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Soil Analysis and Mycoflora of the Industrial Yanbu City, Saudi Arabia

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ABSTRACT. Twenty four isolates species belonging to eleven fungal genera were isolated from soil samples of ten localities from the industrial Yanbu city, Saudi Arabia. *Aspergilli* were predominant and represented by six species. Numbers of *Aspergillus flavus* and *A. niger* colonies were predominant as compared to the other detected *Aspergillus* spp. *Alternaria* and *Penicillium* were represented by 3 species each. While, two species of *Curvularia, Fusarium, Mucor* and *Ulocladium* were isolated. *Cladosporium, Drechslera, Neurospora* and *Rhizopus* were represented by one species each. Soil type is sandy, alkaline and differs in the organic matter content, total soluble salts, moisture content and total metal content.

Several investigation have been made to study the soil analysis and mycoflora of Saudi Arabia, but these studies were mainly concentrated on Central and South Western regions (Ali 1977, Ali *et al.* 1977, Abou-Heila *et al.* 1982, Ali and Abou-Heila 1984, Abdel-Hafez 1981, Hashem 1991). No information is available about the soil analysis and mycoflora of the industrial Yanbu city. Industrial Yanbu city is the one of the corner stones of Saudi Arabia's industrial development and diversification program. In late 1977, the Royal Commission completed a 30-years master plan for the development of the industrial Yanbu complex on the Red Sea about 350 kilometers north of Jeddah.

Pollution of soil by heavy metals for example occur due to industrial wastes, application of fertilizer, corrosion of sheeting, wires, pipes and burning of coal and wood (Hashem 1990).

Biological and microbiological factors also contribute heavy metal pollution. The importance of microorganism as reflected in biological activity of soils has been disccussed very well. The abudance of microorganisms on soils varies with soil and climatic

condition (Ali and Abou-Heila 1984). Microorganisms are very important ecologically because they are the producing, consuming and transporting member of the soil ecosystem and therefore involved in the flow of energy and in the cycling of chemical elements (Ehrlich 1981). In the present investigation an attempt was made to isolate fungal flora from different localities collection from the industrial Yanbu city with soil analysis.

Materials and Methods

Collection and Analysis of Soil Samples

Soil samples from different localities of the industrial Yanbu city (Figs. 1 and 2) were collected according to the method described by Johnson *et al.* (1960) at a depth of 1-10 cm during the month of February (1991) in which the temperature was 36°C and the percentage humidity was 65%. Five collections of a total weight of 1000 gm from each locality were mixed and used for soil analysis and isolation of fungal content.

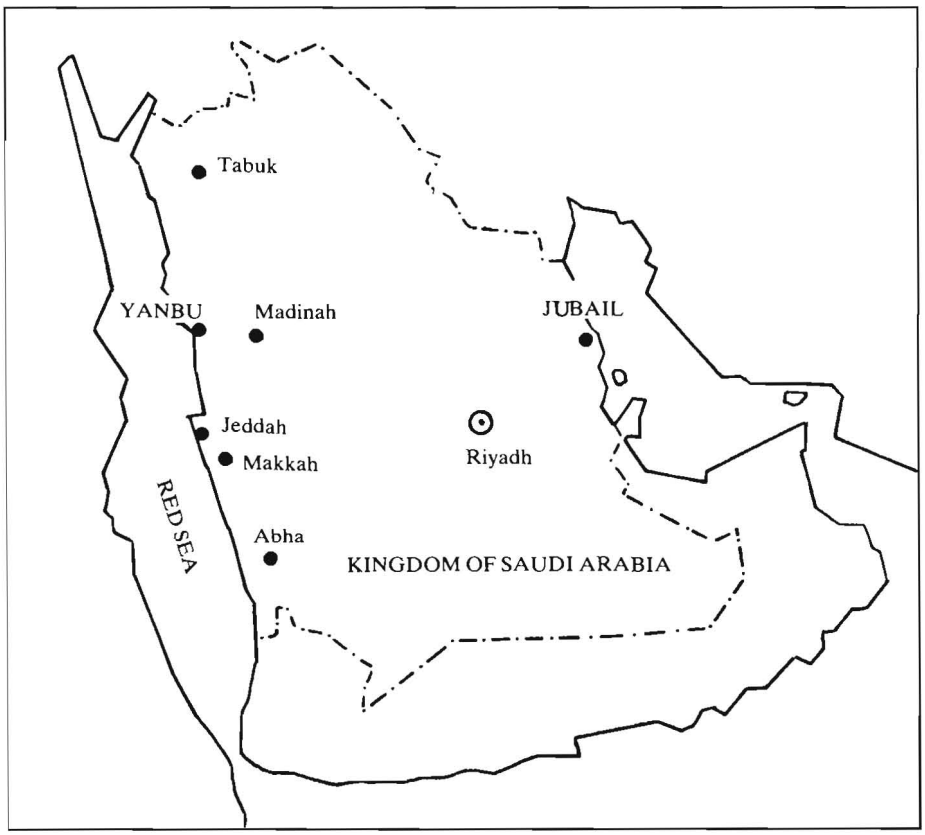
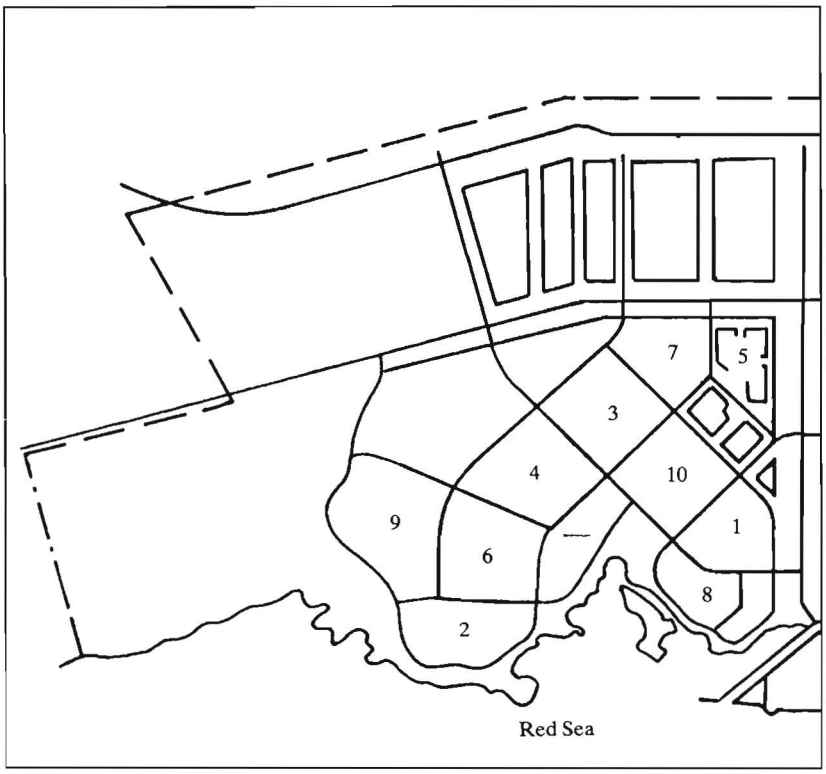


Fig. 1. A map showing the site of the industrial Yanbu city.



1. Ain-Al-Nawa 2. Al-Bathna 3. Al-Jaberiya
4. Al-Nakheel 5. Al-Nawa 6. Al-Oyoun
7. Al-Semairi 8. Al-Sobh 9. Johaina 10. Radwa

Fig. 2. A map showing the sites of soil samples collections.

The soil type was determined by the hydrometer method as described by Piper (1955). Determination of moisture content, organic matter, total soluble salts and pH value of each soil sample were determined according to the techniques devised by Black (1965).

For metal analysis, soil samples were passed through a 2.0 mm sieve and were digested in concentrated nitric acid to obtain a measure of total metal content, the procedure was as follow:

0.5 g of air dried soil was placed in a 100 ml beaker with 15 ml concentrated nitric acid, covered with a watch-glass and heated at 95-100°C for 15 min. After digestion, the digest were made up to 50 ml with deionised water and analysed using an atomic absorption spectrophotometer (Bye Unicam sp9 equipped with sp9 computer) to determine Al, Ca, Cd, Cu, Fe, K, Mg, Pb and Zn.

Determination of Mycoflora

The dilution plate method was used for the determination of fungal flora as described by Johnson *et al.* (1960). Six replicates of Czapek's agar plates containing rose bengal and streptomycin sulphate (Martin 1950) were used for each soil sample. Dishes were incubated for 3-5 days at 27°C, after which the number of colonies per dish was counted and isolated. Further inspections of the plates were made two weeks after plating to record slow-growing colonies. The fungal genera and species were identified according to Raper and Fennell (1965), Ellis (1971) Gilman (1971), Booth (1971, 1977), Kendrick (1971), Hunter and Hunter (1972) and Ramirez (1982).

Results and Discussion

The effect of moisture content, organic matter and total soluble salts of soil samples were negligable since all soil samples contained low percentages (Table 1) and this consistent with the finding of earlier studies on some Saudi Arabian soil (Ali and Abou-Heila 1984, Abdel-Hafez 1981, Hashem 1991).

Table 1. Soil characteristics of different localities (n=5)

Locality	Moisture content %	Organic matter %	Total soluble salts %	pH Value
Ain Al-Nawa	5.31	1.06	0.81	7.3
Al-Bathna	4.63	1.91	1.91	7.5
Al-Jaberiya	3.24	1.10	1.03	7.7
Al-Nakheel	4.01	0.85	0.60	7.6
Al-Nawa	2.93	1.09	0.31	7.4
Al-Oyoun	4.34	1.00	0.43	7.2
Al-Semairi	3.67	0.98	0.82	7.6
Al-Sobh	2.81	0.86	0.64	7.5
Johaina	4.96	1.01	1.00	7.5
Radwa	3.33	0.83	0.49	7.1

The estimation of the content of the total soluble salts of the various soil samples revealed a negative correlation between fungal density and total soluble salt contents, similar correlations between salt contents and number of fungi in the soil were reported earlier by Sabet (1935) in Egyptian soils and by Tolba *et al.* (1957) and Al-Doory *et al.* (1959) in Iraqi soils. The pH values of the soil samples reveal no appreciable differences and all were alkaline with pH ranging from 7.1 to 7.7.

The plant cover of the considered soils was dominated by *Alhagi maurorum, Blepharis ciliaris, Calotropis procera, Hamada elegans, Lycium shawii, Rhazya stricta* and *Zygophyllum coccineum* in all localities, They were identified according to Wild Plant of Jubail and Yanbu (1990).

The results of mineral content of different localities are represented in (Table 2), the soils from the ten localities differ slightly in their mineral composition. The estimated concentration of Al recorded here was found to be similar to earlier finding in some Saudi Arabian soils (Hashem 1990) is well as to that in some other countries like Canada and Russia (Frank *et al.* 1976, Prikhodki 1977), while Cd concentration was higher than that reported earlier (Hashem 1993a), cadmium content of surface soils of Japan and Denmark ranged from 0.2 to 400 µ/g (Itoh and Yumura 1979, Tjell and Hovmand 1972). The concentration of Cu in the present study, resemble earlier findings (Boratynski *et al.* 1971, Zborishchuk and Zyrin 1978, Hashem 1990, 1993a) from Poland, Russia and Saudi Arabian soils.

Table 2. Total metals content (µg/g) of the soil samples collected from different localities (n = 5, ± standard deviation)

Locality	Total Metals Content (µg/g)								
	Al	Ca	Cd	Cu	Fe	K	Mg	Pb	Zn
Ain Al-Nawa	89 ± 3.1	2600 ± 5.11	3.8 ± 8	10 ± 1.0	20 ± 2.1	2090 ± 4.00	2100 ± 4.31	1.6 ± 0.3	14 ± 2.0
Al-Bathna	100 ± 2.6	3010 ± 6.39	2.31 ± 0.3	11 ± 1.0	26 ± 2.6	1830 ± 3.61	2531 ± 4.93	2.01 ± 0.5	8 ± 1.1
Al-Jaberiya	95 ± 3.1	3090 ± 5.93	2.0 ± 0.6	13 ± 2.0	31 ± 3.1	2120 ± 4.13	1930 ± 3.61	3.1 ± 0.9	13 ± 2.0
Al-Nakheel	110 ± 2.0	3100 ± 6.02	1.98 ± 0.8	9 ± 1.9	28 ± 2.8	2001 ± 4.21	1990 ± 3.93	1.95 ± 0.6	9 ± 1.6
Al-Nawa	120 ± 1.0	2680 ± 5.31	2.1 ± 0.6	10 ± 1.0	19 ± 1.8	1963 ± 3.96	2120 ± 4.06	2.11 ± 0.3	10 ± 0.9
Al-Oyoun	86 ± 1.9	2760 ± 5.66	3.0 ± 0.3	9 ± 1.0	23 ± 2.06	2100 ± 4.36	2660 ± 4.53	2.13 ± 0.5	13 ± 1.1
Al-Semairi	93 ± 2.0	3000 ± 5.89	2.11 ± 0.9	14 ± 2.0	32 ± 3.31	1893 ± 3.83	2280 ± 4.33	2.91 ± .8	10 ± 1.8
Al-Sobh	101 ± 3.0	2900 ± 5.86	3.6 ± 0.8	12 ± 1.8	24 ± 2.01	2121 ± 4.61	2390 ± 4.19	1.84 ± 0.7	11 ± 2.0
Johaina	106 ± 1.1	2680 ± 5.59	2.05 ± 0.6	10 ± 1.9	30 ± 2.95	2330 ± 4.13	2430 ± 4.86	3.01 ± 0.8	9 ± 0.8
Radwa	113 ± 1.8	2890 ± 5.71	3.19 ± 0.9	8 ± 1.0	21 ± 1.96	2160 ± 4.01	2110 ± 4.32	2.61 ± 0.9	12 ± 1.3

Iron concentration in the present investigation resembles the earlier findings from Saudi Arabian soil (Hashem 1990, 1993a).

Lead in the top horizon of different soils from Ireland, Poland, England and Saudi Arabia ranged from 3 to 189 µg/g (Fleming *et al.* 1968, Sapek and Sklodows 1976, Duddy 1980, Hashem 1993a).

The mean Zn content in surface soils of Tasmania and Missour ranged from 17 to 125 µg/g (Tiller 1963, Erdman *et al.* 1976) while in some Saudi Arabian soils ranged from 6 to 14 µg/g (Hashem 1990, 1993a). Total metal content of Ca, K and Mg were less than reported earlier for some soil from different places in the world (Mengel and Kirkby 1982). Some heavy metals present in natural soil environments at low concentrations serve as essential micronutrients for microorganisms, animals and plants *e.g.* Al, Cu and Zn (Foy 1974, Mutsch *et al.* 1979). However, heavy metals released by human activities such as industrial wastes, application of fertilizer and burning of coal may be enriched and become available at potentially toxic concentrations for organisms (Bowie and Thronton 1985).

The effect of heavy metals on the growth of soil fungi with the phenomenon of fungal resistance to heavy metals is well known, many species are capable of acquiring resistance (Ashida 1965, Ross 1975, Gadd and Griffiths 1980, Firestone *et al.* 1983, Nordgren *et al.* 1985, Brown and Wilkins 1985, Trevors *et al.* 1986, Gadd and White 1985, 1989a, b, El-Sharouny *et al.* 1988, Ramadan *et al.* 1988a, b, c, Razak 1989, Sabie and Gadd 1990, Hashem 1987, 1989, Hashem and Al-Homaidan 1989).

The present study reveal that heavy metal contens in the tested soil were high and could affect the density of fungal flora of the soil.

A total number of 24 species belonging to 11 genera of fungi were isolated from 10 localities (Table 3). The predominated genus was *Aspergillus* with six species. *Aspergillus* was reported earlier as a dominant genus of fungi from the Saudi Arabian soils (Abdel-Hafez 1981, 1982, 1984). *Alternaria* and *Penicillium* were dominating genera as well with three species each, followed by *Curvularia, Fusarium*, *Mucor* and *Ulocladium* with two species each and *Cladosporium, Drechslera, Neurospora* and *Rhizopus* with one species each.

Table 3. Fungal isolates from the soils of different localities of the industrial Yanbu City.

Isolates	Number of colonies per gram of soil										
	Ain Al-Nawa	Al-Bathna	Al-Jaberiya	Al-Nakheel	Al-Nawa	Al-Oyoun	Al-Semairi	Al-Sobh	Johaina	Radwa	Frequency %
Alternaria alternata (Fr.) Keisler	4	3	5	2	1	6	4	–	3	–	80
Alternaria chlamydospora Mouchacca	3	–	1	4	–	–	1	2	–	–	50
Alternaria phragmospora van Enden	–	–	3	–	2	1	–	4	1	2	60
Aspergillus amstelodami (Mnangin) Thom & Church	4	1	–	2	–	1	3	2	6	–	70
Aspergillus candidus Link	–	–	–	6	1	–	–	1	9	–	40
Aspergillus clavatus Demazieres	5	4	3	2	1	4	2	2	–	–	80
Aspergillus flavus Link	6	3	5	7	1	4	6	3	2	1	100
Aspergillus niger van Tieghem	13	16	10	15	11	9	10	8	5	7	100
Aspergillus repens (Corda) Sacc.	1	3	–	–	–	1	2	–	–	–	40
Cladosporium herbarum (Pers.) Link ex Fr.	5	3	4	1	3	9	1	3	–	1	90
Curvularia lunata (Walker) Boed.	1	–	–	–	2	–	–	–	–	–	20
Curvularia siddiquii Ahmed & Quraishi	–	–	9	–	–	–	–	–	–	–	10
Drechslera rostrata (Drech.) Rich & Fras.	–	–	–	2	–	–	3	–	–	–	20
Fusarium moniliforme Scheldon	3	–	6	1	3	1	–	–	–	–	50
Fusarium solani (Mart.) Sacc.	1	3	7	–	10	4	–	6	–	–	60

Isolates	Number of colonies per gram of soil										
	Ain Al-Nawa	Al-Bathna	Al-Jaberiya	Al-Nakheel	Al-Nawa	Al-Oyoun	Al-Semairi	Al-Sobh	Johaina	Radwa	Frequency %
Mucor circinelloides van Tieghem	–	–	–	1	2	–	–	4	–	–	30
Mucor racemosum van Tieghem	1	–	–	–	1	–	–	–	–	–	20
Neurospora crassa Shear et Dodge	–	–	1	–	3	–	–	–	–	–	20
Penicillium chrysogenum Thom	3	5	4	6	9	3	4	3	1	5	100
Penicillium citrinum Thom	3	–	–	–	2	3	–	1	2	–	50
Penicilium notatum Wesling	1	–	2	4	6	3	10	7	–	–	70
Rhizopus stolonifer (Ehern. ex Fr.) Lind	3	9	2	6	4	10	6	1	–	–	80
Ulocladium atrum Preuss	–	–	1	–	3	–	3	1	–	–	40
Ulocladium chlamydosporum Mouchcca	1	13	–	6	4	9	5	6	3	1	90
Sterile mycelium	15	1	9	1	8	3	3	7	6	2	100

Aspergillus flavus, A. niger, Penicillium chrysogenum and *Rhizopus stolonifer* were the dominating species in the soil samples from all the localities. *Alternaria alternata, Aspergillus amstelodami, A. clavatus, Cladosporium herbarum, Penicillium notatum* and *Ulocladium atrum* were the other species with frequency more than 60%. *Alternaria* was found in the Saudi Arabian soils of other localities (Abdel-Hafez 1981, Ali 1977) isolated 4 species of *Alternaria. Penicillium* was alos isolated earlier by Abdel-Hafez (1982, 1984) and Hashem (1991).

The genera like *Curvularia, Fusarium, Mucor, Ulocladium* and *Cladosporium, Drechslera, Neurospora* and *Rhizopus* were previously isolated from Saudi Arabian soils (Abdel-Hafez 1981, 1984, 1985, Hashem 1991, 1993b).

Aspergillus flavus, A. niger and *Penicillium chrysogenum* were isolated from all localities in the present study, the result, consistent with the findings of Ali (1977), Ali *et al.* (1977), Ali and Abou-Heila (1984), Abdel-Hafez (1981, 1982, 1984) and Hashem (1993b).

Overall, the effect of heavy metals on soil fungi may generally toxic at high concentrations (El-Sharouny *et al.* 1988, Somashekar and Sreenath 1988, Hashem 1989), but some fungi appeared to benefit from some treatments (Hashem 1987, Mutsch *et al.* 1979). In the present study, the degree of metal toxicity on the distribution of fungal flora various from one metal to another.

The result in Table 2 and 3 shows that Al, Ca, Cd, Cu, Fe, Pb and Zn significantly increased number of some fungal isolates such as *A. flavus, P. chrysogenum* and *A. niger* (100%), *C. herbarum* and *U. chlamydosporum* (90%), *A. amstelodmi* and *P. notatum* (70%) while high concentration of these metals affected the distribution of species such as

F. solani and *A. phragmospora* (60%), *U. atrum, A. candidus* and *A. repens* (40%) , *M. ciricinelloides* (30%), *D. rostrata, M. racemosum, N. crassa* and *C. lunata* (20%), *C. siddiquii* (10%). A chemical balance in living organisms is a basic condition for their proper growth and development, interactions of chemical elements also are of similar importance to deficiency and toxicity in the physiology of plants and fungi (Kabata-Pendias and Pendias 1985, Gadd and Griffith 1980).

Antagonism occurs when the combined physiological effect of two or more elements is less than the sum of their independent effects, and synergism occurs when the combined effects of these elements is greater, these interactions may also refer to the ability of one element to inhibit or stimulate the absorption of other elements (Gadd and Griffith 1978).

According to Kabata-Pendias and Pendias (1985) interactions between Ca, Pb and Mg are the main antagonistic elements against the absorption and metabolism of several trace elements.

Antagonistic effects occur most often in two ways, the macronutrient may inhibit trace element absorption and, in turn, the trace element may inhibit absorption of a macronutrient. These reactions have been observed especially for phosphate, but also have been reported for other macronutrients whose uptake and metabolic activity may be inhibited by several trace elements (Leal *et al.* 1972, Kitagishi and Yamane 1981).In the present study, high concentration of Ca, K and Mg may inhibit absorption of trace element and this is could affect the density of fungal flora in some tested soils.

Conclusively, the frequencies of fungi in the examined localities may be affected by the nature and component of the soil and also by the prevailing environmental condition. Heavy metals content of the tested soil affected the distribution and the frequency of fungal flora. Most of these isolated fungi in the present study have been reported earlier as plant pathogens in Saudi Arabia (Nagieb *et al.* 1980, Kassim *et al.* 1981, 1983, 1987, Bokhary *et al.* 1984, 1987).

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تحليل التربة والفلورا الفطرية لمدينة ينبع الصناعية المملكة العربية السعودية

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تمّ في هذا البحث عزل أربعة وعشرون نوعاً من الفطريات التابعة لأحد عشر جنساً من عشرة مواقع مختلفة لتربة مدينة ينبع الصناعية. وجد في هذه الدراسة أن الفطرة *Aspergillus* من أكثر الأجناس السائدة في جميع المواقع ممثلة بستة أنواع ثم تليها الفطرة *Alternaria* والممثلة بثلاثة أنواع من الفطريات *Fusarium* و *Mucor* و *Ulocladium* والممثلة بنوعين كما أن الفطريات *Cladosporium* و *Drechslera* و *Neurospora* و *Rhizopus* ممثلة بنوع واحد فقط. جرى في هذه الدراسة أيضاً تحليل كيميائي للتربة بالإضافة الى التحليل الفيزيائي وقد أثبتت النتائج أن هذه التربة تحتوي على نسبة قليلة من المحتوى العضوي ونسب قليلة ومختلفة من الرطوبة النسبية كما أنها تحتوي على نسبة قليلة من الأملاح الكلية الذائبة كما وجد أن التربة رملية وأن الرقم الهيدروجيني للأنوع المختلفة من التربة التي حللت يتراوح بين ٧,١ - ٧,٧ . أما بالنسبة للعناصر التي حللت فكانت كالتالي:

عنصر الألومنيوم والكالسيوم والكادميوم والنحاس والحديد والبوتاسيوم والمغنيسيوم والرصاص والخارصين. وعموما كانت نسبة كل من الكالسيوم والبوتاسيوم والمغنيسيوم عالية جداً بالنسبة للعناصر الأخرى في التربة التي حللت.

تمّت في هذه الدراسة مناقشة وعرض النتائج بالمقارنة مع الأبحاث الأخرى والتي نشرت في هذا المجال بالإضافة إلى مناقشة العلاقة بين تواجد العناصر المعدنية وبعض

الفطريات المعزولة وأيضاً تمّ التطرق إلى التداخلات التي تحدث بين العناصر الغذائية الكبرى والصغرى وأثرها على توزيع الفطريات المعزولة.

لوحظ في هذا البحث زيادة نسبة عنصر الألومنيوم في جميع المواقع التي حللت والذي يتراوح بين ٨٩ - ١٢٠ ميكروغرام ولوحظ أيضاً احتواء التربة على نسب أقل من كل من الكادميوم والنحاس والحديد والرصاص والخارصين وقد تم الربط بين نسب تلك العناصر الثقيلة وأثرها على توزيع الأنواع الفطرية المعزولة.