ORIGINAL ARTICLE

PHYSICO-CHEMICAL PROPERTIES OF WATER FROM KAHA RIVER, IN GONDAR TOWN, ETHIOPIA

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ABSTRACT

Background: *Surface waters are habitats for aquatic plants and animals and source of nations' development. Particularly, rivers are important source of drinking water supply and they have a remarkable role to nations' development. However, currently, rivers face pollution due to rapid agricultural expansion, urbanization, industrialization and land use change.*
Objective: *the current study was carried out during February to August 2014 to assess the status of physico-chemical parameters of Kaha River water. Some of the main physico-chemical parameters: pH, temperature, electrical conductivity, total dissolved solid (TDS), salinity and dissolved oxygen (DO) measured on site while others like NO_3 and PO_4were determined in lab.*
Methods: *Water samples were collected monthly during dry (February to May, 2014) and wet (July to August, 2014) seasons from four representative sites. At the same frequency, duration and sites in situphysico-chemical parameters measurements were deployed.*
Results: *The pH of Kaha River water varied from 4.86 to 8.06 with mean value 7.15; the surface water temperature from 19^{o}C to 29^{o}C with mean 24^{o}C; conductivity from 2.50mS/cm to 6.10mS/cm and mean value 3.74; total dissolved solid from 148.88mg/l to 360mg/l and mean value 203.71mg/l. The minimum salinity recorded was 0.99mg/l and the maximum 3.10mg/l with value 1.70mg/l and dissolved oxygen between 4.98mg/l to 8.15mg/l with mean value 6.77mg/l. In addition, nitrate was varied from 0.06mg/l to 2.60mg/l with mean value 0.74mg/l and phosphate from 0.04mg/l to 7.13mg/l with mean value2.28mg/l.*
Conclusion: *in this study, the mean value of pH was within the permissible limit of EEPA and World Bank standard values. The values of DO are within the permissible limit of Canadian water quality guidelines for the protection of aquatic life. Moreover, temperature, TDS and nitrate are below the limit of WHO and EC and phosphate are beyond the limit.*

Keywords: *fresh water, in situ measurement, urban river, water quality.*

INTRODUCTION

Water is the prime necessity of life in the world(1) but it is a scarce resource that requires serious safe guard. As forecasted in (2),by the year 2025,40% of the world people will face water scarcity. Surface water that includes rivers, lakes, streams, ponds and dams are important for power generation, drinking and irrigation. They are also habitats for both aquatic plants and animals. Rivers are important source of drinking water together with streams, wells and boreholes(3). Moreover, they have a remarkable role to nations' development.

However, currently, rivers face pollution due to rapid agricultural expansion, urbanization, industrialization and land use change. As a result, river water physico-chemical parameters and quality are largely heterogeneous spatiotemporally(4). Studies in different parts of Tigray Region, close to Gondar town reported spatiotemporal variation of river physico-chemical parameters(5-7). Another study by Charles et al(8) noticed that physical and chemical characteristics of water were higher along agricultural zones of water bodies.

As explored by works (9, 10),the status of physical and chemical parameters in water bodies determine

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the composition, distribution and abundance of aquatic organisms. Another studies by Sangpal et al. (11) reported that the physical and chemical characteristics of water bodies are important to assess their pollution level. Therefore, the current study conducted in Kaha River in Gondar Town, Ethiopia is to evaluate the quality of its water by assessing physico -chemical parameters.

River Kaha is serving as small scale irrigation, bathing and washing cloth. Small scale irrigation and agricultural landsaround the river are using fertilizers and pesticides. In addition, the livestock production association in 200m West direction of the river is releasing the wastes and using as a drinking water for their cattle. Moreover, people are dumping their solid and liquid wastes into the river. However, no information is available concerning the status of physico-chemical parameters and water quality of the river. Therefore, the current study carried out to assess the status of physico-chemical parameters and quality of the Kaha River water.

MATERIALS AND METHODS

Description of the study area: Kaha River is found in Gondar town in Amhara Regional State, Northwest Ethiopia. Gondar town I s found 180km from Bahir Dar city (capital of Amhara Regional State) and 738km from Addis Ababa (capital of Ethiopia). Kaha River is found close to Gondar University Referral Hospital and itflows across North to South direction of Gondar town. It feeds Angereb River-which is the tributary of Lake Tana (the largest lake of Ethiopia) and the source of Angereb Reservoir i.e. the drinking water supply of Gondar town population. Kaha River is used as dumping sites for wastes, bathing, washing cloth and at its upstream and downstream for drinking.

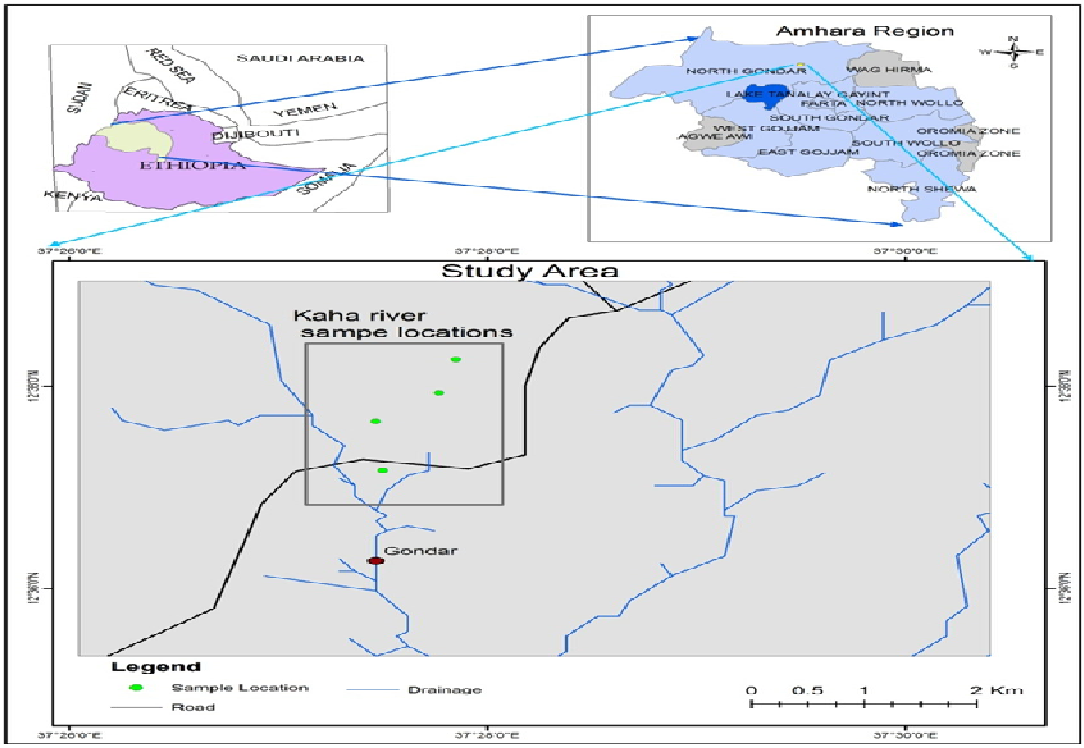

Fig.1.*Sampling sites and water sampling*

Water sample collection and physico-chemical parameters measurements were deployed monthly during dry (February to May, 2014) and wet (July to August, 2014) seasons. The sampling sites were site 1 (upstream), site 2, site 3and site 4 (downstream). The first site was the place before the river joins the town and the second close to Gondar University Hospital. The third place was where human activities (livestock production, cloth and car washing) were seen and the fourth was downstream nearby St. George church (Abera George).

A liter of water sample was collected monthly from each site and laboratory analysis of nitrate (NO_3) and phosphate (PO_4)were conducted following the standard methods (12). Moreover, in each sampling site, in situ measurement of pH, temperature, electrical conductivity (EC), total dissolved solid (TDS), salinity and dissolved oxygen (DO) were made. Both water sample collection and in situ measurement were conducted in dry season (February-May, 2014) and wet season (June-August, 2014).

Statistical analysis: Descriptive statistics such as mean and standard deviation (SD) computation were made using MS excel and assess the relations of physico-chemical characteristics one another were Pearson's correlation of SPSS version 20.

RESULTS

The results of physico-chemical characteristics of Kaha River from each of the sampling sites are given in Figure 1 and Table 1. The pH of Kaha River water was varied from acidic (4.86) during wet season (July, 2014) to slightly alkaline (8.06) during dry season (March, 2014).The mean value was 7.15 (Fig. 1A and Table 1). The surface water temperature of Kaha River was varied from 19^{o}C during July, 2014 at the downstream to 29^{o}C during August, 2014 in site 2 and its mean value was 24^{o}C (Fig. 1B and Table 1).

The minimum conductivity was 2.50mS/cm during March, 2014 at site 4 (downstream) and the maximum was 6.10mS/cm during August, 2014 at site 2 (Fig. 1C and Table 1). The total dissolved solid varied from 148.88mg/l during August, 2014 at site 3 to 360mg/l during July, 2014 at site 2 and the mean value was 203.71mg/l (Fig. 1D and Table 1). The minimum salinity (0.99mg/l) recorded during June, 2014 at the sites 4 (downstream) and the maximum (3.10mg/l) during July, 2014 at site 2 and the mean salinity value was 1.70mg/l (Figure 1E and Table 1). The range of dissolved oxygen was 4.98mg/l during June, 2014 in site 3 to 8.15mg/l August, 2014 in site 2 with mean value of 6.77mg/l (Fig. 1F and Table 1).

Both Nitrate (NO_3) and phosphate (PO_4) showed remarkable variation ($p<0.05$) temporally. The minimum nitrate in Kaha River water was 0.06mg/l in July, 2014 at site 3 and the maximum 2.60mg/l in August, 2014 at site 2 and the mean was 0.74mg/l (Fig. 1G and Table 1).Phosphate (PO_4) was varied from0.04mg/l in June, 2014 at site 1 to 7.13mg/l in May, 2014 at the same site and the mean was2.28mg/l (Fig. 1H and Table 1).

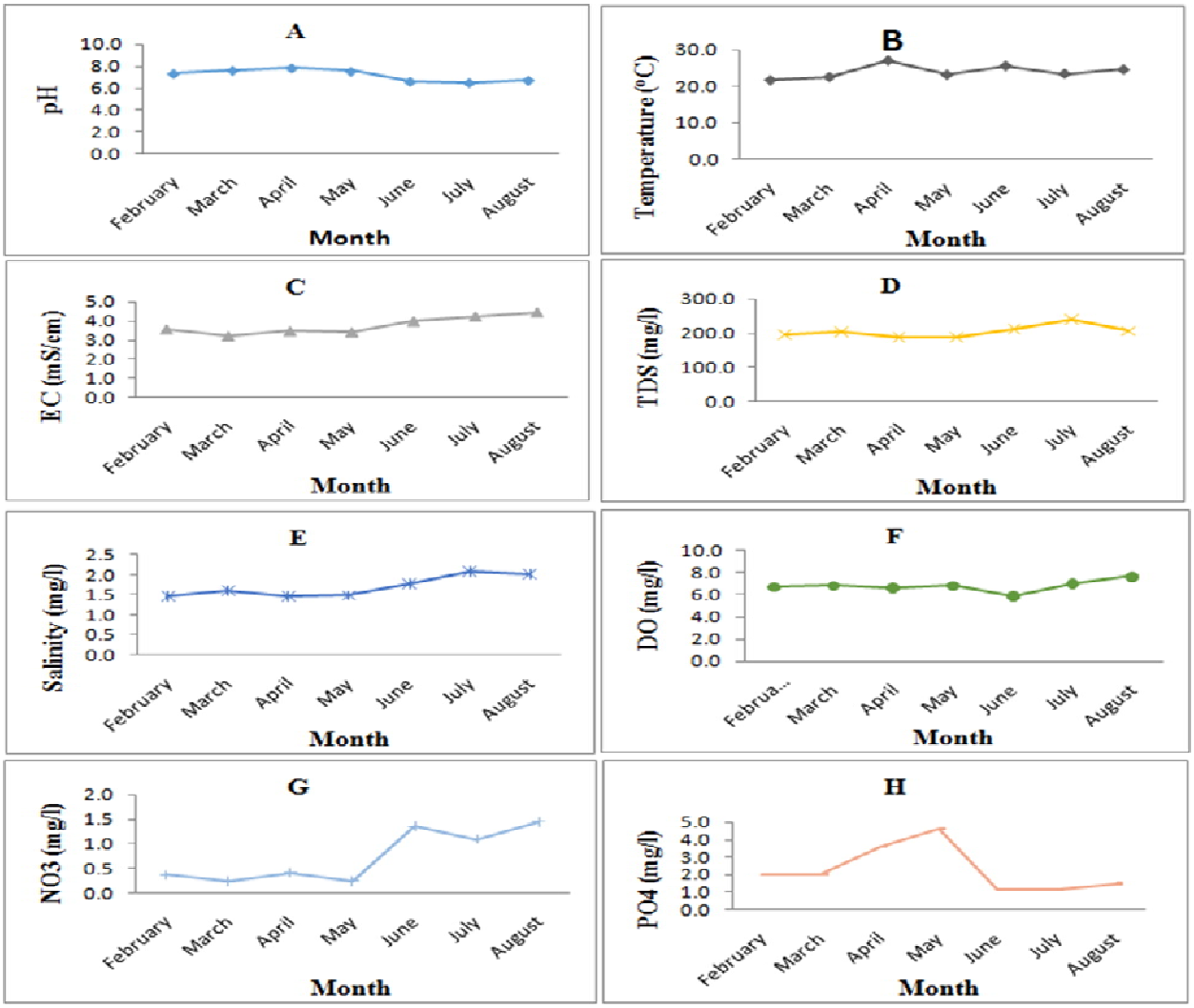

Fig.2: *Monthly variation of Physico-chemical parameters (A= pH, B= Temperature, C= Electrical Conductivity, D= total dissolved solid, E= salinity, F= DO,G= NO3 and H=PO4) of water at four different sites of Kaha River.*

Table 1. Descriptive statistics of physico-chemical parameters of physico-chemical parameters of Kaha River water (February to August, 2014).

Parameter	Minimum	Maximum	Mean±StD
pH	4.86	8.06	7.15±0.88
Temperature	19.00	29.00	24.00±2.69
EC	2.50	6.10	3.74±0.81
TDS	148.88	360.00	203.71±45.64
Salinity	0.99	3.10	1.70±0.52
DO	4.98	8.15	6.77±0.95
NO3	0.06	2.60	0.74±0.69
PO4	0.04	7.13	2.28±1.84

Table 2. Pearson's correlation of physico-chemical parameters of Kaha River water (February to August, 2014).

	pH	Temperature	EC	TDS	Salinity	DO	NO3	PO4
pH	1							
Temperature	0.24	1						
EC	0.15	0.31	1					
TDS	0.36	0.38	0.49	1				
Salinity	0.15	0.27	0.58	0.47	1			
DO	-0.02	0.05	0.17	0.17	0.11	1		
NO3	0.24	0.44	0.51	0.74	0.25	-0.02	1	
PO4	0.47	0.2	-0.12	0.04	-0.11	0	-0.15	1

DISCUSSION

The acidic water recorded at site 3 can dissolve metals and may lead to pollution. The mean pH value was within the limit of standards. However, the lower limit of pH (4.86) was below the permissible limit of standard values(13-15)implying that there was fluctuation in acidity and alkalinity of the river water. Temperatures of water bodies affect the degree of proliferation and survival of aquatic microorganisms and solubility of gases and salts(16).

The mean conductivity 3.74mS/cm is beyond WHO standard value (0.25mS/cm) (17)for drinking water supply. Conductivity is a good and rapid method to measure the total dissolved ions and is directly related to total solids. The highest the value of dissolved solids, the greatest the amount of ions (salinity) in water, and electrical conductivity were reported (18-21). Though it was not strong, direct correlation was also observed in the current study (Table 2). Total dissolved solid can be used as a ''watchdog'' for environmental test, and it depends on various factors such as geological character of watershed, rainfall and amount of agricultural and urban runoffs. Total dissolved solid is indicator of the amount of dissolved substances.

A little change in freshwater salinity drastically kills green algae from the water ecosystem and allowed cyanobacteria to be dominant as they can tolerate higher osmotic stress (22). Therefore, the higher salinity in the downstream of the current river may exclude green algae and favour the cyanobacteria resulting impairment of the river ecology. Many reports showed that DO values were higher at the upstream sampling stations than the downstream stations(22-24). However, in our results, there is no regularity in DO across sampling stations. Dissolved oxygen is very important for aquatic organisms and it is also used to assess the river water freshness (1). The value of DO in the current study is within the permissible limits of Canadian water quality guidelines for the protection of aquatic life(25).

The mean nitrate value (0.74mg/l) is found lower than the permissible level of Canadian Water Quality Guidelines for the Protection of Aquatic Life (13mg/l) (25)and very much lower than Ethiopian guidelines specification for drinking water quality (50mg/l)(15). In natural waters, phosphate is found in the form of

PO_4-P and usually it is available from low to moderate concentration. This is due to agriculture runoff containing phosphate fertilizers from agricultural lands, wastes from the stock production and domestic waste dumped into the water and the detergents from cloth and car washing and bathing practice. The current finding revealed that phosphate was higher during May. This might be due to the month May is the beginning of raining in the study area that could take the agricultural waste including phosphate in to the river that lead increase to the phosphate of the river water (26-28).

CONCLUSIONS

Physico-chemical characteristics of water bodies are important indicators of water quality. Therefore, it is essential to assess the physico-chemical parameters of the water in a regular basis to be able to monitor the water quality. In the current study, the mean pH value is within the permissible limit of EEPA and World Bank standard values. The values of DO are within the permissible limits of Canadian water quality guidelines for the protection of aquatic life. Moreover, temperature, TDS and nitrate are below the limit of WHO and EC and phosphate are beyond the limit. The mean nitrate value is found lower than the permissible level of Canadian Water Quality Guidelines for the Protection of Aquatic Life and Ethiopian guidelines specification for drinking water quality. Continuous monitoring of the wastes from the livestock production, small irrigation and farm lands should be taking place. In addition, appropriate waste disposal system for Gondar University referral hospital, in which it is being released into Kaha River (personal observation) should be practiced. Moreover, further study is recommended to determine heavy metals and bacterial constituents of the river water to further ascertain its safety.

Conflict of interest: The author declared that there is no any conflict of interest.

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