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RESEARCH ARTICLE

DETERMINATION OF FLUORIDE IN DRINKING WATER IN AL-HUSSEIN DISTRICT, AL-DALEA GOVERNORATE, YEMEN BY USING PALINTEST PHOTOMETER 7500

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Abstract

The study carried out to determine the quality of drinking water in Al-Hussein district, compare it with parameters of the World Health Organization (WHO). fifteen of drinking water samples were collected from several sources; surface water and ground-water. The study aimed to investigate the concentration of Fluoride in Drinking Water in study area. The problem of the study was that there is deterioration in the characteristics of drinking water in Al-Hussein district, Al-Dalea Governorate, also appearance of dental fluorosis and osteoporosis in Children. In this study an experimental methodology by palintest photometer 7500 was used. The results expressed that fluoride concentration in surface water was within the WHO permissible limits, but in ground-water exceeding the WHO permissible limits. The study recommended the residents not to drink from groundwater wells, but must be bring drinking water from surface wells to maintain their health, also recommends the government institutions and organizations to conduct a study of the soil and find out the reasons for increasing concentration of fluoride and make solutions.

Key Words: Palintest Photometer, Fluorides, Dental fluorosis, Skeletal Fluorosis.

عنوان البحث

تقدير نسبة الفلورايد في مياه الشرب بمديرية الحصين بمحافظة الضالع اليمن باستخدام مقياس الضوء Palintest 7500

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المستخلص

أجريت الدراسة لتحديد جودة مياه الشرب في مديرية الحصين ومقارنتها بمعايير منظمة الصحة العالمية. تم جمع خمسة عشر عينة من مياه الشرب من عدة مصادر –مياه سطحية ومياه جوفية–. هدفت الدراسة إلى معرفة تركيز الفلوريد في مياه الشرب بمنطقة الدراسة. تمثلت مشكلة الدراسة في وجود تدهور في خصائص مياه الشرب في مديرية الحصين بمحافظة الضالع، وظهور تسمم الأسنان بالفلور وهشاشة العظام عند الأطفال. في هذه الدراسة تم استخدام الطريقة التجريبية بواسطة المقياس الطيفي (palintest 7500). أظهرت النتائج أن تركيز الفلوريد في المياه السطحية ضمن الحدود المسموح بها من قبل منظمة الصحة العالمية، ولكن في المياه الجوفية تجاوز الحدود المسموح بها من قبل منظمة الصحة العالمية. أوصت الدراسة السكان بعدم الشرب من الآبار الجوفية، ويجب عليهم جلب مياه الشرب من الآبار السطحية للحفاظ على صحتهم، كما أوصت الدراسة المؤسسات الحكومية والمنظمات بإجراء دراسة للتربة ومعرفة أسباب زيادة تركيز الفلوريد وتقديم الحلول.

Introduction:

Due to the deterioration of the characteristics of drinking water in Al-Hussein district, Al-Dalea Governorate, Yemen, whether improved or unimproved water and its effect on the population, hence the problem of the study by assessing the validity of this water used for drinking through the investigation and analysis of drinking water samples. In this study, used the experimental methodology to explain and solve the study problem. The main objective of this paper is to investigate the concentration of Fluoride in Drinking Water in the study area, compare it with parameters of the World Health Organization (WHO), and its suitability for drinking purposes.

Water intended for human consumption and drinking must be free from organisms and from concentrations of chemical substances that may be effect on humans and hazard to health. **(WHO, 1971)** Good drinking water quality is essential for the well-being of all people, **(Akoto, O. 2008; Keeler, 2012)** Fluoride in drinking water has beneficial effects on teeth at low concentrations, **(Shivaprakash, 2011; Khan, 2015)** but excessive exposure to fluorides in drinking water may give rise to a number of adverse effects in human**. (Shivaprakash, 2011)** It leads to many diseases such as: mottling of teeth, bone diseases, and lesions of the endocrine glands, thyroid, kidney, liver, and other organs. **(Ghosh, 2013)**

Water Supply

A daily struggle for water is one of the terrible burdens of poverty, especially for women and girls who spend endless hours for fetching water over long distances. Sources of water are often unclean or unaffordable, or groups are simply cut off from using a particular water source. Many poor urban dwellers have to pay very high-water prices to informal water vendors or do without water. Around the world, 748 million people lack access to an improved drinking water source, while billions more lack drinking water that is really safe. **(WHO/UNICEF, 2014)** Access to water is main condition to health and livelihood, access to clean drinking water is prerequisite to the prevention of the most common diseases. **(Crow B., 2001)**.

In several regions of Al-Hussein district there are wells in which a high concentration of fluoride caused health problems such as: osteoporosis and rickets, and curvatures in the bones. Also, dental fluorosis and dental caries (especially in children) as a result of increased fluoride led to excretion of calcium from the body.

Fig. (1): Children with dental fluorosis

Fig. (2): Children suffering from bone curvature

Many newspapers and journalists in Yemen wrote about this problem, including Al-Ayyam newspaper, which conducted interviews with a number of specialized doctors ,the beginning was with Dr. Abbas Muhammad Abbas Baabad who is consultant pediatrician and neonatologist, he said: This disease was noticed due to found large numbers of children under the age of eight infected with Osteomalacia and osteoporosis, in addition to decay, discoloration and erosion in the teeth, these diseases concentrated in areas where groundwater wells deep , such as: Marfad, Khobar and Al-Uklah . while Dr. Samir Kassem Mohammed Qassoum consultant of orthopedic surgery, joints and spine, saying: The presence of pathological cases of osteoporosis in children and adults, especially in the areas of Marfad, Khobar, Al-Uqla ,and Lakamat Lashuob in Al-Hussein District is mainly due to the increase in fluoride in the drinking water, which leads to the appearance of curvatures in the bones and curvatures in many places such as the legs, knees and hips. As for Dr. Ahmed Mohamed Abbas Baabad, who is Oral and dental surgery specialist, said: This disease begins to form in children at an early age, at the age of one to eight years, during the period of formation of permanent teeth inside the jaw before their eruption, erosion and fragility appear to be visible when they come out, this is due to an increase of fluoride in the drinking water of groundwater, which works to displace calcium from the bones and teeth, and this substance (fluoride) replaces the substance (calcium) after it leaves the teeth and bones through urination. (https://alameenpress.info/news/10289)

The dentist Saddam Al-Shuaibi works near these areas, he posted an article on his Facebook page about drinking water in these areas and the problems they cause. He said that residents who drink from these wells, their teeth are in an embarrassing and confusing health situation when choosing treatment, he published several pictures of children with dental problems that he treated in his private clinic. (https://www.facebook.com/100000981584549/posts/3324152627627424/?app=fbl)

Fig. (3): Children with teeth in an embarrassing health situation in study area.

The challenge to attaining equity in access is finding ways to channel the stream to those who have less social and financial power, thereby reducing the vulnerability of poor people (especially women and children) to livelihood insecurities and water-related diseases and disasters. **(Lewis, K. ed., 2004).**

Fluorine

Fluorine is the lightest member of the halogen group; it is the most electronegative and is one of the most reactive of all chemical elements. **(Hem, 1985)**.

Atomic Symbol	F
Atomic Number	9
Atomic Weight	18.998403
Electron Configuration	$[He]2s^2 2p^5$
Valence	1
Melting point (M.P)	219.62°C (1 atm)
Boiling Point (B.P)	188.12°C (1 atm)
Density	1.696 g/L (0°C, 1 atm)
Liq. Density	1.50 g/cm3 (188.12°C , 1 atm)

Table (1): Fluorine properties **(Lide, D.R. ed., 2004; LANL, 2001)**

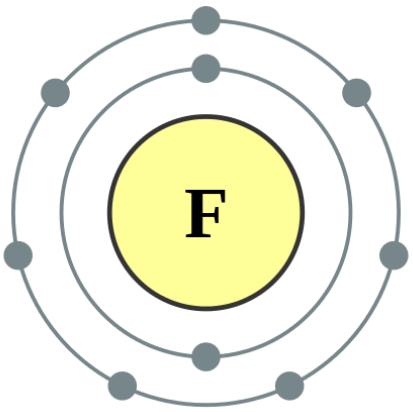

Fig. (4): Fluorine Electron Configurations

Fluorine is the seventeenth in order of frequency of occurrence of the elements, therefore found as fluorides which together representing about 0.06–0.09 per cent of the earth's crust. **(Murray, 1986)** it is in final water is always present as fluoride ions, whether the source is natural or synthetic, the amounts added to drinking-water are such that final concentrations are usually between 0.5 and 1.5 mg/l. **(WHO, 2011)**

Absorption of Fluoride

fluoride absorption is via the gastrointestinal tract, principally from both the stomach and the intestine. **(Easmann, 1984)** fluoride is converted into hydrogen fluoride (HF) and up to about 40 per cent of the ingested fluoride is absorbed from the stomach as HF, Fluoride not absorbed in the stomach is absorbed in the intestine and is unaffected by pH at this site. **(Whitford, 1997; Fawell et al., 2006)**

Diseases related to Fluoride

Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which affects the teeth and bones. Paradoxically, low levels of fluoride intake help in prevent dental caries. So, control of drinking water quality is therefore critical in preventing fluorosis. Excessive exposure to fluoride in drinking water can lead to a number of adverse effects These range from mild dental

fluorosis to crippling skeletal fluorosis as the level and period of exposure increases. **(Fawell et al., 2006)**

Effects on teeth: Fluoride has a great affinity for the developing enamel because tooth apatite crystals have the capacity to bind and integrate fluoride ion into the crystal lattice. Excessive intake of fluoride during enamel development can lead to enamel fluorosis, a condition of the dental hard tissues in which the enamel covering of the teeth fails to crystallize properly, leading to defects that range from barely discernable markings to brown stains and surface pitting**. (Committee on Fluoride in Drinking Water, 2006)**

Dental fluorosis: is a discoloration of teeth and is a recognized side effect associated with excess fluoride exposure. Its effects on teeth occur just prior to eruption. In its mildest form dental fluorosis manifests as barely noticeable whitish marks on teeth. Dental fluorosis can be more severe, resulting in staining and pitting of the teeth. **(NSW Health, 2015**) White and yellow glistening patches on the teeth are seen which may eventually turn brown. The yellow and white, patches when turned brown present itself has horizontal streaks. The brown streaks may turn black and affect the whole tooth and may get pitted, perforated and chipped off at the final stage. **(Nagendra Rao, 2003)**

Enamel fluorosis is a mottling of the tooth surface that is attributed to fluoride exposure during tooth formation. The enamel maturation process consists of an increase in mineralization within the developing tooth and concurrent loss of early secreted matrix proteins. **(Aoba, 2002)**

Skeletal Fluorosis

Endemic skeletal fluorosis is well documented, known to occur with a range of severity in several parts of the world **(Fawell et al., 2006)** Skeletal fluorosis is condition that may arise following long term exposure to elevated levels of fluoride, Osteomalacia may be observed in fluorotic individuals with a reduced or suboptimal intake of calcium; secondary hyperparathyroidism may also be observed in a subset of patients. Individuals with impaired renal function, such as those with diabetes, may be more prone to developing fluoride-related toxicological effects. **(Ms Gomes, WHO, 2002; Grynpas, 1990)** Skeletal fluorosis may be observed when drinking-water contains 3–6 mg of fluoride/L, particularly with high water consumption. While crippling skeletal fluorosis usually develops where drinking water contains over 10 mg /L of fluoride. increased risk of bone fractures occurs at a total intake of 14 mg of fluoride/ day. **(WHO, 2011)**

fluoride has been used for the treatment of age-dependent osteoporosis at high dose levels, Exposure to fluoride during treatment for osteoporosis may lead to calcium deficiency, owing to the stimulation of bone growth, even in cases where patients are given supplemental calcium as part of the therapeutic protocol. **(Dure-Smith, 1996)** there are some signs and symptoms appear in skeletal fluorosis such as: (**Nagendra Rao, 2003)**

- Severe pain in the backbone
- Severe pain in the joints
- Severe pain in the hip region
- Stiffness of the backbone.
- Immobile /Stiff joints
- Increased density of bones, besides calcification of ligaments
- Construction of vertebral canal and intervertebral foramen-pressure on nerves
- Paralysis

Cancer

In 1987, the International Agency for Research on Cancer (IARC) concerned that the carcinogenicity of fluoride and concluded that there was inadequate evidence of carcinogenicity in experimental animals. **(Fawell et al., 2006)** There have also been a significant number of epidemiological studies examining the possible association between various cancers and exposure to fluoride in drinking-water. However, in spite of the large number of studies conducted in a number of countries, there is no consistent evidence to demonstrate any association between the consumption of controlled fluoridated drinking-water and either morbidity or mortality from cancer. **(Fawell et al., 2006)**

Neurobehavioral effects:

A study in China has considered the potential effects of fluoride from drinking water on children's intelligence, it was carried out in Shanxi and involved 160 children (ages 7–14) randomly selected from each of two villages, one with a high level of fluoride contamination of the water (4.12 mg/l, with 86% of the population having signs of dental fluorosis), and one with low contamination (0.91 mg/l and 14% dental fluorosis). The "official Intelligence Quotient (IQ)" was measured. The average IQ in the first village was 97.69, and in the second it was 105.21 ($P < 0.01$). **(Ms Gomes, WHO, 2002)**

Effect on the Endocrine system

The major endocrine effects of fluoride exposures reported in humans include elevated Thyroid Stimulating Hormone (TSH) with altered concentrations of Triiodothyronine (T3) and thyroxine (T4), increased calcitonin activity, increased PTH activity, secondary hyperparathyroidism, impaired glucose tolerance, and possible effects on timing of sexual maturity. **(Committee on Fluoride in Drinking Water, 2006)**

Gastro intestinal problems

The problems due to elevated fluoride are Acute abdominal pain, constipation, diarrhea, blood in stools, bloated feeling (gas) tenderness in stomach, feeling of nausea and mouth sores. **(Nagendra Rao, 2003)** Some effects on liver enzymes have been observed in studies of osteoporosis patients treated with fluoride, but the available data are not sufficient to draw any conclusions about potential risks from low-level long-term. (**Committee on Fluoride in Drinking Water, 2006)**

Materials and Method:

The study area is located in the eastern part of Al-Dhalea Governorate, about 12 kilometers from the Governorate's capital. Also located in: Latitude: 13° 47' 24" N & Longitude: 44° 46' 12" E

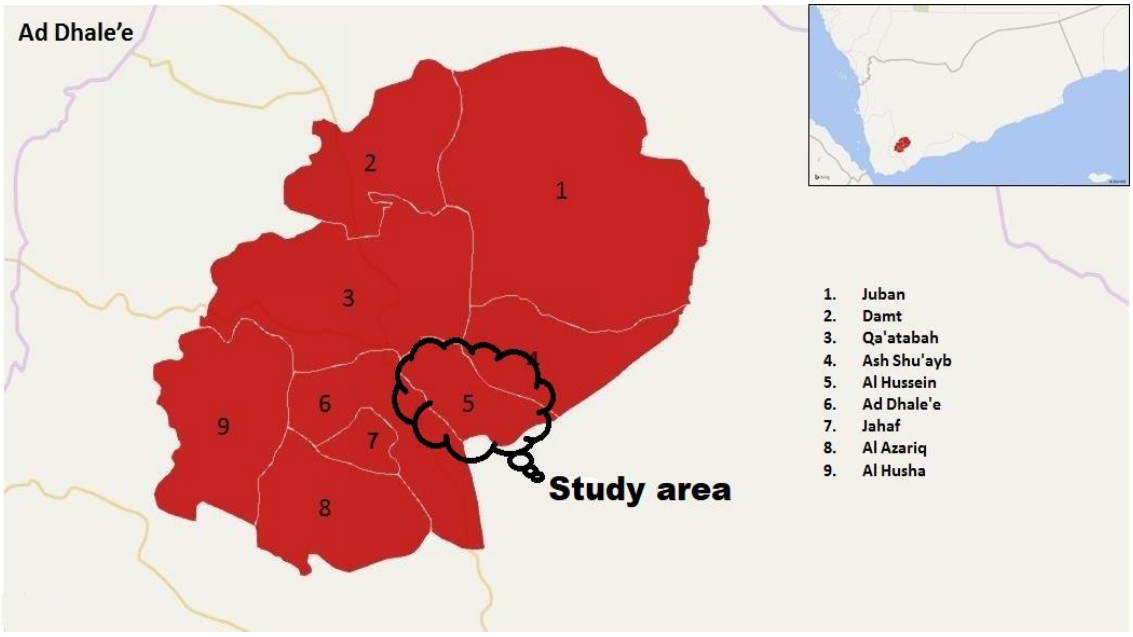

Fig. (5): Map of study area **(Berghof Foundation, 2020)**

Fifteen of drinking water samples were collected from several wells in multiple locations of the study area, five samples are surface water and ten are ground water. The samples were taken between 9 to 19 August 2021. To determine the physical and chemical parameters, samples were collected from the study area by glass bottles of 1500 ml capacity, each sample bottles were washed with the same well drinking water from which the sample was taken before filling to make the results more accurate and avoid any error in the results. the samples were analyzed for physical and chemical parameters like temperature, turbidity, pH and Fluoride. Using the Palintest Photometer 7500, for the analysis 10 ml test tubes were filled with the water sample and the palintest water test tablets was added, after their solution was left to stand for the specified time to allow for full color development, For the determination of the concentrations of Fluoride; reading was taken directly from the photometer.

Fig (6): Palintest photometer 7500

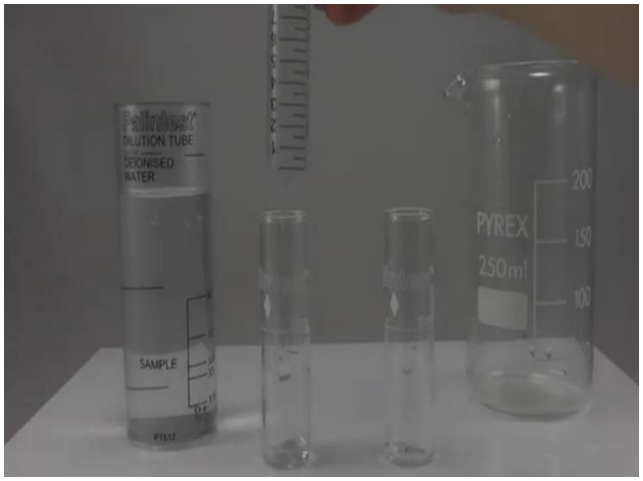

Fig (7): Fill test tube with sample

Fig (8): color development of sample

Fig (9): palintest water test tablets

Results and Discussion

The results showed variations in the physical and chemical properties of surface and ground water sources. Water quality varies from location to location, according to the geographical location. Table (2) shows the results of surface water samples, Table (3) shows results of groundwater samples, Table (4) shows the results of surface and ground water samples together in the study area.

Name of well	village	Date of Test	Para-meter	Turbidity	Temper-ature	PH	Fluoride
			Formula		C	PH	F-
			Unit	NTU	C°		mg/l
			WHO limits	1 -- 15	8-28	6.5-8.5	0.5-1.5
Al-Kumerat Well	Harir	9/8/2021	Sample1	0.00	24	7.5	0.7
Mothadah Well	Harir	9/8/2021	Sample2	0.10	25	7.4	0.9
Marrat Well	Harir	9/8/2021	Sample3	0.00	25	7.4	0.8
Al-Fokaha Well	Harir	9/8/2021	Sample4	0.00	25	7.1	0.6
Adeenah Well	Harir	9/8/2021	Ssample5	0.00	26	7.4	0.7
Average				0.02	25.00	7.36	0.74
Standard deviation				0.04	0.71	0.15	0.11
Minimum				0.00	24.00	7.10	0.60
Maximum				0.10	26.00	7.50	0.90
Ave ± STD				0.02±0.04	25±0.71	7.3± 0.1	0.74±0.11

Table (2): Results of the surface water samples

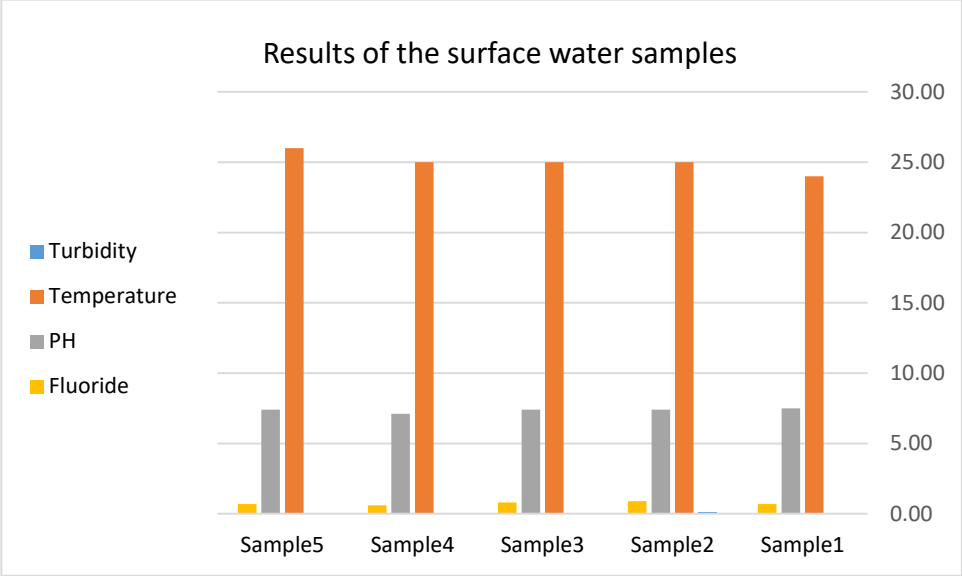

Fig. (10): Results of the surface water samples graphically

Table (3): Results of the groundwater samples

Name of well	Village	Date of Test	Para-meter	Turbidity	Tempe-rature	PH	Fluoride
			Formula		C	PH	F-
			Unit	NTU	C°		mg/l
			WHO limits	1 -- 15	8-28	6.5-8.5	0.5-1.5
Al-Sheikh Obaid well	Marfad	12/8/2021	Sample6	12.1	27	7.55	4.4
Almarafdah Well	Marfad	12/8/2021	Sample7	7.82	28	7.75	11.1
Dehbash Well	Lakamat Lashuob	14/8/2021	Sample8	0.83	28	8	13.3
Tarish Well	Lakamat Lashuob	14/8/2021	Sample9	3.19	28	8.25	9.1
Al-Qareah Well	Al-Uqla	15/8/2021	Sample10	1.66	28	7.6	2.64
Faisal Well	Al-Uqla	15/8/2021	Sample11	3.08	28	7.95	2.28
Mohamed Ben Mohamed	Al-Uqla	17/8/2021	Sample12	6.82	27	7.95	2.26
Al-Ja'arir Well	Al-Uqla	17/8/2021	Sample13	1.74	27	7.55	1.8
Ahmed Mokbel Well	Algahda'ah	19/8/2021	Sample14	0.97	28	7.55	1.62
AbdulRaqib Well	Algahda'ah	19/8/2021	Sample15	1.31	28	7.95	2.78
Average				3.95	27.70	7.81	5.13
Standard deviation				3.75	0.48	0.24	4.35
Minimum				0.83	27.00	7.55	1.62
Maximum				12.10	28.00	8.25	13.30
Ave. ± STD				3.95±3.75	27.70±0.48	7.81± 0.24	5.13±4.35

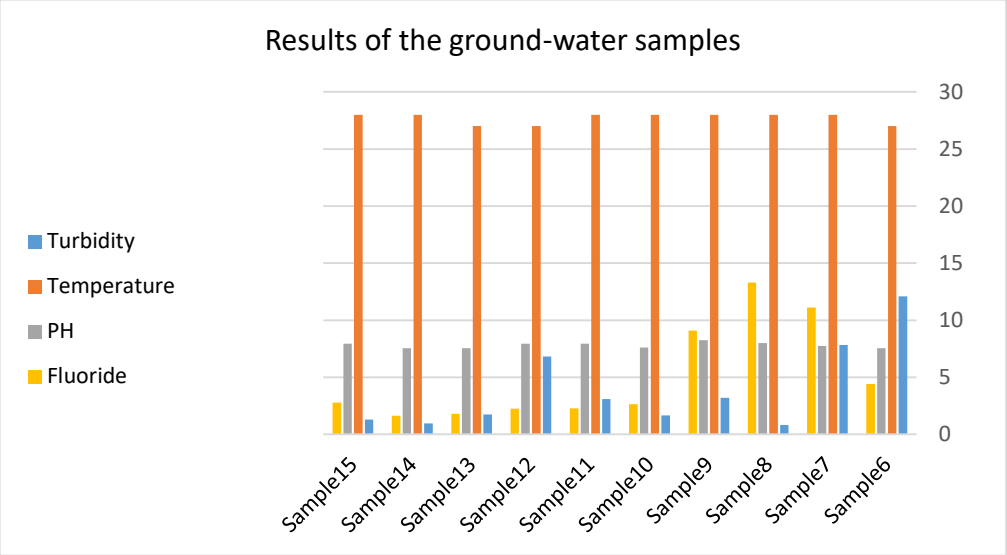

Fig. (11): Results of the ground-water samples graphically.

Table (4): Results of the surface and ground water samples together

Name of well	village	Date of Test	Parameter	Turbidity	Tempe-rature	PH	Fluoride
			Formula		C	PH	F-
			Unit	NTU	Cº		mg/l
			WHO limits	1 – 15	8-28	6.5-8.5	0.5-1.5
Al-Kumerat Well	Harir	9/8/2021	Sample1	0.00	24	7.5	0.7
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Marrat Well	Harir	9/8/2021	Sample3	0.00	25	7.4	0.8
Al-Fokaha Well	Harir	9/8/2021	Sample4	0.00	25	7.1	0.6
Adeenah Well	Harir	9/8/2021	Sample5	0.00	26	7.4	0.7
Al-Sheikh Obaid well	Marfad	12/8/2021	Sample6	12.1	27	7.55	4.4
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Tarish Well	Lakamat Lashuob	14/8/2021	Sample9	3.19	28	8.25	9.1
Al-Qareah Well	Al-Uqla	15/8/2021	Sample10	1.66	28	7.6	2.64
Faisal Well	Al-Uqla	15/8/2021	Sample11	3.08	28	7.95	2.28
Mohamed Ben Mohamed	Al-Uqla	17/8/2021	Sample12	6.82	27	7.95	2.26
Al-Ja'arir Well	Al-Uqla	17/8/2021	Sample13	1.74	27	7.55	1.8
Ahmed Mokbel Well	Algahda'ah	19/8/2021	Sample14	0.97	28	7.55	1.62
AbdulRaqib Well	Algahda'ah	19/8/2021	Sample15	1.31	28	7.95	2.78
Average				2.64	26.80	7.66	3.67
Standard deviation				3.57	1.42	0.31	4.09
Minimum				0.00	24.00	7.10	0.60
Maximum				12.10	28.00	8.25	13.30
Ave ± STD				2.64±3.57	26.8±1.42	7.66± 0.31	3.67±4.09

The results for the determination of the turbidity, temperature and pH in all samples in Table (4) showed that the parameters correspond with WHO standards for Drinking Water Quality. The turbidity results for all surface and ground water samples ranged between 0.00 to 12.10 NTU, Average 2.64 and standard deviation 3.57. The temperature is between 24.0 to 28.0 Cº, Average 26.80 and a standard deviation 1.42, While the pH ranged between 7.10 to 8.25, Average 7.66 and a standard deviation 0.31. There is a large difference in turbidities between surface and groundwater wells, but all samples are within the permissible limits.

The results for the determination of fluoride in the study samples showed a significant difference between the results of surface and groundwater water. In the surface water, the concentration of fluoride was corresponded with WHO standards, where the concentration of fluoride ranged between 0.6 mg/L to 0.9 mg/L, Average 0.74 and a standard deviation 0.11, indicates that it is suitable for drinking. While the concentration of fluoride in groundwater wells ranged between 1.62 to 13.30, Average 5.13 and a standard deviation 4.35. the concentration of fluoride in groundwater wells is very large, so; is not suitable for drinking and human use.

The results also showed a difference in the concentration of fluoride in groundwater according to the geographical location in the study area, the concentration of fluoride in the two regions wells - Al-Uqla and Al-Gahda'ah - was less than 3, as this percentage may be less dangerous than other regions with high fluoride concentration. While the concentration of fluoride in the other two regions wells - Marfad and Lakamat Lashuob- where the highest rate reached to 13.3, which portends a health disaster that leads to arching, fragility and curvature of the bones, may lead to bone fractures.

Conclusions

The results of all samples are indicated that turbidity, temperature and pH were within the permissible limits of the WHO drinking water parameters. fluoride concertation in surface water was within the WHO permissible limits, but in groundwater fluoride concentration exceeding the WHO permissible limits. The reason may be in the different geographical location or the digging deep of wells to get water. It is recommended the residents in regions where there are groundwater wells not to drink from these wells, but must be bring drinking water from surface wells to maintain their health. Also recommending the government institutions and organizations to conduct a study of the soil and find out the reasons for increasing concentration of fluoride and make solutions.

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