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Full Length Research Paper

Annual effective dose and concentration levels of heavy metals in different types of tea in Egypt

Y. F. Lasheen, N. S. Awwad*, A. El-khalafawy and A. A. Abdel-Rassoul

Hot Laboratories and Waste Management Center, Egyptian Atomic Energy Authority, P. O. 13759, Cairo, Egypt.

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Six marked brands of black tea (S1, S2, S4, S5, S6, and S7) and one type of green tea (S3) which commonly consumed in Egypt, were collected from local markets. The total alpha and beta gross activities in different tea samples were measured. The annual effective dose (mSv/y) for both total alpha and beta gross activities (Bq/2 gm) related to different types of tea drink corresponding to each radionuclide was calculated based on the dose conversion factors. The qualitative and quantitative assessment of tea sample S1 supplied from Ceylon proved the presence of different naturally occurring radionuclides. Also, the total contents of heavy metals in different types of tea were measured and the data obtained show the ability of them to accumulate the heavy metals, particularly Mn and Fe. The results of metal contents in infusion of different types of tea show that the concentration values of Mn for the all types were the highest concentration values and the concentration levels of Cu were the lowest concentration values. The studied heavy metals could be arranged in descending order according to their contents in tea brew as the following Mn > Fe > Zn > Cu > Pb.

Key word: Tea/annual effective dose/ alpha and beta gross/ heavy metals/ assessment.

INTRODUCTION

Tea is one of the most popular beverages all over the world. The 75% of the estimated 2.5 million metric tons of dried tea that are manufactured annually processed as black tea which consumed by many countries (Saleh, 1982). Tea is liquor prepared from the leaves of the tea plant. Hot or cold, tea remains one of most popular beverages in the world. The chemical composition of tea and tea leaves is the object of broad scientific studies from, e.g. a medical, toxicological or environmental point of view. Tea is a popular drink in many countries. At present more than forty countries in the world grow tea with Asian countries producing 90% of the world's total output. However, no data are available on the uptake of heavy metals by the tea plant and the environmental fate of these metals in a tea plantation. Metallic constituents of the tea leaves is normally different according to the type of tea (green or black) and geological source, (Ahmad et al., 1983). During the past several years, some researchers analyzed the tea leaf and reported the determination of heavy metals (mostly aluminum) in various brands of tea leaves (Kojima et al., 1988; Koch, 1989; Wang, 1993; Sud et al., 1995; Lamble and Hill, 1995; Liu et al., 1995; Manickum and Verbeek, 1994; Kingston and Jassie, 1988; Mierzwa et al., 1997).

Plants can take up the heavy metals from the soil and under certain conditions high levels can be accumulated in the leaves and other edible parts of the plant. For instance tea plants can uptake Pb from the soils, and inevitably, a proportion will be transported to the tea leaves which are used to prepare one of the most popular beverages in the world. Each country sets its own allowable limit for Pb concentration in tea leaves. In Europe it is 5 mg/kg, in Japan it is 20 mg/kg, while in China the limit is 2 mg/kg. Recent increases in the Pb concentration of commercial tea supplies have caused concern to both consumers and producers. For instance, one brand of tea showed annual increases in its Pb concentration from 0.63 mg/kg in 1996 to 2.11 mg/kg in 1999. Furthermore, the soluble Pb concentration in beverages prepared from some teas high in Pb concentration can exceed the 0.05 mg/l limit set for drinking water in China (Yang and Li,

*Corresponding author. E-mail: nsawwad20@yahoo.com. Tel: 002 010 2590157, 002 02 44625633.

2001; Jin et al., 2005).

By far the largest proportion of human exposure to radiation comes from natural sources from external sources of radiation, including cosmic and terrestrial radiation, and from inhalation or ingestion of radioactive material. The United Nations Scientific committee on the effects of atomic radiation (UNSCEAR, 2000) has estimated that the global average annual human exposure from natural sources is 2.4 mSv/yr (World Health Organization, 2004). Acute health effects of radiation, appearing with symptoms of nausea vomiting, diarrhea, weakness, headache, anorexia leading to reduced blood cell counts and in very severe cases to death, occur at high doses of exposure of the whole body or large part of the body (IAEA, 1998). Therefore, acute health effects of radiation are practically not a concern for continuously monitored – for radioac-tivity content – central drinking water supplies. However, extreme situations of possible terrorist use of radioactive materials to contaminate drinking water supplies, theore-tically, cannot be excluded (World Health Organization, 2004).

The dose arising from the intake of 1 Bq (by ingestion) of radioisotope in particular chemical from can be estimated using a dose conversion factor. Data for age-related dose conversion factors for ingestion of radionuclides has been published by the (ICRP, 1996). The dose conversion factors– synonyms are dose coefficients or dose per unit intake values (mSv/Bq) – for naturally occurring radionuclides (detectable primarily at higher natural background radiation areas) or those arising from human activities that might be found in water supplies at somewhat higher probability (in case of incident) (World Health Organization, 2004).

^{210}Po was determined in 34 types of imported tea and 9 kinds of mate collected from the Syrian local market. The ^{210}Po concentration was found to vary from 5.5 to 39 Bq/kg in tea and mate samples. In addition, ^{210}Po was also determined in tea and mate infusions where different infusion conditions have been examined. The results have shown that the amount of ^{210}Po transferred from tea and mate leaves to the aqueous extract ranged from 9 to 21% and 3 to 15%, respectively. The annual intake of ^{210}Po by Syrians due to tea consumption and mate infusions was found to be 9 and 151 Bq for tea and mate, respectively, Al-Masri (2004).

Several attempts have been made to assess tea quality by chemical analysis the first aim of the present work was to study the main analytical task was to develop and evaluate sensitive, reliable and relatively rapid techniques for the determination of some heavy metal impurities in tea leaves or plant samples of a similar matrix. The second aim was preformed for measurement the alpha and beta growth for different kind of tea to evaluate the tea leaves or plant samples of a similar matrix. The second aim was preformed for measurement the alpha and beta growth for different kind of tea to evaluate the internal radiation dose received.

MATERIALS AND METHODS

Sampling and sample preparation

Six marked brands of black tea and one type of green tea which commonly consumed in Egypt, were collected from local markets. For sample preparation, the two methods commonly used for preparation of tea were adopted for this study to assess the actual amount of heavy metal reach human body. The two methods are:

Brew

In this method, 2 g of black tea particles or one tea bag was boiled with 100 ml of distilled water for 5 min the mixture was held for 5 min at room temperature and then filtered. Then tea bag was removed to obtain the clear solution for analysis.

Infusion

In this method, 100 ml of hot distilled water was added to either 2 g of black tea particles or one tea bag. The mixture left to cool at room temperature for 5 min and then filtered to obtain the clear solution for further processing.

Total contents of metals

Portions of 0.5 g of each brand were digested using 10 ml of a mixture (2:1 v/v) of concentrated HNO_3 and HCl. The mixture was heated on sand bath until the solution a turned white and gives out he white fumes. The digest was transferred into 100 ml volumetric flask and the volume was adjusted to the mark using distilled water.

Instrumentation

Atomic Absorption Spectrometry (AAS):

AAS measurements were carried out with AA spectrometer; model Z-8100 polarized Zeeman, manufactured by Hitachi, Ltd., from Japan. Hitachi single element hollow cathode lamps were used with air-acetylene flow rate ranging from 0.5 to 4.0 l/ min with an auxiliary oxidant gas pressure ranging from 140 to 160 Kpa. The instrument is provided with temperature regulation device and automated sampling by a built- in autosampler, type SSC-200. Selection of wavelength ranged from 190 to 900 nm.

Liquid scintillation counting system (LSC)

Ultra-low-level time- resolved liquid scintillation counting system (type 2770 TR/SL) supplied from Canberra-Packard, USA (model Tri-Carb) was used. It is designed for determination of very low radioactivity levels through reduction of background count rates by discriminating the unquenchable background component originating outside the cocktail from the true quenchable component. the system includes a pulse shape analyzer, which separates pulses produced by alpha and beta radiations into separate spectra through a built in discrimination setup, The resulting scintillations are converted and multiplied by the photomultiplier tube and counts emitted from measured nuclides, the energy region from 30.0 to 350 keV is used for alpha measurements and from 0.00 to 185 keV emitted from measured nuclides, the energy region from 30.0 to 350 keV is used for alpha measurements and from 0.00 to 185 keV for beta measurements.

Table 1. Spectroscopic measurements

Operational conditions	Zn	Mn	Fe	Cu	Pb
Wavelength, nm	213.9	279.6	248.3	324.8	283.3
Hollow cathode lamp current, mA	7.5	7.5	15	7.5	10
Acetylene flow rate,1min^{-1}	1.5	1.7	1.5	1.7	1.7
Slit width, nm	1.3	0.4	0.2	1.3	1.3

Table 2a. Measurement of total alpha and beta gross activities using LSC in different. Tea samples prepared by total digestion.

Sample	Country of origin	Gross count rate c/m		Net count rate, c/m *)		Total activity gross, Bq/2gm	
		Alpha gross	Beta gross	Alpha gross	Beta gross	Alpha gross	Beta gross
Blank		0.75 ± 0.11	12.00 ± 0.440	--	--	--	--
S1	Ceylon	1.22 ± 0.14	17.43 ± 0.540	0.47 ± 0.18	5.43 ± 0.670	0.13 ± 0.05	1.51 ± 0.187
S2	Ceylon	1.23 ± 0.14	14.68 ± 0.494	0.48 ± 0.18	2.68 ± 0.660	0.133 ± 0.05	0.74 ± 0.183
S3	Ceylon	2.23 ± 0.14	15.42 ± 0.510	1.48 ± 0.22	3.42 ± 0.673	0.411 ± 0.06	0.95 ± 0.187
S4	Ceylon	1.10 ± 0.13	14.27 ± 0.487	0.35 ± 0.17	2.27 ± 0.656	0.097 ± 0.047	0.63 ± 0.182
S5	Ceylon	1.42 ± 0.15	13.82 ± 0.479	0.67 ± 0.19	1.82 ± 0.650	0.186 ± 0.053	0.50 ± 0.180
S6	Ceylon	1.42 ± 0.15	14.85 ± 0.497	0.67 ± 0.19	2.85 ± 0.663	0.186 ± 0.053	0.79 ± 0.184
S7	Ceylon	1.73 ± 0.17	14.07 ± 0.484	0.98 ± 0.20	2.07 ± 0.654	0.272 ± 0.055	0.57 ± 0.182

*) The net count rate is expressed for the total radioactivity for alpha and beta emitting radionuclides considering c/m = d/m considering the counting efficiency in both alpha and beta region 100%.

Gamma spectroscopy

Sample (S1) was directed to a gamma ray spectrometer with a HPGe detector P-type with the following specifications resolution (FWHM) at 122 KeV ^{57}Co is 1100 eV and at 1.33 MeV ^{60}Co is 2.0 KeV. Relative efficiency at 1.33 MeV ^{60}Co is 30 %. The detector is shielded in copper (30 mm thick), lead (100 mm thick) and finally cadmium (3 mm thick).The germanium crystal is operating at 3000V and a dewar filled with liquid nitrogen used for cooling the germanium crystal.

The system was calibrated for energy by using radioactive standards of known energy as ^{22}Na Eγ = 511 keV, ^{137}Cs E_γ = 662 keV, ^{60}Co E_γ = 1332 keV, ^{57}Co E_γ = 122 keV, ^{133}Ba Eγ = 356 keV. The spectra were evaluated using the computer software (Gene 2000).

The radioactivity level of ^{238}U in test sample was determined based on the intensity and efficiency of 63.29 keV (I = 3.83 %) and 92.8 keV (I = 5.42%) γ-lines of the first daughter ^{234}Th irrespecting the dependent on the daughters that emitted after ^{222}Rn such as the intensities of 351.9 and 609.3 keV γ-lines of ^{214}Pb and ^{214}Bi, respectively. The radioactivity level of ^{226}Ra was determined based on 3.6 % intensity of 186 keV γ-line. ^{232}Th activity was obtained through the γ-line of ^{228}Ac at 911.21 keV with intensity 26.6%. The activity of ^{40}K was determined based on intensity 10.7% of 1460.75 keV γ-line.

Procedure

For total digestion samples

All samples were counted for 60 min (1 cycle) using LSC. 3 ml of each total digested sample was taken from stock solution (2gm/50 ml) and mixed with 15 ml ultima gold LS cocktail. The count rate in both alpha and beta regions were determined in 50 ml total digested sample by multiply with factor (50/3).The results of the count rate were corrected regarding to SIS mode efficiency and correcting for counting in alpha and beta regions. The net count rate is expressed for the total radioactivity for alpha and beta emitting radionuclides considering c/m = d/m considering the counting efficiency in both alpha and beta region 100%.

For leached sample (Infusion method)

All samples were counted for 300 min (1 cycle) using LSC. 3 ml of each sample was taken from leached stock solution (2 gm in 50 ml de-ionized water) after being warmed for 5 min and optimized as Egyptian habits after that mixed with 15 ml Ultima Gold LS cocktail. Both alpha and beta gross activities were calculated based on count rate in both alpha and beta regions and considering the counting efficiencies closed to 100% and were determined in 50 ml total leached sample by multiply with factor (50/3).The results of the count rate were corrected regarding to SIS mode. The net count rate is expressed for the total radioactivity for alpha and beta emitting radionuclides considering c/m = d/m

Spectroscopic measurements

AAS measurements were carried out under a constant air flow rate (15.0 l/min), according to the following operational conditions for each element (Table 1)

Chemical and reagents

All chemicals used were of analytical grade. A set of standards were prepared from readily made standard solutions provided form Merck, AG, Darmstadt, Germany by dissolution in, or adequate dilution with dilute nitric acid solution. Bidistilled water in all glass apparatus was used for preparation of different solutions, used standards and for final glass ware washing.

Table 2b. The annual effective doses of alpha and beta emitters in different tea samples.

Sample Number	Total Alpha gross activity Bq/2gm *)	Annual effective dose (alpha emitters) mSv/y **)							Average of alpha annual dose	Total Beta gross activity, Bq/2gm *)	Annual effective dose (beta emitters) mSv/y		Average of beta annual dose
		U-238	U-234	Th-230	Ra-226	Po-210	Th-232	Th-228			Pb- 210	Ra – 228	
		Dose per unit intake (mSv/Bq) ***)									Dose per unit intake (mSv/Bq)		
		4.5 E -5	4.9 E -5	2.1 E-4	2.8 E-4	1.2 E-3	2.3E- 4	7.2 E-5			6.9 E-4	6.9 E-4	
S1	0.011±0.003	0.543E-3	0.59E-3	0.25E-2	0.33E-2	0.0144	0.28E-2	0.87E-3	3.572E-3	0.122±0.11	0.922E-1	0.922E-1	0.922E-1
S2	N.D	--		--	--	--	--	--	--	N.D	--	--	--
S3	0.212±0.013	1.04E-2	1.14E-2	0.49E-1	0.65E-1	0.28	0.53E-1	1.67E-2	0.069	0.803±0.12	6.07E-1	6.07E-1	6.07E-1
S4	0.013±0.003	0.64E-3	0.7E-3	0.3E-2	0.4E-2	0.0171	0.32E-2	0.10E-2	4.23E-3	0.35±0.11	2.64E-1	2.64E-1	2.64E-1
S5	N.D	--	--	--	--	--	--	--	--	N.D	--	--	--
S6	N.D	--	--	--	--	--	--	--	--	0.16±0.10	1.21E-1	1.21E-1	1.21E-1
S7	0.025±0.005	0.12E-2	0.13E-2	0.57E-2	0.77E-2	0.33E-1	0.63E-2	0.2E-2	8.1E-3	0.24±0.10	1.813E-1	1.813E-1	1.813E-1
Annual dose limits (WHO, 2004, UNSCEAR, 2000)		**Average radiation dose from natural sources, Ingestion (food and drinking)**							**0.3**	**Typical range**		**0.2 – 0.8**	

*) Total alpha and beta gross activities (Bq/2 gm) measurements after being subtracted from background.
**) the annual effective dose for each radionuclide was determined based on dose conversion factors for ingestion of radionuclides by adults members of the public (WHO, 2004) considering 3 Cups of tea/day (2 gm leached in 200 ml boiled water in each one cup). The total consumption of tea per year considered to be 1095 cub.
***) represent the dose per unit intake (mSv/Bq) for each radionuclides (WHO, 2004).
N.D: Not detectable.

Table 3. Monitoring of 150 gm of sample 1 supplied from Ceylon tea by gamma spectroscopy.

Energy, keV	Radionulide	Net count	Net Count rate C/S	ε *)	I**)	Radioactivity Bq/150 g	Radioactivity Bq/2gm
63.1	Th-234 (U-238)	600 ± 24.5	0.7E-2±3.5E-4	0.0289	0.038	6.40 ±0.255	0.085 ±0.003
92.8	Th-234 (U-238)	562 ± 23.7	6.5E-3±2.7E-4	0.0285	0.0542	4.21 ±0.175	0.056 ±0.002
186	Ra-226	317 ± 17.8	3.7E-3 ±2.1E-4	0.025	0.033	4.48 ±0.254	0.06 ±0.003
238.5	Pb212(Th-232)	255 ± 16.0	2.95E-3 ±1.85E-4	0.022	0.446	0.301 ±0.019	0.004 ±0.0002
295.2	Pb-214 (U.238)	158 ± 12.6	1.83E-3 ±1.46E-4	0.019	0.197	0.49 ±0.038	0.006 ±0.0005
352	Pb-214 (U-238)	157 ± 12.5	1.82E-3 ±1.45E-4	0.017	0.389	0.27 ±0.022	0.004 ±0.0003
582	Tl-208 (Th-232)	70 ± 8.4	8.10E-4 ±9.7E-5	0.013	0.858	0.073 ±0.009	0.001 ±0.0001
611	Bi-214 (U-238)	103 ± 10.1	1.19E-3 ±1.17E-4	0.0126	0.433	0.218 ±0.021	0.003 ±0.003
911	Ac-228 (Th-232)	52 ± 7.21	6.02E-4 ±8.3E-5	0.0089	0.277	0.244 ±0.034	0.003 ±0.0004
1461	K-40	413 ± 20.3	4.78E-3 ±2.3E-4	0.005	0.106	9.02 ±0.44	0.120 ±0.006

*) ε is the counting efficiency for each gamma energy line.
**) I is the relative intensity of gamma energy line.

Table 4. Determination of extract percent in aqueous of both alpha and beta gross activity for tea samples.

Sample	Total activity gross, Bq/2gm (using total digestion)		Total activity gross, Bq/2gm (in aqueous)		Percent of extract in aqueous, %	
	Alpha gross	Beta gross	Alpha gross	Beta gross	Alpha gross	Beta gross
S1	0.13 ± 0.05	1.51 ± 0.187	0.011 ± 0.003	0.122 ± 0.11	8.5	8.1
S2	0.133 ± 0.05	0.74 ± 0.183	N.D	N.D	NA	NA
S3	0.411 ± 0.06	0.95 ± 0.187	0.212 ± 0.013	0.803 ± 0.12	51.6	84.5
S4	0.097 ± 0.047	0.63 ± 0.182	0.013 ± 0.003	0.35 ± 0.11	13.4	55.5
S5	0.186 ± 0.053	0.50 ± 0.180	N.D	N.D	NA	NA
S6	0.186 ± 0.053	0.79 ± 0.184	N.D	0.16 ± 0.10	NA	20.2
S7	0.272 ± 0.055	0.57 ± 0.182	0.025 ± 0.005	0.24 ± 0.10	9.2	42.1

N. A: not applicable.

Table 5. Metal contents in different types of tea.

Tea samples , (µg/g	Zn	Mn	Fe	Cu	Pb	Co
*(Ref. Value)	(31.96)	(610)	(194.70)	(24.08)	(0.35)	(0.25)
S1	60.70	550	150.6	17.76	0.32	0.13
S2	75.88	490	160.75	16.84	0.20	0.08
S3	70.94	405	156.80	15.56	0.15	N.D
S4	67.70	385	146.82	13.44	0.12	0.05
S5	65.84	354	120.54	11.78	0.03	0.01
S6	88.50	675	77.48	22.63	0.28	N.D
S7	90.65	715	302	32.42	0.76	0.10

N.D. = Not Detectable.
*) Chong Wei Jin et al., (2005).

RESULTS AND DISCUSSION

Radioactivity determination

The data presented in Table 2a reveal the total alpha and beta gross activities in different tea samples of Ceylon origin using 2.0 gm of each type using total digestion. The total alpha gross activities are within range 0.097 ± 0.047 Bq/2gm sample S4) to 0.272 ± 0.055 Bq/2gm (sample S7). For beta gross activities the range is from 0.50 ± 0.18 Bq/2gm (sample S5) to 1.51 ± 0.187 Bq/2gm (sample S1). The data revealed the beta gross activities in all samples are much more the total alpha gross activities.

Table 2b reveals the annual effective dose (in mSv/y) for both total alpha and beta gross activities (Bq/2gm related to different types of tea drink corresponding to each radionuclide as shown in the Table 2b based on the dose conversion factors. The average of total alpha annual dose is within range from 3.572E-3 to 0.069 mSv/y. The average of total beta annual dose is ranged from 0.922E-1 to 6.07E-1 mSv/y. These ranges are lying within the limit of annual radiation dose from natural sources (0.2 to 0.8 mSv/y) for beta annual dose and still below the average 0.3 mSv/y for alpha annual dose (WHO, 2004). Table (2b) also represents a typical example (as a case of drinking water) for practical monitoring purpose, the recommended guideline values remain 0.1 Bq/L for gross alpha and 1 Bq/L gross beta activity. These values are to be used for screening only. They should be followed by radionuclide-specific analysis incase of any finding for elevated gross activities in drinking water (WHO, 2004).

The total alpha gross activity as calculated from Table 2a is ranged from 65 ± 25 Bq/kg to 136 ± 27.5 Bq/kg dry black tea and 205.5 ± 30 Bq/kg dry for green tea (S3). The most effective annual dose is referred to Ceylon tea (S3) according the result of ^{210}Po and ^{210}Pb (alpha annual dose is 0.28 mSv/y and beta annual dose 0.606 mSv/y, Table 2b). These values are high comparable with other black tea samples so it is recommended to extend the work for further investigation referring to radio-analytical procedure for separation and subsequent determination of both ^{210}Po and ^{210}Pb as well as the research that was done by Al-Masri et al. (2004) in which the concentration of ^{210}Po (as naturally occurring radionuclides of uranium series) in tea samples supplied from Ceylon is ranged from 6 to 39 ± 2.0 Bq/kg dry and samples supplied from Argentina is ranged from 47 ± 3.0 to 74 ± 4.0 Bq/kg dry (Al-Masri et al., 2004) .

Table 6. Metal contents in infusion of different types of tea

Tea samples , (μg/g)	Zn	Mn	Fe	Cu	Pb
(Ref. Value)	(14.25)	(211.10)	(56.00)	(3.85)	N.D
S1	30.0	190	80.50	10.5	0.2
S2	39.54	150.5	85.67	8.77	0.10
S3	37.68	140.67	83.88	6.54	0.05
S4	34.44	132.8	77.8	5.55	0.02
S5	31.0	130.77	67.54	3.34	N.D
S6	43.5	220.0	30.56	11.0	0.15
S7	36.67	167.7	122.45	20.12	0.25

The data presented in Table 3 reveals the qualitative and quantitative assessment of different naturally occurring radionuclides in Ceylon tea as real example to prove the presence of uranium and thorium and their relative daughters. This may confirm the use of dose conversion factor for effective annual dose assessment especially when dealing with low radioactivity levels. Concentration of ^{210}Po in tea and green tea leaves and their aqueous extracts were investigated by Al-Masri et al (2004), (5 g of tea samples were in-fused in 500 ml of water at 100^{o}C while 20 g of green tea samples were infused in 10 ml of water at 100^{o}C).

The results showed that ^{210}Po in the original samples is 8.9 ± 1.0 Bq/Kg dry for tea and 34.4 ± 2.2 Bq/kg dry for mate. ^{210}Po in the aqueous extract 0.9 ± 0.1 Bq/Kg dry in tea (within extraction percent 10.1 %) and 4.1 ± 0.5 Bq/Kg dry for mate (within extraction percent 11.9 %) (Al-Masri et al., 2004).

The data presented in Table 4 reveal the extract percent in aqueous of tea samples (S1, S2, S4, S5, S6, and S7) and green tea sample (S3). The results show that the amount of alpha gross activity transferred from tea to the aqueous extract ranged from 8.5 to 13.4% which is close to reference value that has been published by Al-Masri et al., 2004). For green tea is 51.6% while for beta the range is from 8.1 to 55.5% for black tea and for green tea is 84.5%.

Heavy metals assessment

The results of total contents of the studied heavy metals in different samples of tea (Table 5) show the ability of these types to accumulate the heavy metals, particularly Mn and Fe to a lesser extent for Zn and Cu. The most abundant metal in tea was Mn (354-715 μg /g). On the other hand, contents of Pb and Co were relatively low. The results also show that the contents of heavy metals are varying widely among the tested types of tea. Among tested tea brands, green tea (S3) has the highest contents of studied heavy metals, Zn, Mn, Fe, Cu and Pb as well as the highest values of total alpha gross activity of naturally occurring radionuclides. One can conclude that the presence of high amount of heavy metals can lead to the accumulation of some naturally occurring radionuclides especially uranium and thorium and or their relative daughters. The level of Pb (0.76 μg/g) in green tea was relatively low compared with the reference value (14.84 μg g^{-1}) for the Chinese tea. The results of metal contents in infusion of different types of tea (Table 6) show that the concentrations of Mn for the all types were the highest concentration values and the concen-tration levels of Cu were the lowest concentration values.

The concentration of Co was too low to be detected by atomic absorption spectrophotometric. Figure 1 shows the relation between metals concentrations in brew and infusion and different samples of tea. The contents of heavy metals in brew extract as in Table 7 shows that the concentration of all elements were lower than their corresponding values in infusion. This could be attributed to chelation of these metals with tannic acid and tannis which exudates during the boiling of tea particles.

Precipitation of these chelates leads to the significant decrease in metal concentration in brew extract. Generally, the studied heavy metals could be arranged in descending order according to their contents in tea brew as the following Mn > Fe > Zn > Cu > Pb.

Conclusion

The most effective annual dose for Ceylon tea according the result of ^{210}Po and ^{210}Pb (alpha annual dose is 0.28 mSv/y) so it is recommended from the present study that the work needs more further investigation referring to radio-analytical procedure for separation and subsequent determination of both ^{210}Po and ^{210}Pb.

The results of metal contents in infusion of different types of tea show that the concentration values of Mn for all types were the highest concentration values and the concentration levels of Cu were the lowest concentration values. General view on contents of heavy metals in brew

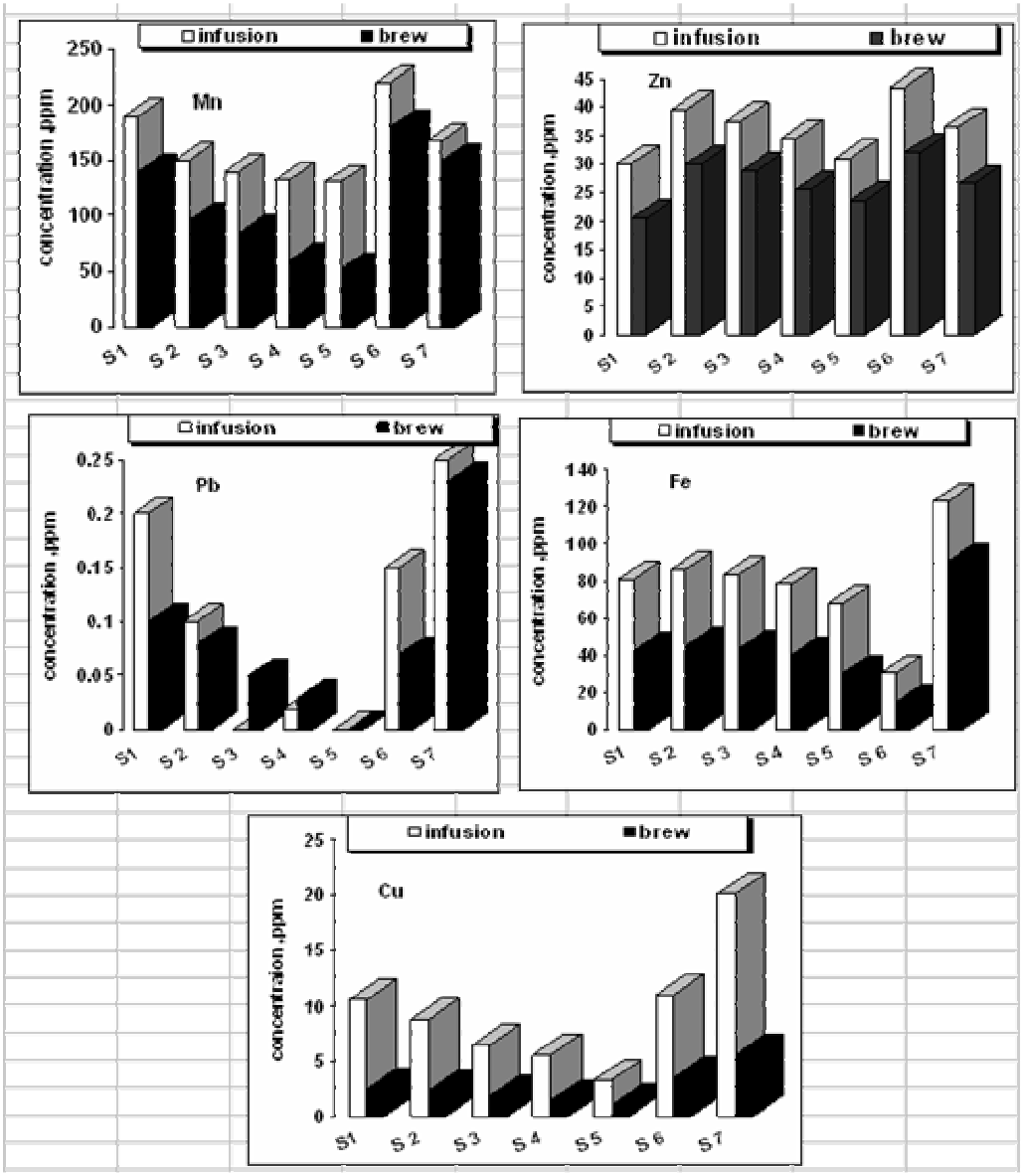

Figure 1. Relation between metal concentrations in brew and infusion and different samples of tea.

Table 7. Metal contents in brew of different samples of tea

Tea samples , (µg/g)	Zn	Mn	Fe	Cu	Pb
(Ref. Value)	11.87	158.0	42.63	0.30	N.D.
S1	20.5	140.5	42.5	2.5	0.1
S2	30.0	96.5	45.6	2.3	0.08
S3	28.8	85.0	43.4	1.9	0.05
S4	25.6	60.0	40.2	1.5	0.03
S5	23.7	52.6	30.4	0.99	N.D
S6	32.0	180.5	15.0	3.5	0.07
S7	26.6	150.0	90.7	5.50	0.23

extract showed that the concentration of all elements were lower than their corresponding values in infusion.

This drop could be attributed to chelation of these metals with tannic acid and tannis which exudates during the boiling of tea particles. Generally, referring to the study of heavy metals, it is recommended to decrease green tea drink intake as well as the tea drinking by infusion process.

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