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Research Paper

Microbial Qualities of Drinking Water and Its Public Health Implication: the Case of Adama Town, Ethiopia

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Abstract

This study is an investigation on microbial quality of drinking water and public health assessment in Adama town during June to December 2016. Accordingly, seven strata were formed from the total distribution system of municipal drinking water supply starting from the raw water intake up to community storage. Public health was assessed by using primary and secondary data. The presences of the indicator organism (TCB, FCB and E.coli) were considered for drinking water quality vis-a-vis public health. A multi-tube fermentation technique was employed to evaluate the indicator organism and the result was expressed in the MPN. Residual chlorine were evaluated at each stratum. 52 sample per month were tested and totally 312 samples are tested entire the study period. The findings revealed that 26.28% of samples examined were positive for TCB, 9.29% for FCB and 0.96% for E. coli. 30% of the E.coli contamination was due to unhygienic handling of water after collection. The result of the present study showed that 27.06% of cases admitted for laboratory test in the government health care centre were either waterborne or water related diseases. Among those positive samples for indicator organism, 79.89% of them were confirmed with the physical address of patients. Quality of drinking water alteration in the study area is mainly at home due to unhygienic handling. Furthermore, illegal extension, infrastructural expansion, low initial concentration of chlorine, aging of pipeline, distribution by rotation and lack public awareness in general are the other main reasons for water quality impairment. These factors have to be considered to maintain public health in the area by concerned bodies drinking water provider and user.

Keywords: - *Adama, indicator organism, multi tube fermentation techniques, public health and waterborne diseases.*

1. Introduction

Maintaining public health was highly dependent on the potability and accessibility of water. However, About 663 million people are living with no access to potable water worldwide. Of which 50% of the people live in sub-Saharan Africa countries (WHO/UNICEF, 2014). Lack of accessibility and potability of water has a dual effect on public health. It is causing diseases either due to an unhygienic condition in the community or/and causing diarrhoeal diseases (Hunter et al., 2010). The report shows that currently the majority of diarrhoea and related deaths around the world are either due to lack of accessibility to safe drinking water or personal unhygienic condition (WHO/UNICEF, 2014). Diarrhoea emanating from unsafe drinking water is responsible for causing 17% of the deaths of ≥5years children' in most of developing countries (Clasen et al., 2007). In another report, diarrhoeal diseases are the second leading cause of deaths of ≥5 year's children. Similarly, diarrhoea kills half million under five children every year in Ethiopia and it is the second largest killer next to pneumonia. In which about 90% cause of diarrhoea is the unhygienic condition, lack of

access to safe water and improved sanitation (Gebru et al., 2014).

According to water aid report, about 43 million people lack access to safe drinking water, 71 million lack access to improved sanitation and 28 million people use open defecation in Ethiopia (Water.org, n.d.). The improvement of social services and public health are dependent of both potability and accessibility of water (Calow, Ludi, & Tucker, 2013). That is why Water service underpins were considered as one of the priority area for sector growth enhancing in Ethiopian's Growth and Transformation Plan I (GTP, 2011-2015). The achievement of 98.5% nationwide for water supply access coverage was planned in GTP-I. However, GTP-I 4th year report shows that 76.7% were achieved.

Adequate and safe water provision is crucial issue for the social service improvement, public health and economic growth in multiple sector in general. Furthermore, the study area is exposed for number of factors limiting potablity and accessibility of water such as industrial expansion, population growths and others. Therefore, monitoring existing water quality in the area is very important to maintain public health and other developmental activity (Calow, Ludi, & Tucker, 2013). Accordingly, the present study aimed to evaluate microbial quality of drinking water, Identify the point of deflection of water quality among the formed strata and assess the rate of waterborne and water related diseases in the study area.

Among powerful environmental determinants of health, drinking water quality is crucial in maintaining public health. Maintaining drinking water quality has been continuing as a key pillar for more than a century and expected to continue as a basic foundation for prevention and control of waterborne diseases. Though water is the most essential for life, it can easily transmit diseases entire the globe. Among the most prominent waterborne diseases, diarrhoeal diseases are most predominant with an estimated annual incidence of 4.6 million episodes resulting in 2.2 million deaths every year (Kirk et al., 2015). The health report of the Adama town health office shows that in the last five years alone 72911 people are infected with diarrhoea while 80078 and 44545 people are affected by Dyspepsia and Pneumonia respectively. The above three diseases are among the top ten diseases in the area with expected cause of unsafe water uses or unhygienic condition.

Mostly, waterborne diseases transmitted either due to contamination of the catchment areas of human and animal faeces, leakages in the distribution system and/or unhygienic handling of water storage at household (Eisenberg et al., 2002). Observations in the present study area showed that high rate of leakages in distribution pipes, illegal extension, line breakage due to expansions and aging and about 20% of water loses due to leakage drinking water distribution system. These observations helped the present study to identify the strata that have more potential for contamination of waterborne and water related diseases in the area. This may be either drinking water source or recontamination of distribution system seems to be the cause of contamination vis-a-vis waterborne and water related diseases. Diarrheal diseases such as cholera and others like Guinea warm, typhoid Fever, hepatitis A, hepatitis E and dysentery are some of waterborne and water related diseases (website, n.d.). Despite the fact that there are disparities on the available data for the mortality caused by waterborne and water related diseases in different years, still 3.4 million deaths were recorded every year by water related diseases (Ashbolt, 2004; WHO, 2013). Waterborne and water related diseases such as typhoid fever, which is bacterial infection due to contaminated water (D'Agostino et al., 2008), hepatitis E due to contaminated drinking water by virus ("Hepatitis E vaccine: WHO, 2015), Guinea worm which is parasitic diseases due to unsafe drinking water, giardiasis which is parasitic diarrheal illness commonly caused by contaminated drinking water (Moriyama et al., 2011; CDC, 2010). Cholera one of most common diarrheal diseases, gastroenteritis, dysentery, diarrhoea, cyclosporiasis and many others were identified scientifically as they are due to water (D'Agostino et al., 2008). The study aimed to evaluate a microbial quality of drinking water, to measure the rate of waterborne and water related diseases and to recommend concerned body to maintain public health.

UN Millennium Development Goals (UNMDG) 4 and 7 are aimed at reducing child mortality rates by 2/3 and ensuring clean drinking water and basic sanitation to all by 2015. However, sub-Saharan Africa and South Asia are remained hotspots (Ntouda et al., 2013; Jeffrey et al.,

2008). Acute Respiratory Infection (ARI) and Diarrheal Diseases (DD) are the two leading causes of death worldwide. Every year about 4.4 and 3.1 million children under 14 year deaths are recorded mostly by pneumonia and DD respectively. However, deaths due to diarrhoeal diseases reached 41,287 per annum in Ethiopia amounting 6.87% of the total deaths, making the country 35th ranked in the world by diarrhoeal deaths (WHO/UNICEF, 2014; Website, n.d.). Cholera still occurs as an epidemic in drought-affected areas due to contaminated water is in use (Jeffrey et al., 2008).

The process and technology to evaluate all pathogenic microorganisms in water are so complex and expensive. Hence, indicator micro-organisms were considered to identify the presence of the pathogenic organisms in water (Taubeneck, 1980). The history of using an indicator organism as an indicator of water and sanitary quality is traced back to 1888 when Von Frestch basically investigated bacteria, such as Klebsiella pneumonia's and K. rhinoscleromatis that were found in faeces (Geldreich, 1996). Therefore, in the study, indicator organisms have been used as indicator of water quality and potential exposes to waterborne and water related diseases. Among available and widely applied methods of microbial quality of water, multiple tube fermentation techniques and membrane filter technique are most common. Though membrane filter technique is most advantages than multiple tube fermentation technique, it is not applicable all types of water (Bartram & Ballance, 1996). Therefore, in this study multiple tube fermentation technique was adapted. E.coli, total Coliforms, Faecal coliforms, Heterotrophic plate count, Enterococci, Faecal Streptococci, Campylobacter, Pseudomonas aeruginosa, Staphylococcus aureus and/or Salmonella are among types of test supposed to be conducted in microbial quality of water samples. Of which E.coli, total Coliforms and Faecal coliforms were tested as indicator organism.

2. Methodology

2.1. Description of the Study Area

Adama town is located in the central parts of Ethiopia, at geographical location of 8° 27' 54" up to 80 35' 7" N and 39°13' 5"E up to 39°19' which is 99Km away from the capital city of Ethiopia to the south east of the country (figure-1). The urban area of the town Spread over 30 km^2. However, the town with included parts of some rural area for water provision covers a total of 968.27 km^2 and bordering with Lume and Boset districts, and Arsi zone. The town found within an altitude of 1500-2300m above sea level. The mean annual minimum and maximum temperature of the study area is 14℃ and 33℃ respectively and yearly minimum rainfall is 808 mm. The district situated in a sub-tropical agro-climatic zone (Oromia Regional State, 2011). Adama is one of a highly populated area in the eastern Shoa zone. The total population of Adama district is estimated at 201,110 for 2016 with 52:48 female to male sex ratio (Ethiopian Central Statistical Agency, 2016).

2.2. Drinking Water Provision and Treatment (DWPT)

Antiquity of the Adama Water Supply begins with the water service given by the former Ethiopian Electric Light and Power Authority (EELPA) which started by drilling about 10 boreholes at the place called Melka Hidda (AWSSSE, 2015). Currently, Adama town receiving potable water from two sources; surface water as the main source and groundwater as the complementary source. Adama municipal drinking water is drawn from Awash River. The establishment of Adama water treatment, known as Koka Drinking Water Treatment Plant (KDWTP) is positioned left to Awash River just after Koka hydropower dam around 10-15 km downward side, in the western part of the town. The treatment plant was designed to harvest 330L/s. The treated water is pumped from KDWTP and it travels 10-15 km to reach the first of two reservoirs known as "Lugo-Reservoirs". The second couple reservoirs known as 02 kebele reservoirs is stationed at a distance of 5-10 km from "Lugo-Reservoirs" at Gelawudios, and the treated water is collected here by gravity. One of the reservoirs in the second group is for emergency purpose, thus sparingly used; hence, the other one distributes water to three other reservoirs in the town and serves as the centre of distribution. The treatment plant is recently upgraded to bridge the gap between demand and supply, as a result of increasing population and industrial expansion (Fortune, n.d.). Nine reservoirs are available in different place with total capacity of

13,700m3 at a time. Of which six reservoirs are functional at the time of this study. The treatment plant capacity is 19, 000 m3 to 23,000m3 per day. However, daily demand is 43,000m3 per day for domestic uses (AWSSSE, 2015).

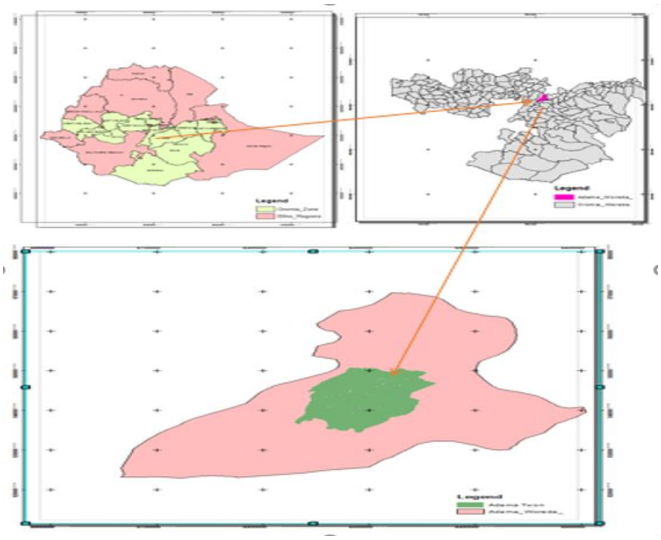

Figure 1 Study area map (Courtesy Adama Drinking water agency)

2.3. Water Sampling and Public Health Data Collection

WHO (2004) and APHA (2013) guidelines have been adopted for sampling and analysis of water samples in the study area (APHA, 2013). Water samples were collected separately for microbial quality examination to reduce sample contamination in collection, preservation and testing. However, sample for the evaluation were taken separately which was evaluated in physico-chemical evaluation quality drinking water in the area. The drinking water quality in the study area correlated with public health. Secondary and semi-processed data from health offices and primary data from all government treatment centres were utilized for public health assessment. An effort was made to identify access to safe drinking water, the top ten causes of morbidity, mortality and public health using as indicators for water quality. Sampling methods based on stratified simple random sampling methods were considered. Accordingly, seven strata were identified from sources-to-end point which is starting from raw water intake point to the community storage as shown below. The7 strata (S1 – S7) include;

- S1-Water sample from raw water intake point before pre-chlorination and coagulant aid point

Here, water samples are untreated raw water. Therefore, expected water quality is low and this point will help to see the treatment level by comparing the treatment plant efficiency and how it will be delivered to the reservoirs.

- S2- Water sample at treatment outlet point with a maximum residence time of 30 min After final treatment and before reaching the reservoir

Here sample collected is treated and expected that treatment have contribution to comply with drinking water standard. Similarly, this sampling point will help to evaluate level of treatment and alteration with the next sampling point.

- S3 - Water sample from the reservoirs:

This sampling point is where water resides relatively for longer time. At which the water stay, material used to reserve water and volume of water at a time is different from other stratum.

- S4 - Water sample from common community base point:

This is common point to harvest water by low-income community at any 500m radius distances. Here human contact is high and relatively unprotected. So source of contamination will be expected that different and helps to compare with other stratums.

- S5 - Water sample from the distribution system before reaching the community. This point of sample is undergrounded, almost least contact with human and relatively protected. This will help to compare and identify point of alteration.
- S6 - Water sample user point at the end of distribution system and before storage at home:

The point is where most of community harvest municipally provided water for both immediate consumption and later uses. This point will help that alteration of water is before collection or after collection, which means that, will help to identify supply system efficiency and hygienic level of water storage.

- S7 - Water sample from community storage after 24hrs up to a maximum of 72 hrs storage time at home.

At this point water will stay longer time than other stratum and expected sources of water contamination is more and residual chlorine will be expected low.

The sample collection and determination of minimum number of the sample per-month made based on WHO guideline and standards. Accordingly, total 312 samples have been sampled from all the 7 strata (52 samples/month). The water samples were collected in the first week of each specified month during 8:00 AM to 11:00 AM. Autoclaved 500ml glass bottle sampler was used, refrigerated (but not iced) and delivered to the Oromia Public Health Research, Capacity Building and Quality Assurance Laboratory at Adama (OPHR Lab) within an hour of collection. All safety precautions have been exercised during sampling, transport and analysis of the samples. All the water samples were analysed for total coliform bacteria (TCB), faecal coliform bacteria (FCB) and E. coli coliform bacteria in OPHR laboratories, at Adama. Multiple-Tube fermentation techniques are the most preferred techniques for detecting the selected group of coliform organisms in microbial analysis of water (APHA, 2013) and the same has been adopted in the present work. Since the water under consideration is from relatively good source, 5 tubes each with 10ml of double strength MacConkey broth and 50ml double strength MacConkey broth were used respectively (APHA, 2013). Since all the water samples except raw water point are chlorinated, 0.1ml of 1.8% of sodium thiosulfate was added to 100ml of water. Water samples collected were placed aseptically into MacConkey agar broth tubes for total coliforms, faecal coliforms and E. coli following the standard protocols as described by (APHA, 2013; Cheesbrough, 2006). Incubation was carried out at 37°C for 24hrs for total coliforms and 44.5°C for 24hrs for faecal coliforms and count was carried out following the standard microbiological procedures by (APHA, 2013). At every sampling point, samples have been taken to evaluate free residual chlorine. Evaluation of free residual chlorine and sampling methods has been conducted as per the standard meted in APHA (2013).

2.4. Public Health Data Sources and Collection

All the patients admitted with laboratory tests in either of eight government healthcare centres were considered for assessing the public health data in the study area. Secondary and semi-processed data were taken from health offices and primary data were collected daily from government treatment centres during June-December 2016 by registering all admitted cases. Only the top 20 diseases in the study area were considered in the assessment of public health data and existence of diseases such as DD in the top ten were considered as an indicators of impacts of water quality. The patients positively tested for waterborne and water related diseases such as typhoid fever, Diarrhea, Dysentery, Pneumonia, Acute upper respiratory infections, other unspecified diseases of the digestive and respiratory system used as indicators of water quality. Additionally, diseases caused either directly or indirectly due to consumption of unsafe water and hygienic problem such as trachoma and other infected people are used as indicators of water quality impacts on public health in the specified period. Health data relating to top 10 diseases causing morbidity and mortality in the area for the last five years was reviewed in relation to waterborne and water related diseases considered as a complement to the data collected from the treatment centres. Additionally, the water quality and public health in that specific area was confirmed with the physical address of patients and medical records.

3. Results and Discussion

3.1. Bacteriological Quality of Drinking Water

The microbial test of water samples were done in the OPHR Laboratory at Adama town. The record of examination of collected water sample revealed that, 30.13% is positive for total coliform bacteria, 13.14% for faecal coliform bacteria and 3.21% for E.coli coliform bacteria. This result is the relative ratio of positive test result including the raw water. With exception of raw water starting from the treatment plant up to community storage, 26.28% of sample examined is positive for total coliform bacteria, 9.29% for faecal coliform bacteria and 0.96% for E.coli coliform bacteria is recorded. Among which 67% of householder (at least one of the family) were hospitalized from where water sample were positive for E.coli. This is confirmed with the water sample and hospital records of the users. While 79.89% of those positive sample for either of indicator organism confirmed with the patients' address and hospital records as well. E.coli exists in two stratum

among the seven strata. It was raw water intake (SA), accounting about 70% of E.coli which can be addressed through treatment. However, 30% was re-contamination due to improper handling at household. SB shows negative for all indicator organisms throughout the study, implying that the treatment plant at this point is complying with National and WHO standards for drinking water as far as microbial quality is concerned. This means that the contamination observed in the water distribution system is probably after water left the first couple of reservoirs. In case of samples taken from Reservoirs (SR), 25% of the samples were positive for TCB specifically SR5 (TV Oromia), SR6 (Dhaka-Adii) and SR7 (Abba-Geda) were positive for TCB, while 5.5% was contaminated with FCB specifically SR7. The analytical data of water samples from the distribution system before reaching the community (Di) reveal that 18.33% was contaminated by TCB. Water samples drawn from the centre of the town (kebele-09, 10, 12, 13 and 15) were contaminated. This is resulted due to aging of the system and leakages. The other positive samples in the distribution are from the newly expanded area in which illegal extension is a major problem in the study area, namely kebele-01, Duket, Daka-Adi and Tikur-Abay areas. Similarly, 6.66% of the water samples from distribution, specifically from the centre are positive for FCB indicates that water has been contaminated with the faecal material of humans or other animal origin. As far as water quality in community storage is concern, 47.4% by TCB, 17.9% by FCB and 3.85% contaminated by E.coli while 25% and 8.3% of water sample examined from common communal point were contaminated with TCB and FCB but not E.coli. Details of collected sample, number of positive sample and its percentage are shown in Table 1.

Table 1: sample distribution ratio and summary of examined sample for bacteriological quality of drinking water (2016)

S.N0	Stratum	Descriptions	**Total Coliform**		**Faecal Coliform**		**E.coli**	
			positive sample	%	positive sample	%	positive sample	%
1	S1	water sample from raw water intake point at different distance before pre-chlorination and coagulant aid point	12	100	12	100	7	58.33
2	S2	water sample no longer stayed for more than 30 minute after final treatment and before reaching reservoir (B)	0	0.0	0	0.0	0	0.00
3	S3	water sample from reservoir each separately (R),	9	25.0	2	5.6	0	0.00
4	S4	water sample from distribution system before reaching community (Di)	11	18.3	4	6.7	0	0.00
5	S5	water sample from user point at the end of distribution system and before storage (Ds)	16	20.5	6	7.7	0	0.00
6	S6	water sample taken from community storage after 24hrs up to maximum of 72hrs storage time (Ei)	37	47.4	14	17.9	3	3.85
7	S7	water sample from common community base point (C or Es),	9	25.0	3	8.3	0	0.00
		Total	**94**		**41**		**10**	
		percentage of positive result including raw water	**30.13**		**13.14**		**3.21**	
		percentage of positive result excluding raw water	**26.28**		**9.29**		**0.96**	

3.2. Public Health, Waterborne and Water Related Diseases in the Area

Among 43,192 patients admitted in governmental health treatment centre with laboratory test during July-December/2016 in the study area, 11,688 patient cases were mostly waterborne and water related problem. Among this, 89.89 percent of patients were confirmed that they are from the area in which water sample result were positive for the indicator organism while the rest were patients using private water sources. About 43,192 gone for laboratory test during the specified period of the study treated in Adama treatment services centre out of 342,974 people (total coverage). Among those patients, 11688 cases were expected waterborne and/or water related health problem. In other words 13% of the total population of the study area were treated in either of the treatment centre. Among those treated in either of treatment centre, 27.061% of treated people which is 3% of the total population were affected by waterborne or water related diseases. According to the report, diseases such as typhoid fever, Diarrhea, Dysentery, Pneumonia, Acute upper respiratory infections, unspecified diseases of the digestive and respiratory system and trachoma are leading top 20 diseases in the study area. Within the spine of four months, 2717 patients were positive for diarrhea.

3.3. Top Ten Mortality and Morbidity Causes

Pneumonia, typhoid fever, diarrhea and other waterborne and water related diseases are among most prone top ten diseases in the study area for the year of 2014-2016. The details of top ten morbidity and mortality with affected people and ratio have been given in the table 2-to-5. According to the result in Table-2, there is no diseases which can have direct relation with water quality in the area rather there are some which can be expected to have correlation with sanitation practices in the affected society. For instance, severe acute malnutrition in the third ranked causes of mortality in the area, which covers 9.29% of mortality causes in the area, may be due to poor sanitation. Because, severe acute malnutrition is indirectly cause due to water quality, which introduced due to improper sanitation. Swollen limbs, feet and face characterize severe acute malnutrition. Severe acute malnutrition, which is affecting about 2/3 of children in Asia and 1/3 of African children and one of the major cause of death particularly in developing countries (Bulti et al., 2017). According to the report, 16 million deaths due to severe acute malnutrition are resulted due to malnutrition itself directly and indirectly due to diarrhoea, pneumonia and poor hygiene (Bulti et al., 2017). Therefore, the existence of severe acute malnutrition in the third ranked causes of mortality in the area, which covers 9.29% of mortality causes in the area, may be due to poor sanitation. Similarly, number of studies revealed that Pneumonia is indirectly related to uses of unsafe water and improper sanitation (El Nopy, 2017; Stöppler, n.d.) and it is among the result in Table-2 and 3, which is causing 4 to 7.10 percent of mortality in the area.

3.4. Mortality and morbidity Vs water quality

The data from the health office of the town reveal that Pneumonia, Typhoid fever, Diarrhea and other waterborne and water related diseases are among the top ten diseases during the years' (2014-16). The data included in Tables 3 to 6 illustrate the affected people and ratios with top ten diseases causing morbidity and mortality in the study area.

Among top ten causes of morbidity in the area, diarrhea, typhoid fever, Pneumonia, acute upper respiratory infection and other or unspecified diseases are expected due to unsafe drinking water and sanitation related issue.

Similarly, diarrhea, typhoid fever, Pneumonia, acute upper respiratory infection and other or unspecified diseases affecting public health in the area. The details are available in table 5 and 6 in which the causes of top 20 diseases admitted in the government hospital. In general, these diseases expected that indirectly caused due to unsafe drinking water and low sanitation.

Table 2: Top 20 diseases identified by laboratory test within 6 months

Top 20 diseases identified by laboratory test		
Rank	types of diseases admitted	No.: Patients
1	Trauma (injury, fracture etc.)	3708
2	Acute upper respiratory infections	3613
3	Factors influencing health status and contact with health services, including visit for examination and investigation (check-up, examination for driving license etc.)	3437
4	Diarrhoea	2718
5	Other or unspecified diseases	2686
6	Acute Febrile Illness (AFI)	2571
7	Urinary tract infection	1670
8	Dyspepsia	1603
9	Other or unspecified diseases of the skin and subcutaneous tissue	1531
10	Pneumonia	1278
11	Dental and gum diseases	1276
12	Infections of the skin and subcutaneous tissue	1231
13	Other or unspecified diseases of the eye and adnexa	1204
14	Other or unspecified diseases of the respiratory system	1165
15	Other or unspecified obstetric conditions	857
16	Helminthiasis	792
17	Causes of abnormal pregnancy, childbirth and puerperium	781
18	Other or unspecified diseases of the digestive system	676
19	Other or unspecified infectious and parasitic diseases	624
20	Other or unspecified disorders of the genitourinary system	579

Table 3: Top ten mortality causes in Adama special zone (2014-2016)

In 2014-15				**In 2015-16**			
Rank	**Diseases type**	**Number of Patients**	**%**	**Rank**	**Diseases type**	**Number of Patients**	**%e**
1	Human immunodeficiency virus (HIV)	53	28.96	1	Human immunodeficiency virus (HIV)	59	29.5
2	Neonatal sepsis	32	17.49	2	Neonatal sepsis	33	16.5
3	Severe acute malnutrition	17	9.29	3	Birth asphyxia	26	13
4	Cerebrovascular accident (stroke)	15	8.2	4	Cirrhosis	17	8.5
5	Pneumonia	13	7.1	5	Severe acute malnutrition	15	7.5
6	Cirrhosis of liver	12	6.56	6	cerebrovascular accident (stroke)	13	6.5
7	Ischemic heart diseases	12	6.56	7	Prematurity	11	5.5
8	All forms of tuberculosis	12	6.56	8	Trauma (injury, fracture etc)	10	5
9	Prematurity	9	4.92	9	Meningitis	8	4
10	Others delivery	8	4.37	10	Pneumonia	8	4
	Total	**183**	**100**		**total**	**200**	**100**

Table 4: Top ten morbidity causes in Adama special zone

In 2014-15				In 2015-16			
Rank	Diseases type	Number of Patients	%	Rank	Diseases type	Number of Patients	%
1	Acute upper respiratory infection	23049	15.3	1	Other or unspecified diseases of the eye and adnexa	28150	16.28
2	Other or unspecified diseases of the eye and adnexa	20538	13.63	2	Acute upper respiratory infection	25325	14.64
3	Acute febrile illness (AFI)	20496	13.6	3	acute febrile illness (AFI)	21691	12.54
4	Dyspepsia	16055	10.66	4	Diarrhoea (non-bloody)	18626	10.77
5	Urinary tract infection	15970	10.6	5	Dyspepsia	18170	10.51
6	Diarrhoea (non-bloody)	15583	10.34	6	Trauma (injury, fracture, etc.,)	17439	10.08
7	Trauma (injury, fracture, etc.)	14131	9.38	7	Urinary tract infection	17195	9.94
8	Other or unspecified diseases of the respiratory system	9465	6.28	8	Pneumonia	9564	5.53
9	Typhoid fever	7900	5.24	9	Helminthiasis	8652	5
10	Infection of the skin and subcutaneous tissue	7471	4.96	10	Infection of the skin and subcutaneous tissue	8134	4.7
	total	**150658**	**100**		**total**	**172946**	**100**

Table 5: List of top 20 diseases in Adama for the last five-year (2011-2016) (Sources: Adama health office, 2016)

Rank	**List of top 20 diseases admitted in government treatment centre in Adama**	Year of treatment in government health care centres (2011-2009 E.C)							Yearly average
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**total**	
1	Acute upper respiratory infections	20398	20411	21613	21613	25271	5267	114573	19096
2	Other or unspecified diseases of the eye and adnexa	16468	15290	16879	16879	28147	3159	96822	16137
3	Acute Febrile Illness (AFI)	17004	14561	14441	14441	21691	5275	87413	14569
4	Other or unspecified diseases	12564	12317	16480	16480	22361	6188	86390	14398
5	Dyspepsia	12954	13129	15658	15658	18068	4611	80078	13346
6	Urinary tract infection	13694	13795	14631	14631	17101	4343	78195	13033
7	Diarrhoea (non-bloody)	14483	12412	11201	11201	18600	5014	72911	12152
8	Trauma (injury, fracture etc.)	14868	14716	10617	10617	16557	4492	71867	11978
9	Pneumonia	9498	8030	7833	7833	9187	2164	44545	7424
10	Factors influencing health status and contact with health services, including visit for examination and investigation (check-up, examination for driving license etc.)	10380	7944	5125	5125	10176	2760	41510	6918
11	Helminthiasis	7332	6315	6572	6572	8650	1929	37370	6228
12	Dental and gum diseases	7012	5769	7042	7042	6279	1593	34737	5790
13	Other or unspecified diseases of the respiratory system	7649	6119	5585	5585	7145	1759	33842	5640
14	Diseases of the musculoskeletal system and connective tissue	5974	5018	6044	6044	7652	1981	32713	5452
15	Infections of the skin and subcutaneous tissue	5242	5038	4933	4933	7973	2171	30290	5048
16	Hypertension and related diseases	5719	5377	5442	5442	6085	1262	29327	4888
17	Typhoid fever	5205	4337	4987	4987	6949	1346	27811	4635
18	Acute bronchitis	4024	4157	4526	4526	6426	1339	24998	4166
19	Other or unspecified diseases of the digestive system	4143	3226	4831	4831	6054	1445	24530	4088
20	Other or unspecified infectious and parasitic diseases	5507	4767	3486	3486	4777	1098	23121	3854
	G. total	**200118**	**182728**	**187926**	**187926**	**255149**	**59196**	**1073043**	**178841**

Table 6: Top 20 diseases treated in government health treatment centers (July-December/2016)

Rank	Types of diseases admitted	Name of hospital or Health centre in which case is treated (August-December/2016)								total	average
		Adama hospital	Adama HC	Biftu HC	Bokku shanan HC	Dambala HC	Hawas HC	Geda HC	Anolee HC		
1	Trauma (injury, fracture etc.)	3335	122	56	28	37	19	111		3708	530
2	Acute upper respiratory infections	948	1286	347	80	280	210	462		3613	516
3	Factors influencing health status and contact with health services, including visit for examination and investigation (check-up, examination for driving license etc.)	0	2220	180	0	8	0	1029	0	3437	491
4	Diarrheal (non-bloody)	1373	620	264	81	252	75	53	0	2718	388
5	Other or unspecified diseases	2435	149	14	17	37	11	23	0	2686	384
6	Acute Febrile Illness (AFI)	1046	922	268	44	127	75	89	0	2571	367
7	Urinary tract infection	1125	280	51	35	12	46	121	0	1670	239
8	Dyspepsia	1099	263	57	21	38	3	122	0	1603	229
9	Other or unspecified diseases of the skin and subcutaneous tissue	1314	85	98	0	4	13	17	0	1531	219
10	Pneumonia	983	156	34	9	23	57	16	0	1278	183
11	Dental and gum diseases	1194	23	11	3	10	5	30	0	1276	182
12	Infections of the skin and subcutaneous tissue	686	177	73	66	78	51	100	0	1231	176
13	Other or unspecified diseases of the eye and adnexa	1081	36	42	15	4	13	13	0	1204	172
14	Other or unspecified diseases of the respiratory system	666	4	128	214	0	29	124	0	1165	166
15	Other or unspecified obstetric conditions	469	132	0	140	21	32	63	0	857	122
16	Helminthiasis	280	148	67	1	72	134	90	0	792	113
17	Causes of abnormal pregnancy, childbirth and puerperium	781	0	0	0	0	0	0	0	781	112
18	Other or unspecified diseases of the digestive system	484	34	31	6	0	30	91	0	676	97
19	Other or unspecified infectious and parasitic diseases	280	51	74	45	0	11	163	0	624	89
20	Other or unspecified disorders of the genitourinary system	502	42	30	0	0	5	0	0	579	83
	G. Total	**20081**	**6750**	**1825**	**805**	**1003**	**819**	**2717**	**0**	**34000**	

Reviewed literature in relation to common pathogenic organism in water system revealed that, in developing countries drinking water is the major sources of pathogenic organism in addition to improper sanitation and unsafe food sources. The report continues that, worldwide1.7 million deaths recorded every year due to poor water qualities, sanitation and unhygienic condition that is resulting diarrhoeal disease infection. Among those deaths, nine out of ten are in developing region (Ashbolt, 2004; Ashbolt, 2015). The major pathogens for these deaths are including organism such as rotavirus, Campylobacter jejuni, Vibro cholerae, Cryptosporidium parvum, Shingella spp, Aeromonas spp and Escherichia coli are reported. Similarly, Clostridium difficile, Salmonella Enterica, Pseudomonas aeruginosa, Legionella pneumophila, Bacillus subtilis, Staphylococcus aureus and Klebsiella pneumonia are repeatedly reported as major waterborne pathogens in the water system (Andy, 2015; Ashbolt, 2015; Trusek-Holownia & Noworyta, 2014; Handley, 2013; Freije, 2005; Ashbolt, 2004; Website, n.d.). These pathogens can be controlled by disinfection process,

especially by chlorination in water treatment system, but their recontamination to the water system with those microorganisms is the main problem (Cloete et al., 2015; Ashbolt, 2004; Website, n.d). Therefore, above listed diseases in the area may be caused due to one of those organisms. As a result, we can say that low level of residual chlorine in the water supply and recontamination of water in the system are affecting public health in the area. Therefore, forthcoming work concerned about developing silver nanoparticles for antibacterial activities as a future direction in order to control those pathogens.

4. Conclusion and Recommendation

The results of the study indicate that the Koka Water Treatment Plant (KDWTP) at Adama town is complying with both Ethiopian national and WHO standards for drinking water with respect to bacteriological quality. Treated water quality continues to satisfy both the standards until it reach the first couple of reservoirs. However, the quality deteriorates stepwise starting from reservoirs, which does not receive treated water directly from the treatment plant. In its course, the treated water pass through TVO Reservoir (R-5), Dhaka-Adi Reservoir (R-6) and Abba-Geda Reservoir (R-7) before making way into the reservoirs. The drinking water quality in R1 and R2 ("Lugo-Reservoirs") which receive water directly from the treatment plant is good as far as microbial quality is concerned. Even the 3rd reservoir at Gelawudios (02 kebele reservoirs), that receives water from reservoir 1 and 2 is safe. It satisfies both national and WHO standards. However, reservoirs 5th, 6th and 7th which are farthest from the treatment plant and receive water from the reservoir 3 are not satisfying either of the standards. The alteration of microbial quality may be due to the low initial and reducing concentration of residual chlorine with distance. The physico-chemical quality of drinking water in those reservoirs shows that the concentration of residual chlorine is below the standard and varies with time. This seems to be the main reason for recontamination and also the leakages in the distribution system may be the cause for aggravating the problem. The contamination of reservoir-7 on the other hand may be due to both ambience and maintenance problems. However, contamination of water in reservoir-6 may be due to bird droppings in and around, opening on the top of the reservoir and declining concentration of residual chlorine. In case of R-5, the leakage observed in the bottom of the metallic reservoirs maybe the main reason for the re-contamination in addition to low residual chlorine concentration. In general, aging of pipeline, especially in kebele 09, 10, 13, and 15 are also other expected reasons for the contamination of water in the distribution system. However, the contamination at the user end point and distribution in kebele-01 and Tikur-Abbay might be due to illegal extension from the main pipeline and breakage of pipelines due to urban expansion work in the area. Generally, the study shows that 20.5% of water in the distribution system, 47.4% of water in the community storage and 25% of common community base points are contaminated with TCB. Similarly, 7.7% of water in the distribution system, 17.9% of water in the community storage and 8.3% of common community base points are contaminated with FCB. However, the most pathogenic bacteriological quality indicator organism E.coli is only re-appearing in community storage. Since waterborne diseases, such as diarrheal diseases and Pneumonia continue to be top ten diseases in the area, the impact of water quality (either source or contaminant) adversely affecting public health. Data taken from Adama town health office for the last five years (2011-2015) and collected data from all government health treatment centres revealed that both morbidity and mortality are dominated by waterborne and water related diseases. Those diseases include typhoid fever, Diarrhoea, Dyspepsia, Pneumonia, dysentery, acute upper respiratory infections, and other or unspecified diseases of the digestive and respiratory system are among top ten diseases. Public health in the study area has been affected by drinking water quality, mainly due to unhygienic handling. Additionally, illegal extension from main pipeline, infrastructural expansion impacts on pipeline, initial concentration of residual chlorine, pipeline aging, intermittent water supply and low level of public awareness in general are the main causes of water quality alteration. Water distribution by rotation is also seen as one of main reasons for the contamination. The distribution system will stay for 1-6 days without water promoting water contamination due to lower pressure in the pipeline. Apart from this, the water is stored for 1-6 days at individual storage points

encouraging water contamination with poor awareness of the community in water handling. Therefore, the discontinuities of supply due to supply and demand gap is also contributing towards diminishing water quality and imposing impact on public health.

In accordance with the findings of the study and reviewed literature the following recommendations were forwarded:

- The initial concentration of chlorination process has to be revised considering the distance between the treatment plant and reservoirs.
- Improvement of the ambience of all the reservoirs is recommended to reduce the contact of human and animal feces with water.
- Maintenance of residual chlorine levels in water is needed as per the WHO standards.
- Curbing the illegal extensions from main pipeline and pipeline breakage due to urban expansions.
- Introduction of integrated development plans for urban expansion and public health programmes.
- Improving local government and public participation in maintaining water quality through intensive and inclusive awareness programmes.

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