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Trace Element Concentration of commercially Available Drinking Water in Makkah and Jeddah

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ABSTRACT. Drinking water is an important factor in survival. Many trace elements, both metals and non-metals, in drinking water are capable of causing human diseases if their concentrations exceed certain permissible levels. This study was directed to measure concentrations of Zinc, Chromium and Cadmium in the commercially available drinking water in Makkah and Jeddah cities using Atomic Absorption Spectrometry technique. A total of 94 water samples were analyzed. The mean concentrations of the metals obtained in this study are within the maximum permissible levels for the drinking water recommended by the World Health Organization (WHO) and Saudi Arabian Standard Organization (SASO). Conductivity and pH of the water samples were also measured to investigate correlation between their values and the concentrations of the three metals. A positive correlation is obtained between the metal concentrations and the corresponding conductivity values, while no significant correlation is seen between the pH values and the metal concentrations.

KEYWORDS: Zinc; Chromium; Cadmium ; Drinking water ; Atomic absorption spectrometer; pH ; Conductivity.

1. Introduction

Human health can be affected by the quality of the food and drink that we take. Water intended for human consumption must be free from organisms and from concentrations of chemical substances that may be hazardous to health. Recent studies show that the levels of trace elements present in drinking water could seriously affect human health [1-5]. World Health Organization (WHO) places great emphasis on the quality of drinking water and has recommended upper limits for a number of trace elements for drinking water [6,7] .

Chromium (Cr) may be present in water in the hexavalent (chromate) or trivalent form, but trivalent chromium rarely occurs in potable water. Water soluble hexavalent compounds are extremely irritating and toxic to human tissues. Chromate poisoning causes skin disorders and liver damage. Chromium is an objectionable contaminant in drinking water due to its suspected carcinogenic effects [2, 8-10]. In human body, Cadmium (Cd) accumulates in the liver and kidney, particularly in the kidney cortex. Manifestations of cadmium toxicity such as histological changes in the kidney, liver, testes, pancreas, bowels, blood vessels, etc. has been reported in the literature [3,4,10,11]. In general, Zinc (Zn) deficiency in animals including humans causes stunted growth and male sexual immaturity. An excess accumulation of Zn in the human body causes harmful effects such as acceleration of anemic conditions [3,4,11,12].

Tayyeb et al. [13] studied the aluminum and lead concentrations in the commercially available drinking water of the Western Province of the Kingdom of Saudi Arabia . The results of the study of Zn , Cr , and Cd concentration in the drinking water of the same area are reported here to provide a more complete profile of the levels of heavy metals in the drinking water of the Western Province . Several physical and chemical parameters are known to affect the concentrations of trace elements in water. Among these, pH and conductivity are important. In this study pH and conductivity were also measured to investigate any correlation between these parameters and the measured trace metal concentrations.

2. Material and Methods

The water from desalination plant is further purified by the so called “healthy water’’ shops and is sold usually in 10 / 20 gallons containers. This type of water is commonly known as galloned water . The other type is the natural / mineral water sold in sealed plastic bottles. This is known as bottled water. We studied both the galloned water and bottled water of two neighboring cities in the western province of Saudi Arabia, namely Makkah and Jeddah. A total of 94 water samples were analyzed.

The VARIAN Atomic Absorption Spectrometer (AAS), Model Spectra AA – 30 P consisting of a double beam, four lamp Turrent Spectrometer with a Deuterium Background corrector and a temperature programmable graphite tube furnace assembly (GTA – 96) was used in the study. Temperature program of the furnace was optimized to obtain the best signal during the atomization process. The drying time and ashing temperature for each element was determined earlier. All these data were fed into the computer associated with the AAS machine.

Standard aqueous solution of different elements obtained from Fisher Scientific Company, USA were used to calibrate the AAS machine. The calibration curves were drawn for Zn, Cr, and Cd by Macintosh microcomputer using linear regression analysis of the concentrations of the standard solutions versus absorbance values.

20 μl of each water sample ,without any pretreatment, was injected directly into a pyrolytically coated graphite tube of the AAS machine with the help of an auto-sampler and the elemental concentration was read from the output of the printer. Each sample was repeated thrice for each element. The concentrations of Zn, Cr, and Cd were determined for each sample and the results were tabulated. The sensitivity of the AAS machine was tested by using 10 ppb standard Lead (Pb) solution. The mean absorbance value of several measurements was found to agree well with the manufacturer's stated value with a relative standard deviation (RSD) of 1.6% .

A Fisher PH-Ion Meter, model 230A was used for pH measurements and a conductivity meter made by Yellow Springs Instrument Co. (Model 33) was employed for the conductivity measurements.

3. Results , Discussions and Conclusions

The calibration curves for Zn , Cr, and Cd obtained in our study were fairly linear. The results of the present study for three trace elements: Zinc, Chromium and Cadmium and two physical parameters : pH and conductivity in 94 commercially available drinking water samples from three different sources are summarized in Table 1. Galloned water from Makkah shows the highest mean zinc concentration (16.09 ± 4.92) ppb , followed by Jeddah galloned water (8.56 ± 4.39) ppb and last bottled water (8.25 ± 4.50) ppb . But for chromium , bottled water has the highest mean concentration (3.45 ± 0.97) ppb. Jeddah and Makkah galloned water are characterized with lower Chromium concentrations than bottled water which are (1.66 ± 1.12) ppb and (1.50 ± 1.07) ppb respectively. Cadmium concentrations are low compared to Zinc and Chromium concentrations . Makkah galloned water and bottled water have same Cadmium concentrations of (1.30 ± 0.47) ppb while that for Jeddah galloned water is (1.22 ± 0.28) ppb.

Table 1: Zinc, Chromium and Cadmium Concentration and pH and Drinking Water from Three Different Sources in Western Region of Saudi Arabia

Sources of Water	No. of Samples	Mean Conc. of Zinc (ppb)	Mean Conc. of Chromium (ppb)	Mean Conc. of Cadmium (ppb)	Mean pH	Mean Conductivity µ mhos/cm
Makkah Gal. water	22	16.09±4.9	1.50±1.07	1.30±0.47	7.42±2.4	380.00±18.96
Jeddah Gal. water	52	8.56±4.39	1.66±1.12	1.22±0.28	7.50±2.5	439.44±19.32
Bottled Water	20	8.25±4.50	3.45±0.97	1.30±0.45	7.87±2.8	467.50±20.17

The maximum permissible level (MPL) for Zinc in drinking water as recommended by Saudi Arabian Standard Organization (SASO) [13] and World Health Organization (WHO) [14] is 5000 ppb. The present values of Zn concentrations in drinking water are far below the MPL recommended by SASO and WHO.

The present values of Chromium concentrations in drinking water are also below the MPL of the drinking water recommended by SASO [13] and WHO [14] which is 50 ppb.

Again the maximum cadmium concentrations found in the present study is below the MPL of 5 – 10 ppb for drinking water as recommended by SASO [13] and WHO [14].

Correlation between pH and concentration and conductivity and concentration are also studied . The figures are not shown here. The correlation coefficients are determined. A positive correlation is observed between the metal concentrations and the corresponding conductivity values . However , no significant correlation is obtained between pH values and metal concentrations.

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إيجاد تراكيز عناصر في مياه الشرب المتوفرة تجارياً في مدينتي مكة المكرمة وجدة

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المستخلص : جودة مياه الشرب عامل مهم في الحفاظ على صحة جيدة , العديد من العناصر المعدنية وغير المعدنية الموجودة في مياه الشرب تستطيع أن تتسبب في مرض الإنسان لو زادت تراكيز هذه العناصر عن حد معين مسموح به. هذه الدراسة وجهت لقياس تراكيز عناصر الزنك والكروم والكادميوم في مياه الشرب المتوفرة تجاريًا في مدينتي مكة المكرمة وجدة باستخدام طريقة طيف الامتصاص الذري . حيث تم تحليل ٩٤ عينة ماء , وكان متوسط تراكيز المعادن التي تم الوصول إليها في هذه الدراسة تحت الحد الأعلى المسموح به في مياه الشرب الآمنة حسب توصيات منظمة الصحة العالمية وهيئة المواصفات والمقاييس السعودية. لقد تم أيضًا قياس درجة التوصيل ودرجة الحمضية أو القلوية لعينات المياه للكشف عن علاقة بين قيمها وتراكيز المعادن الثلاثة لنفس العينة , بينما لم يكن هناك علاقة مهمة بين قيم درجة الحمضية أو القلوية وتراكيز المعادن .