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Research Article

Determination of Heavy elements in Drinking Water from Different Regions of Baghdad City (Iraq) Using EDXRF Spectrometer

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Abstract

It was calculated the average concentrations of elements manganese, iron, cobalt, nickel, copper, zinc, arsenic, cadmium and lead in the sixteen samples of drinking water (tap water), were collected from different areas in the Baghdad city. The Results indicated that the average of concentrations of the elements Mn, Fe, Pb, Ni and Cd (0.44ppm, 0.49ppm, 0.04ppm, 0.17ppm and 1.2ppm respectively) higher than permissible limit while the concentrations of elements Cu and Zn (0.11ppm and 0.14ppm respectively) were lower than the permissible limit of World Health Organization (WHO) standards (1ppm and 3ppm) respectively for drinking water and the concentration of Arsenic in the nuclear lab sample in college of sciences - Mustansiriyah University was higher than permissible limit.

All the drinking water samples were analyzed and determined the physical and chemical properties such as Electrical Conductivity (EC), pH, and Total Dissolved Solids (TDS). The highest value was (1064µS/cm) in Al-Tuwaitha sample and the lowest value (531µS/cm) in Al-Sadr City (Sector 7) sample for the Electrical Conductivity. The pH values ranged from (7.0-8.2). The average levels of Total Dissolved Solids (TDS), the highest value was 550 mg/L in the Diyala Bridge sample while the lowest value 276mg/L in Al-Sadr City (Sector 7) sample. The results were compared with national and international standards, and it's also showed that the values of the parameters within the permissible limit of World Health Organization (WHO) standards, except the Electrical Conductivity values for some samples were higher than permissible limit. According to these results, all the water projects must be monitored as well as using the proper and modern techniques for treatment the drinking water.

Keywords: Drinking water contamination, Energy-dispersive X-ray Fluorescence Spectrometer, Heavy elements.

الخلاصة

تم حساب متوسط تركيزات العناصر المنغنيز والحديد والكوبالت والنيكل والنحاس والزنك والزرنيخ والكادميوم والرصاص في ستة عشر عينة من مياه الشرب (مياه الصنبور) جمعت من مناطق مختلفة في مدينة بغداد. وأشارت النتائج إلى أن متوسط تراكيز العناصر المنغنيز، الحديد، الرصاص، النيكل والكادميوم (0.44 ppm، 0.49ppm، 0.04 ppm، 0.17ppm، و 1.2 ppmعلى التوالي) أعلى من الحد المسموح به في حين أن تراكيز العناصر النحاس والزنك (كانت 0.11 ppm و 0.14ppmعلى التوالي) أقل من الحد المسموح به لمعايير منظمة الصحة العالمية (WHO) حيث كانت (1ppm و 3ppm) على التوالي لمياه الشرب وتركيز الزرنيخ في عينة مختبر النووية في كلية العلوم - الجامعة المستنصرية كان اعلى من الحد المسموح به.

وقد تم ايضاً تحليل جميع عينات مياه الشرب من حيث الخصائص الفيزيائية والكيميائية مثل التوصيلية الكهربائية (EC) والأس الهيدروجيني والمواد الصلبة الذائبة (TDS). حيث كانت أعلى قيمة (1064 µS/cm) في عينة التويثة وأقل قيمة (531 µS/cm) في عينة مدينة الصدر (القطاع 7) للتوصيلية الكهربائية. وقد تراوحت قيم الأس الهيدروجيني من (7.0-8.2) لتلك العينات. أما متوسط المواد الصلبة المذابة (TDS)، فكانت أعلى قيمة (550mg/l) في عينة جسر ديالى في حين أن أدنى قيمة لها276 (mg/l) في عينة مدينة الصدر (قطاع 7). ومن خلال مقارنة النتائج مع المعايير المحلية والدولية أظهرت أن قيم تلك الخصائص ضمن الحدود الموصى بها من قبل منظمة الصحة العالمية (WHO)، بإستثناء قيم التوصيلية الكهربائية لبعض العينات كانت أعلى من الحد الموصى به. وفقا لتلك النتائج، لا بد من مراقبة جميع مشاريع مياه الشرب وكذلك استخدام التقنيات الحديثة والمتطورة في معالجة تلك المياه لغرض استخدامها للأستهلاك البشري بشكل صحيح.

Introduction

Water is the precious gift of nature to the human being. It is essential for the growth and maintenance of our bodies, as it is involved in a number of biological processes. The quality of water is of vital concern for mankind since it is

directly linked with human health [1]. Some elements present in drinking water at ppm or ppb levels, can improve or affect the function of the human physiology as deficit or excess of certain elements may lead to many diseases. Since drinking water is one of the most essential pathways to uptake harmful heavy metals by people, the quality control is particularly important in water supply. Some of the trace elements known to be essential are As, Co, Cu, Fe, Mn, Ni, Zn, Pb and Cd [2]. Therefore, it is important to determine the heavy metal content of environmental samples [3] the most popular methods for this purpose at present are atomic absorption spectrometry (AAS), inductively coupled plasma- atomic emission spectrometry (ICP-AES) and instrumental neutron activation analysis (NAA). The necessity of a nuclear reactor for NAA, the necessity of exhaustively prepare the samples (depending on the matrix) for AAS and ICP-AES, however, stimulate the interest towards energy dispersive X-ray spectrometry (EDXRF) in ecological investigations [3]. EDXRF is a non-destructive and multi-elemental technique which can be applied to any kind of sample, liquid, solid, thick, intermediate or thin, with, in many cases, sufficient sensitivity for many trace elements [4] and EDXRF technique combined with simple procedures of sample preparation such as drying of a few droplets of liquid on filter paper allow measurement of calcium, potassium, chlorine, sulfur and phosphorus in blood serum and in cellular fluids. Ashes of tissue, serum and bones may be analyzed for heavy elements such as iron, zinc, copper and strontium. EDXRF technique further allows to detect electro phonetically separated protein fractions of the serum and to detect pathologic changes [5].

Materials and Methods

Collection of Water Samples

The sampling points were located in the different areas of Baghdad city. A plastic bucket was used to collect the water samples.Heavy elements concentrationis measured in the collected water samples using Energy Dispersive X-Ray Fluorescence (EDXRF) technique, in The Ministry of Science and Technology. The pH and Electrical Conductivity for all water samples were measured by (pH and EC Meters), type (WTW, versions: Cond 315i). Total dissolved solids (TDS) were also measured by a portable TDS meter (WTW, versions: Cond 340i).

Method of Elemental Analysis (Energy Dispersive X-Ray Fluorescence)

Energy dispersive X-ray Spectrometer designed for the elemental analysis of a wide range of samples. The system is controlled by a personal computer running the analytical software. X-ray spectrometer, which is an energy dispersive microprocessor controlled analytical instrument designed for the detection and measurement of elements in a sample from sodium to uranium.
The sample is loaded in the sample chamber of spectrometer and a voltage and a current is applied to produce the X-ray to excite the sample for a preset time (15 minutes). The spectrum from the sample is now analyzed to determine the concentration of the elements in the sample.

Physico-chemical parameters

The physico-chemical properties such as: hydrogen ion concentration (pH), electrical conductivity (EC), and total dissolved solids (TDS) in water samples were analyzed on pH/EC meter.

Results and Discussion

The results of all measurements and laboratory tests that have been conducted for the purpose of determining the qualities of drinking water and compare them with the specifications of the World Health Organization (WHO). Table 1, gives the concentration of elements: Mn, Fe, Co, Ni, Cu, Zn, As, Cd, and Pb, as heavy elements and WHO specification of drinking water. Table 2, shows the pH, EC and TDS values of samples and the detection limit of each value.
The comparison between the elements concentrations and the WHO standards [6] showed that the concentrations of these elements were above the permissible limits.
The mean concentration of Manganese 0.44 mg/l, the concentration of Mn was recorded above the permissible limit according to WHO specification for most samples. Furthermore, results revealed the absence of Mn concentration in water sample of (nuclear lab). This may be attributed to the huge amounts of raw sewage [7].
The concentration mean of Fe was 0.49 mg/l, in all the collected water samples, the concentration

of iron was recorded above the permissible limit according to WHO specification of drinking water, except the sample of (Al-Adamiyah) which is lower than standard. Iron in drinking water is present as Fe2+ or Fe3+ in suspended form. It comes into water from natural geological sources, industrial wastes, and domestic discharge and also from byproducts [8].

The concentration of mean of Co was (0.10) mg/l, the maximum admissible limit of Cobalt in drinking water is not mentioned by WHO. Results revealed the absence of Co concentration in water samples from (Al-Sadr City Se.7 – Al-Maghreb - Abu Ghraib – Al-Rashdiya – Al-Tuwaitha). Cobalt is beneficial for humans because it is part of vitamin B12, essential for human health. It is used to treat from anemia with pregnant woman as it stimulates the production of red blood cells. High concentration of Co may damage human health [9].

The concentration mean of Ni (0.17) mg/l. In all the collected water samples, the concentration of Ni was recorded above the permissible limit according to WHO Spec. of drinking water except Al-Adamiyah sample which was lower than standard. Results are also revealed the absence of Ni concentration in Al Maghreb sample. The concentration of Ni in water depends on the quality of the pipes. In the case of metal pipes, the level of Ni in hot water is lower than in cold water. However, when PVC pipes are used the concentrations are opposite and nickel come from pipes, containers and corrosion processes [10].

The concentration mean of Copper 0.11 mg/l in the drinking water samples. In all the collected water samples, the concentration of Cu was recorded above the permissible limit according to WHO Spec. of drinking water. Results also revealed the absence of Cu concentration in water samples in Diyala Bridge and Al-Qahira. Copper in drinking water supplies largely comes due to leaching from piping and plumbing fixtures. Addition of Cu into water ways also anthropogenic sources such as: industrial effluents and sewage treatment plant effluents largely contribute to elevated copper levels. Although copper serves as a nutritional requirement for body, exposure to excessive levels of copper can result in number of adverse health effects, most commonly gastrointestinal distress [11].

The concentration mean of Cd was (>1.2) mg/l, in all the collected water samples, the concentration of Cd was recorded above the permissible limit according to WHO of drinking water. Sources of water contamination by cadmium are erosion of natural deposits, corrosion of galvanized pipes, oil refineries spills [12].

The concentration mean of Zn (0.14) mg/l in the drinking water samples ranged from (0.05 - 0.26) mg/l. In all the collected water samples, the concentration of Zn was recorded under the permissible limit according to WHO of drinking water, zinc is an essential requirement for a healthy body, excess zinc can be harmful and cause zinc toxicity [9].

The concentration of arsenic does not appear in all samples except nuclear laboratory sample in the college of sciences - department of physics at Mustansiriyah University (0.03mg/l), which is higher than the standard concentration for drinking water. The most important cause of environmental arsenic impact relates to the consumption of arsenic-contaminated drinking water. In most cases, the arsenic is of natural origin but in some instances mining activities are responsible [13].

The concentration mean of Pb was (0.04mg/l) in the drinking water samples. In all the collected water samples, the concentration of Pb was recorded above the permissible limit according to WHO of drinking water except Al Za'franiya sample which was lower than standard. Results revealed absence of Pb concentration in water samples in (Nuclear Lab. - Abu Ghraib - Diyala Bridge – Al-Sadr City Se.7 – Al-Sadr City Se.4 – Al-Dora and Al-Tuwaitha). The sources of lead in these samples could be associated with the corrosive water effects on household plumbing systems containing lead in pipes, the Pb level is reduced since exposure to lead level above 0.01 mg/L is associated with a wide range of effects, including renal failure, impaired fertility and adverse pregnancy outcomes, hematological and neurological problems, permanent damage to the central nervous system, the brain, and kidney [14].

In the present study the value of Hydrogen ions concentration ranged from 7.0 to 8.2. All samples show pH Value, fall within the permissible limits by WHO (6.5 – 8.5) [15]. In general, water with a pH of 7 is considered neutral while lower of it referred acidic and a pH greater than 7 known as basic. Normally, water pH ranges from 6 to 8.5. It is noticed that water with low pH is tend to be toxic and with high degree of pH it is turned into bitter taste [16]. The results of Electric Conductivity (EC), and Total Dissolve Solids (T.D.S.) values for all samples in Table 2 lower than the permissible limits. But biological parameters such as pH, total dissolved solids In addition; corrosion tends to increase heavy metals concentration. In general, different water resources have different water characteristics and therefore their tendency to corrode the water pipes [17].

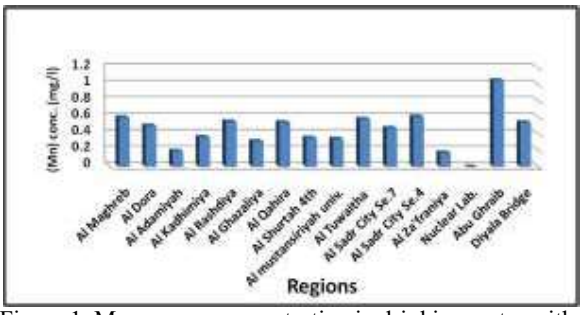

Figure 1: Manganese concentration in drinking water with regions

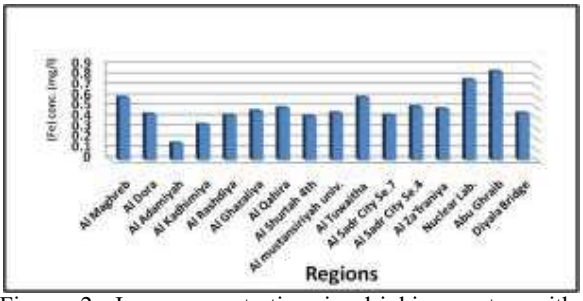

Figure 2: Iron concentration in drinking water with regions.

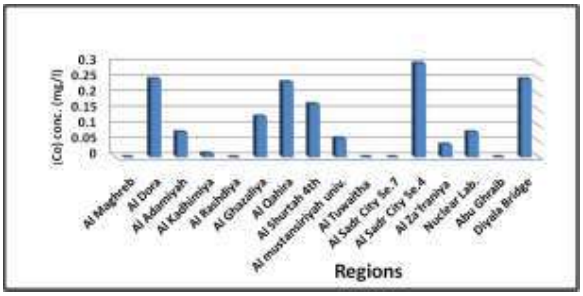

Figure 3: Cobalt concentration in drinking water with regions.

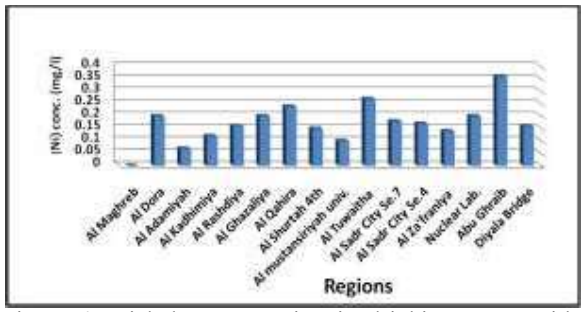

Figure 4: Nickel concentration in drinking water with regions.

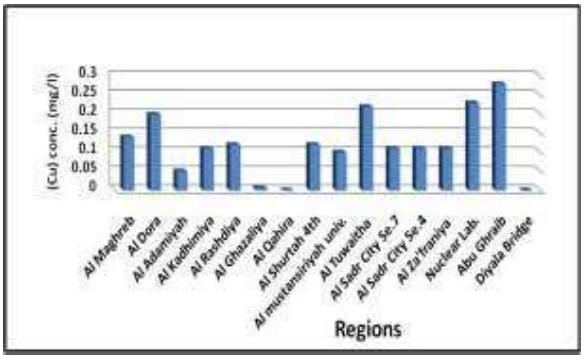

Figure 5: Copper concentration in drinking water with regions.

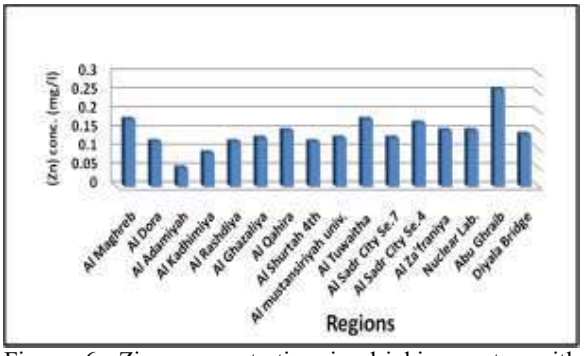

Figure 6: Zinc concentration in drinking water with regions.

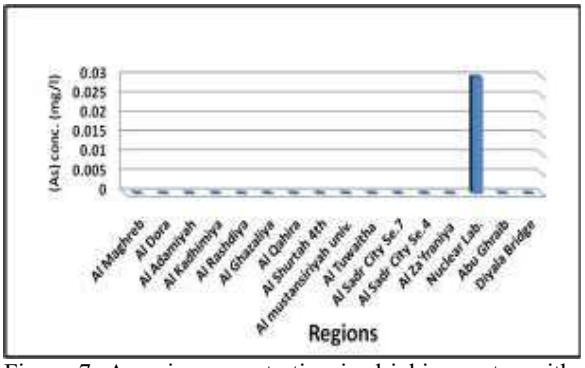

Figure 7: Arsenic concentration in drinking water with regions.

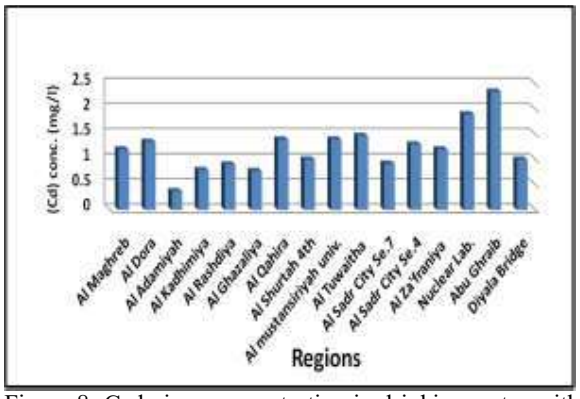

Figure 8: Cadmium concentration in drinking water with region

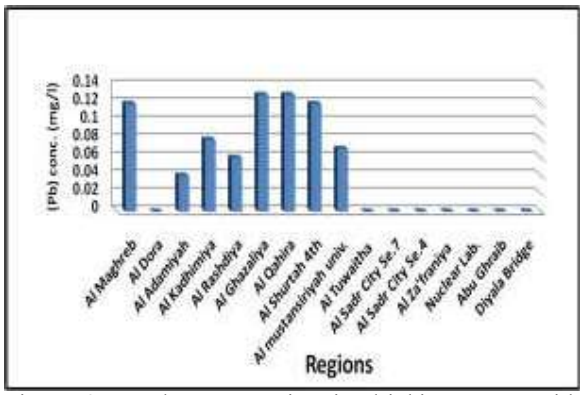

Figure 9: Lead concentration in drinking water with regions.

Table 1: Concentration (mg/l) for the elements in the water samples collected from different locations of Baghdad city.

Samples location	Mn	Fe	Co	Ni	Cu	Zn	As	Cd	Pb
WHO Spec.	0.1	0.3	-	0.02	0.1	3	0.01	0.003	0.01
Al-Maghreb	0.6	0.6	N.A	N.A	0.14	0.18	N.A	>1.2	0.12
Al-Dora	0.5	0.44	0.25	0.2	0.2	0.12	N.A	1.35	N.A
Al-Adamiyah	0.19	0.16	0.08	0.07	0.05	0.05	N.A	>0.37	0.04
Al-Kadhimiya	0.36	0.34	0.012	0.12	0.11	0.09	N.A	>0.79	0.08
Al-Rashdiya	0.55	0.43	N.A	0.16	0.12	0.12	N.A	>0.9	0.06
Al-Ghazaliya	0.31	0.47	0.13	0.2	0.007	0.13	N.A	>0.77	0.13
Al-Qahira	0.54	0.5	0.24	0.24	N.A	0.15	N.A	>1.4	0.13
Al-Shurtah 4th	0.35	0.42	0.17	0.15	0.12	0.12	N.A	>1	0.12
Al-MU'Un.	0.34	0.45	0.06	0.1	0.1	0.13	N.A	>1.4	0.07
Al-Tuwaitha	0.58	0.6	N.A	0.27	0.22	0.18	N.A	1.47	N.A
Al-Sadr City Se.7	0.47	0.43	N.A	0.18	0.11	0.13	N.A	>0.92	N.A
Al-Sadr City Se.4	0.61	0.51	0.3	0.17	0.11	0.17	N.A	>1.3	N.A
Al-Za'franiya	0.17	0.49	0.04	0.14	0.11	0.15	N.A	>1.2	0.0002
Nuclear Lab.	N.A	0.77	0.08	0.2	0.23	0.15	0.03	>1.9	N.A
Abu Ghraib	1.05	0.85	N.A	0.36	0.28	0.26	N.A	>2.35	N.A
Diyala Bridge	0.54	0.45	0.25	0.16	N.A	0.14	N.A	>1	N.A
Mean	0.44	0.49	0.1	0.17	0.11	0.14	0.001	>1.2	0.04
Minimum	0.1	0.16	0.1	0.07	0.007	0.05	0	>0.37	0.0002
Maximum	0.61	0.85	0.3	0.36	0.28	0.26	0.03	>2.35	0.13

* N.A: Not available

Table 2: The pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) for water samples and value WHO standard.

Location	PH	EC µs/cm	TDS mg/
Al Maghreb	7.0	814	423
Al Dora	7.1	610	317
Al Adamiyah	7.0	782	407
Al Kadhimiya	7.3	936	486
Al Rashdiya	7.3	650	338
Al Ghazaliya	7.5	625	325
Al Qahira	7.6	865	450
Al Shurtah 4th	7.9	590	307
Al MU.Un	7.5	827	430
Al Tuwaitha	7.5	1064	553
Al Sadr City Se.7	7.9	531	276
Al Sadr City Se.4	7.8	545	280
Al Za'franiya	7.9	897	467
Nuclear Lab.	7.6	822	428
Abu Ghraib	8.1	622	323
Diyala Bridge	8.2	1060	550
Mean	7.5	765	397.5
Minimum	7.0	531	276
Maximum	8.2	1064	553
WHO Spec.	**6.5-8.0**	**1500**	**< 600**

Conclusion

The levels of elements (Mn, Fe, Ni, Cu, Cd and Pb) were higher than the permissible limit of WHO.

In few cases the concentrations of Zn and As did not exceed the WHO maximum permissible limit. Except the concentration of arsenic in the nuclear laboratory was higher than the allow limit.

The monitored physico-chemical parameters of the water samples of study area within the permissible limits of WHO (2004) for drinking water. It is recommended that drinking water sources in the study area should be routinely monitored to ascertain its suitability for drinking and other purposes

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