Meride and Ayenew *Environ Syst Res (2016) 5:1*
DOI 10.1186/s40068-016-0053-6

Environmental Systems Research
a SpringerOpen Journal

RESEARCH Open Access

Drinking water quality assessment and its effects on residents health in Wondo genet campus, Ethiopia

Yirdaw Meride* and Bamlaku Ayenew

Abstract

Background: Water is a vital resource for human survival. Safe drinking water is a basic need for good health, and it is also a basic right of humans. The aim of this study was to analysis drinking water quality and its effect on communities residents of Wondo Genet.

Result: The mean turbidity value obtained for Wondo Genet Campus is (0.98 NTU), and the average temperature was approximately 28.49 °C. The mean total dissolved solids concentration was found to be 118.19 mg/l, and EC value in Wondo Genet Campus was 192.14 µS/cm. The chloride mean value of this drinking water was 53.7 mg/l, and concentration of sulfate mean value was 0.33 mg/l. In the study areas magnesium ranges from 10.42–17.05 mg/l and the mean value of magnesium in water is 13.67 mg/l. The concentration of calcium ranges from 2.16–7.31 mg/l with an average value of 5.0 mg/l. In study areas, an average value of sodium was 31.23 mg/1and potassium is with an average value of 23.14 mg/1. Water samples collected from Wondo Genet Campus were analyzed for total coliform bacteria and ranged from 1 to 4/100 ml with an average value of 0.78 colony/100 ml.

Conclusion: On the basis of findings, it was concluded that drinking water of the study areas was that all physico–chemical parameters. All the Campus drinking water sampling sites were consistent with World Health Organization standard for drinking water (WHO).

Keywords: Drinking water, Bacteriological, WHO, Physico–chemical, Safe water

Background

Safe drinking water is a basic need for good health, and it is also a basic right of humans. Fresh water is already a limiting resource in many parts of the world. In the next century, it will become even more limiting due to increased population, urbanization, and climate change (Jackson et al. 2001).

Drinking water quality is a relative term that relates the composition of water with effects of natural processes and human activities. Deterioration of drinking water quality arises from introduction of chemical compounds into the water supply system through leaks and cross connection (Napacho and Manyele 2010).

Access to safe drinking water and sanitation is a global concern. However, developing countries, like Ethiopia, have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services (WHO 2006). As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells. Since these sources are open, they are highly susceptible to flood and birds, animals and human contamination (Messeret 2012).

The quality of water is affected by an increase in anthropogenic activities and any pollution either physical or chemical causes changes to the quality of the receiving water body (Aremu et al. 2011). Chemical contaminants occur in drinking water throughout the world which could possibly threaten human health. In addition, most sources are found near gullies where open field

*Correspondence: yirdawmeride@gmail.com
School of Natural Resource and Environmental Study, Wondo Genet College of Forestry and Natural Resources, Hawassa University, P.O. Box 128, Shashemene, Ethiopia

defecation is common and flood-washed wastes affect the quality of water (Messeret 2012).

The World Health Organization estimated that up to 80 % of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water (WHO 1997). A review of 28 studies carried out by the World Bank gives the evidence that incidence of certain water borne, water washed, and water based and water sanitation associated diseases are related to the quality and quantity of water and sanitation available to users (Abebe 1986).

In Ethiopia over 60 % of the communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation practices (MOH 2011). About 80 % of the rural and 20 % of urban population have no access to safe water. Three-fourth of the health problems of children in the country are communicable diseases arising from the environment, specially water and sanitation. Forty-six percent of less than 5 years mortality is due to diarrhea in which water related diseases occupy a high proportion. The Ministry of Health, Ethiopia estimated 6000 children die each day from diarrhea and dehydration (MOH 2011).

There is no study that was conducted to prove the quality water in Wondo Genet Campus. Therefore, this study is conducted at Wondo Genet Campus to check drinking water quality and to suggest appropriate water treated mechanism.

Results and discussions

Turbidity

The turbidity of water depends on the quantity of solid matter present in the suspended state. It is a measure of light emitting properties of water and the test is used to indicate the quality of waste discharge with respect to colloidal matter. The mean turbidity value obtained for Wondo Genet Campus (0.98 NTU) is lower than the WHO recommended value of 5.00 NTU.

Temperature

The average temperature of water samples of the study area was 28.49 °C and in the range of 28–29 °C. Temperature in this study was found within permissible limit of WHO (30 °C). Ezeribe et al. (2012) reports similar result (29 °C) of well water in Nigeria.

Total dissolved solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. These minerals produced un-wanted taste and diluted color in appearance of water. This is the important parameter for the use of water. The water with high TDS value indicates that water is highly mineralized. Desirable limit for TDS is 500 mg/l and maximum limit is 1000 mg/l which prescribed for drinking purpose. The concentration of TDS in present study was observed in the range of 114.7 and 121.2 mg/l. The mean total dissolved solids concentration in Wondo Genet campus was found to be 118.19 mg/l, and it is within the limit of WHO standards. Similar value was reported by Soylak et al. (2001), drinking water of turkey. High values of TDS in ground water are generally not harmful to human beings, but high concentration of these may affect persons who are suffering from kidney and heart diseases. Water containing high solid may cause laxative or constipation effects. According to Sasikaran et al. (2012).

Electrical conductivity (EC)

Pure water is not a good conductor of electric current rather's a good insulator. Increase in ions concentration enhances the electrical conductivity of water. Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not exceeded 400 μS/cm. The current investigation indicated that EC value was 179.3–20 μS/cm with an average value of 192.14 μS/cm. Similar value was reported by Soylak et al. (2001) drinking water of turkey. These results clearly indicate that water in the study area was not considerably ionized and has the lower level of ionic concentration activity due to small dissolve solids (Table 1).

PH of water

PH is an important parameter in evaluating the acid–base balance of water. It is also the indicator of acidic or alkaline condition of water status. WHO has recommended maximum permissible limit of pH from 6.5 to 8.5. The current investigation ranges were 6.52–6.83 which are in the range of WHO standards. The overall result indicates that the Wondo Genet College water source is within the desirable and suitable range. Basically, the pH is determined by the amount of dissolved carbon dioxide (CO_2), which forms carbonic acid in water. Present investigation was similar with reports made by other researchers' study (Edimeh et al. 2011; Aremu et al. 2011).

Chloride (Cl)

Chloride is mainly obtained from the dissolution of salts of hydrochloric acid as table salt (NaCl), $NaCO_2$ and added through industrial waste, sewage, sea water etc. Surface water bodies often have low concentration of chlorides as compare to ground water. It has key importance for metabolism activity in human body and other main physiological processes. High chloride

Table 1 Physico-chemical parameters of the drinking water of Wondo Genet campus

Sample no	Location	Tem (°C)	Turbidity (NTU)	TDS (mg/l)	EC (µS/cm)
1	Dam1	28.6	1.4	119.5	199.6
2	Dam2	28.4	1.23	118.6	185.6
3	Dam3	29	1.1	121	198.1
4	Academic office	28.5	0.8	114.7	197.4
5	Tanker2	28.2	0.9	116.7	198.7
6	Residential house	28.6	1.2	117.1	201
7	Dormitories	28.6	0.8	119.7	179.3
8	Sida hall	28.5	0.7	118.5	184.2
9	Workers launch and bagalo	28	0.7	121.2	185.4
10	Ranges	28—29	0.7–1.4	114.7—121.2	179.3—201
11	Average	28.49	0.98	118.56	192.14

concentration damages metallic pipes and structure, as well as harms growing plants. According to WHO standards, concentration of chloride should not exceed 250 mg/l. In the study areas, the chloride value ranges from 3–4.4 mg/l in Wondo Genet Campus, and the mean value of this drinking water was 3.7 mg/l. Similar value was reported by Soylak et al. (2001) drinking water of Turkey.

Sulfate

Sulfate mainly is derived from the dissolution of salts of sulfuric acid and abundantly found in almost all water bodies. High concentration of sulfate may be due to oxidation of pyrite and mine drainage etc. Sulfate concentration in natural water ranges from a few to a several 100 mg/liter, but no major negative impact of sulfate on human health is reported. The WHO has established 250 mg/l as the highest desirable limit of sulfate in drinking water. In study area, concentration of sulfate ranges from 0–3 mg/l in Wondo Genet Campus, and the mean value of SO_4 was 0.33 mg/l. The results exhibit that concentration of sulfate in Wondo Genet campus was lower than the standard limit and it may not be harmful for human health.

Magnesium (Mg)

Magnesium is the 8th most abundant element on earth crust and natural constituent of water. It is an essential for proper functioning of living organisms and found in minerals like dolomite, magnetite etc. Human body contains about 25 g of magnesium (60 % in bones and 40 % in muscles and tissues). According to WHO standards, the permissible range of magnesium in water should be 50 mg/l. In the study areas magnesium was ranges from 10.42 to 17.05 mg/l in Wondo Genet Campus and the mean value of magnesium in water is 13.67 mg/l. Similar value was reported by Soylak et al. (2001) drinking water of Turkey. The results exhibit that concentration of magnesium in Wondo Genet College was lower than the standard limit of WHO.

Calcium (Ca)

Calcium is 5th most abundant element on the earth crust and is very important for human cell physiology and bones. About 95 % of calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may caused rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases. According to WHO (2011) standards, its permissible range in drinking water is 75 mg/l. In the study areas, results show that the concentration of calcium ranges from 2.16 to 7.31 mg/l in Wondo Genet campus with an average value of 5.08 mg/l.

Sodium (Na)

Sodium is a silver white metallic element and found in less quantity in water. Proper quantity of sodium in human body prevents many fatal diseases like kidney damages, hypertension, headache etc. In most of the countries, majority of water supply bears less than 20 mg/l, while in some countries the sodium quantity in water exceeded from 250 mg/l (WHO 1984). According to WHO standards, concentration of sodium in drinking water is 200 mg/1. In the study areas, the finding shows that sodium concentration ranges from 28.54 to 34.19 mg/1 at Wondo Genet campus with an average value of 31.23.

Potassium (k)

Potassium is silver white alkali which is highly reactive with water. Potassium is necessary for living organism functioning hence found in all human and animal tissues

Table 2 Chemical constituents of the drinking water samples of Wondo Genet campus

Sample no	Location	pH	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	Cl^- (mg/l)	SO_4 (mg/l)	NO_3^-(mg/l)
1	Dam1	6.53	6.52	17.05	22.84	34.19	4.1	3	2.33
2	Dam2	6.75	6.85	15.34	24.6	32.04	4.3	ND	2.23
3	Dam3	6.55	7.31	13.91	27.51	31.58	4.4	ND	2.42
4	Academic office	6.54	5.09	15.82	21.07	29.04	3.2	ND	4.84
5	Tanker2	6.70	5.83	11.46	23.6	32.86	3	ND	4.97
6	Residential house	6.83	2.16	14.21	21.92	33.71	3.8	ND	2.55
7	Dormitories	6.68	3.51	10.42	20.83	28.66	3.4	ND	1.5
8	Sida hall	6.52	3.62	12.75	23.07	28.54	3.5	ND	1.75
9	Workers launch and Bagalo	6.82	4.8	12.07	22.81	30.49	3.6	ND	1.42
10	Ranges	6.52—6.83	2.16—7.31	10.42—17.05	20.83—27.51	28.54—34.19	3—4.4	0—3	1.42—4.97
11	Average	6.66	5.08	13.67	23.14	31.23	3.7	0.33	2.67

particularly in plants cells. The total potassium amount in human body lies between 110 and 140 g. It is vital for human body functions like heart protection, regulation of blood pressure, protein dissolution, muscle contraction, nerve stimulus etc. Potassium is deficient in rare but may led to depression, muscle weakness, heart rhythm disorder etc. According to WHO standards the permissible limit of potassium is 12 mg/1. Results show that the concentration of potassium in study areas ranges from 20.83 to 27.51 mg/1. Wondo Genet College with an average value of 23.14 mg/1. Present investigation was similar with reports made by other researchers' study (Edimeh et al. 2011; Aremu et al. 2011). These results did not meet the WHO standards and may become diseases associated from potassium extreme surpassed.

Nitrate (NO_3)

Nitrate one of the most important diseases causing parameters of water quality particularly blue baby syndrome in infants. The sources of nitrate are nitrogen cycle, industrial waste, nitrogenous fertilizers etc. The WHO allows maximum permissible limit of nitrate 5 mg/l in drinking water. In study areas, results more clear that the concentration of nitrate ranges from 1.42 to 4.97 mg/l in Wondo Genet campus with an average value of 2.67 mg/l. These results indicate that the quantity of nitrate in the study site is acceptable in Wondo Genet campus (Table 2).

Bacterial contamination

The total coliform group has been selected as the primary indicator bacteria for the presence of disease causing organisms in drinking water. It is a primary indicator of suitability of water for consumption. If large numbers of coliforms are found in water, there is a high probability that other pathogenic bacteria or organisms exist. The WHO and Ethiopian drinking water guidelines require the absence of total coliform in public drinking water supplies.

In this study, all sampling sites were not detected of faecal coliform bacteria. Figure 1 shows the mean values of total coliform bacteria in drinking water collected from the study area. All drinking water samples collected from Wondo Genet Campus were analyzed for total coliform bacteria and ranged from 1 to 4/100 ml with an average value of 0.78 colony/100 ml. In Wondo Genet College, the starting point of drinking water sources (Dam1), the second (Dam2) and Dam3 samples showed the presence of total coliform bacteria (Fig. 1). According to WHO (2011) risk associated in Wondo Genet campus drinking water is low risk (1–10 count/100 ml).

According to the study all water sampling sites in Wondo Genet campus were meet world health organization standards and Ethiopia drinking water guideline. Figure 2 indicated that mean value of the study sites were under the limit of WHO standards.

Effect of water quality for residence health's

Diseases related to contamination of drinking-water constitute a major burden on human health. Interventions to improve the quality of drinking-water provide significant benefits to health. Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all (Ayenew 2004).

Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve a drinking-water quality as safe as practicable. The great majority of evident water-related health problems are the result of microbial (bacteriological, viral, protozoan or other biological) contamination (Ayenew 2004).

Excessive amount of physical, chemical and biological parameters accumulated in drinking water sources, leads to affect human health. As discussed in the result, all

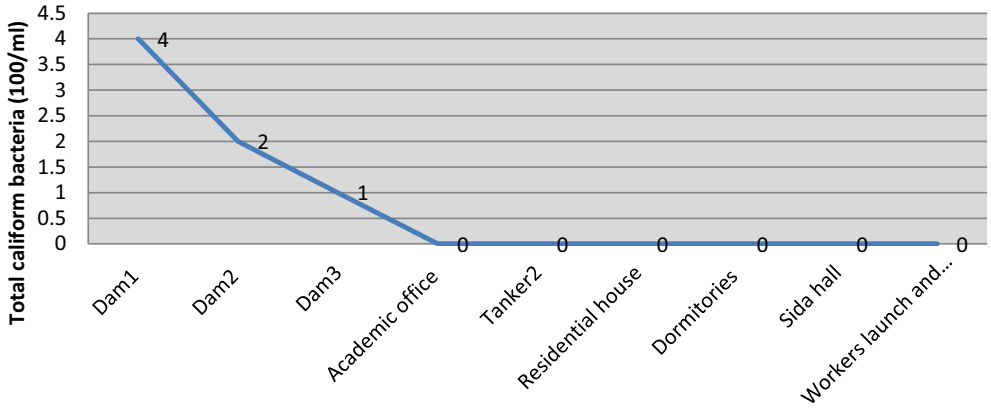

Fig. 1 The mean values of total coliform bacteria in drinking water

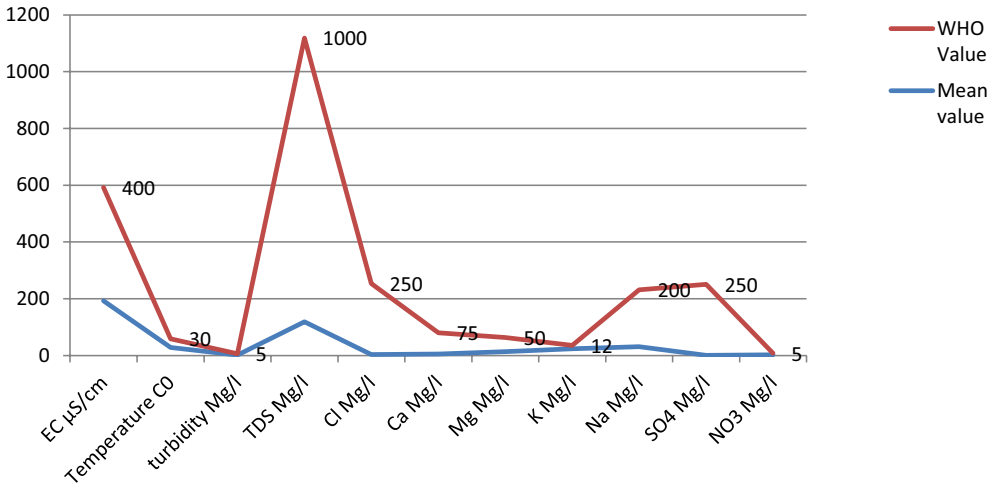

Fig. 2 Comparison of water quality parameters of drinking water of Wondo Genet campus with WHO and Ethiopia standards

Wondo Genet drinking water sources are under limit of WHO and Ethiopian guideline standards. Therefore, the present study was found the drinking water safe and no residence health impacts.

Conclusion

On the basis of findings, it was concluded that drinking water of the study areas was that all physico–chemical parameters in all the College drinking water sampling sites, and they were consistent with World Health Organization standard for drinking water (WHO). The samples were analyzed for intended water quality parameters following internationally recognized and well established analytical techniques.

It is evident that all the values of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), chloride (Cl), SO_4, and NO_3 fall under the permissible limit and there were no toxicity problem. Water samples showed no extreme variations in the concentrations of cations and anions. In addition, bacteriological determination of water from College drinking water sources was carried out to be sure if the water was safe for drinking and other domestic application. The study revealed that all the College water sampling sites were not contained fecal coliforms except the three water sampling sites had total coliforms.

Methods

The study was conducted in Wondo Genet College of Forestry and Natural Resources campus, which is located in north eastern direction from the town of Hawassa and about 263 km south of Addis Ababa (Fig. 3). It lies between 38°37′ and 38°42′ East longitude and 7°02′ and 7°07′ north latitude. Landscape of the study area varies

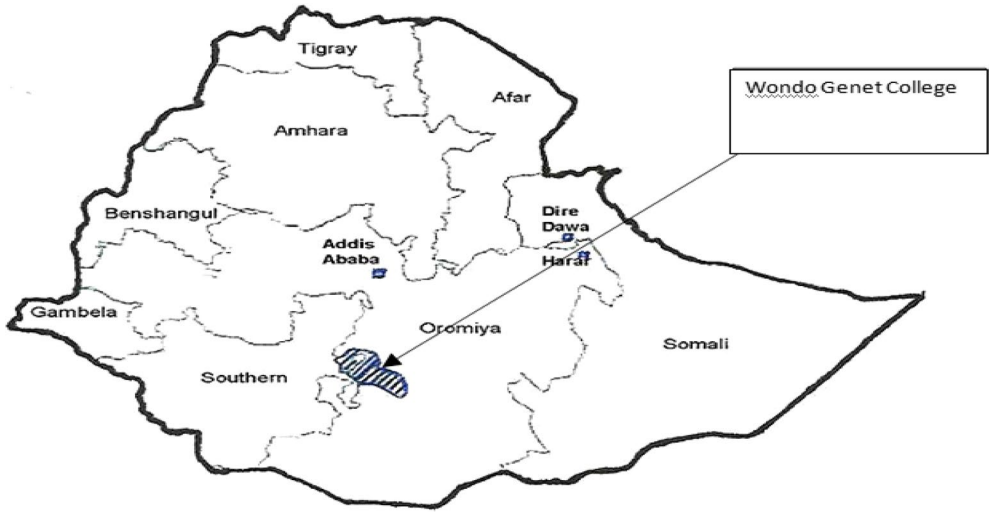

Fig. 3 Map of study area

with an altitude ranging between 1600 and 2580 meters above sea level. Landscape of the study area varies with an altitude ranging between 1600 and 2580 meters above sea level.

The study area is categorized under Dega (cold) agro-ecological zone at the upper part and Woina Dega (temperate) agro-ecological zone at the lower part of the area. The rainfall distribution of the study area is bi-modal, where short rain falls during spring and the major rain comes in summer and stays for the first two months of the autumn season. The annual temperature and rainfall range from 17 to 19 °C and from 700 to 1400 mm, respectively (Wondo Genet office of Agriculture 2011).

Methodology

Water samples were taken at ten locations of Wondo Genet campus drinking water sources. Three water samples were taken at each water caching locations. Ten (10) water samples were collected from different locations of the Wondo Genet campus. Sampling sites for water were selected purposely which represents the entire water bodies.

Instead of this study small dam indicates the starting point of Wondo Genet campus drinking water sources rather than large dams constructed for other purpose. Taps were operated or run for at least 5 min prior to sampling to ensure collection of a representative sample (temperature and electrical conductivity were monitored to verify this). Each sample's physico–chemical properties of water were measured in the field using portable meters (electrical conductivity, pH and temperature) at the time of sampling. Water samples were placed in clean containers provided by the analytical laboratory (glass and acid-washed polyethylene for heavy metals) and immediately placed on ice. Nitric acid was used to preserve samples for metals analysis.

Analysis of water samples

Determination of pH

The pH of the water samples was determined using the Hanna microprocessor pH meter. It was standardized with a buffer solution of pH range between 4 and 9.

Measurement of temperature

This was carried out at the site of sample collection using a mobile thermometer. This was done by dipping the thermometer into the sample and recording the stable reading.

Determination of conductivity

This was done using a Jenway conductivity meter. The probe was dipped into the container of the samples until a stable reading will be obtained and recorded.

Determination of total dissolved solids (TDS)

This was measured using Gravimetric Method: A portion of water was filtered out and 10 ml of the filtrate measured into a pre-weighed evaporating dish. Filtrate water samples were dried in an oven at a temperature of 103 to 105 °C for $2\frac{1}{2}$ h. The dish was transferred into a desiccators and allowed cool to room temperature and were weighed.

$$\mathrm{TDS} = [(\mathrm{A} - \mathrm{B}) \times 1000] / \mathrm{ml\ sample}$$

In this formula, A stands for the weight of the evaporating dish + filtrate, and B stands for the weight of the evaporating dish on its own Mahmud et al. (2014).

Chemical analysis

Chloride concentration was determined using titrimetric methods. The chloride content was determined by argentometric method. The samples were titrated with standard silver nitrate using potassium chromate indicator. Calcium ions concentrations were determined using EDTA titrimetric method. Sulphate ions concentration was determined using colorimetric method.

Microorganism analysis

In the membrane filtration method, a 100 ml water sample was vacuumed through a filter using a small hand pump. After filtration, the bacteria remain on the filter paper was placed in a Petri dish with a nutrient solution (also known as culture media, broth or agar). The Petri dishes were placed in an incubator at a specific temperature and time which can vary according the type of indicator bacteria and culture media (e.g. total coliforms were incubated at 35 °C and fecal coliforms were incubated at 44.5 °C with some types of culture media). After incubation, the bacteria colonies were seen with the naked eye or using a magnifying glass. The size and color of the colonies depends on the type of bacteria and culture media were used.

Statically analysis

All data generated was analyzed statistically by calculating the mean and compare the mean value with the acceptable standards. Data collected was statistically analyzed using Statistical Package for Social Sciences (SPSS 20).

Abbreviations

EDTA: ethylene dinitrilo tetra acetic acid; MOH: Minstor of Health; NTU: nephelometric turbidity units; TDS: total dissolved solid; WHO: World Health Organization.

Authors' contributions

YM: participated in designing the research idea, field data collection, data analysis, interpretation and report writing; BA: participated in field data collection, interpretation and report writing. Both authors read and approved the final manuscript.

Authors' information

Yirdaw Meride: Lecturer at Hawassa University, Wondo Genet College of Forestry and Natural Resources. He teaches and undertakes research on solid waste, carbon sequestration and water quality. He has published three articles mainly in international journals. Bamlaku Ayenew: Lecturer at Hawassa University, Wondo Genet College of Forestry and Natural Resources. He teaches and undertakes research on Natural Resource Economics. He has published three article with previous author and other colleagues.

Acknowledgements

Hawassa University, Wondo Genet College of Forestry and Natural Resources provided financial support for field data collection and water laboratory analysis. The authors thank anonymous reviewers for constructive comments.

Competing interests

The authors declare that they have no competing interests.

Received: 1 September 2015 Accepted: 6 January 2016
Published online: 21 January 2016

References

Abebe L (1986) Hygienic water quality; its relation to health and the testing aspects in tropical conditions. Department of Civil Engineering, University of Tempere, Finland

Aremu MO et al (2011) Physicochemical characteristics of stream, well and borehole water sources in Eggon, Nasarawa State, Nigeria. J Chem Soc Nigeria 36(1):131–136

Ayenew T (2004) Environmental implications of changes in the levels of lakes in the Ethiopian Rift since 1970. Reg Environ Chang 4:192–204

Edimeh et al (2011) Physico-chemical parameters and some Heavy metals content of rivers Inachalo and Niger in Idah, Kogi State. J Chem Soc Nigeria 36(1):95–101

Ezeribe AL et al (2012) Physico-chemical properties of well water samples from some villages in Nigeria with cases of stained and mottle teeth. Sci World J 7(1):1–13

Jackson et al (2001) Water in changing world, Issues in Ecology. Ecol Soc Am, Washington, pp 1–16

Mahmud et al (2014) Surface water quality of Chittagong University campus, Bangladesh. J Environ Sci 8:2319-2399

Messeret B (2012) Assessment of drinking water quality and determinants of household potable water consumption in Simada district, ethiopia

MOH (2011) Knowledge, attitude and practice of water supply, environmental sanitation and hygiene practice in selected worked as of Ethiopia

Napacho A, Manyele V (2010) Quality assessment of drinking water in Temeke district (Part II): characterization of chemical parameters. Af J Environ Sci Technol 4(11):775–789

Sasikaran S et al (2012) Physical, chemical and microbial analysis of bottled drinking water. J Ceylon Medical 57(3):111–116

Soylak et al (2002) Chemical analysis of drinking water samples from Yozgat, Turkey. Polish J Environ Stud 11(2):151–156

WHO (1984) Guideline for drinking water quality. Health Criteria Support Inf 2:63–315

World Health Organization (1997) Basic Environmental Health, Geneva

World Health Organization (2004) Guidelines for drinking-water quality. World Health Organization, Geneva

World Health Organization (2006) In water, sanitation and health world health organization

WHO (2011) Guidelines for drinking-water quality, 4th edn. Geneva, Switzerland