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Bacteriological and physicochemical quality of Jimma town water supply at pre and post distributed to Jimma town residents, Oromia regional state, southwestern Ethiopia

[1]Diriba Fufa, [1]Shiferaw Demissie and [1]Gadisa Natea

[1]Department of Biology, Jimma University, P.O. Box 378, Jimma, Ethiopia

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Abstract: Often, the quality of drinking/potable water has been a major health concern, particularly in developing countries, where 80% of the disease cases are attributed to inadequate sanitation and use of contaminated water. The aim of this study was to assess the bacteriological and physicochemical quality of Jimma town water supply. During this study, survey of sanitary programs applied by local water system supplier was conducted. Moreover, standard microbiological methods were carried out for determination of bacterial load and detection of coliforms, and also physicochemical analysis such as free residual chlorine, total dissolved solids (TDS), chemical oxygen demand (COD), turbidity and odour were conducted, accordingly. Results of this study indicated that, the turbidity of the water at site A and B had been a ranged from 1.0 – 1.22, 15.6-16.0 NTU(nephelometric turbidity units), dissolved solids 515 – 525, 1150-1250 mg/l, total hardness 118-134, 255-265mg/l, and free residual chlorine 0.31-0.53, 0 mg/l, respectively. Moreover, water samples collected from site B (Jimma town, i.e. from water pipes) were positive for coliform bacteria, which was ranged between 11-33 MPN (CFU/100 ml). In contrast, none of coliform bacteria detected from site A (at Jimma town water treatment plant). Generally, result of bacteriological and physicochemical study indicated that potable water used by Jimma town residents was beyond the maximum

tolerable level recommended by WHO. Thus, it calls for appropriate intervention and improving the existing methods of water treatments.

Keywords: Bacteriological, Jimma, physicochemical, potable water, treatment

INTRODUCTION

Water is very essential natural resource in the world and require for metabolic functions and homeostasis in living cells. The human body is composed of about 60% water by weight in adult males, 50% in females and 70% in new born infants[1].The human dietary requirement for water is estimated to be approximately two liters per day for an average adult[2]. The regular intake of adequate amount of water is essential in maintenance of good health and well-being[2]. However, the most important attributes of drinking water has to be assured and maintained is safety and quality[3] to insure that it is safe for human consumption.

It have been understood that potable water should be free from harmful contaminants, such as pathogenic microorganisms, toxic substances, physical and chemical residue, undesirable organoleptic properties like odor, color and taste[3]. Water borne illness could be occurring as result of water supply contamination by biological and chemical contaminants. In 2004, a waterborne illness outbreak affected 1450 visitors and residents in south bass island, Ohio[4]. In fatal *w*ater borne disease outbreak had occurred in Ontario, Canada, in May 2000, and 2300 persons became seriously ill and seven died because of water contamination with bacterial pathogens *Escherichia coli* O157:H7 and *Campylobacter jejuni*[5].

The United Nations general assembly has been declared period 2005 to 2015 as international decades for action, 'Water for Life' (WHO) [6]. The UN also recently announced that "safe and clean drinking water is human right essential to full enjoyment of life and all other human right" (WHO) [6]. Hence, provision of safe drinking water is paramount issue of health and development at Local, Nationals and International levels.

In spite of the importance and popularity of water, they have been understood as posing a risk for infection by some fast growing pathogenic microorganism[7]. Usually, water can be contaminated by different contaminants at various points either before treatment or after treatment. This includes water at the source of distribution and after it is distributed to the communities. Therefore, water should meet potable water standard by being free or limited to microorganisms, transparent, odorless, and tasteless liquid having freezing point of 0 °C and boiling point of 100 °C[7]. Thus, this study was designed to determine the bacteriological and physicochemical quality of Jimma town water supply at pre and post distributed to the town residents.

MATERIALS AND METHODS

Descriptions of the study area: This study was conducted at Jimma town, Oromia regional state, located at about 353 km to southwestern of Addis Ababa, the capital city of Ethiopia. The town has an altitude of 1740 m above sea level and has latitude and longitude of 7°, 39' N and 36°, 50' E, respectively. And also has annual minimum and maximum temperature of 13.2° and 28°, respectively and with annual average

rainfall of 152 mm. Jimma water treatment plant provides treated water to Jimma town residents. The treatment plant is found 5 km to the southeastern part of the town. The oldest one had been built in 1991 and produces 13,000 m^3 volume of water per day, while the newly constructed in 2015 was produces 21,000 m^3 water per day.

Sample collection: Stratified sampling techniques were carried out to sample water for bacteriological and physicochemical analysis[8].The sample was taken repeatedly from treated water at the source and distributed water. A 250 ml potable water sample was collected using sterilized, non-reactive borosilicate glass bottle.

Physicochemical characteristics of water samples: Physicochemical parameters of waters samples including pH, turbidity, total dissolved solids, color, odor, total hardness, chemical oxygen demand, temperature, and free residual chlorine were determined, accordingly.

pH: After stirred of about 250 ml potable water sample, it's pH was measured using pH meter (HANNA instrument, Portugal).

Turbidity: Turbidity was determined using the cell riser, which installed in the cell holder of model 2100A turbid meter in one of the two highest ranges (100 or 1000 NTU). A clean sample cell of turbid meter filled with 25 ml of each sample and covered with light shield and turbidity read in nephelometric turbidity units (NTU) [9]. Moreover, the temperature and chemical oxygen demand (COD) of water sample were measured using Thermometer and Wagtech photometer (POTALAB), respectively.

Free residual chlorine: Free residual chlorine is amount of chlorine residue left in the water after treatment. It was analyzed using Wagtech photometer.

Total hardness and dissolved solids: The presence of total hardness in water may affect its taste (WHO) [10]. For this reason, total hardness and total dissolved solids determined by Wagtech photometer for both sample types.

Bacteriological enumeration and analysis: From appropriate serial dilutions, 0.1 ml of the aliquot was seeded on Plate Count Agar (PCA)[11], MacConkey agar[12] ,Mannitol Salt Agar (MSA)[13] and incubated at 32°C for 48 h for count Aerobic mesophilic bacteria, Enteriobacteriaceae and *Staphylococci*, respectively.

Most probable number test for determination of coliform bacteria: MPN is the statistical multistep lab analysis based on assumption of poison distribution of number of coliform bacterial cell present in the water[14]. This was carried out using the three phases including Presumptive, Confirmed and Completed tests as described below:-

Presumptive test for coliform bacteria: Three sets of five tubes each in a test-tube rack were arranged. The tubes in the first set (S1) hold 10 ml of double-strength presumptive Mackonkey broth medium with inverted Durham tubes, while the tubes in the second and third sets (S2, S3) contain 10ml of single-strength presumptive medium with inverted Durham tubes. With a sterile pipette 10ml of water sample was inoculate into each of the five tubes in set one (S1), 1ml of sample to each of the five tubes in set two (S2), and 0.1ml of water sample into each of five tubes in set three (S3). All tubes had been shaken gently to distribute the sample uniformly throughout the medium. Then, the tubes were incubated at 37°C for 24-48 h. After incubated for 24h, each tube was examined for the presence of gas. A tube produced

gas considered as positive, while tube with no gas produced further incubated for 24 h. Then, number of the positive tubes were recorded, which was produced gas either after 24 or 48 and MPN was calculated according to MPN tables.

Confirmation test for coliform bacteria: From each presumptive positive tube (gas production), a loop full of bacterial culture was streaked onto Eosin-methylene blue agar (EMB), and incubated at 37°C for 24h. Nucleated small colonies (dark centers) surrounded with metallic sheen considered as *E. coli*.

Completed test for coliform bacteria: To differentiate *E. coli* from *Enterobacter aerogenes*, Indole test was performed. The sample from presumptive tube had been added into each tube of tryptone water. Then, approximately 0.1 ml of Kovacs reagent was added and mixed gently. Formation of indole and gas production indicated the presence of *E. coli* (APHA) [15].

Data analysis: Results are presented as mean ± SD. Percentage of coefficient variation (% CV) was calculated to see if there was significant variation in counts within the water samples analyzed. Mean values of water samples were compared using one way ANOVA ($P \leq 0.05$).

RESULTS

Jimma town water supply sanitation status: Overall, the Jimma town water supply manager and workers reflexed that potable water of Jimma town was poor due to ineffectiveness of treatment plant and deficiency of expertise (**Table 1).**

Table 1: Key sanitation elements implemented at Jimma town potable water supplier

Sanitation program elements	At Jimma town water supplier plant
Physicochemical parameters	Coagulation, Sedimentation, Filtration, Disinfection(chlorination) were performed
Bacteriological parameters monitored	None
Water sources	Seka Gibe River

Physicochemical characteristics of Jimma town potable water: Results of physicochemical characteristics indicated that turbidity 15.80, 1.02 NTU, total hardness 255-265, 118-134 mg/l, and chemical oxygen demand 16-18, 8-10 ppm were recorded from site B and A, respectively. Moreover, in both site (A and B) colourless and odourless water sample was observed **(Table 2).**

Table 2: Physicochemical characteristics of potable water, Jimma town, 2017

Parameters	Mean values of water physicochemical characteristics			
	Site "A"	Site "B"	WHO standard	National standard
pH	7.01 ± 0.9	6.4 ± 2	6.5-8	6.5-8.5
Color(TCU)	5	6	5-50	5-50
Odor	unobjectionable	unobjectionable	unobjectionable	Unobjectionable
Temperature (°C)	20 ± 2	28 ± 2	-	-
Turbidity(NTU)	1.02 ± 0.2	15.80	< 5	< 5
Chemical oxygen demand (ppm)	8 ± 2	16 ± 2	10	< 12
Total hardness as $CaCO_3$ (mg/l)	126 ± 8	260 ± 5	100-500	100-600
Free residual chlorine(mg/l)	0.51±0.2	0	0.2-0.5	0.2-0.6
Total dissolved solids(mg/l)	520 ± 5	1200 ± 50	< 1000	500-1500

Note:- Site "A" represents water sample taken from Jimma town water treatment plant,while site "B" water taken from Jimma town (water pipes). Values represent means from the three replicates ± standard deviation.

Bacteriological analysis of water samples: The result of this study indicated highest mean count of aerobic mesophilic bacteria (3.17 log $CFUg^{-1}$) and Enterobacteriaceae (2.04 log $CFUg^{-1}$) were recorded from site B. However, others microbial group such as Staphylococci and spore former bacteria were not detected from the both sites **(Table 3).**

Table 3: Mean of microbial counts (log $CFUg^{-1}$) from water treatment plant and pipes

Sample source	Microbial mean counts (log $CFUg^{-1}$ ± SD)		
	AMB	Entero	Staph
Site A	1.02 ± 0.03	-	-
Site B	3.17± 0.2	2.04 ± 0.05	-

Where: AMB = Aerobic mesophilic bacteria, Entero = Enterobacteriaceae, Staph, Staphylococci, SD= Standard deviation, CFU= Colony forming unit.

Determination of coliform bacteria: The result of MPN has shown that none of coliform bacteria were detected from Site A (at water treatment plant) (**Table 4**), while at site B (from water pipes), among a total of 12 water samples had been examined, 9 water samples were positive for coliform bacteria, in which growth of bacteria, gas and acid production were observed (Table 5). Furthermore,

nucleated small colonies" (dark centers) with metallic sheen were indicated onto EMB agar, and also indole and gas production in Tryptophan medium was showed.

Table 4: Values of MPN per 100 ml of water sample (10, 1, 0.1ml test portion were used) at Jimma town water treatment plant (at source of distribution)

		No. of tubes giving positive reaction at treatment site			MPN (per 100ml)	95% confidence limits	
Sampling Time		**5 of 10ml**	**5 of 1ml**	**5 of 0.1ml**		**Lower**	**Upper**
Morning	S1	0	0	0	< 2	0	5.9
	S2	0	0	0	< 2	0	5.9
	S3	0	0	0	< 2	0	5.9
Evening	S1	0	0	0	< 2	0	5.9
	S2	0	0	0	< 2	0	5.9
	S3	0	0	0	< 2	0	5.9

Where: S- stand for sample.

Table 5: Values of MPN per 100 ml of water sample (10, 1, 0.1ml test portion are used) for water sample at Jimma town (From water pipes)

		No. of tubes giving positive reaction at Jimma town (after distributed for residents)			MPN (per 100ml)	95% confidence limits	
Sampling Time		**5 of 10ml**	**5 of 1ml**	**5 of 0.1ml**		**Lower**	**Upper**
Morning	S1	4	2	0	22	6.8	67
	S2	4	3	1	33	11	90
	S3	3	2	1	17	5	46
Evening	S1	3	2	1	17	5	46
	S2	3	1	1	14	4	34
	S3	3	1	0	11	2	25

DISCUSSION

Drinking water is a live, not sterile by its nature. It have been realized that potable water should be free of biological and chemical contaminants. Thus, both its physicochemical and bacteriological standard should meet WHO standard. In the current study, the physicochemical and bacteriological qualities of Jimma town potable water at the treatment plant and after it is distributed was assessed. The study was targeted to compare bacteriological and physicochemical quality at the treatment site and after it is distributed for consumers with WHO standard and Ethiopian drinking water standard (National standard).

Often, the water is collected from the source (Seka Gibe River) using pump, and treated. Thereafter, it is distributed to residents through pipes lines. In terms of water treatment and disinfection, the

methods employed were coagulation by addition of aluminum sulfate, filtration and chlorination. In both cases at treatment plant as well as in pipes, bacteriological monitoring was not applied, which may be due to deficiency of resources (materials), and bacteriological techniques. Thus, potable water of Jimma town could be exposed to human pathogenic microorganisms. As a result, it is difficult whether it's safe for drink or not as a context of biological quality. In addition there was also no inspection of the pipe from time to time, which might be seep slowly into underground water pipe, thereby polluting it.

Furthermore, long lasting usage of water from Seka Gibe River may lead to deterioration of the water quality, because the pipeline may become corroded with random cracks and in most cases clogged with sediment[16]. This could allow the passage of inorganic metals and bacteria. The founding of this study directing that there is a the possibility of the presence of pathogens that may cause acute intestinal illness, which are generally considered discomfort to health, particularly to immunocompromised groups (such as infants, pregnant, elderly and those who are sick) [17].

The result of physicochemical analysis of water showed that the pH of the water samples taken from Jimma town (site B) couldn't accordance with standard requirements. Their values are less than the lower limits of the pH (6.5) recommended by WHO, which determine the physicochemical characteristics of waters [18].

Total dissolved solids (TDS) is used to describe the inorganic salt and small amount of organic matter present in water, which its presence may affect the taste water[9] (WHO, 1996). Although in the current study the TDS of Jimma town potable water within the range of National standard, it was inflated beyond the WHO standard, which has been shown from 1150- 1250mg/l. It has been indicated that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste[10]. Moreover, its turbidity was not with WHO and National standard. Water turbidity is very important because high turbidity is often associated with higher level of toxic chemical, heavy metals and disease causing microorganism and parasites[19]. All the water samples analyzed in this study have unobjectionable odor and color which is in agreement with the standard color of 6 TCU and 5TCU by WHO (WHO) [20].

In the present study, the mean total counts of AMB (3.17 $CFUg^{-1}$), and Enterobacteriaceae (3.17 $CFUg^{-1}$) were observed from water sample taken from pipes, while insignificant amount of bacterial load detected from treatment plants. The increment of these bacteria load at site B could be because of the leakage and getting old water pipes, which is greater than earlier result of drinking water of India[21]. But, lower than the earlier report from Awetu River cross the Jimma town[22], as they indicated AMB 4.1-6.8, and Enterobacteriaceae 3.91-5.59 log $CFUg^{-1}$.

The coliform counts of water taken from Jimma town (site "B") were generally not fit (i.e.11- 33MPN (CFU/100 ml) with that of WHO and National standards of drinking water. It have been exceeded the standard requirement of 10 coliforms count per 100 ml for national standard and zero coliform count per 100 ml for WHO (WHO, 2002)[23]. High coliform counts indicate that the potable water of Jimma town could be fecal contaminated, which also a risk for pathogenic microorganisms (i.e. *Salmonella*, *Campylobacter* spp.) and parasitic organism such as *Giardia* and *Cryptosporidium* may be present[19]. Thus, it needs regularly treatment and inspection.

Nevertheless, water samples taken from treatment plant (site "A") were negative for coliforms. This indicated that, the water at treatment plants safe from microbial as well as its physicochemical contaminants. But, after it was distributed into Jimma town its physicochemical and bacteriological qualities were deviated from the normal standard recommended by WHO and National standard of drinking water. This was due to the fact that there were no proper and adequate inspections of the

water pipe lines as well as the distribution system regularly starting from the treatment plant to the consumers end.

On the other hand in this study, no *E. coli* were detected from site 'A' (at treatment plant), which indicates that all the water samples are free from faecal contamination. However, the water sample taken from Jimma town has been shown *E.coli*. Undoubtly, detection of coliform bacteria and physicochemical characteristics of potable water is a crucial because of the determinant indicator of faecal, pathogenic microorganisms and toxic chemicals/elements contamination of drinking water that greatly danger for public health. In conclude, the physicochemical and bacteriological value of Jimma town pipe water is beyond the maximum tolerable limits recommended by WHO standards. Thus, it needs immediate inspection by concerned body.

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*** Corresponding author: Shiferaw Demissie,**

Department of Biology, Jimma University, P.O. Box 378, Jimma, Ethiopia

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