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Full Length Research Paper

Effect of blended irrigation water quality on soil physico-chemical properties and cotton yield in Middle Awash Basin Ethiopia

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Awash River is the main irrigation water source for mechanized farms and small land farmers established in the Basin for the last few decades. Recently, with the rise of Beseka Lake, the amount of discharging rate into the Awash has been a serious concern to Agricultural Production in the Middle and Lower Awash Areas. This study was conducted to evaluate the effects of Beseka Lake on irrigation water quality, soil physical–chemicals properties and Cotton yield. Seven levels of Awash River and Beseka Lake blended water (8, 10, 15, 20, 25, 30 and 50% of Beseka water) and a control (0% of Beseka water) as a treatment were arranged in randomized complete blocks design with three replications. Yield of cotton showed significant ($p<0.05$) difference among irrigation treatments and maximum yield of 41.393 q/ha was obtained from the control treatment and significantly differed from all other treatments. Blended irrigation water had impact on soil properties which decreased yield with increasing blending ratio. Soil properties, such as electrical conductivity (EC) (1.18), exchangeable sodium percentage (ESP) (12.95), as well as pH (8.66), increased due to blending effect of Beseka water. Blended irrigation water treatment ratio of 8% gave the highest yield (39.143 q/ha) and reduced yield by 5% as compared to the control treatment (41.39q/ha).

Key words: Irrigation water quality, blended irrigation water, Beseka lake, soil properties, cotton yield, awash river.

INTRODUCTION

Background and justification

Water is critical for sustainable livelihoods and is impossible for a single life to live without it. Water is vital to the survival of ecosystems, and plants and animals that live in them, and in turn ecosystems, help to regulate the quantity and quality of water (Rosegrant et al., 2002). Over 97% of the world's water resources is in the oceans and seas and is too salty for most productive uses. Two thirds of the remainder is locked up in ice caps, glaciers,

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permafrost, swamps, and deep aquifers (Seckler et al., 1998). At global level, the withdrawal ratios are 70% agricultural, 11% municipal and 19% industrial (Food and Agricultural Organization (FAO), 2014).

Agriculture is the main stay of Ethiopia's economy, providing the livelihood base for nearly 83% of the population, contributing over 50% of gross domestic product, and accounting for about 90% of foreign exchange earnings (Fassil, 2009). Based upon the various river basin master plans, net irrigation potentials of Ethiopia have been estimated as 2.6 million hectares and the gross irrigation potential is about 3.7 million hectares (Seleshi and Mokonnen, 2011).

Awash River basin has a catchment area of 112,696 km^2 and originates from Central West part of Ethiopia, flowing 1200 km long, and provides a number of benefits to Ethiopia. Relatively, the most utilized river basin and the only river entirely in the country. The total mean annual flow from the river basins is estimated to be 4.9 billion cubic meters (Awulachew et al., 2007).

Recently, the river faces a great environmental concern; mainly the saline water of Beseka lake expansion affects the surface and ground water dynamics and soil properties of the region and the condition is specifically dangerous for the sustainability of Matahara Sugar Estate and Matahara town in particular, and the Awash river basin in general (Megersa et al., 2009). This would be disastrous, as the quality of the river water will be deteriorated such that agricultural development downstream (such as in Amibara Irrigation scheme) would be at risk (Eleni, 2009).

The expanding Beseka lake is in less than 3 km from the River Awash, which is the source of drinking water and irrigation for millions of people downstream. If the lake continues to expand at the current rate and other influencing factors remain the same, the lake will cross the natural water divide and invade the town of Addis Ketema and join the River Awash. This would be disastrous, as the quality of the river water will be polluted and agricultural development downstream (such as in Amibara Irrigation scheme) would be at risk (Eleni, 2009; Megersa et. al., 2009). Hence it was decided to discharge water of Beseka lake into Awash River and reduced its volume to certain level. The blending proportion is fixed to 2% of the Awash River flow rate, during peak flow, which was studied by the Water Resource Authority as harmless. Thus the study identifies effect of blended irrigation water for cotton yield and soil physical and chemical properties, for sustainable use of the water resource, thereby improving the appropriate use of blended irrigation water for agricultural production.

METHODOLOGY

Climatic data

Amibara irrigation scheme, particularly the study area (Werer), falls within the semi-arid agro-climatic zone. Thus, agricultural practices depend on the abstraction of water from the Awash River. The long-term (1972 to 2012 G.C) WARC climatic data indicate the mean and annual rainfall as 560 mm and ET_0 3000 mm/year. Average minimum and maximum temperatures ranged from 14.7°C on December to 37.9°C in June. Relative humidity ranges from 58% in August to 39% in June. Wind speeds were highest in June and July, at about 180 km/day. Daily sunshine hours vary from 7.2 in July to 9.6 h in November. Reference evapotranspiration (ET_0) ranges from 4.1 mm/d in December to 6.8 mm/day in June.

Agricultural practices

The major crops grown in the study area are cotton, maize, sesame, banana and vegetables. Crop production by the state farm and two large private enterprises (Amibara Farm Development and Africa Private farm) is entirely for commercial purposes, while small holders/agro-pastoralists cultivate cotton, sesame and vegetables for cash income and maize for subsistence. The large and medium enterprises practice mono-cropping that is cotton. Banana used to be grown in the former Melka Sedi banana unit, which was later replaced by cotton between 2001 and 2002 (Gedion, 2009). Very recently, the cotton farmland has been replaced by sugarcane plantation.

Experimental design

The samples (amount of water) applied were 8, 10, 15, 20, 25, 30, 50 and control (0% of Lake Beseka) water blended with Awash River water (Table 1). The seven blended irrigation water samples and a control (0% beseka water) were arranged in a randomized complete block design (RCBD) in three replications. Accordingly, the samples including the control treatment were assigned randomly to the experimental units within a block. The amount of water applied to the field was based on Werer Research Center recommended schedule for cotton which was 75 mm every two weeks interval with twice 125 mm pre-irrigation and measured using 3’’ Parshal flume.

Experimental layout

The experimental plot sizes were 5*5 m^2 dimensions with recommended plant spacing 25 cm * 80 cm for Cotton. Each plot consisted of 5 rows of 5 m in length and spaced 25 cm apart. A total of 24 plots were arranged in RCBD in three replicationsand Agronomic management was done according to local recommendation.The adjacent blocks and plots were separated by 1.6 m wide-open space and 0.8 m blank rows; respectively.

Data collection

Soil samples were taken before and after harvesting and analyzed for soil chemical and physical properties such as pH, electrical conductivity (EC), exchangeable cation and anion, field capacity (FC), infiltration rate, permanent wilting point (PWP), texture, bulk density (BD). The water samples collected from Awash river (upstream and downstream of lake Beseka) and Lake Beseka were analyzed at WARC laboratory before the experiment period. Agronomic data (yields, and yield parameters) of the cotton were collected according to quality standards such as plant height, stand count, boll number and lint yield set by Ethiopian Institute of Agricultural Research.

Table 1. Fresh river water mixing ratio of Beseka water.

Treatment (T)	Awash water (%)	Beseka Lake water (%)
Treatment 1	92	8
Treatment 2	90	10
Treatment 3	85	15
Treatment 4	80	20
Treatment 5	75	25
Treatment 6	70	30
Treatment 7	50	50
Treatment 8 (control)	100	0

All ratio of mixing irrigation water are on volume basis.

Soil and water sampling and analysis

Soil sampling and preparation

Composite soil samples were taken from the plots up to 0.9 m depth with 0.3 m interval. A total of 45 soil samples were collected before sowing and for the chemical analysis 24 samples were taken from each plot at a depth of 30 cm interval composite into eight (8) after harvesting (Table 4). The soil samples were bagged and properly labeled. Then, soil samples were air dried, grounded and sieved with 2 mm sieve for laboratory characterization and analyzed.

Soil physical and chemical analysis

The soil samples were analyzed for physico-chemical soil properties at Werer Research Soil Laboratory following standard test procedures. Soil texture (particle size distribution), bulk density, and water holding capacity at field capacity and permanent wilting point are some of the physical properties which were determined. Similarly, the soil chemical properties analyzed were soil pH, electrical conductivity (EC), cation exchange capacity (CEC), exchangeable bases (Ca, Mg, K and Na), soluble bases (Ca^{2+}, Mg^{2+}, Na^+, K^+), anions (Cl^-, HCO_3^-,CO_3^{2-}), sodium absorption ratio (SAR) and Exchangeable sodium percentage (ESP).

Particle size distribution was determined in the laboratory by the modified Bouyoucos hydrometer method (Bouyoucos, 1962) using sodium hexametaphosphate as dispersing agent. Then, the soil textures were determined using the United States Department of Agriculture (USDA) textural triangle. In the field, soil infiltration measurement was made for the identified fields/plots using double ring infiltrometer. Soil bulk density from the undisturbed soil samples were determined following the procedures described in Blake (1965). Soil pH were measured potentiometrically using a digital pH-meter in the supernatant suspension of 1:2.5 soils to distilled water mixture and 1:2.5 (on volume basis) soils to KCl solution in the bathing solution with glass electrode (Baruah and Barthakur, 1997). The EC values measured at the prevailing temperature were converted to EC at 25°C temperature.

Exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) of the soils were extracted by excess ammonium acetate (1 M NH_4OAc at pH 7) solution. Exchangeable Ca^{2+} and Mg^{2+} in the extracts also determined by atomic adsorption spectrophotometer while exchangeable K^+ and Na^+ in the extracts were measured by flame photometer (Okalebo et al., 2002). CEC (cmol (+)/kg) of the soils were determined from the ammonium acetate saturated samples through distillation and measurement of ammonium using the modified Kjeldahl procedure as described by Okalebo et al. (2002).

Finally, ESP was computed as the percentage of the sum of exchangeable bases and exchangeable Na to the CEC of the soil as follows:

$$\mathbf{ESP(\%)} = \frac{\textbf{Sodium Exchangeable } (\mathbf{Na^+})}{\mathbf{CEC}} * \mathbf{100} \tag{1}$$

Where concentrations are in cmol(+)/kg of soil.

Basic cations (Ca, Mg, Na, and K) and anions (Cl^-, SO_4^{2+}, HCO_3^-, $CO_3^{2-}$and NO_3^-) were measured on a 1:5 soil water ratio extract following the methods described by the US Salinity Laboratory Staff (Richards, 1954). Soluble Ca and Mg were read using AAS while that of Na and K using flame photometer. Chloride was determined by titrating the extract against 0.1 N $AgNO_3$ solution using potassium chromate as an indicator. The CO_3^{2-} and HCO_3^{2-} ions were also determined by titrating with sulfuric acid (H_2SO_4) to phenolphthalein and methyl orange end points, respectively. Nitrate (NO_3^-) content was analyzed as per the methods outlined by Okalebo et al. (2002). Sodium adsorption ratios (SAR) of the soil solution were calculated from the concentrations of soluble Na, Ca and Mg as follows:

$$\mathrm{SAR} = \frac{\mathrm{Na}^+}{\sqrt{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+}}} \tag{2}$$

Then, the soils were classified to the different salinity soil classes based on the criteria established by the USSLS (1954).

Water sampling and analysis

Location of sampling sources and water sampling sites: Water samples were collected from the existing surface irrigation water sources (irrigation canals) and pollution contributing sources such as Lake Beseka along the Awash River. The samples were collected from Beseka Lake at blending point and Werer Research Center Pump Site (MWPS) (Table 2).

Water sampling and preparation: Water samples were collected from 2 sampling sites from March to August, 2014 (Table 7). The water sampling was conducted once per month and lasting to six months. A 35 of total water samples were collected by mixing several portions (sub-samples) taken at 5 min interval in order to obtain representative samples using a grab method. Acid washed polyethylene bottles (2 L) were used to collect irrigation water samples from all the sample sites. The samples were transported to

Table 2. Location of water sampling sites at Awash River.

Site	Sampling site	Northings	Eastings	Elevation
1	Beseka	08° 53” 55’	039° 54” 22’	946.00
2	M.W.P.S	09° 20” 39’	040° 10” 20.6’	749.00

MWPS (Werer Research Center Pumping Site).

the laboratory in dark boxes containing water from the same source to maintain the temperature of the samples close to that of the *in situ* temperature and analyzed for their physical and chemical composition immediately. Generally, the collection and handling of irrigation water samples were done in accordance with the procedure outlined by Richards (1954) and the USSLS (1954). Each of the water sampling points was also registered using global positioning system (GPS).

Water analysis: The collected water samples were subjected for the analysis of pH, EC, dissolved cat ions (Ca, Mg, Na and K), alkalinity (HCO_3^- and CO_3^{2-}) and Cl^- contents in the laboratory. Total dissolved salts (TDS), SAR and residual sodium carbonate (RSC) were estimated from the measured parameters. EC and pH of the water samples were measured in the laboratory within 24 h using conductivity meter and a digital pH meter, respectively (Richards, 1954) with appropriate conversion factors for temperature. Alkalinity (HCO_3^- + CO_3^{2-} ions) was determined by titrating with standard acid (pH of 4.5) within 12 to 24 h of sample collection. Chloride was measured by the mercuric nitrate titrimetric methods outlined by Okalebo et al. (2002) and EIAR quality manual (2013). Ca and Mg ions were measured using atomic absorption spectrophotometer, while Na and K was analyzed using flame photometer. Irrigation water salinity, as total dissolved salts (TDS), was determined by summing the concentration of the individual ions (EIAR Quality Manual, 2013). Moreover, the TDS (mg/l or ppm) can be obtained by multiplying the EC value expressed in mmhos/cm by 640. The SAR value was calculated using equation of SAR with the concentrations expressed in meq/L. The RSC (Equation 3) was determined using from the concentrations of HCO_3^-, CO_3^{2-}, Ca^{2+} and Mg^{2+} ions as follows:

$$\mathbf{RSC} = \left[\left(\mathbf{HCO_3^-}\right) + \left(\mathbf{CO_3^{2-}}\right) - \left(\mathbf{Ca^{2+}}\right) + \left(\mathbf{Mg^{2+}}\right)\right] \quad (3)$$

Where concentrations are expressed in meq/l (USSLS, 1954).

Adjusted RNa (adj. RNa), which is recommended by Suarez (1981) as more acceptable than adjusted SAR and represents the true picture of the SAR was calculated as:

$$\mathbf{Adj.R_{Na}} = \frac{(\mathbf{Na^+})}{\sqrt{\frac{\mathbf{Ca_X^{2+} + Mg^{2+}}}{2}}} \quad (4)$$

Where Na^+ is the concentration of sodium in the irrigation water expressed in meq/L. Ca_X is a modified Ca value set by FAO (1985b). Ca_X represents Ca in the irrigation water but modified due to salinity of the water (EC), its HCO_3/Ca ratio (HCO_3 and Ca in meq/l) and the estimated partial pressure of CO_2 in the top surface of soil is P_{CO2} = 0.0007 atmospheres, and Mg is the concentration of Mg in the irrigation water expressed in meq/L. Finally, the water was classified to the different suitability classes as per the criteria established by FAO (1985b).

Statistical data analysis

Analysis of variance (ANOVA) was used for agronomic and irrigation based experiments. Irrigation water quality data were interpreted and compared with descriptive statistics and applied to all physico-chemical parameters. Results of yields and yield parameters were analyzed using the statistical software analysis (SAS) window 9.0 version.

RESULT AND DISCUSSION

The effects of different blended irrigation water applications on soil physical and chemical properties, cotton crop yield, and blended irrigation water quality studied were presented in subsequent section.

Soil analysis before planting

The result of soil physical parameters analyzed for soil samples taken before planting is shown in Table 3. Based on the observation of the study as indicated in Figure 1, the soil of the field was dominated by silt size fractions. The analytical results indicated that the textural class of the experimental site has a proportion of 31.5% clay, 52.8% silt and 15.7% sand. The results in general, indicated that soil physical properties infiltration rate, water-holding capacity, and bulk density show no change after application of the blended water. This is due to the physical properties nature of soil, it indicated that the effect of blended water on the soil will need further experiment and assessment.

pH

Mixed Beseka and Awash water irrigation treatments applied to the field showed increased soil pH in the experiment site (Figure 2). Soil pH increased after cotton harvest involving Awash water as the first pre irrigation, and fluctuated around (8.5 to 8.9) values attained during the experimentation.

Lower proportion 8,10 and 15% blended water application and intervening higher rainfall might have also helped to reduce the soil pH after harvesting in treatments T1 (8.50), T2 (8.70) and T3 (8.60). Maximum soil pH was found in T5 (8.9) treatments involving a blended water with mixed ratio (30%) except T8 (8.7) which has nearly the same pH before planting. This could mainly be attributed to the fact that the maximum ratio of Beseka water will affect fresh water quality of Awash River. The pH values in treatments T3 (8.60), T2 (8.70)

Table 3. Soil chemical properties of experimental field before sowing.

Depth (cm)	PH	EC (dS/m)	Water soluble cations and ions					Exchangeable cations			SAR	CEC	ESP%
			(Ca+Mg)	Na	CO_3^{2-}	HCO_3^-	Cl^-	Ca+Mg	Na	K			
0-30	8.8	0.8	6.3	1.6	Nil	8	6.8	55.0	1.15	0.25	1.08	56.4	2.0
30-60	8.1	0.82	4.3	1.4	Nil	7	7.7	48.8	1.26	0.17	0.98	50.2	2.3
60-90	8.3	1.69	9.3	1.4	Nil	7	16.5	55.7	2.17	0.37	0.69	58.2	3.73

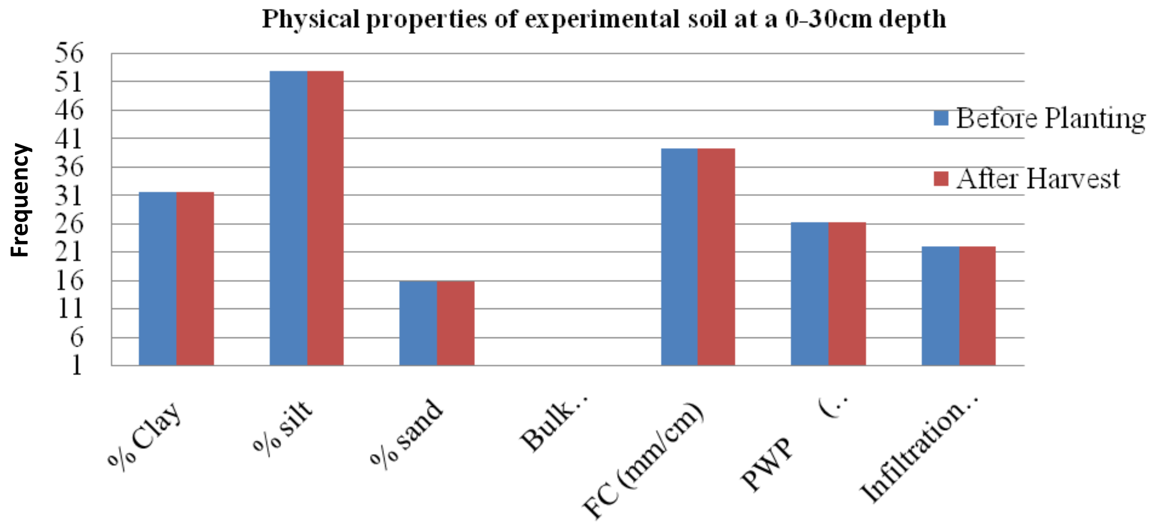


Figure 1. Experimental field soil characteristic of the study area.

and T1 (8.50) tended to be closer to the pH of T8 (8.70) treatment. Other treatments such as T4 (8.7), T6 (8.6) and T5 (8.9) were higher (4 to 8.0) as per the standard of FAO (1985) and the pH increased due to poor irrigation quality. This is due to high bicarbonate and carbonate levels in water which can cause calcium to precipitate from the soil: this reduces the soil's exchangeable calcium content and increases soil sodicity. Magnesium can also be lost in this way. The loss of soil calcium and magnesium will affect plant growth. This demonstrates the use of the blended waters of different ratio which negatively affects the soil and yields of cotton. A similar result was stated that increasing soil pH due to saline irrigation water reduced cotton yield (Chemura. et al., 2011; Chauhan et al., 2007; Anna et al., 2006; Minhas and Gupta, 1993). According to USSSL (1954) soils that have a pH values 7 to 9 are categorized under saline and hinders yield. FAO (1985b) reported that the preferable pH ranges for most crops and productive soils are from 4 to 8. The pH (8.84) result shows nearly saline nature of the soil. Thus, the pH of the experimental soil was within the range of unproductive soils. Thus, results clearly indicate that if Beseka water is diluted to Awash River at a rate higher than

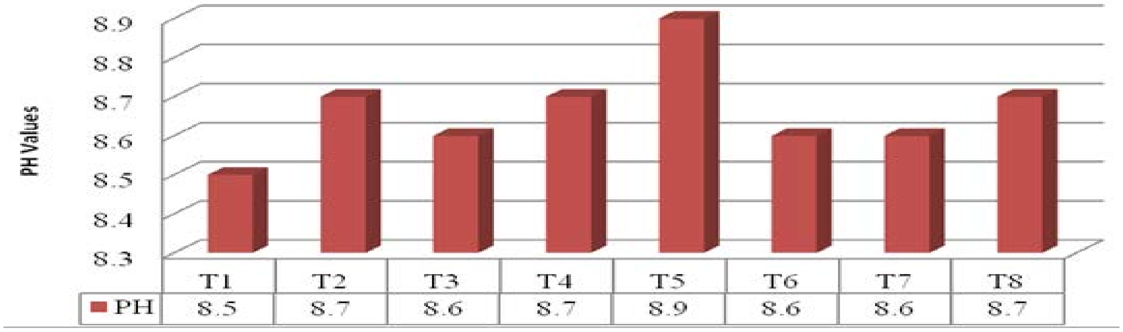


Figure 2. Soil pH values of experimental field.

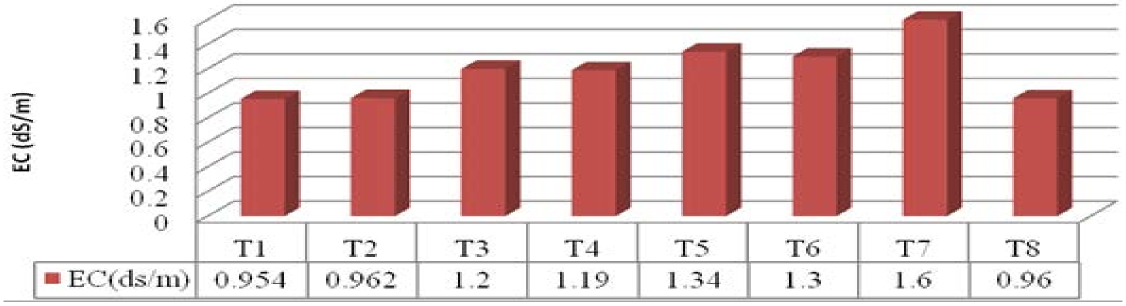


Figure 3. Composite EC (dS/m) values of experimental field after harvesting.

currently in use, which is 2% it will affect the cotton yield and soil quality.

Electrical conductivity (EC)

Electrical conductivity of the soil obtained in irrigation treatments T7 (1.60 dS/m), T6 (1.30 dS/m) and T5 (1.34 dS/m) were higher than other treatments (Figure 3). When Beseka was blended with Awash water, there was increment in EC which remained higher at the end of cropping period. EC values after harvest remained much higher than before planting. The trend in all treatments throughout the soil showed slight increase in EC at 30 cm depth after harvest (Table 4). The EC increased with the increasing salinity of irrigation water, especially in the surface soil (Chauhan et al., 2007).

Electrical conductivity of soil at experiment site before planting was 0.81, 0.83 and 1.92 dS/m at 0 to 30, 30 to 60 and 60 to 90 cm depth, respectively. The EC of the soil increased at harvesting time as compared to the before planting. In general, EC of soil values remained much lower than threshold level of salinity for cotton crop (4.8 dS/m) (Maas, 1987; Maas and Hoffman, 1977).

Blended water with an EC of 12 to 14 dS/m can be used as part of the irrigation water during the last stages of wheat growth even though a yield reduction of about 15% may occur as compared to fresh irrigation water (Dougherty and Hall, 1995; Minhas and Gupta, 1993).

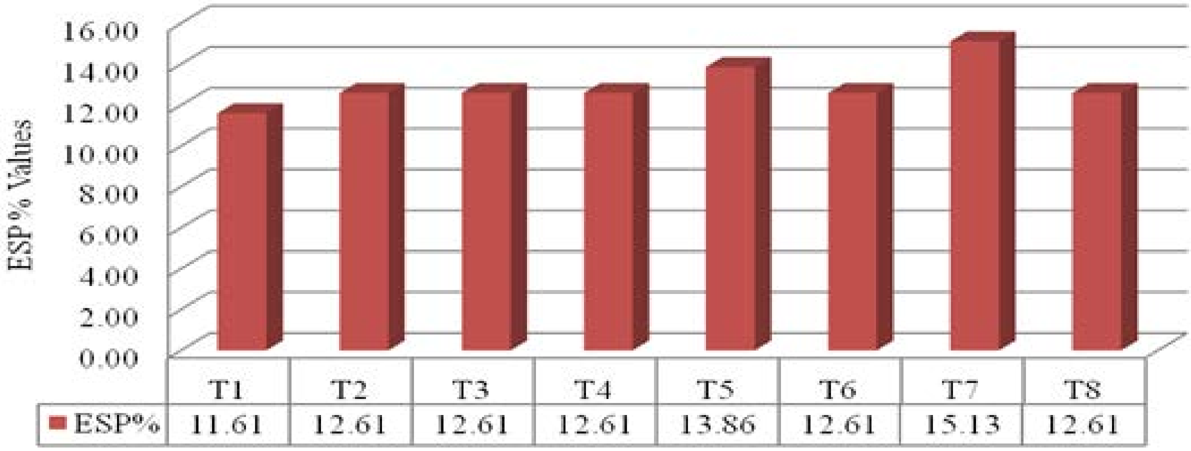
This indicates application of high mixed water aggravate excess salts contained in the root zone, which limits the crop development. Results of this research are similar to findings of Chauhan et al., (2007). Choudhary et al., (2006) and Minhas and Gupta (1993) showed that plants are sensitive to salinity at the beginning of the growth stage. Therefore, according to FAO classification the values of EC of the soil are grouped to be suitable for cotton production with no reduction in yield.

Exchangeable sodium percentage (ESP)

Exchangeable sodium percentage of experiment soil values were obtained in a range (11.10 to 15.13 %) at a depth of (0 to 0.3 m). A soil in T8 (Awash River without mixed Beseka water) showed a value for exchangeable sodium percentage of 12.61 (Figure 4) which was much higher than threshold limit. Irrigation treatments involving the use of mixed Beseka with Awash water increased ESP with increasing mixing ratio T7 (15.13%) and T5 (13.86%), and the same results were obtained in T2 (12.61%), T3 (12.61%), T4 (12.61%) and T6(12.61%) with that of T8 (11.61%) having 100% Awash water as full irrigation cycle throughout growing period. This could

Table 4. Soil chemical properties of experimental field (0 to 0.3 m) after harvesting.

Irrigation Treatment	Mixing ratio (%) (Awash:beseka)	pH	EC (dS/m)	Water soluble cations and ions						Exchangeable basic cation			SAR	CEC	ESP%
				Ca+Mg	Na	K	Cl^-	CO_3^-	HCO_3^-	Ca+Mg	Na	K			
T1	92:08	8.50	0.95	3.95	0.59	0.16	7.75	trace	5.75	59.5	8.13	2.38	0.42	70.01	11.6
T2	90:10	8.70	0.96	4.95	0.74	0.20	7.00	trace	5.75	53.5	8.03	2.14	0.47	63.67	12.6
T3	85:15	8.60	1.20	4.50	0.68	0.18	8.25	trace	6.25	55.5	8.33	2.22	0.45	66.05	12.6
T4	80:20	8.70	1.19	4.45	0.67	0.18	8.25	trace	5.75	55.5	8.33	2.22	0.45	66.05	12.6
T5	75:25	8.90	1.34	4.95	0.74	0.20	10.75	trace	5.85	57.5	9.63	2.30	0.47	69.43	13.8
T6	70:30	8.60	1.30	5.95	0.89	0.24	9.50	trace	6.25	62.5	9.38	2.50	0.52	74.38	12.6
T7	50:50	8.60	1.60	5.45	0.82	0.22	10.25	trace	7.25	56.5	10.48	2.26	0.50	69.24	15.1
T8	100:00	8.70	0.96	2.95	0.44	0.12	7.00	trace	5.75	55.5	8.33	2.22	0.36	66.05	12.6



	T1	T2	T3	T4	T5	T6	T7	T8
▮ ESP%	11.61	12.61	12.61	12.61	13.86	12.61	15.13	12.61

Figure 4. Exchangeable sodium percentage (ESP %) of composite soil after harvesting.

be mainly due to rainfall, and leaching downward might be the case. On the other hand, the ESP had higher values in the top layer of soil experiment field because the exchangeable sodium was less soluble than the sodium in the soil solution (Minhas and Gupta, 1992; Bajwa and Josan, 1989).

Cotton yield

Awash irrigation water alone produced significantly ($p < 0.05$) higher yield than mixed Awash and Beseka blended irrigation water. Awash water T8 gave the highest cotton yield (42.2 q/ha) and significantly different to all other treatment. The lowest blended ratios T1 gave the highest average yield (39.143 q/ha) among the blended water and significantly different to all other treatments (Table 5). Comparing the control treatment with other blended irrigation water 5 to 40% of yield reduction was observed under mixed percentage of 50, 30, 25 and 20%. Hence, this

Table 5. Cotton yield and yield parameters analysis.

Irrigation treatment	Mixed ratio (%)	Stand count	Average plant height (cm)	Boll number	Yield (Q/ha)
T1	92:08	26.6667^{a}	69.333^{a}	11.0000^{ba}	39.143^{b}
T2	90:10	24.3333^{b}	69.333^{a}	11.6667^{a}	36.450^{c}
T3	85:15	26.0000^{ba}	69.333^{a}	11.0000^{ba}	34.497^{dc}
T4	80:20	25.3333^{ba}	63.333^{a}	10.0000^{bc}	33.403^{d}
T5	75:25	25.0000^{ba}	59.000^{a}	8.6667^{dc}	29.657^{e}
T6	70:30	26.0000^{ba}	74.333^{a}	8.6667^{dc}	28.233^{e}
T7	50:50	26.3333^{a}	72.333^{a}	8.0000^{d}	25.243^{f}
T8	100:00	25.3333^{ba}	71.000^{a}	11.3333^{ba}	41.393^{a}
Mean	-	25.666	67.708	33.502	25.666
LSD(0.05)	-	1.827	17.759	1.351	2.218
CV (%)	-	4.066	14.977	7.683	3.781

indicated that increasing Beseka water ratio gradually decreased cotton yield.

Poor irrigation water can reduce 10% to 25% cotton yield potential (FAO, 1985b; Josan et al., 1998; Grattan and Oster, 2003).Therefore, in this study, blended irrigation water reduced cotton yield by 5 to 40%. The lowest yield was found in treatment (T7) that were subjected to irrigation with high blended ratio during the whole irrigation cycle and significantly different to all other treatments. Although, applied awash water early in the growth season (sensitive stage) and mixed with Beseka water (8, 10, and 20%) in later stages (relatively tolerant) after maturity gave optimum yield (10%) when it was compared with cotton grower farmers at Amibara irrigation scheme. However, blended irrigation water had a similar effect on yield and may be advantageous only with water of low to moderate salt content. The EC higher than 1.367 dS/m in irrigation water resulted in more than 50% reduction in final shoot dry weight of cotton crop (Dougherty and Hall, 1995). These results were similar from those reported by other authors that observed reduction in yield of maize plant (Chemura et al., 2011; Chauhan et al., 2007; Minhas, 1996; Shalhavet, 1984; Minhas and Gupta, 1993).

Chemical properties of irrigation treatments/blended water

pH of blended irrigation water

A six month result shows high values of pH occurred in May (9.88) and low value was obtained at March (8.80). The result found in June (9.12), July (9.23) and August (9.13) were decreasing, in fact this might be due to high flood during rainy season. Generally, results indicate that the value of pH increased after Beseka water blending point. Considering monthly results (Table 7), maximum pH (9.88) value was obtained in May which is dry and low flow period of River Awash decreased with high flooding season, comparatively showing lower pH. It may be due to decrease in the water level and presence of suspended particulate matter and low rainfall. Similarly, results of the data shows high pH ranges from 7.8 to 9.2 were obtained after blending of Beseka water and from 8 to 8.5 at Awash River before joining Beseka which indicates that the value of pH has increased after Beseka blending point. High pH values above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations, known as alkalinity (Bauder et al., 2004).

Electrical conductivity (EC) of blended irrigation water

Results have shown the EC value of blended (Awash and Beseka) irrigation water of the study area ranges from 1.606 to 2.97 dS/m. Maximum EC of Blended irrigation water obtained from treatment (T7, 50%) was 2.97 dS/m and all Blended irrigation treatments were increased with increasing mixed ratio as shown in Table 6. In the same way a six month (Table 7) result showed that high values of EC occurred in August (2.16 dS/m) and low was obtained in April (1.90 dS/m). The result found in March (2.60), May (1.92), June (1.98) and July (2.03) were decreasing; in fact this might be due to high flood during rainy season. It is easily presumable from the result shown in Table 7 that in terms of EC value, all the mixed irrigation water treatments were suitable for irrigation purpose. According to FAO (1985) standard, EC value of treatment (T8, 100%) falls within 'permissible' irrigation water quality classification standard. In terms of the 'degree of restriction on use', EC values of all treatments are categorized under 'slight to moderate' according to UCCC (1974). On the other hand, in terms of salinity and sodicity, hazard classification treatments such as T1,T2 and T3 fell under C2 (medium) and T4,T5 and T6 fell C3 (High) but exceptionally, T7 fell under C4 (very high).

Table 6. Chemical parameters of blended water over six months.

Parameters	T1	T2	T3	T4	T4	T6	T7	T8
EC ds/m	1.61	1.68	1.84	1.98	2.15	2.32	2.98	1.44
PH	9.12	9.14	9.23	9.29	9.49	9.50	9.59	9.12
TDS mg/L	1028	1072	1174	1267	1375	1487	1905	1026
Ca + Mg	1.67	1.62	1.66	1.78	1.43	1.67	1.53	1.68
Na^+	4.77	3.43	4.39	4.93	4.45	5.22	6.20	4.17
K^+	0.38	0.25	0.16	0.17	0.16	0.18	0.27	0.24
CO_3^{2+}	2.56	2.84	2.95	3.43	3.84	4.30	6.28	2.59
HCO_3^-	10.65	11.54	12.25	13.53	15.00	16.17	19.59	10.65
Cl^-	3.96	4.28	4.80	4.92	5.32	5.64	7.05	4.00
SAR	1.61	1.68	1.84	1.98	2.15	2.32	2.98	1.44
RSC	9.12	9.14	9.23	9.29	9.49	9.50	9.59	9.12

Table 7. Chemical and Physical parameters of blended water over six months.

Parameters	March	April	May	June	July	August
EC ds/m	2.06	1.90	1.92	1.98	2.03	2.10
PH	8.80	9.50	9.88	9.33	9.23	9.13
TDS mg/L	1382.76	1237.82	1226.58	1292.72	1297.66	1315.88
Ca + Mg	1.26	1.63	1.42	1.95	1.90	1.62
Na^+	3.00	5.39	2.55	5.74	5.77	5.73
K^+	0.28	0.15	0.40	0.15	0.19	0.20
CO_3^{2+}	4.31	3.51	4.10	2.95	3.09	3.63
HCO_3^-	14.69	12.72	13.26	13.58	13.67	14.10
Cl^-	5.31	4.81	4.81	5.03	4.99	5.02
SAR	3.93	6.01	3.02	5.95	6.05	6.37
RSC	17.75	14.60	15.94	14.65	14.87	16.11

Sodium adsorption ratio (SAR) of blended irrigation water

Low value of SAR in T1 was found to be 3.45 meq/L and maximum were obtained in T7 (7.24) as shown in Table 6. According to the UCCC (1974), the studied water samples fell in class 2 (medium sodium hazards) except Blended water of T7 (50%) which had an SAR value of 7.24 and fell in the S3 class (high sodium hazards). The result indicated that rating of sodicity hazards based on SAR values for all Blended water treatments were of medium hazards (S2) except treatment T7 (50% ratio) water which was high sodium hazards (S3). As a result, Blended Irrigation water ratio such as 50, 30, 25, and 20% Beseka with Awash in terms degree of restriction, fell under slightly moderate category and can be used for irrigation.

Residual sodium carbonate (RSC) of blended irrigation water

In all irrigation treatments RSC values were above 2.5 meq/lit (Table 6) and very high at month of March during study season (Table 7). According to the RSC data presented in Table 7, the classification of different water samples for irrigation in the studied area indicate that all of the studied samples are above 2.5 meq/l and classified as class 4 and hence very RSC hazards (unsafe water), this indicates that blended water is unsuitable for irrigation, USSLS (1954). So water of mixed Beseka and Awash River can be considered unsafe for irrigation purpose according to USSLS considerations.

Conclusion

From the study it can be concluded that the discharge rate of Beseka water into Awash River will affect its quality and aggravate the soil salinity and reduce cotton yield. Moreover the result revealed that Beseka lake is a great source of pollution for down streams agricultural farm and it is a great environmental concern than need immediate attention.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Physical, chemical and bacterial analysis of drinking water: Kakua Chiefdom, BO district, Sierra Leone

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Water makes the difference between living and non-living things, base on this there is a strong need to look at the chemistry, to make sure that it is free from contamination because of chemical reaction that take place in the living cell. In the case of this study, it is critical to determine the quality of the water supplied, because of the chemical reaction. This study analyzes 10 representative well water systems for 18 quality parameters in Kakua Chiefdom of Bo District, Sierra Leone. The study note among others, well-water total dissolved solids (TDS), turbidity, electrical conductivity (EC), coliform and nitrate ($NO_3^{-)}$, in the region that are fairly high. The incidence of coliform in well waters is highest in April and those iron (Fe_2^+) and nitrate in May. The Dipha street well is amongst the most contaminated and TDS, Non-faecal and fluoride (F^-) have the highest scores in a three-category plot along wells. Correlation analysis among the water chemistry shows an interesting results; ranging strong positive (R=1.0) to strongly negative (R=-1.0).

Key words: Physico-chemical, parameter chemical parameters, bacteriological parameters, water molecule.

INTRODUCTION

Sierra Leone is located on the west coast of Africa between latitudes 6.91 to 10.08°N and longitudes 10.21 to 13.32°W (Figure 1, inset plate). It is bordered on the west by the Atlantic Ocean, on the north and northeast by Guinea and on the southeast by Liberia (Figure 1). Sierra Leone has a population of 5.5 million people (Squire, 2001), with a total area of 71 740 km^2, 71 620 km^2 (99.8%) of which is land and 120 km^2 (0.2%) water (Barnett et al., 2000).

Sierra Leone has a tropical monsoon climate with two distinct seasons; the wet and dry seasons. While night time temperatures in the dry season can be as low as 16°C (NRDS, 2009), the annual average temperature is 26°C. Tropical rainfall is the dominant precipitation, ranging from 5000 mm in the coastal regions to 2000 mm in the hinterlands. Dense networks of tributaries carrying

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Facts		
Northern Province	Area Population (2004) Capital	35 936 sq km 1 745 553 Makeni
Eastern Province	Area Population (2004) Capital	15 553 sq km 1 191 539 Kenema
Western Area	Area Population (2004) Capital	557 sq km 947 122 Freetown
Southern Province	Area Population (2004) Capital	19 694 sq km 1 092 657 Bo

Figure 1. Map showing administrative district shesad.

abundant water flows throughout the year (USAID, 2012) feed the seven main rivers of Sierra Leone (Figure 1).

The land cover mainly includes lowland deciduous forests, inland valley swamps, coastal mangrove swamps, bolilands, and wooded savannah and the main cultivated crops are coffee, cocoa, oil palm, rice, cassava, groundnut, coconut, citrus, maize and cashew (USAID, 2012). Rain fed agriculture is the main mode of livelihood, directly employing 75% of the population (Barnett et al., 2000). Sierra Leone is divided into 149 chiefdoms, 12 districts, 3 provinces and 1 western area. Bo is a district in the southern province of sierra Leone with 15 chiefdoms, total area of 1400 km^2 and population of 463 668 people. This study was conducted in Kakua Chiefdom (Figure 1, right plate), one of the 15 chiefdoms in Bo District.

World Health Organization (WHO) and its member states has its objectives to all people, in respect to their stages in progress and their social and economic circumstances have right to have access to enough supply of safe drinking water. At the beginning of 2000, about 1.1 billion people in the world were without access to improved supply of clean water. Africa has the lowest water supply coverage with only 62.0% of the population having access to improved water supply. The continent contains 28.0% of world's population without access to improved water supply. Ethiopia is one of the ten African countries, which have less than 50.0% water supply coverage, with only 24.0% of the population having access to improved water supply. In Ethiopia the situation is much worse in rural areas where coverage is only 13.0% compared with 77.0% in urban areas .Water is considered one of the most important and sensitive issues in the Middle East, where increasing water deficiency and deterioration of the available water are imminent (Al-Khatib et al., 2003).

Most of the middle-eastern countries, including Palestine, are characterized by arid to semi-arid climatic conditions and have very limited water resources. The majority of fresh water supplies in these countries come from scarce groundwater resources. Future population growth in these countries and its associated water demands is expected to place severe pressure on the limited groundwater reserves (Nasserdin et al., 2009).

The risk of microbiological contamination of drinking water during collection and storage in the home has long been recognized (Van Derslice and Briscoe, 1995; Lye, 2002; Thomas et al., 2003; Gerba and Smith, 2005). Factors such as site characteristics, interval duration, and ultra violet ultraviolet (UV) intensity would all affect the survival of microorganisms on the catchment surface and their viability in the run-off (Evans et al., 2006). Septic systems have been noted as one of the largest sources of pollution in the suburbs (along with construction erosion) through failing systems and subsurface movement of pollutants. Water pollution induced by storm runoff from different roofing materials is considered a non point source (Chang et al., 2004).

The parameters (pH, TDS, TH, alkalinity, free available chlorine, sulfate and ammonia-N) could influence drinking water flavor, while the turbidity and coliform group were measured due to esthetic and health concerns, respectively (Lou et al., 2007). Many consumers will link the presence of offensive tastes or odors with the possibility of a health risk though an unpleasant taste in water does not necessarily indicate that the water is unsafe to drink (Lou et al., 2007).

Variation of roof runoff quality seems to reflect differences in roofing materials, age and management, the surrounding environment, season, storm duration and intensity, and air quality conditions of the region (Chang et al., 2004). This is the first explanation about analysis of drinking water in the Kakua Chiefdom in Bo District Southern Sierra Leone West Africa, which deals with environmental Chemistry to the study knowledge.

In this study, the environment will be looked as consisting of five spheres - the hydrosphere, atmosphere, geosphere, biosphere and astrosphere. Although often not acknowledged as one of the environmental spheres, the astrosphere, consisting of the things humans construct, use, and do in the environment, is very important to consider as one of these five spheres. By so doing, the study can begin the essential process of using our human activities to preserve and enhance the earth environment upon which all-living organisms and we depend. Water composes one of the five “spheres” in which environmental chemistry is discussed. This research introduces the environmental chemistry of water.

Properties of water as a unique substance

Water has a number of unique properties that are essential to life, and that determine its environmental chemical behavior. Many of these properties are due to water’s polar molecular structure and its ability to form hydrogen bonds. The most important special characteristics are shown in Table 1.

MATERIALS AND METHODS

Characteristics and description of sample collection points

Because of the limited time of study, ten (10) different points were collected out of the total of fifty (50) water sources in the Kakua Chiefdom that is, Bo Town. These sampling points were done by considering the various uses of the sources being put to; their location in the community, relative magnitude and direction are shown in Table 2.

Instrumentation and uses

Conductivity meter is the instrument used to determine electrical conductivity, salinity, temperature and total dissolved solids (TDS). The CO150 conductivity meter is a valued priced, full featured portable meter, which can be used for a wide variety of application in the field or the laboratory. Water quality acid base and other samples can be easily analyze for conductivity with the available conductivity probe. This meter feature a microprocess or design which is complicated and time-consuming calibration and measurement procedure for a wide variety of application. Hydrometer is an instrument made up of metal with a round plate and a curve handle with black/blue sponge. It is calibrated in meter

Table 1. The main characteristics of water as a universal solvent.

Property	Effects and Significance
Excellent solvent	Transport of nutrients and waste products, making biological processes possible in an aqueous medium
Highest dielectric constant of any common liquid	High solubility of ionic substances and their ionization in solution
Higher surface tension than any other liquid	Controlling factor in physiology; governs drop and surface phenomena
Transparent to visible and longer-wavelength fraction of ultraviolet light	Colorless, allowing light required for photosynthesis- to reach considerable depths in bodies of water
Maximum density as a liquid at 4°C	Ice floats; vertical circulation restricted in stratified bodies of water
Higher heat of evaporation than any other material	Determines transfer of heat and water molecules between the atmosphere and bodies of water
Higher latent heat of fusion than any other liquid except ammonia	Temperature stabilized at the freezing point of water
Higher heat capacity than any other liquid except ammonia	Stabilization of temperatures of organisms and geographical regions

Table 2. Details of the characteristics of water wells used in sample collection in Kakua Chiefdom, Bo District, Sierra Leone.

Well site (Code)	Use	Impact	Depth (m)	Safety
St. Andrews (SAS)	Multi-use	High	37.4	Covered and fenced
SALWACO Bo (SBO)	Domestic	High	18.6	Covered and unfenced
Cheshire home (CHE)	Domestic	High	58.1	Covered and fenced
J-Quarters (JQS)	Domestic	High	10.3	Covered and fenced
Kebbie town (KTN)	Domestic	High	13.7	Covered and fenced
New York (NYK)	Domestic	Moderate	8.4	Covered and fenced
Sewa river plant (SRP)	Multi-use	High	59.2	Covered and fenced
Water street (WST)	Domestic	Moderate	7.5	Covered and unfenced
Diepha street (DST)	Domestic	Moderate	8.9	Covered and fenced
Sewa road (SRD)	Domestic	High	11.2	Covered and unfenced

with a tape rule at the end of the tape, there is a two (2) meter long metal attached to it, it uses two medium cells battery with 1.5v. As the battery is fixed, it shows a red light. When put into the well, as the metal touches the water at the surface it alarms and you drop it at the base of the well; it makes a second alarm from there you can take your readings, that is from the initial depth, subtract from the final depth which will give your final answer. For you to know the depth of the well, that is, initial depth –final depth = 0.63-0.3 =0.33m pH meter pH |mv| temperature meter was used to determine the pH and temperature of the water samples.

This meter features a custom digital Liquid-crystal display (LCD) display, which simultaneously shows temperature and pH measurement results. This meter has all the features of a simple pH meter plus a mill Volt Mode 1p69 (waterproof design, electrode holder ergonomic design and ultra buffer recognition).

Oxfarm delagua portable water testing kits was used to carry out bacteriological (faecal and non-feacal) analysis. The kit contains the following: incubator, turbidity, methanol dispenser and other necessary field materials. Hachdigital titration (Model 16900) Hach digital titrator is a new concept in trimetric analysis. It is a precision dispending device fitted with compact cartridges that contain concentrated titrants. Accurate titrations are made without the buck fragility of conventional burette. A main drive in the digital titration controls a plunger, which forces the solution from a titration cartridge in a carefully regulated flow. The titration body is constructed of precision model heavy duty chemical and impact resistance acetyl plastic. Accuracy is rated at ±% or better for a titration of more than 100 digits. For less than 100 digits, the accuracy is ±1. Pack test ion selection water inspection test kits (WAK COD) was used to determine the level of chloride. The kit contains several tubes containing very strong oxidizing agent ($KMnO_4$), with a standard colour chart with measuring range of 0 to 100 mg/L (ppm) and a desiccant. Found also in the kit is the instruction manual. This kit was used to determine chemical oxygen demand (COD) of the water sample.

Transmittance photometer (Palintest 5000) instrument was used to determine the level of phosphate $(PO_4)^{3-}$. This photometer like the DR2010 spectrophotometer is a microprocessor controlled single beam photometer design for volumetric testing in the laboratory and in the field. The wavelength range of 410 to 640 nm is selected on the photometer and result is shown on percentage transmittance (%T). Unlike the spectrophotometer that uses power pillows, the palintest tablet and results obtained is correlated with a chart for each ion determined.

Potable data logging (HACHDR 2010) spectrometer HACH model DR 2010 spectrophotometer is a microprocessor controlled, single beam for data logging spectrophotometer designed for colorimetric testing in the laboratory or in the field. The instrument is recalibrated for over 120 different colorimetric testing of water quality and has been factory-installed to streamline testing procedures within its wavelength range of 400 to 900 nm; the DR 2010 provides a result in concentration unit, percentage transmittance (%T) and absorbance (ABS) units. This instrument was used to determine the level of sulphate $(SO_4)^{2-}$, iron (Fe^{2+}) and nitrate $(NO_3)^{-}$. Refrigerator (Zero model) was used to maintain a temperature of 4°C required to store samples for chemical analysis. Pressure cookers and stoves were used to sterilize sample kits and culture medium. The following items were used in the preparation of the culture medium at the Ministry of Energy and Power, Water Division Laboratory, Tower Hill.

1. Membrane lauryl sulphate broth.
2. Distilled water.
3. Polypropylene N Bottles.
4. Measuring Cylinder.
5. Pressure cooker and stove

Sampling procedures

For water wells with pump was operated on for about 20 min, by allowing some water to run through in order to clear any substance in the water column. After this exercise, the out-let pipe is sterilized using an alcohol flaming. The pump was operated for further two minutes and the sample was taken in the following stream of water. For well without hand pumps, a weighed bottle or shallow sampling device was used. A stone of suitable size sterilized and attached to the sampling bottle with a piece of string. 20 m length of clean string was rolled around a stick and tied onto the bottle string. The sample bottle was lowered, weighed down by the stone into the well. It was immersed completely in the water and lowered to the bottom of the well, once it is filled the string was rewind round the stick to bring the bottle up. The bottle was then Stoppard and given a field code.

Preparation and preservation of sample analysis

The samples collected for chemical analysis were filtered immediately after collection using 0.7um membrane filter. The filter removes algae, bacteria and particulate matter that contaminate or rapidly absorb elements from water. The samples collected in the field were protected from the direct sunrays to avoid further reaction, and were therefore stored in special container, which were partially dark. Also each sample was protected from extractable contamination by sealing the sample bottle tightly with clean plastic cover. All physical parameters together with the chemical oxygen demand (COD) were performed in the field, as samples were collected. For chemical analysis, the sample bottles were completely filled with samples since the presence of air may chemically biologically alter the samples especially for the Fe^{2+} determination. Three parameters were used; physico-chemical and bacteriological parameter; temperature, pH, turbidity, electrical conductivity, TDS are physico-parameter; chloride (Cl^-), sulphate $(SO_4)^{2-}$, nitrate $(NO_3)^{2-}$, phosphate (PO_4^{3-}), chemical oxygen demand (COD)-chemical parameter; bacteriological faecal coli form counts and non-faecal coli form counts.

RESULTS AND DISCUSSION

The results of the analysis of the quality of well water used for various purposes (but mainly for drinking) in Kakua Chiefdom in Bo District, Sierra Leone, are sufficiently summarized in the plots given in Figure 2 and Figure 3. The discussions in the next sections done in relation to that analysis give further in-depth insight of the reactions as influenced by the environmental (physical, chemical and biological) conditions in the study area. Such discussion is necessary to inform policy/decision makers on the risks posed by the water supply system in the country and develop the most efficient measures to mitigate or eliminate these risks.

Temperature

Most individuals find water at temperatures of 10 to 15°C most palatable. Ground waters and waters from mountainous areas are normally within this range.

Surface waters are, of course, subject to the effect of ambient temperatures and can be very warm during dry season. The temperature of water affects the efficiency of treatment units. For example, from the period when the sample was collected, the range of temperature is from 27.97 to 28.19°C in Table 2 with high temperatures, the viscosity decreases. This, in turn, fall the efficiency of settling of the solids that the water may contain because of the resistance that the high viscosity offers to the downward motion of the particles as they settle. Pressure drops also increase in the operation of filtration units, again, because of the resistance that the higher viscosity offers.

pH determination

The pH of natural waters on land is controlled mainly by the bicarbonate–carbonate system. Most of the CO_2 absorbed into the ocean is in the form of $HCO_3^{\,-}$ (93%) and $CO_3^{\,2-}$ (6%). The pH of the upper regions of the sea is controlled by the carbonate as well as the borate systems. In the lower regions of the sea, pH appears to be controlled by the precipitation and solution of various minerals. The bicarbonate alkalinity of natural waters has the following typical ranges: rainwater 0 to 2.5 ppm (mg/L), river and groundwater 6 to 600 ppm, and seawater 140 to 159 ppm. pH is a measure of the hydrogen ion (H^+) concentration. Solutions range from

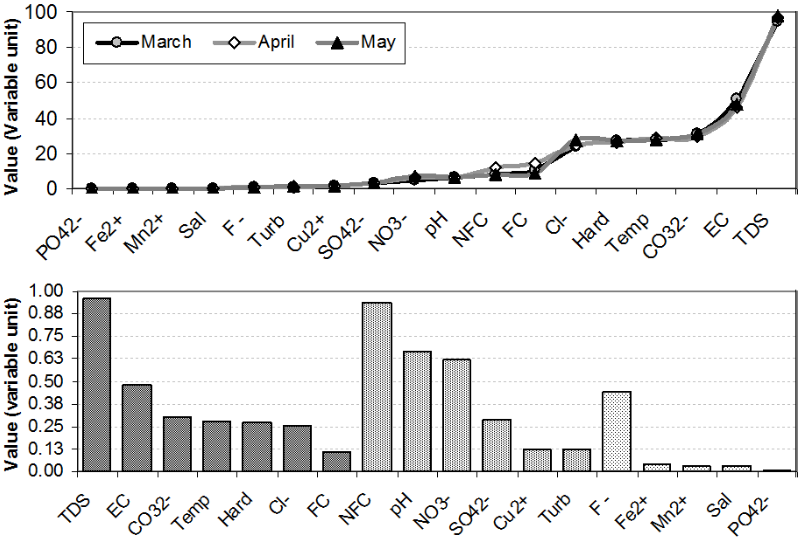

Figure 2. The top-plate is the trend in measured well-water quality variables for the months of March to May averaged spatially for the 10 wells across the study area. The bottom plot is the trend in measured well-water quality variables averaged temporally for the months of March through May and spatially for the 10 wells across the Kakua Chiefdom study area. For the actual variable values in the bottom-plate, the first seven variables (TDS to FC) are multiplied by 1.0×10^2, the second six (NFC to Turb) by 1.0×10, and the last five (F- to PO42-) by 1.0×10^2. Note that the definitions and units of the coded variables on the X-axis are as defined in Table 2 and Table 3.

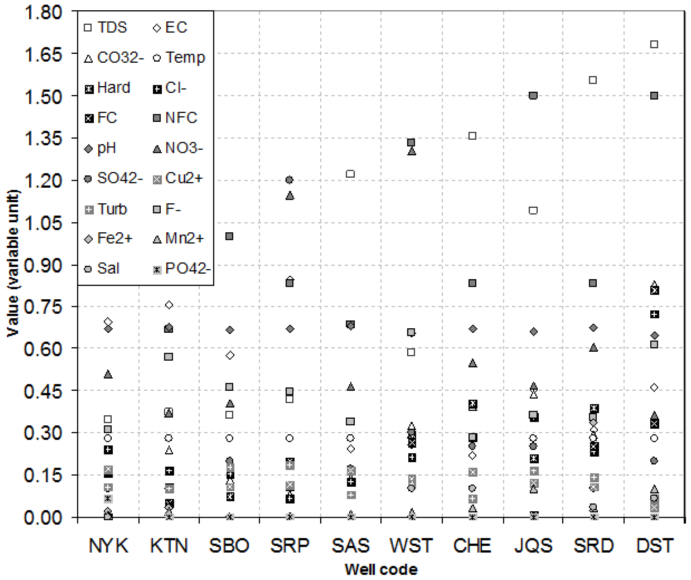

Figure 3. Plot of the trends in measured well-water quality variables averaged for the months of March through May in the Kakua Chiefdom study. For the actual values of the variables on the plot, the first seven variables (TDS to FC) are multiplied by 1.0×10^2, the second six (NFC to Turb) by 1.0×10, and the last five (F- to PO42-) by 1.0×10^2. Note that the well codes on the X-axis and the units of the variables are as defined in Table 2 and Table 3.

Table 3. Well-by-well mean values of measured well-water variables in the Kakua Chiefdom study area, Bo District, Sierra Leone.

Well-site/Variable	Unit	SRD	SRP	DST	KTN	NYK	SAS	WST	CHE	JQS	SBO	AVG
Total dissolved solid (TDS)	ppm	155.67	41.80	233.33	37.30	34.70	122.00	58.53	135.67	109.03	36.27	96.43
Electrical conductivity (EC)	µS/cm	31.10	84.63	46.10	75.63	69.63	24.40	26.00	21.87	45.43	57.50	48.23
Carbonate (CO_3^{2-})	mg/100 ml	29.33	8.00	83.00	23.67	15.67	14.00	32.67	39.33	43.67	13.33	30.27
Temperature (Temp)	°C	27.97	27.80	27.83	27.90	28.13	28.00	27.90	27.93	27.80	28.03	27.93
Hardness (Hard)	mg/100 ml	38.67	10.67	80.67	10.67	16.00	12.67	29.33	40.67	21.00	7.33	26.77
Chloride (Cl^-)	mg/100 ml	23.33	6.67	72.33	16.33	24.00	12.67	21.33	28.33	35.67	15.33	25.60
Faecal coliform (FC)	u/100 ml	25.00	20.00	33.33	5.00	0.00	0.17	26.67	0.00	0.67	0.00	11.08
Non-faecal coliform (NFC)	u/100 ml	8.33	8.33	15.00	6.67	1.67	6.83	13.33	8.33	15.00	10.00	9.35
pH	-	6.73	6.70	6.47	6.77	6.70	6.80	6.53	6.70	6.60	6.67	6.67
Nitrate (NO_3^-)	mg/100 ml	6.03	11.47	3.63	3.70	5.10	4.63	13.03	5.50	4.70	4.07	6.19
Sulphate (SO_4^{2-})	mg/100 ml	1.00	12.00	2.00	1.00	1.00	1.70	3.00	2.50	2.50	2.00	2.87
Cupper (Cu^{2+})	mg/100 ml	1.09	1.17	0.36	1.03	1.72	1.65	1.37	1.60	1.22	1.08	1.23
Turbidity (Turb)	mg/100 ml	1.43	1.87	0.67	1.00	1.07	0.80	1.20	0.67	1.63	1.80	1.21
Fluoride (F^-)	mg/100 ml	0.36	0.45	0.61	0.57	0.31	0.34	0.66	0.28	0.36	0.46	0.44
Iron (Fe^{2+})	mg/100 ml	0.34	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.04
Manganese (Mn^{2+})	mg/100 ml	0.04	0.00	0.10	0.02	0.01	0.01	0.02	0.03	0.10	0.00	0.03
Salinity (Sal)	mg/100 ml	0.03	0.00	0.07	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.03
Phosphate (PO_4^{2-})	mg/100 ml	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.01

The values are averages over March, April and May 2010, and AVG denotes average and the rest of the well codes are as defined in Table 2

very acidic (having a high concentration of H^+ ions) to very basic (having a high concentration of OH^-ions). The pH scale ranges from zero to 14, with 7 being the neutral value and Table 2 pH ranges from 6.73 to 6.67 which is recommend by WHO. The pH of water is important to the chemical reactions that take place within water, and pH values that are not high or low which cannot inhibit the growth of microorganisms. With high and low pH values, high pH values are considered basic and low pH values are considered acidic. Stated in another way, low pH values indicate a high level of H^+ concentration, while high pH values indicate a low H^+ concentration. Because of this inverse logarithmic relationship, there is a ten-fold difference in H^+ concentration. Natural water varies in pH depending on its source. Pure water has a neutral pH, with an equal number H^+ and OH^-.

Turbidity determination (NTU)

Water clarity is one of the first characteristics people notice (Table 3). Turbidity in water is caused by the presence of suspended matter, resulting in the scattering and absorption of light rays. The greater the amount of total suspended solids in the water, the murkier it appears and the higher the measured turbidity. Thus, in plain English, turbidity is a measure of the light-transmitting properties of water. Natural water that is very clear (low turbidity) allows you to see images at considerable depths, while high turbidity water appears cloudy. Keep in mind that water of low turbidity is not necessarily without dissolved solids. Dissolved solids do not cause light to be scattered or absorbed, making the water look clear. High turbidity causes problems for the components that cause high turbidity that can cause taste and odor problems, and will reduce the effectiveness of disinfection.

Electrical conductivity determination

The reading was allowed to stabilize, after stabilization meter displayed “ready” indicated at the top right of the display. The reading was then noted. The probe was removed and rinsed with de-ionized water before repeating the experiment. The same procedure was done for the remaining samples. The result from Table 3, Sewa River plant has high electrical conductivity (EC) values of 84.63 µS/cm and Kebie Town is the second highest with 75.63 µS/cm.

Total dissolved solids determination

Gases can also be dissolved in water. Oxygen, carbon dioxide, hydrogen sulfide, and nitrogen are examples of gases that dissolve in water. Gases dissolved in water are important. For example, carbon dioxide is important because of the role it plays in pH and alkalinity. Carbon dioxide is released into the water by microorganisms and consumed by aquatic plants. However, dissolved oxygen (DO) in water is of most important. DO is not only important to most aquatic organisms, but it is also an important indicator of water quality. Like terrestrial life, aquatic organisms need oxygen to live. As water moves past their breathing apparatus, microscopic bubbles of oxygen gas in the water, DO, are transferred from the water to their blood. Like any other gas diffusion process, the transfer is efficient only above certain concentrations. In other words, oxygen can be present in the water, but at too low a concentration to sustain aquatic life. Oxygen also is needed by virtually all algae and macrophytes, and for many chemical reactions that are important to water body functioning. From the mean result in Table 3, DST has 233.33 ppm, which is very high than the other.

ALKALINITY AND ACIDITY

Alkalinity

The capacity of water to accept H^+ ions (protons) is called alkalinity. Alkalinity is important in water treatment, and in the chemistry and biology of natural waters. From Table 3 it shows that, water is not alkaline non-basic, but neutral from the pH values. This must be known to calculate the quantities of chemicals to be added in treating the water. Due to the low alkaline and basicity of water often has a low pH and generally contains low levels of dissolved solids. These characteristics may be good for water to be used in boilers, food processing, and municipal water systems in Bo town. Alkalinity is not serving as a pH buffer and reservoir for inorganic carbon, thus helping to determine the ability of water to support algal growth and other aquatic life. Biologists use it as a measure of water fertility. Generally, the basic species responsible for alkalinity in water are bicarbonate ion, carbonate ion and hydroxide ion:

$HCO^-_3 + H^+ \rightarrow CO_2 + H_2O$
$CO_3^{2-} + H^+ \rightarrow HCO_3$
$OH^- + H^+ \rightarrow H_2O$

Other, usually minor, contributors to alkalinity are ammonia and the conjugate bases of phosphoric, silicic, boric, and organic acids. It is important to distinguish between high basicity, manifested by an elevated pH, and high alkalinity, the capacity to accept H^+.

Acidity as applied to natural water systems is the capacity of the water to neutralize OH^-. Acidic water is not frequently encountered, except in cases of severe pollution. Acidity generally results from the presence of weak acids such as $H_2PO_4^-$, CO_2, H_2SO_4, proteins, fatty acids, and acidic metal ions, particularly Fe^{3+}. Acidity is more difficult to determine than is alkalinity. One reason for the difficulty in determining acidity is that two of the major contributors are CO_2 and H_2SO_4, both volatile solutes that are readily lost from the sample from the table mart is (3) which show that the above chemical is low which make the acidy values insignificant. The acquisition and preservation of representative samples of water to be analyzed for these gases is difficult. The term *free mineral acid* is applied to strong acids such as H_2SO_4 and HCl in water. Pollutant acid mine water contains an appreciable concentration of free mineral acid. Whereas total acidity is determined by titration with base to the phenolphthalein end point (pH 8.2, where both strong and weak acids are neutralized), free mineral acid is determined by titration with base to the methyl orange endpoint (pH 4.3, where only strong acids are neutralized). The acidic character of some hydrated metal ions may contribute to acidity as shown by the following example:

$Al(H_2O)_6^{3+} + H_2O \rightleftarrows A\ l(H_2O)_5OH^{2+} + H_3O^+$

For brevity in this research, the hydronium ion, H_3O^+, is abbreviated simply as H^+ and H^+-accepting water is omitted so that the above equation becomes

$Al\ (H_2O)_6^{3+} \rightleftarrows A\ l(H_2O)_5OH^{2+} + H^+$

Some industrial wastes, for example pickling liquor used to remove corrosion from Steel, contain acidic metal ions and often some excess strong acid. For such wastes, the determination of acidity is important in calculating the amount of lime, or other chemicals, that must be added to neutralize the acid (Table 3).

OXIDATION-REDUCTION

Oxidation-reduction (redox) reactions in water involve the transfer of electrons between chemical species. In natural water, bacteria carry out wastewater, and soil, most significant oxidation-reduction reactions, so they are considered in this section as well. The relative oxidation-reduction tendencies of a chemical system depend upon the activity of the electron, e-. When the electron activity is relatively high, chemical species (even including water) tend to accept electrons and are reduced.

$2H_2O + 2e- \longleftrightarrow H_2(g) + 2OH^-$

When the electron activity is relatively low, the medium is oxidizing, and chemical species such as H_2O may be oxidized, losing electrons:

$2H_2O \longleftrightarrow O_2(g) + 4H^+ + 4e-$

Table 4. Correlation matrix for the 18 water-quality variables analyzed in this study.

R	$PO4^{2-}$	Sal	Mn^{2+}	Fe^{2+}	F^{-}	Turb	Cu^{2+}	SO_4^{2-}	NO_3^{-}	pH	NFC	FC	Cl^{-}	Hard	Temp	CO_3^{2-}	EC
Sal	-0.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn^{2+}	0.73	-0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe^{2+}	0.50	-0.87	-0.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F^{-}	-0.99	0.92	-0.01	-1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Turb	0.83	-1.00	-0.70	0.96	0.80	-	-	-	-	-	-	-	-	-	-	-	-
Cu^{2+}	0.63	-0.16	1.00	1.00	-0.47	-0.17	-	-	-	-	-	-	-	-	-	-	-
SO_4^{2-}	-0.43	0.82	0.88	1.00	0.75	0.48	1.00	-	-	-	-	-	-	-	-	-	-
NO_3^{-}	0.95	-0.98	-0.41	1.00	0.55	0.42	0.99	-	-	-	-	-	-	-	-	-	-
pH	0.92	-0.99	-0.54	1.00	0.38	0.98	0.74	-0.21	0.86	-	-	-	-	-	-	-	-
NFC	0.50	0.00	0.99	0.98	0.30	0.62	0.75	-0.20	0.35	0.58	-	-	-	-	-	-	-
FC	0.19	0.33	0.96	0.96	0.44	0.30	0.97	1.00	0.00	0.17	1.00	-	-	-	-	-	-
Cl^{-}	0.72	-0.97	-0.78	1.00	0.33	-0.42	0.84	1.00	1.00	0.79	-0.68	-1.00	-	-	-	-	-
Hard	-0.08	-0.43	-0.95	1.00	0.34	1.00	0.75	-0.20	-0.13	0.01	0.99	-0.29	-0.80	-	-	-	-
Temp	0.60	-0.12	1.00	1.00	0.31	-0.89	0.73	1.00	-0.12	-0.18	0.96	0.90	-0.31	-0.96	-	-	-
CO_3^{2-}	-0.37	-0.15	-0.98	1.00	0.27	-0.95	0.37	1.00	0.72	0.87	0.41	-0.66	0.87	0.57	0.95	-	-
EC	-0.94	0.64	-0.92	1.00	0.35	0.52	1.00	0.48	0.89	0.98	1.00	-0.53	0.28	0.44	0.87	0.06	-
TDS	0.97	-0.96	-0.31	1.00	-0.99	0.05	0.89	0.84	-0.21	1.00	0.98	0.97	0.90	0.66	-0.88	-0.69	-0.83

The acronyms and units are as defined in Table 3.

The relative tendency toward oxidation or reduction is based upon the electrode potential, E, which is relatively more positive in an oxidizing medium and negative in a reducing medium. It is defined in terms of the half reaction (Table 4).

$$2H^{+} + 2e- \longleftrightarrow H_{2}$$

Chloride determination

The actual concentration of the chloride was obtained by multiplying digit required by digit multiplier; also corresponding to the sample volume and the titration cartridge selected. Table 3 shows how the figures were obtained during titration where the chlorine is a halogen that cannot react with the heavy metal in the water.

Sulphate determination (0 to 70 mg/L SO_4^{2-})

Sulphate content in Table 3 is very low, because sulphur cannot exhibit it distinct property as allotrope, and it lack one component phase equilibrium. The sulfur cycle involves interconversions among a number of sulfur species, including inorganic soluble sulfates, insoluble sulfates, soluble sulfide, gaseous hydrogen sulfide, and insoluble sulfides; biologically bound sulfur; and sulfur in synthetic organic compounds. The major microbial mediated processes in this cycle are the following: Sulfate reduction to sulfide by bacteria such as *Desulfovibrio*, which utilizes sulfate as an electron acceptor in the oxidation of organic matter:

$$SO_4^{2-} + 2\{CH_2O\} + 2H+ \rightarrow H_2S + 2CO_2 + 2H_2O$$

The odiferous and toxic H_2S product may cause serious problems with water quality.

Sulfide oxidation by bacteria such as *Thiobacillus*:

$$2H_2S + 4O^2 \rightarrow 4H^{+} + 2SO_4^{2-}$$

Oxidation of sulfur in a low oxidation state to sulfate ion produces sulfuric acid, a strong acid. Some of the bacteria that mediate this reaction, such as *Thiobacillus thiooxidans* are remarkably acid tolerant. Acid-tolerant sulfur-oxidizing bacteria produce and thrive in acidic waters, such as acid mine water, which can be very damaging to the environment.

Nitrate HR (0-30.0 mg/L)

Some of the most important microorganism-mediated and human activities chemical reactions in aquatic and soil environments are those involving nitrogen compounds. They are key constituents of the nitrogen cycle, which take place in the atmosphere, a cycle that describes the dynamic processes through which nitrogen is interchanged among the atmosphere, organic matter, and inorganic compounds. The range values in Table 2 are 6.03 to 6.67 mg/100 ml which can lead to the key microbial mediated processes in the nitrogen cycle.

Nitrogen fixation

The binding of atmospheric nitrogen in a chemically combined form:

$3\{CH_2O\} + 2N_2 + 3H_2O + 4H^+ \rightarrow 3CO_2 + 4NH_4^+$

Biological nitrogen fixation is a key biochemical process in the environment and is essential for plant growth in the absence of synthetic fertilizers.

Nitrification

The conversion of N (-III) to N (V) is catalyzed by *Nitrosomonas* and *Nitrobacter*:

$2O_2 + NH_4^+ \rightarrow NO_3- + 2H^+ + H_2O$

Nitrification is important in nature because plants absorb nitrogen primarily as nitrate ion, which is produced by nitrification. When fertilizers are applied in the form of ammonium salts or anhydrous ammonia, a microbial transformation to nitrate enables maximum assimilation of nitrogen by the plants. Nitrate reduction is a system by which nitrogen in chemical compounds is reduced by microbial action to lower oxidation states in the absence of free oxygen:

$2NO^{3-} + \{CH_2O\} \rightarrow 2NO^{2-} + H_2O + CO_2$
$2NO^{2-} + 3\,\{CH_2O\} + 4H^+ \rightarrow 2NH_4^+ + 3CO_2 + H_2O$

Denitrification, which produces N_2 gas from chemically fixed nitrogen:

$4NO^{3-} + 5\{CH_2O\} + 4H^+ \rightarrow 2N_2 + 5CO_2 + 7H_2O$

Denitrification is the mechanism by which fixed nitrogen is returned to the atmosphere and is useful in advanced water treatment for the removal of nutrient nitrogen. Loss of nitrogen to the atmosphere may also occur through the formation of N_2O and NO by bacterial action on nitrate and nitrite catalyzed by several types of bacteria.

Phosphate determination HR (PO_4^{3-})

The phosphorus cycle involves natural and pollutant sources of phosphorus including biological, organic, and inorganic phosphorus. Biological phosphorus is a key constituent of cellular DNA. Organic phosphorus occurs in organophosphate insecticides. The major inorganic phosphorus species are soluble H_2PO^{4-} and HPO_4^{2}- and insoluble $Ca_5(OH)(PO4)_3$. Soil and aquatic microbial processes are very important in the phosphorus cycle. Of particular importance is the fact that phosphorus is the most common limiting nutrient in water, particularly for the growth of algae. Bacteria are even more effective than algae in taking up phosphate from water, accumulating it as excess cellular phosphorus that can be released to support additional bacterial growth, if the supply of phosphorus becomes limiting. Microorganisms that are died release phosphorus that can support the growth of additional organisms. Biodegradation of phosphorus compounds is important in the environment for two reasons. The first of these is that it is a mineralization process that releases inorganic phosphorus from the organic form. This process provides an important source of nutrient orthophosphate required for the growth of plants and algae. Second, biodegradation deactivates highly toxic organophosphate compounds, such as the organophosphate insecticides.

Copper determination (COPPERCOL)

Clinical, epidemiological, and toxicological studies have demonstrated some heavy metal such as lead, copper iron etc, Exposure can adversely affect human health and most of them are radioactive material. The three systems in the human body most sensitive to some of them are the blood-forming system, the nervous system, and the renal system. In children, blood levels from 0.8 to 1.0 g/L can inhibit enzymatic actions. In addition, in children, this lead can alter physical and mental development, interferes with growing, decrease attention span and hearing, and interferes with the synthesis. In older men and women, lead can increase blood pressure. Lead is emitted into the atmosphere as Pb, PbO, PbO_2, $PbSO_4$ PbS, $Pb(CH3)_4$, $Pb(C_2H_5)_4$, and lead halides. In drinking water, it can be emitted from pipe solders. The source of copper in drinking water is the plumbing used to convey water in the house distribution system. In small amounts, it is not detrimental to health, but it will impart an undesirable taste to the water. In appropriate concentrations, copper can cause stomach and intestinal distress. It also causes Wilson's disease. Certain types of PVC (polyvinyl chloride) pipes, called CPVC (chlorinated polyvinyl chloride), can replace copper for household plumbing. In Table 2 copper values ranges from 1.09 to 1.23 mg/100 ml which cannot affect the life of the people.

Ammonia determination

Ammonia is a primary breakdown product of nitrogen containing organic matter in aquatic environments. Because a great deal of organic matter and waste is introduced into the hydrologic cycle by natural and anthropogenic processes, ammonia can be found in aquatic environments, especially those exposed to large amounts of human or domestic animal wastes. Ammonia is also of great importance in understanding the global cycling of several key elements, including nitrogen and carbon. Ammonia is one of the compounds uniquely critical to life that when not present in adequate amounts in aquatic environments can be associated with negative biological effects and when in excess can result in adverse ecological and toxic effects. When insufficient ammonia is available to plants, which assimilate ammonia to grow, they may experience metabolic problems due to nutrient limitations. Conversely, excess ammonia is commonly associated with eutrophic conditions in water bodies and toxicity to some organisms. Further, nitrous oxide *(*N_2O*)* a molecule involved in the environmental cycling of ammonia is considered a potential 'greenhouse gas' which can also destroy stratospheric ozone. Because of these adverse effects, ammonia is frequently considered a pollutant in aquatic systems.

Iron and manganese

Iron (Fe) and manganese (Mn) are objectionable in water supplies because they impart brownish colors to laundered goods. Fe also affects the taste of beverages such as tea and coffee. Mn flavors tea and coffee with a medicinal taste. The range value for (Fe) and (Mn) is 0.34-0.04, and 1.09-1.23 mg/100 ml respectively.

Total hardness determination (ppm) 20 ml

1 m NaOH solution was added to 50 ml of water sample to produce pH of 12 or 13. The solution was stirred and an appreciable amount of murexide indicator was added to the solution. This was immediately titrated with 0.01 m ethylene diamine tetra-acetic acid (EDTA) solution with continuous shaking. Colour change from red to blue showed the end, and the volume of EDTA titrant used was recorded. This was repeated for the blank and was therefore stored in special containers that were partially dark. In addition, each sample was protected from excreta contamination by sealing the sample bottles tightly with clean plastic cover. The samples were then taken to the laboratory at the Ministry of Energy and Power, Water Division at Tower Hill for physical, chemical and bacteriological analysis. At the laboratory, split sampling was done, various parameters of the analysis (that is, physical, chemical and bacteriological [biological] analyses) to make allowance for appropriate preservation method. The sample for chemical analysis were generally acidified with 2 ml of 10% HNO_3, the samples were then taken in the refrigerator (zero models) at 4°C. All chemical analysis was done within 48 h when the samples for bacteriological analysis were analyzed within 5 h. All the physical parameters w together with the chemical oxygen demand (COD) were performed in the field as samples were collected.

For chemical analysis, the samples bottles were completely filled with the samples since the presence of air may chemically, biologically alter the samples especially for Fe^{2+} determination. In addition, the pH of 2 was aimed for Fe^{2+} by 1 ml concentrated hydrochloric acid per 100 ml of samples, before storage to avoid any oxidation reaction. Samples were collected and analyzed once every month for the three months under investigation (March to May 2009); each of these:

Fluorides: The absence of fluorides in drinking water encourages dental caries or tooth decay; excessive concentrations of the chemical produce mottling of the teeth or dental fluorosis. Thus, managers and operators of water treatment plants must be careful that the exact concentrations of the fluorides are administered to the drinking water. Optimum concentrations of 0.7 to 1.2 mg/L are normally recommended, although the actual amount in specific circumstances depends upon the air temperature, since air temperature influences the amount of water that people drink. In addition, the use of fluorides in drinking water is still controversial. Some people are against its use, while some are in favor of it. In the study research, the fluoride values in Table 2 range from 0.34 to 0.44 mg/100 ml, which might prevent took decay.

Salinity: The presence of salinity in drinking water can affect persons suffering from heart, kidney, or circulatory ailments. It may elevate blood pressures of susceptible individuals. Sodium is plentiful in the common table salt that people use to flavor food to their taste. It is a large constituent of sea water; hence, in water supplies contaminated by the sea as in the case of Antipolo mentioned earlier, this element would be plentiful. The salinity content in the sample is insignificant from Table 2 it ranges from 0.03 to 0.03 mg/100 ml.

Bicarbonate alkalinity: If the initial pH of a sample is less than 7.0 in Table 2, then there is bicarbonate alkalinity. Alternatively, even though the amount of pH in Table 2 is 6.73 the acidity is low so the Bicarbonate is not alkaline. It is in the range value that is recommended by WHO which is 29.33 to 30.27 mg/100 ml.

Carbonate alkalinity: There were interference changes in pH during alkalinity titration, which make the pH 6.73 to 6.67 in Table 2. If only CO_3^{2-} ions are present, the amount of acid necessary to lower the pH below 6.73 is one-half the total acid necessary to lower the pH below 6.67. The first abrupt pH change at 6.73 represents the conversion of carbonate to HCO_3^- (that is, half of the carbonate has been neutralized), and the second abrupt pH change at 6.67 represents neutralization of the HCO_3^- created from carbonate. If only CO_3^{2-} ions. carbonate rocks, mainly aragonite and calcite, constitute about 11% of the total sediments of the earth's crust. Bicarbonate salts are relatively soluble in water, but calcium carbonate is not. Freshwater does not sustain extreme super saturation of calcium carbonate. In most cases, the phase precipitated is calcite—the polymorph of calcium carbonate that has the lowest solubility product. Carbonate solubility in seawater is governed essentially by the same parameters, but kinetically the precipitation of calcium carbonate is complicated by high concentrations of Mg^{2+} and the actions of marine organisms.

Bacteriological analysis bacteria: Are single-celled prokaryotic microorganisms shaped as rods (bacillus), spheres (coccus), or spirals (vibrios, spirilla, spirochetes) that are uniquely important in environmental chemistry. Characteristics of most bacteria include a semi rigid cell wall, motility with flagella for those capable of movement, unicellular nature (although clusters of cloned bacterial cells are common), and multiplication by binary fission in which each of two daughter cells is genetically identical to the parent cell. Bacteria obtain the energy and raw materials needed for their metabolic processes and reproduction by mediating chemical reactions. Nature provides a large numbers of such reactions and bacterial species have evolved that utilize many of them. Because of their participation in such reactions, bacteria are involved in many biogeochemical processes and elemental transitions and cycles in water and soil. The metabolic activity of bacteria is greatly influenced by their small size, which is of the order of a micrometer in magnitude. Their surface-to-volume ratio is very large, so that the inside of a bacterial cell is highly accessible to a chemical substance in the surrounding medium. Thus, for the same reason that a finely divided Catalyst is more efficient than a more coarsely divided one, bacteria may bring about very rapid chemical reactions compared with those mediated by larger organisms. The study research on bacteria is base faecal coliform (FC) and non-faecal coliform (FC), from Table 2 the range values are 25.00 to 11.08 and 8.33 to 9.35 µ/100 ml. From chemistry point of view, those values may not influence the oxidation and reduction.

Conclusion

The available information on the presence of physio-chemical and bacteriological in water samples is spotty, many studies lack specific information on the type of water sample (blowholes, river, or tap water), where, when, and why samples were collected. However, taken as a whole, the studies indicate that the presence of physiochemical in water samples should be low at concentrations in the tenths to single mg/100 ml range. Chemical analysis in water concentrations near landfills, agricultural sites, chard coal regions, or locations are nitrogen-and phosphorus -enriched rock can have elevated levels, typically of carbonate. Higher nitrogen and phosphorus carbonate in water concentrations are limited by the low solubility of most mineral species.

Water quality can be a geologic or anthropogenic function, both of which could influence well-water compositions in the study area. About 20% of the well-tested wells have high TDS concentrations. Another 44% of the turbidity is above 1 mg/100 ml. Also 16 of the well have faecal coliform counts above 20µ/100Ml. While the SRP has the highest sulphate concentration (SO_4^{2-}), WTS well has the highest nitrate concentration (NO_3^-). The pH<7.0 indicated a tendency of acidity.

There are also low irons (Fe^{2+}) values in the well. pH value treated to WHO standard can even cause some damage in the human system due to it acidity.

Conflicts of interest

The authors have not declared any conflict of interests.

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