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Research paper

Assessment of heavy metals and radioactivity concentrations in Iraqi truffles

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Abstract

Concentrations of heavy metals in several species of desert truffles, collected from different Iraqi provinces, were determined. Samples were collected from Al-Anbar Salah ad-Den and AlMuthana provinces. The levels of Cd, Cr, Pb, Mn, Ni, and Zn were analyzed. As well as the level of radon in the truffle samples were also measured using the solid-state nuclear track detector (CR-39). The results reveal that the concentrations of the investigated elements in the Iraqi truffles were below the recommended levels and the ascending order of the measured toxic elements was Ni<Mn<Zn. The concentrations of the other elements (Cd, Cr and Pb) were below the detection limit of the measuring method. Radon activity levels in the study truffle samples were between (156.23 to 513.83) Bq.m-3 with mean value of (323.23) Bq.m-3. the results reveal that most measured radon activity were below the world recommended value given by ICRP except Ramadi sample. All the computed values of health risk index (HR) of all elements were within safe limits (HR<1), therefore, the consumption of the investigated truffles does not pose any health risks from the investigated heavy elements and from radiological point of view.

Keywords: *Atomic Absorption Spectroscopy; CR-39; Desert Truffles; Health Risk Assessment; Heavy Metal; Radon.*

1. Introduction

Desert truffles are a very common and appreciated food in many Middle East countries. The desert truffles have a number of special features. They have a high economic value and are the world's most expensive truffles [1]. Desert truffles have a distinguishable chemical characteristic compared with other common everyday consumed truffles [1-3]. They have generally no stem, no gills, and they grow underground. Mature truffles have a tendency to be intense and hard rather than have mushy and delicate characteristics [2]. They have good taste and there are many researches about their health advantages [4]. Desert truffles can be concerned as antioxidants fruit because they contain many polyphenolic compositions [5], as well as, the studies show that truffles have antimicrobial [6], [7], antioxidant [8] and hepato-protective activity [9].

Several studies on chemical composition of desert truffles show that they contain high protein and amino acids and they are rich in fiber, fatty acids (linoleic, palmitic, oleic), minerals (such as K, P, Fe, Ca and S) as well as carbohydrates which they may enhance people health [4], [10-14]. There are various types of truffles around the worlds but only two kinds of truffles in Iraq, the black truffles which belong to the genus Terfezia and the other one is the white truffles which belong to the genus Tirmania which is usually grow in Al Muthana province [15]. Both types are known by the arabic name kamah. In Iraq and in many Gulf countries, the truffles usually grow in the deserts during winter (the rainy season) [16]. As Terfezia and Tirmania are habitually spread to the arid and semi-arid parts of the Mediterranean, therefore they are also called desert truffles [1], [2].

Two main goals for this research: examining whether the truffle fruiting bodies can be considered as bio-indicators of ecological pollution and investigating whether they accumulate high levels of some trace elements.

2. Materials and methods

2.1. Plant sampling

Samples of black truffles were collected from different cities in Al-Anbar province (Anah, Haditha and Ramadi) as well as one sample was collected from Salah ad-Den province. One white truffle sample was collected from Al Muthana province. The samples were stored in labeled polythene sampling bags and brought to the Environmental Research Center, University of Technology, Baghdad, Iraq. The truffles samples were washed with tap water to remove any kind of deposition like soil particles. Then truffles were oven dried and ground into powdered form, sieved with 0.3mm mesh size and they stored in polyethylene bags to prepare the samples for digesting. 10g of each sample was put in plastic containers in order to measure radon concentration.

2.2. Heavy metals analysis

a) Digestion of samples

A weight of 1 g of each desert truffle samples was digested by 16 ml acid mixture (f) at 2:6 ratio and heated on a hot plate at Temperature 120^0C until the transparent solution appeared. When the solution becomes cold, 10ml of distilled water was added. Then the liquid samples were filtered through Whatman No. 42 filter papers and made up to 50 ml volume using deionized distilled water. The samples were kept for 24 hours to allow the solution to settle and stored for further analysis.

Concentrations of heavy metal samples were analyzed using Atomic Absorption Spectrophotometer (AA-6300 SHIMADZU – Japan) according to standard method 3030E at the Environmental Research Center laboratory, University of Technology, Baghdad.

b) Quality control analysis

Chemicals were supplied from fine-CHEM limited, MUMBAI, India and used for the sample preparation. Double deionized water was used for solution preparation and glassware was washed with 10% HNO_3. Standards were prepared for each metal from their stock solution to calibrate the instrument.

c) Data analysis

i) Average daily intake of metals (ADI)

In this study, the risks to human health posed by chronic exposure to heavy metals were assessed. The average daily intake of metal was evaluated for the study of potential health risk assessment, in accordance with Eq. 1[17]

$$\mathrm{ADI} = \frac{\mathrm{C_m \times C_f \times D_{FI}}}{\mathrm{B_{AVw}}} \quad (1)$$

Where C_m, C_f, and D_{FI} represent the heavy metal concentrations in analyzed foodstuffs (mg/kg), conversion factor (0.085) and daily intake of truffle (30 g per person per day), respectively (Mahmood and Malik, 2014). Also, B_{avw} indicates average body weight equaling 60kg for adults [18].

ii) Health risk index (HR)

To assess the human health risk of heavy metals, it is necessary to calculate the level of human exposure to that metal by tracing the route of exposure of pollutant to human body. A higher concentration of heavy metals which enters the human body leading to health risks [19]. In the present research work, metal concentration was used to calculate the health risk index (HR). Value of HR depends upon the average daily intake of metals (ADI) and oral reference dose (D_{ref}). D_{ref} is an estimated per day exposure of metal to the human body that has no hazardous effect during life time [20]. The health risk index for the measured heavy metals by consumption of desert truffles was calculated by following equation [17]

$$\mathrm{HR} = \frac{\mathrm{ADI}}{\mathrm{D_{ref}}} \quad (2)$$

Where, ADI indicates daily intake of metal (mg) and D_{ref} refers to reference dose of metal (mg/kg/day). The oral reference doses were 0.14 for Mn, 0.02 for Ni and 0.30 for Zn (mg/kg body weight/day). Also, an HR<1 means the truffle consumption is assumed to be safe [21-23].

Total HR (THR) of elements for the Truffles was evaluated in accordance with Eq. 3 [17]

$$\mathrm{THR} = \mathrm{HR_{toxicant1}} + \mathrm{HR_{toxicant2}} + \mathrm{HR_{toxicant}} + \cdots + \mathrm{HR_{toxicantn}} \quad (3)$$

2.3. Radon measurement

The solid-state nuclear track detection technique (SSNTD) (sealed can technique) was used during the present study. The CR–39 nuclear track detector sheet was cut into small pieces each of (1.5x1.5 cm^2) area. Equal amount of the dried samples (30 gm) placed in the plastic container of radius (4cm) and height (10cm) to ensure radon detection only. The CR–39 pieces were placed in the bottom of each container cover, with samples at the bottom of the container and then left for exposure of 60 days. At the end of exposure time the collected CR–39 detectors were chemically etched using a 6.25 N solution of NaOH, at temperature of 70°C, for a period of 5hrs in the etching bath. An optical microscope with magnification of 400X was used to count the number of tracks per FOV in each detector and subsequently the average radon (Rn-222) concentration in Bq/m^3 have been calculated. The activity concentrations of radon in (Bq/m^3) for truffle samples have been obtained using the expression [24]:

$$\mathrm{C(Rn)} = \frac{\rho}{\mathrm{K.T}} \quad (4)$$

Where, ρ is the radon track density (Track cm^{-2}) which it is calculated by number of tracks per area of field of view (Tracks/cm^2), T is the exposure time and K is the calibration factor. The Concentration of uranium (ppm) was calculated using the formula

$$\mathrm{C_u(ppm)} = \frac{\mathrm{W_U}}{\mathrm{W_s}} \quad (5)$$

Where, W_u and W_s are the weight of uranium in the sample and the weight of the sample.

3. Results

3.1. Heavy metals

The concentrations of six metals (Mn, Ni, Zn, Cd, Cr and Pb) in Iraqi truffle samples were measured and shown in Table 1. Figures (1-3) illustrate the concentrations of Mn, Ni and Zn, respectively. The lowest Zn observed concentration was (0.5481) mg/kg in sample T6 collected from Salah ad-din province, while the highest observed concentration was (1.1134) mg/kg in sample T2 collected from Anah city. The Mn concentration ranged from (0.1725) mg/kg to (1.2274) mg/kg. The lowest Mn level detected was in samples T2 (Anah city) and T4 (Al Muthanna province), whereas the highest Mn level detected was in sample T5 (Haditha city). The concentration of Ni metal was ranged from (0.0601) mg/kg to (0.1474) mg/kg in T4 (Al Muthanna province) and T5 (Haditha) samples, respectively.

However, the concentration of the toxic metals (Cd, Cr and Pb) were tried to be analyzed but they were below detection limit which are (0.2, 0.1 and 1 mg/kg), respectively. Among the six determined metals Zn was the highest in all truffle samples (Table 1).
As it was shown in Table 1, the order of harmful element levels was Ni < Mn < Zn in both types of truffles.

Table 1: Mean Values of Heavy Metal Concentrations

Heavy Metal concentration (mg/kg)							
City	Code	Mn	Ni	Zn	Cd	Cr	Pb
Ramadi	T1	0.4415	0.1147	0.6595	ND	ND	ND
Anah	T2	0.1725	0.0855	0.5481	ND	ND	ND
Ramadi	T3	0.2129	0.0928	0.6194	ND	ND	ND
Al Muthanna	T4	0.1725	0.0601	0.6207	ND	ND	ND
Haditha	T5	1.2274	0.1474	1.0281	ND	ND	ND
Salah ad-Din	T6	0.7317	0.1037	1.1134	ND	ND	ND

The Joint FAO/WHO Expert Committee on Food Additives [25] recommends that provisional tolerable weekly intakes (PTWI) of Ni, and Zn are 35 and 420 µg/kg/week, respectively, while, there is no PTWI data for Mn. Therefore, the weekly tolerable intakes of Ni and Zn for a person weighing 60 kg would be 2.1 and 25.2 mg, respectively [18].
Considering the average body weight (60kg) of an adult, fresh Truffle consumption (30 g daily) and median concentration in (mg/kg bw/wk) of Mn, Ni, and Zn in truffle found in this study 0.01796, 0.00367 and 0.02786 then the estimated mean HR for Mn, Ni, Zn and THR are 0.1283, 0.18342, 0.09288 and 0.40460, respectively (Table 2). All the values of HRs and THR based on median concentration were less than one (closer to zero), suggesting that consumption of the investigated truffles do not pose any health risks from investigated elements for Iraqi consumers.

Table 2: Daily Intake of Metals (Mg/Kg Bw/Wk), Health Risk Index and Total Health Risk Index in Desert Truffles

Sample Code	ADI			HR			THR
	Mn	Ni	Zn	Mn	Ni	Zn	
T1	0.11258	0.02925	0.16817	0.11488	0.20892	0.08008	0.40388
T2	0.04399	0.02180	0.13977	0.04489	0.15573	0.06656	0.26717
T3	0.05429	0.02366	0.15795	0.05540	0.16903	0.07521	0.29964
T4	0.04399	0.01533	0.15828	0.04489	0.10947	0.07537	0.22972
T5	0.31299	0.03759	0.26217	0.31937	0.26848	0.12484	0.71269
T6	0.18658	0.02644	0.28392	0.19039	0.18888	0.13520	0.51447
Mean	0.12574	0.02568	0.19504	0.12830	0.18342	0.09288	0.40460
PTWI	No data	2.1	25.2	HR<1			

PTWI – Provisional Tolerably Weekly Intake (mg per kg of body weight) established by JECFA.

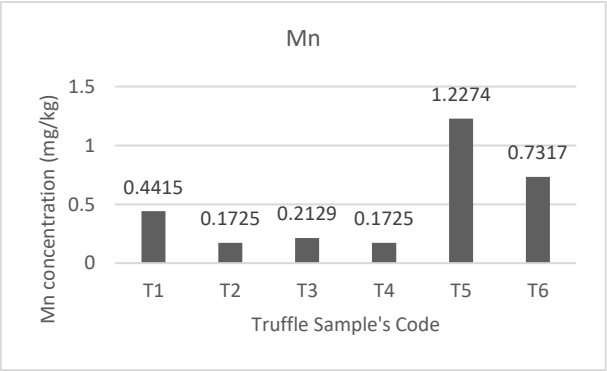

Fig. 1: Mn Concentration in Truffle Samples.

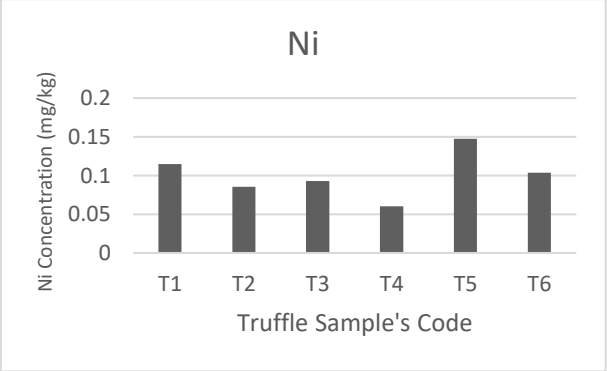

Fig. 2: Ni Concentration in Truffle Samples.

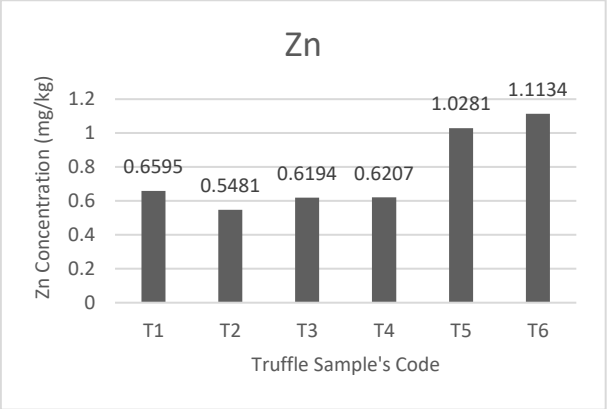

Fig. 3: Zn Concentration in Truffle Samples.

3.2. Radon concentration

The activity concentration of radon in the measured truffle samples is given in Table 3. The mean value of radon concentration was 323.23 $Bq.m^3$with the highest value of 513.83 $Bq.m^3$ and the lowest value of 156.23 $Bq.m^{-3}$ in Ramadi Truffle sample and Haditha Truffle sample respectively. Highest value of C_U was 0.092 ppm and the lowest value was 0.028 ppm with an average value of 0.058 ppm. The differences in the radon activity concentrations due to the differences in the level of radioactive materials concentrations and the differences in the geological formation of the soil where the truffles grew. The results show that all values of radon concentration are lower than the recommended value of 400 $Bq.m^{-3}$ given by ICRP [26].

Table 3: Radon Activity Concentration ($Bq.M^{-3}$) and Uranium Concentration (Ppm) for the Study Truffle Samples

City	Sample	C_{Rn}	C_U
Ramadi	T1	513.83	0.092
Anah	T2	227.41	0.041
Al Muthanna	T4	277.75	0.050
Haditha	T5	156.23	0.028
Salah ad-Din	T6	328.09	0.059
Mean		323.23	0.058
Min		156.23	0.028
Max		513.83	0.092

4. Conclusions

Heavy metal concentrations in desert truffles, Terfezia and Tirmania have been determined on a dry weight basis using atomic absorption spectroscopy. It was observed that the heavy metal concentration ranged from 0.1725- 1.2274 for Mn, 0.0601- 0.1474 mg/kg for Ni, 0.5481- 1.1134 mg/kg for Zn, whereas the concentrations of Cd, Cr and Pb were below the detection limit of the used method.
The order of the levels of heavy metals in the truffle samples was found to be; Ni < Mn < Zn. The study also shows that the measured toxic metals content in all the samples was under permissible level. This may imply that consumption of these truffles has no deleterious effects in health if consumed in proper amounts. However, HR was also calculated and its value was less than 1 in all investigated samples. Future work should focus on measuring the levels of other metals, in order to supply more information for risk assessment.
Radon activity concentration was also been measured using CR-39 solid state nuclear track detector. The values of the radon activity samples were below the world recommended value given by ICRP except for the sample T1 which was higher than the world recommended value. However, the results indicate that the radon activity level does not exceed the safe limit for radon activity concentration and there are no health hazards concerning truffle consuming.

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