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Determination of Physico-Chemical Properties Of Sources of Water In Narok North Sub- County, Kenya

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Abstract

A study was conducted in Narok north sub-county, Kenya to analyze physico-chemical properties of water in various water sources in dry and wet season to determine water quality for domestic use. Properties analyzed included pH, temperature, DO, BOD, TDS, TSS and total hardness. The results indicated that most parameters fell within the accepted range according to WHO except for the BOD which indicated the presence of microorganisms and hence the water is not fit for human use unless treated prior to consumption.

Keywords: pH, TSS, BOD, TDS, DO, water sources.

Introduction

Water has been known as a changing system that contains living and non living organisms, organic, inorganic soluble and insoluble substances. Therefore there is possibility of variation in its quality that could occur on a daily basis and also from the origin of the water[1]. A shift in the natural composition of the water could disturb the balance and result in the water being unsuitable for the intended consumption[1]. Important information can be attained concerning the suitability of the water, the origin of deviations from the norm, their effects on the functions and biodiversity of the water source by checking for colour change, temperature variations, occurrence of acidity, degree of hardness, pH, amount of dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand[2]. Elevated rate of growth of plants and algae resulting from increase in temperature which causes an increase in photosynthetic rate of aquatic plants and algae can have negative effects on the ecosystem[3]. The corrosive nature of water is measured by the pH. The corrosive nature of water is inversely proportional to the pH in that the lower the pH value, the higher the corrosive nature of the water[4]. Direct and indirect information on bacterial activity, photosynthesis, availability of nutrients and stratification of a water body can be obtained by measuring the dissolved oxygen concentration[3]. Measurement of organic material contamination in water is determined by obtaining the biochemical oxygen demand (BOD). The amount of dissolved oxygen required for biochemical breakdown of organic compounds and oxidation of inorganic elements like iron and sulfites is referred to as biochemical oxygen demand. High BOD results in decrease in level of dissolved oxygen[5]. The presence of calcium and magnesium ions in water is checked by determination of total hardness. This results in poor lathering with soap and scale formation[1]. Total dissolved solids measure the presence of all dissolved salts. These cause undesirable taste of the water, gastro- intestinal irritation and corrosion[4]. Total suspended solids cause water treatment process to be less effective especially when the values are high, resulting in end supply with sediments, discolouration and not so clear appearance[5]. Various studies have been carried out to demonstrate that physico- chemical parameters of water can be used to determine its quality[2,6-10]. A research was conducted in Narok north sub-county, Kenya to analyze physico-chemical properties of water in various water sources like river, rain and water tanks during wet and dry seasons so that the composition of the water could be determined with reference to suitability for human consumption. Analysis of pH, temperature, DO, BOD, total dissolved solids (TDS), total suspended solids (TSS) and total hardness was carried out.

Material and Methods

The Study site: Three study sites located in Narok North sub-County were selected strategically along the Narok- Bomet road, which was used as a transect line with 5km distance on either side. These sites were sampled purposely at the point where the community fetched their water for domestic use. The rivers sampled were Enkare Narok, Ewaso Ng'iro and Nkareta. Sampling was also carried out in water tanks and water pans.

Assessment of Physicochemical properties: Water samples were obtained from all the sampled areas in triplicates at 10cm depth during the dry and wet season. 398 samples were obtained and measured. Temperature was measured at the site of sample collection by use of a mercury thermometer. Hanna pH 211 meter was used to determine the pH. The MRC-Q082472

oxygen meter was used to measure the dissolved oxygen. BOD was determined as the difference between the oxygen concentration of a sample before and after incubation for 5 days at 20^{o}C in the dark[11]. The TDS was obtained as per methods described in APHA 2540C. The total suspended solids concentration was determined as per APHA 2540D. Total hardness was determined using the titration method as described by APHA 2340[11,12].

Results and Discussion

Water pH: In the dry season, the highest pH of 9.163 ± 0.050 was recorded in water tanks and the lowest pH value of 7.874 ± 0.008 was recorded in Nkareta River as shown in table-1. The mean pH of the sampled areas during the dry season was 8.545 ± 0.564. In the wet season, the highest pH was recorded in water pans with a value of 8.937 ± 0.006 and the lowest pH was recorded in the water tanks with a value of 5.128 ± 0.025. The mean pH value for all sampled areas during the wet season was 6.853 ± 1.150. The highest pH of 9.163 ± 0.050 which was recorded in water tanks during the dry season was alkaline and this could be due to the carbonates and bicarbonates present in water[13,14]. The lowest pH of 5.128 ± 0.025 was recorded in the water tanks during the wet season and was slightly acidic and this could be attributed to the presence of carbon dioxide which dissolves to form carbonic acid[2,14-16] and reaction of water with chlorine to form hypochlorous acid and hypochlorite which could have led to the decreased pH value[17]. Most of the pH values obtained in this study agreed well with those of studies done in Irigu river, Meru, surface water samples in Akot city and water supplies at Nsukka, south east Nigeria where the mean pH of the sampled water ranged between 7.38- 8.41, 5.4- 9.5, 5.6- 6.4 respectively[13,15,18]. Most of the pH values obtained in this study agreed well with those of WHO[19] which range between 6.5- 8.5 except three; of which one was low with a value of 5.128 ± 0.025 recorded in the water tanks and two which were higher than the WHO range and had values of 8.937 ± 0.006 and 9.163 ± 0.050 which were recorded in the water pans and water tanks respectively.

Temperature of water: In the dry season, the highest temperature of 26.013 ± 0.052°C was recorded in Nkareta river and the lowest temperature of 22.913 ± 0.334°C was recorded in the water pans as shown in table-1. The mean temperature of all the sampled areas during the dry season was 24.951 ± 0.900°C. In wet season, the highest temperature was recorded in water tanks with a value of 24.216 ± 0.199°C and the lowest temperature was recorded in the water pans with a value of 12.367 ± 0.202°C. The mean temperature value for all sampled water sources during the wet season was 22.832 ± 3.486°C. The highest temperature was recorded in Nkareta river with a value of 26.013 ± 0.052°C and this could be attributed to decrease in depth of water resulting in light rays penetrating the water and heating up the sand hence consequently raising the water temperature[15]. It could be attributed to increase in photosynthetic processes of aquatic plants and algae[3]. The lowest temperature of 12.367 ± 0.202°C was recorded in the water pans and could be due to increased volume from rain water and decreased penetration of the light rays due to deposition of silt and suspended material[15]. These results concur with findings in Irigu river, Meru, Manipur river system, India and Zayandeh Rud River, Iran where the mean temperature recorded during the wet season on analyzed water samples was 21.8- 24.6^{0}C 16-28^{0}C and 12.92^{0} respectively[15,20,21]. However, temperature from all the water sources in this study fell below the recommended level of 30- 35°C[22].

Dissolved oxygen: In the dry season, the highest DO value of 8.720 ± 0.194 mg/l was recorded in the water pans and the lowest DO value of 1.427 ± 0.108 mg/l was recorded in Ewaso Ng'iro river as shown in table -2. The mean value of DO of all the sampled areas during the dry season was 5.509 ± 3.232 mg/l. During the wet season, the highest DO value was 13.180 ± 0.296 mg/l recorded in the water pans and the lowest DO value was recorded in Enkare Narok with a value of 8.023 ± 0.157. The mean DO value for all the sampled areas during the wet season was 8.805 ± 1.466 mg/l. The highest DO value of 13.180 ± 0.296 mg/l was recorded in the water pans and could possibly be due to increase in photosynthesis and availability of nutrients[5]. The lowest DO value of 1.427 ± 0.108 mg/l was recorded in Ewaso Ng'iro river and this could possibly be due to increased organic load in the water which requires a high level of oxygen for chemical oxidation and breakdown[23]. These findings agree with those from borehole water in Akwa Ibom state, Oyun reservoir, Nigeria, surface water samples in Akot city, water supplies in Nsukka, south east Nigeria, Manipur river system, India, river Yobe, Nigeria and Zayandeh Rud river, Iran where the water samples analyzed had mean DO value of 0.2 - 4.82 mg/l, 4.8 - 8.2 mg/l, 4.9- 8.2 mg/l, 5.4- 6.4 mg/l, 4.43- 13.09 mg/l, 5.87 - 7.20 mg/l and 8.86 mg/l respectively[16,2,13,18,20,24,21]. The values of DO allowed for domestic water is 6 mg/l[22] hence all of the water sources in the study did not meet this criterion.

Table-1
Temperature and pH values of the water sources during the dry and wet season

Water Source	pH		Temperature (°C)	
	Dry season	Wet season	Dry season	Wet season
Enkare Narok	7.893± 0.148	7.963 ± 0.101	25.581 ± 0.185	24.130 ± 0.389
Ewaso Ng'iro	8.485 ± 0.080	8.111± 0.027	25.683 ± 0.077	23.374 ± 0.263
Nkareta	7.874 ± 0.008	7.285 ± 0.009	26.013 ± 0.052	23.807 ± 0.103
Water Pans	8.045 ± 0.005	8.937 ± 0.006	22.913 ± 0.334	12.367 ± 0.202
Water tanks	9.163 ± 0.050	5.128 ± 0.025	24.535 ± 0.191	24.216 ± 0.199

Biochemical oxygen demand: During the dry season, the highest BOD value of 9.434 ± 0.061 mg/l was recorded in the water pans while the lowest value of 8.663 ± 0.072 mg/l was recorded in Ewaso Ng'iro river as shown in Table -2. The mean BOD value of all the sampled water sources in dry season was 9.062 ± 0.305 mg/l. During wet season, the highest value of BOD was 29.987 ± 0.544 mg/l and was recorded in the water pans and the lowest value of 10.157 ± 0.077 mg/l was recorded in Enkare Narok. The mean BOD value of the sampled water sources during the wet season was 17.983 ± 5.221 mg/l. The highest BOD value of 29.987 ± 0.544 mg/l recorded in the water pans could possibly be due to a high influx of organic material resulting from rain water runoff[25] and animal waste as they drank water. The lowest BOD value of 8.663 ± 0.072 mg/l recorded in Ewaso Ng'iro river could be due to the fact that organic material for decomposition was not much. In a study carried out on River Yobe, Nigeria and Zayandeh Rud River, Iran, the mean BOD value recorded was in the range of 2.43 mg/l -3.34 mg/l and with a mean of 3.67 mg/l respectively, which was much lower than the findings from the present study[21,24]. However, findings on water supplies in Nsukka, South East Nigeria concur with the findings from the present study where the BOD values recorded ranged from 10.0- 20.4 mg/l[18]. From the study, it can be concluded that the quality of the water sources in the sampled areas is not fit for human consumption since they fall below the recommended standards by WHO of 1- 2 mg/l[22].

Total dissolved solids: During the dry season, the highest TDS value of 0.537 ± 0.093 mg/l was recorded in Ewaso Ng'iro river and the lowest value of 0.017 ± 0.010 mg/l was recorded in the water pans as shown in table-3. The mean TDS value of all the sampled areas in the dry season was 0.271 ± 0.199 mg/l. During the wet season, the highest TDS had a mean value of 1.647 ± 0.546 mg/l was recorded in Ewaso Ng'iro river and the lowest value of 0.437 ± 0.081 mg/l was recorded in the water pans. The mean TDS value of all the sampled areas during the wet season was 0.697 ± 0.536 mg/l. The lowest TDS value was found in the dry season and it could be due to silt and settling of dissolved salts[2]. During the wet season, the TDS values were seen to increase due to run offs from sediment and catchments watershed[9]. These findings agree with results on analysis of water from Irigu river, Meru where the TDS values ranged between 0.13- 0.63 mg/l during the dry season and 0.08- 11.71 mg/l during the wet season[15]. However, the TDS values were within allowable limits for drinking water as they were not above 500 mg/l[12].

Total suspended solids: During the dry season, the highest TSS value of 0.412 ± 0.015 mg/l was recorded in the Enkare Narok and the lowest value of 0. 067 ± 0.010 mg/l was recorded in the water pans as shown in Table -3. The mean TSS value for all the sampled water sources in the dry season was 0.215 ± 0.129 mg/l. In wet season, the highest TSS was recorded in Ewaso Ng'iro river with a value of 1.448 ± 0.066 mg/l and the lowest value was recorded in Enkare Narok with a mean value of 0.102 ± 0.034 mg/l. The mean TSS value for all the sampled water sources during the wet season was 0.586 ± 0.466 mg/l. The TSS values recorded in the dry season were found to be much lower than those of the wet season possibly due to sedimentation while the higher values recorded in the wet season could be due to natural processes like erosion, flooding and wind since suspended solids are a natural part of the environment[26]. The findings from this study concur with those reported in borehole water from Akwa Ibom state where the mean values recorded were 0.24- 2.1 mg/l and in Irigu river, Meru, where the mean values recorded were 3.52- 8.00 mg/l in the dry season and 0.10- 0.91 mg/l in the wet season respectively[16,15]. In this study, the TSS values were much lower than the recommended 30 mg/l value for drinking water[19] hence the water was fit for domestic use.

Table-2
DO and BOD values of the water sources during the dry and wet season

	DO (mg/l)		BOD (mg/l)	
Water Source	Dry season	Wet season	Dry season	Wet season
Enkare Narok	1.603 ± 0.085	8.023 ± 0.157	8.913 ± 0.073	10.157 ± 0.077
Ewaso Ng'iro	1.427 ± 0.108	8.223 ± 0.119	8.663 ± 0.072	20.073 ± 0.151
Nkareta	7.553 ± 0.074	8.453 ± 0.074	9.227 ± 0.103	18.307 ± 0.120
Water Pans	8.720 ± 0.194	13.180 ± 0.296	9.434 ± 0.061	29.987 ± 0.544
Water tanks	8.060 ± 0.148	8.495 ± 0.114	9.195 ± 0.272	17.779 ± 0.260

Table-3
TDS, TSS and total hardness values of the water sources during the dry and wet season

	TDS (mg/l)		TSS (mg/l)		Total hardness (mg/l)	
Water Source	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Enkare Narok	0.405 ± 0.132	0.466 ± 0.142	0.412 ± 0.015	0.102 ± 0.034	30.335 ± 0.310	23.265 ± 0.228
Ewaso Ng'iro	0.537 ± 0.093	1.647 ± 0.546	0.265 ± 0.060	1.448 ± 0.066	37.521 ± 0.223	32.251 ± 0.370
Nkareta	0.327 ± 0.046	0.547 ± 0.083	0.303 ± 0.005	0.399 ± 0.001	25.432 ± 0.209	25.744 ± 0.011
Water Pans	0.017 ± 0.010	0.437 ± 0.081	0.067 ± 0.010	0.811 ± 0.008	30.867 ± 0.253	34.677 ± 0.518
Water tanks	0.129 ± 0.068	0.453 ± 0.092	0.112 ± 0.034	0.398 ± 0.004	27.445 ± 0.391	28.326 ± 0.352

Total hardness: During the dry season, the highest total hardness value of 37.521 ± 0.223 mg/l was recorded in Ewaso Ng'iro river and the lowest value of 25.432 ± 0.209 mg/l was recorded in Nkareta river as shown in Table -3. The mean total hardness value for all the sampled water sources during the dry season was 30.125 ± 4.014 mg/l. During the wet season, the highest total hardness value of 34.677 ± 0.518 mg/l was recorded in the water pans and the lowest value of 23.265 ± 0.228 mg/l was recorded in Enkare Narok. The mean total hardness value recorded for all the sampled water sources during the wet season was 28.473 ± 3.581 mg/l. The highest value of 37.521 ± 0.223 mg/l recorded during the dry season was possibly due to decreased volume of water and high evaporation rate at higher temperatures hence concentrating the calcium and magnesium salts concentration[7,27]. The lowest value of 23.265 ± 0.228 mg/l was recorded in wet season and could be due to dilution of calcium and magnesium ions by the increased inflow of water. These findings were much higher than those reported in Irigu river, Meru where the values ranged between 7.01- 19.47 mg/l in the dry season and 0- 7.23 mg/l in the wet season[15]. However, they were below those reported in borehole water in Akwa Ibom state, Oyun reservoir, Nigeria, water supplies in Nsukka, south east Nigeria, Manipur river system, India and Zayandeh Rud River, Iran where the mean values recorded were 26.70- 60.31 mg/l, 32 - 68 mg/l, 46.3- 68.0 mg/l, 38- 136mg/l and 189.33 mg/l respectively[16,2,18,20,21]. The hardness in this study was found to be lower than that recommended by WHO of 100- 500 mg/l[19] hence it can be recommended for domestic use.

Conclusion

The physico- chemical parameters were found to significantly vary both in the dry and wet season. During the dry season, decreased water volume resulted in increased water temperature and increased organic load which possibly led to low dissolved oxygen levels. BOD is a measure of organic material present in water and in the study it was found to be low during the dry season hence could be an indication that the amount of organic material for decomposition was not much. During the wet season, increased water volume could have resulted in lower water temperature and increased DO values indicating that there could have been increased photosynthesis and availability of nutrients. There was increase in BOD meaning that it could have been as a result of a lot of organic material for decomposition resulting from rain water runoff. TDS and TSS values increased in the wet season possibly due to soil erosion and flooding. Total hardness values were found to be higher in dry season which could be due to decreased volume of water and increased rate of evaporation at high temperatures. From the physico- chemical properties analyzed, most parameters indicated that the water sources were fit for domestic use except for the BOD values were high which was an indication of the presence of micro- organisms and therefore this source of water should not be supplied for domestic purposes unless treatment on the microorganisms is done.

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