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Physico-Chemical Analysis of Drinking Water from Maoh (Zafar) Village, Yemen

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Abstract: Maoa (Zafar) village near Dhamar. Dhamar is a city in south western Yemen. It is situated 100 Km to the south of Sana'a (capital of Yemen) 2700 m above sea level. It is located at 14°33'0″N 44°24'6″E Coordinates, at an elevation of around 2400 meters. Maoa (Zafar) is gaining importance as a archaeological and tourist village. Maoa (Zafar) residents complain the prevalence of colon cancer and drinking water may be is the reason, where drinking water samples are not treated before it is consumed. This study consisted of the determination of the trace metals and some physical and chemical parameters in drinking water samples from the Zafar village, Dhamar governorate. The analysis have been investigated by using Uv-Vis spectrophotometer, flame photometer and standard analytical methods. The data show that: the physical and chemical parameters and levels of the nitrogenous compounds are agreement with the standard values of the World Health Organization (WHO) but concentrations of all the metal elements and the metal ions are very below compared with the standard acceptable levels for drinking water.

Key words: Physico-chemical parameters · Drinking water · Anions · Cations and metal elements

INTRODUCTION

Water is one of the very precious substances on the earth. Water quality analysis is one of the most important aspects in groundwater studies [1]. The natural water analysis for physical and chemical properties including trace element contents is very important for the public health and the environment studies [2-5]. There are around thirty chemical elements that play a pivotal role in various biochemical and physiological mechanisms in living organisms and recognized as essential elements for life [6]. For example the possible health consequences of low mineral content water consumption are: Direct effects on the intestinal mucous membrane, metabolism and mineral homeostasis or other body functions. Transition metals readily form stable covalent complexes and normally interact as parts of macromolecules (proteins, enzymes, hormones, etc.) according to their chemical characteristics including oxidation state. Health damage caused by toxic metals may be less (irritation) or acute (teratogenic, mutagenic and carcinogenic) [7]. Groundwater often consists of seven major chemical elements: Ca^{+2}, Mg^{+2}, Cl^{-1}, Na^{+1}, K^{+1}, HCO_3^{-1} and SO_4^{-2}. The chemical parameters of groundwater play a significant role in classifying and assessing water quality [1]. Some transition metals like Fe, Mn, Cu, Zn, Co, Ni etc at trace levels in our metabolism are very important for the proper functioning of the biological system and their deficiency or excess in the human system can lead number of diseases [8, 9]. Trace metals Cu and Fe play a major role in health, for even minute portions of them can significantly affect health. Fluoride is a trace element increases the resistivity of tooth enamel against acids which cause the initiation of tooth decay. Calcium and magnesium are both essential elements. Calcium plays a role in neuromuscular excitability and the coagulability of blood. Magnesium plays an important role as a cofactor and activator of more than 300 enzymatic reactions including glycolysis, transport of some elements

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through membranes, synthesis of proteins and nucleic acids, neuromuscular excitability and muscle contraction. Recent studies also suggest that the intake of soft water, i.e. water low in calcium, may be associated with higher risk of fracture in children, certain neurodegenerative diseases [10], pre-term birth and low weight at birth [11] and some types of cancer [8, 9]. In addition to an increased risk of sudden death [14-16], the intake of water low in magnesium seems to be associated with a higher risk of motor neuronal disease [17], pregnancy disorders [18] and some types of cancer [19-20]. The results of Yang C. Y. *et al*. show a significant negative relationship between drinking water hardness and colon cancer mortality, where trend analyses showed an increasing odds ratio for colon cancer with decreasing levels of hardness in drinking water [23]. The area under investigated has a high prevalence of colon cancer compared to other parts of the Dhamar Governorate based on information of general hospital of Dhamar and national assembly against cancer in Yemen, in addition to the author's visit to the area and interview a number of area residents. Hence this study aims to knowledge if there any relation between this phenomenon and the drinking water in this village. According to our literature review, there has been no published report concerning the drinking water quality in the Maoh (Zafar), Dhamar Governorate, Yemen.

MATERIALS AND METHODS

Samples Collection: Thirty samples ($\bar{S}_1$, $\bar{S}_2$ and $\bar{S}_3$) from three springs (the mark-means the average of tin samples from each spring), which using as drinking water sources in Maoh (Zafar) village, Directorate of Yarim, Governorate of Dhamar, Yemen have been collected in May 2011. Fig. (1) represents map of Yemen and Dhamar city location. The drinking water samples were collected in polyethylene bottles which prewashed with detergent, doubly de-ionized distilled water diluted HNO_3 and doubly de-ionized distilled water, respectively.

Methodology: pH and electrical conductivity (EC) of the samples were measured by using pH and EC meters (HACH Models) while collecting the samples. The determinations of the major anions and cations and physical and chemical properties of the water samples were performed on the second day of the sampling. Zn, Fe, CN^-, F^-, SO_4^{-2}, Cu^{+2}, NO_2 and NO_3

Fig 1: Represents map of Yemen Republic and Dhamar Governorate location.

concentrations measurement investigated by using spectrophotometer meter UV-Vis, HACH Dr/ 4000 Model 48100. K^+ determined by using flam photometer (PFP7). Chloride was determined by using the mercuric method. The total hardness ($CaCO_3$) and calcium hardness and calcium ions were obtained by using the Ethylene Di-amin Titra Acetic-acid (EDTA) methods. Magnesium hardness is calculate from the difference between the total hardness and calcium hardness and magnesium ions = 2.43 (magnesium hardness).

RESULTS AND DISCUSSION

Average data of pH, electrical conductivity (EC), total dissolved solids (TDS), alkalinity and total hardness of the investigated samples are listed in Table 1. pH average values of all the samples in the rang safe 6.5-8.5, where pH average value of the both samples S_1 and S_2 equal to 7.3 and pH average value of the sample S_3 equal to 7.8. This will indicate that water is probably hard and calcium and magnesium. Results of the electrical conductivity show that the EC average values of the samples S_1 and S_2 are 570 µS/cm and 593 µS/cm respectively, which within the recommended values average value (400 µS/cm) of WHO [24]. Average value of the EC can give idea of the amount of dissolved chemicals in water and it has a significant impact on user's acceptance of the water where it effects on the taste. Total dissolved solids (TDS) levels of all the investigated samples are a agreement with the standard value of WHO [24]. This result is good and it means that the samples contain low concentration of dissolved salts and inorganic population. Ranges for alkalinity were 196 to 260 mg/l and these are satisfied ranges for drinking water according on the standard ranges of WHO [24]. Total hardness average values of the investigated

Table 1: The average physical and chemical parameters of the investigated samples.

The investigated samples	$\bar{S}_1$	$\bar{S}_2$	$\bar{S}_3$	W.H.O
The parameters				
pH	7.3	7.3	7.8	6.5- 8.5
EC (µS/cm)	570	593	353	400-1500
TDS (mg/l)	371	385	229	1000
Alkalinity (mg/l)	260	214	196	500
Total Hardness (mg/l)	320	320	214	100-500

Table 2: Average concentration of nitrogenous compounds in the investigated samples.

The investigated samples The nitrogenous compounds (mg/l)	$\bar{S}_1$	$\bar{S}_2$	$\bar{S}_3$	W.H.O
NH_3	0.116	0.06	0.035	0.05-0.5
NO_3	28	9	13	25-50
NO_2	0.092	0.011	0.01	0.1

Table 3: Average concentration of major anions in the investigated samples.

The investigated samples Major anions (mg/l)	$\bar{S}_1$	$\bar{S}_2$	$\bar{S}_3$	W.H.O
Cl^-	30	58	14	250
F^-	0.58	0.5	0.32	0.5-1.5
CN^-	0.022	0.012	0.038	0.1
$SO4^{2-}$	44.5	45.5	19.5	25-400
HCO_3^-	317	262	239	150-500

Table 4: Average concentration of metal elements major cations in the investigated samples.

The investigated samples Metals and major cations (mg/l)	$\bar{S}_1$	$\bar{S}_2$	$\bar{S}_3$	W.H.O
Fe	0.29	0.031	0.028	0.3-1
Zn	0.117	0.178	0.159	5-15
K^+	0.7	6.56	0.59	8-12
Cu^{2+}	0.444	0.12	0.072	0.5-1
Ca^{2+}	112	112	36	75-200
Mg^{2+}	9.6	9.6	29.76	30-50

samples were in the range of 320 to 214 mg/l which within the range (100-500) mg/l of WHO [24]. According on the average values of total hardness of drinking water in the village of Maoh (Zafar) can be considered this water (as $CaCO_3$) is hard.

Levels of the Nitrogenous Compounds: Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2) are given in Table 2. Levels of NO_2 of the samples S_1, S_2 and S_3 are 0.09, 0.011 and 0.01mg/l respectively and these levels within the standard levels of NO_2, so that the there no significant water quality problem. Levels of NH_3 in the S_1 and S_2samples are 0.116 and 0.6 mg/l respectively which within the standard concentration range (0.05-0.5 mg/l) of WHO whereas, level of NH_3 in the sample C (0.0385 mg/l) is smaller than the lowest average value of NH_3 in the range of WHO [24]. Standard value of NO_3 level in WHO is 25-50 mg/l. Results of NO_3 levels of the samples S_1, S_2 and S_3 equal to 28, 9 and 13 mg/l respectively, this means that the level of NO_3 in the sample S_1 is appropriate but levels of NO_3 of the samples S_1 and S_3 are not appropriate Data of major anions (chloride, fluoride, cyanide and sulphate ions) are shown in Table 3. From this table it can be seen that the concentrations of chloride ion (Cl^-) in the samples S_1, S_2 and S_3 are 30, 58 and 14 mg/l respectively and these concentrations within the standard concentration (250 mg/l) of WHO [24]. Concentrations of cyanide ions (CN^-) of all the samples within the values range of W.H. O as shown in the Table 2. Concentration of sulphate (SO_4^-) of the samples S_1 and S_2 are 44.5 and 45.5 mg/l respectively, these Concentrations in the range of values (25-400 mg/l) of WHO but Concentration of SO_4^- (19.5 mg/l) of the sample S_3 is smaller than the lowest value (25mg/l) of WHO [24]. Similarly, concentrations of fluoride ions (F^-) of the samples S_1 and S_2 are 0.58 and 0.5 mg/l respectively which within the standard range of WHO. Concentration of F^- ions 0.32 mg/l of the sample S_3 is smaller than the lowest value in WHO range [24] and This may be leads to decreases the resistivity of tooth [13].

Measurements of the metal elements and the major cations are listed in the Table 4. Results show that concentrations of the both metal elements (Zn and Fe) and all the metal ions (Cu^{2+}, Ca^{2+}, Mg^{2+} and K^+) are smaller than the standard concentrations of WHO, this leads to possible bacterial growth [24]. The lowest concentration values of the metal elements and the metals ions in the sample S_3, which represent the president source of drinking water for the popular of Maoh village. This means that the drinking water springs in the Maoh (Zafar) village are very poor in mineral metals this may be the reason of the prevalence of colon cancer among Maoa (Zafar) residents [12, 22].

CONCLUSION

Thirty drinking water samples were collected from three springs, which using by Maoa (Zafar) residents. The physical and chemical properties and trace metal elements were investigated. Results of this study show that the springs of drinking water in the Maoh (Zafar) village are very poor in the metal elements and metal ions. This study recommends Water Authority Dhamar search for the new and convenient source of drinking water or treatment drinking water of springs S_1, S_2 and S_3 before use.

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