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Evaluation of Mineral Drinking Water in Duhok City

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ABSTRACT

Background: Mineral water samples are taken from nine different factories for the production of mineral drinking water in Dohuk Governorate.

After conducting all the physical, chemical and bacteriological tests in the laboratories of the Environment Department, it is found that all the results obtained are within the international standards, as shown in the attached tables in the research. This indicates that the groundwater is water suitable for human use, in addition to treating it with the best modern scientific techniques available in these laboratories.

It also indicates the interest of quality control departments in maintaining the cleanliness and health of drinking mineral water because of its importance in human life.

Aim: The present study was undertaken to determine the physico-chemical properties and heavy metals in mineral drinking water samples collected from different sources in other factories producing mineral drinking water in Duhok.

Methods: Total number of 100 bottles 1L water samples was collected from different nine factories products. The gross appearance, taste, odor, temperature, pH, physical, chemical and bacteriological tests will be started.

Results:

Chemical analysis: The chemical analysis involves both the in-laboratory analysis (TDS and TSS) and the on-site analysis (pH, turbidity, and conductivity) as shown in the table1 and as follow.

pH is regarded as a significant parameter of water quality. The pH measurement portrays the acidity and alkalinity of the water. Samples with a p.H that is less than 7.0 are regarded as acidic. Samples with a p.H higher than 7.0 are regarded as alkaline. Water that is acidic can result in metal pipes and plumbing system corrosion. Meanwhile, alkaline water depicts disinfection in water. According to the WHO and NDWQS, the p.H of normal drinking water should range between (6.5 and 8.5). The pH values of all samples of mineral drinking water in all factories are found between the range between (6.7 and 7.4) and the turbidity is (0.2- 0.4), and the EC in us is(176.4-234) the total dissolved solids (112.7-150) and the total alkalinity is (46-94), and the total hardness is (72-104) and the result for the element study in this search are Ca (16-27.2), Mg (5.9-11.7), Cl (4.0-14.0), S (9.7-58.2), Na(1.2-29.0), K (0.2-1.0), N(0.2-15.3) respectively.

Chemical measurement of the elements (Pb, Zn, Fe, Ni) in the mineral drinking water

The results for the elements that were measured in the mineral drinking water as shown in table 2 and as follows Pb (Nil), Zn (0.021-0.0471), Fe (0.002-0.0141), Ni (0.002-0.0031), respectively for all factories.

Bacteriological analysis of the mineral drinking water: The results for the bacteriological analysis in the mineral drinking water for all factories are shown in table 3 and as follow. Residual free chlorine (0.0), the presumptive total coliform (<2.2), the confirmatory coliform (<2.2), the confirmatory faucal coliform (<2.2), and the results of the E-coli is (0.0) respectively.

Conclusion: This study confirms the estimation and measurement of heavy and minute metals and other inorganic elements in the mineral drinking water used by people in this province.

After obtaining the results of this study, it is found that the concentrations of all the samples are within the international measurement, although there is a slight difference in some of the results, and it is less than the level of risk.

Key words: Mineral drinking water, Water contaminants, pH, Total suspended solids

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INTRODUCTION

Water is crucial in the maintenance of the health and welfare of human beings. Access to clean drinking water is now regarded as an important human being right. Approximately 780 million individuals lack access to clean drinking water, and about 2.5 billion people lack proper sanitation. Therefore, approximately 6.8 individuals die annually as a result of water-related disasters and diseases [1]. Hence, control of water quality is a crucial agenda in different parts of the world [2]. In the current world, domestic water is the water used in household supplies. This water is mainly made for consumption and other household purposes. The determinants of water quality for consumption include its colour, taste, odor and organic and inorganic matter concentration [3]. Water contaminants affect its quality and also human health. Some of the possible sources of water contamination include water treatment plants, agricultural and industrial activities and geological conditions. The contaminants can further be classified as radionuclides, inorganics, disinfectants, microorganisms, and organics. [4]. There are several scientific tools and methods that are used to measure water contaminants [3]. The methodologies involve the evaluation of various parameters like pH, total suspended solids (TSS), turbidity, total organic carbon (TOC), heavy metals and conductivity. The water quality is affected if the values of these parameters are higher than those recommended by the World Health Organization (WHO) and other regulatory bodies [2]. Hence, researchers across the world and governmental departments have investigated the drinking water quality [5–12].

In the past few years, the consumption of bottled mineral water has abruptly increased across the world. According to the U.S. and International Developments and Statistics report, there has been an increase in the use of bottled water in Western European countries, the United States and several Asian nations [13] and by 2017, it is anticipated that individuals worldwide are expected to use approximately 391 billion litres of mineral bottled water [14].

Numerous researches have concentrated on the safety of bottled water, specifically on chemical migration from plastic containers to water. Plasticizers (additives used in the manufacturing of plastics) [15] and endocrine disruptors (EDs–chemicals influencing endocrine system functioning) [16] are the main components that have adverse impacts on human health.

Accordingly, natural mineral waters have portrayed intrinsic features, and this work will examine them and their diverse effects on the treatment and prevention of various pathological and physiological statuses.

Characteristics of natural mineral waters

“Natural mineral water” is the 'microbiologically wholesome' water but makes sure the main contamination indicators (Escherichia coli and faecal streptococci, pseudomonas aeruginosa, parasites and pathogenic microorganisms, sporulated sulphite-reducing anaerobes) are absent at the source and in the process of its marketing [13].

The natural mineral water characteristics have to be verified from different perspectives:

Geological and hydrological, that needs an in-depth description of the site of the catchment, putting into consideration the terrain nature, a description of the operations of catchment and the stratigraphy of the hydrogeological layer.

physical, chemical and physicochemical, that depicts a report concerning the main chemical and physical analysis to give a final description of mineral water characteristics (i.e. trace elements, rate of flow of the spring, dry residues at 180°, the temperature at source, pH, anions and cations, the toxicity of certain constituent elements) microbiological, that ensures there are no main indicators of contamination.

Possible pharmacological, physiological and clinical effects. It is crucial for conducting clinical research so as to evaluate physiological consequences and advantages to the health of humans. They need to be scientific research conducted within a stipulated period of time with the application of different methods [13-18].

Principal analytical techniques

It is crucial to standardize laboratory procedures and methods. International standard methods need to be assessed in local conditions before being used formally by surveillance programs. ISO standard methods lists are shown in the references.

There are three commonly used methods in the separation of indicator organisms from water which include the multiple-tube (MT) or most probable number (MPN) method, membrane-filtration (MF) method, and presence-absence tests.

Physicochemical analysis; chlorine residual

The decontamination of drinking-water supplies protects the possibility of the occurrence of waterborne diseases. Even though there are numerous disinfectants that can be used in water treatment, chorine is regarded as the main disinfectant agent that is used by small communities in different parts of the world.

Some of the advantages of the use of chlorine are that it is cheap, easy to measure both in field and laboratories, and efficient. Also, chlorine leaves a disinfectant residual that is crucial in preventing recontamination during transport, distribution, and household storage of water. In some circumstances, the absence of chlorine residual in the distribution system may show the likelihood of contamination after treatment.

Interpreting a mineral analysis

Alkalinity

Alkalinity involves the measurement of the capability of water to neutralize acids. The most common chemicals found in natural waters include bicarbonates, carbonates and hydroxides. Mostly, the bicarbonate ion dominates. Though, these ions ratio is a function of ionic strength, temperature, pH and mineral composition. In some circumstances, water may have a low alkalinity level but a high pH or vice versa. Hence, alkalinity alone should not be considered as the main factor in the measurement of water quality.

Alkalinity in water is not regarded as harmful to human beings, although it is associated with high pH values, excessive dissolved solids and hardness. Water with high alkalinity levels may also have a distinctly flat, unpleasant taste. It can be treated by ion exchange through the addition of reverse osmosis.

Arsenic

This is a semimetal component that is tasteless and odorless. The main sources of this element to water supplies are agricultural and industrial activities and also natural deposits in the earth.

In line with the EPA, drinking water with arsenic could be associated with carcinogenic features. It can lead to blood cancer, liver cancer, kidneys, skin, lungs and prostate cancer. It can also lead to cardiovascular, endocrinal, pulmonary and neurological problems.

The treatment depends on the degree of the contamination of the element. Ideal recommendations involve adding an anion filters or tank media.

Calcium and magnesium

Calcium and magnesium are the main elements that result in water hardness. Heating of water results in the decomposition of calcium which precipitates out of the solution, forming scale. There is no specific limit that has been established for the expected limits of calcium in the water. A concentration of Magnesium above 125 mg/l may affect some people. Calcium can be treated by softening and reverse osmosis. Magnesium can be treated by distillation.

Chloride

High levels of chloride ions in water cause the water to have a salty taste and make hot water plumbing systems corrode. High concentrations of chloride ions in water may have a laxative effect on some individuals. A concentration limit of above 250 mg/l is regarded as excess and harmful. However, it is hard to notice the taste at this level, and even a higher concentration may not have many effects on human health. Some sources that may cause an increase in normal chloride levels of water include human sewage pollution, industrial wastes or animal manure.

Color

Color may show dissolved organic minerals, insufficient treatment and a greater disinfectant demand. It may also indicate the possibility of the production of high amounts of disinfectant byproducts. Inorganic contaminants, like metals, are usually frequent causes of color. Overall, the consumer mostly complains when the color is in the range of 5 to 30 color units, although many people find color disturbing when in excess of 10 color units. Other pollutants that may cause a change in water color include Iron, Aluminium, manganese, copper, total dissolved solids, foaming agents and manganese. This can be treated reverse osmosis.

Conductivity; Conductivity is a measure of the water to pass the electric currents. It is easier to measure since it relates to the total dissolved solids content in water. The recommended level of contamination (MCL) is 0.4 to 0.85 micro-Siemens per centimeter. The treatment could be through reverse osmosis, particularly for consumption water.

Fluoride

The concentration of water with levels of 0.7 to 1.2 mg/l of fluoride helps in preventing dental cavities. However, a higher concentration (more than 1.5 mg/l) may result in discoloration or teeth mottling. This is common in developing teeth before they push through. Excessive fluoride levels may also cause bone diseases and skeletal damage. Many municipalities add fluoride to water since groundwater commonly has low levels of fluoride.

Iron and manganese

A concentration of Iron above 0.3 mg/l and manganese concentration above 0.05 mg/l may result in brown and black stains on sinks, laundry and plumbing fixtures. There is a possibility of the occurrence of a metallic taste. This may affect beverages taste from water. However, high concentrations of manganese and irons may not have adverse effects on health. The presence of these elements can be treated by a water softener and reverse osmosis for manganese.

The end of the page lists of publications gives more information on softening and removal of Iron and manganese.

Nitrates

The nitrates results can be a bit confusing because they can appear in the form of nitrogen (N), nitrate-nitrogen or nitrate ($NO3$). Below are the recommended levels for each:

Nitrogen (N) or nitrate-nitrogen ($NO3$-N) should be below 10mg/L.

Nitrate ($NO3$) should be below 45mg/L.

A high concentration of nitrates in drinking water may cause methemoglobinemia in infants or formula created from the water having nitrate levels more than expected.

A higher concentration of nitrates, however, has lesser effects on adults. The method of treatment of these elements in water include ion exchange, distillation and/or deionization and reverse osmosis.

pH

The pH measures the acidity and alkalinity of water. It is a logarithmic scale that relies on the presence of free hydrogen ions in the water. It has a scale that a range from 0 to 14, in which a range of 0 to 7 is acidic, 7 is neutral, and 7 to 14 is considered alkaline. Since pH may be influenced by the presence of dissolved minerals and chemicals, it can be used as an indicator for the chemical change of water.

Based on the U.S. Environmental Protection Agency, consumption of water with a pH ranging 6.0 and 9.5 is overall recommended as satisfactory. Most public supplies of water that consumes water from Red River, Missouri and James as their main source have to observe the P.H of more than 9 so as to be in line with the Lead and Copper Rule of the Safe Drinking Water Act, which ensures leaching of these elements from the piping system is prevented.

The presence of a p.H below 6 or above 9.5 in water can cause corrosion in metal plumbing pipes. The performance of pesticides, specifically, herbicides can be influenced by the pH of water.

Potassium

Generally, the concentration of potassium in water is usually low. However, a high concentration of potassium in drinking water may have a laxative effect. There is no standard limit that is set by the EPA for these elements in the water. Potassium (chloride) can be used in place of salt in water softeners when dietary sodium consumption is a health matter.

Sodium

Sodium is an active element that rarely occurs in a free state naturally. It usually occurs as a compound. Sodium is helpful in maintaining the water balance in the human body. The consumption of sodium as table salt or sodium chloride mainly influences the human intake of sodium. The intake of sodium from drinking water is usually small as compared to other sources.

Treatment of kidney disease or certain heart conditions can be done by the regulation of excessive intake of sodium. These people have special diets that consider the removal of sodium in their meals and drinking water.

According to the National Academy of Sciences, it is recommended that public drinking water should not have more than 100 mg/l of sodium. This restricts water supplies from adding more than 10 percent of the normal person intake of sodium.

According to the American Health Association, a standard of 20mg/l is recommended for the protection of kidney and heart patients.

Ion exchange softening or lime-soda ash raises the sodium content roughly 8 mg/l for each gr/gal (grain per gallon) of hardness removed. The treatment can involve the application of potassium chloride as a substitute for sodium chloride softener pellets (softener salt) or, on the other hand, making restrictions on drinking water from this source.

Sulfates

High levels of sulfates in water, especially magnesium sulfate (Epson salts) and sodium sulfates (Glauber's salt), may cause a laxative effect on people. The effect is experienced differently within different people until they get adapted to using the water. The taste of water is also affected by a high concentration of sulfates, and it also forms a hard scale in heat exchangers and in boilers. Concentrations of sulfates above 250 mg/l are considered harmful. Reverse osmosis is used for the treatment.

Total dissolved solids (TDS)

The water taste may be affected by high concentrations of TDS. It may also destroy appliances and plumbing systems. According to EPA, water with a concentration of TDS above 500 mg/l should not be consumed if there is an alternative to other less mineralized supplies. However, water with concentrations above 500 mg/l TDS is still safe for consumption. Apart from the many public treated water, the Missouri River, a few freshwater lakes and scattered wells, we have fewer water supplies in North Dakota that have less than the recommended levels of 500mg/L TDS concentration. Most of the households consume water with concentrations of up to 2,000 mg/l and greater. Reverse osmosis is used for treatment for household use.

Total hardness

Water hardness is a feature that makes water form an insoluble curd and scum with soap. The presence of calcium and magnesium in water is the main cause of water hardness. More water hardness has no determined health effect and may be more beneficial to humans as compared to soft water. The disadvantage of using hard water is that more soap is needed for cleaning. Also, scum and curd cause fabrics to have a yellow colour. The vegetables cooked in hard water appears tough and forms scale in pipes, boilers and water heaters. High-quality water hardness should not be more than 270 mg/l (15.5 grains per gallon) measured as calcium carbonate. Water that is soft than 30 to 50 mg/l may cause pipe corrosion in reliance on the dissolved oxygen, p.H and alkalinity. Water softeners can be used to treat hard water of more than 270 mg/l.

Turbidity

Turbidity measures the total suspended materials, dissolved organic and inorganic materials, plankton and bacteria. Surface water sources are the common determinant of turbidity. This can be treated by mixing with other components like alum that cause coagulation of the suspended materials that are thereafter removed by sand filter filtration.

Results are further explained in tables (Tables 1 to Table 3).

Table 1: Chemical examination of mental drinking water (All parameter in mg/l unless otherwise states).

Characteristics		Turbidity in (NTU)	Color	PH	EC in uS	Total dissolved solids	Total Alkalinity	Total Hardness	Ca	Mg	Cl	S	Na	K	N
Max: Permissible		5	-	6.5-8.5	-	1000	125-200	100-500	75-200	250	250	250	200	3-Feb	50
1	F1	0.3	clear	6.7	198.1	126.8	46	104	22.4	11.7	8	58.2	1.2	0.3	0.4
2	F2	0.3	clear	7	189.9	121.5	94	92	20.8	9.8	10	15.5	1.7	0.2	0.1
3	F3	0.2	clear	7	176.4	112.9	66	80	20.8	6.8	8	27.9	3.5	0.6	3.3
4	F4	0.2	clear	6.8	190.6	122	46	92	20.8	9.8	6	51.3	1.3	0.4	0.2
5	F5	0.4	clear	7	192.6	123.2	92	100	24	9.8	10	20	2	0.3	0.3
6	F6	0.3	clear	7.3	176	112.7	94	96	25.6	7.8	4	2.7	1.1	0.2	0.2
7	F7	0.4	clear	6.9	187.1	119.8	82	92	27.2	5.9	14	10.7	3	0.4	14.8
8	F8	0.3	clear	7.3	234.4	150	92	72	16	7.8	12	18.7	29	1	10.8
9	F9	0.3	clear	7.4	200.2	128.1	86	100	27.2	7.8	8	9.7	3.2	0.4	15.3

Table 2: Chemical examination of drinking water (All parameter in mg/l unless otherwise states) (Heavy metal lab).

No.	Max- Permissible Level	0-05	3-0	0-3	0-1
	Sample name	Pb	Zn	Fe	Ni
1	F1	Nil	Nil	Nil	0.0031
2	F2	Nil	Nil	0.012	0.003
3	F3	Nil	0.0021	0.011	0.0021
4	F4	Nil	0.0064	Nil	0.0025
5	F5	Nil	Nil	0.01	0.0028
6	F6	Nil	0.0027	0.002	0.0023
7	F7	Nil	0.0064	0.01	0.0029
8	F8	Nil	0.0471	0.01	0.0023
9	F9	Nil	0.0053	0.0141	0.002

Table 3: Bacteriological analysis of drinking water.

No.	Location	Sources (ml)	Residual Free Chlorine mg/1	MPN per/100ml			
				Presumptive Total Coliform	Confirmatory Total Coliform	Confirmatory Faucal Coliform	*E. Coli*
1	F1	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
2	F2	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
3	F3	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
4	F4	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
5	F5	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
6	F6	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
7	F7	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
8	F8	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-
9	F9	100	-	≤ 2.2	≤ 2.2	≤ 2.2	-

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