Journal of Global Biosciences
ISSN 2320-1355
Volume 8, Number 11, 2019, pp. 6556-6567
Website: www.mutagens.co.in

SCAN ME

Research Paper

COMPARATIVE STUDY OF ELEMENTAL CONCENTRATION IN SOFT AND NATURAL DRINKS BY USING ICP-MS TECHNIQUE

Aleti Jaya Sree[1], B.Aruna[2], P.V.Lakshmi Narayana[3] and A.Durga Prasada Rao[4]

[1]Department of Nuclear Physics,
Andhra University, Visakhapatnam,
Andhra Pradesh, India
[2]Department of Nuclear Physics,
Andhra University, Visakhapatnam,
Andhra Pradesh, India
[3]Assistant Professor of Nuclear Physics,
Department of Nuclear Physics,
Andhra University, Visakhapatnam,
Andhra Pradesh, India
[4]Chairman
Board of Studies
Department of Nuclear Physics
Andhra University, Visakhapatnam,
Andhra Pradesh,
India.

Abstract

The present work is aimed to investigate the elemental concentration levels in both soft (Maaza, Limca, Fanta, Coca-Cola, Thums up & Kinley soda) and natural drinks (butter milk, Sugar Cane juice, Coconut Water). A total of 10 commercially available samples are collected from the local market of Visakhapatnam and analyzed for elemental concentration levels by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Around 18 elements in the present study have been identified. In Soft drinks, the obtained average elemental concentrations as Fe > Al > Sr > Ba > Rb > Pb > Mn > Li > Ni > Cd > Cr > V > Cu > As > Cs. In natural drinks these are given in the descending order (µg/L) Fe > Zn > Rb > Mn > Pb > Sr > Ba > Al > Cu > Cd > Ni > Co. A few high Z elements also been detected in Soft drinks and found that their elemental concentrations are at a higher level when compared with the natural drinks. Obtained values of both the drinks are compared with the Recommended Daily Allowance (RDA) limits and the World Health Organisation (WHO) set values.

Key words: Natural Drinks, Soft drinks, Contaminated, Heavy Metal.

INTRODUCTION

Drinking water plays a significant role in the lives of different living organisms as it contains minerals and a few trace elements that needed for good health [1, 2]. Natural drinks are essential for body growth as they contain nutrition's namely vitamins, minerals, anti-oxidants facilitating to reduce the risk of several critical diseases [3]. The evaluation of commercial soft drinks is a key issue for consumer safety, as they are widely consumed by them all over the world [4]. These drinks are consumed regularly due to their affordable prices; during outings and relaxation time serve the drinks to the general public in the celebrations like weddings; funerals, etc [5]. Their characteristics are defined by the constituents that present in them respective drugs become responsible for their sweetness, carbonated water; which compressed with carbon dioxide to make it an ultimate thirst quencher and flavoring agents to add flavor to the drinks [6]. Elements such as Cr, Mn, Fe, Co, Ni, Cu, Zn, V, Se are found in both soft and natural drinks may be considered as essential for the human body for beneficial health effects. In the earlier studies Li and Ba were detected showing some advantages along with the obtained non-essential elements namely Cd, Pb, Cs, Rb, Sr, As, Be and Al; which may be toxic to the human health [7].In Human Health, Lead and Cadmium elements are considered as non-essential and toxic at certain levels of them. Lead is known to have severe chronic effects on human health and called a multi-organ system toxicant, which can cause anemia, kidney dysfunction, neurological and reproductive effects. A long-term and excessive consumption of Cadmium may lead to kidney damage, yellowing of teeth, softening of bones, etc.

The main aim of the present study is to investigate the elemental concentrations belong to soft and natural drinks and to evaluate whether the levels of elements comply with the standards of the World Health Organization (WHO) or not. A preliminary report on the elemental concentrations of 18 elements belongs to soft and natural drinks and also in mineral water that could be useful to identify which drink is significant or useful for the human body in the nutritional -health prospective.

MATERIALS AND METHODS

Sample collection six samples of soft drinks belong to different brands are undertaken in the present study. Three different types of natural drinks and one standard mineral water were purchased from local department stores in Visakhapatnam, India and

analyzed qualitatively for the presence of sugar, carbon dioxide, acidity, and pH levels. The concentration of sugar, carbon dioxide, acidity was determined according to the procedures of AOAC [8]. The achieved experimental data is shown in table 1.

Test for sugar

Benedict solution was used to test for the presence of sugar. In this process, 3 ml of different samples of both soft and natural drinks were taken into a test tube and 2 ml of Benedict reagent added. The test tube was heated for 5 min in a water bath and the formation of reddish colour confirmed the presence of sugar in soft and natural drinks.

Test for carbon dioxide

As soon as the bottles opened, 3 ml of the sample belong to each brand of soft and natural drinks were added to 2 ml of calcium hydroxide. The change of colorless to milky confirmed the presence of carbon dioxide.

Test for acid concentration

The acidity of the soft and natural drinks was carried out by the acid titration method. 1 ml of 0.1 M sodium hydroxide was taken into a burette. 10 ml of the prepared sample was added followed by 2 drops of 1% phenolphthalein. Further, the sample was titrated until the colour changed from colourless to pink and the acid concentration was determined.

Determination of pH

This was performed by the Digital pH meter. The electrode rod was dipped into the 2ml of the sample and noted the reading displayed on the digital pH meter. The observed results are presented in Table 2.

Sample preparation:

0.5ml of each sample was mixed with 4ml of concentrated nitric acid separately and left for 24 hours. Later the container of the aforementioned solution was placed at 100 $^{\theta}$c on the hot plate till the evaporation of liquid leaving some residue in the container. Further 0.5ml of the leftover residue mixed thoroughly with 25ml of distilled water and used for elemental evaluation by using ICP-MS.

Preparation of Blank solution

Cleaned the samples with concentrated nitric acid and water with a 1:1 ratio. The quantity of concentrated nitric acid 4 ml is taken into a test tube and was evaporated on a hot plate at 100 $^{\theta}$c leaving the residue. The residue of 0.5 ml was mixed with 25 ml of distilled water lender taken the solution for elemental concentration determination by using the ICP-MS technique.

ICP- MS Analysis ICP-MS (Inductively Coupled Plasma Mass Spectrometry) technique with the model Agilent 7700 series that available at the center for study on Bay of Bengal, Andhra University, Visakhapatnam, India. It has been used for the determination of elemental concentration, which has greater speed and high sensitivity [9]. ICP-MS technique converts the atoms of the elements into ions and these are separated and detected by the mass spectrometer. When compared with other types of mass spectrometry, ICP-MS has capable of detecting multi-elements even at low-level concentrations; part per billion [10].

RESULTS AND DISCUSSION

The elemental concentrations of Li, Al, V, Cr, Fe, Mn, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Cd, Cs, Ba, Pb are determined based on the experimental results obtained in the present studies and presented in table 3 and table 4 for soft and natural drinks respectively.

The present studies have been evaluated the trace and heavy elements present in the soft and natural drinks. The amount of copper in the soft drink samples ranged from 0.56 (µg/L) in Soda to 1.37 (µg/L) in Coca Cola while in the natural drinks samples it ranged from 0.97 (µg/L) in Butter Milk to 28.1 (µg/L) in Sugar Cane. The observed value of Cu in Mineral Water is zero. According to the WHO maximum permissible limit for Cu in drinking water is 2(µg/L). It shows that Cu is within the limits of WHO suggested value. Copper is one of the essential elements for functioning of the human body but if it exceeds 10 mg then it shows toxic effects. Excess of Cu may lead to Hypotension, Heartburn, Nausea, Vomiting, Coma, and Jaundice. Long term excess intake of Copper may lead to damage of kidney and liver function [11].

The obtained result of Chromium in the soft drink samples shows its range from 0.4 (µg/L) in Thums up to 4.31 (µg/L) in Mazza and the observed value of Cr in natural drinks and Mineral water is zero. The maximum allowed limit for Cr in drinking water is

0.05(µg/L). Chromium exists in two valence states namely trivalent chromium (Cr III) and hexavalent chromium (Cr VI). It may be an essential element for the maintenance of glucose and protein metabolism. When it exceeds the limit it indicates the toxic impact on the human body. Cr (VI) may not have any beneficial role in the human body. If it exceeds 0.05 (µg/L) limit, may have a toxic effect on the human body. The high amount of Cr may affect Cardiovascular and Neurological systems [12].

The lowest concentration of Zinc is observed in natural drinks ranging from 80.53 (µg/L) in Butter Milk to 139.03 (µg/L) in Sugar Cane. No value of Zn is found in soft drinks and mineral water. Zinc deficiency can cause growth retardation, diarrhea in children and excess consumption of Zn may cause Lethargy and leads to copper deficiency [11].The lowest concentration of Fe is recorded in soft drinks such as 414 (µg/L) in Coca Cola and highest concentration of Fe 1009.22 (µg/L) in Mazza. The obtained lower concentration of Fe in natural drinks is 136.96 (µg/L) in Butter Milk and higher concentration 898.57 (µg/L) observed in Sugar Cane. In mineral water, the value of Fe is recorded as zero. Iron plays a vital role in the human body as its deficiency may cause Anemia. Iron also a part of erythropoietin hormone function that is important in Red Blood Cells (RBC) production. It is stored in liver and bone marrow in the form of Ferritin and Hemosiderin. However, excess intake of Fe may lead to Alzheimer's disease, hyperactive behaviors etc.

The amount of Cd in soft drinks samples ranged from 0.86 (µg/L) in soda to 4.74 (µg/L) in Fanta, and in natural drinks, it ranges from 0.35 (µg/L) in Coconut water to 1.06 (µg/L) in Butter Milk. Cd is the toxic element and may cause damage to the liver, kidney [13]. Cd can cause bone demineralization either through direct bone damage or indirectly to rental dysfunction. Cd is not detected in mineral water. The amount of Pb in the soft drinks samples ranged from 0.72 (µg/L) in Mazza to 41.86 (µg/L) in Fanta. In natural drinks Pb ranges from 63.16 (µg/L) in Sugar Cane to 77.5 (µg/L) in Butter Milk. Lead is known to have acute and chronic effects on human health. It can cause Neurological, Cardiovascular, Renal, Gastrointestinal, Hematological, Reproductive effects [14].

The highest value of Al in soft drinks is found to be 179.69 (µg/L) in Mazza while its lowest value seems to be 79.69 (µg/L) is obtained in soda. The observed results of Al in

natural drinks ranged from 32.8 in Sugar Cane. No mean value is found in mineral water. The range of values for Al may affect the developing nervous and reproductive systems [15]. In the nervous system, Al blocks the electrical discharge of nerve cells, thereby reducing nervous system activity, memory loss, Alzheimer's disease, and kidney dysfunction, etc [16]. The obtained value of Mn in soft drinks ranges from 6.31(µg/L) in Coca-cola to 28.03 (µg/L) in Mazza and in Natural drinks it ranged from 63.95 (µg/L) in Sugar Cane to 82.79 (µg/L) in Coconut water. No Mn value is found in mineral water. WHO maximum permissible limit for Mn intake is 2mg / day. It clearly is shown that Mn range is within the WHO limit. Mn is essential to human beings. It is significant for bone growth and lipid metabolism. The highest observed value of Rb in soft drinks is 113.55 (µg/L) in Mazza while the lowest value found to be 2.06 (µg/L) in limca and in natural drinks it ranged from 40.53 (µg/L) in Butter Milk to 85.5 (µg/L) in Sugar Cane.

The highest value of Vanadium in soft drinks seems to be 2.16 (µg/L) in Fanta while the lowest value shows 0.39 (µg/L) in Soda. In natural drinks, the highest value of V is 0.04 (µg/L) in Butter Milk and the lowest value is 0.08 (µg/L) in Sugar Cane. Vanadium may be an essential element as it is needed in converting glucose to glycogen for storage. V is involved in the mineralization of bone and teeth. A high level of Vanadium consumption for a long time causes abdominal cramps, decreased levels of vitamin c. Toxicity may affect kidney and liver functions [17, 18]. The highest concentration of Ba found to be 99.02 (µg/L) in Coca Cola in soft drinks and the lowest 2.33 (µg/L) observed in Soda. In natural drinks, the highest value of barium shows 32.11 (µg/L) in Sugar Cane and the lowest is 4.61 (µg/L) in Butter Milk. Ba can be considered a non-essential element and may be toxic to the human body. High consumption of barium may cause neurodegenerative diseases, high blood pressure and Multiple sclerosis [19, 20].

Table-1 the presence of Carbon dioxide, sugar, the acid level in soft and natural drinks

Samples	Test for Carbon dioxide	Benedict test	Acid level
Mazza	#	###	###
Limca	##	###	###
Coca Cola	##	###	###
Soda	#	###	###
Thums up	##	###	###
Fanta	#	###	###
Butter milk	_	###	###
Coconut water	_	###	###
Sugar cane	_	###	###
Mineral water	_	###	###

Present; ## moderately present; ### abundantly present; _ absent

Table-2 PH concentration

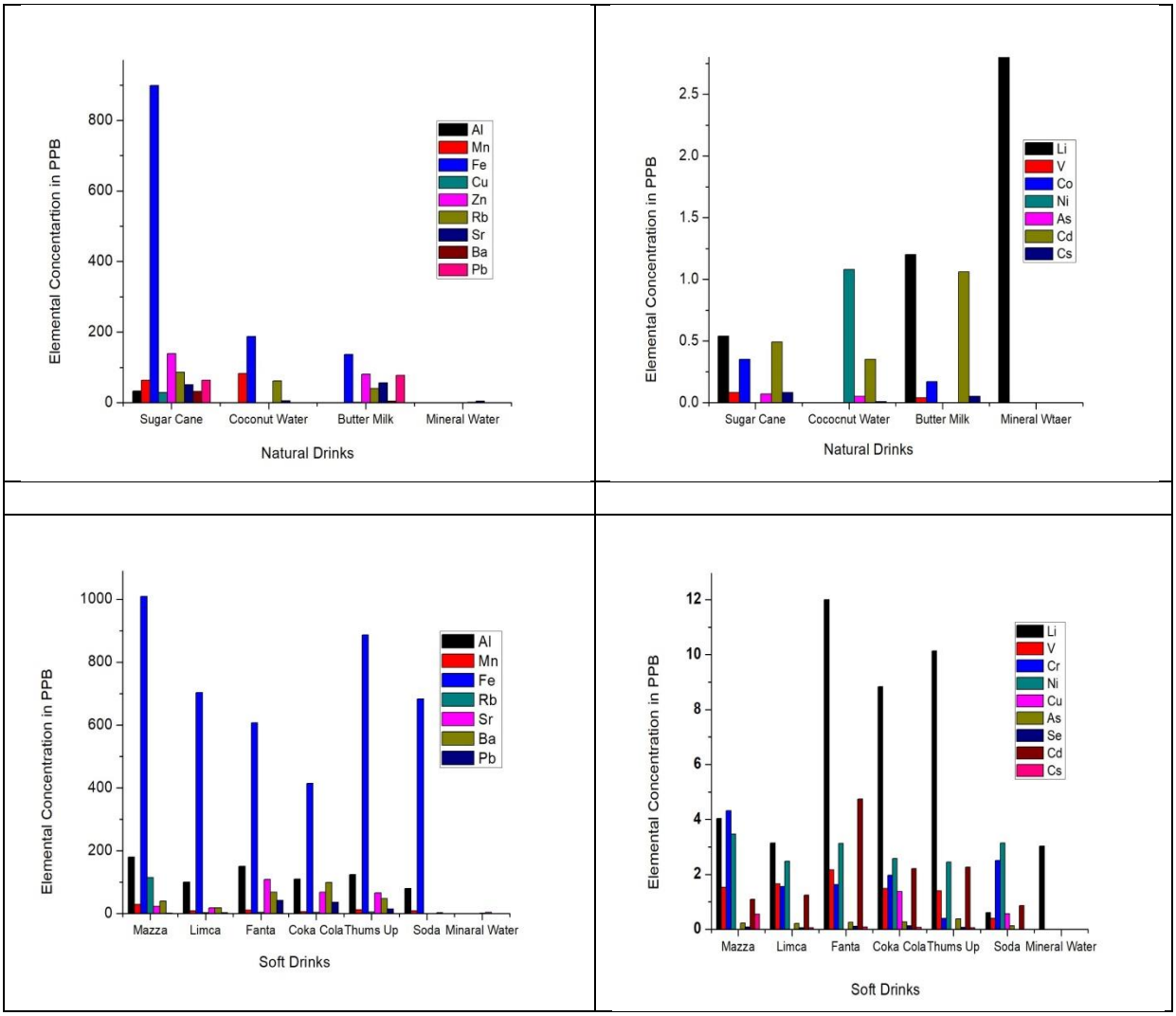
Samples	pH
Mazza	4.43
Limca	3.84
Coca Cola	3.51
Soda	5
Thums up	3.45
Fanta	3.8
Butter milk	5.12
Coconut water	5.63
Sugar cane	5.8
Mineral water	7.35

Table-3 Elemental Concentration of soft drinks in PPB

S.No	Element	Mazza	Limca	Fanta	Coka Cola	Thums Up	Soda	Mineral Water
1	Li	4.03	3.14	12	8.83	10.13	0.61	3.03
2	Al	179.69	99.51	149.37	109.71	123.66	79.69	0
3	V	1.53	1.66	2.16	1.49	1.4	0.39	0
4	Cr	4.31	1.56	1.63	1.97	0.4	2.5	0
5	Mn	28.03	8.72	10.03	6.31	11.25	8.65	0
6	Fe	1009.22	703.15	606.3	414	886.77	683.38	0
7	Co	0	0.06	0	0	0	0.03	0
8	Ni	3.47	2.47	3.13	2.57	2.45	3.14	0
9	Cu	0	0	0	1.37	0	0.56	0
10	Zn	0	0	0	0	0	0	0
11	As	0.22	0.21	0.26	0.27	0.38	0.12	0
12	Se	0.08	0.05	0.11	0.12	0.07	0	0
13	Rb	113.55	2.06	3.74	3	4.78	0	0.46
14	Sr	22.19	17.39	108.49	67.42	64.81	0	3.86
15	Cd	1.09	1.25	4.74	2.21	2.26	0.86	0
16	Cs	0.55	0.05	0.08	0.07	0.06	0	0
17	Ba	39.46	17.94	67.45	99.02	47.44	2.33	0
18	Pb	0.72	2.15	41.86	35.28	14	0	0

Table-4 Elemental concentration of natural drinks in PPB

S.no	Element	Sugar Cane	Coconut Water	Butter Milk	Mineral Water
1	Li	0.54	0	1.2	3.03
2	Al	32.8	0	0	0
3	V	0.08	0	0.04	0
4	Cr	0	0	0	0
5	Mn	63.95	82.79	0	0
6	Fe	898.57	187.04	136.96	0
7	Co	0.35	0	0.17	0
8	Ni	0	1.08	0	0
9	Cu	28.1	0	0.97	0
10	Zn	139.03	0	80.53	0
11	As	0.07	0.05	0	0
12	Se	0	0	0	0
13	Rb	85.5	60.84	40.53	0.46
14	Sr	50.81	5.21	55.94	3.86
15	Cd	0.49	0.35	1.06	0
16	Cs	0.08	0.01	0.05	0
17	Ba	32.11	0	4.61	0
18	Pb	63.16	0	77.5	0



Graph represents the elemental concentration of natural drinks and soft drinks in PPB

CONCLUSIONS

A study related to the determination of elemental concentrations of 18 trace and heavy elements was carried out for soft and natural drinks besides mineral water. In Soft and Natural drinks the mean value of order of elements in the decreasing order is Fe>Al>Sr>Ba>Rb>Pb>Mn>Li>Ni>Cd>Cr>V>Cu>As>Cs and Fe>Zn>Rb>Mn>Pb>Sr>Ba>Al>Cu>Cd>Ni>Co respectively. The values data of present samples are compared with the drinking water standards set by the WHO. The Present study indicates that almost all the elements present are below the permissible limits. The analysis of this data indicated that none of the elements exceeded the WHO maximum recommended levels of the drinking water [21]. But long term consumption of drinks containing these elements may have a hazardous impact on the human body. This study reveals that natural drinks are beneficial to the human body when compared

to soft drinks as natural drinks contain a low level of toxic and heavy elements compared to soft drinks.

REFERENCES

1. World Health Organization (WHO), Nutrients in Drinking Water. Water, Sanitation and Health Protection and the Human Environment, WHO, Geneva, 2005.
2. US-EPA, Drinking Water Standards and Health Advisories, EPA 822-R-04-005, Office of Water, US Environmental Protection Agency, Washington, D. C., 2004.
3. Bao, S. X.; Wang, Z. H.; Liu, J. S. X-ray fluorescence analysis of trace elements in fruit juice. Spectrochim. Acta, Part B 1999, 54, 1893-189
4. M. Bingol, G. Yentur, E.R. Buket, A.B. Oktem, Determination of some heavy metal levels in soft drinks from Turkey using ICP-OES method, Czech J. Food Sci. 28 (2010) 213–216.
5. I.F. Asiegbu, et al., Salesforce competence development and marketing performance of industrial and domestic products firms in Nigeria, Far East J. Psychol. Bus. 2 (3) (2011).
6. B.B. Phillip, A.M. Shittu, O.F. Ashaolu, Demand for non-alcoholic beverages among urban households in South West, Nigeria, Afr. J. Food Agric. Nutr. Dev. 13 (3) (2013) 7853–7869.
7. National Soft Drink Association (NSDA). Available at: http:// org/ soft drinks. Accesses in April 2004.
8. AOAC, Official Methods of Analysis of AOAC International, 18th ed., AOAC International, Gaithersburg, MD, USA, 2005.
9. Howard E. Taylor, Inductively Coupled Plasma Mass Spectrometry, Practices and Techniques, Academic press.
10. Akbar Montaser, Inductively Coupled Plasma Mass Spectrometry, Wiley.
11. Ma J, Betts NM. Zinc and Copper intakes and their major food sources for older adults in the 1994-96 continuing survey of food intakes by individuals (CSF- II). Journal of Nutrition. 2000; 130:2838-2843.
12. E.M. Garcia, C. Cabrera, J. Sanchez, M. Lorenzo and M.C. Lopez, “Chromium levels in potable water, fruit juices and soft drinks: influence on dietary intake”, Sci. Total Environ, Vol. 241, No. 1-3, 1999, pp. 143-50.
13. WHO, Cadmium in drinking-water, WHO/SDE/WSH/03. 04/80, WHO, Geneva, 2003.

14. WHO, Lead in drinking-water, WHO/SDE/WSH/03, 04/9, WHO, Geneva, 2003.
15. Onianwa, P. C.; Adetola, I. G.; Iwegbue, C. M. A.; Ojo, M. F.; Tella, O. O. Trace heavy metals composition of some Nigerian beverages and food drinks. Food Chem. 1999, 66, 275-279.
16. H. Ofori, M. Owusu and G. Anyebuno. "Heavy Metal Analysis of Fruit Juice and Soft Drinks Bought From Retail Market in Accra, Ghana", Journal of Scientific Research & Reports, Vol. 2, and No. 1, 2013, pp. 423-428
17. A. G. Engwa, C.J. Ihekwoaba, U. S. Ilo, M. Unaegbu, E. L. Ayuk and A. G. Osuji, "Determination of some soft drink constituents and contamination by some heavy metals in Nigeria" Elsevier Toxicology Reports Vol. 2, 2015, 384–390
18. O.O. Ogunlana, O.E. Ogunlana, A.E. Akinsanya and O. Ologbenla, (2015) "Heavy metal analysis of selected soft drinks in Nigeria", Journal of Global Biosciences Vol. 4, No. 2, 2015, pp. 1335-133
19. H.F. Al-Mudhaf and A. I. Abu-Shady, Comparison of the trace element contents in bottled and desalinated household drinking water in Kuwait, CLEAN – Soil, Air, Water, Accepted, January 5th, 2012 (In production).
20. A.M Magomya, G.G. Yebpella, U.C. Okpaegbe, An Assessment of metal contaminant levels in selected soft drinks sold in Nigeria. Inter. J. Innov. Sci., Eng. Technol., 2015, 2, 517-522.
21. WHO, Guidelines for Drinking Water Quality, 2nd ed., 1993, Geneva, Switzerland.