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RESEARCH ARTICLE

Quantitative measurement of the radioactivity from the truffles growing naturally in Samawa desert – Iraq

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Abstract

The environmental pollution in general and the radiant pollution in particular constitute one of the most dangerous problems affecting population and other life forms. Because our country has been exposed to intensive military operations since 1991 until 2003 especially in the south where different types of radiological weapons were used in addition to the natural radiation doses which increase the radioactivity concentration in this area.

Measurement of the radioactivity in the crops grown naturally in areas which were thought to has been fired upon by DU munitions, dust, or anywhere it`s dust has been settled. The crop under study was the truffle which grows in the desert of Samawa - south west of Iraq in large quantities. In the late years, the truffle`s growing influenced by the force of thunderclaps and the rains which fell in October to November.

The study included three overlapping trails; in the first trail, (fresh wet samples with sand) were cut in to small pieces, and samples of (100 gram) were prepared for activity concentration measurement.

In the second trail (fresh washed samples) were cut in to small pieces and samples of (100 gram) were prepared for activity concentration measurement also. The third trail (washed-dry samples) used for measurements and (100 gram) of the powdered ash examined with the Geiger Muller Radalert 100 detector.

The radioactivity concentration and the annual effective dose received by the Iraqi population were calculated and it was found to be ranged from (1.33 Bq/kg) to (32.61 Bq/kg) and (0.36 mSv/yr) to (2.42 mSv/yr) respectively. These results were compared with those from other countries.

The present results of the study revealed that the radioactivity was relatively low in the crop whether it was fresh or after drying it and within the permissible limit recommended by the International Commission of Radiation Protection (ICRP).

From radiation protection point of view, truffles do not pose a threat to the Iraqi population health as the results showed that the growing crops hadn`t any unacceptable level of radiation doses.

Introduction

Human populations have been always exposed to ionizing radiation from natural sources. Natural radioactivity was spread in the earth's environment and it exists in various formations in soils, rocks, plants, water and air [1].

Natural radioactivity in the environment comes from soils which contain U^{238} and Th^{232} series, and natural radioactive potassium K^{40}. The environmental radioactivity built up in the environment leads to exposure of humans , plants, animals, etc., and may results severe health effects.

Heavy metals and gamma radioactive elements are found in fruits, vegetables, rice, flour,…. etc. and the annual effective dose due to the ingestion of vegetables and their derived products was found to be approximately 14.5μSv [2]. Large number of investigations has been made in the past to study the concentration of the radioactive elements .These studies and measurements done especially after the Chernobyl accident in 1986 [3].

However, desert`s truffles grow naturally in some open undisturbed areas in the Middle East region. It is not as popular for human consumption as mushrooms, but it is a seasonal delicacy food for the Iraqi population during it`s high season (from January to April).

The desert truffle is a wild monotypic genus. It fruits hypogeously near the soil surface. As the sporocarps expand, they raise a mound of soil, which tends to crack radially as it dries. In Iraq , it`s a habitat exists in the west region near the Saudi Arabia border; to collect the truffles fruit which spans 2-3 month after adequate rainfall in the autumn season [4].

Because our country has been exposed to intensive military operations since 1991 especially in the south where different types of radiological weapon (Depleted uranium projectiles) were used in addition to the natural radiation doses, the radionuclides present in contaminated soil are absorbed by the truffle and become a part of the food chain, and when truffle are grown in the contaminated soil the activity is shifted from the soil to the truffle. Ultimately the activity is transferred to the human diet [5].

A thorough literature search reveals that no studies on the radioactivity measurements of truffles consumed in Iraq. Such lack was the main motive to conduct the current study in addition to meet radioactivity exposure to the general public from truffle consumption.

The aim of the present work was to study the natural radioactivity from Samawa desert`s truffle, and to calculate the annual effective doses to the general public due to this consumption, since the first factor contributing to the internal effective dose in the human organism is contaminated food.

1. Area under study

The area under study was the Samawa desert including Al- Salman district which is one of the districts of Al-Muthanna Province, the land as the agriculture resources reported is approximately 18 million acres.

Al- Salman district is a town situated about 150 km south west of Samawa the capital of the province, and this district has many small cities and villages like Al- Bussaih , Al- Sahil, Nasab, Samah , Hadaniah, Al- Rifaeeh and Al- Shihee. The lands surround these villages produced a large quantities of truffles in the present year. Desert truffles have been traditionally treasured as an income source used as food. There are more than 30 varieties of truffles — Brown, black, creamy white, sometimes pink and zubaidi. They are usually no more than a few centimeters across, but occasionally the size of a fist, light in the hand, typically weighing from 30 to 300 grams. The Iraqis call them 'Kamaa' or 'Chima', depending on local dialects.

A common belief in these areas that the truffles' numbers and size are influenced by the force of thunderclaps. In fact, there is a connection, for the rains must be just right during October and November to start the truffles germinating. Researchers found that as little as 200-250 millimeters of rain can produce a good crop. Farmers think that rain water on desert lands free from pesticides and fertilizer provides the best medium for the growth of truffles.

Truffles grow in arid areas after winter season, and it is commonly understood that strong sunlight after heavy rain is ideal for their healthy growth, provided their land of growth is left intact.

The truffles usually grow near a herbal called locally as Guraid and it lies about 20 mm deep in the soil which is a mixture of sand and clay , the region where the truffles grow seems as burst up or cracked and any farmer with experience can identify it easily. Map of the studied area is shown in Fig. (1).

2. Biology of Truffles

Truffles are hypogenous (underground) version of mushrooms. They don't form a prominent stem and their spore-bearing surfaces are enclosed. They rely on animals eating them (mycophagy) to distribute their spores, instead of air currents like mushrooms. Truffles resemble small potatoes, and often between the size of a marble and a golf ball. There are hundreds of different kinds of truffles, while few are known to be poisonous and only a few are considered as delicacies [6].

Truffles are the macro fungi that form underground fruit bodies. These true truffles of *Tuber* genus belong to ascomycetes (spore sac fungi). The fungi live in ectomycorrhizal association with a broad variety of gymnosperm and angiosperm hosts in a variety of habitats including subtropical cloud forests, temperate forests, boreal forests, floodplains, tree nurseries, restoration sites and Mediterranean woodlands [7].

The geographic distribution of known truffle species mainly covers the temperate zones of the northern hemisphere, with at least three differentiation areas: Europe, South-East Asia and North America. The geographical distribution patterns of truffles are not fully understood, although recently it has been shown that evolutionary lineages can be related to the bio geographical origin of the host species [8, 9].

Truffles have no chlorophyll and so they can't produce the necessary substances (sugar and starches) to survive; for these reasons they are tied to some plant species (trees and bushes) with reciprocate advantages.

The truffle lives underground in rich calcium soils, with a Ph. sub-alkaline or alkaline level, (Ph 7 - 8, 8). It has a roundish irregular shape, it`s size varying in dimensions from a pea to an orange. Every truffle species has a different type of spore. Using a microscope the classification of the species is relatively simple.

When the truffles are ripe, under the soil, it is possible for well-trained man to locate them. The inside called "Pulp" contains millions of spores which have a reproductive function. The spores when germinating, give origin to the Mycelium which, besides joining the plant to the truffle, carries out the function of mycorrhizing the new young roots found in the ground. On ripening, every truffle species emits it`s own smell which means a trained man is able to identify and then pick up [10].

The biochemical composition and nutritional quality of truffles were showed that it contains 19.6 - 27.2% protein, 2.8 - 7.4% fat, 7.0 - 13.2% crude fiber, 4.6 - 5.4% ash and 1.8 - 5.1% ascorbic acid. It contains high amounts of the K and P and fair levels of Fe, Cu, Zn and Mn. All essential amino acids were minerals present in fairly good amounts, in addition to leucine and lysine amino acids [11].

There are various types of truffles; these types determine mainly their appearance, size, color, shape, texture and its price in the market. Among these types, the most expensive and rare type is the White Truffle found in Italy , the Black truffle , the Chinese Truffles, and the Summer Truffle or the Black Summer Truffle [12].

Desert truffles are found in every known desert, irrespective of the habitat – cool or hot, loamy or acidic, sandy or heavy soil – the only common condition seems to be a limited supply of water. In contrast to 'true' truffles, desert truffles have evolved over time in different families, while in some arid areas, desert truffles have been traditionally used as food, in most regions interest has only recently been increasing, and truffles are now treasured for their nutritional value, as an income source and for research [13].

3. Materials and Methods

Truffles samples used in the present study were collected from various areas of the Samawa desert, (see Fig; 1). All the samples were weighted before making any detection. The analysis carried out before and after drying the samples.

Three kilograms of truffles collected randomly from various areas of the Samawa desert were divided in to three parts with one kilogram each, the first part (fresh wet with sand) , the second part (fresh washed) and the third part which was (washed dry).

The first part (fresh wet with sand) was cut in to small pieces, and samples of (100 gram) were prepared for activity concentration measurement. The second part (fresh washed) was cut in to small pieces and samples of (100 gram) were prepared for activity concentration measurement also. The third part (fresh washed) were cut in to small pieces and prepared for measurements by first drying in an electric oven (memmert type UNB200, Germany) at 110 ° C for 48 hours and then powdered, (100 gram) of the powdered ash were placed in sealed cans and stored in a cold place for a period of three weeks before the measurements to establish the equilibrium between parent radionuclides and their daughters [14].

The Geiger Muller Detector-Radalert100 (Medcom Radalert 100 Nuclear Radiation Monitor, USA) was used for the determination of activity concentration [15], the detector has background count rate of 20 counts per minute.

4. Results and Discussion

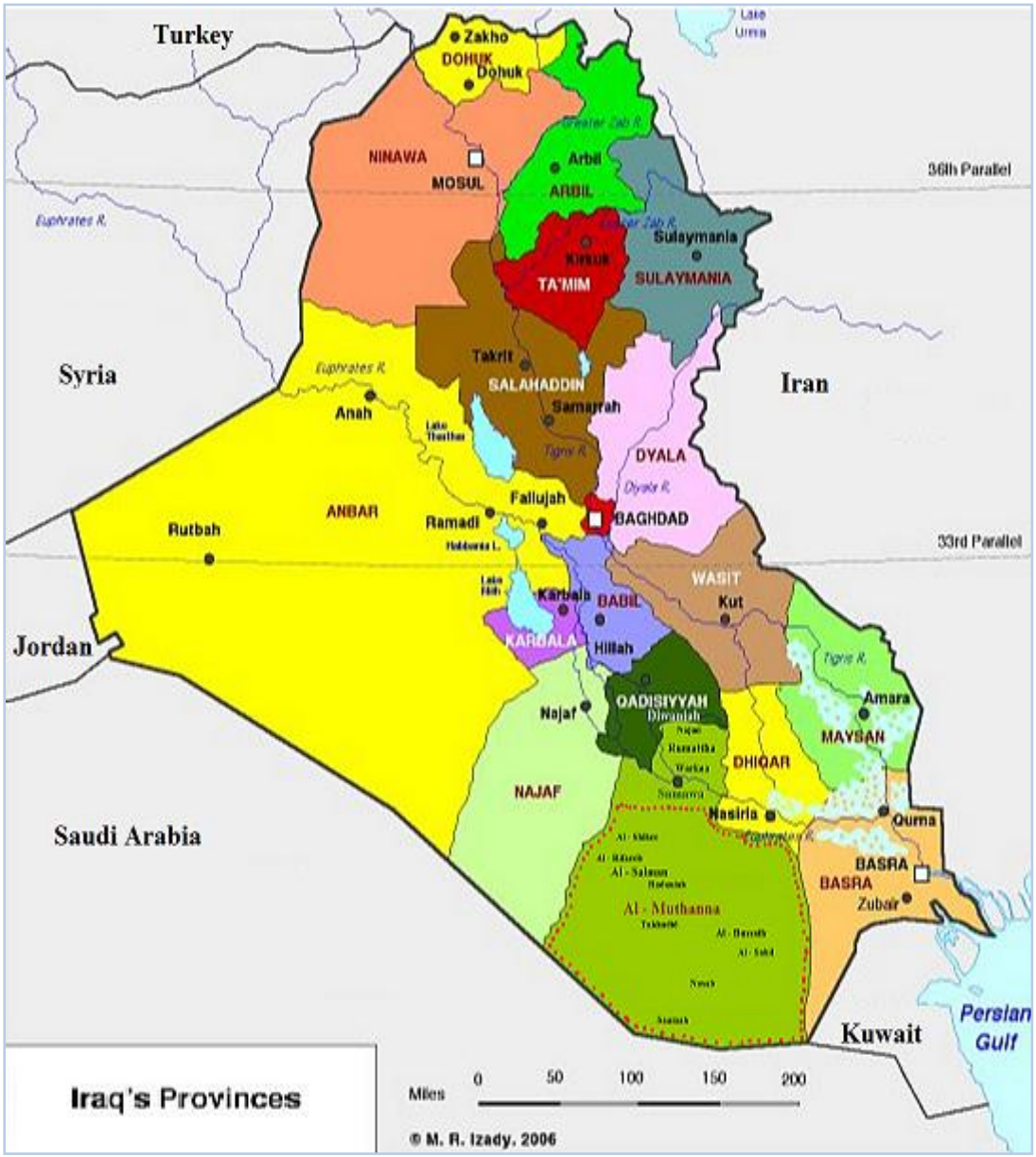

Fig. (1): Map showing the studied area in Samawa desert bounded with red dotted line.

Table 1: Radioactivity concentration from the truffles investigated in the current study.

Sample No.	Fresh wet with sand (Bq/kg.)	Fresh washed (Bq/kg.)	Dry powdered (Bq/kg.)
1.	3.67	3.83	13.88
2.	4.17	5.16	16.11
3.	3.65	3.21	13.98
4.	4.73	4.92	16.20
5.	3.5	1.83	10.56
6.	5.33	5.84	21.67
7.	3.68	6.78	21.68
8.	1.46	1.54	10.66
9.	3.12	1.84	19.44
10.	4.67	5.13	25.1
11.	2.24	1.93	16.12
12.	1.51	1.66	13.89
13.	5.13	6.67	29.54
14.	3.17	2.62	16.31
15.	4.91	4.14	17.78
16.	2.25	1.67	16.21
17.	3.71	1.33	8.34
18.	4.84	4.16	19.51
19.	3.68	2.52	17.62
20.	5.83	4.51	32.61

Radioactivity was measured in randomly collected samples in three variable conditions, fresh wet with sand, fresh washed and washed dry, (for both washed and unwashed with sand samples were cutting to small pieces).

In the fresh (unwashed and washed) conditions the maximum activity (5.83 Bq/kg) was found in sample no. (20), the least activity (1.46 Bq/kg) was found in sample no. (8), and from (6.78 Bq/kg) in sample no. (7) to (1.33 Bq/kg) in sample no. (17), respectfully. For the dry - powdered samples, the results showed that sample no. (20), has maximum activity (32.61 Bq/kg), and sample no. (17), has least activity (8.34 Bq/kg). An investigation for the activity of the different samples (wet and dry) indicates that non uniform activity distribution of the radionuclide in the collected samples.

The variation in the activity concentration may be due to or because the truffles were collected from different areas in the Samawa desert or due to the different absorbing and radiating powers of radionuclides. From the results above, it was observed that the activity concentration in fresh samples is less than the activity in dry samples.

Nevertheless, similar variability in the natural radioactivity in different food samples has been reported by others, [16, 17]. Table (1) summarizes the average activity concentration in (Bq/kg) obtained in the present work.

However, mushrooms are known to be good absorbers of radionuclide [4,18] , so desert truffles are expected to have similar behavior. Moreover, wild mushrooms grown in the forest at which the deposition of radionuclide is partially caught by the surrounding trees and fallout on the earth could be less than that in the open desert areas, where wild truffles grown. The heavy rain (180 mm) that had fallen in Iraq in general and Samawa desert specifically during the winter of 2013 stabilized the soil and increase the solubility of the radionuclides, which enhances the absorbability of the radioactive nuclides by the truffles.

However, from the radiological protection point of view the radioactivity concentration in the soil and wheat grown in these sites was measured and showed non uniform activity distribution [5]. For cereal samples radioactivity concentration lies in the range of (1- 3.5 PCi/kg) of Pb^{210} per composite meal [19]. The Turkish

Atomic Energy Authority imposed maximum limit (25.5 Bq/kg) for the tea in the market [20]. Radioactivity concentration values measured in food items from Saudi local markets were in the range (33- 300 Bq/kg), whereas meat (lamb, mutton and beef) samples showed (112 Bq/kg) [21]. The small values of activity concentration observed from the present study which were less than the above guideline limit, showed that truffles consumption in Iraq is safe for the presence of the investigated radioactivity.

It is important to estimate the annual effective dose for the Iraqi population from consumption of desert truffles. The annual effective dose was calculated for the fresh (unwashed and washed) and dry samples which found to be varied from (0.65 mSv/yr to 1.41 mSv/yr), (0.53 mSv/yr to 2.42 mSv/yr) and (0.36 mSv/yr to 1.57 mSv/yr) respectively. Table (2) summarizes the annual effective dose in (mSv/ yr) obtained in the present study for fresh and dry samples.

Naturally occurring radionuclides are present in leafy vegetables, fruit, root, bean, rice, and derived products like sugar, coffee, corn flour, wheat flour and pasta. The annual effective dose due to the ingestion of vegetables and their derived products was found to be (14.5 µSv) [2], and the annual effective dose from rice consumption in Kuwait were estimated to be varied from (33 to 60 µSv) with the activity concentration of (0.1 Bq/kg) [22]. In the present measurements, we found that the annual effective dose is higher than the UNSCEAR recommended safety limit for general public (0.29 mSv/yr world average of the ingestion exposure from natural sources) [23], and in the range of the action level (3- 10 mSv/yr) recommended by ICRP [24].

Moreover the external exposure due to natural radioactive sources is estimated to be approximately (1 mSv/yr) , about 40% of this annual effective dose is caused by cosmic rays while the remaining 60% is caused by gamma rays in buildings, outdoors and radon [25]. Because the annual effective dose reflects the fact of radioactive pollution, hence, if the maximum value of the annual effective dose of the desert truffles obtained from the present study is added to the value of the external exposure (i.e. the total dose from truffle ingestion and the natural background exposure to which human being are exposed), the total effective dose will be about (3.42 mSv/yr) which is in the range of the action level (3- 10 mSv/yr) recommended by ICRP [26]. Table; 3 shows the annual effective dose obtained from the present study compared to those reported in the literatures. The values of the annual effective dose of the present study agreeing in some cases with those reported in some European countries, while exhibit lower values than those reported in others. However; the annual effective dose obtained above from consumption of truffles indicates that it is radiologically safe for the presence of the investigated samples.

5. Conclusions

Radioactivity concentration in truffles consumed in Iraq was investigated. The truffle`s samples originated from different areas of the Samawa desert. The results showed that the radioactivity concentration in truffle`s samples were ranged between (1.33 Bq/kg) to (32.61 Bq/kg) for fresh and dry samples.

The annual effective dose for the Iraqi population from consumption of truffles was calculated. It was found that consumption of truffles in Iraq is radiologically safe for the presence of investigated radioactivity.

The present study is the first at the national level to investigate the radioactivity of Samawa desert truffles. The findings of this study will help in establishing a baseline of radioactivity exposure to the general public from ingestion of foodstuffs. To establish a more robust baseline, there is a need to investigate more types of foodstuffs.

Table 2: Annual effective dose (mSv/yr.) from consumption of Samawa desert truffles.

Sample No.	Fresh wet with sand (mSv/yr.)	Fresh washed (mSv/yr.)	Dry powdered (mSv/yr.)
1.	0.96	0.41	1.19
2.	1.29	0.57	1.14
3.	1.41	0.53	0.74
4.	0.75	0.61	0.62
5.	1.16	1.77	1.19
6.	0.74	1.64	0.64
7.	0.97	1.19	0.61
8.	1.24	1.31	1.01
9.	0.87	1.52	0.83
10.	0.69	0.86	0.89
11.	0.89	1.49	1.29
12.	1.13	1.29	0.88
13.	1.14	1.02	1.25
14.	1.12	2.21	1.38
15.	0.92	0.77	1.15
16.	0.86	1.03	0.92
17.	0.65	0.62	0.36
18.	1.07	1.29	1.25
19.	1.21	1.04	1.16
20.	1.04	2.42	1.57

Table 3: the annual effective dose obtained from the present study compared to those reported in some countries.

Countries	Average annual effective dose (mSv/yr)	References
Unite Kingdom	About 1.7	23, 24, 25, 26
Bulgaria, Holland	About 2.3	23, 24, 25, 26
Italy, Germany, Denmark, Belgium	About 3.0	23, 24, 25, 26
Portugal	About 4.0	23, 24, 25, 26
France	About 5.0	23, 24, 25, 26
Sweden	About 6.0	23, 24, 25, 26
Finland	About 8.0	23, 24, 25, 26
Iraq*	About 3.42	Present study

* (the total dose from truffle ingestion added to the natural background exposure to which human being are exposed)

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