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Quality of Portable Groundwater and Its Implications for Health and Livelihood in Jigjiga City, Somali Regional State of Ethiopia

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ABSTRACT

Background: Ethiopia being one of the developing countries, with majority of communicable diseases is attributed to poor environmental condition as lack or poor-quality water supply, hygiene and sanitation and around 80% and 20% of rural and urban have inadequate access to safe water. The present study focused on the groundwater quality and its role on health and livelihood among adults in Jijiga town.

Methods: The groundwater quality was analysed by collecting water samples from the seven kebeles and to understand the role of groundwater quality on health and livelihood we developed a structured interview schedule. Further, the descriptives of the responses were analysed to get an insight on the disease's occurrence in family and frequency in community along with awareness and the reported influence on the livelihood aspects.

Results: The properties of groundwater levels at different kebeles were not at the permissible levels as on WHO water quality index, with higher content of fluorides and chlorides. Further, the common diseases occurrence reported by individuals were diarrhoea (98.8%), cholera (98.1%) and typhoid (98.1%). In addition, it was identified that more than 85% acknowledged the role of poor accessibility and quality of water on livelihood and financial burden due to the water-borne diseases caused by it.

Conclusion: These results points at the need for treating groundwater before consumption to promote health and well-being among these individuals. Further, the community practices need to be enhanced along with improving groundwater quality.

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INTRODUCTION

Water safety and quality are indispensable part of human health and well-being. The global access to clean water and sanitation is one of the key sustainable development goals to be reached by 2030 (United Nations[UN], 2018). Although the agenda was set more than half decade ago, the availability and accessibility to safe water is strained and not feasible to all the people due to their social and economic underpinnings. As on 2021, about 2 million people lived in water stressed regions, where the condition is projected to increase in the near future due to climate change and population growth (World Health Organization [WHO], 2023). In addition, Joint Monitoring Programme (JMP; 2021) report, evidenced a significant lack of safe drinking water services, as 367 million and 122 million used unimproved water sources and surface water, respectively. Safe and required amount of water is essential to be hygienic and to prevent diseases, however, about 1.7 billion used contaminated drinking water sources in 2022 (WHO, 2023). Therefore, to prevent the water-borne diseases and enhance well-being of people World Health Organization (WHO) provides drinking water quality regulation and guidelines with a water quality index (WHO, n.d.).

The water quality is determined by the physical, chemical and biological properties. These characteristics are influenced by dissolved or suspended solutes in the water and the quality can be determined both by natural and human activities (Luvhimbi et al., 2022). In addition, the water is seldomly safe in developing nations as the quality of water including groundwater has deteriorated from the past and is expected get worse over time (Biswas, 2022; Luvhimbi et al., 2022) due to urbanization and increased demands for infrastructure (Sarker et al., 2021). This deterioration to groundwater resources due to geogenic and anthropogenic activities has reduced the supply for safe drinking water influencing the health of individuals making it a public health concern (Xie et al., 2023).

This poor availability of safe water has significant impact on the health as it increased the risk of water-borne diseases (Lin et al., 2022). In this line, WHO estimated that about 88% of diarrheal death is attributed to poor water quality, sanitation and hygiene (as cited by Mebrahtom et al., 2022). Diarrhoea is one of the common disease caused by water contamination (Lin et al., 2022) and the prevalence of this disease increased when individuals used municipal water directly without desalinating or filtering it (Yassin et al., 2006). Furthermore, the contaminated of groundwater also lead to carcinogenic and non-carcinogenic health risks among individuals with significantly higher risk among children than adults (Bodrud-Doza et al., 2020; Chakraborty et al., 2022; Ghosh et al., 2023). As mentioned before, the quality of water including groundwater and its influence on health is a public health concern as about 50 diseases and 80% of deaths were attributed to unsafe drinking water with more than 50% child deaths due to the infections caused by poor water quality (Lin et al., 2022). In addition, the variations in the properties (elements) of water from its threshold can have a cumulative effect on health and can pave for a range of chronic health conditions (Xie et al., 2023). Interestingly, the improved water supply not only decreased the occurrence of diseases but also improved the livelihood and well-being of the individuals (Abanyie et al., 2023).

Although the essentiality of good groundwater quality and its role on health is been studied widely, there exists significant gap in understanding these factors in various parts of developing nations. Ethiopia being one of the developing countries, about 60% of communicable diseases is attributed to poor environmental condition as lack or poor-quality water supply, hygiene and sanitation and around 80% and 20% of rural and urban have inadequate access to safe water (Meride & Ayenew, 2016). This makes it crucial to understand quality of groundwater and its role on health and well-being among individuals living in different parts of Ethiopia. The present study focused on the groundwater quality and its role on health and livelihood among adults in Jigjiga town.

Methods

Study locality and Data

The data was collected from Jigjiga town (capital of Ethiopian Somali region) with seven kebeles and estimated population of 170003 among which 83001 are male and 87002 are female (*Ethiopia Demographic and Health Survey 2011*, n.d.). In the recent days Jigjiga town has become an important urban hub playing a pivotal role in the political, economic and social scenarios of that region. The data was collected from individuals living across seven kebeles along with water samples from seven bore holes. Furthermore, collected seven boreholes groundwater samples sent to the Diredewa water laboratory for physical and chemical parameter analysis as per the world health organization water quality index.

The sample size was calculated using the formula:

$$n = Z^2_{\alpha/2}\, p(1-p)/\, \varepsilon^2$$

where,

n= sample size

Z= 95% confidence interval level under the normal curve, (1.96)e=marginal error 5% that means 0.05

p&qare estimates of the proportion of population to sample.

p is estimates of the proportion of the population improved **50%, which** is **p** value.

Then **q** is equal **to 1-(0. 5)=. 5**

$= (1.96)^2 * 0.5 * 0.5 / (0.05)^2$

n = 383.71~ 384

Although, the required sample size was 384, we selected 60 members from each of the seven kebeles and in total collected the data from 420 (Male = 90; Female = 330) members from the households through systematic random sampling.

Measures/ Tools

A study tool was developed by the research team to understand the role of groundwater quality on health and livelihood of the individuals along with assessing the physical and chemical properties of groundwater from the different kebeles.

Health Factors: The role of groundwater quality on health was understood through 17 questions among which the 12 items addressed the occurrence of waterborne diseases (diarrhoea, typhoid, cholera, jaundice, tooth decay, skin problems, cryptosporidiosis and shigellosis) in their family and its frequency in the last one year in their community. The disease occurrence had a dichotomous response pattern (yes or no), while the frequency was assessed using four-point Likert scale (1 = Never; 4 = very frequently). In addition, 6 questions taped on the awareness and the reason for occurrence of few of these diseases among individuals.

Livelihood Factors: We generated 7 questions to understand the influence of groundwater quality on livelihood of the individuals. The questions include 1) Do you or any of your family members spend substantial time fetching water? 2) If yes, how much time?; 3) Did you miss a day of work due to difficulty in fetching drinking water?; 4) If yes, how often?; 5) Have you or any of your family members ever missed days of work due to health problems of water-borne diseases?; 6) If yes, how often did you/they miss the work?; 7) Did the health problems associated with the water-borne disease put a financial burden on your family?. The response pattern differed with the type of questions. The questions 1, 3, 5 and 7 had a binary response pattern (yes or no) and except question 2 (15-30 minutes; 30-45 minutes; 45 minutes 1 hour and more than 1 hour), others had a response pattern ranging from 1 – 4 (1 indicates never and 4 is very frequently).

Socio-demographic factors: This includes, age (18-25 years, 26-32 years, 33-40 years), gender, educational level (primary, high school and degree level), marital status (in a union, not in a union), family size [small (1 member) , medium (2-6 members) and large (more than 6 members)], religion (Muslim and Christian), occupation, individual and family income (low, middle and high). In addition, the resident type (own, rented) and house owned time (house owned during employment and not owned during employment), ethnicity (Somali and Amhara), quantity of water consumption (20 liters; 15-20 liters per day) sources of water (public tap; truck water, donkey water purchase) and health issues (diagnosed in the past 1 year) were considered during the analysis.

Data Analysis

The Diredewa laboratory examined the collected groundwater samples for its physical and chemical properties to compare it with the WHO water quality standards. The water quality index cross-checked by Mr. Robin Selvaraj, a GIS expert from the Department of hydraulics and water resources, conducted a spatial distribution analysis using GIS software to highlight the differences between one borehole and the next. In addition, the descriptive characteristics of data collected from the members of the household were analyzed using SPSS 25. This helped in understanding the percentage of occurrence of water-borne diseases along with its frequency and the possible role of groundwater on livelihood.

Ethical considerations

This community-based study was approved by Research Ethics Review Committee, Jigjiga University (Ref. No. RERC/044/2022). The respondents provided their informed consent before participating in the survey and they were aware about the voluntary nature of their participation and can leave the study anytime they wish to without any consequences. In addition, confidentiality and anonymity was maintained throughout the conduction of the study.

Results

The present study tried to analyse the physical and chemical properties of groundwater and its role on health and livelihood among individuals in that locality. The table 1 presents the physical and chemical properties of groundwater from the seven boreholes located at different kebeles (1, 2, 5, 6, 10, 11 and 12). Further, we used WHO water quality index to compare the water quality of these seven boreholes. The variations in physical and chemical properties of water points at the gradients of certain chemical and physical aspects of the water quality. The water quality is considered to be good when its components and properties are at permissible level as on WHO water index. In term of chemical properties, the groundwater at kebele 1 and 10 had above permissible level of magnesium (Mg), calcium (Ca), fluoride(F) and chlorine (Cl). Similarly, kebele 2 and 5 groundwater had higher level Mg, F and Cl, along with increased level of F and Cl in kebele 6. Further, kebele 11 and 12 had higher range of Ca, F, and Cl. In addition, kebele 5, had above permissible level of conductivity and hardness in their groundwater. In addition, kebele 10, 11, and 12 above permissible level of dissolved solids in the groundwater. Considering physical properties, kebeles 5, 6, 10, 11 and 12 high level of conductivity and hardness. Noteworthily, the alkalinity of groundwater was very low in all the kebeles which could promote the corrosive nature of water.

Kebeles	Mg	Ca	F	Cl	Na	Conductivity	TDS	Hardness	Alkalinity	Ph	K	Status(Not in the Std. limits)
1	51*	76*	0.64*	340*	32.3	1.7	490	300	27	7.17	1.51	Mg, Ca F, Cl
2	55*	75	0.64*	340*	32.3	1.7	490	300	27	7.17	1.51	Mg, F, Cl
5	52*	75	0.58*	270*	32	3.64*	400	750*	17.2	6.77	1.8	Mg, F, Cl, Conductivity, Hardness
6	46	75	0.58*	270*	32	3.64*	400	750*	17.2	6.77	1.8	F, Cl, Conductivity Hardness
10	60*	76*	0.60*	310*	17	3.01*	600*	640*	19.2	7.00	1.67	Mg, Ca, F, Cl, Conductivity, TDS, Hardness
11	48	79*	0.58*	320*	22	2.74*	590*	440*	28	7.8	1.54	Ca, F, Cl, Conductivity, TDS, Hardness
12	48	81*	0.58*	320*	22	2.74*	590*	440*	28	7.8	1.54	Ca, F, Cl, TDS, Conductivity, Hardness
Permissible limit	**50**	**75**	**1-1.5**	**250**	**<45**	**0.5-2.5**	**<500**	**<300**	**<200**	**6.5- 8**	**0.7-10.5**	**WHO water Quality IndexPermissible limits**

Note: All the properties measures in the unit of Mg/L; * indicates variation from the permissible limits

The descriptive characteristics of the study sample are presented in table 2. The age of the participants ranged between 18 – 40 years with 48.6% under the category of 26-32 years. The study had greater proportion of females (78.6%) and in terms of education level about 62.4% had a high school level of education with only 10.5% having degree level education. Further, considering marital status, 99.6% were in a union and greater proportion had a larger family size (85.8%; more than 6 family members). In respect to occupation about 85% were employed while 12.6% were home makers It is interesting note that, 80% had middle range income individually, however in terms of family majority (79.5%) were under low-income category. In addition, only 19.3% had a won house with 41.9% buying a during employment. About 61% of the household consumed 15-20 liters of water per day with major source of water being public tab 83.8% followed by donkey water purchase (15.5). In addition, 71.2 % (n = 299) had water-borne diseases in the past year.

Table 2: Descriptive characteristics of the study sample

Variables	Frequency	Percentage
Age		
18-25 years	108	25.7
26-32 years	204	48.6
33-40 years	108	25.7
Gender		
Male	90	21.4
Female	330	78.6
Educational Status		
Primary level	114	27.1
High school level	262	62.4
Degree level	44	10.5
Marital Status		
In a union	417	99.4
Not in a union	3	0.6
Family Size		
Small	1	0.2
Medium	59	14.0
Large	360	85.8
Religion		
Muslim	348	82.9
Christian	72	17.1

Occupation		
Employed	357	85.0
Self -employed	5	1.2
Agriculture-related	5	1.2
Home-maker	53	12.6
Individual Income		
Low (0-3500)	8	1.9
Middle (3501-5000)	336	80.0
High income (5001 and above)	76	18.1
Family Income		
Low (0-5000)	334	79.5
Middle (5001-10000)	80	19.0
High (10001 and above)	6	1.5
Resident type		
Own	81	19.3
Rented	339	80.7
Time house owned		
Owned during the employment	176	41.9
Not owned during the employment	244	58.1
Ethnicity		
Somali	298	71.0
Amhara	122	29.0
Water Consumption		
20 liters/day	164	39.0
15-20 liters/day	256	61.0
Source of water consumption		
Public tap	352	83.8
Truck water purchase	3	0.7
Donkey water purchase	65	15.5
Health issues		
Water-borne	299	71.2
Chronic-conditions	68	16.2
Others	53	12.6

The table 3 represents the occurrence of diseases in the family and frequency of the same in the community in the past one year. The occurrence of diarrhoea was reported by 88 (20.9%) participants with its frequency of sometimes (82.4%) in the community. Further, 98.1% of the household members reported the occurrence of typhoid and cholera with the frequency of sometimes (82.9%) and very frequently (97.6%) in the community, respectively. About, more than 50% of the participants reported the occurrence of jaundice in the family along with very frequent (85.7%) occurrence in the community. In addition, 18.3% and all the members (100%) of the household reported the occurrence chronic conditions as tooth decay and unexplained skin problem. Noteworthily, the infection that led to diarrhoea (cryptosporidiosis; 98.8%)) and stomach infections (Shigellosis; 99.5%) were very common in the family.

Table 3: The occurrence and frequency of water borne diseases in the family and community as reported by the participants in the past year

Diseases	Occurrence in the family (%)		Frequency in the community (%)			
	Yes	No	Very Frequently	Sometimes	Less Frequently	Never
Diarrhoea	415 (98.8)	5 (1.2)	48 (11.4)	346 (82.4)	25 (6.0)	1 (0.2)
Typhoid	412 (98.1)	8 (1.9)	47 (11.2)	348 (82.9)	25 (6.0)	0 (0)
Cholera	412 (98.1)	8 (1.9)	410 (97.6)	4 (1.0)	0 (0)	6 (1.4)

Jaundice	283 (67.4)	137 (32.6)	360 (85.7)	54 (13.6)	3 (0.7)	0
Tooth decay	77 (18.3)	343 (81.7)	As these were chronic and common conditions the frequency of these were not estimated.			
Unexplained skin problems	420 (100)	0				
Cryptosporidiosis	415 (98.8)	5 (1.2)				
Shigellosis	418 (99.5)	2 (0.5)				

The awareness of the household members on water quality and its role on health is presented in table 4. Surprisingly, all the participants were aware of impact poor quality of water would have on health and 94.5% were dissatisfied with the present water quality. In addition, 96.2% of the members reported changes in taste and quality in the recent years. Furthermore, the household members reasoned out that poor water quality was the reason for tooth decay and diarrhoea (also supported by the water analysis report presented in table 1).

Table 4: The percentage of awareness on various aspects related to water quality and its role on health

Variables	Frequency	Percentage
Impact on Health		
Yes	420	100
No	0	0
Quality of water		
Very dissatisfied	8	1.9
Dissatisfied	397	94.5
Satisfied	3	.7
Very satisfied	12	2.9
Taste and quality change		
Yes	404	96.2
No	16	3.8
Reason for tooth decay		
Poor water quality	298	0.7
Food particle deposition	10	2.4
Personal Habit	109	71.0
Not known	3	26.0
Reason for unexplained skin problem		
Poor water quality	4	0.7
Climate	75	80.5
Life style	338	17.9
Don't know	3	1.0
Reason for Diarrhoea		
Poor water Quality	409	97.4
Food infection	4	1.0
Others	1	0.2
Not known	6	1.4

The role of groundwater accessibility and quality on livelihood of the individuals in presented in table 5. It is evident from the results that about 99% of the household spent their substantial time in fetching water with 98.1% spending more than one hour. Further, 96.2% of individuals reported that this substantial time led to missing a day of work with 85.7% endorsing it to occur very frequently. In addition, 98.6% and about 95% of household members reported their family member missed work due to fetching water and this occurred sometimes, respectively. Further, 96% of individuals reported that the occurrence of water borne diseases was a financial burden with 85.5% of individuals acknowledging it to occur very frequently.

Table 5: The role of groundwater accessibility and quality on livelihood of the individuals

Variables	Frequency	Percentage
Spend substantial time in fetching water		
Yes	418	99.5
No	2	2

Time spent		
15-30 minutes	6	1.4
30-45 minutes	0	0
45 minutes – 1 hour	2	0.5
More than one hour	412	98.1
You missed a day of work due to fetching water		
Yes	404	96.2
No	16	3.8
How frequent		
Very frequent	360	85.7
Sometimes	53	12.6
Less Frequently	4	1.0
Never	3	0.7
Family member miss a day of work due to fetching water		
Yes	414	98.6
No	6	1.4
Frequency missing a day of work due to fetching water		
Very frequent	14	3.3
Sometimes	400	95.2
Less Frequently	6	1.4
Never	0	0
Water-borne disease put a financial burden		
Yes	403	96.0
No	17	4.0
Frequency of water-borne diseases on financial burden		
Very frequent	359	85.5
Sometimes	53	12.6
Less Frequently	4	1.0
Never	4	1.0

Discussion

The present study tried to understand the groundwater quality from seven different kebeles and its role on health and livelihood of individuals living in Jigjiga city. It is evident from the water quality analysis that none of the kebeles had all the elements and properties in the permissible level. The fluoride and chloride contents were above the permissive level in all the kebeles along with variations in physical properties in few kebeles. The higher fluoride and other micro-elements may suggest the exposure of groundwater to the industrial wate and agricultural fertilizers (Xie et al., 2023). Similarly, a study analysed drinking water in Jigjiga city with five-parameters and identified the deviations in hardness and conductivity of drinking water from the standard quality (Werkneh & Kelemework, 2015). In addition, a recent study in this locality identified significant presence of heavy metals in drinking water and its association with lifetime health risks among adults and children (Belew et al., 2024). However, to our knowledge no study has considered all the 11 parameters included this study to analyse the groundwater.

The poor groundwater quality played a role in health and livelihood of the individuals living in these regions. As majority of them reported the occurrence of water-borne diseases in their family and acknowledged its higher frequency in the community. The reported diseases occurrence includes diarrhoea, typhoid, cholera, jaundice, along few other chronic conditions as tooth decay and unexplained skin problems and infections that led to diarrhoea (cryptosporidiosis) and enteric inflections (shigellosis). These results are in are in line with earlier studies as these outbreak of these diseases are considered to be public health concerns (Park et al., 2022; Sitotaw & Geremew, 2021). Although a study suggested the decline in the prevalence of diarrhoeal cased from 1990, it prevalence was higher among children below five-years and older adults (Gessese et al., 2023) as majority of the participants reported the occurrence of cryptosporidiosis infection that leads to diarrhoea in their family. Further, the tooth issues and skin problems can be attributed to the high fluoride content and water hardness as evidenced from groundwater analysis and these results are supported

by the works of Demelash et al., (2019) and Lopez et al., (2022).

In terms of awareness among individuals on the role of groundwater quality on health, all the were aware and mentioned groundwater quality had the potential to influence health. Further, identified differences in water quality and taste in recent times. Majority of the participants attributed poor water quality as the reason for tooth decay and diarrhoea. Furthermore, the household members reported to have inadequate accessibility (as higher proportion of participants took more than an hour to fetch water) and acknowledged that the inaccessibility and poor quality of water had a negative role in their livelihood and increased financial burden due to occurrence of diseases. On this note, a study in Ghana evidenced reduced risk of health and enhanced livelihood among individuals when supplied with improved safe water supply (Abanyie et al., 2023).

Although this study holds its strength in shedding light on the groundwater quality (considering 11 parameters) from seven boreholes and its role on health and livelihood as reported by household members of different kebeles from Jigjiga city, the limitations are inevitable. First, the study is descriptive in nature and does not provide association or cause-and effect relationship between the variables. Second, the occurrence and frequency of diseases are self-reported, even though it is reliable source in social sciences researches it holds certain constrains. Third, bio-medical markers were not used to test the impact of poor groundwater quality on health.

Conclusion

The present study analysed the groundwater quality and its role on health and livelihood of individuals as reported by household members living in seven kebeles in Jigjiga city. It was evident from water analysis results that in all the seven water samples from different boreholes there was certain parameters that does not fit the permissible level. Especially the higher level of fluoride and chloride content was common in all the groundwater samples along with variations in physical properties. In terms of health and livelihood factors majority of them reported the occurrence of water-borne diseases in their family and its higher frequency in community. The common diseases were diarrhoea (mainly due to the infection cryptosporidiosis), cholera and typhoid along with unexplained skin infection and enteric infection. In addition, all the participants acknowledged the negative role of poor groundwater quality on health and attributed it to the occurrence of diarrhoea and tooth decay. Further, the poor accessibility and quality of water played a role in their livelihood (missing a day's work) and were reported to increase financial burden due to the ill effect it has on the health. These results points at the need for treating groundwater before consumption to promote health and well-being among these individuals. The government and policy makers should consider these regions a priority to improve and bring right initiates as majority had low family income and only high school level of education. Further, the community practices need to be enhanced along with improving groundwater quality.

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