0.355	0.245	0.538*	0.233	0.477	0.224			
FC	0.138	0.143	-0.08	-0.304	-0.139	0.268	0.427	0.243	0.16	-0.106	**.876****		
TC	-0.213	-0.206	0.125	0.034	-0.107	0.398	-0.137	-0.097	-0.115	-0.04	0.56	.754**	

*****Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION
The results indicated that most of the physico-chemical parameters of Ke-nya stream were within the WHO recommended values for drinking water excluding turbidity and colour. The high values of turbidity and colour could be attributed to the rainfalls, erosion and run-offs at the study area. However, the microbial quality of the stream at all sampling points, for E.coli, Total and Faecal Coliform and Total Heterotrophic Bacteria counts, exceeded Ghana and WHO's standards of 0 CFU/ 100ml and 500 CFU/ml respectively for potable water. In general, the bacteriological quality of the stream was not good which is an indication of heavily bacterial-contaminated water body and could pose a serious risk to users without treatment. Nevertheless, the stream can be used for other domestic activities including washing. Possible sources for bacterial contamination could be due to the settlements along the stream, open defecation by community members, direct contamination by animals, improper waste management and other poor sanitary conditions.

RECOMMENDATIONS
The regulatory agencies such as the Regional Environmental Protection Agency, the district Environmental Health Department, the Water and Sanitation unit of the Municipal Assembly and other environmental Non-governmental Organizations (NGOs) could embark on an intensive educational campaign to create awareness on the poor quality of the stream, the dangers of drinking directly from the stream without treatment and behavioural change especially with regards to open defecation, proper waste management practices, intensive system of rearing animals just to mention a few. Alternative sources of water supplies in the form of hand-dug wells or boreholes if possible should be provided by the Municipal assembly, NGOs and other philanthropies to the inhabitants whose traditional sources of drinking water is directly from this stream. This would be beneficial in reducing the health implications associated with the pollution.

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REFERENCES
[1] Smol, J.P. (2008), pollution of lakes and rivers paleoenvironmental world water development report, UNESCO, Paris.

[2] Rasier, k. A. and Thomson, W. R. (2O06). Contested territory strategic Reveries and conflict Gleic, P.H; 1996; Water resources, In Encyclopaedia of climate and weather, ed by SH.

Schneider Oxford University press, Ney York, Vol, 2pp817-823.

[3] Partha Pal (2014). Detection of coliforms in drinking water and its effect on human health - A Review. International Letters of Natural Sciences Vol 17 (2014) pp 122-131.

[4] Rompre, A., Servais, P. b., Baudarta, J., de-Roubin, M.R., Laurent, P. (2002). Detection and enumeration of coliforms in drinking water: current methods and emerging approaches. Journal of Microbiological Methods 49 (2002) 31–54.

[5] World Health Organization (2004). Guidelines for Drinking-water Quality. Vol. 1: 3rd Ed. ISBN 92 4 154638 7. WHO, Geneva.

[6] World Health Organization (2006). Guidelines for drinking-water quality, first addendum to 3rd ed., vol. 1. Recommendations. WHO, Geneva.

[7] World Health Organization and UNICEF Meeting the MDG Drinking Water and Sanitation Target. A Mid-term Assessment of Progress. Geneva: World Health Organization, and New York: United Nations Children‟s Fund, 2004.

[8] MPCU (2011): Profile of Kintampo Municipality. Government of the Republic of Ghana, Ministry of Local Government and Rural Development, Kintampo Municipal Assembly.

[9] American Public Health Association (1998). Standard Methods for the Examination of Water and Wastewater, 20th ed. Washington, DC: APHA.

[10] Mitchell M, Stapp W (2005). Red River Water Quality Monitoring Volunteer Manual. United Book Press International, Baltimore.

[11] Peavy Howards, S., Rowe, D.R., Tehobanoglous, G., (1985). Environmental Engineering Pub. McGraw-Hill Int. Edition. Civil Engineering Series.

[12] World Health Organization, (1993). Guidelines for drinking water quality. Volume I Recommendations 2nd edition, World Health Organization, Geneva.

[13] Morgan, P. (1990). Rural Water Supplies and Sanitation, Blair Research Laboratory, Macmillan Education Ltd. London.

[14] Mintz, E. D., Reiff, F. M. and Tauxe, R. V. (1995). Safe water treatment and storage in the home. A practical new strategy to prevent water-borne disease. JAMA 273: 948–953.