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Physicochemical Analysis of Hora and Spring Water Bodies in Anderacha Woreda, Sheka Zone, South West Ethiopia

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Abstract

Access to safe water is a worldwide need though, many of the world's population lack access to adequate and safe water. Contaminated water jeopardizes both the physical and social health of all people. Hence the purpose of the research was to assess the physicochemical analysis of hora/salty unprotected springs and protected springs in Anderacha wereda, sheka zone south west of Ethiopia. Water samples collected were analyzed for physicochemical parameters such as temperature, pH, conductivity, total hardness, Cl-, NO_3^-, NO_2^-, CO_3^{2-}, PO_4^{3-}, Co, Cd, Cu, Zn, Mn, Fe, Mg, Ca, Cr, Ni and Pb using standard analytical methods, Analysis of official analytical chemist 1990. The obtained results of each parameter are comparable with the standard values set by WHO and other national guidelines. The values of most physicochemical parameters were found to be within the recommended permissible limits except temperature, Fe, Cu and Mn. These outcomes demonstrate the need to come up with water source protection strategies for the study area.

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Introduction

Water is one of the most important compounds that constitute the largest part of life. All living organisms on the earth need water for their survival and growth. Potable or water of good drinking quality is of the basic importance to human physiology and man's continued existence (FAO, 1997a). The accessibility and availability of good quality drinking water plays the most important role in both social and economic development and; it is a basic factor in guaranteeing public health, the protection of the environment and sustainable development (WSPA, 2000; Ranjini *et al.*, 2010). Access to safe water for drinking and sanitation is a right to every citizen, and they should be available to every human being, now and in the future (WCW, 2002). Although there are efforts and progress, many countries in the world met Millennium Development Goals target to water and a number of diversified and multipurpose international, regional and national governments, local and international NGOs exerted their efforts and invest huge capital every year at global scale in general and in developing countries in particular.

The majority of the world's populations without access to improved water supply or sanitation services live in developing regions mainly in Africa and Asia (WHO and UNICEF, 2000). In Ethiopia, access to improved water supply and sanitation was estimated at 38% for improved water supply (98% for urban areas and 26% for rural areas) and 12% for sanitation (29%in urban areas, 8% in rural areas) (UNICEF and WHO, 2008).

Clean, pure and safe water can exist only briefly in nature and immediately polluted by prevailing environmental factors aided by human activities. Water from most sources is therefore unfit for immediate consumption without some sort of treatment (Okonko *et al.*, 2008); and before water can be described as potable, it has to comply with certain physical and chemical standards, which are designed to ensure that the water is potable and safe for drinking. Potable water is defined as water that is free from disease producing microorganisms and chemical substances deleterious to health. Hence, treat, made safe and provision of portable water to rural and urban population is necessary to prevent health hazards associated with poor drinking water (Lemo, 2002).

Materials and Methods

Study design

A cross sectional and analytical study was carried out to assess the physicochemical quality water sources. The study was conducted from May 2016 to March 2017.

Site selection

Gecha town and the surroundings were selected from Anderacha Woreda purposively by considering the prevalence of kidney infection in the town, which might be due to water sources, used for human consumption.

All water sources were considered in the study. Hora/ salty spring water bodies which used for animal and human consumption as special events were selected as study water source.

Sample collection

The method of sample collection was according to WHO drinking water guideline (WHO, 2006), and American public health association guideline (APHA)

For physicochemical analysis water samples were collected with 500ml polyethylene bottles rinsed with deionized water, labeled and transported to the Addis Ababa University science laboratory and JIJE

Labo Glass analytical laboratory by keeping in ice box. Water samples for metal analysis were preserved with 0.2M HNO_3 to immobilize metals against surface adsorption. In all cases, composite samples were used for analysis.

Physicochemical analysis

The analyses of various physicochemical parameters were carried out following the standard method described by (APHA 2006). The temperature, potential of hydrogen (pH) and electrical conductivity were measured at the time of sample collection. Temperature, pH and conductivity were measured with an instrument that measures all the three aforementioned parameters by shifting buttons. Total Hardness (TH) was determined by the volumetric method with EDTA (Ethylene diammine tetra acetic acid).Nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3)were determined by photometric method using Palin test Photometer 7500.Whereas phosphate (PO_4^{2-}), carbonate (CO_3-) and chloride (Cl^-) were analyzed by the method described by APHA 2006, 4500PC. Vanadomolybdophospheric, APHA-4500-Cl-B. Agrentometric and APHA 2320 B. Titration respectively. Metals such as Ca, Mg, Fe, Cu, Zn, Mn, Ni, Cr, Pb and Cd were analyzed using Atomic Absorption Spectroscopy

Data analysis

Instruments were pre-calibrated using buffer solution to measure pH, and rinsed with deionized water to measure temperature and conductivity. The calibration curves were prepared separately for all the metals by running different concentrations of standard solutions prepared from the stock solutions. A reagent blank sample was analyzed and subtracted from the samples to correct for reagent impurities and other sources of errors from the environment. 85% and 81.52% of recovery were calculated for anions and cations which imply the validation of methods used to estimate both anions and cations. Average values of two replicates were taken for each determination. Recorded data were organized and summarized in sample descriptive statistics methods using SPSS-PC statistical package (SPSS 16 for windows version) and presented in table as mean ± standard deviation.

Results and Discussion

Physicochemical analysis

The results of the physicochemical analysis and the metallic analysis of the Hora and spring water samples are shown in tables 1 and 2 respectively. Temperature is one of the physicochemical parameters used to evaluate water quality of potable water. The data showed that the highest mean temperature of 24.94^0C recorded from

Hora composite sample whereas the lowest mean temperature 19.10^{0}C measured from Gedosa protected spring. However, water sample from the remaining two water sources (Ferenge Minche reservoir and Kerito protected spring) did not show significant difference among one another.

The study conducted by Desta (2009) in Debrezeittown showed a mean temperature of all water samples ranging between 22.8±1-24.4±3 ^{0}C, which is in agreement with the present study though they did not meet the WHO standard of <15^{0}C (WHO, 1997). Likely, the study conducted by Kassahun (2008) in Zeway reported a mean temperature of 23.2 ^{0}C from different water source samples. In addition mean temperature of 23.8^{0}C was measured from drinking water source supply of Bahir Dar town (Getnet, 2008).

In contrary with the present study a relatively higher mean temperature were recorded potable surface (river) and ground water samples in Dubti, Amibara and Awash-Fentale Woredas of Afar region ranging between 32-33^{0}C and 40-53^{0}Crespectivelyfrom river and ground water sources (Abadi, 2013).

Concerning to pH of water samples the recorded mean pH were range between 7.24±0.14-8.07±0.07the highest was recorded Kerito protected spring and the lowest was measured from Hora springs composite sample. They did not show significant difference except Hora springs composite sample. The slightly lower pH recorded for water samples from Hora springs composite sample may be due to the marshy surrounding of the area that enhances microbiological activities that release acidic leachates into the source water. In the present study all water sources met national and WHO guidelines which states drinking water pH between 6.5 and 8.5 is satisfactory.

The finding of the present study is comparable to the average basic pH record ranging between 7.13 ± 0.499 to 7.70 ± 0.65 in Arebaminch (Amanial Haile, 2015) a 7.6 from water sources at Akaki-Kalit sub- city of Addis Ababa (Mengstayehu, 2007), a record of pH ranging between 7.2±.1 -7.77.2± 0.3 in Debrezeit town (Desta, 2009). Moreover record of pH ranging between 6.7 ± 0.4-7.5 ± 0.4from study conducted in a rural community of Ethiopia (Tsega *et al.*, 2013) a record pH 8.3 from water sources at Ziway town (Kassahun, 2008), and measurement of pH of 7.8 from Adama (Nazareth) town (Temesgen, 2009) are in agreement with the present study.

Electrical conductivity (EC) was found to be good indicator of the water quality. In the present study, electrical conductivity varied from1626.67±8to 112±1.32µS/cm. Electrical Conductivity (EC) of the water samples from Hora composite sample was above WHO standard limit of 300 µs/cm. Thus the water has very high electrical conductivity, implying the presence of reduced level of ionic species. Analysis of the results show that the samples from gendosa (167.3±0.6µs/cm), ferenge (272.26±7µs/cm) and kerito (112.36±1.32µs/cm) have EC value less than the standard limit of WHO (2008)

The hardness of water depends mainly on the presence of dissolved calcium and magnesium salts. The experimental value for hardness was found to be 521mg/l for hora 393mg/l for gendosa, 439mg/l for ferenge and 398mg/l for kerito spring water which were higher the WHO standard value that was 300 mg/l.

As per WHO, water containing more than 500 mg/l of TDS is not considered as desirable for drinking water. The experimental value for TDS of water sample was found to be in the range from1626.67±8 to 112±1.32mg/l which is less than WHO standard in the spring water sample but higher in hora river sample, so the spring water is potable.

The level of nitrate in the water samples is low generally. The results in table 2 showed that ranged from Not Detected (ND) for hora to about 0.96±0.11 mg/L for gendosa, 0.43±0.05mg/l for ferenge and 0.2±0.005mg/l for kerito. The WHO standard for nitrate is 50mg/L and above this limit may cause cyanosis disease or blue baby syndrome in infants less than 3months (WHO, 2006).The present study indicated that the nitrate content is much lower than the WHO standard, thus the water is safe.

No amount of phosphate in water is believed to have effects on human health (EPA, 1995). Phosphate has no significant adverse effect on man’s health. However, too much phosphate in water could lead to eutrophication.

The level of phosphate in all the water samples is above the permissible limit (0.1 mg/l), 2.39mg/l for hora 3.2mg/l for gendosa, 2.49mg/l for ferenge and 1.32mg/l for kerito. Therefore, they are good both for drinking and domestic uses.

The springs and the hora were characterized by low chloride concentrations from the limits recommended by WHO.

Table.1 Physicochemical analysis of water samples

Parameter	Water source				Standard values
	Hora (Composite sample)	Ferenge Minche reservoir	Gedosa Protected Spring	Kerito protected Spring	
T (^{0}C)	24.94±1.2	20.23±0.66	19.10±0.6	21.66±0.08	≤15^{0}C*
pH	7.24±0.14	7.9±0.025	7.52±0.06	8.07±0.07	6.5-8.5*
Cond. µs/cm	1626.67±8	272.26±7	167.3±0.6	112.36±1.32	300µs/m*
Total hardiness ($CaCO_3$)	522±1.5	439±2.5	393±2.3	398±0.7	300mg/l***
Nitrate (mg/l)	>DL	0.43±0.05	0.96±0.11	0.20±0.005	50mg/l*
Nitrite (mg/l)	>DL	0.20±0.005	0.51±0.11	0.43±0.06	2mg/l*
Ammonia (mg/l)	0.84±0.23	0.03±0.006	0.03±0	0.03±0.006	1.5mg/l*
Phosphate(mg/l)	2.39±0.6	3.20±0.5	2.49±0.3	1.32±0.2	0.25mg/l
Chloride(mg/l)	36.16±1	3.55±0.8	2.13±0.4	2.84±0.4	200mg/l*
Carbonate(mg/l)	<DL	<DL	<DL	<DL	-

Note: < DL-Less than detection limit; * Standard value set by WHO; ** Standard value set by Standard of Nigeria; *** Standard value set by Ethiopian Standard Value and –No set guide value

Table.2 Metal analysis of water samples

Parameter	**Water source**				**Standard values**
	Hora (Composite sample)	**Ferenge spring reservoir**	**Gedosa Protected Spring**	**Kerito protected Spring**	
Ca (mg/l)	10.49±0.43	9.61±0.13	9.94±0.08	4.53±0.16	200mg/l*
Cd (mg/l)	0.0097	0.0349	0.00850	0.0068	3µg/L
Cu(mg/l)	0.70±0.01	0.11±0.02	0.60±0.01	0.49±0.11	2 µg /l*
Zn(mg/l)	0.85±0.001	1.16±0.04	0.28±0.002	0.37±0.013	15mg/l*
Mn (mg/l)	0.54±0.03	0.73±0.04	0.12±0.04	0.10±0.01	0.4µg/l*
Fe (mg/l)	1.7±0.2	0.77±0.01	0.57±0.02	0.4±0.02	0.2mg/l*
Mg (mg/l)	9.45±0.15	4.4±0.02	8.95±0.10	2.45±0.03	150mg/l
Cr (mg/l)	< DL	< DL	< DL	<DL	0.05mg/l*
Ni(mg/l)	< DL	< DL	< DL	<DL	-
Pb (mg/l)	< DL	< DL	< DL	< DL	0.01 µg /l*

Note: < DL-Less than detection limit
* Standard value set by WHO

WHO standard value for chloride was 250 mg/l and the experimental value for chloride was found to be 36.16mg/l from Hora, 3.55mg/l from gendosa, 2.13mg/l from ferenge and 2.84mg/l from kerito spring water. Nitrate, nitrite and ammonia, which are of great interest because of their nutrient values (Dallas and Day., 1993), were low in all samples.

The Ca and Mg of the investigated spring waters could be due to the contact between the water body and the rock layers. Because these springs are naturally occurred springs that come out on the earth's surface by crossing rock layers which leach these minerals and others to the water body. The Ca mean values were ranged from the minimum value 4.53mg/l (kerito) to 10.49mg/l hora composite sample and Mg mean values were ranged from the minimum value 2.45±0.03 mg/L (Kerito) to 9.45±0.15 mg/L (hora composayit sample). The study results were below the WHO and Ethiopian guidelines for drinking water showing that no health problem concerned with Ca and Mg.

Cadmium occurs mostly in association with zinc and gets into water from corrosion of zinc coated ("galvanized") pipes and fittings (danamark.com 2008). Cadmium is found in low concentrations ranging between 0.0068mg/l (kerito) to 0.0349 mg/l (ferenge). At higher concentrations, it is known to have a toxic potential. The main sources of cadmium are industrial activities and lead mining. The most important sources for aquatic contamination are active and inactive lead-zinc mines, land application of sewage sludge, zinc-cadmium smelters and effluents from plastic and steel production, and wastewaters from the production of nickel-cadmium batteries and electroplating (Zuiderveen, 1994).

The range of copper was between 0.11±0.02-0.70±0.01mg/l. The standard given by WHO (1995) on copper content range is 0.05- 1.5 mg/l. These water samples have copper within the recommended limit as the result indicated that they are good for drinking and also domestic uses.

In the present study, the maximum concentration of Zn was 1.16 mg/L observed for sample collected from Ferenge spring sample while minimum concentration of 0.28 mg/L was found in Gedosa spring as indicated from table 2. The amount of Zn was below the maximum limit given by WHO (15mg/l). Excessive concentration of Zn may result in necrosis, chlorosis and inhibited growth of plants. The major sources of zinc contamination in the aquatic environment are industrial wastes, metal plating, plumbing, and acid mine drainage (Manahan, 1991). Presently, zinc is not considered mutagenic, carcinogenic, or teratogenic to humans.

Manganese is often found with iron in ground waters and concentrations of Mn, less than 0.05 mg/L are generally satisfactory because, the characteristic black stains and deposits of hydrated manganese oxides do not create problems at this level. However, the obtained overall quality of Mn (0.10-0.73mg/l) in all water sources were above recommended value that might lead manganese problems. Excess manganese in a diet prevents the use of iron in the regeneration of blood hemoglobin. Large doses of manganese cause apathy, irritability, headaches, insomnia, and weakness of the legs. Psychological symptoms may also develop including impulsive acts, absent-mindedness, hallucinations, aggressiveness, and unaccountable laughter. Finally, a condition similar to Parkinson's disease may develop (Kolega and Wooding, 1979).

The level of iron as indicated from the above table range between 0.4±0.02-1.7±0.2mg/l which is relatively higher as compared with EPA standard of 0.2mg/L. The highest iron content was observed from hora sample whereas the least was seen from kerito spring. The higher values of iron in the hora river samples may be caused by run-off water from residential. Iron when presence in high detectable amounts can affect the flavor of tea, coffee and alcoholic beverages. It can also promote the growth of iron bacteria in water and also makes the water distasteful (Yagoub and Ahmed, 2009).

The results in table 2 showed that Chromium, Lead and Nickel ranged Not Detected (ND) to all samples. Chromium is an essential micronutrient for animals and plants, and is considered as a biological and pollution significant element. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high level of chromium (Hanaa *et al.*, 2000; Pandey *et al.*, 2010). In this study, chromium was not detected. The WHO (2008) maximum admissible limit for Ni in drinking water is 70μg/L. In this study, Nickel was not detected in all the sampling areas

Lead is the most significant of all the heavy metals because it is toxic, very common (Gregoriaadou *et al.*, 2001) and harmful even in small amounts. Lead enters the human body in many ways. It can be inhaled in dust from lead paints, or waste gases from leaded gasoline. It is found in trace amounts in various foods, notably in fish, which are heavily subjected to industrial pollution. Studies on lead are numerous because of its hazardous effects. High concentration of lead in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys (Hanaa *et al.,* 2000). Lead concentration within the WHO (2008) MAL of lead in drinking water (10μg/L). In the present study lead was not detected in all the water samples.

In this study physico-chemical parameters such as pH, temperature, EC, total hardness, CL-, PO_4^{2-}, CO_3^- $NO_3^{-,}$ NO_2^-, NH_3 Ca, Mg, Fe, Cu, Zn, Mn, Cr, Ni, Cd and Pb content of the study water source were measured. And all water sources met both the international standards set by WHO and other standards except for temperature among physical parameters and Fe, Mn and Cu of chemical parameters. The temperature records from sources to tap water samples showed a higher measurement (19.10ºC-24.94ºC) compared to the standard of <15ºC.And those metals were recorded in those respective range Iron (Fe) (0.4 -1.7mg/l), Cu (0.11-0.70mg/l)and Mn (0.10-0.73mg/l) which is higher than WHO recommended limit.

Recommendations

Though all water sources met international and national physic-chemical standards to most physicochemical parameters except temperature, Fe, Cu and Mn microbiological analysis disclosed that all water sources were contaminated. Therefore these outcomes demonstrate the need to come up with source water protection strategies for the study area.

The present work didn't consider all physic-chemical parameters and done with few sampling frequency. Therefore, year round sampling and analysis of additional water quality parameters which was not considered should be undertaken.

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