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RESEARCH ARTICLE

Sanitary Survey and Drinking Water Quality Performance of Treatment Plant: The Case of Dilla Town, Ethiopia.

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Abstract

Background: Drinking water treatment is considered as a critical challenge especially in developing countries since this treatment is an essential facility to conserve the public health and environment by eliminating pathogens of the waterborne diseases. This study was conducted to assess the sanitary risks associated with quality of drinking water sources (surface water and 8 deep boreholes) in Dilla town and performance evaluation of Dilla town water treatment plant.

Methods: The comprehensive sanitary survey was conducted from October to November 2019 on 9 community drinking water supply sources in Dilla town. Sanitary inspection using observational checklist, secondary data analysis and in-depth interview were conducted. Significant risks were identified in all the investigated water sources. The treatment units have been assessed based on observation and laboratory tests.

Result: Most of the physicochemical parameters were within the World Health Organizations (WHO) acceptable drinking water guideline range except for iron (0.73 mg/l) and Turbidity (6.17 NTU) from Hostel Deep borehole site which were above the guideline limit and the bacteriological water quality analysis indicated that the water treated from Lege Dara surface water treatment and two deep boreholes (Chichu number one and Millennium borehole) sites have bacterial load of 5, 47 and many to count Colony Forming Unit respectively, which violets the WHO's bacteriological drinking water quality standard. Possible sources of pollutants were identified in all the water sources and human activity was the main reason for the risk.

Conclusion: Human activities could be a potential source for pollution. Physicochemical and bacteriological test results of raw water were moderately of poor quality, while the treated water was relatively satisfactory. Based on the risks identified, this study suggests that the units and process operations need to be improved, rescaled, and re-designed to enhance safe and adequate water supply to the town.

Keywords: Dilla Ethiopia, Sanitary survey, Treatment plant performance, Water supply

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Background

A sanitary survey is an on-site evaluation of the water source and its adequacy, facilities, equipment, operation and maintenance of a public water system and its capability for producing and distributing safe drinking water. It is an essential element of an effective primary enforcement (primacy) agency Public Water System Supervision (PWSS) program. A sanitary survey provides a snapshot of the operating status of a public water system which can help evaluate the status of a system. Well-executed and documented sanitary surveys are fundamental to helping the Public Water System Supervision PWSS program ensure that a water system is providing safe drinking water and protecting public health [1,2]. More generally, water quality monitoring can allow water managers to identify contamination events, take corrective actions when needed, and close high-risk water sources. Water quality monitoring thus constitutes a crucial tool for water safety management [3,4].

Access to safe and continuous water supply is an essential prerequisite for health, and poor water supply which is usually contaminated with fecally transmitted microbial pathogens associated with significant health risks [5,6].Ethiopia is among the few countries where such problems have clearly manifested. Health is highly influenced by water and sanitation related diseases [1]. According to [7] the majority (67%) of the respondents was less than 20 liter per capita per day which is under the recommended standard 20-50 liter of safe water.

Information about water quality can be used to manage the safety of water sources. While regulatory structures often exist that specify the responsibilities of health or water surveillance agencies to test water sources, institutions in developing countries especially in Sub-Saharan Africa region often have limited capacity to carry out these responsibilities [6,8,9].

Water quality testing is expensive and complicated: collecting and testing water samples requires labor, equipment, consumables, transportation, and training [10–13]. Given the large amount of resources required for testing water quality, there is a need to improve its cost-effectiveness. Alternative approaches for identifying high-risk water supplies such as sanitary surveys, which are observational checklists for identifying potential hazards, have been promoted by environmental health specialists and the World Health Organization (WHO) [14].

In most countries, including Ethiopia, institutional responsibilities for water quality monitoring are established by national regulations or guidelines. These responsibilities generally fall into two categories: (1) operational monitoring (or water quality control) by water suppliers; and (2) surveillance (or compliance) monitoring by an independent agency, usually responsible for public health. However, in Sub-Saharan Africa, actual testing levels by these institutions often fail to meet regulatory requirements, potentially due to institutional, personnel, and economic constraints [15–17].

This importance of water quality data is reflected in the framework that is proposed by the WHO/ UNICEF Joint Monitoring Programme (JMP) to measure progress toward the United Nations' post-2015 Sustainable Development Goals (SDGs) for drinking water, namely SDG target 6.1, which specifies universal and equitable access to safe and affordable drinking water for all by 2030.Consequently, information about drinking water quality is essential for guiding efforts to reduce waterborne illnesses: accurate water quality data identifies high-risk water sources, determines effective water treatment methods, and contributes to the evaluation of water and sanitation improvement programs [14]. Despite the water quality and water quantity problems in Dilla town there is no or little evidence that can link the quality and quantity of water sources and the treatment efficiency with public health risks. Therefore, this case study was conducted to assess the sanitary risks associated with quality of drinking water sources (surface water and 8 deep boreholes) in Dilla town and to determine the efficiency of Dilla town water treatment plant (DTWTP).

Methodology

Study design and setting

A case study was conducted in Dilla town, which is located in Southern Ethiopia at a distance of 359 km from the capital city, Addis Ababa, on the way from Addis Ababa to Moyale. It is located at $6^o22'$ to $6^o42'$ N and $38^o21'$ to $38^o41'$ E longitude with an altitude of about 1476 m.a.s.l. [7]. The town's water supply represents an annual consumption of 494,164 m^3, in 2018 which was collected from ground water (70 %) and surface water (30%) sources [17].

The town is bounded by Lega Dara, Walame and Chichu rivers. Currently, water is supplied to the town from two different sources. The first one is Lege Dara River and the other source is ground water from which eight boreholes are developed. The data obtained from Dilla Town Water Supply Service Enterprise (DTWSSE) showed that the production capacities of the boreholes are 8 liter per second (Millennium), 6 liter per second (Chichu number 1), 6 liter per second (Chichu number 2), 5 liter per second (Chichu 3), 8 liter per second (HiwotBirhan), 5 liter per second (Mengesha), 6 liter per second (Hostel) and 6liter per second (MaremyaJerba). In addition, there are 36 public stand pipes in the different parts of the town that supply water for those households that do not have access to piped connections [18].

Process Description

The plant is constructed as a conventional water treatment plant, where six essential processes were applied starting from aeration followed by screening, coagulant mixing, sedimentation, filtration and ending with disinfection. The water from 8 deep boreholes is pumped from the each site directly to the central two reservoirs and finally will be distributed to residents without any treatment. Only the water from LegaDara River is treated only to join the untreated water which will be distributed to the public [19].

Intake: The Lega Dara River is diverted and first encountered with an aeration unit followed by a screening bar each of 400 mm collect raw water to the plant from nearby channel. The draw of intake water is made by the force of gravity and no pumping mechanism was utilized.

Rapid mixing: There is no rapid mixing during the addition of aluminum sulfate to the incoming water.In this stage alum (aluminum sulfate) is added at the incoming raw water by the action of gravity and it will be mixed by itself. The raw water is not coagulated continuously with alum in flash mixer tank with a specific retention time.

Sedimentation: Dilla town's water treatment plant has a rectangular sedimentation tank with a depth of 2 m width 8 m and length 19.3 m. The detention time in the sedimentation tank for Dilla town's water treatment plant is one to two hours. The amount of added alum at this stage is 10-20 kg/day depending on the level of turbidity of the incoming raw water.

Slow Sand Filtration: Dilla town's water treatment plant has two slow sand filter chambers with a length of 13.6 m and 7.74 m width with an area of 105.3 m^2 each, which are used alternatively when one sand filter is clogged. Therefore, assuming a production of 8 liter/second of the plant the filtration rate of the slow sand filter will be approximated to $6.83 m^3/d.m^2$.

Disinfection: After filtration stage, the water passes to the disinfection room located behind filters. Here, the chlorine is added before the storage and distribution of treated water.

Storage and other Facilities: DTWTP is equipped with two elevated water storage tanks (200 and 500m^3) capacity. The plant contains also secondary buildings, stores, water distribution pumping units and other parts.

Sample Collection and Analysis

Samples from deep boreholes and from the final treated surface water (Lega Dara River) reservoir were directly collected from their outlets. Taps at the final treated surface water (Lega Dara river) reservoir tanks were sterilized with a flame before sample collection. Water samples were collected in 100 ml glasses and put on ice for transport to a laboratory located at the Gedeo Zone Water and Energy laboratory and tested within 3hours. Laboratory measurements for physicochemical and bacteriological tests were carried out according to the standard methods [20].

Samples from boreholes were collected by drawing from a sterilized pipeline that had been wiped with ethanol and rinsed with deionized water and put in the vaccine cold box before it was transported to a laboratory located at the Dilla town, Gedeo zone Department of Water and Energy. Bacteriological parameters were counted after 24 hoursof incubation. Physico-chemical parameters were tested within 20 minutes.

Samples were assessed for E. coli, using a Compact Dry growth plates. The microbiological tests were incubated at 35^oC for at least 24 hours using electric incubators. After incubation, the visible colonies (or colony-forming units, CFUs) were counted. Each 100 ml test result is thus expected to be about 100 times higher than the 1 ml test result. When teams found more than 100 colonies on a growth plate, the results were reported as "> 100" or as 'any to count'. We quantified TTC counts using the membrane filtration system and calibrations for the equipment were performed before the procedure began.

For the surface water sources which undergone aeration, screening, coagulation sedimentation filtration and disinfection, we used the design criteria set by different literature to assess the effectiveness of their performance on removal of impurities. We used secondary data from Dilla town Water supply enterprise and in-depth interview was used to assess the amount of monthly water distributed, production capacity, water demand and consumption.

Sanitary Survey Assessment

A sanitary survey was conducted for each selected water source. The sanitary survey questionnaire relied on a list of observations, unique for different water source types. We used the sanitary survey observational checklist in the WHO Guidelines for Drinking Water Quality (GDWQ) for boreholes [14]. Accordingly the risks are given risk scores and further categorized as '**high risk**' for risk scores > 9, '**High**' for risk scores 6-8, '**Moderate**' for risk scores 3-5 and 'low' for risk scores 0-2 [14].

Population Estimation and Water Demand

The population was approximately 100,000 in 2016 and by taking a growth rate of 2.8% the total population of Dilla town is estimated to be 108,637 for 2019 [18] and 45liter/c/day [21] was considered the individual level water demand for the water demand calculation. Water treatment plant (WTP) capacity is always based on the real population of the city being served. In our case, to estimate the needed capacity of DTWTP, the current estimated population size and water production rate were used to measure the water treatment capacity.

Result

Dilla Town Water Supply System

The town has an intermittent type of water supply system where residents get water once a week in most kebeles and twice a week in some villages. The data obtained from Dilla town Water Supply Service Enterprise showed that the total production capacities of the boreholes and surface water were 60 liter/second (Table 1). The maximum production of potable water supply for the town was from Laga Dara River which was 10 liter/second and the minimum production from Chichu number 3 and Mengesha borehole 5 liter/second each. Annual production capacity from all the water sources *i.e*, from eight boreholes and Laga Dara River was 1,019,664 m^3 per year. But since most of the time there is a power shortage in most of the source sites the above figure is somewhat hypothetical and is lower than the actual potable water production. The actual water distributed and revenue is collected for only 494,164 m^3 of water per year in 2019 [7,19].

Table 1 Production Capacity and Service Hour of Dilla Town Water Source, 2019

Water source	Production capacity in Liter/second	Total production per year in m^3	Service hour within 24 hours
Millennium	8	168,192	16
Chichu 1	6	78,840	10
Chichu 2	6	78,840	10
Chichu 3	5	39,420	6
HiwotBirhan	8	168,192	16
Mengesha	5	65,700	10
Hostel	6	47,304	6
MaremyaJerba	6	110,376	14
Lagadara River	10	262800	20
Total	60	1,019,664	

Dilla Town Water Treatment Plant (DTWTP) Capacity Assessment

Dilla Town Water Supply Service Enterprise report of 2019 showed that the total water supplied was 494,164 m^3/year, which was 1353 m^3/day. The current DTWTP capacity to supply potable water is, surely cannot compete the growing population in Dilla town, as it was established about 30 years ago. The required capacity for DTWTP was estimated in depending on the contemporary situation of the city using the methods mentioned in section 2.5. Table 2 illustrates the current and required capacity for DTWTP to provide potable water for Dilla Town residents. The required capacity was calculated as follows. The total number of Dilla town population according to recent estimation is about 108,637 capita. For the proposition of water consumption per capita of 45liters per capita per day, the required maximum capacities were calculated on this basis as demonstrated in table 2.

Table 2 Current and Required DTWTP Capacities

Current Capacity Q (m^3/day)	Average Capacity av. Q_{req}(m^3/day)	Maximum Capacity Max Q_{req}(m^3/day)	Actual water demand (m^3/day)
1353	-	2793.6	4888.6

Performance Evaluation for Aeration at DTWTP

As shown in figure 1, the aeration unit in Dilla town water treatment plant has only two cascades with a step height and step length and step width of 0.65 m, 1.4 m and 0.78 m respectively. The aeration process also comes before the screening chamber which can affect the efficiency of the aeration process. A result in a study [22] indicates that the increment in dimensions of tread leads to good aeration improvement in all kinds of flow rates. Even the same trend was found in both qualities of water. Comparatively better aeration efficiency is found out with 0.6 m tread length than the water treated with lesser treads. The range of average aeration efficiencies for different the ratio of tread and height(t/h) combination varies from 0.28 to 0.34 and 0.30 to 0.40 for Potable water with chemical and Potable water without chemicals respectively.

Moulick *et al.*, 2010 [23] conducted experimental study on aeration performance of a rectangular stepped channel system with a height of 3.00 m. The study provides that 90 % of aeration is achievable if cascade system consists of 14 steps for a hydraulic loading 0.009 $m^3/s/m^2$ with a slope of 0.35118. However, Dilla town water treatment plant aeration has only two steps which are lower than the recommended number for cascade aerator to function properly.

Figure 1 Dilla Town Water Treatment Plant Aeration System

Coagulation and Flocculation

The coagulant used in water treatment for Dilla town water supply is Alum (aluminum sulfate). The Coagulation is not as efficient as expected because the chemical is not dispersed rapidly throughout the mixing tank. There is a mixing section for coagulant and the water will be allowed to pass to the next or to the sedimentation tank without proper mixing. The dimension of the mixing chamber is 2.5 m (length), 2.5 m (width) and 2.16 m (depth). According to Baruth, 2005 [24] several factors affect the type and amount of coagulating chemicals required, including the nature of suspended solids and the chemical characteristics of the influent water. The amount of alum added depends on raw water turbidity and the result of Laboratory Daily Jar test, a system which is absent at DTWTP. There is no flocculation in Dilla town's water treatment plant since there is no mixing or propelling of the coagulant with the water. For optimal output, the findings of Davis, [25] recommended that for conventional treatment where settling follows flocculation, the flocculation time must range from 20 to 30 minutes.

Performance Evaluation for Sedimentation Basin at DTWTPS

Dilla town's water treatment plant has a rectangular sedimentation tank with a depth of 2 m width 8m and length 19.3 m. Unlike wastewater treatment units, longer detention times tend to affect more solids removal in water treatment, in primary sedimentation. The detention time in the sedimentation tank for Dilla town's water treatment plant was 1 to 2 hour, but the time extends to three hours depending on turbidity of the raw water. It is quite clear that the current performance for sedimentation basins at DTWTP cannot deliver the needed quantity and quality of treated water to the next filtration step in the plant. The present performance of the flocculation and sedimentation basin is not satisfactory as the handled water operating volume in sedimentation basin is not as required to be for the working condition with existing dimensions.

The need to supply the minimum necessary outlet water quantity affected the performance basins, where short and non-appropriate retention time was used which was from 1 to 2 hour. To overcome these obstacles the number of flocculation and sedimentation basins at DTWTP need to be increased and reformed. Additional sedimentation basin must be installed to be more suitable for the existing condition of water treatment capacity and quality at Dilla town.

Performance Evaluation for Slow Sand Filtration Basin at DTWTPS

Dilla town's water treatment plant has two slow sand filter chambers which have a length of 13.6 m and 7.74 m width and an area of 105.3 m^2 each, which are used alternatively when one sand filter is clogged. Therefore, assuming a production of 8 liter/second for 20 hours a day, the filtration rate of the slow sand filter was approximated to $6.83m^3$ $/d.m^2$. Even if the filtration rate is in the normal range according to literatures [26], the capacity of the slow sand filter was not in a position to deliver the required effluent discharge that can address the towns' water supply needs.

Performance Evaluation for Disinfection Process at DTWTPS

For Dilla town water treatment chemical disinfection method (chlorine solution) is used to disinfect the pathogenic microorganisms. Dilla town water treatment plant disinfection chamber is rectangular in shape and has a dimension of 3.4 m width 7 m length and 2.4 m height. There is a separate manual chlorine dose preparation that can continuously feed the treated water from the slow sand filter. The dosage of chlorine is based on the pump capacity, not based on the actual amount of water treated. Sodium Hypochlorite is added before the storage and distribution of treated water. After the disinfection step, water is ready to be pumped into the storage facility. In addition, on-site water quality testing laboratory facilities were lacking and the effect of pH and temperature, on the disinfection process were also not assessed and recorded. The other most prominent issue regarding the disinfection process for DTWS is only the treated water from Laga Dara River is disinfected before joining the central storage facility. Whereas the water from all the 8 ground water sources join the central reservoirs without any chlorination. This is a practice which compromises the safety of the water by reducing residual chlorine which must be available in the distribution line. Different findings suggest that the amount of chlorine required for a particular water sample during chlorination depends on the impurities present in raw water and the process of disinfection is measured by the characteristics of disinfectant, microorganism and environmental factors [27] and subsequently, the effectiveness of this process depend on raw water quality; disinfectant dosage; disinfection types; and contact time [28].

Storage Facilities

Water from all the ground water sources without any treatment and the treated water from Lege Dara River will be pumped to two central storage tanks with a capacity of 200 and 500 m3 in the outskirt of the town located in Dama secondary school. The storage facility is located in outskirt of the city with an elevated site where it will be ready for distribution to the town by the force of gravity.

Sanitary Survey for Surface and Ground Water Source

Dilla town's water treatment plant located across Laga Dara River and surrounded by residents of Gedeo and Sidama zone as shown in figure 2. There is an ongoing pollution risk from the community since the river in upstream is being used for different human activities such as bathing and other purposes which could be a potential source for pollution by human excreta, urine, animal and domestic wastes, soaps and detergents, pesticides and fertilizers. This could be potential sources for microbial contaminations. The greater risk of contamination is most likely to be with microbiological pathogens from human and animal excreta. The activities of upstream users of the river water would affect the quality of the water for downstream users and the existing treatment efficiencies. Because the treatment may not be targeted to all types of pollutants except for common ones.

Figure 2 Human Activities in the Upper Stream of Laga Dara River, Dilla Town

The absence of regular maintenance of pipes and fixtures at ground water sources and at distribution systems can compromise the safety of drinking water. Since the infrastructure is typically underground, the town and the zonal water supply agencies must usually do a proper review of schematics, operation and maintenance records, operating procedures, construction standards, and distribution system water quality data. It was observed that almost all bore holes have a common problem (Figure 3); the misuse of water, through high leakages. Some were outdated; due to this they had been giving a very low volume of water discharge.

Figure 3 Typical Borehole as Water Source of Dilla Town

The finding from the observational sanitary survey indicated that only 'Millennium' and 'Hostel' boreholes were in low risk categories while the borehole at 'MaremyaJerba' was found to be a high risk water source and the rest were in the medium risk level. It was observed that almost all groundwater sources share common defaults specially leakages.

Table 3 Sanitary Survey Questions for Boreholes Adapted from the WHO Guidelines for Drinking Water Quality [14].

S/N	Specific Diagnostic Information for Assessment Risk	Water source							
		1	2	3	4	5	6	7	8
1	Is there a latrine or sewer within 100m of pump house? Y/N	N	Y	Y	N	Y	Y	N	Y
2	Is the nearest latrine unsewered? Y/N	N	Y	Y	N	Y	Y	N	Y
3	Is there any source of other pollution within 50m? Y/N	Y	N	Y	Y	Y	N	N	Y
4	Is there an uncapped well within 100m? Y/N	N	N	N	N	N	N	N	N
5	Is the drainage around pump house faulty? Y/N	N	N	Y	N	N	N	N	Y
6	Is the fencing damaged allowing animal entry? Y/N	N	Y	N	N	N	N	N	Y
7	Is the floor of the pump house permeable to water? Y/N	Y	Y	Y	Y	Y	Y	Y	Y
8	Does water forms pools in the pump house? Y/N	N	N	Y	N	N	N	N	Y
9	Is the well seal insanitary? Y/N	N	N	Y	N	N	N	N	Y
	Total Score of Risks …./9	2	3	6	3	4	3	1	8
	Risk Category	L	M	M	M	M	M	L	H

The factor present poses a risk; the factor not present means that risk factor does not exist. 1=Millennium DBH 2=HiwotBirhan DBH 3=Mengesha DBH 4=Chichu 1DBH 5= Chichu 2DBH 6= Chichu 3DBH 7=Hostel 8=MaremyaJerba L=Low risk M= Medium Risk H=High Risk

Water Quality Analysis

Treatment processes has removed most of undesirable constituents from raw water, wherein Table 5 it can be found that turbidity and total dissolved solids are mainly removed in Dilla town water treatment plant by sedimentation and filtration processes. Chlorination is applied to disinfect water and to produce the recommended residual reaching the consumer through the distribution systems. The chlorination in Dilla town water treatment plant was not effective to sanitize the supplied drinking water to prevent any possibilities of waterborne diseases and contamination that may occur at the outlet. Since, the dosage of the disinfection process only considers the amount of water from the treatment plant; the ground water or the deep boreholes that is pumped from different sites were found to finally join the water from the pumping sites without disinfection. This will significantly affect the final microbial quality of water and the residual chlorine concentration. In addition, the contact time, effect of pH and temperature of the disinfection process is not well established and not recorded. WHO, 2006 [27] had recommend that the residual chlorine of 0.6-1.0 mg/l as standard. Even though we didn't measure the residual chlorine in our study using the presence of 5 CFU in the final treated water as s proxy indicator, we can conclude that the residual chlorine is below the recommended level. And since 70 % of the water from the ground water source is also not chlorinated before distribution, it will clearly indicate that the there is no residual chlorine for the distribution line for Dilla town. According to [28–30] the residual chlorine concentration in the water below 0.6 mg/l is inadequate for disinfection and this might result in recontamination of the distribution system.

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Bacteriological Analysis

Three ground water sources namely (Hiwot-Birhan, Mengesha and MaremyaJerba) were not functional at the time of data collection. Therefor these water sources were not considered for laboratory analysis of water quality in the study. Out of the rest six water sources four samples were taken for water quality analysis and three of them were positive for bacteriological analysis. The concentration detected in water samples were 5 cfu/100ml in Laga Dara surface water (after the treatment process), many to count in millennium borehole and 47 cfu/100 ml in Chichu #1 borehole. Therefore, the counts of colony forming units were beyond the recommended value of WHO (0 cfu/100ml of sample). Only Hostile borehole sample met the recommended limit, 0 cfu/100 ml. However, the pH of all water sources was within the acceptable limit of WHO (6.4-8) (Table 4). The potential sources for microbial contamination in surface water/treatment plant/ could be ongoing pollution risk from the community since the river in upstream is being used for different human activities (Figure 3). The greater risk of contamination is most likely to be with microbiological pathogens from human and animal excreta.

Table 4 Bacteriological Analyses of Drinking Water Sources of Dilla Town, 2019

Kebele	Village	A sample collected	Risk level	CFU/100ml	pH
Woldena	Laga dara	Largadara /Rx plant/	-	5	6.8
Woldena	Laga dara	Millennium borehole	Low	MTC	7.4
Woldena	Dama school	Chichu #1 borehole	High	47	7.6
Hasedela	Hostel	Hostile borehole	Low	0	7

MTC=Many to count

In a combined analysis of sanitary inspection and water quality data as presented in table 10, Chichu #1 borehole had ‘high risk’ score and the Hostile borehole has a ‘Low risk’ score classification. The sanitary survey result was in agreement with the bacteriological test result. Chichiu #1 borehole is classified as high risk because it was mainly surrounded by residents’ and there was a source of pollution (latrine) within 50 m radius, and leakage in the pipeline. However, the finding from the sanitary survey and the bacteriological test was different for Millennium borehole. It was classified as ‘low risk’ water source on the sanitary survey but it was found to contain many to count colony forming unit per 100 ml in the bacteriological test. The survey indicated that the Laga Dara River is nearby to Millennium borehole and the pollution mainly through infiltration was the main risk source identified for the presence of bacterial load in the area. The presence of excess bacterial load in low risk water source is a clear indication that sanitary surveys using only physical observation alone could be misleading and must always be accompanied by laboratory investigations to generate data for sound decision making.

Physico-chemical Analysis

Physico-chemical analyses summarized in table 5; pH, conductivity, temperature and, TDS of all water sources were within acceptable limit of WHO standard. However, the turbidity of hostel borehole greater than the WHO standard (< 5 NTU) which was 6.17 NTU. In addition, mineral and gas in the water sources such as; potassium, manganese, nitrate, nitrite and ammonia were within the acceptable limit of WHO. But, Iron content of hostel borehole was above the WHO acceptable limit (0.3) which was 0.73.

Table 5 Physico-chemical Analyses of Water Sources of Dilla Town, 2019

S. No.	Parameter	Water Sources: Laga dara surface water	Millennium Borehole	Chichu-1 bore hole	Hostel borehole	WHO Standard
1.	Potassium, mg/l	1.8	10	0.05	6.4	10
2.	Iron (II) ion, mg/l	0.09	0.24	0.17	0.73	0.3
3.	Fluoride, mg/l	0.08	1.22	0.66	0.38	1.5
4.	Manganese, mg/l	0.03	0.017	0.02	0.027	0.1
5.	Nitrate ion, mg/l	3.20	0.8	1.26	0.86	50
6.	Nitrite ion, mg/l	0.01	0.02	0.01	0.01	3
7.	Ammonia, mg/l	0.042	0.516	0	0	5
8.	pH	6.8	7.4	7.6	7	6.5-8.5
9.	Conductivity, ms/cm	2.75	17.37	9.75	8.2	500
10.	Temperature, ^{o}C	28.6	28.1	25.6	29.1	25-30
11.	Turbidity, NTU	0.33	3.83	1.08	6.17	5
12.	TDS, mg/l	1.375	8.685	4.875	4.1	1000

Conclusion

These sanitary survey findings showed that both surface and ground water sources were in general are not safe in terms of bacteriological quality but relatively better in terms of physico-chemical aspect. Capacity assessment of Dilla town water treatment plant including the ground waters indicated that with the current potable water production rate the town water supply enterprise could not achieve the current demand and major alteration needs to be made in the DTWTP construction to overcome the huge increasing demand on the water supply now and for the coming years.

The final performance of the water treatment units is not efficient to provide the right reduction in amount of bacteriological water quality for the town. Therefore the right treatment units along with the designs must be installed.

Even if disinfected water sources are better than non-disinfected water sources, the treatment plant was found at levels of 5 CFU per 100 ml which is above WHO and National standards (CFU/100 ml= 0).

The result of the sanitary survey for the ground water sources was in line with the sanitary risk scores except the ground water sources at Millennium borehole. The sanitary risk score was low yet it was found bacteriologically not safe. Therefore future sanitary surveys must not only rely on the observational assessment only. The sanitary survey must be supported by laboratory analysis.

Assertions

Abbreviations

CFU	Colony Forming Unit
DTWTP	Dilla Town Water Treatment Plant
JMP	Joint Monitoring Programme
MTC	Many to count
NTU	Nephron Turbid Unit
SDG	Sustainable Development Goal
TDS	Total Dissolved Solid
WHO	World Health Organization

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Ethical concern:
Before we conduct the survey we have a written supportive letter from the University for Permission to all the concerned bodies.

Consent for publication: not applicable

Availability of data and materials: The datasets underlying the study are available from the corresponding author

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Gelaneh Kusse Korita, and Misganaw Yigzaw Gebeyehu involve on data collection and taking water samples. Birtukan Getahun, Mengistu Abate, Tariku Figa Ana and Belay Negassa primarily conduct the bacteriological and physico-chemical analysis

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