University of Benghazi
Faculty of Education Al marj
Global Libyan Journal

جامعة بنغازي
كلية التربية المرج
المجلة الليبية العالمية

العدد الثلاثون – 25/ أكتوبر (2017)

Determination of Heavy toxic metals (Pb, Cr, Co, Cu, Zn, Fe and Cd) and Total Dissolved Solids in Bottled Drinking Water

*** Amal A. S. Amar, ** Hanai. A.M. Hamd**

(Department of Chemistry, Faculty of Science, Tobruk University, Tobruk, Libya)

University of Benghazi
Faculty of Education Al marj
Global Libyan Journal

جامعة بنغازي
كلية التربية المرج
المجلة الليبية العالمية

العدد الثلاثون – 25/ أكتوبر (2017)

Determination of Heavy toxic metals (Pb, Cr, Co, Cu, Zn, Fe and Cd) and Total Dissolved Solids in Bottled Drinking Water

Abstract:

This study was achieved to verify the quality of drinking water which was packed in bottles from different companies and used as basic source of drinking water in Tobruk city, Libya. The studied water samples were randomly collected from different shops and supermarkets. The contaminated toxic elements and heavy metals in water were assessed and analyzed using Flame Atomic Absorption Spectroscopy (Flame AAS) instrument, in same time, the total dissolved solids (TDS) were also detected by. The obtained results showed the appearance and contaminated of the most tested samples by toxic heavy elements *vis*: Pb, Cr, Co, Cu, Zn, Fe and Cd. Additionally, the results were showed that most of samples suffer from losing total dissolved solids which are important to human health. According to the above results, the study concluded that the most samples of water had greater levels of toxic heavy metals and lower content of total dissolved solids than the standard values mentioned by World Health Organization (WHO) and Libyan Health Organization (LHO). Therefore, study recommended that the decision makers in Tobruk city should be taken more care about bottled drinking water concerning with monitoring, checking and comparing with the standard level of Libyan Health Organization.

Key words: Contamination, Heavy metals, Bottled drinking water, Total dissolved solids, Flame AAS.

الملخص:

أجريت هذه الدراسة من أجل تقدير جودة المياه المعبأة في القناني بواسطة 6 شركات مختلفة، والتي تعتبر من أهم مصادر مياه الشرب في مدينة طبرق، ليبيا. جمعت عينات المياه المعبأة عشوائيا من المحلات التجارية بالمدينة. في هذا البحث قدرت العناصر الثقيلة والسامة المياه باستخدام جهاز Atomic Absorption Spectroscopy ، كما قدر محتوى المياه من المواد الصلبة الذائبة الكلية فيها باستخدام جهاز تقدير TDS meterأوضحت نتائج الدراسة تلوث المياه بدرجات متفاوتة بالمعادن الثقيلة الآتية: الرصاص (Pb)، الحديد (Fe)، الزنك (Zn) ، النحاس (Cu)، الكوبالت (Co)، الكادميوم (Cd) والكروم (Cr). فيما يخص المواد الصلبة الذائبة الكلية، دلت الدراسة أن معظم عينات المياه تعاني نقص في محتوى المواد الصلبة الذائبة والتي تعتبر مهمة جدا لصحة الإنسان. خلصت الدراسة أن جل عينات المياه التي درست ملوثة بالعناصر الثقيلة السامة بالإضافة إلى نقصان محتواها من المواد الصلبة الذائبة الكلية ولذا أنها غير متطابقة مع المواصفات القياسية لمياه للشرب حسب منظمة الصحة العالمية (WHO) ومنظمة الصحة الليبية (LHO). وتوصي الدراسة على الجهات المعنية ومتخذي القرار بالمدينة الفحص والتحليل الدوري لمياه الشرب المعبأة للتأكد من مطابقتها للمواصفات القياسية الليبية.

الكلمات المفتاحية: التلوث، المعادن الثقيلة، مياه الشرب المعبأة، المواد الكلية الصلبة الذائبة، جهاز الامتصاص الذري.

Introduction

Water is one of the essentials that supports all forms of plant and animal life and it is generally obtained from two principal natural sources; surface water such as fresh water lakes, rivers, streams, etc. and Ground water such as borehole water and well water (8,9).Water has unique chemical properties due to its polarity and hydrogen bonds which means it is able to dissolve, absorb, adsorb or suspend many different compounds, thus, in nature water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities (11).

The term "heavy metals" refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration. Heavy metals is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3 , or 5 times or more, greater than water. However, being a heavy metal has little to do with density but concerns chemical properties. Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), and the platinum group elements (5).

Heavy metal can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested (11). Lead is one of the most extensively studied toxic chemicals (1). it can be absorbed through the digestive tract, the lungs and the skin. It accumulates in the body and can cause lead poisoning. Even at low concentrations when there are no outward symptoms, lead can damage the brain, kidneys, nervous system and red blood cells. Some effects of lead poisoningmay diminish if the source of exposure is removed, but some damage is permanent.

Symptoms of lead poisoning include tiredness, ashort attention span, restlessness, poor appetite, constipation, headaches, sudden behavior change, vomiting and hearing loss. Adults with lead poisoningmay be irritable and disoriented (3).

Chromium toxicity in humans varies depending on the form of the compound, its oxidation state and the route of exposure. Studies show that there is little or no toxicity associated with the trivalent form of chromium, whereas hexavalent chromium compounds are classified as carcinogenic to humans by the inhalation route of exposure, based on sufficient evidence in both humans and animals. The critical health effect on which to establish a guideline for chromium in drinking water is diffuse hyperplasia of the small intestine, as it is the most sensitive endpoint and a precursor of tumor formation(6).

Acute toxicity arises from the ingestion of excessive amounts of zinc salts, either accidentally or deliberately as an emetic or dietary supplement. Vomiting usually occurs after the consumption of more than 500 mg of zinc sulfate. Mass poisoning has been reported following the drinking of acidic beverages kept in galvanized containers; fever, nausea, vomiting, stomach cramps, and diarrhoea occurred 3–12 h after ingestion(13). Ingesting high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of high density lipoprotein (HDL) cholesterol(2).

Even though we require 1,000 micrograms of copper daily in our diet, elevated levels of ingested copper can be harmful. Elevated levels of copper for 14 days or more can lead to health problems such as permanent kidney and liver damage in infants under the age of 1 year. In adults, high levels of copper can cause digestive disorders such as nausea, vomiting,

diarrhea and stomach cramps. People affected with Wilson's disease, a rare genetic disorder that affects approximately one in 30,000 people worldwide, cannot excrete excess copper. Copper can accumulate in these individuals to dangerous levels and, if not detected and treated, can cause death (4).

Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status, and iron bioavailability and range from about 10 to 50 mg/day. The average lethal dose of iron is 200–250 mg/kg of body weight, but death has occurred following the ingestion of doses as low as 40 mg/kg of body weight . Autopsies have shown haemorrhagic necrosis and sloughing of areas of mucosa in the stomach with extension into the submucosa. Chronic iron overload results primarily from a genetic disorder (haemochromatosis) characterized by increased iron absorption and from diseases that require frequent transfusions . Adults have often taken iron supplements for extended periods without deleterious effects, and an intake of 0.4–1 mg/kg of body weight per day is unlikely to cause adverse effects in healthy persons(14).

Exposure to very high levels of cobalt can cause health effects. Some people who drank large quantities of the beer experienced nausea, vomiting, and serious effects on the heart. The International Agency for Research on Cancer has determined that cobalt is a possible carcinogen to humans(12).

Low level exposure to cadmium decreases bone density and disrupts bone composition. Rapidly growing bones are the most sensitive to these effects, so children are at an increased risk. Cadmium does not easily leave our bodies and tends to build up in the kidney. As a result, both shorter, higher exposures and lifetime low level exposures to cadmium can cause kidney disease in older adults. Although cadmium can cause cancer when inhaled, there is little evidence to support that it can cause cancer when ingested(10)

Table1.Guideline in drinking water by Libyan Health Organization(LHO) and the World Health Organization (WHO)

Heavy element	**Max. Acceptable. Conc. (LHO) (mg/L)**	**Max. Acceptable. Conc.(WHO) (mg/l)**
Lead	0.05	0.01
Zinc	5	5
Chromium	0.05	0.05
Cobalt	less than 1	Less than 1
Cadmium	0.005	0.005
Copper	1	1
Iron	0.3	0.3

Total dissolved solid (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions. The presence of dissolved solids in water may affect its taste. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/L;

fair, between 600 and 900 mg/L; poor, between 900 and 1200 mg/L; and unacceptable, greater than 1200 mg/L. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste (15).

The present study was carried out to verify the quality of bottled drinking water used in Tobruk city, eastern Libya; in specially to detect the toxic elements and heavy metals, and also to determine the total dissolved solids (TDS).

Experimental

Sample Collection.

Bottled water samples were collected in Tobruk city located in Libya. In the sample collection, bottles used for the samples were previously rinsed with double distilled water. 6 different brands of bottled water samples were bought from the local markets of the city for lead, copper, zinc, chromium, cobalt and cadmium determinations. Samples were brought to the laboratory and kept in the fridge prior to analysis.

Determination of Heavy Elements:

The heavy elements were determined by atomic absorption spectrophotometry (Thermo scientific iCE 3300AAS) instrument, (U.S.A).

Determination of Total dissolved solids (TDS):

The total dissolved solid were detected by TDS meter (TDS-3 HM Digital) (U.S.A). The TDS were detected according to the following methodology:-

- Calibrate the TDS meter by standard solution (distilled water).
- Immerse the meter into the sample of water and wait up to one minute for steady reading.
- The reading is observed after the indicated value becomes constant.

Result and discussion

The TDS content in water samples were shown in Table 2. The results indicated that the most of samples are suffered and had low quantity of total dissolved solid except sample of Kh. which was recorded 235 mg/L. Moreover; the results explained that samples of Yk. and Ka. had the lowest value of TDS and had been lead to become unhealthy.

Table2. Total dissolved solid (TDS) content (mg/L) in water samples

Company	**TDS**
Kh.	61.5
Yk.	4.8
Ba.	235
Th.	45.5
Ka.	5.19
Sh.	83.3

The concentrations of heavy metals in samples of bottled water were presented in Table 3. The results of seventh heavy elements concentration showed that high levels of lead was recorded in those samples which belonged to samples Ba., Th., Ka., and Sh. with values of 0.054, 0.080, 073, 0.079 mg/L; respectively. These concentrations of lead are greater than that recommended by **LHO** and **WHO.** However, the concentrations of lead in the rest of two samples Kh. (0.038 mg/L), Yk.(0.040 mg/L) were not exceeded the allowed range that recommended by **LHO**. The levels of zinc in all studied samples were lesser than the recommended value. The results indicated that concentrations of chromium were 1.4, 1.7, 2.03, 2.4, 2.8 and 2.9 mg/L for Kh., Yk., Ba., Th., Ka and Sh. samples respectively. However, these concentrations were too higher than that allowed value (0.05 mg/L).

The result in Table 3 indicated that the obtained concentrations of cobalt in bottled drinking water in three samples were 0.4613 mg/L for sample Kh. 0.4411 mg/L for sample Yk. and 0.9235 mg/L for sample Ba.were lesser than 1 mg/L as recommended concentration. However, the concentration of the same element in three remains samples were 1.8291, 2.0584, and 2.0409 mg/L and for Th. sample, Ka. sample and Sh. sample respectively. The concentrations of these three samples were approximately two times greater than the specified maximum contaminant level of cobalt in drinking water.

Cadmium is a very toxic metal and it should not exceed 0.005 mg/L in the drinking water (7). Its concentration in all samples was very high comparing with allowed value, thus there is no doubt that all samples studied were contaminated by cadmium. However, Sh. sample was recorded the highest level (0.1 mg/L) so that it is more dangerous.

The results showed the concentrations of the last two heavy elements were copper and iron, which all of their concentrations in all samples were in the allowed range and not exceeded 1 mg/L for copper and 0.3 mg/l for iron, respectively as they are shown in table 3.

Table3. Flame AAS Results for Bottled Drinking Water.

	Concentration of metal (mg/L)						
The company	Lead	Zinc	Chromium	Cobalt	Cadmium	copper	Iron
Kh.	0.038	0.0264	1.4353	0.4613	0.027	0.1191	0.01
Yk.	0.040	0.0377	1.7199	0.4411	0.033	0.2072	0.01
Ba.	0.054	0.0344	2.0307	0.9235	0.072	0.1888	0.02
Th.	0.080	0.0361	2.4049	1.8291	0.0882	0.2565	0.1
Ka.	0.073	0.0363	2.8266	2.0584	0.0738	0.3238	0.02
Sh.	0.079	0.0642	2.9849	2.0409	0.1	0.6116	0.12

Conclusion

The results showed that, the water are unfit for drinking because of their content from heavy elements, in spite of Kh. sample was less of them content from heavy metal this does not mean it healthy as some of element have exceed the allowed level .it is therefore recommend the drinking water should be monitor before drinking. In addition, the amount of

the total dissolved solids in five studied samples is less than 100 ppm .it is only Ba. Sample was above of that value. Therefore, it seems that more care should be taken to monitor the drinking water. It is clear that samples of Kh. and Yk. are the best at least the amount of heavy element is less than ideal limit. This because the two samples are ground water.

References

1- Archbold, J., and Bassil, K. (2014). Toronto Public Health.Health Impacts of Lead in Drinking Water. Technical Report.

www.toronto.ca/health/reports

2- ATSDR.(2005) .Public Health Statement Zinc. Department of Health and Human Services, Public Health Service. Agency for Toxic Substances and Disease Registry . ATSDR . CAS#: 7440-66-6

http://www.atsdr.cdc.gov/

3- Dozier,M.C. and McFarland, M. L. (2001). Drinking Water Problems: Lead, TheTexas A&M University System, Department Of Agriclture ,and the County Commissioners Courts of Texas CooperatingU.S. Texas A&M AGRIIFE Communication.

www.AgriLifeExtension.tamu.edu

4- Dozier,M.C., McFarland,M. Lesikar,B.J.(2005). Drinking Water Problems: Copper. TheTexas A&M University System, Department Of Agriclture ,and the County Commissioners Courts of Texas Cooperating U.S. Texas A&M AGRIIFE Communication.

http://publications.tamu.edu/WATER/L-5472

5- Duruibe, J. O., Ogwuegbu, M. O. C, and Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences Vol. 2 (5), pp. 112-118

http://www.academicjournals.org/IJPS

6-Health Canada.(2015) .Chromium in Drinking Water. Document for Public Consultation. Technical Document.

http://www.healthycanadians.gc.ca/health-system-systeme-sante/consultations/chromium-chrome/alt/chromium-chrome-eng.pdf

7- Martin, S. and Griswold, W. (2009). Human Health Effects of Heavy Metals. Environmental Science and Technology Briefs for Citizens. Center for Hazardous Substance Research (CHSR).

www.engg.ksu.edu/CHSR/

8- McMurry, J. and R.C. Fay, 2004. Hydrogen, Oxygen and Water. In: McMurry Fay Chemistry. K.P. Hamann, (Ed.). 4th Edn. New Jersey: Pearson Education, pp:575-599

9- Mendie, U., 2005. The Nature of Water. In: The Theory and Practice of Clean Water Production for Domestic and Industrial Use. Lagos: Lacto-Medals Publishers, pp:1-21

10-MDH. (2014). Cadmium and Drinking Water. Environmental Health Division. Minnesota Department of Health (MDH).

www.health.state.mn.us/eh

11- Momodu, M.A. and Anyakora , C.A. (2010). Heavy Metal Contamination of Ground Water: The Surulere Case Study, Research Journal Environmental and Earth Sciences 2(1): 39-43.

https://www.researchgate.net/publication/258329889

12- Ontario. (2001).Cobalt in the environment. Ministry of the Environment programs and initiatives .Queen's Printer for Ontario.

http://foodshedproject.ca/wp-content/uploads/2015/12/CoFacts

13- WHO. (1996).Zinc in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. World Health Organization, Geneva.

http://www.who.int/water_sanitation_health/dwq/chemicals/zinc

14- WHO. (2003) .Iron in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality .World Health Organization, Geneva.

http://www.who.int/water_sanitation_health/dwq/chemicals/iron

15- WHO. (2003).Total dissolved solids in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality .World Health Organization, Geneva.

http://www.who.int/water_sanitation_health/dwq/chemicals/tds.