

Water quality analysis of municipality public water supply in the case of Asella town at the source of Ashebeka River, a cross-sectional study design.

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Research article

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Abstract

Background Drinking water quality is the main concern because in developing countries like Ethiopia, where contaminated water was one of the main vehicles for the transmission of water borne diseases. Therefore, the objective of this research was to assess the physicochemical & bacteriological water quality in Asella town, Ethiopia.

Methods A cross-sectional study was carried out from November, 2015 to April, 2016 G.C. 8 liter composite water samples in plastic bottles packed cold chain had been taken by the investigator from eight different sites with two round totally 192 parameters were analyzed. A standard instrument like AAS for heavy metal analysis was using APAAH procedures. Statistical analysis was done by the use of software for data entry Epi info 7 & Minitab 19.2.

Results The first round of laboratory had showed that mean \pm SD TH 59.5 ± 7.4 mg/L, COD 30 ± 25.8 mg/L, calcium 15 ± 4.3 mg/L, magnesium 5.3 ± 0.9 mg/L, BOD₅ 3 ± 2.6 mg/L and Nitrate 1.5 ± 0.1 mg/L. The result of microbial analysis was 180CFU/100ml for TF & FC, 40CFU/100ml was E.coli detected in the first study site. The second round physical analysis had showed that municipality water was colourless, odourless & tasteless. But the Mean \pm SD turbidity was 32.6 ± 63.4 mg/L. The mean \pm SD pH 4.5 ± 0.8 , EC 101.8 ± 23.1 , TH 24 ± 2.5 mg/L, calcium 6.9 ± 0.8 mg/L, magnesium $1. \pm 0.6$ mg/L, Fluoride 0.4 ± 0.2 mg/L, aluminum 0.3 ± 0.2 mg/L, DO 4.6 ± 1.2 mg/L, nitrate 3.3 ± 2.5 mg/L, nitrite $0.9 \pm 2/5$ mg/L, zinc 0.3 ± 0.4 mg/L, CO₃²⁻ $7. \pm 6$ mg/l, chloride 6 ± 1.3 mg/L, alkalinity 6 ± 4.9 mg/L, total solid 96 ± 50.3 mg/L, TDS 62 ± 14.8 mg/L, sodium 3.9 ± 2.4 mg/L, potassium 1.7 ± 0.1 mg/L, iron $0. \pm 1$ mg/L and ammonia 0.9 ± 0.3 mg/L. There was strong pair wise statistical correlation among water quality parameters with p value < 0.05

Conclusions The water quality analysis was below the limit of WHO standard, but some chemical, turbidity & microbes need a critical attention. So, efficient water treatment must be monitored by the municipality & homemade water treatment by urban community

Background

Water is one of the fundamental substances that determines for the existence of live on earth. Adequate, safe & accessible supply of water is one of the basic human requirements. To satisfy the human water demands maximum effort should be implemented on improvement of water quality. In addition to human beings water is also the raw materials for the industries to produce different products. Agricultural activities also highly dependent on water for crop production as a solution of food security even though their quality parameter different from human water supply. Animals also require some quantity of water to enhance the existence of their life, then they can serve as a source of food especially milk and meat for human beings. Although 70% of the earth surface covered by water, only 1% of water from surface & ground water sources used for domestic water supply (1).

The surface & ground water sources highly exposed to pollutants which are generated in anthropogenic and natural sources. The laboratory analysis result of Physico-chemical parameter of sewage polluted ground water samples were EC, TH, COD, nitrate, sulphate and trace metals (2).

Fluorine is essential mineral for the strength of human tooth. Low concentration causes dental carriers while excess concentration causes tooth damage, bone fluorosis & tooth decay. Then to solve deficient or excess fluorine concentration regulating adequate fluorine concentration by the mechanism of fluoridation or de-fluoridation of water is essential for human health (3).

Total dissolved solid (TDS) is a substances that were found in a form of dissolved substances in a water sources. It includes carbonates, bicarbonates, chlorides, sulphate, calcium, magnesium, phosphate, nitrate, sodium, potassium, and iron. It is a term used to describe the inorganic salt and small amount of organic matter present in solution form of water. The principal constituents are usually calcium, magnesium, sodium and potassium metals, carbonate, hydrogen carbonate, chloride, sulphate and nitrate. It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste(4).

The acceptable limit of Ca^{++} & Mg^{++} for domestic use is 75 mg/L & 200 mg/L respectively. Calcium & magnesium have important function for bone growth. Researches and studies proved that water with low magnesium can cause increased morbidity and mortality for cardiovascular disease, higher risk of motor neuronal disease, pregnancy disorders and preeclampsia. Water with low concentration of calcium may be associated with higher risk of fracture in children, certain neurodegenerative diseases, preterm birth and low weight at birth. Lack of both calcium and magnesium in water can also cause some types of cancer (5).

In developing countries water related diseases prevail as major public health problems. As literature pointed in the year 2000 (6), 4 billion diarrheal cases happened to caused 5.7% of deaths in the worldwide. The main causes of water borne diseases were faecal contamination that discharges from human beings as a result of poor waste management practices. Therefore, regular microbial testing of drinking water is a major task to confirm the absence of diseases pathogen (3).

The research done In Pakistan 2010 had shown that due to the sanitation & water line system damaged by flood water, then the laboratory investigation of E.coli in swat & sucker village were 76% & 96 % respectively (7). The access to potable water supply in developing countries might be very low so they need to rely on unsafe water supply sources like shallow & bore wells besides to surface water sources like river water which is highly exposed for water pollution due to natural & man made process (8).

The effective measures to improve the quality of water obtained from varies sources is to treat water by the use of house hold water treatment system in addition to conventional water treatments handle by municipality water offices to eliminate microbial contaminants of water in order to save the life of people from infection of water borne diseases mostly in developing countries (9).

As a principle sanitary system of excreta disposal & access to safe water to the community is a basic human necessities, though the majority of developing countries lack off this facilities, so that they exposed to water borne diseases (10). In the world Eight hundred eighty four million people get their water from unimproved water sources. From this data, one third was found in sub-Saharan African countries. The population number in these countries increases from day to day, so their waste generated poorly managed finally pollute water sources (11).

Water contaminated with wastes especially which contains excreta of human & animal's was at great risk to public health due to microbial concerns. Lots of pathogenic microbes found in human faeces which contain pathogens of intestines of the gastro-enteritis like dysentery, typhoid and cholera. It has been found that the main victims of diarrhea are due to faecal-route disease transmission. The incidence rate of diarrhea was 4.6 billion episodes occur & causes every year 2.2 million deaths (12).

It has been found that the main victims of diarrhea are due to faecal-route disease transmission. Diarrhea also found to be the main source of infectious diseases (13). The microbial load of water is determined by the assessment of total & faecal coliform organisms (14). The foundations of these organisms were an indication of water contaminated by faecal pathogens especially human faeces. Drinking water taken from unimproved raw water sources are more liable to faecal pathogens than protected water sources (15). The most common pathogens identified in contaminated water was Vibrio and Salmonella bacteria, bacillary and amoebic dysentery, and acute infection diarrhea caused by E. coli bacteria(16). Water that were contaminated with these microbial pathogens ingested causes death of children in developing countries (17).

Ethiopia is one of the sub-Saharan African countries that had low water & sanitation coverage. More than 80% of communicable diseases in Ethiopia were hygiene related diseases results from lack of adequate & safe water supply & sanitation services. The human waste discharge to the environment & contaminated water sources. Thus unimproved water sources was at great risk of contaminated with disease causing pathogens (18).

The rationale /Significance of the study

The Oromia regional state is one of the largest regions of the Federal Democratic Republic of Ethiopia. Asella, the town of Arsi zone found in this region, was exposed to a high risk environment in many aspects, like deficiency of pure water supply. Thus, this assessment is therefore essential and well-timed as public health issues like pure water supply are crucial in such environments especially among peoples in Asella town. Finally, assessing the quality of municipality water supply will have a dual benefit to the concerned governmental authorities, stakeholders, partnership and community beneficiaries at large. It helps to probe the grounds for the threat; helps to set and develop programs and strategies based on the study area's setup.

General objective

The objective of this research was to assess the physicochemical & bacteriological water quality in Asella town, Ethiopia.

Specific objectives

- To test physical quality of drinking water
- To analyses chemical quality of municipality water supply
- To examine bacteriological load of Asella town water supply

Methods

Study area and period

Asella town is located 175kilometers away southeast from Addis Ababa the capital city of Ethiopia. The city has a latitude, longitude and Altitude of 7°57'25.21"N,39°07'56.02"E&2,430meters respectively (19). According to 2007 population census data the town has a total population of 68,269 among which 33,826 were men and the rest 33,443 were women; 67.43% of the population worshiped Orthodox, 22.65% Muslim and 8.75% of the population were Protestant. Asella has newly decentralized to eight kebeles situated as a high land area. Town population obtains municipality water supply originating from Ashebeka River after passing Dosha treatment plant.

The study period was from November, 2015 to April, 2016 G.C.

Site figure 1 here

Study design

Laboratory based cross sectional study had been carried out throughout study period. Water samples were collected from at the inlet & out let site of Dosha water treatment plant, at the water reservoir found kebeles 01, at Asella kebele-04, 06,& 07 public water fountains (Birka) & Asella hospital water reservoir out

Sites table 1.

Sample collection

Water samples had been collected from preselected sites at monthly intervals in the morning hours. eight composite water samples had been collected in plastic bottles, pre-cleaned by washing & rinsing in tap water, sanitize with 1:1 hydrochloric acid and finally with pure tap water. The actual sampling had been collected by taking from each sampling sites. The samples then transported in cold boxes containing ice to Water Works Design and Supervision Enterprise for laboratory analysis within four hours intervals from the collection sites. The total study was repeated twice to confirm the determination of water quality indicator impurities based on the results of laboratory analysis.

Sample size

Eight composite water samples had been collected from eight different sites with two rounds. $12 \times 4 = 48$ water quality parameter for first round & $24 \times 6 = 144$ water quality parameters for second round. A total of 192 water quality parameter had been carried out at Addis Ababa water & sewerage laboratory.

Reliability & validity

Water samples had been collected by health professional including medical laboratory technologist. All samples were transported to analysis laboratory before four hours. Before starting any water sample collection three days sensitization training was provided by principal investigators for data collectors.

Sampling Technique

The study had been repeated for two rounds. The study also supported by sanitary survey handling for four days to collect on site information by filling the check list by BSc level health professionals.

Physicochemical analysis

Water quality parameters like pH, temperature, and dissolved oxygen had been analyzed in situ while the Total Hardness (TH), Turbidity, Electrical Conductivity, Nitrate Nitrogen, Nitrite-Nitrogen, Phosphate, Biochemical Oxygen Demand (BOD); Chemical Oxygen Demand (COD) & Ammonia had been analyzed at Addis Ababa water & sewerage Laboratory offices. Preservation and analysis of the water samples were done following the principles of standard methods of APHA (20,21).

Bacteriological Analyses

The bacteriological quality of water samples had been assessed by the MPN test and Total Plate Count Method. Total coliform (TC), Faecal coliform (FC) & E.coli also analyzed for the representatives of bacteriological water quality (22).

Data analysis

All results were entered into statistical software Epi info version 7 for data entry & Minitab 19.2 for data analysis & interpretations including pair wise correlations of water parameters with a cut of point $P\text{value} < .05$.

Result

The first round of laboratory had showed that mean \pm SD TH 59.5 ± 7.4 mg/L, COD 30 ± 25.8 mg/L, calcium 15 ± 4.3 mg/L, magnesium 5.3 ± 0.9 mg/L, BOD₅ 3 ± 2.6 mg/L and Nitrate 1.5 ± 0.1 mg/L, Ammonia 1.1 ± 0.4 mg/L, Nitrite 0.1 ± 0 mg/L & PHO_4^{2-} 0.4 ± 0.2 mg/L. The result of microbial analysis was 180CFU/100ml for TF & FC, 40CFU/100ml was E.coli detected in the first study site.

The first round laboratory analysis had showed that BOD & COD result was greatest at site eight & lowest at site seven. The ammonia concentration was highest at site one & lowest site seven. The total hardness measurements highest at site eight & lowest at site four. From metal analysis calcium concentration was highest at site eight & lowest at site four. The magnesium concentration fluctuates as we go through the sites that were highest at site four & lowest at site eight. The nitrite, nitrate & phosphate tests vary as we passed through water sampling sites

Site table 2 here

The percent mean distribution of chemical water quality increases in the order of nitrite, phosphate, ammonia & nitrate in the study sites of Asella tow respectively figure 2.

Site figure 2

The highest percent mean concentration of chemical water quality identified was total hardness (TH) 52.8%mg/L & the lowest was BOD5 2.7mg/L (figure 3).

Site figure 3 here

For the bacteriological analysis of water sample taken from site one the tests were positive for total coliform, fecal coliform & E.Coli. But for the rest sites i.e. after treatment plants no bacteriological tests were positive (table 2).

The second round physical analysis had showed that municipality water was colourles, odourles & tasteless. But the Mean \pm SD turbidity was 32.6 ± 63.4 mg/L. The mean \pm SD pH 4.5 ± 0.8 , EC 101.8 ± 23.1 , TH 24 ± 2.5 mg/L, calcium 6.9 ± 0.8 mg/L, magnesium $1. \pm 0.6$ mg/L, Fluorine 0.4 ± 0.2 mg/L, aluminum 0.3 ± 0.2 mg/L, DO 4.6 ± 1.2 mg/L, nitrate 3.3 ± 2.5 mg/L, nitrite $0.9 \pm 2/5$ mg/L, zinc 0.3 ± 0.4 mg/L, CO₃²⁻ $7. \pm 6$ mg/l, chloride 6 ± 1.3 mg/L, alkalinity 6 ± 4.9 mg/L, total solid 96 ± 50.3 mg/L, TDS 62 ± 14.8 mg/L, sodium 3.9 ± 2.4 mg/L, potassium 1.7 ± 0.1 mg/L, iron $0. \pm 1$ mg/L and ammonia 0.9 ± 0.3 mg/L.

The second round laboratory analysis found that all sites municipality water was colourles, odourles & tasteless. The turbidity measurement analysis was highest at site one & lowest at site four, but variations were recorded for the rest four water sampling sites. EC test was highest at site six, then variations recorded with rest sites & lowest values were analyzed at site one. The total dissolved solid result was highest at site six & lowest at site one followed by significant variation for the rest four sites sampling points (figure 4). The total solid analysis result was highest at site one & lowest at site three. The total hardness result was slight deviations with all areas of study in Asella water quality analysis (table 3).

Site figure 4 here

The percent mean concentration of EC was highest while turbidity lowest which indicates solid pollutants available in Asella town water supply.

The dominant metal was sodium ranging from 2.7mg/L to 8.8mg/L. The concentration of sodium was highest at site one & lowest at site four of public trial fountain, then vary for the rest sites. The potassium tests were identical at four sites with slight variation at site four & site six. Total iron test were highest at site one & lowest at site three for the rest sites little variation were obtained. Calcium test were highest at site one & site three, similar results were obtained for the rest four trial. Aluminum test was highest at site two & lowest at site one, followed by variation for the rest sites. The test result for zinc was highest at site four & lowest at site one. The heavy metal analysis result shows there was a variations when we had moved from one study sites to the others (table 3).

Alkalinity test were highest at site one, while for the rest five sites identical results were obtained. The bicarbonate maximum result was obtained at site one followed by similar results for the rest five test sites. The maximum chloride test was found at site six & lowest result was recorded at site one followed with identical result for the rest four sites (table 3).

Ammonium concentration was highest at site one & lowest at site four, with slit variation for the other sites. The maximum nitrate concentration was obtained at site one & lowest result at site six with variation to other sites. The result for nitrite was highest at site five & lowest at site two & four. The dissolved oxygen test was raised at site three & lowest at site six then variation to other sites. The fluoride concentration was highest at site one & lowest at site six.

The bicarbonate concentration was higher than from the respective test of others water quality parameters, while the lowest concentration was obtained ammonia (table 3).

Site table 3 here

Water quality index

Water quality index was analyzed by taking physicochemical & bacteriological laboratory analysis result of Asella town water supply. The equation developed was using ANOVA analysis

$$WQA = 1.2 + 1.9 * BOD_5 + 13.9 * Ca^{2+} + 28.8 * COD + 8.8 * E.coli + 43.9 * FC + 4.1 * Mg^{2+} + 0.0 * NH_3 - 1.0 * NO_2^- + 0.1 * NO_3^- - 0.8 * PHO_4^{2-} + 43.8 * TC + 58.4 * TH.$$

The analysis result of water quality index (WQA) above mean of 20 was COD, FC, TC & TH in Asella town water supply figure 5.

site figure 5 here

The statistical analysis result had shown that a strong pair wise correlation with selected water quality parameters. For example, Turbidity had strong positive correlation with pH & TS while negative correlation with ECs. E.coli, Alk & CO_3^{2-} had a significant Pvalue with strong correlation with. pH, ECs, E.coli, TS, TURB, Na, NH_3 & Alk (table 4).

Site table 4 here

Discussion

The physical water quality analysis of Asella municipality water supply had colourless, odourless & tasteless which meets WHO standard for drinking water.

The guide line value for turbidity is less than 1NTU maximum find exceeded 5NTU (3). The turbidity value was greater than standard value in this study sites. The test result of the first site was maximum, this may indicate the need for water treatment of Ashebeka river water. The other remaining test result had turbidity values raises over WHO standards, this might be, even though treatment plant of Asella municipality treat water effectively the turbidity value still indicates further treatment plant & water reservoir needs critical measures. High turbidity is often associated with higher level of disease causing microorganism, such as bacteria and other parasites. Similar study in Nigeria turbidity value ranged 0.77-0.99 NTU (23), which was lower than Asella town municipality water supply from Ashebeka river.

The health based guide line value for TDS was not proposed, but TDS less than 600mg/L tolerable, beyond 1000mg/L not tolerable because objectionable to the consumers (3). The highest TDS was recorded in Asella hospital water sample site. This may be due to solid settled in hospital water reservoir might be not properly removed with the appropriate time interval. Similar study done in Malaysia had found for TDS ranged 9-11 mg/L(24).

But the TDS result of Asella finding was ranged 34.4-76.6mg/L which was higher than the previous study. A total dissolved solid is an indication of dissolved metals in water.

The important test result was detected out fluoride & aluminum tests. The aluminum concentrations derived to 0.9mg/L, but large water treatment plant less than 0.1mg/L & less than 0.2mg/L for small scale water treatment (3). The finding of Asella was raised up above WHO standard 0.2mg/L at site two, three, four & five. This might be due to high dose of alum utilization by Asella water & sewerage authority office for coagulation process.

The WHO guide line value for fluorine is 1.5mg/L (3). The result of fluorine in Asella water supply range 0.01-0.5mg/L too much lower than standard value. Similar study in Iran the result of fluorine concentration in ground water was 0.25- 1.72 mg/L(25). The Asella town result is lower than Iranian findings because surface water sources lower fluorine concentration than ground water.

No health base guide line for hardness, some people may tolerate excess hardness of 500mg/L (3). Water hardness in Asella Town of Ashebeka River was grouped under soft water. Total hardness of water is due to the presence of bicarbonate, sulphate, chloride, and nitrates of Ca and Mg (26). Similar studies in Kolhapur and Sangli cities river water ranged 44-490 mg/L (27). The result of Asella town was lower than Sangli city. Ca⁺⁺ & Mg⁺⁺ are important ions contributing towards total hardness. Hardness has no

known adverse health effects. Hardness above 200mg/L (3) water is not suitable for domestic use in washing clothes, cleaning and laundry because of the formation of scale deposition.

The threshold limit for calcium 100-300mg/L while lower for magnesium (3). The finding of calcium was 6.4-8mg/L & magnesium 0.6-1.9 mg/L in Asella town. Similar studies in Nigeria ranged 3.1±0.26mg/L to 1524±131.06 mg/L for calcium & 21±0.59mg/L to 1375±38.5 mg/L for magnesium ground water (28). The finding of this study was too much lower than with Nigerian ground water, this might be the ground water concentration of metals is higher than surface water sources.

The WHO standard for fluoride concentration is 1.5mg/L. The result of this investigation in all sites was below this standard. Low fluoride concentration causes tooth decay. Similar study on boreholes in Nigeria ranged 0.13-0.92 mg/L(23), which was higher than Asella municipality water supply. The difference might be due to ground water had greater fluoride concentration than river water.

Use full water quality test like alkalinity & electrical conductivity tests result indicate the existence of metals in water supply of Asella town.

The health based guideline value for dissolved oxygen were not proposed(3), but this study result had found dissolved oxygen which is important for water treatment for the removal of heavy metal like iron & carbonate removal, but if the concentration too much high may be corrosion in water conveying metallic pipe. Similar study in Malaysian river was dissolved oxygen ranges 5.32-7.86 mg/L (24).

The findings of BOD₅ & COD was an indication of organic & inorganic contaminants might be occur due to infiltration from leakage or cross contamination in water connecting pipes. Similar study in Malaysia river water ranges 0.04-1.42 mg/L & 0.33-1.67 mg/L of BOD & COD respectively (24). The Asella municipality water supply result was higher than Malaysian River water sources.

The pathogenic microbes detected in drinking water must be less than one organism per 10⁴ to 10⁵ liters (3). The indicator organism for bacteriological analyses was carried out by the detection of Escherichia coli (E.coli) count. Both results had shown that the tests were above WHO standards before the treatment plants. The fecal coliform & E.coli tests after water treatment plant was with the range of acceptable standards.

Similar studies on E. coli & total coliform were 1-16 CFU/ml & 3-48 CFU/ml in Malaysian river water respectively (24), which were lower than Asella municipality water supply findings.

The ammonia concentration throughout the study sites was above WHO recommends to occur until 0.2mg/L (3) for surface water from site 2 to site 5. The finding of ammonia availability was an indication of water pollution by bacteria, sewage & animal waste. This may be due to the occurrence of organic pollution after water treatment plants. The presence of nitrite concentration above WHO standards 3mg/L (3) at station five might be indication of pollutants appear after treatment plants might have an effect on health effects.

The statistical significance test result had shown that the pollution load might had a contribution for increasing the variety level of water pollutants due to natural & man made factors.

Conclusion

Asella town water quality had been assessed for the last one year for its quality with comparing of WHO water standard & comparative with similar study done on other areas. The physical quality of water after the treatment plants had been within the range of the standards. The turbidity result before the treatment plant above the expected standards. The chemical test result especially fluorine below the standards.

The variation of chemical water quality parameters were found across different study sites in Asella water supply. There was increase BOD & COD concentration above the expected water quality of referenced similar study sites. The analysis of microbes indicator E.coli. & coliform tests were concluded above WHO standards. Over all the quality of Asella water supply from Ashebeka River have to be corrected for the consumers of human health.

Recommendation

- Asella water & sewerage office will have to add water aeration systems.
- Mechanisms may be developed by municipal water consumers about fluoridation of their water supply.
- Pre-equation have to be taken while coagulation process to reduce excess coagulant usage.
- Regular washing of water reservoir tankers have to be monitored by water organization offices.
- The leaking metal pipes will be changed by plastic pipes may reduce the pollution load.
- The town health office professionals have to teach about water quality improvement methods.
- Homemade water treatment will have to practice by urban community to reduce post contamination of water pollutants.

Limitation of the study

Due to shortage of resources water samples were not carried out from all Asella town kebeles.

This study also had not included commercially prepared bottled water supply for urban consumers.

The study also limited about the individual house hold water storage tankers.

List Of Abbreviations And Acronyms

ALK Alkaline

APHA American Public Health Association

BOD	Bio-Chemical Oxygen Demand
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
E.coli	Escherichia Coli
IDPS	Internally Displaced Person
MPN	Most Probable Number
NTU	Nephelometric Turbidity Units
TURB	Turbidity
TH	Total Hardness
TS	Total solid
TDS	Total dissolved solid
UNICEF	United Nations Children's Emergency Fund
WHO	World health organization

Declarations

Ethics approval and grant

Since the study was carried out on water sample analysis in Asella town the sample was not taken from humans or animals including plants. Therefore "Not applicable"

Consent to publish

To come to visualize the scientific world the status of water quality in Asella town for serving of the underdeveloped world population in case of Asella town how much exposed to water borne diseases.

Availability of data and materials

Physicochemical & bacteriological water quality parameters of laboratory investigation results were available at the hand of principal investigator & Addis Ababa water & sewerage laboratory office for the safety of mishandling data not to occur for avoiding public violence process. If the journal needs it I will attach with email address separately;

Competing Interests

The authors declare that I have no competing interests

Funding

Adama & Arsi University were the source of financial support to paying per diem for water sample collector & laboratory analyzer professionals including transportation cost and cost of laboratory reagent & chemical while handling laboratory investigation process of this research project.

For reviewers their professional revising of my manuscript and journal publication cost will be covered by World Bank that is waived by World Bank based my request which I had gotten their witness through my email address.

Authors' contributions

Author's contribution was to determine the main physico-chemical and bacteriological water pollutants and analyze their impacts on human health. He can develop a correction measures for controlling this pollutants from drinking water supply. He can also recommend for the responsible partnership to add up water treatment facility for standardizing of drinking water quality of municipal water supply for the case of Asella town. It is my original work. I am accountable for any question raised concerning my work.

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Tables

Table 1:-water sampling site description that collected November, 2015 to April, 2016 G.C.

Site	Description
1	Raw water coming from Ashebeka River at entrance site of water reservoir
2	Treated water leaving out from Dosha site water treatment plant
3	Water reservoir at Asella kebele 01
4	Public water fountain at Asella kebele 06
5	Public water fountain at Asella kebele 14
6	Asella hospital
7	Public water fountain at Asella kebele 09
8	Public water fountain at Asella kebele 10

Table 2:-First round results of chemical & bacteriological water quality laboratory analysis April, 2015 G.C,

Sites	BOD ₅	COD	NH ₃	TH	Ca ²⁺	Mg ²⁺	NO ₂ ⁻	NO ₃	PHO ₄ ²⁻	TC	FC	E.coli
Site Three	4	40	1.9	60	14.4	5.8	0.1	1.1	0.9	180	180	40
Site Four	2	20	0.6	50	9.6	6.3	0.1	1.4	0.3	0	0	0
Site Seven	0	0	0.5	60	16	4.8	0.1	1.3	0.1	0	0	0
Site Eight	6	60	1.6	68	20	4.3	0.1	1.4	0.1	0	0	0

Table 3:-The physical & chemical water quality analysis of Asella town water supply laboratory result of second round tests, March, 2016 G.C.

PARAMETERS	Site one	Site two	Site three	Site Four	Site Five	Site Six
p ^H	6.18	4.27	4.12	4.21	4.28	4.14
EC	57	107	104	121	104	118
TS	198	72	71	78	72	85
TDS	34.4	64.4	62.4	72.8	62	76.6
TURBIDITY	162.06	5.84	6.94	5.48	6.57	8.76
SODIUM	8.8	3.1	3	2.7	3	2.8
POTASIUM	1.7	1.7	1.7	1.8	1.7	1.8
TOTAL Iron	2.58	0.09	0.07	0.23	0.18	0.12
AMMONIA	1.63	0.84	0.8	0.71	0.78	0.78
TH	24	24	28	24	20	24
CALCIUM	8	6.4	8	6.4	6.4	6.4
MAGNESIUM	0.96	1.92	1.92	1.92	0.96	1.92
ALKANITY	16	4	4	4	4	4
BICARBONATE	19.52	4.88	4.88	4.88	4.88	4.88
CHLORIDE	3.98	5.96	5.96	5.96	5.96	7.95
NITRATE	6.42	1.65	1.92	5.44	4.58	0.01
NITRITE	0.038	0.007	0.008	0.007	5.584	0.009
FLUORIDE	0.5	0.48	0.44	0.44	0.43	0.01
ALUMINIUM	0	0.54	0.24	0.48	0.39	0.11
ZINC	0.01	0.25	0.03	0.93	0.66	0.02
DO	3.667	5.333	6	4.667	5	2.667

Table4:-pair wise statistical correlation with selected water quality parameters with respected Pvalue<0.05 taken as a cut of point

	pH	EC	CO ₃ ²⁻	ALK	TDS	TUR	SOD	Iron	NH ₃
pH	1								
EC	-0.9529	1							
	0.0033								
CO ₃ ²⁻	0.9967	-0.9496	1						
	0	0.0037							
ALK	0.9967	-0.9496	1	1					
	0	0.0037	0						
TDS	-0.9254	0.9886	-0.916	-0.916	1				
	0.0081	0.0002	0.0103	0.0103					
TUR	0.9957	-0.9488	0.9998	0.9998	-0.9128	1			
	0	0.0039	0	0	0.0111				
Na	0.9967	-0.9654	0.9981	0.9981	-0.9348	0.9978	1		
	0	0.0018	0	0	0.0062	0			
Iron	0.9968	-0.9378	0.9982	0.9982	-0.9064	0.9977	0.994	1	
	0	0.0057	0	0	0.0127	0	0.0001		
NH ₃	0.9908	-0.9694	0.9927	0.9927	-0.9348	0.9929	0.9974	0.9848	1
	0.0001	0.0014	0.0001	0.0001	0.0062	0.0001	0	0.0003	

Figures

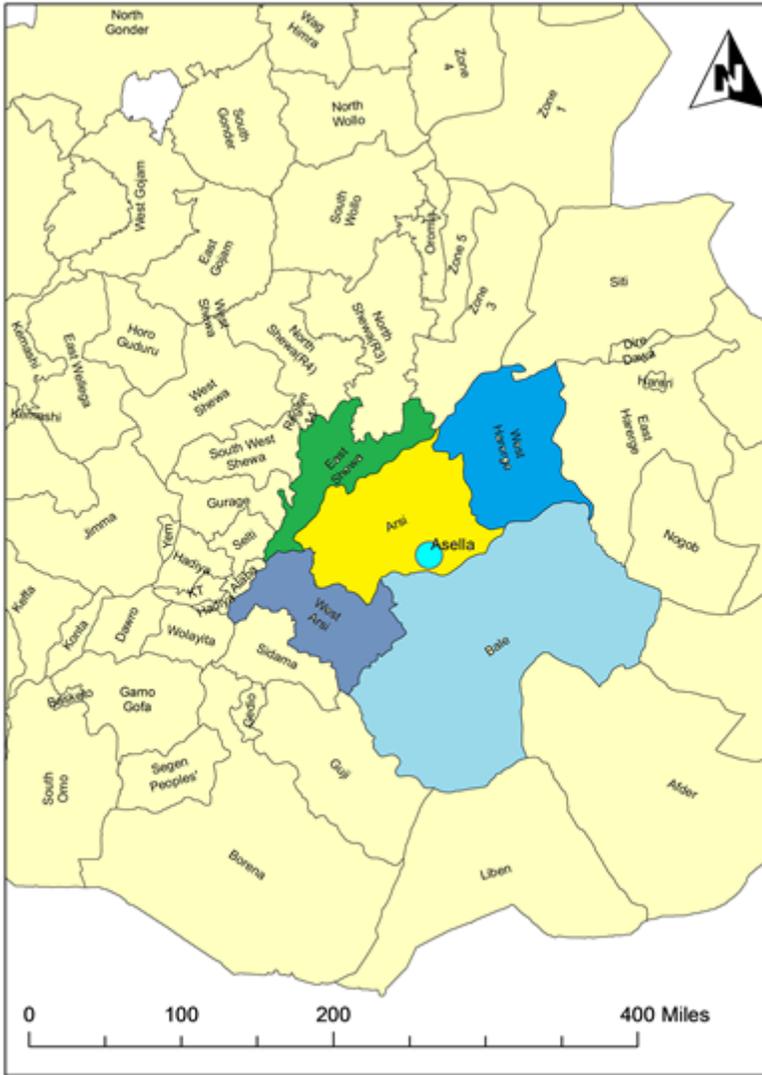


Figure 2

Water sampling site Asella town of Arsi zone, Oromia, Ethiopia

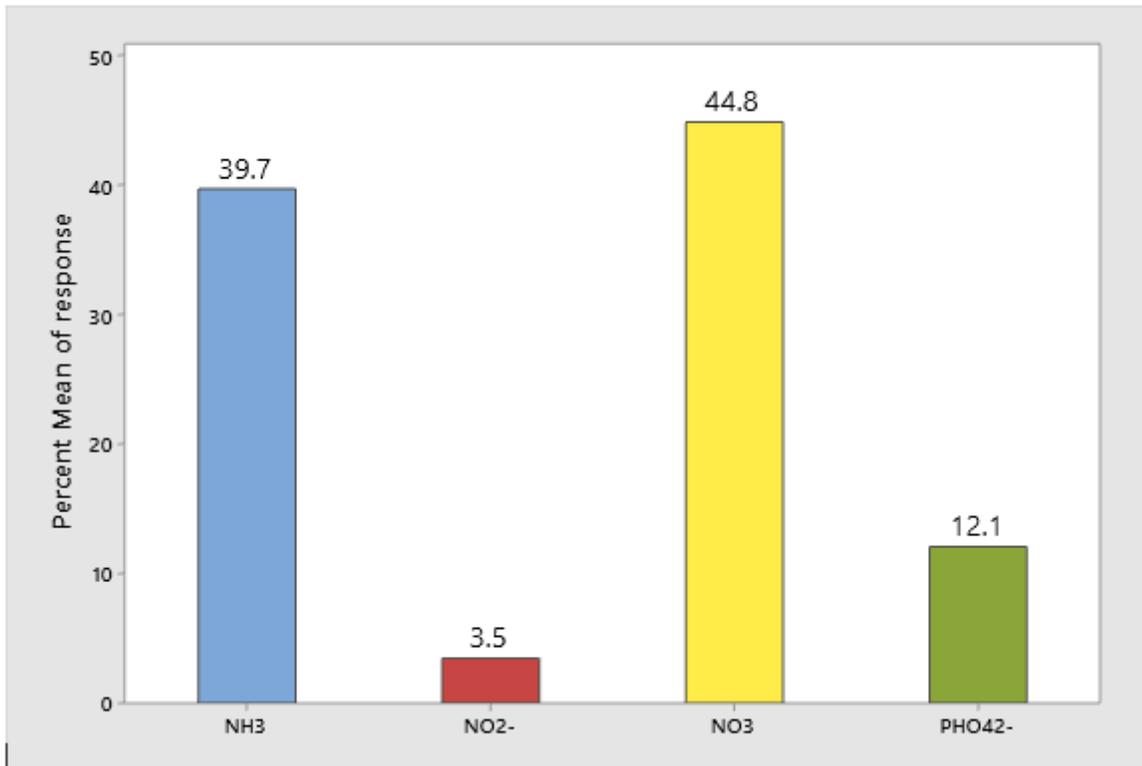


Figure 4

Mean nutrient water quality analysis in Asella town water supply, April, 2015

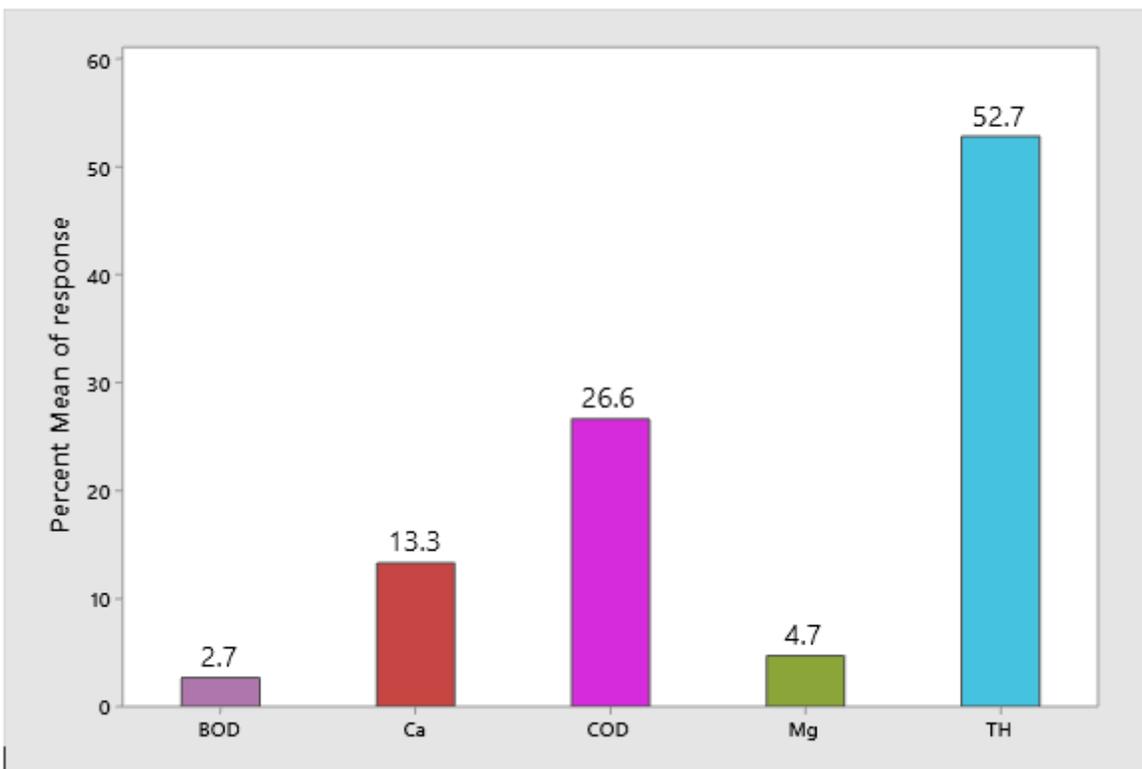


Figure 6

The mean distribution of chemical water quality parameter analysis in Asella town water supply, April, 2015

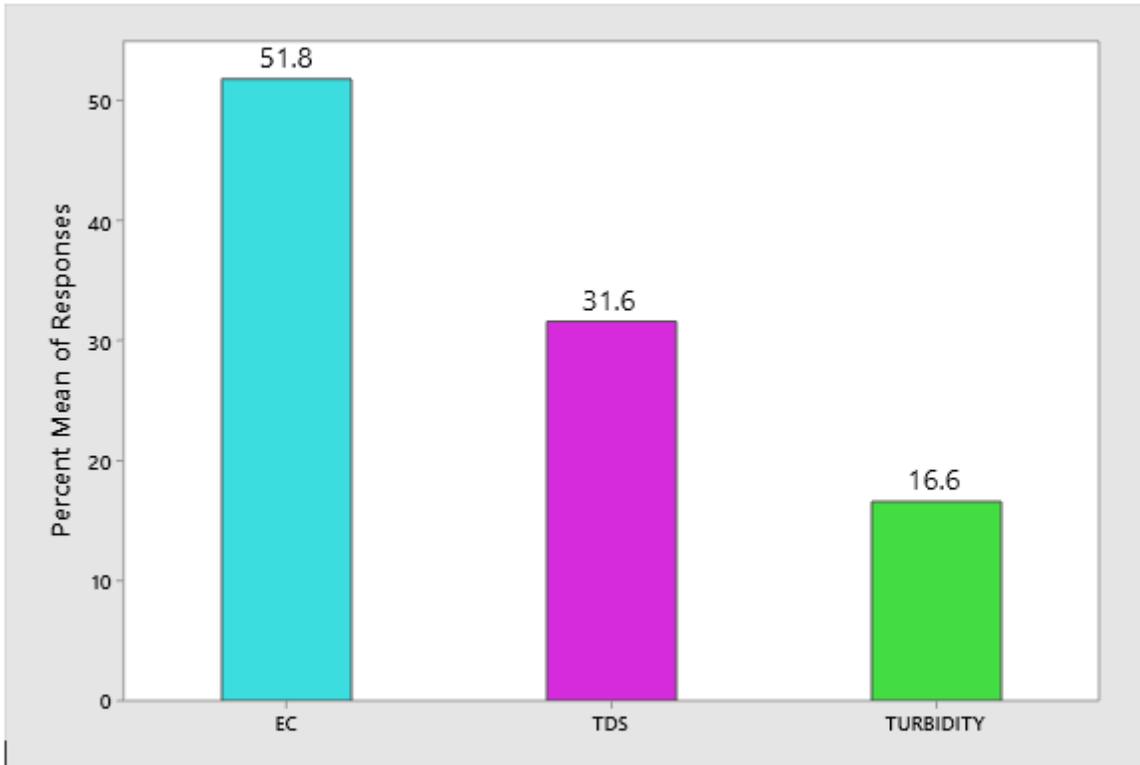


Figure 8

The mean physicochemical water quality analysis Asella town, March, 2016

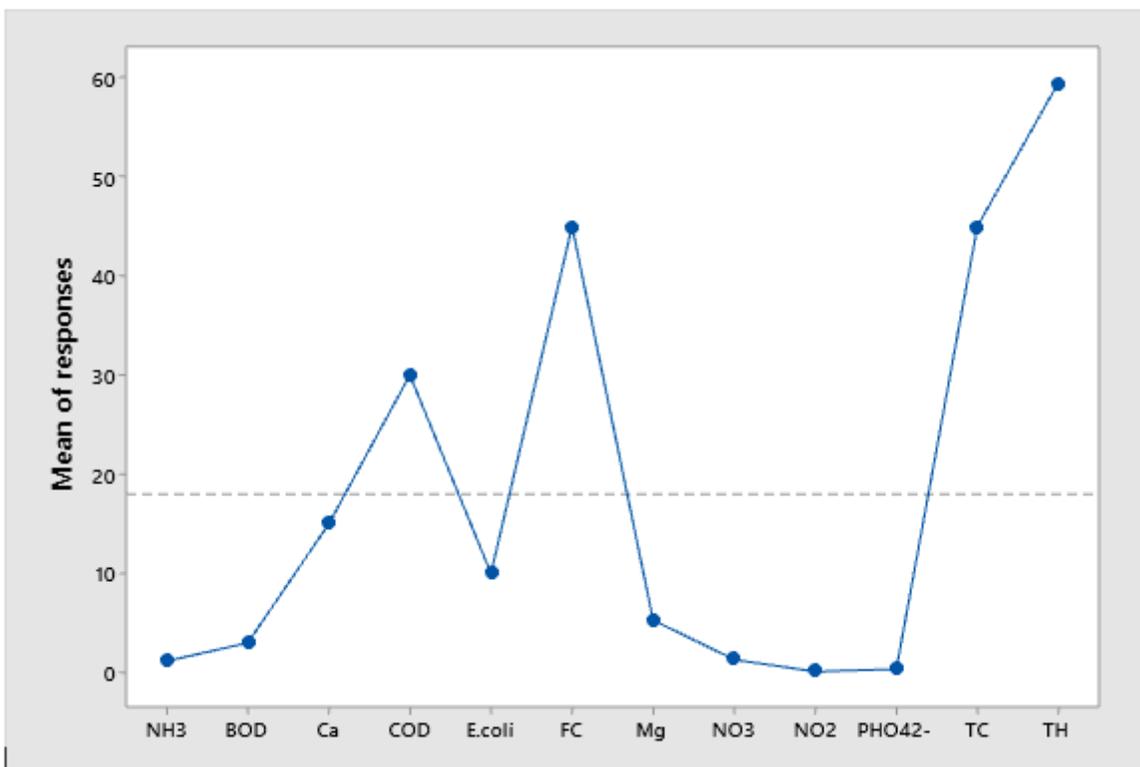


Figure 10

Water quality index of Asella town water supply March, 2016

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