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The relationship between different kinds of drinking water in Saudi Arabia with the incidence of renal diseases

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ABSTRACT

Water purity and the mineral content are important for human health. This study aimed to determine the quality of tap water and determined if any has renal health hazards. Tap water samples were brought from 5 regions of Hail. All samples were subjected to physical examination, including electrical conductivity (EC), pH, turbidity and total dissolved solids (TDS), chemical analysis including free chlorine, fluoride, iron, sulfate, nitrate, calcium, magnesium, total hardness and alkalinity with trace element analysis (uranium, cobalt, zinc, cadmium, lead, nickel, copper, arsenic, and selenium). Microbiological and cytological examinations were done. No microbiological contamination was detected. Increased EC and TDS in Alkhuta and Qnaa with high fluoride, calcium and total water hardens. High pH value was found in Hail, Ugda and Twaran, with high water turbidity in Twaran. Magnesium level was high in Alkhuta, Qnaa and Ugda with low level in Hail. Total water alkalinity was high in Qnaa. 65% of patients had urinary symptoms. 27% of patients had calcium oxalate crystals, 45% had uric acid crystals and 36% had urate crystals. 41% of patients had bacteriurea, while 5% had yeast. Utrasonography (US) revealed renal gravels (39%), renal stones (9%), cyst (15%), nephrosis (2%), hydronephrosis (1%) and renal mass (1%). In conclusion, all sample results were within the standard level. Alkhuta and Qnaa revealed high EC, TDS, fluoride, nitrate, calcium, and total hardness and higher degree of alkalinity in Qnaa with high prevalence of renal gravels and stones in both areas. Ugda samples revealed high pH, nitrate and uranium with patients had high urine calcium oxalate, uric acid and bacterurea. Twaran samples revealed a high pH and turbidity with high calcium oxalate crystals and prevalent of renal gravels with one case of hydronephrosis. Hail samples revealed low calcium and magnesium levels.

Keywords: Drinking water, quality guidelines, renal diseases, Saudi Arabia.

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INTRODUCTION

Water is the most essential resource for humans. It constitutes about 50 to 60% of human body weight and plays an active role in all the vital processes of the human body. Safe and good quality drinking water is essential for human health. However, when polluted, it may become a source of undesirable substances dangerous to human health (Eisenberg, 1992). Groundwater is the main source of drinking water in Saudi Arabia (Al-Abdula'aly, 1997). Although, most areas in Saudi Arabia do not face serious problems regarding drinking water as other parts of the world, there are still water quality problems (Moghazi and Al-Shoshan, 1999). There are several sources that may cause chemical and microbial contamination of groundwater; these include the intensive use of organic and inorganic fertilizers, pesticides, and animal waste (Zubari et al., 1994). Seepage from septic tanks and wastewater discharged to soil might also in some locations affect both chemical and microbial quality of groundwater. Drinking water standards have been developed to define the quality of water that is safe for consumers. Therefore, most of the standards set limits for chemicals and organisms that are potentially dangerous or hazardous to human (Pritchard et al., 2007). In Saudi Arabia, the quality of drinking water is receiving attention from environmentalist and water scientists (SASO, 1984; Al-Turki and Abdel Magid, 2003; Al-Abdula'aly et al., 2003). Saudi Arabian Standards Organization, 1984 (SASO) developed drinking water standards for both bottled and unbottled water to define a quality of water that sustains a healthy population. These standards set limits for the permitting and maximum contaminant level of chemical elements and microorganisms that endanger the health of consumers. Epidemiological studies have reported the occurrence of many health problems, including cardiovascular disease, renal diseases, congenital malformations of the central nervous system, cancer and even death due to exposure to high trace elements and mineral contents of the water (Aschengrau et al., 1989; Eisenberg, 1992). Calcium and magnesium are essential elements for human body. Diets rich in calcium and magnesium intake may not be able to compensate their absence in drinking water. Calcium is important for fetal growth, pregnancy and lactation.

It is essential for teeth and bone formation, blood coagulation, proper functioning of the nervous system (Mc Dowell, 1992). Drinking water poor in calcium is considered dangerous for the risk of coronary diseases. Excess water calcium can alter the water taste and cause many health problems. The magnesium plays an important role as a cofactor and activator of more than 300 enzymatic reactions, ATP metabolism, elements transport such as sodium, potassium and calcium, synthesis of proteins and nucleic acids, neuromuscular excitability and muscle contraction. Magnesium deficiency increases risk of hypertension, cardiac arrhythmia, atherosclerosis, myocardial infarction, preeclampsia in pregnant women, possibly type 2 diabetes mellitus and osteoporosis (Garzon, 1998). Numerous studies have shown that a high Na+ intake is associated with hypertension. However, drinking certain types of waters may unnecessarily increase Na+ intake to a level may be detrimental for health, especially for individuals on a Na+ restricted regimen (Pomeranz et al., 2002). Chlorinated water increases intestinal peristalsis. If water has a low concentration (hypotonic) it stimulates gastric secretion. Fluorine is useful for the good health of bones and teeth.

Fluorine useful values are close to toxic values. Chronic poisoning may lead to skeleton deformation, spots on tooth enamel, osteosclerosis, neurological disorders, thyroids damages and even tumors (Garzon, 1998). Nitrates are the main source of nitrogen essential for nucleic acids and amino acids. Excessive nitrate can be transformed to nitrites, which are toxic to the human body (Lopez et al., 2002). Microbiological pollution of drinking water includes bacteria, virus and fungi. They can be responsible for serious diseases as typhoid, cholera, hepatitis, etc. and their presence can be easily detected. Bacterial growth is encouraged by the lack of a residual disinfectant and by the possibly great variability of nutrients in water, such the low-mineral water, particularly if it has a high temperature (Legnani et al., 1999). In Hail, a region located in north central of Saudi Arabia, there are many wells scattered throughout some villages used as a main source of drinking water by rural residents. The present study was conducted to evaluate the quality of the most common used drinking water in these areas, determine the clinically important levels of minerals, determine the microbiological content of tap water and find any relation to renal diseases in Hail region, Saudi Arabia.

SUBJECTS AND METHODS

Our study proposes to investigate the quality of drinking waters used for human consumption in Hail area, a region located in north central of Saudi Arabia, where there are many wells scattered throughout some villages used as a source of drinking water. Samples were collected from five different areas of Hail, namely Hail project, Alkhuta, Ougda, Qenaa and Tawaren. Four samples were collected from each region from water tanks of water treatment plants; for chemical, physical, microbiological and cytological analysis. For chemical and physical analysis, water samples were collected in high density polyethylene containers; previously washed in a solution of 10% nitric acid in an ultrasonic bath for 15 min, followed by repeated rinsing with bidistilate water and finally rinsing with ultrapure water (resistivity 18 $M\Omega cm^{-1}$). Until collection containers were kept in sealed polyethylene bags, water samples were stabilized with ultrapure nitric acid (0.5% HNO_3). Physical analysis for collected water samples includes the determination of pH using a calibrated pH meter, EC uses a calibrated conductivity meter, turbidity and TDS use the gravimetric method.

A quantitative method was used for accurate determination of concentrations of common ions and heavy metals (calcium, sulfate, magnesium, iron, chlorine, fluorine and nitrate), (uranium 238, cobalt 59, zinc 66, cadmium 111, lead 208, nickel 60, copper 63, arsenic 75 and selenium 77, 78) in waters with inductively coupled plasma quadrupole mass spectrometry (ICP-Q-MS). ICP-MS is a relatively new method for determining multi-element analysis and ideal for water, since the vast majority of target compounds can be detected below 0.1 mg/L (Ammann, 2007; Thomas, 2004). Therefore a Perkin Elmer ELAN DRC (e) instrument was used with a Meinhart nebulizer and the silica cyclonic spray chamber and continuous nebulization. The operating conditions were listed below: Nebulizer Gas flow rates: 0.95 l/min; Auxiliary Gas Flow: 1.2 L/min; Plasma Gas Flow: 15 L/min; Lens Voltage: 7.25 V; ICP RF Power: 1100 W; CeO/Ce = 0.031; Ba++/Ba+ = 0.016. Therefore a multi-standard calibration method was applied: Perkin Elmer 10 mg/ml of twenty-nine metals (ICP-MS Standard, Matrix: 5% HNO_3, Perkin Elmer Life and Analytical Sciences), a standard of 10 mg/ml Hg (Mercury standard 5% HNO_3 matrix, Perkin Elmer), and multi-standard PerkinElmer 10 mg/ml rare-metal standard (Atomic Spectroscopy Standard, Matrix 5% HNO_3).

For microbiological and cytological analysis, the samples were collected in sterile plastic containers and kept in a cooling bag at

4°C and sent within 6 h to Hail regional laboratory where each bottle was adequately shaken then, two samples of one milliliter each was taken for microbiological analysis, properly labeled and recorded:

1. One ml sample was inoculated in Blood Agar Plate (BAP) and another one ml was inoculated on Sabouraud's Dextrose Agar Plate (SDAP).
2. All samples were incubated for 24 to 48 h at 25 to 30°C and observed for growth.
3. Fungal identification was done microscopically. Samples were cultured quantitatively and levels of bacteria were determined as Colony-forming Units (CFUs) per milliliter. Bacterial identification was conducted using the Vitek II system of bacterial identification.

One hundred patients attending primary health care center in the five regions were asked to participate in the study after taking their written consent.

Exclusion criteria

Patient with:

i) Diabetes mellitus
ii) Chronic renal diseases
iii) Hypertension
iv) Senile enlarged prostate
v) Receiving nephrotoxic drugs (e.g., NSAIDs, Aspirin, Sulfonamides, Quinolone or diuretics), were excluded from the study.

All subjects were subjected to:

1. Full history taking with particular emphasis on age, gender, residence, occupation most frequent type of drinking water used, high-salt intake diet, history of any systemic diseases, any drug intake, family history of renal diseases and any urinary symptoms e.g., dysurea frequency, nocturea, change urine color and abnormal urine odor.
2. Thorough clinical examination.
3. Complete urine analysis.
4. Kidney urinary Ultrasonography (US) after an overnight fasting.

The physical and chemical data were collected and represented in numbers, then compared to known standards (SAS, 1984; GCCS, 1993; WHO limits, 2011). Ages of the studied groups were represented in mean ± standard deviation with the comparison performed by an independent t-test using SPSS version 20 X2 while, results of clinical examination, urine analysis and kidney-urinary tract Utrasonography of all persons enrolled in the study were represented in numbers and percent.

RESULTS

Table 1 revealed the physical characteristics of drinking water samples of the five examined areas Hail, ALkhuta, Ugda, Qnaa and Twaran. As regards EC (µS/cm) it was 347, 1046, 521, 717 and 384 respectively, with higher values detected in ALkhuta and Qnaa. The pH was 8.4, 7.91, 8.49, 7.8 and 8.4 respectively, where most samples were near higher limit. Water turbidity was 0.44, 0.26, 0.38, 0.31 and 1.38 with the higher value detected in Twaran. Lastly, TDS was 229, 724, 350, 487 and 254 respectively, with highest level detected in ALkhuta.

Table 2 revealed chemical analysis of studied drinking water samples (mg/L). Free chlorine, all samples were free of chlorine. Iron level was 0.02, 0, 0.03, 0.02 and 0.01 mg/L, respectively, where the ALkhuta samples show zero results. Fluoride was 0.25, 1.1, 0.84, 1.07 and 0.89 mg/L, respectively, where ALkhuta and Qnaa revealed high results. Sulfate results was 24, 90, 43, 60 and 29 mg/L which was high compared to the maximum allowed level in all areas especially in ALkhuta. Nitrite results were 8.1, 22.8, 17.3, 14 and 7.7 mg/L, respectively, with the highest value present in ALkhuta while nitrogen dioxide results were zero for all groups. As regards calcium levels was 23.84, 108.16, 54.56, 90.72 and 51.04 mg/L, respectively, with the highest value present in the ALkhuta although lie within the standard range. Magnesium was 2.69, 11.33, 11.52, 16.13 and 9.02 mg/L respectively. Calcium hardness was 59.6, 270.4, 136.4, 226.8 and 127.6 respectively, while magnesium hardness was 11.2, 47.2, 48, 67.2 and 37.6 mg/L respectively. Total hardness was 70.8, 317.6, 184.4, 294 and 165.2 which were all within the standard values. Lastly, total alkalinity was 43.43, 75.64, 128.83, 215.7 and 143, respectively.

Table 3: revealed classification of water hardness as mg/L $CaCO_3$ (calcium carbonate) (INERIS 2004), where level 0 to 30 is very soft, 31 to 60 is soft, 61 to 120 is moderately soft/moderately hard, 121 to 180 is hard and >180 is very hard.

Table 4 revealed trace element levels (µg/L) in the studied drinking water samples where uranium was 0.26, 5.249, 22.976, 3.402 and 8.638, respectively. Cobalt was 0.015, 0.245, 0.017, 0.014 and 0.01 respectively. Zinc was 20.558, 54.623, 28.081, 1.064 and 2.481, respectively. Cadmium was 0.004, 0.036, 0.006, 0.001 and 0.004, respectively. Lead was 0.059, 0.492, 0, 0.01 and 0.061, respectively. Nickel was 0.465, 3.666, 0.198, 0.14 and 0.157, respectively. Copper was 3.478, 0.677, 0.251, 0.173 and 0.229, respectively. Arsenic was 0.38, 0.38, 0.12, 0.082 and 0.09, respectively. Selenium 77 was 0.55, 4.481, 0.55, 1.213 and 1.159, respectively, while Selenium 78 was 0.28, 4.678, 0.33, 1.393 and 1.289, respectively. It was noticed that all levels were within the allowed values. Microbiological examination and culture for all samples revealed no growth.

Table 5 revealed the results of clinical examination, urine analysis and kidney-urinary tract US of all patients enrolled in the study where the mean age of all patients was 45.95 ± 22.37. As regard urinary symptoms 33% had frequency, 27% had dysurea and 5% had change urine color. Urine analysis results revealed that 25% had calcium oxalate crystals, 45% had uric acid crystals and 36% had urate crystals. 41% had bacteria and 5% had yeast. 27% revealed mucus in the urine. Kidney-urinary tract US revealed 39% of patient had renal gravels, 9% had stones, 15% had renal cyst, 2% with nephrosis, 1%

Table 1. The physical characteristics of drinking water samples.

Sample site	EC (μS/cm)	pH	Turbidity (NTU)	TDS (mg/L)
Hail	347	8.4	0.44	229
ALkhuta	1046	7.91	0.26	724
Ugda	521	8.49	0.38	350
Qnaa	717	7.8	0.31	487
Twaran	384	8.4	1.38	254
SAS (1984)	800-2300	6.5-8.5	25.0	1500
GCS (1993)	160-1600	6.5-8.5	5.0	1000
WHO limits (2011)	1500	< 8	5.0	1000

EC: Electrical conductivity; NTU: Nephelometric turbidity unit; TDS: total dissolved solids; ND: not detected; SAS: Saudi Arabia Standard; GCS: Gulf Countries Standard; WHO: World Health Organization.

Table 2. Chemical analysis of studied drinking water samples (mg/L).

Parameter	Free chlorine (mg/L)	Iron (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Calcium. Hardness	Magnesium Hardness	Total hardness (mg/L)	Total alkalinity
Hail	0	0.02	0.25	24	8.1	0	23.84	2.69	59.6	11.2	70.8	43.43
ALkhuta	0	0	1.1	90	22.8	0	108.16	11.33	270.4	47.2	317.6	75.64
Ugda	0	0.03	0.84	43	17.3	0	54.56	11.52	136.4	48	184.4	128.83
Qnaa	0	0.02	1.07	60	14	0	90.72	16.13	226.8	67.2	294	215.7
Twaran	0	0.01	0.89	29	7.7	0	51.04	9.02	127.6	37.6	165.2	143
SAS (1984)	NS	1.0	0.6-1	400	<45	NS	200	30-150	500	NS	500	NS
GCS (1993)	NS	0.3	0.6-1.7	400	10	<1.0	200	150	500	NS	500	NS
WHO limits (2011)	5	0.3	1.5	400	50	3	NS	NS	NS	NS	500	200

NS: No known standard level.

Table 3. General guidelines for classification of water hardness (INERIS, 2004).

Hardness as mg/L $CaCO_3$	Degree of hardness
0 – 30 Very soft	0 – 30 Very soft
31 – 60 soft	31 – 60 soft
61 – 120	120 Moderately soft/ moderately hard
121 – 180	Hard
>180	Very hard

had renal mass and 1% had hydronephrosis.

Table 6 revealed the detailed results of clinical examination, urine analysis and kidney-urinary tract Utrasonography of persons enrolled in the study of the different five regions. Each group includes 25 patients attained local primary health center for medical consultation. The mean age for Hail was 35 ± 14.67, ALkhuta was 46.33 ± 29.3, Ugda was 57.5 ± 22.37, Qnaa was 42.1 ± 20.95 and Twaran was 62 ± 17.89 with no statistical significant reference between all groups. In Hail area 3 (12%) cases had frequency. ALkhuta 11

Table 4. Trace elements in studied drinking water samples (μg/L).

Element	Hail	ALkhuta	Ugda	Qnaa	Twaran	WHO limit
Uranium 238	0.26	5.249	22.976	3.402	8.638	30
Cobalt 59	0.015	0.245	0.017	0.014	0.01	NS
Zinc 66	20.558	54.623	28.081	1.064	2.481	5000
Cadmium 111	0.004	0.036	0.006	0.001	0.004	3
Lead 208	0.059	0.492	0	0.01	0.061	10
Nickel 60	0.465	3.666	0.198	0.14	0.157	70
Copper 63	3.478	0.677	0.251	0.173	0.229	2000
Arsenic 75	0.38	0.38	0.12	0.082	0.09	10
Selenium 77	0.55	4.481	0.55	1.213	1.159	40
Selenium 78	0.28	4.678	0.33	1.393	1.289	40

Table 5. Total results of clinical examination, urine analysis and kidney-urinary tract ultrasonography of all persons enrolled in the study.

Item	Patient data	
Age	45.95 ± 22.37	
	N	**%**
Urinary symptoms		
Frequency	33	33
Dysurea	27	27
Change color	5	5
Urine analysis		
Crystals		
Ca oxalate	25	25
Uric acid	45	45
Urate	36	36
Organelle		
Bacteria	41	41
Yeast	5	5
Mucus	27	27
Kidney-Urinary Tract US		
Gravels	39	39
Stone	9	9
Cyst	15	15
Nephrosis	2	2
Mass	1	1
Hydronephrosis	1	1

(44%) cases had frequency, 11 (44%) cases had dysurea and 5 (20%) cases had changed urine color. Ugda 6 (24%) cases had frequency. Qnaa 3 (12%) cases had frequency, 6 (24%) cases had dysurea, and in Twaran 10 (40%) cases had frequency, and 10 (40%) cases with dysurea. Urine analysis revealed in Hail group 6 (24%) cases had uric acid crystals and 9 (36%) cases had urate crystals. ALkhuta group 3 (12 %) had calcium oxalate crystals, 9 (36%) cases had uric acid crystals and 6 (24%) had urate crystals. Ugda group 12 (48%) cases had calcium oxalate crystals, 12 (48%) cases had uric acid crystals and 12 (48%) had urate crystals. Qnaa group, 7 (28%) cases had calcium oxalate crystals, 8 (32%) cases had uric acid crystals and 4 (16%) had urate crystals. Twaran group 3 (12%) cases had calcium oxalate crystals and 10 (40%) cases had uric acid crystals and 5 (20%) had urate crystla. Hail group 6 (24%) cases had bacteria and 6 (24%) cases with mucus in the urine, ALkhuta group 5 (20%) had bacteria, 5 (20%) cases had yeast and 3 (12%) with mucus in the urine, Ugda group 12 (48%) cases had bacteria and 12 (48%) cases with mucus in the urine, Qnaa group, 3 (12%) cases had bacteria with 6 (24%) with mucus in the urine and Twaran group 5 (20%) cases had bacteria. Kidney urinary tract US revealed that Hail group 6 (24 %) cases had renal gravels and 3 (12%) cases with renal cyst, ALkhuta group 9 (36%) had renal gravels, 3 (12%) cases had renal stones, 6 (24%) cases had renal cyst and 2 (8%) showed renal nephrosis, Ugda group 6 (24%) cases had renal gravels, 6 (24%) had renal cyst and 1 (4%) case with renal mass, Qnaa group, 8 (32%) cases had renal gravels with 6 (24%) had renal stones and Twaran group 10 (40%) cases had renal gravels and 1 (4%) case had hydronephrosis.

DISCUSSION

Drinking water must be free from organisms that are capable of causing disease and from minerals and organic substances to ensure proper health and wellness. Drinking water should be palatable; free from apparent turbidity, color, odor and any objectionable taste. Potable water means that it may be consumed in any desired amount without health adverse effects. Drinking enough water will decrease the burden on the

Table 6. Results of clinical examination, urine analysis and kidney-urinary tract ultrasonography of persons enrolled in the study of the different five regions.

Item	Hail		ALkhuta		Ugda		Qnaa		Twaran	
Age	35 ±14.67		46.33 ± 29.3		57.5 ± 22.37		42.1 ± 20.95		62 ± 17.89	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Urinary symptoms										
Frequency	3	12	11	44	6	24	3	12	10	40
Dysurea	0	0	11	44	0	0	6	24	10	40
Change color	0	0	5	20	0	0	0	0	0	0
Urine analysis										
Crystals:										
Ca oxalate	0	0	3	12	12	48	7	28	3	12
Uric acid	6	24	9	36	12	48	8	32	10	40
Urate	9	36	6	24	12	48	4	16	5	20
Organelle:										
Bacteria	6	24	5	20	12	48	3	12	5	20
Yeast	0	0	5	20	0	0	0	0	0	0
Mucus	6	24	3	12	12	48	6	24	0	0
Kidney-Urinary Tract US										
Gravels	6	24	9	36	6	24	8	32	10	40
Stone	0	0	3	12	0	0	6	24	0	0
Cyst	3	12	6	24	6	24	0	0	0	0
Nephrosis	0	0	2	8	0	0	0	0	0	0
Mass	0	0	0	0	1	4	0	0	0	0
Hydronephrosis	0	0	0	0	0	0	0	0	1	4

kidneys by flushing out waste products. Water quality standards normally identify the component concentration and properties to be safe and acceptable. The maximum allowed concentration of different substances in public water supply is controlled throughout the world by legislation which varies to some extent from one country to another. Drinking water quality standards in Saudi Arabia (SAS) are emanated by the Saudi Arabian Standards Organization (SASO). Gulf Cooperation Council Countries Standards (GCCS, 1993) for un-bottled drinking water has been issued in 1982 by SASO and Standardization and Metrology Organization for Gulf Cooperation Council Countries (GSMO). Beside the primary aim of the World Health Organization (WHO) Guidelines for drinking water quality (WHO, 2011).

EC is considered to be an indication of the TDS content. Conductivity value in the studied area varied from 347 to 1046 μs/cm. All samples were within the recommended range however it is relatively high in Alkhuta (1046) and Qnaa (717). High EC indicates the presence of high quantity of dissolved inorganic substances (DWAF, 2001). TDS is the summation of all solids dissolved in the water, such as non-organic materials, bicarbonate, carbonate, nitrate, potassium, sodium, magnesium and chloride. TDS influences alternate attributes of drinking water, for example, taste and hardness (Pontius, 1990). TDS varied from 229 to 724 mg/L with high levels found in Alkhuta (724) and Qnaa (487) still with the standard levels. Solid information on conceivable wellbeing impacts connected with the ingestion of TDS in drinking water is not accessible. Certain components of TDS, such as chlorides, sulfates, magnesium, calcium, and carbonates, affect corrosion in water-distribution systems. TDS levels (>500 mg/L) result in excessive scaling in water pipes, water heaters, boilers, and household devices such as kettles and steam irons. Water with TDS concentrations less than 1000 mg/L is usually acceptable to customers. Extremely low concentrations of TDS may be unacceptable to customers because of its flat, tedious taste and it is also corrosive to water-supply systems (Harilal et al., 2004).

Turbidity is a measure of the relative clarity of water. Turbidity is used as an indicator of the effectiveness of drinking water treatment processes, particularly filtration.

All our samples had very low levels of turbidity. Three samples had a high allowed level of pH Hail (8.40), Ugda (8.49) and Twaran (8.4). Some studies revealed that pH range from 7.5 to 8.3 are ideal. The lower the pH, the more corrosive the water will be. It will lead to corrosion and indenting of pipes in distribution systems. This can lead to health problems if metal particles are leached into the water supply from the corroded pipes Iron may also be found at problem levels in acid water. Also, excessively alkaline water may be corrosive (Guidelines for Canadian Drinking Water Quality, 2014). Excess water iron may increase the hazard of pathogenic contamination as many organisms require iron to grow. Iron has been recognized as a potential nephrotoxin where some studies found that excess iron leads to fragile renal lysosomes. The extent of the above changes correlates with the extent and duration of iron accumulation and could be reversed when the iron load was reduced. However, all our drinking water samples were within the standard range (Dimitriou et al., 2000).

In healthy adults, the kidneys are able to excrete approximately 50% of an ingested dose of fluoride. In adults with renal disease, the kidneys may excrete from 10 to 20%, while young children may only excrete 15% of an ingested dose, thus increasing the body burden of fluoride and increasing susceptibility to fluoride toxicity e.g. renal osteodystrophy (Ludlow et al., 2007). Individuals with renal disease are at risk of developing fluorosis even at the normal recommended limit of 0.7 to 1.2 mg/L (Bansal and Tiwari, 2006). Persons with renal failure can have a fourfold increase in skeletal fluoride content, are at more risk of spontaneous bone fractures even at 1.0 µg/L fluoride in drinking water (Ayoob and Gupta, 2006). Alkhuta and Qnaa had higher levels of fluoride (1.1 and 1.07 mg/L) which is above the SAS standard, so careful monitoring of water and persons in these areas especially with renal diseases. Sulfate concentrations in all studied samples were much lower than standard levels. The only known adverse effect of the high sulfate content of drinking water is soft stool or diarrhea (osmotic diarrhea) (Abernathy et al., 2000). Nitrate is used in fertilizers and is found in sewage and wastes from humans and/or farm animals and generally gets into drinking water as a result of those activities. Once taken into the body, they are converted to nitrites. Excessive nitrate levels in drinking water have caused serious illness in infants as nitrite interferes with the oxygen-carrying capacity of the blood. Pregnant women may be less able to tolerate nitrate, and nitrate in the milk of nursing mothers may affect infants directly. These persons should not consume water containing more than 10 mg/L nitrate directly.

Little is known about the long-term effects of drinking water with increased nitrate levels (Fewtrell, 2004). Some research have suggested that nitrate may play a role in spontaneous miscarriages, thyroid disorders, birth defects, and the development of some cancers in adults as bladder cancer. Nitrate can cause human cancer due to the formation of N-nitroso compounds (NOC), which have been shown to cause tumors in experimental animals, however, additional studies are needed to clarify these links and define any other nitrate-related cancer risks. Our study revealed higher levels of nitrate in Alkhuta (22.8 mg/L), Ugda (17.3 mg/L) and Qnaa (14 mg/L) with no detectable level of nitrite in all studied samples which lies within SAS but above GCS and WHO standard, so better mentoring of water sources in these areas with special care for infant and pregnant and nursing women is recommended. Also, study the causes of these high levels (Ward et al., 2005). Our results revealed that Alkhuta and Twaran had relatively higher calcium levels (108.16 and 90.72, respectively) while Qnaa, Ugda and Alkhuta had relatively higher magnesium levels (16.13, 11.52, and 11.33, respectively). Magnesium is rapidly expelled from the bodies of healthy humans. People with kidney disease, who cannot excrete excess magnesium, may suffer from hypertension, confusion, muscle weakness, and coma. High calcium levels are not considered a health concern; however, it can lead to the formation of excess calcium carbonate deposits in plumbing and decreased cleansing action of soaps (Costi et al., 1999).

Two examined areas had very hard water (Alkhuta and Qnaa) and two samples were hard (Ugda and Twaran). Water hardness is the total concentration of calcium and magnesium picked up by water passing through underground mineral deposits. Hard water is not harmful to health. Some studies have revealed a weak inverse relationship between water hardness and cardiovascular disease. The United States National Research Council has announced that hard water can act as a dietary supplement for calcium and magnesium (Sengupta, 2013). More than 3/4th of renal stones are mainly composed of calcium salt and occur as calcium oxalate and less commonly as calcium phosphate. Increased urinary ion excretion and decreased urine volume will increase free ion activity and favor stone formation. The impact of water hardness on urinary stone formation remains unclear. A weak correlation between water hardness and urinary calcium, citrate, and magnesium levels has been observed. Some studies suggest that intake of soft water is preferable to hard water since it is associated with a lower risk of calcium nephrolithiasis (Bellizzi et al., 1999).

Urine analysis results revealed calcium oxalate crystals were 12% in Alkhuta and 28% in Qnaa while it was 48% in Ugda and 20% in twaran. Uric acid crystals were more common in Ugda (48%), Twaran (40%), and Qnaa (32%). Also, urate crystals were more common in Ugda (48%) and Hail (36%). US revealed presence of gravels in 40% in Twaran, 36% in Alkhuta and 32% in Qnaa and the presence of renal stones in Qnaa (24%) and 12% in Alkhuta. Nephrosis was detected in 8% in Alkhuta. It was noticed that the incidence of renal gravels, stone and nephrosis occurred in samples with hard and very hard water. Alkalinity is a measure of water ability to neutralize acids, and is related to the pH. It results primarily from carbonate minerals, such as those found in limestone. Alkalinity and total hardness are usually equal in concentration when both are reported in mg/L calcium carbonate as they come from the same minerals. Much higher alkalinity than total hardness considered testing for sodium whiles much lower alkalinity than total hardness, test for chloride, nitrate and sulfate. The lower the alkalinity, the more likely water is to be corrosive. Water with high alkalinity (greater than 150 mg/L) may contribute to scale buildup in plumbing. There is no health standard for alkalinity however. Values near 150 are considered ideal (Addy et al., 2004). Only Qnaa sample had a higher degree of alkalinity (215.7 mg/L) with a high incidence of renal gravels and stone formation. Many trace elements found in drinking water may cause health problems if their concentrations exceed certain permissible levels. All our studied samples were much lower than standard levels except high uranium level detected in Ugda although within standard level one case with suspected renal mass (4%) detected. Among the most common signs of acute toxicity are weight loss and hemorrhages in the eyes, legs and nose.

The most common renal injury caused by uranium in experimental animals is damage to the proximal convoluted tubules, predominantly in the distal two-thirds (Domingo, 1995). At doses not high enough to destroy a critical mass of kidney cells, the effect appears to be reversible, as some of the cells are replaced; however, the new epithelial lining differs morphologically and possibly functionally, from normal epithelium. Also, Nephritis is considered the primary chemically induced effect of uranium in humans (Zamora, 1998). Some trace element in over dose exposure in drinking water may have unfavorable effects on the urinary system. Cadmium accumulates in the kidney cortex. This chemical has been shown to damage the kidneys in experimental animals exposed at high levels over their lifetimes (Tayyeb et al., 2004). Chronic Lead exposure may lead to kidney damage and high blood pressure adults (Missoun et al., 2010). Many areas have high arsenic levels naturally particularly from deep groundwater or water from deep wells. Arsenic can also be formed by certain fertilizers and animal feeding operations. Arsenic has been linked to cancer of the bladder and kidney. Long term exposure to copper causes liver or kidney damage. People with Wilson's disease should consult their personal doctor if the amount of copper in their water exceeds the action level (Emsley et al., 2000). As regards US findings, there was one case (4%) with hydronephrosis in Twaran region 15 cases (15%) with cyst in Hail, Alkhuta and Ugda which discovered accidentally.

Turki (2009) examined the quality of 40 wells water in selected villages in Hael Region used mainly for drinking purposes without receiving any treatment. Of the 40 well water tested, about 20% of the samples failed to meet drinking water guidelines of SAS, GC.S and WHO respectively. TDS varied widely from 166 to 2400 mg/L. 36% of the tested water samples had higher nitrate level above the limit set by local and international standards. Only 52.5% of tested samples comply with the range of fluoride concentrations and Coliform bacteria (mainly *E. coli* and *E. aerogenes*) were detected in 20% of examined well water indicating faecal contamination. This revealed much improvement of water quality and availability of water treatment plants in this short period, which will be reflected in the general health in this area.

CONCLUSION

All studied water sample results were within the standard level with different changes from one area to another with no detectable microbiological or cytological contamination. Alkhuta and Qnaa revealed high EC, TDS, fluoride, nitrate, calcium, calcium and total hardness. Many patients had frequency and/or dysurea. Both areas showed high prevalence of renal gravels and renal stones. Ugda samples revealed high pH, nitrate and uranium. The only presenting symptom is frequency with high urine calcium oxalate, uric acid and bacterurea. High uranium level was detected in Ugda although within standard level, one case with suspected renal mass was discovered in this region. Twaran samples revealed a high pH and turbidity. Frequency and dysurea were common symptoms. There was high calcium oxalate crystals and prevalent of renal gravels with one case of hydronephrosis. Hail samples revealed high pH, low calcium and magnesium levels. Alkhuta and Qnaa had very hard water while Ugda and Twaran had hard water which favors stone formation. Qnaa sample had a higher degree of alkalinity (215.7 mg/L) with a high incidence of renal gravels and stone formation.

RECOMMENDATIONS

1. Regular monitoring of water quality on a routine basis is imperative to reduce the deterioration of well water quality and eliminate any possible health problems.
2. More water treatment plants should be installed by local government to provide safe drinking water especially in remote areas.
3. Alkhuta and Qnaa had higher levels of fluoride, which is above the SAS standard, so careful monitoring of water and persons in these areas especially with renal diseases.
4. Higher levels of nitrate detected in Alkhuta, Ugda and Qnaa so, careful use for infants, pregnant and nursing mothers in the study of the causes of these high levels.
5. Qnaa, Ugda and Alkhuta had a relatively higher magnesium levels. People with kidney disease, who cannot excrete excess magnesium, may suffer from hypertension, confusion, muscle weakness and coma.
6. Ultrasonographic screening in areas with the relevant water quality is mandatory for early detection of renal

complication and diseases.

Work limitation

Some of the studied area has a water treatment plant recently and many of our patients were old and may have used well water directly for many years before the availability of clean water, and this may explain the high incidence of renal gravels and stone in some area.

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