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Comparative Study Of Surface And Ground Water Quality, Nyeri County Urban-Rural Surroundings, Kenya

Kinyua A.N

Thuku T.

Githira P.

Siele W.

Department of Chemistry, JKUAT

***Abstract:** The main objective of this research was to establish the comparative quality of surface and ground waters by monitoring the trends of the water quality through analyzing its physicochemical parameters; pH, temperature, turbidity, EC, water nutrient loads of NH_4^+–N, NO_3^-–N, PO_4^{3-} TP, SO_4^{2-} and the levels of selected heavy metals (Cr, Zn, Cu, Fe, Cd, and Pb). Water samples were collected along the Chania River and boreholes within the catchment area. Sampling point were selected based on the dominant human activity, accessibility of the sampling point and safety. This was done over two seasons that is wet and dry season. The physiochemical parameter were determined insitu by use of a portable 3505 multi-parameter meter while the nutrients load was determined by use of UV-Vis 1800 Shimadzu spectrophotometer and the concentration of each heavy metals determined by using the AAS-6200 Shimadzu instrument against the standard calibration curve. The results displayed that for the physiochemical expect for one of the boreholes for the pH and two boreholes and the surface water for the turbidity all the others were below the recommended WHO values in both seasons. For nutrients load both surface and ground water recorded values below the WHO recommended values for both seasons though the values were generally higher during the dry seasons than wet seasons. For heavy metals both surface and ground water recorded higher values than the WHO values for lead, chromium and cadmium although all values for iron were below the WHO standards but copper had some values higher for two boreholes and three points on the river. There was no significant difference between the surface and ground water.*

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***Keywords:** surface water, ground water, concentrations nutrients and heavy metals*

I. INTRODUCTION

Adequate purity of water is of paramount importance to living things. It is the life blood of species. Every race and tribe everywhere and everyday makes use of water. Health experts have suggested and stressed the need to drink two litres of water every day. Water occupies about 70% of the earth's surface and composes 65% of the human body [WHO]. Water is essential to urban and rural life. It plays an important role in the bodily intake of trace elements. Even though some trace elements are essential, at elevated levels these elements can cause morphological abnormalities reduce growth, increase mortality and mutagenic effects (Nkono and Asubiojo, 1998). The concerns about trace elements are that they pose both environmental and health consequence problems (Almas *et al*., 2009). Water quality is important to humans as well as plants and animals that live in and around water bodies (Merritts *et al.,* 1998). Chemical attributes of water are important indicators of water quality, they affect aesthetic qualities such toxicity. Among environmental pollutants, metals are of particular concern, due to its potential toxic effect and ability to bio-accumulate in aquatic ecosystems (Censi et al., 2006). Heavy metals refer to heavy metallic chemical elements that have relatively high density and are toxic or poisonous at low concentration. They include essential and non- essential chemical elements. Surface and ground water are two separate entities, so they must be regarded as such. However, there is an ever-increasing need for management of the two as they are part of an interrelated system that is paramount when the demand for water exceeds the available supply (Fetter 464).

Nyeri Municipality the main source of surface water with the environments of is River Chania. River Chania flows from the Aberdares through Nyeri Hill, Nyeri town to Sagana River. In the recent future, resident have started to extensively explore the use of ground water. Within this environ are a great number of industries such as the Highland, Cocacola Mt. Kenya Bottlers among others which are of great economic significance to the county. However the impacts of these economic activities to the surface and ground water quality are not documented.

II. METHODOLOGY

A. STUDY AREA

This study was carried out in Nyeri County, Kenya along the River Chania and the ground water to be considered was within a radius of 2km from the river. The sampling point were selected based on the dominant land use activity within the area such as agricultural activity, industrial activities, logging activities, other human activities and the presence of borehole for the provision of ground water along the river. Accessibility of the sampling points and safety was also taken into consideration.

B. SAMPLING

Grab (simple random) samples of surface water from the Chania River were taken and an equivalent number of ground water samples from within the same localities taken. During sampling the bottles were rinsed with sample three times and then filled from each of the designated sampling points. Samples were collected from this was done into seasons, i.e. during the rainy season and during a relatively dry season. The water was then be transferred into labeled 500ml plastic bottles pretreated with 5 % HNO_3 and then immediately acidified with 10% HNO_3, frozen for the preservation of nutrient analysis samples. This was then be stored in an ice box and transported to the laboratory for analysis. For the ground water, water was be drown from a well, put in a 500ml plastic bottle frozen as a preservation which has been rinsed thoroughly using the well water. Another set of water was then be transferred into labeled 500ml plastic bottles pretreated by addition of 3 drops concentrated nitric acid (72 %) in each bottle. This was then transported to the laboratory for elemental analysis.

C. ANALYTICAL ANALYSIS

a. THE PH, TEMPERATURE, AND ELECTRICAL CONDUCTIVITY

The water pH, temperature, and electrical conductivity was measured in situ at the points of sample collection using a 3505 multi parameter-water quality meter. The pH meter was calibrated before sample determination using pH 4 and pH 7 standard buffers.

b. TURBIDITY

Turbidity was determined by use turbid meter, type SGZ-B portable turbidity meter which was standardized to zero NTU using distilled water, then 200 NTU standard. The sample was shaken and poured into a cuvette and readings taken using the turbid meter.

c. AMMONIUM IN WATER

In distilled water, 10g $ZnSO_4.7H_2O$ was dissolved and diluted to 100mL.Sodium hydroxide, 6N (24g NaOH) was dissolved and diluted to 100mL. 50g EDTA was dissolved in 60mL water containing 10g NaOH. Cooled and dilute to 100mL. In 100mL 50g potassium sodium tartarate was dissolved. Ammonia was removed by boiling off 30mL solution, cooled and diluted to 100mL. 100g Hgl_2 and 70g Kl was mixed well and dissolved in small quantity of water. This mixture was then added to a cooled solution of 160g NaOH in 500mL water and diluted to 1000mL, kept overnight, stored supernatant in coloured bottle. In distilled water, 3.819g of NH_4Cl dried at 100°C was dissolved and diluted to 1000mL. 10mL of the solution was diluted to 1000mL. 1mL = 10µg NH_3. 1 mL $ZnSO_4$ solution and 0.4 or 0.5 mL NaOH was added 100mL of the sample to obtain the pH of 10.5. Allowed to settle and the supernatant filtered through 42 No. Whatman filter paper. To suitable aliquot of sample 3 drops of Rochelle salt solution or 1 drop of EDTA was added and mixed well. 3mL Nessler reagent if EDTA was used or 1mL if Rochelle salt solution was used added and made up to 100mL mixed well and percent transmission read after 10 minutes at 410nm using a blank prepared in the same way by taking distilled water instead of the sample.

d. NITRATE IN WATER

The concentration was determined against a standard calibration curve prepared from (AR) potassium nitrate (KNO_3) made by dissolving 721.8mg anhydrous potassium nitrates in 1000ml distilled water with 1N hydrochloric added. 100ml stock nitrate solution was diluted to 1000ml. The samples and the standards were treated the same way. The absorbance read at a wavelength of 300nm using a UV-Vis 1800 Shimadzu spectrophotometer.

e. TOTAL PHOSPHOROUS (TP)

Total phosphorous in water was determined using the ascorbic acid reduction method. TP was determined by taking 50ml of unfiltered sample, to which 5 ml of the mixed reagent was added, followed by digestion in an autoclave -pressure steam sterilizer at 200-250°F for a proximately 2 hours. The solution was allowed to cool and the absorbance read at a wavelength of 885nm using the UV-Vis 1800 Shimadzu spectrophotometer. Total phosphorous concentration was

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determined against a standard calibration curve prepared from analytical grade potassium dihydrogen phosphate (KH_2PO_4).

f. ORTHOPHOSPHATE (PO_4^{3-} -P)

Orthophosphate phosphorous was determined in the same way only that acid digestion was not be done.

g. SULPHATES IN WATER

A suitable volume of sample was diluted to 100mL into a 250mL Erlenmeyer flask. Exactly 5.0 mL conditioning reagent (stabilization reagent) prepared by Slowly adding 30 mL concentrated HCl to 300 mL distilled water, 100 mL 95% ethanol or isopropanol, 75 g NaCl in solution in a container and 50 mL glycerol and mixed was added. The flask was constantly stirred with the help of stirrer. 1-spatula $BaCl_2$ crystals was added with stirring. Stirring for 1 minute continued after addition of $BaCl_2$. The suspension added into an absorption cell of photometer and turbidity measured at 5±0.5 min. using a type SGZ-B portable turbidity meter. To correct for sample colour and turbidity, a blank to which $BaCl_2$ is not added was ran. A calibration curve was prepared by using standard sulphate solution (147.9 mg anhydrous Na_2SO_4 dissolved in distilled water in a 1-liter volumetric flask and dilute to the mark with distilled water.) treated the way as the sample spaced at standards at 5-mg/L increments in the 0-40 mg/L sulphate range.

h. HEAVY METALS

The heavy metal in water were determined by the procedure adopted by Mzimela et al., (2003). Water sample 100ml were filtered through a cellulose acetate filter paper. This was then acidified with 1ml con nitric acid (AR) and then placed in a digester at 60°c and allowed to evaporate to 15mls. The sample was then transferred in to a 25ml volumetric flask and made up to volume with double distilled and deionized water. The concentration of heavy metals was determined in mg/l using an AAS-6200 Shimadzu instrument against the standard calibration curve which had been prepared by plotting the absorbance of appropriate amounts of analytical grade salts of the respective metal salts dissolved in distilled water and diluted to working standards solution, ranging from 0.1mg/L-100mg/L.

III. RESULTS AND ANALYSIS

The results in Table 1 below shows the mean values for physiochemical parameters of water while table 2 shows the mean concentration of selected nutrients and table 3 a summary of mean values for selected heavy metals in both surface (River Chania) and ground water in Nyeri County Kenya against guidelines on food safety by the WHO.

Point of sampling	Season	Temp ^{0}c	pH	E.C µS	Turbidity NTU
1U	WET	22.0	6.55	149	21
	DRY	23.4	7.08	297	22.8
2U	WET	22.2	5.19	51.2	7.0
	DRY	23.0	7.2	65.1	8.0
3U	WET	22.3	7.19	460	8.1
	DRY	22.7	7.85	1147	8.8
4U	WET	22.0	7.02	744	7.0
	DRY	22.5	7.32	1242	6.5
5U	WET	22.7	7.19	668	2.3
	DRY	23.4	8.00	1087	1.0
6U	WET	22.8	7.17	342	2.2
	DRY	23.3	7.40	1194	2.0
7U	WET	21.8	7.11	347	1.8
	DRY	22.0	7.45	1470	1.0
1R	WET	21.9	6.72	20.2	6.8
	DRY	22.0	7.08	107.6	41.0
2R	WET	21.9	6.74	24.8	7.8
	DRY	22.1	8.56	93.8	36.6
3R	WET	21.4	6.91	26.0	7.5
	DRY	22.0	8.42	102.0	35.5
4R	WET	22.3	6.79	26.2	7.6
	DRY	22.4	8.54	118.0	148.3
5R	WET	21.6	6.90	29.9	17.7
	DRY	22.0	8.52	122.0	180.1
6R	WET	22.3	6.84	30.7	17.6
	DRY	22.4	8.52	121.7	185.8
7R	WET	22.5	6.88	43.5	18.1
	DRY	22.2	8.60	133.9	222.0
8R	WET	21.5	6.90	32.10	19.2
	DRY	22.4	8.45	131.6	225.1
	WHO	Cool	6.5-9.5	-	5.0

Table 1: Mean values for physiochemical parameters

From the above data it's clear that the temperature for both ground and surface water are good for healthy drinking water. For the pH all the values are within the recommended WHO standards safe for Borehole two during the wet season which was far below the recommended value. For the turbidity all the surface water was far above the recommended WHO standards in both wet and dry seasons. For the ground water, only borehole 5, 6, and 7 that displayed save drinking water in terms of turbidity for both seasons. Turbidity levels were higher during the dry seasons which would be accounted for due to increase in concentration after having suspended particles being transported during the wet seasons

Point of Sampling	Season	NH_4^+ mg/l	NO_3^- mg/l	TP mg/l	PO_4^{3-} mg/l	SO_4^{2-} mg/l
1U	WET	0.6308	0.0253	0.1472	0.1015	75.65
	DRY	ND	3.6525	0.8965	0.9095	75.684
2U	WET	ND	ND	0.0193	ND	38.514
	DRY	ND	5.6685	0.1782	0.1128	48.495
3U	WET	ND	0.0862	0.1221	0.1064	58.938
	DRY	ND	20.1163	0.6494	0.6472	67.764
4U	WET	ND	ND	0.0386	ND	37.348
	DRY	ND	18.3423	0.4060	0.3597	46.278
5U	WET	0.3081	0.1105	0.0036	0.0028	47.868
	DRY	ND	0.9908	0.2690	0.2186	52.485
6U	WET	ND	ND	0.0217	0.0056	61.274
	DRY	ND	22.3086	0.6175	0.6120	67.911
7U	WET	ND	ND	0.0505	0.0303	57.868
	DRY	ND	0.8407	0.2346	0.2071	63.272

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1R	WET	*1.0544*	*0.4005*	*0.0113*	*0.0044*	*46.578*
	DRY	*ND*	*1.5256*	*0.3269*	*0.2964*	56.208
2R	WET	*0.7236*	*0.3123*	*0.0395*	*ND*	55.490
	DRY	*ND*	*1.6634*	*1.2805*	*0.6940*	64.070
3R	WET	*0.4372*	*0.3618*	*0.0241*	*ND*	51.022
	DRY	*ND*	*1.5960*	*0.3425*	*0.3567*	51.037
4R	WET	*0.4341*	*0.3210*	*0.0014*	*ND*	34.802
	DRY	*ND*	*2.073*	*0.3447*	*0.3280*	47.106
5R	WET	*0.7689*	*0.2957*	*0.0042*	*ND*	40.742
	DRY	*ND*	*1.5440*	*0.3064*	*0.2855*	58.011
6R	WET	*0.8597*	*0.3308*	*0.0087*	*ND*	37.984
	DRY	*ND*	*1.6505*	*0.3467*	*0.3189*	45.628
7R	WET	*0.6499*	*0.4258*	*0.1261*	*ND*	37.348
	DRY	*ND*	*2.0817*	*0.3302*	*0.2893*	49.382
8R	WET	*0.4593*	*0.4005*	*0.0192*	*ND*	53.364
	DRY	*ND*	*2.4637*	*0.3249*	*0.2987*	**56.563**
	WHO	**-**	***50***	***10***	***1.0***	***250***

Table 2: Mean concentration of nutrients load

From the above results it's clear that nutrients load exceeds the recommend WHO limits. There was a clear display of high levels of nutrients in both ground and surface water during the dry season than during the wet season safe for ammonia which displayed the reverse of this. This may be explained by the fact that due to evaporations nutrient loaded by runoffs during the rain seasons displayed a higher concentration.

Point of sampling	Season	Zinc mg/l	Iron mg/l	Copper mg/l	Lead mg/l	Chromium mg/l	Cadmium mg/l
1U	WET	1.2331	15.0984	1.8824	0.5857	0.4129	0.2611
	DRY	*ND*	*0.3007*	*ND*	*0.3499*	*ND*	*ND*
2U	WET	*1.7315*	*16.2230*	*4.5723*	*0.5451*	*0.4285*	*0.0944*
	DRY	*0.4499*	*0.6023*	*ND*	*0.2292*	*ND*	*ND*
3U	WET	*1.3328*	*14.4608*	*0.5374*	*0.5857*	*0.5065*	*0.0667*
	DRY	*ND*	*0.2498*	*ND*	*0.3073*	*ND*	*ND*
4U	WET	*1.0338*	*14.3564*	*1.0978*	*0.3584*	*0.5533*	*0.0944*
	DRY	*ND*	*0.3554*	*ND*	*0.2718*	*ND*	*ND*
5U	WET	*0.5438*	*13.5449*	*2.3307*	*0.2604*	*0.7248*	*0.1222*
	DRY	*ND*	*0.3667*	*ND*	*0.2647*	*ND*	*ND*
6U	WET	*0.2697*	*13.0232*	*4.4603*	*0.7891*	*0.8340*	*0.03167*
	DRY	*ND*	*0.2573*	*ND*	*0.2292*	*ND*	*ND*
7U	WET	*0.2447*	*14.7042*	*2.7791*	*0.2198*	*0.4753*	*0.1222*
	DRY	*ND*	*2.3687*	*ND*	*0.3002*	*ND*	*ND*
1R	WET	*0.8095*	*14.8318*	*1.2099*	*0.5044*	*0.3662*	*ND*
	DRY	*ND*	*0.2649*	*ND*	*0.4422*	*ND*	*ND*
2R	WET	*0.0454*	*14.5535*	*1.8824*	*0.9924*	*0.6469*	*0.0944*
	DRY	*ND*	*0.3459*	*ND*	*0.4493*	*ND*	*ND*
3R	WET	*0.1368*	*15.0289*	*4.3482*	*0.4637*	*0.4597*	*0.0944*
	DRY	*ND*	*0.3704*	*1.5524*	*0.4209*	*0.1224*	*ND*
4R	WET	*0.2364*	*15.1564*	*4.4603*	*0.5857*	*0.6780*	*0.1222*
	DRY	*ND*	*0.2592*	*ND*	*0.3215*	*ND*	*ND*
5R	WET	*0.3444*	*16.2114*	*2.1066*	*0.4323*	*0.5845*	*0.1778*
	DRY	*ND*	*1.0755*	*ND*	*0.4990*	*ND*	*ND*
6R	WET	*1.8473*	*15.1680*	*0.6495*	*0.7760*	*0.6313*	*0.2056*
	DRY	*ND*	*0.3271*	*ND*	*0.3641*	*ND*	*ND*
7R	WET	*2.4873*	*16.0259*	*0.3133*	*0.4323*	*0.4753*	*0.2056*
	DRY	*ND*	*0.3365*	*ND*	*0.3215*	*ND*	*ND*
8R	WET	*2.454*	*11.0291*	*4.2361*	*0.6264*	*0.4285*	*0.2611*
	DRY	*ND*	*0.3855*	*ND*	*0.3712*	*ND*	*ND*
	WHO	***3.00***	***2.00***	***2.00***	***0.05***	***0.05***	***0.05***

Table 3: Mean values for concentration of heavy metals

ZINC

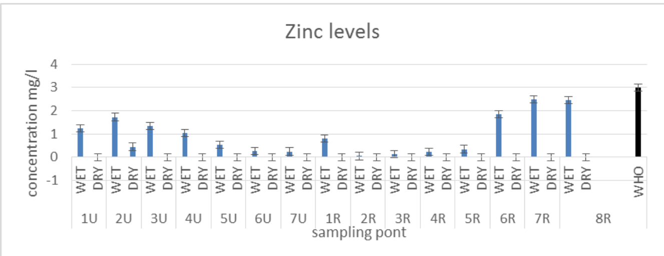

Figure 1

Zinc is very essential micronutrient in human being and only at very high concentration; it may cause some toxic effect. From the above it clear that the levels of zinc in both seasons in both ground and surface water were below the WHO standards. Though wet seasons displayed higher levels of zinc than during the dry season. This can be attributed to runoffs which may transport zinc ions into the river and into bore holes

IRON

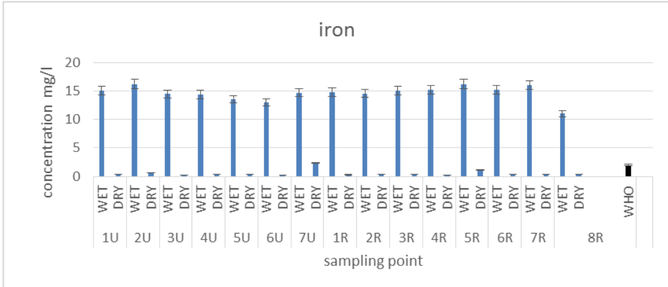

Figure 2

Iron in drinking water is present as Fe^{2+} or Fe^{3+} in suspended form. It comes into water from natural geological sources, industrial wastes, and domestic discharge and also from byproducts. This may explain the cause of high levels of iron in the wet seasons over the dry.

LEAD

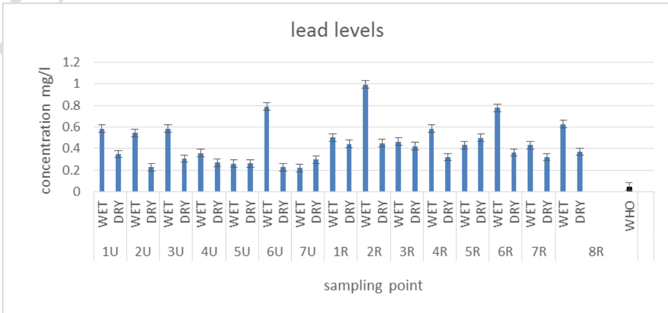

Figure 3

Lead enters in drinking water from industrial effluents, different wastes and household sewage. Lead is a dangerous heavy metal whose consumption should be minimized (Ogola *et al.*, 2001). It causes impairment of the nervous system and is a possible human carcinogen (UN, 1998). It's prone to accumulate in surface horizons of soils, this its quite high levels during the wet seasons over the dry seasons. In all samples lead levels were above the permissible levels by the WHO. This could be attributed to the fact that there are a lot of mechanical activity taking place in the area.

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CHROMIUM

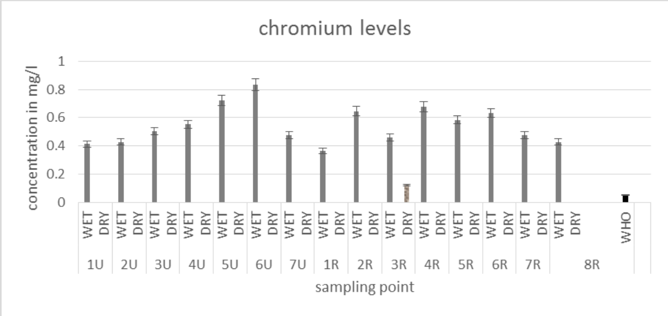

Figure 4

During the wet season, the levels of chromium in all the water samples wet above the recommended levels by the WHO.

CADMIUM

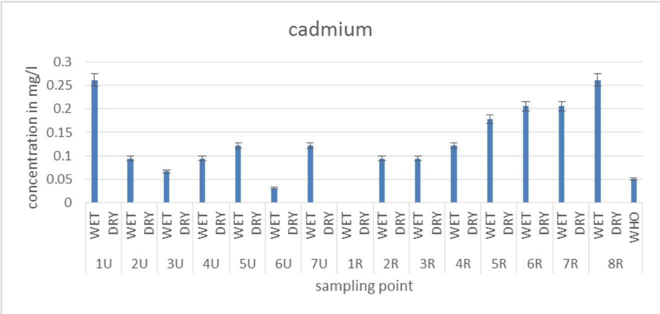

Figure 5

Like in the cases of all the heavy metals, the levels of chromium during the wet seasons were greater than during the dry season and well above the permissible level by the WHO.

IV. CONCLUSION AND RECOMMENDATIONS

From the above results it very clear that for physical parameter there a simultaneous change of parameters from wet to dry seasons for ground and surface water. There is also no significance difference between the levels of heavy metals in surface and ground water within the region. Though a thick line has been drawn between wet and dry seasons with the wet seasons displaying a high level concentration in all the surface and ground water sampled. The High heavy metals concentration has been reported could affect enzymatic and hormonal activities, as well as impede growth rate and may also increase mortality rate (Bubb and Lester, 1991), thus the need to always assess and closely monitor water quality especially in the rural areas. This therefore is a wakeup call for the county government to ensure that water is thoroughly treated especially during the wet seasons to lower the levels of heavy metals to avert the crises which would be caused by bio- accumulation.

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