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RESEARCH ARTICLE

PROFILING OF PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SOURCES USED FOR DRINKING AND PROCESSING IN ISIOLO COUNTY IN KENYA

***Abok Elisha Onyango, Michael Wandayi Okoth and Catherine Nkirote Kunyanga**

Department of Food Science, Nutrition and Technology, College of Agriculture and Veterinary Sciences - University of Nairobi, P.O Box 29053 – 00625, Kangemi, Nairobi-Kenya

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ABSTRACT

Water quality, wholesomeness and palatability is usually influenced by the level of dissolved minerals as well as the physical appearance of color, turbidity and suspended matter. Climatic conditions and changes in the hydrological cycles have been reported to alter the physico-chemical attributes of water exposing the end users to health risks. Forty four water samples were purposively sampled aseptically and analyzed as per ISO procedures for electrical conductivity, color, pH, hardness, turbidity, and magnesium and calcium ions concentration. Means and Pearson correlation were compared at 5 % level of significance. Results show that highest and lowest total hardness values were 638.5 mg/l and 138.5 mg/l for borehole and tap water respectively. Calcium and magnesium ions mean values were 33.92 mg/l and 68.43 mg/l. Rain water had the lowest pH of 3.4. Pan water had the highest turbidity of 3026 NTU while borehole water had the lowest turbidity of 0.8 NTU. Mean value range for electrical conductivity and color were 139 µS/cm to 454 µS/cm and 13 TCU to 280 TCU respectively. Physico-chemical properties significantly differed ($p \leq 0.05$) across the water sources.

INTRODUCTION

Water is a natural resource that is required in all aspects of life (Hanasaki *et al*, 2013; Omar *et al*, 2017; Ferreira *et al*, 2017). Only 1 % of the total water coverage is available for use, 99 % of which are ground water sources (Ferreira *et al.,* 2017). Ground water while in the aquifers interacts with both beneficial and toxic components of soil and rocks and changes its physical and chemical properties (Peh *et al.*, 2010; Nair *et al.*, 2015). Pollution and modification of the hydrological cycle due to fluctuating climatic conditions tremendously alters the water quality characteristics (Nair *et al.,* 2015). Water scarcity and pollution of surface and ground water sources not only cause immediate effect on public health but can prove fatal to the continuous users in the long run (Shen and Chen, 2010; Simpi *et al.*, 2011; Juneja and Chaudhary, 2013). Pollution by heavy metals from industrial wastes renders the available water sources unsafe for drinking and food processing, some of these metals raises the physical and chemical properties of the water to unacceptable levels (Juneja and Chaudhary, 2013). Climatic changes and the trending global warming especially in the arid and semi-arid areas increase the rate of evaporation in surface water sources and hence the concentration of dissolved solutes (Simpi *et al.*, 2011; Hanasaki *et al.*, 2013; Wang *et al.*, 2014; Bada *et al.*, 2017). Water PH, electrical conductivity, turbidity, alkalinity and water hardness among other chemical properties are greatly influenced by seasons and location (Simpi *et al.*, 2011). Agricultural activities along the river banks also contributes to high water alkalinity (Pradesh *et al.*, 2012). The agricultural inputs on the farms are washed off by surface run-off into the surface water sources where they accumulate (Shen and Chen, 2010). Leaching through the soil occurs as rain water percolates and infiltrates through the soil profile (Pradesh *et al.*, 2012). Rural dwellers rely on surface and ground water for drinking and food processing (Malik *et al.,* 2010; Ahmad *et al,* 2012; Muhammad *et al,* 2013; Muhammad *et al.,* 2017). Due to contamination, majority of the human population do not have access to potable water and are therefore exposed to water borne health risks (Muhammad *et al.*, 2013). High alkalinity and pH of most of these water sources induces unpalatable taste as well as high salt intake that is implicated in high blood pressure and kidney stones (Anwar *et al.*, 2011; Muhammad *et al.,* 2017). However fluoride in optimal concentration in the drinking water is beneficial for strong teeth formation (Muhammad *et al.*, 2013). Meat and milk are the major items of trade from the pastoral communities in Kenya. The initial processing that involve cleaning of milk cans, carcass and mixing ingredients require water. The quality and safety of the available water sources in Isiolo County is unknown given their diversity. To enhance level of hygiene and public health among the population through provision of

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Corresponding author: **Abok Elisha Onyango,**
Department of Food Science, Nutrition and Technology, College of Agriculture and Veterinary Sciences - University of Nairobi, P.O Box 29053 – 00625, Kangemi, Nairobi-Kenya.

potable water, this study sought to establish the physico-chemical quality of water sources utilized by the residents.

MATERIALS AND METHODS

Study setting

The study was conducted in Isiolo County. Isiolo is an expansive County covering an area of 25, 336.1 square kilometers in the Northern Kenya classified as Arid and Semi-Arid land. It is located 285 kilometers north of Nairobi. Administratively Isiolo County consists of six divisions namely Central, Garbatulla, Sericho, Merti, Oldonyiro and Kinna. The plains gradually rise from an altitude of 200 -300 m above sea level. The main water sources includes river Ngare Mara, Ngare Ndare river, river Ewaso Nyiro, Leparua spring, Boreholes, Shallow wells, Pans and Dams and treated urban water supply in Isiolo town among others.

Data collection

Purposive sampling based on the available water sources distributed across the three locations of Ngare Mara, Burat and Wabera in Isiolo central. All the laboratory apparatus and polyethylene sampling bottles were pre-cleaned sanitized and sterilized. This procedure was very crucial to remove any contaminants before the analysis (APHA, 2012). The sterile sampling bottles were opened at the point of sampling to allow aseptic water sampling. Afterwards, the collected samples were stored in the cooler box at approximately 4˚C to minimize any activity that might alter the physico-chemical property of the water (APHA, 2012). During sampling, the polyethylene sample bottles were normalized with sampled water. Triplicate samples were collected and homogenized from each sampling station in order to obtain an average value for the analysis. Each bottle was labeled with corresponding sampling station and the time of sampling was recorded. The samples were then transported to the laboratory for analysis within 48 hrs of sampling owing to the long distance between sampling points and analysis station.

Sample size

Forty four (44) 100 ml water samples were purposively sampled aseptically from eight water sources. Samples from each water source were then mixed aseptically to obtain a randomized homogenous representative sample for analysis. Secondary data for treated urban water of river Isiolo over a period 6 years was also collected courtesy of Isiolo Water and Sewerage Company (IWASCO).

Analytical methods

pH determination

pH was determined as per ISO 10523:2017. Water quality pH determination, Using HACH pH meter model E-08328 Crisson Instruments, South Africa. The pH meter was calibrated using buffers 4.01 followed by 7.01 and 10.01 at 25˚C, then the electrode probe rinsed with distilled water. 50 ml of each water sample was placed in a beaker, then stirred for 15 seconds on the titrator using magnetic stir bar. pH values were then read off without stirring, the probe was rinsed between each sample determination.

Turbidity determination

Turbidity of the water samples was determined as per IS0 7027: 2016, using Turbidi meter HACH model 2100 Q01-2010- USA. 5 ml of each water sample was placed in the Turbidi meter and the turbidity read out in NTU.

Determination of total hardness

The total hardness of the water samples was determined as per ISO 6059. 50 ml of the water samples were placed in conical flask. 1 ml of buffer solution was added to each sample. To the sample buffer solution, 3 drops of Eriochrome black T indicator was added then the solution titrated against E.D.T.A solution to end point. Total hardness was calculated using the formula:

Total hardness = titre volume (ml)*20mg/l.

Determination of calcium and magnesium hardness

Calcium hardness was determined as per ISO 6059. 50 ml of water samples were placed in conical flask, 2mls of normal sodium hydroxide was added followed by Addition of 1ml hydroxynaphthol blue indicator, and the solution titrated against E.D.T.A without magnesium chloride to end point. The calcium and magnesium hardness was calculated using the following formulas based on titre volume of E.D.T.A:

Calcium hardness (mg/l) = titre volume (ml)* 8mg/l
Calcium carbonate hardness (mg/l) = calcium hardness (mg/l)*2.4975
Magnesium carbonate hardness (mg/l) = total hardness – calcium carbonate hardness
Magnesium hardness (mg/l) = magnesium carbonate hardness/4.116

Determination of electrical conductivity

Electrical conductivity of the water samples was determined as per ASTM-D1125 (2014). Standard test method for electrical conductivity and resistivity of water using H1 9033 Multi range conductivity meter. Electrical conductivity were reported in µS/cm

Determination of Color

Color of the water samples was determined as described by ISO 7887: (2011). Color values were recorded in TCU units.

Data Analysis

Analysis of variance (ANOVA) at 5 % level of significance was used to compare means of the physico-chemical water quality among all the sampled sources; river, spring, borehole, pans and shallow wells, using statistical analysis software (SAS) version 9.0. Least significant difference (Lsd) was used to separate the means. Significant differences were indicated by different letters. Pearson correlation was used to establish the relationship among the chemical quality aspects of the sampled water at 5 % and 1 % levels of significance.

RESULTS

Water hardness

Magnesium and calcium carbonates hardness and total hardness of ground water sources analyzed are shown in Table 1. Mean total hardness significantly differed ($p \leq 0.05$) across the water sources except between Tap and rain water. Borehole water had mean total hardness that was higher than 600 mg/l recommended for potable water by KS EAS 12: 2014. Tap water had the lowest mean total hardness of 138.5 mg/l. River water total hardness were similar to those analyzed between 2011 and 2016.

Table 1. Total hardness, Magnesium and Calcium Carbonates Hardness of the water sources

Water source	Total Hardness	Magnesium Carbonate Hardness	Calcium Carbonate Hardness
Tap	138.5±2.1a	125.0±1.4a	13.5±2.1a
Rain	139.5±0.7a	117.0±0.7a	21.0±2.4b
River	225.5±0.7b	145.0±1.4a	80.5±0.7cd
Open Shallow well	274.5±30.4c	210.0±7.1b	46.0±1.8ab
Spring	362.0±1.4d	269.5±0.7c	91.0±1.6d
Pan	478.0±4.2e	381.0±1.4d	93.0±1.4d
Shallow well	579.0±25.5f	448.5±24.7e	119.5±13.4e
Borehole	638.5 ±3.5g	467.0±32.5e	170.5±28.9f
Mean	354.4	270.4	84.7
cv%	4.0 %	5.4 %	13.4 %
L.S.D	32.72	33.89	26.18

1. Values are means of ten determinations ± standard deviations
2. Values with the same letters on the same column are not significantly different at 5% level of significance.

Table 2. Magnesium and Calcium Ions concentration and Water pH

Water source	Calcium ions concentration (mg/l)	Magnesium ions concentration (mg/l)	pH
Rain	6.85±0.2a	8.45±0.1a	3.4±0.13a
Tap	22.0 ±1.2b	31.0 ±1.4b	7.4±0.21b
Open shallow well	18.5±1.7b	49.5±0.7c	7.6±0.1b
Spring	35.0±3.2c	67.0±2.1d	8.1±0.04c
Pan	36.0±1.4c	90.0±2.4e	7.7±0.21b
River	34.0±2.8c	91.0±2.8e	7.7±0.07b
Shallow well	53.0±1.4d	102.0±2.8f	7.6±0.04b
Borehole	66.0±2.3e	108.0±1.4g	8.7±0.1d
Mean	33.92	68.43	7.24
cv%	4.5 %	2.7 %	1.7 %
L.S.D	3.51	4.24	0.29

1. Values are means of ten determinations ± standard deviations
2. Values with the same letters on the same column are not significantly different at 5% level of significance.

Table 3. Water turbidity, Electrical conductivity and Color

Water source	Turbidity (NTU)	Electrical conductivity (µS/cm)	Color (TCU^a)
Borehole	0.8±0.14a	454.0±2.8g	13.0±1.41a
Tap	1.7±0.14a	251.0±2.83b	39.0±5.65c
Shallow well	1.8±0.1a	310.5±2.1e	124.0±2.82ab
Open shallow well	2.2±0.35a	299.5±2.1d	133.0±2.34bc
Rain	9.6±0.35b	139.0±8.4a	117.0±1.3a
River	35.5±0.71c	317.5±2.1e	238.5±4.95e
Spring	40.3±1.9d	272.5±4.9c	80.0±5.66d
Pan	3026±4.2e	437.0±4.2f	280.0±9.9f
Mean	389.74	310.1	603.1
cv%	0.4 %	1.4 %	0.8
L.S.D	3.89	9.78	11.54

1. Values are means of ten determinations ± standard deviations
2. Values with the same letters on the same column are not significantly different at 5% level of significance.

Mean magnesium carbonate hardness significantly differed ($p \leq 0.05$) among pan, spring and open shallow well water. Tap and rain water as well as borehole and spring water insignificantly differed ($p \leq 0.05$) in their mean magnesium carbonate hardness. The highest and lowest mean magnesium carbonate hardness were 117 mg/l and 467 mg/l in rain and borehole water respectively. Grand magnesium hardness mean was 270.4 mg/l. Calcium carbonate mean hardness significantly differered ($p \leq 0.05$) across the water sources except between spring and pan water. Calcium carbonate mean hardness values range was 13.5 mg/l to 170.5 mg/l and an average mean of 84.7 mg/l. borehole water had the highest calcium carbonate concentration of 170.5 mg/l.

Magnesium and calcium ions concentration in the water sources

Mean magnesium ions concentrations varied from 8.45 mg/l to 108 mg/l. Across the water sources significant differences occurred ($p \leq 0.05$) except between pan and River water. Grand magnesium ions concentration was 68.43 mg/l as shown in Table 2. Calcium ions concentration significantly differered across the water sources ($p \leq 0.05$) except among pan, shallow well and river water and between tap and open shallow well water whose mean calcium ions concentration insignificantly differed ($p \leq 0.05$). Grand calcium ions concentration mean was 33.92 mg/l. Higher calcium ions concentrations were found in borehole and shallow well water than the other water sources.

Insignificant differences occurred among the mean pH values ($p \leq 0.05$) except that of rain, spring and borehole water that differed from the other water sources. The grand pH mean was 7.24 which is within the acceptable limit of 6.5 to 9.5 for naturally potable water by KS EAS 12: 2014 standards. Rain water had an acidic pH of 3.4 pointing towards the possibility of acid rains in Isiolo County. The mean pH values are similar to those of Isiolo river water between 2011 and 2016 drawn from secondary data.

Water turbidity, Electrical conductivity and Color

Ground water sources of borehole, open shallow well and shallow well had low mean turbidity values compared to surface water sources of pan, spring and river whose mean turbidity exceeded the 25 NTU for naturally potable water by KS EAS 12: 2014 standards. Significant differences in mean turbidity values only occurred in the surface water sources ($p \leq 0.05$). Ground water sources insignificantly differed ($p \leq 0.5$) in their turbidity mean values. Table 3 shows the mean values of water turbidity, electrical conductivity and color of the various water sources analyzed. Electrical conductivity mean values significantly differed ($p \leq 0.05$) across the water sources. Borehole water had the highest electrical conductivity of 454 μS/cm while rain water had the lowest electrical conductivity of 139 μS/cm. mean electrical conductivity values for the water sources were lower than 1500 μS/cm limit for treated potable water. The water sources significantly differed in their color mean values ($p \leq 0.05$). Pan water had the highest mean color value of 280 TCU which was higher than 50 TCU limit for naturally potable water. Most of the water sources had un-desirable color except borehole and urban treated water from the taps. Mean turbidity, electrical conductivity and color of the water were as higher as those of 2011 to 2016 for river water.

Pearson Correlation matrix for the physico-chemical water attributes

The relationships among the physical and chemical characteristics of the water samples analyzed are shown in Table 4.

Table 4. Pearson correlation for the physico-chemical characteristics of the water sources

	Total hardness	Calcium ions	Magnesium ions	pH	Turbidity	Electrical conductivity	Color
Total hardness	1	0.903^{**}	0.843^{**}	0.58^{*}	0.254	0.77^{**}	0.134
Calcium ions	0.903^{**}	1	0.904^{**}	0.713^{**}	0.043	0.773^{**}	0.041
Magnesium ions	0.843^{**}	0.904^{**}	1	0.755^{**}	0.244	0.839^{**}	0.341
pH	0.58^{*}	0.713^{**}	0.755^{**}	1	0.104	0.77^{**}	0.157
Turbidity	0.254	0.043	0.244	0.104	1	0.507^{*}	0.913^{**}
Electrical conductivity	0.77^{**}	0.773^{**}	0.839^{**}	0.77^{**}	0.507^{*}	1	0.499^{**}
Color	0.134	0.041	0.341	0.157	0.913^{**}	0.499^{**}	1

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

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

Water electrical conductivity and pH were greatly influenced by concentration of magnesium and calcium ions as shown in Table 4. Turbidity and color had a significant positive relationship (r = 0.913). Similarly an increase in water turbidity results into more dissolved minerals that significantly induces the electrical conductivity (r = 0.507).

DISCUSSION

Water hardness

Mean water hardness was 354.4 mg/l. Hardness mean values ranged from 138.5 mg/l to 638.5 mg/l. Reported values of 161 mg/l to 183 mg/l are within the range in the present study but have a much lower upper hardness range value (Pradesh *et al,* 2012). Ground water had higher hardness values than surface water. Environmental pollution and deforestation have led to climatic changes that have resulted in high rate of water evaporation from the surface waters and increased concentration of carbonates in the water (Simpi *et al.*, 2011; Hanasaki *et al.*, 2013; Wang *et al.*, 2014; Bada *et al.*, 2017). Given the harsh prevailing conditions of arid and semi-arid regions of Kenya of which Isiolo County form part, modification of the hydrological cycle occurs as rate of replacement of evaporated water is intermittent (Nair *et al.*, 2015; Ferreira *et al.*, 2017). Majority of the rural population relies on ground water held in aquifers during dry seasons which occur most of the year (Olaleye and Ogunbajo, 2015; Megha *et al.*, 2015; Muhammad *et al.*, 2017). Water hardness is season dependent with higher values in the months of April – July (Simpi *et al.*, 2011). Lithology, ground velocity and recharge greatly impact on the calcium and magnesium ions concentration (Ferreira *et al.,* 2017). During these dry seasons the population utilizing these water sources are therefore exposed to high health risk as they have to bear with the highly saline water for drinking. As the ground water infiltrates and percolates through the Earth crust after precipitation it carriers dissolved minerals in the form of calcium ions and magnesium ions from the surface bed rock through which the water flows into the aquifers (Bada *et al.*, 2017; Ferreira *et al.,* 2017). Similarly surface run-offs to the surface water sources flow through the farming regions on the slopes of Mount Kenya, the source of springs and rivers utilized in Isiolo County. In these areas application of chemical inputs on farms is the normal practice. Some of the carbonates applied in the farms therefore contribute to the observed levels in the analyzed samples. Calcium ions values ranged from 6.85 mg/l to 66.0 mg/l which were within the acceptable limit of less than 150 mg/l recommended by East African as well as WHO standard for potable water (WHO, 2014; KS EAS12, 2014). Similarly magnesium ions concentration values were in the range of 6.85 mg/l to 120.04 mg/l, only few water samples had mean magnesium values greater than 100 mg/l limit recommended for potable water (WHO, 2014; KS EAS 12, 2014). Borehole and shallow well water sources had the highest magnesium and calcium hardness. The bed rocks through which the underground water rises and the surface water flows, is weathered and the carbonates that constitute these rocks dissolve in water delivering the minerals of calcium and magnesium into the water (Mokhtar *et al.*, 2009). Boreholes and shallow wells are always enclosed by the earth crust rocks and therefore the concentration is greater as the constant contact provide adequate time for more of the rocks carbonates to dissolve into the water enhancing the concentration of the carbonates (Mokhtar *et al.*, 2009). Rate of contaminations depends on the aquifer lithology, ground velocity and recharge replacement (Ferreira *et al*., 2017). Water with high concentration of calcium and magnesium carbonates causes formation of scales in steam and boiler pipes if used in steam generation at industrial level, thereby inducing heat resistance and increased fuel consumption leading to extra cost of food processing (Talabi *et al*., 2013; Singh *et al*., 2013). Hard water does not lather well with soap and thus more detergent consumption when used for cleaning food handling equipment (Karikari *et al*., 2011; Sigh *et al.,* 2013).

Water pH

pH values of the water samples ranged from 3.4 to 8.7 and are favorable for the growth of planktons that are useful for breeding of fish that is food to the population (Pradesh *et al*., 2012). Alkaline skewed pH values have been reported in various studies in different environments pointing towards the trend extent of environmental and water pollution (Simpi *et al*, 2011; Pradesh *et al*., 2012; Muhammad *et al*., 2013). The pH values differered significantly ($P \leq 0.05$) from one water source to another. Majority of the pH values were within the range of 6.5 to 8.5 standard specification for potable water (WHO, 2004; KS EAS 12, 2014). Ngare Mara rain water had the least pH of 3.4. As the rain falls, it dissolved the exhaust gases within the atmosphere forming weak carbonic acid thereby the low pH. The low pH also indicates that there is heavy pollution in the environment and possibility of acid rains was high (Simpi *et al*., 2011; Hanasaki *et al*., 2013; Wang *et al*., 2014; Bada *et al*., 2017). Similar acidic skewed pH values were observable in most surface water sources, acidity arises from the soil through which the water flows washing off-acidic farm inputs into the surface water reservoirs. The alkaline condition normally indicates the presence of carbonates of magnesium and calcium in the water (Begum *et al*., 2009; Reza and Singh, 2010). The concentrations of calcium and magnesium were moderate and the pH mean values were skewed to neutral. The significant positive relationship ($r = 0.713$) explains the close association of water pH to dissolved ions. Higher concentration of calcium ions in water induces higher pH values that are skewed to the alkaline extremes (Begum *et al*., 2009; Reza and Singh 2010). Water with extreme pH is not suitable for use in industrial food processing as well as for drinking due to their unpalatable taste (Simpi *et al*., 2012; Ferreira *et al*., 2017). Close association of pH to dissolved ions can then be used to gauge the level of contamination of the water source (Pradesh *et al*., 2011).

Water Turbidity

Pan water had the highest turbidity mean values that were greater than 25 NTU maximum limit for potable water (WHO, 2004; KS EAS 12, 2014). Turbidity was highest in pan water, followed by river water and spring water respectively. Borehole and protected shallow wells had the lowest turbidity values. Urban treated tap water also had lower values of turbidity but this differed significantly ($P \leq 0.05$) from one sampling location to another depending on the household handling. Turbidity of borehole water, shallow wells and urban treated water were within the acceptable limits of less than 25 NTU East African standard for potable water. Generally, water turbidity significantly ($P \leq 0.05$) differed across all the water sources. Surface run-off as well as dredging at the sites carried sediments into the pan (Ashraf et al., 2011). Turbidity has high association with total suspended solid that makes the water un-clear and higher cost to purify for use in food processing (Bada *et al*., 2017; Ferreira *et al*., 2017). The suspended solids observed in turbid water includes organic matter and consequently higher microbial load that dominates such water making them unsafe (Simpi *et al*., 2011; Bada *et al.,* 2017). Riparian vegetation cover on at some points of the river bed served to purify the water trapping most of the suspended solids. As the water flows over uncovered river surface greater siltation occur hence the higher value turbidity (Ashraf *et al*., 2011). At the town center through which river Isiolo traverses pollution emanates from the settlement around the river as the population channel their wastes directly into the river as surface run-offs that wash the top soil on their way and consequently cause siltation of the river (Pradesh *et al*., 2012; Simpi *et al.,* 2011; Muhammad *et al*., 2013). Spring water that emerges from the earth crust similarly had higher turbidity value but this is from the soil through which the spring emerges (Balke and Zhu, 2008; Momba *et al*., 2012). Shallow well, borehole and urban treated water had low turbidity levels that are within acceptable limits of less than 25 NTU for potable water (WHO, 2004; KS EAS 12, 2014).

Water Electrical conductivity

Electrical conductivity is influenced by the presences of dissolved minerals in the water (Begum *et al*., 2009; Reza and Singh, 2010). Concentration of calcium and magnesium ions in the water acts as electrolyte to promote current flow ($r = 0.773$ and 0.839). The electrical conductivity of the utilized water sources were within the acceptable limit of 2500 µS/cm for potable water (WHO, 2004; KS EAS 12, 2014). Despite the pollution that increases the concentrations of calcium and magnesium ions in water, the increase requires longer period of time to negatively impact on electrical conductivity.

Water Color

The presences of dissolved minerals such as ferrous among other ions such as manganese have been reported to be responsible for the off color of water (Simpi *et al*., 2011). As the turbidity of the water rises due to dissolved and suspended solids the water loses its clarity and becomes non-pleasant (Ashraf *et al*., 2011). The close association of color and turbidity ($r = 0.913$) implicates discharge of solid wastes and soil erosion occurring on bear soil on which surface run-off occurs as well as the eroded river bed and banks with little riparian vegetation in the observable poor color of surface water sources (Bada *et al*., 2017; Ferreira *et al*., 2017). Ground water passes through a bed of soil, rocks, gravel, fine and course sand that traps most of the dissolved and suspended solids as the water infiltrates and percolates through the earth crust and hence the low turbidity and clear color.

Conclusion

Water scarcity is a major challenge facing most residents of Isiolo County. The available water sources are limited to seasons and locations. Most of the surface water are exposed to contaminants such siltation that raises the turbidity and poor color rendering them unpalatable for direct use. Ground water sources which are dominantly utilized by majority of the population for drinking and other domestic uses are highly saline. Greater exposure to salt intake induces health risk of public concern such as high blood pressure. Consequently a large proportion of the population are rendered incapacitated hence retarded economic activities. Non-potable water supply has hindered the setting up of most food processing industry in the area yet raw food process materials such as meat and milk are predominantly produced by the population who fail to secure better value market as spoilages claim the value. Creating environmental awareness to minimize pollution of the water sources would go a long way to supply of potable water. Water treatment is effective in provision of potable water. However, the water treatment plant is only accessible to those residing within the location of Isiolo Water and Sewerage Company (IWASCO). Cheap and affordable household water treatment techniques are necessary.

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