



Assessment of the Quality of Water Sources for Taiz City for Drinking and other Domestic Uses-Yemen

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Abstract There are many water sources for Taiz City. The water fields provide the need water to the city and the include areas in the Al-Dabab, Al-Hawban, Al-Janad, Dhi-Sufal and the Central region of the study area. The study aims at assessing the quality of the various water sources that supply the city of Taiz with water for drinking purposes and other domestic uses. The microbiological analysis shows that the microbes of the pathogenic the existence in the water samples in the water of the Central region, Al-Janad, Al-Dabab of the study area at different rates, while the water samples in the areas of Al-Hawban and Dhi-Sufal are free from contamination with pathogenic microbes. The results of the physical study shows a different degree of temperature, it was between 18 and 50 degrees Celsius, while the (pH) is included within the Yemeni Standards and (WHO) Guideline, except for one sample in the area of Dhi-Sufal. The chemical analyses show an increased concentration of most chemical elements in comparison with the local and international standards.

Keywords Taiz City, Water sources, Domestic Water, Pathogenic, Contamination, Standards

Introduction

Taiz City faces the most important environmental problem one of them is the water problem, both in terms of storage, depletion and pollution. The water problem stems from the scarcity of natural water resources and the depletion of the water basin, which has led to the problem of falling ground water storage, the shortage of fresh water and deterioration of water quality in the water basin [1,2].

The problem of water in Taiz city resulted from lack of comprehensive policies and lack of treatments that take into account the population density and the growth, dispersion of the population in the high plateaus and valleys that make the supply of water to the highlands is an expensive matter. Although Taiz is an industrial, commercial and tourist city. The water problem has remained for decades, compounding the magnitude and extent of the water crisis.

The increase in the concentration of some chemical elements in the groundwater of some of the water sources of Taiz City, part of which is due to the nature of Hydro geological Aquifers, the other part due to lack of rainwater and the lack of recharge the ground water storage and also because of increased consumption resulting from the increase of population, especially in recent decades and the depletion of water Exploration for agricultural purposes [3].

This increase in total dissolve solids concentration leads to deterioration of water quality in these sources [4,5]. In the city of Taiz, the main sources of water for drinking and other domestic uses are from wells in the groundwater fields such as Al-Hawban, Al-Hawjala, Al-Dabab, Al-Haymah and Habir. As a result of the increase in sewage in the city because of the increase of population [6], epidemiological diseases associated with contaminated water have been registered [7]. Therefore, drinking water in Taiz city remains to be a high value commodities. Hence necessary to allocate large amounts of fund for the purpose of establishing an integrated water system, starting with searching for the qualitative and quantitative source of water, such as Drilling wells



and associated technical equipment's. In addition to the designing, implementing and distribution networks that supply water to consumers of all categories.

Objectives

- Identification and evaluation of the chemical and microbial content of drinking water sources of Taizcity and other domestic uses in comparison with national and international standards.
- To submit proposals and recommendations to improve the current situation of water supply of Taiz city.

Study Area

The study area is located at the following coordinates from the point 378 UTM E and 1510UTM N. This area covers approximately 750 km² [7]. The study area spreads over five sub-catchments, part of one of them located in the Governorate of Ibb, it includes Dhi-Sufal, and four in the governorate of Taizas shown in figure [1].

The five sub-catchments spread over seven districts, one of which is in the governorate of Ibb and six in the governorate of Taiz. The One district in the governorate of Ibb is Dhi-Sufal.

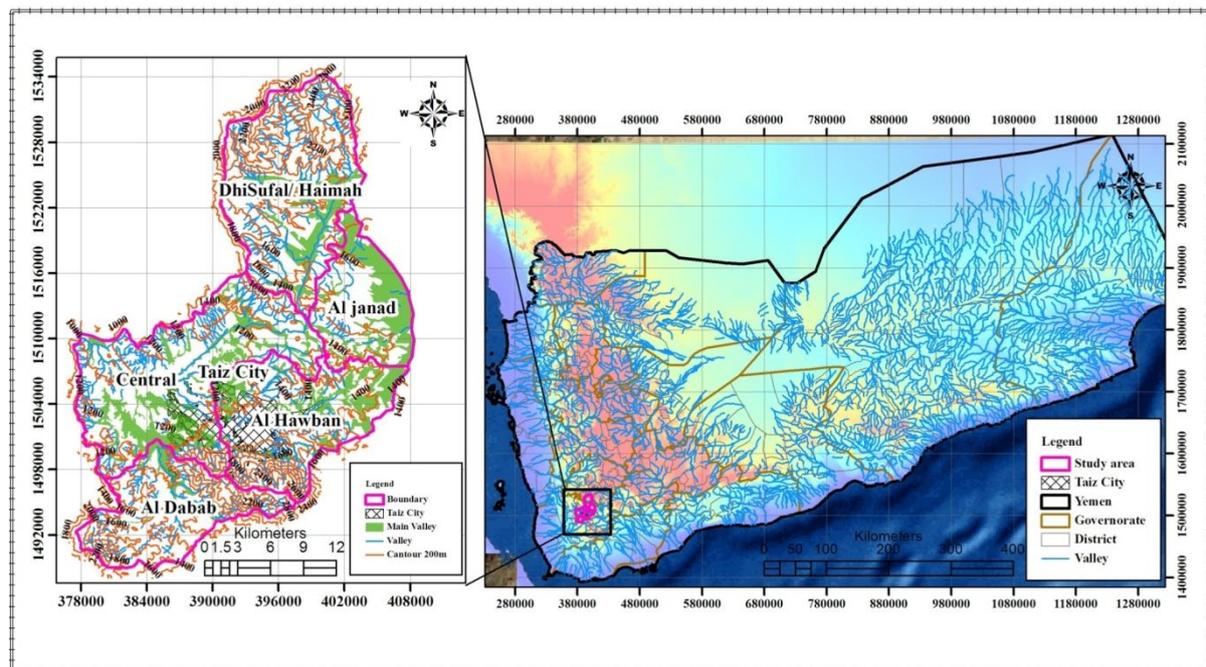


Figure 1: Location of the study area

Methodology of the Study

1. A visit to the boundaries of the field study was carried out, which included several areas, namely Al-Hawban, central region, Al-Dabab, Al-Janad, Al-hima and Habeer (Dhi-Sufal).

2. Collection water samples from wells and preservation

Fifteen samples were collected from different locations in the study area according to ArcGIS 9.3 Soft ware (Arc Map Version 9.3), sampling locations are shown in (Figure 1).

The water samples for lab analysis were taken from wells and collection water tank, according to standards methods [9], the well criteria are, as the flowing [7]:

- Wells inventory in the study area.
- Tub deep wells and hand-dug wells (Private Wells, Public water supply projects, and tankers) that used for drink.
- From different depths of wells.



- Wells that have operating pumps at present.

Fifteen water samples were chemically analyzed for the major cations (Ca^{++} , Mg^{++} , Na^+ , K^+), major anions (HCO_3^- , SO_4^{--} , Cl^- , NO_3^- and CO_3^-), trace elements (Zn, Pb, and Co) and biologically analyzed for TC and Escherichia Coli.

Water samples for major cations, anions and trace metals were Collected and Stored in Polyethylene Bottles. The Water in the first bottles (group one) was acidified upon collection with ultrapure concentrated nitric acid (HNO_3) in order to stops bacterial growth, blocks oxidation reactions and prevents adsorption or precipitation of cations. The Water in the second bottles (group two) was kept un acidified for (Cl^- , SO_4^{--}) and HCO_3^- [8].

3. Analytical techniques of water samples

The field measurements of water samples include temperature ($^{\circ}\text{C}$), pH, and electrical conductivity (EC). The field measurement instruments were calibrated before use by the certain and standard buffer solutions according to the standard methods [9]. The color of samples in the study area was visually observed by using Spectrophotometer meter DR/2010. Water temperatures were measured during sampling collection by using graduated thermometers ($\pm 5^{\circ}\text{C}$).

A pocket pH-meter (370 Meter ELE International) was used in situ to measure the pH of Water samples. The pH meter was calibrated prior to using buffer measurement of pH 4, 6 and 9.

The electrical conductivity (EC) of Water samples was measured directly by using conductivity meter (300 YSI Environmental).

Total dissolved Solids (TDS) were calculated from summation of cations and anions concentration and were estimated from (EC) values of water samples according to the following equation:

$$\text{TDS (mg/L)} = \text{EC } (\mu\text{S/cm}) \times 0.65$$

Cations and anions were analyzed according to [9]. The samples of water were carried out in the Laboratory of Agricultural Research Authority/ Taiz governorate.

Trace elements (Pb, Zn, and CO) were determined by using Atomic Absorption Spectrophotometer (AAS) at the laboratory of Central Health Laboratory/ Taiz governorate.

4. Microbiological Examination

According to the Standard Methods [9] membrane filtration method was used to determine Total and Faecal Coliform of Water samples.

Results and Discussion

The identifications of water standards as a natural source for domestic consumption are governed by the purposes of use, whether for drinking and other uses. As for the drinking water available in the wells fields that supply Taiz city, this water should not contain water pathogenic bacteria or toxins that have concentrations affecting public health. The microbiological analyses of the water samples taken from the wells in the fields of the Al-Hawban, central region, Al-Janad, Al-Dabab and Dhi-Sufal, are shown in table [1] which indicate that the water wells in Al-Hawban and Dh-isufal are free of contamination by pathogenic bacteria, Except for one well in the area of Dhi-Sufal.

Table 1: Results of microbiological analyzes of water samples for the water sources of Taiz city.*

Sample No.	Total coliform	Faecal coliform
1	Positive	Zero
2	Zero	Zero
3	Positive	Positive
4	Positive	Positive
5	Positive	Positive
6	Positive	Zero
7	Positive	Zero
8	Positive	Positive
9	Positive	Positive



10	Zero	Zero
11	Zero	Zero
12	Zero	Zero
13	Zero	Zero
14	Zero	Zero
15	Positive	Positive

*Source- Al-Saban, S.A (2018).

In contrast the fields of wells of Al- Janad, Central region and the Al- Dabab, pollution by pathogenic bacteria was 100%, 73% and 60%, respectively.

Therefore, it is necessary to treat the water by chlorination prior to pumping into the network or transportation of water with tankers to consumers.

As for the chemical aspects shown in the table [2,3], according to [7] it causes health risks after exposure for a long period of time. Hence it is necessary to evaluate the groundwater sources in the study area in terms qualitative. This the physical and chemical analysis of the samples conducted as follows;

The results of the measurement of acidity ranged from 5.7 to 7.8, indicating the low acidity in one of the wells in the field of Dhi-Sufal may be due to the presence of some acid salts in the aquifers of geological formations of groundwater, whether acidic strong or acidic weak, example Carbonate or bicarbonate dissolved in water is composed of carbonic acid, which leads to a decrease in the value of pH, whereas the rest of the samples did not exceed their values and were within the limits allowed by locally and internationally standards.

Table 2: Results of physical analysis of water samples of the water sources of Taiz city.

Sample No	PH	EC (MS/cm)	T ^o
1	7.3	860	21
2	7.3	4000	25
3	7.0	5120	24
4	7.8	723	18
5	7.2	4480	27
6	6.6	1228	27
7	6.8	1100	26
8	6.6	1185	23
9	7.7	8720	26
10	7.5	4495	20
11	6.9	7350	27
12	7.8	865	24
13	7.3	1480	29
14	5.7	816	26
15	7.1	1700	28

By observing the results of the measurement of electrical conductivity, we find that it ranges from 723 to 8720 microsemens / cm, whereas a section of these samples is within the limits allowed and the other section exceeded the limits local and international standards [10,11].

The results of the total dissolve solids showed a clear variance with the international standards, whereas some of them were close to the Yemeni standards. This increase is due to the dissolving processes of the ground water rock aquifers.

Table 3: Results of chemical analysis of water samples for the water sources of Taiz/mg/l

Sample No.	H N	TDS	Cations				Anions				
			Ca ⁺	Mg ⁺	Na ⁺	K ⁺	HCO ³⁻	Cl	SO ⁴⁻	NO ³⁻	CO ³⁻
1	95.0	559	70	50	7	20	323	117	77	7	12
2	203	2600	120	132	343	0.6	775	756	451	37	12
3	222	3328	270	196	437	1.2	220	1054	840	50	24
4	303	470	44	52	47	1.2	470	46	43	7	24



5	260	2912	244	179	428	4	561	721	998	40	24
6	13	798	154	11	57	1.2	305	135	96	4	12
7	199	715	162	10	37	0.5	506	75	30	22	36
8	79	770	142	47	57	0.8	397	188	67	7	60
9	566	5668	326	216	737	3513	1294	1598	864	50	0.0
10	215	2922	246	124	235	9	519	479	815	37	0.0
11	113	4778	234	222	499	8	799	1257	1296	53	0.0
12	93	562	42	14	6	0.4	201	36	ND*	1.24	112
13	161	962	110	17	128	8	403	192	60	24	12
14	45	530	94	20	61	0.4	250	64	46	7	24
15	89	1105	90	52	148	3.12	348	115	115	43	24

Table [3] shows that the exceeded results of measurement of total hardness due to the presence of positively charged metal ions such as calcium and magnesium, as shown in the increase in samples of these elements, where the high concentration of these ions cause an unpalatable taste of water and not accepted by the consumer.

It was observed that most samples exceeded the limits of the World Health Organization for the results of measurement of bicarbonate, chloride and sulfate, while a large proportion of them is close to the standards of Yemen.

By observing the nitrate measurement results, it was found that most of the values are within the permissible limits locally and internationally, except for some samples, there was a deviation in the measurement results.

Most samples exceeded permissible limits for alkali measurement results due to carbonate, sodium bicarbonate, potassium and hydroxide ions found in water. Current laboratory analyses have shown a significant increase in the concentration of most chemical elements from permissible standards. The salinity, Hardness, alkali, sulphate and bicarbonate concentrations in this water have been observed. This indicates that water is not suitable for drinking in this condition prior to the necessary treatment because of the health risks it poses to humans. The main objectives of all published research have focused on cumulative chemicals such as heavy metals and carcinogens. These standards have been used as indicators and guidelines by the World Health Organization. In this light, each country can set its own standards and Guidelines according to environmental, climatic, economic and social conditions. The concentration of Cobalt (Co) was measured for all water samples from the studied area, Co value exceed the limit of WHO standards. The high level of Lead (Pb) was recorded in central region and is related to several factors: geology structure, soil metal retention and sewage sludge, as shown in table [4].

Table 4: Results of chemical trace elements of water samples for the water sources of Taiz city mg/l .

Sample No.	Pb	Co	Zn
1	2.4	ND*	0.082
2	1.7	0.271	0.041
3	2.1	ND*	0.121
4	0.3	ND*	0.049
5	2.3	ND*	0.025
6	2.4	ND*	0.032
7	2.6	ND*	0.003
8	1.91	3.4	0.02
9	3.95	3.85	0.05
10	3.4	4.92	0.03
11	ND*	5.66	ND
12	ND*	6.5	0.06
13	ND*	6.63	ND
14	ND*	5.98	0.03
15	ND*	6.23	0.04

ND- No detected



The concentration of total metals (Pb, Co, Zn) leaking into the groundwater aquifers from various sources. Heavy metals are transferred from sludge sewage to both natural and anthropogenic soils and subsequently to the aquifers [12].

Conclusions

- The most important environmental problem in Taiz city is the problem of water in terms of inventory, depletion and pollution of groundwater.
- Water wells in Al-Hawban, City of Taiz and Dhi-Sufal, were free from contamination by pathogenic bacteria.
- 3.A significant increase in the concentration of total dissolve solids in Al-Hawban, Central Region, Al-Janad and some wells in the Al-Dabab in terms of the standards allowed locally and internationally.
- Cobalt values exceed the limit of (WHO) standards in the study area.
- High level of Lead (Pb) was recorded in central sub-catchment.

Recommendation

- For the purpose of using the existing water sources of the city of Taiz, water must be treated for the disposal of chemicals that exceed the limits allowed locally and internationally and chlorination the water from pathogens.
- Conducting comprehensive research studies of the water resources of Taiz city, and evaluate the sources of pollution by heavy metals.
- Providing new water sources for drinking and other uses by adopting desalination and rainwater harvesting options.
- Establishment of water and environmental friend groups in the neighborhoods and Harat of Taiz city for the purpose of support and community participation for decision-makers in the provision of safe drinking water and adequate for economic and social development.

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