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Assessment of Quality of Borehole Water as Sources of Domestic Water in Nairobi

Metropolitan Region: Use of Secondary Data.

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ABSTRACT

Kenya, classified as a water-scarce country faces challenges from both natural and anthropogenic factors compromising the quality and water sources. Surface water sources have become severely polluted creating a big demand on the use of groundwater as sources of water for domestic uses mainly through drilling of boreholes. This study focused on quality of borehole water in Nairobi, Kajiado, Kiambu and Machakos which together form the Nairobi Metropolitan region. A total of 277 water quality reports were used in this study. 47 % from Nairobi, 19% Kajiado, 17% Kiambu and 17% Machakos. The study focused at assessing the quality of water as per the following parameters necessary for water for domestic sources; pH, Color, Turbidity, Conductivity, Nitrates (NO₃), Nitrites (NO₂), Calcium Magnesium, Total Hardness, Chlorides, Fluoride, Ammonia, and Sulphate. The main objective of this study was to assess the status of borehole sources of water in the Nairobi metropolitan region. The study used data obtained from water quality reports which were analyzed using MS Excel and the conclusions and recommendations were made based on the results. From the study, water quality in all Kiambu boreholes met the recommended limits for drinking water for Total Dissolved Solids, Conductivity, Chlorides, Sulphates and Total Hardness levels; Calcium was the only parameter that all the boreholes in Machakos had values within the recommended limits for drinking water. Fluoride was the only parameter that recorded levels higher than those recommended for drinking water in all regions except in Kiambu where only 27.9% of boreholes had values higher than 1.5mg/l. The study therefore concludes and recommends that borehole water from the Nairobi Metropolitan region should be treated before being used as drinking water sources.

1.0: Introduction

Kenya is classified as a water-scarce country with only 647 cubic meters of renewable freshwater per capita per annum. In addition to being a water scarce country, Kenya is faced with the challenge of water pollution which affects the quality of water for domestic use. According to Onesmus, N. S (2018), fresh water has become a scarce basic commodity as a result of over utilization coupled with water pollution. Water quality has an impact on both the public health and aesthetic value of water as a consumable product.

Nyakundi, V., et al., (2020) noted that several factors that compromise water quality in urban areas include the natural occurrence of high fluoride levels in groundwater. Further the author noted that many residents are forced to rely on private water distributors from boreholes whose quality cannot be ascertained. The reliance on private suppliers is partly due to the scarcity of water supplied by water service providers in the metropolitan region due to water demand exceeding supply. As a result of the uncertainty in water quality from boreholes, Makokha, M. (2019) carried out research to examine groundwater quality so as to determine its suitability for domestic purposes. The study indicated that groundwater along Kenyan Coastal region was unsuitable for human consumption in dry season due to high Electric conductivity, Total dissolved solids and Chlorides.

This current study was therefore important since the Nairobi Metropolitan (Nairobi, Kajiado, Machakos and Kiambu) has a big population of urban dwellers. For instance, Machakos town has experienced rapid population increase since the inception of devolved system of government but the supply of piped water by the local water service provider has not been adequate due to the infrastructural capital investments required therefore, borehole water is among the alternative sources for drinking water in the area (Nzeve, J.K and Mbate, G.N., 2021).

The main objective of this study was to assess the status of borehole water in the Nairobi metropolitan region as sources of domestic water. The levels of parameters were assessed by comparing to the World Health Organization and Kenya Bureau of Standards acceptable limits for drinking water. Similar studies have been carried out by examining the physicochemical characteristics of the water sources with the aim of qualifying the water for domestic use (Chebet, E. B. , et. al., 2020). This study however used secondary data in form of water quality reports whereas Chebet, E. B. , et. al., (2020), collected water samples and analysed the water so as to obtain water quality data.

2.0 Study Area

The area under this study is the Nairobi Metropolitan area which covers Nairobi, Kajiado, Machakos and Kiambu. A total of 277 water quality reports were used in this study. 47 % of the reports were for Nairobi, 19% for Kajiado, 17% for Kiambu and Machakos each. The distribution of borehole reports used as per the 4 regions is indicated in Figure 1.

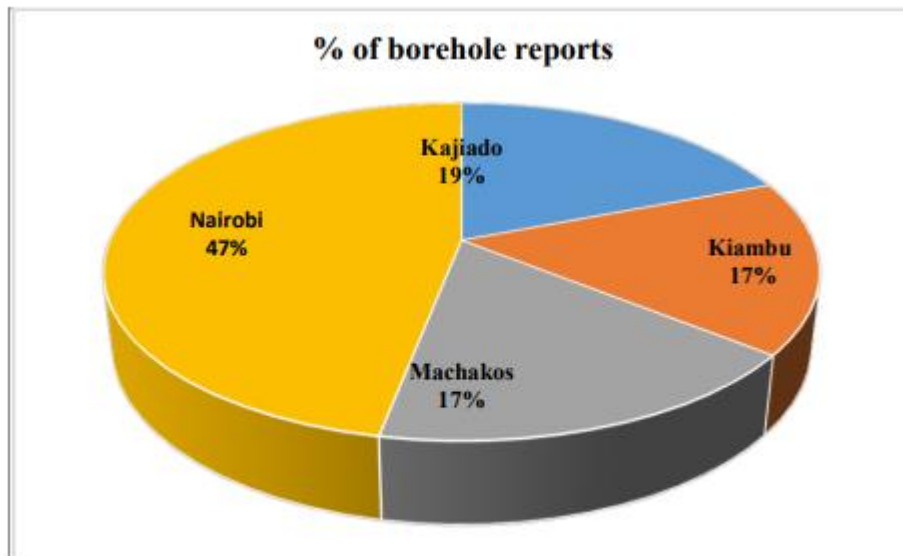


Figure 1: No. of borehole reports per region

3.0 Methodology

A total of 277 water quality reports for borehole sources for Nairobi, Kajiado, Machakos and Kiambu were used in this study. From the reports, the levels of the following parameters necessary for determining water quality for domestic sources were analysed and discussed; pH, Color , Turbidity, Conductivity, Nitrates, Nitrites, Calcium, Magnesium, Total Hardness, Chlorides, Fluoride, Ammonia, and Sulphates.

4.0 Results and Discussions

4.1 Nitrates

An average of 64.3% of boreholes in Nairobi Metropolitan have Nitrate levels within the limits of safe drinking water. The only exception is Kajiado with 50% of boreholes exceeding 10mg/l.

Table 1: Over 60% of boreholes in Nairobi Metropolitan area have Nitrate levels within the recommended limits for drinking water.

	Nitrates (mg/l)	
	< 10	> 10
Kajiado	50.0	50.0
Kiambu	59.5	40.5
Machakos	62.8	37.2
Nairobi	84.9	15.1
Average %	64.3	35.7

4.2 pH, Turbidity and Iron, Magnesium levels within the limits of safe drinking water

Table 2 indicates that over 70% of Nairobi metropolitan boreholes have pH, Turbidity and Iron levels within the limits of safe drinking water.

pH- 75.4% of boreholes in Nairobi Metropolitan area have pH levels within the limits of safe drinking water as per Kenya Bureau of Standards (KEBS) and World health Organization (WHO) standards. Allowable pH for drinking water should range between 6.5 - 8.5 (WHO Guidelines for Drinking water Quality). The remaining 24.6% of boreholes in the study area have pH levels that fall above the upper limit of 8.5 (21.0%) and below the lower limit of 6.5 (3.6%). Acidic water with a pH of less than 6.5 is more likely to be contaminated with pollutants, making it unsafe to drink, higher pH levels causes a bitter taste.

Turbidity- 71.5% of boreholes in Nairobi Metropolitan have turbidity levels within the recommended levels of drinking water while the remaining 28.5% indicated turbidity values above 5 NTU. An increase in turbidity is as a result of high percentage of suspended particles in water including soil particles or algae. Clean drinking water should be clear from suspended particles. Turbid water may be a breeding medium for pathogens, which may lead to outbreaks of waterborne diseases (N.O. Boadi, S.A. Saah, F. Baa-Poku et al, 2020).

Iron-74.1% of boreholes in Nairobi Metropolitan have Iron levels below 0.3mg/l whereas 25.9% of boreholes have Iron levels higher than 0.3mg/l which is beyond the recommended limits of drinking water by KEBS. High iron in water leads to an overload which can cause health problems such as stomach problems, and nausea. It can also damage body organs.

Table 2: Parameters that are within the recommended limits for drinking water in over 70% of boreholes in Nairobi Metropolitan area

	pH (pH scale)			Turbidity (NTU)		Iron (mg/l)	
	< 6.5	6.5-8.5	> 8.5	< 5	> 5	< 0.3	> 0.3
Kajiado	0.0	71.7	28.3	84.3	15.7	85.4	14.6
Kiambu	11.1	80.0	8.9	67.4	32.6	69.8	30.2
Machakos	2.1	83.3	14.6	56.3	43.8	67.4	32.6
Nairobi	3.1	72.3	24.6	73.6	26.4	73.6	26.4
Average %	4.1	76.8	19.1	70.4	29.6	74.1	26.0

4.3 Magnesium, Nitrites and Ammonia.

Magnesium (mg/l)- 85.6% of the boreholes in Nairobi Metropolitan have Magnesium levels below 100mg/l. Only 2% of Kiambu boreholes have Magnesium levels above 100mg/l. Kajiado boreholes have the highest percentage of boreholes with Magnesium levels that exceed KEBS limits for drinking water. KEBS guidelines state that the maximum Magnesium levels for drinking water should be 100mg/l. There are no adverse health effects associated with consumption of exceeding level limit. Magnesium ions are of particular importance in water pollution as they may contribute to water hardness.

Nitrites(mg/l)- An average of 82.1% of boreholes in Nairobi Metropolitan have Nitrites level within the recommended limits of drinking water. Kajiado had the highest level (23%) of boreholes that do not meet KEBS standards of 0.1mg/l.

Ammonia (mg/l)- According to KEBS guidelines the Ammonia levels should not exceed 0.2 mg/l in drinking water. From the study, 17.4%, 15.9% and 12.2% of boreholes in Machakos, Nairobi and Kajiado respectively recorded levels above the recommended level of 0.2 mg/l with only 2% of Kiambu boreholes records the least levels of of all studied boreholes. High levels of ammonia of above 0.2 mg/l in drinking water causes damage to organ systems in human body and respiratory problems.

Table 3: Parameters that are within the recommended limits for drinking water in over 8% of boreholes in Nairobi Metropolitan area

	Magnesium (mg/l)		Nitrites (mg/l)		Ammonia (mg/l)	
	<100	>100	< 0.1	> 0.1	< 0.2	> 0.2
Kajiado	67.3	32.7	76.9	23.1	87.8	12.2
Kiambu	97.7	2.3	82.8	17.2	97.7	2.3
Machakos	85.1	14.9	81.3	18.7	82.6	17.4
Nairobi	92.2	7.8	87.3	12.7	84.1	15.9
Average %	85.6	14.4	82.1	17.9	88.1	12

4.4 Colour, Total Dissolved Solids, Total Alkalinity, Conductivity, Calcium, Chlorides, Sulphates and Total Hardness

Table 4 indicates parameters that are within KEBS acceptable limits for drinking water in over 90% of the boreholes in the study area.

Colour (Hazen units)- From Table 4 above, it is evident that an average of 91% of boreholes meets the recommended levels of colour in drinking water which is up to 15 hazen however in the remaining 9% of boreholes, the water might be contaminated by several contaminants making the water unpleasant or unsafe for drinking hence requiring treatment. Colour change in water is an indicator of possible contamination or presence of heavy metals which are associated with health cases. In addition, heavy metals cause water to have unpleasant taste or colour which is the primary indicator and simplest test of acceptance of water as clean. Studies have shown color levels of up to 15hazen units may not make it harmful to drink but it certainly

makes it unappealing`114g to drink. So, color in our water does matter when it comes to drinking it, as well as in water for other home uses, industrial uses, and in some aquatic environments. For drinking water that has colour levels higher than 15 require treatment.

Total Dissolved Solids (mg/l)- 93.3% of boreholes meet the recommended levels of Total Dissolved Solids as ions in drinking water. All boreholes in Kiambu meet the levels of less than 1500mg/l. Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic matters or salts which are found in water.

Total Alkalinity (mg/l)- 93.6% of boreholes in Nairobi Metropolitan have alkalinity levels below 500mg/l which are within the recommended limits of drinking water. Only 2.2% of Kiambu borehole do not meet Total Alkalinity levels for drinking water.

Conductivity ($\mu\text{S/cm}$)- While all boreholes in Kiambu meet the recommended limits for drinking water, an average of 93.9% of the boreholes in the metropolitan region have conductivity values below 2500 $\mu\text{S/cm}$ which is within the recommended limits for drinking water according to KEBS guidelines. Conductivity is useful as a general measure of water quality. It indicates the ability of water to pass an electrical current. High conductivity is not necessarily a cause for concern due to its lack of direct health impacts. However, dissolved ionisable solids may cause water hardness or alkalinity and therefore impact consumer satisfaction (Dorairaju, S.V., Rao, C.N., Raju, M.B., and Chalapathi, P.V., (2013).

Calcium (mg/l)- For the metropolitan region, an average of 96.7% of boreholes in the region recorded Calcium levels less than 100mg/l. Calcium levels in all Kajiado and Machakos boreholes were below 100mg/l whereas Kiambu and Nairobi recorded 9% and 5% of boreholes having Calcium levels above 100mg/l respectively. Calcium is abundant in water through the erosion of rocks. There are no adverse health effects associated with consumption of water exceeding level limit. Calcium is largely responsible for water hardness, and may negatively influence toxicity of other compounds. Elements such as copper, lead and zinc are much more toxic in soft water.

Chloride (mg/l)- 91.5% of boreholes have Chloride levels below 250mg/l which is within the recommended limits for drinking water. All boreholes in Kiambu meet the recommended limits for drinking water. KEBS guidelines state that the maximum Chloride levels for drinking water should be up to 250 mg/l. Drinking water with small amounts of chloride does not cause harmful health effects and provides protection against waterborne disease outbreaks.

Sulphate (mg/l)- 96.8% of Nairobi Metropolitan boreholes have Sulphate levels below 450 mg/l. 100% of Kiambu boreholes meet the recommended limits for drinking water which is up to 450 mg/l. High levels of sulphate in drinking water does not have health-based effects but impart a noticeable taste. Sulphate gives a bitter or medicinal taste to water if it exceeds a concentration of 450 mg/l. This may make it unpleasant to drink the water. Health effects for people who are not used to drinking water with high sulphate include diarrhea and dehydration from drinking the water. Infants are often more sensitive to sulphate than adults.

Total Hardness (mg/l)- 93.4% of Nairobi Metropolitan boreholes have total hardness levels below 500mg/l which is the recommended level for drinking water. Total hardness in all Kiambu boreholes is within the limits for drinking water. Hard drinking water generally contributes a small amount towards the total calcium and magnesium needed in the human diet. Hard water makes human skin dry and also leads to bumpy patches on the skin. These skin problems are caused by the presence of excessive minerals in the water.

Table 4: Parameters that are within the recommended limits for drinking water in over 90% of boreholes in Nairobi Metropolitan area

	Colour		Total Dissolved Solids		Total Alkalinity		Conductivity	
	< 15	> 15	<1500	> 1500	< 500	> 500	< 2500	> 2500
Kajiado	98	2	86.8	13.2	92.2	7.8	86.8	13.2
Kiambu	93.3	6.67	100	0	97.8	2.2	100	0
Machakos	81.3	18.7	89.6	10.4	87.5	12.5	91.7	8.3
Nairobi	91.3	8.7	96.9	3.1	96.8	3.2	96.9	3.1
Average %	91	9	93.3	6.7	93.6	6.4	93.9	6.1
	Calcium		Chloride		Sulphate		Total Hardness	
	< 100	>100	< 250	> 250	< 450	> 450	< 500	> 500
Kajiado	100	0	82	18	90.2	9.8	90	10
Kiambu	91.5	8.5	100	0	100	0	100	0
Machakos	100	0	87.5	12.5	97.8	2.2	85.4	14.6

Nairobi	95.4	4.6	96.5	3.5	99.1	0.9	98.3	1.7
Average %	96.7	3.3	91.5	8.5	96.8	3.2	93.4	6.6

4.5 Fluoride

Fluoride was the only parameter that recorded over 50% of boreholes having values above the recommended limits for drinking water of 1.5 mg /l in Kajiado (57 %) and Nairobi (55%). Only 28% of Kiambu boreholes had fluoride levels above 1.5mg/l.

Table 5: Over 50% of boreholes in Nairobi Metropolitan area have Fluoride levels within the recommended limits for drinking water.

	Fluoride (mg/l)	
	< 1.5	> 1.5
Kajiado	42.9	57.1
Kiambu	72.1	27.9
Machakos	52.1	47.9
Nairobi	44.9	55.1
Average %	53	47

5.0 Conclusions and Recommendations

- 1) All the Kiambu boreholes have Total Dissolved Solids, Conductivity, Chlorides, Sulphates and Total Hardness levels within the recommended levels of drinking water while Calcium was the only parameter that had recommended limits for drinking water in Machakos.
- 2) Fluoride was the only parameter that recorded levels higher than those recommended for drinking water in all regions except in Kiambu where only 27.9% of boreholes had values higher than 1.5mg/l.
- 3) Over 70% of Nairobi metropolitan boreholes have pH, Turbidity and Iron levels within

the limits of safe drinking water; over 80% of boreholes in Nairobi Metropolitan area have Magnesium, Nitrites and Ammonium within the recommended limits for drinking water while over 90% of the boreholes in the study area have Colour, Total Dissolved Solids, Total Alkalinity, Conductivity, Calcium, Chlorides, Sulphates and Total Hardness within KEBS acceptable limits for drinking water.

- 4) The study therefore concludes that borehole water from the Nairobi Metropolitan region should be treated before being used as drinking water sources.

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