



## DETERMINATION OF HEAVY METAL IN SAMPLES OF *TIRMANIA NIVEA* FUNGI IN DIFFERENT SOILS

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### Abstract

*Tirmania nivea* (Desf.) Trappe, 1971 has high commercial value. This study was aimed to assess the quality and suitability of *Tirmania nivea* for human use by determining their heavy metals content and susceptibility to heavy metals accumulation. Concentrations of lead (Pb), Cadmium (Cd), Chromium (Cr) and Nickel (Ni) were tested in different fungus samples grown in different soils of the semi-arid regions of Iraq. Heavy metals concentrations were found in range of level ordered from high to low Cr < Ni < Cd < Pb. The soil contents of cadmium were about five times and the firm was about one and a half times above the global scale (0.1 to 1) mg/kg, while Cr, Ni and Pb concentrations were lower than the reference ranges in the United States and Chinese soil (70, 20, 300) mg/kg respectively. Transfer factor from soil to the fruits was more than one except for Cr. The high transport rate of this mineral in the buds of *Tirmania nivea* makes it suitable to extract the mineral from the soil. There was a significant linear correlation between the concentration of heavy metals in the fruit of *T. nivea* and those in the study soil except for Cr. This finding suggests that *T. nivea* can be considered a biological indicator of soil heavy metal contamination. Concentrations of heavy metals in the current study below the danger state of human health that makes *Tirmania nivea* (Al Kamah) suitable for use as a food.

**Keywords:** Cadmium, Chromium, Heavy metals, *Tirmania nivea*, Lead.

### Introduction

*Tirmania nivea* belongs to a family of fungi called terfeziaceae, a seasonal wild fungus that grows in the desert after rainfalls. It grows from 5 to 15 cm below the ground and is used as for human food. The truffle weight usually ranges from 30 to 300 grams. It is considered the most delicious and most valuable types of desert fungi (Lassoe, & Hansen, 2007). The truffle grows like a potato tuber in deserts. It grows near a desert fungi close to the fruits of huge trees. Its shape is spherical, loose, fleshy, and its surface is smooth or tuberous and its color varies from white to black. Truffles are generally known as "Kamah" in Arabic, which literally means hidden (Wang and Marcone, 2011).

Toxic problems and bioaccumulation of heavy metals make them dangerous pollutants in natural environments, the accumulation of heavy metals in the environment causes health risks to humans and animals and soil contamination with minerals at high levels mainly through human activities (Gryndler *et al.*, 2017). Recently, there has been a growing interest in soil-growing organisms that are used as food for humans (Pickles *et al.*, 2015) due to taking, storage and assembly, specifically the organism with high annual primary production can extract large amounts of heavy metals from their environment and store them in biomass (Suman *et al.*, 2018).

The aim of this study is to increase our knowledge of the mineral content of truffle *T. nivea* from arid regions in Iraq. Furthermore, AL-Kamah ability to accumulate heavy metals and their danger to humans. Desert truffles are considered to be one of the oldest foodstuffs. In Iraq, desert truffles, are seasonal and socio-economically important wild-growing edible mushrooms. Among the various known edible desert truffles, only two species of the black color truffles belonging to the genus *Terfezia* and one species of the white color truffles belonging to the genus *Tirmania* are found in Iran (Jamali and Banihashemi, 2012). In Iraq as

At many Gulf countries, the truffles typically emerge in the deserts after the rainy period between February and April (Al-ruqaie, 2006). However, no studies have been conducted on the assess the quality and suitability of *Tirmania nivea* for human use by determining their heavy metals content. Previous studies have reported associations between heavy metals exposure and increased risk of human mortality, the objective of this study was to test the hypothesis that heavy metals transport by food chain for example (Fungi). The Fungi (Kamah) could affect human and increase health risks. Therefore, the present study was done to a determination of heavy metal in samples of *Tirmania nivea* fungi in different soils.

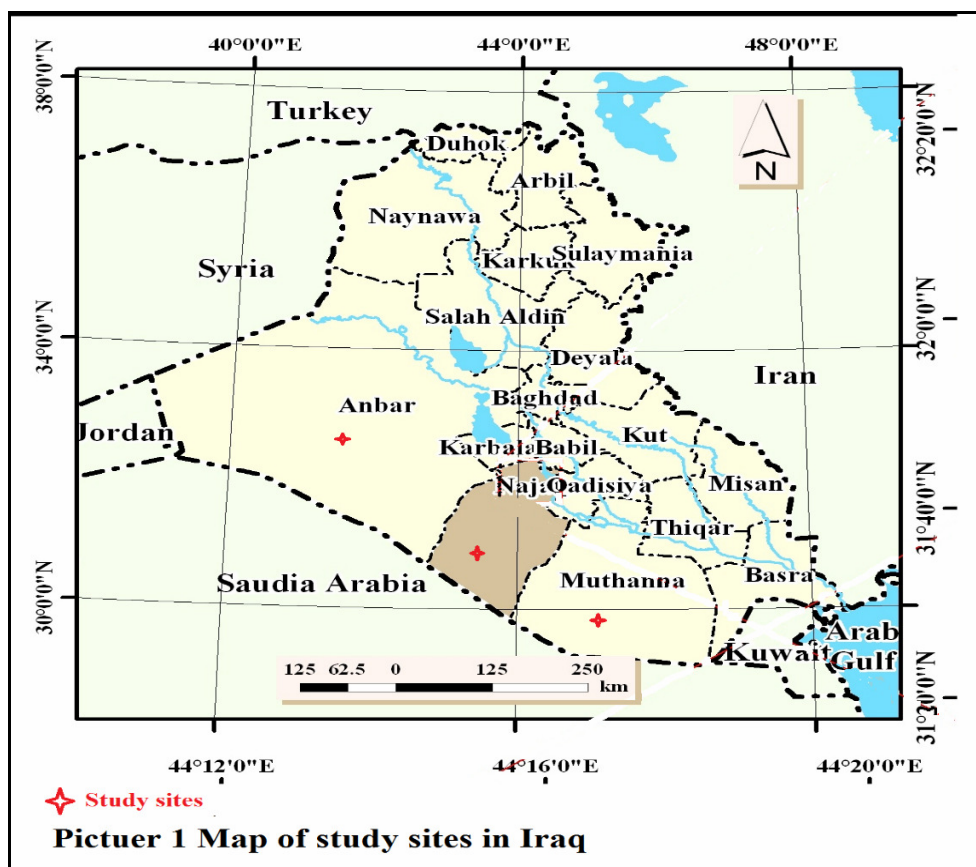
### Materials and Methods

#### Study Area

Three types of soils in Al Najaf-Al Ashraf, Muthanna and Anbar Governments were taken for evaluating the heavy metals in *T. nivea* fungus. Soils are desert sand from the arid region. Their coordinates are 32 10° 05.6 "N. and 44 16° 14.6" E., 32 10° 05.6 "N. and 44 16° 14.6" E. and 32 10° 05.6 "N. and 44 16° 14.6" E., respectively. For six replicates per area (picture 1). The three soils belong to the arid region where the climatic conditions are hot summers (35°C – 50 °C) and mild winters (10°C - 20 °C).

#### Sample Collection

The sample was carried out at three locations Najaf, Muthanna and Anbar of Iraq and six sampling sites were randomly chosen in each location (Picture1). In each sampling site, *T. nivea* were collected twice in March and April of 2019 from more than 10 individual fungi within a 100 m<sup>2</sup>, and then they were mixed up to form a composite sample. At each sampling site, one soil sample was collected near sampling fungi as a profile of 20cm depth.



**Sample Analysis**

The fungi samples were cleaned well with tap water and rinsed with Distal Water (DW). Water, then an oven-dried at 65C° to constant weight after that was ground into a powder by using a plastic mill. The soils were air-dried up at room temperature and passed through the 2-millimeter sieve. Fungi samples were digested with concentrated HNO<sub>3</sub> and HClO<sub>4</sub> (4:1, v/v), while soil samples with concentrated HF:HNO<sub>3</sub>: HClO<sub>4</sub> (4:1:1, v/v). Estimation of Pb, Cd, Cr and Ni was carried out by Atomic absorption (Shimadzu AA7000. Each one of these procedures is according to (Maurya *et al.*, 2018). The pH and EC measured by multimeter WTW German origin after preparation soil dough according (Rayment & Higginson, 1992), total Organic Matter measured according to (Nelson and Sommers, 1982)

**Statistical Analysis**

All statistical analyses were carried out using SPSS version 14.0. The translocation of heavy metals from soil to fungi tissues was assessed following transfer factor. It was calculated to determine the relative uptake of heavy metals by the fungi with respect to soil (Mirecki *et al.*, 2015).

$$TF = \frac{\text{Concentration of metals in fungi body (mg/kg)}}{\text{Concentration of metals in soil (mg/kg) at that site.}}$$

**Results**

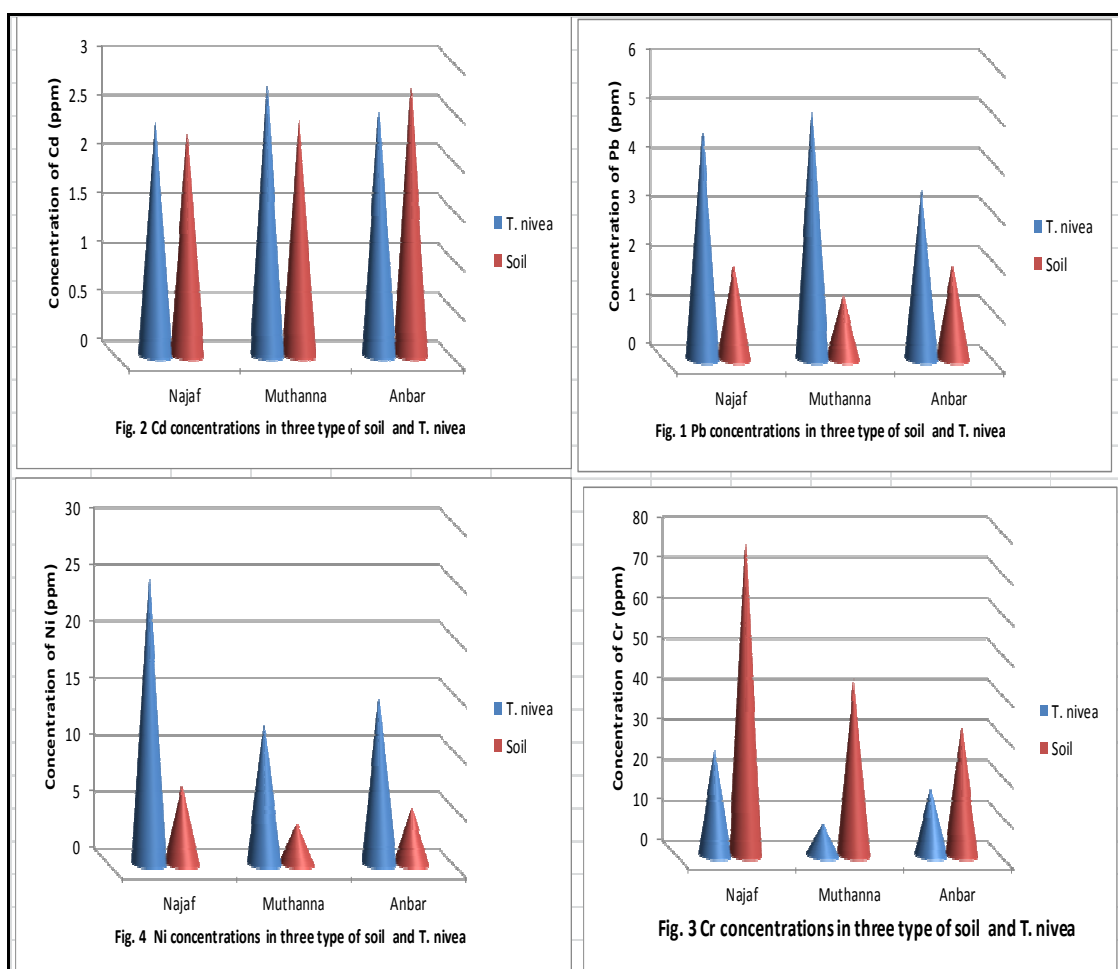
The heavy metals in Deserts soils of Najaf, Muthanna and Anbar soils were found to increase in the order of Cr < Ni < Cd < Pd. The highest mean concentrations of Cr are 78.75 mg/kg in Najaf soil, while the lower value in Muthanna soil is 32.3 mg/kg. The recorded higher value of Ni is 7.05 mg/kg in Najaf soil, while the lower value in Muthanna soil is 3.65mg/kg. Cd and Pd values are close in all types of soil, the same in TOC, pH and EC (Table 1).

**Table 1 :** Soil properties in three types of soil in Iraq(mean ± SE)

Characteristics	EC (µs/cm)	pH	TOC%	Pb(mg/km)	Cd(mg/kg)	Cr(mg/kg)	Ni(mg/kg)
Soil type							
Najaf soil	2075±41.21	6.54±0.13	4.54±0.01	1.95±0.04	2.30±0.03	78.75±1.8	7.05±0.31
Muthanna soil	2089±38.5	7.08±0.29	3.87±0.04	1.30±0.02	2.45±0.07	43.85±0.13	3.65±0.2
Anbar soil	2025±28.21	7.94±0.3	3.76±0.01	1.85±0.14	2.80±0.13	32.3± 1.7	5.00±0.31

Heavy metals concentrations in the soils and Fruit of AL Kamah are shown in (Fig.1; 2; 3 and 4). The bioaccumulation increased according to the order of soil< fruit for Pd; Cr and

Ni but Cd showed revers bioaccumulation soil ≥ fruit (Fig. 2). It was found that AL Kamah had significant differences in heavy metals concentrations. (Fig. 1, 2, 3 and 4).



**Table 2 :** The transfer factor of heavy metals from soils to fruits (RT/SE) of *AL Kamah* in three types of soil in Iraq(mean ± SE)

Characteristics (RT/SE)Soil	Pb mg/kg	Cd mg/kg	Cr mg/kg	Ni mg/kg
Najaf soil	2.44±0.003	1.06±0.027	0.33±0.034	3.62±0.467
Muthanna soil	3.92±0.022	1.14± 0.052	0.18±0.001	3.41± 1.013
Anbar soil	1.80±0.011	0.91± 0.041	0.52±0.087	2.98±0.043

**Table 3 :** Pearson correlation coefficient (r-values) between heavy metals of soil and fruits of *AL Kamah* in three types of soil in Iraq. The significant values are in the bold letters. (p-value, P < 0.05, \*\*P < 0.01 )

Characteristics (r-values) fruit*soil	Pb mg/kg	Cd mg/kg	Cr mg/kg	Ni mg/kg
<b>Najaf</b>	0.99**	0.60**	-0.85*	0.88**
<b>Muthana</b>	0.99**	0.50**	-0.84*	0.75*
<b>Anbar</b>	0.99**	0.80*	-0.99*	0.62*

The transfer factors of Pb, Cd, Cr and Ni from soil to fruits were more than one, except Cr in all studied soils. The lead had the maximum transfer factors from soil to fruit in Muthanna soil was 3.92, while Cd had the minimum transfer factors in Anbar soil 0.91 (Table 2). Lead accumulated in higher concentration in fruit containing greater amount of this element than soil (r = 0.99, P < 0.01; Table 3). Significantly positive correlation was found between all contents in all studied soils but negative correlation all studied soil in Cr contents (r = - 0.85, - 0.84, -0.99, P < 0.05) respectively.

### Discussion and Conclusion

Soils throughout the world contain on Lead (Pb), as reported in various countries are mean concentrations of ≤250 ppm by weight (Yang et al., 2018). Pb concentrations in all soils were in the world range. The phytotoxic Pb concentrations range widely among fungi species and cultivars from 10 to 50 mg/kg (Işiloğlu et al., 2001). The mean Pd values detected in *AL Kamah* fruit were below these phytotoxic range.

There is no evidence of an essential role of Cd in fungi metabolism. The world average levels of cadmium is 0.41

mg/kg (Kabata –Pendias, 2011), however, its mean cadmium concentrations, in Desert soils about (0.08-0.47) mg/kg, while in Agriculture soils were (0.13-1) mg/kg (Page *et al.*, 1987). In the present study, Cd concentrations in both soils were above the world range. The phytotoxic Cd concentrations range among fungi species from 5 to 30 mg/kg. Yamaç *et al.* (2007) found the Cd concentrations in different fungi species about (0.26-3.24) mg/kg, the mean Cd values detected in *AL Kamah* fruits were below the phytotoxic range. The Cd content of fungi was higher than the most of literature values (Isildak *et al.*, 2004; Mendil *et al.*, 2005; Turkecul, Elmastas, & Tuzen, 2004).

The average Cr element content for worldwide soils is estimated at range (29.05-67.25) mg/kg (Salman *et al.*, 2019). In the present study, Cr concentrations of Iraq desert soils were  $\leq$ 36.35 mg/kg. The concentration of Cr in mushroom that reported in the study Yamaç *et al.* (2007) to range from (1.95 to 73.8) mg/kg dry weight. In the present study, the average concentrations of Cr were about (7.9-26.35) mg/kg in fruits of *AL Kamah*; and these detected values were below reported by (Yamaç *et al.*, 2007; Isildak *et al.*, 2004). Soils throughout the world contain Ni in the very broad range, however, its mean concentrations, as reported for various countries are within the range (0.2 – 450) mg/kg (Kabata-Pendias and Mukherjee, 2007), although the common background range of mean nickel content seems to vary between (20-40) mg/kg (Adriano, 2001). In the present study, Ni concentrations in soil were in the world range. The phytotoxic Ni concentrations range widely among fungi species from 1.22 to 58.6 mg/kg (Yamaç *et al.*, 2007). In the present study Ni concentration below from reported by (Yamaç *et al.*, 2007; Soylak *et al.*, 2005).

The transfer factor generally showed the transport of heavy metals from soil to fruit, that indicates the efficiency to uptake of the bio-available heavy metals from the external environment and that refer if the fungi is an accumulator, excluder or indicator [14] reported that TF > 1 were determined in metal accumulating fungi, whereas TF was typically < 1 in metal excluding and indicator fungi. In the present study, the mean TF(Rt/SE) in all studied soils for (Pb, Cd, Co and Cr) were more than one. The higher translocation ratio of this metal in *AL Kamah* fruit make it suitable for phytoextraction from the soil. The differences in TF values indicated that each metal has a different phytotoxic effect on *AL Kamah*. In addition, these results could be related to differences in solubility and availability of each heavy metal ion in different soils (Bose *et al.*, 2008). Probably attributed to the fact that the TF was calculated based on the total metal concentrations in soil instead of the bioavailable fractions, which are the dominant form for metal uptake by organism (Kim *et al.*, 2003; Guda *et al.*, 2017). There was a significant linear correlation between the concentration of most metal studied in the fruit of *AL Kamah* and that in soil. Also, the correlation were found in our soils with *AL Kamah*, as in soil increased, it will be also increased in *AL Kamah*. This result suggested that *AL Kamah* can be regarded as bio-indicator for soil pollution of Iraq, defined as organisms providing a quantitative assessment of the environmental quality and that no danger in human health. For example, our results showed a rare and low heavy metals concentration in *AL Kamah* compared to the limitation level of world health organization.

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