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The relationship between heavy metal concentration and soil mycoflora in the Gizan region, Saudi Arabia

By

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تأثير المعادن الثقيلة على الفلورا الدقيقة في تربة منطقة جيزان ـ المملكة العربية السعودية

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قسم الاحياء ـ كلية المعلمين ـ بالرياض

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جمعت عينات التربة من ثلاثة عشر موقع من منطقة جيزان في المملكة العربية السعودية وقد جرى تحليلها ميكانيكيا وكيميائيا لتقدير كمية المعادن الثقيلة فيها.

أوضحت نتائج تحليل الترب انها جميعها ترب رملية وان الرقم الهيدروجيني لهذه الترب قاعدي ، كما وجد ان نسبه كل من الخارصين والرصاص والنحاس في المعدل الطبيعي، بينما كانت نسبة كل من الحديد والكوبلت والألومنيوم عالية مقارنة بتركيز هذه المعادن في تربة المملكة وفي اماكن مختلفة من العالم. وقد أثبتت النتائج ان الترب التي جمعت من منطقة جيزان فقيرة في محتواها العضوي وبها نسب قليلة من املاح النيتريت NO3 وتركيزات عالية من الاملاح الكلية الذائبة.

وجد في هذه الدراسة ان التركيزات العاليه من المعادن الثقيلة والاملاح الكلية الذائبة قد تكون السبب في التأثير الملحوظ على كثافة وغزارة الفلورا الدقيقة في تربة منطقة جيزان . حيث اظهرت النتائج انخفاض كبير في العدد الكلي لبكتيريا التربة وبكتيريا التآزت، ونقص معنوي في اعداد الأكتينوميسيتات والفطريات في الترب التي حللت.

وتم في هذا البحث عزل ثمانية وثلاثون نوعا من الفطريات التابعة لثمانية أجناس. وجد في هذه الدراسة ان الفطرة *Aspergillus* من أكثر الاجناس في جميع المواقع ممثلة بأحد عشر نوع ثم تليها الفطرة *Alternaria* و *Curvularia* و *Fusarium* و *Penicillium* . أما الفطرة *Mucor* فكانت أقل الاجناس تواجدا في تربة جيزان. ودلت النتائج على أن كلا من فطرة *Curvularia* وفطرة *Fusarium* هما اكثر الفطريات حساسية للمعادن الثقيلة.

وقد تمت مناقشة وعرض النتائج المتحصل عليها في هذه الدراسة ومقارنتها مع الأبحاث الأخرى المنشورة في مجال الفلورا الدقيقة في التربة والمحتوى المعدني للترب في اماكن مختلفة من العالم والمملكة العربية السعودية.

Kew Words: Heavy metals, soil, mycoflora, bacteria, nitrifying bacteria, actinomycetes.

Abstract

Soil samples were collected from different places from the Gizan region, Saudi Arabia, and analyzed mechanically and chemically for mineral content. The soils were highly alkaline and sandy in texture in all cases. The concentration of Zn, Pb and Cu were within the ranges reported earlier for some Saudi Arabian soils, while Fe, Co and Al occurred in high concentrations. There was a high content of total soluble salts in the samples tested.

There was a marked decrease in bacterial counts, as well as a significant decline in numbers of actinomycetes, nitrifying bacteria and fungi. The high contents of some heavy metals and total soluble salts in the Gizan soils may have caused the impact on the population and frequency of the soil microflora. *Aspergilli* was predominant and represented by eleven species followed by *Alternaria*, *Curvularia*, *Fusarium*, *Penicillium* and others have dominated the soils investigated. However member of mucorales were least represented from the view point of dominance. The genera of *Curvularia* and *Fusarium* were considered as sensitive to heavy metal toxicity in the Gizan soils.

Introduction

The soil microflora and the heavy metal contents of Saudi Arabian soils have been studied by a few workers, though largely on the central, southwestern and northern parts of Saudi Arabia [1-7]. No information is available about the microflora and heavy metals of soils from the Gizan area. Gizan, a port on the Red sea, is one of the most important cities in Saudi Arabia because, it is the gateway for import and export of many industrial products. In addition, Gizan is the oldest agricultural area in the Arabian peninsula. Pollution of soil by heavy metals may be caused by several factors including industrial wastes, application of fertilizer, corrosion of sheeting, wires, pipes and burning of coal and wood [8]. Saudi Arabian soils are most likely to be polluted by irrigation with treated sewage water and application of fertilizers.

Heavy metals originating from various sources may finally reach the surface soil, and their further fate depends on chemical and physical properties of the soil. Although the chemistry of soil contaminations has been recently the subject of many studies, our knowledge of the behavior of polluting heavy metals is far from complete [9]. The relationship between microorganisms and heavy metal toxicity is well documented [9-11].

The population and activities of the soil microflora are very important factors in soil development, because of their role in soil minerals cycling and in the flow of energy [12]. Nitrogen transformation is mainly carried out by soil microflora. Although the ability of bacteria and fungi to nitrify reduced nitrogen producing nitrate via nitrite is well established [13; pp. 174-231], most of the studies to date on nitrifying fungi have been limited to species of *Aspergillus*, *Fusarium* and *Penicillium* [14]. There is no available study on the microflora and mineral content of Gizan soils. The present investigation is concerned with the relationship between soil microflora population and heavy metal contents and the examination of other related soil physical and chemical properties.

Materials and Methods

Collection and analysis of soil samples.

Soil samples were collected in sterile polyethylene bags from ten different localities from Gizan region (Fig. 1), with five samples of each site from soil surfaces at a depth

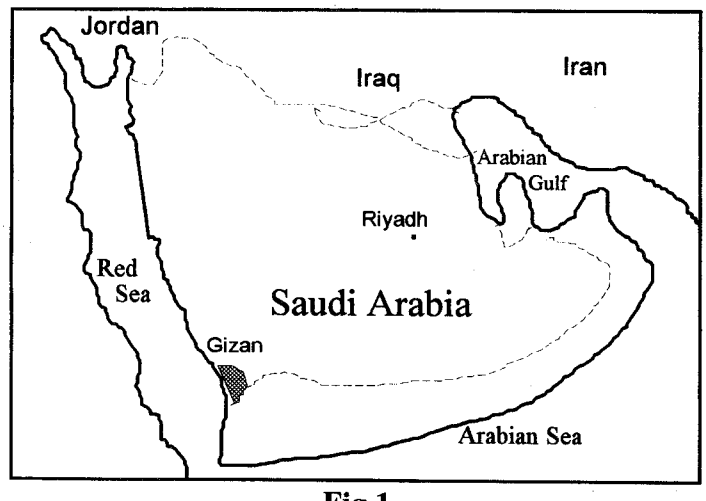

Fig 1.

Map showing the sites of soil samples collection

of 0-15 cm. Mechanical analysis of the soil was made by the sieve method and soil texture was determined using the soil texture triangle. The methods described by Jackson [15] were used for determination of the total soluble salts (T.S.S)

and soil pH. Soil pH was determined with a glass electrode with a water-soil slurry (10:1). Soil organic matter percentage was determined colorimetrically using the method described by Walinga *et al* [16]. Nitrate was extracted from soil with deionized water. A 1:10 soil extractant ratio was used and the slurry was shaken for 15 min (100 throws min-1). After being shaken, the soil slurries were filtered through Whatman No1 filter paper and the concentration of nitrate was determined using the Orange 1 method [17].

For mineral analysis, soil samples were first passed through a 2 mm sieve. Then one gram of air dried soil (five replicates for each site) was placed in a 100 ml beaker and digested with 20 ml conc. HNO3 at 100°C for 15 min. After digestion, the digest was made up to 50 ml by deionised water. Al, Co, Cu, Fe, Pb and Zn were analyzed using a spectrophotometer (Pye Unicam SP9 equipped with SP9 computer).

Determination of soil microbial numbers.

For the quantitative estimation of fungi, actinomycetes and bacteria the dilution plate method of Waksman as detailed by Johnson and Curl [18] was used. Soil (1 g) was shaken in sterile Ringer's solution (10 ml) for 15 min. Samples of the resulting suspension were then serially diluted in Ringer's solution. The final dilution was then spread on the surface of the medium. Incubation periods were 3 days at 37°C for total bacteria and 5-7 days at 30°C for total fungi and actinomycetes. Counts of nitrifying bacteria were determined according to the method described by Nacos and Wolcott [19].

The fungal genera and species were identified using standard text books: Johnson and Curl [18], Raper and Fennell [21], Gilman [22], Pitt [23], Ramirez [24], Nelson et al [25].

Standard statistical procedures were applied in order to see the relation between microbial numbers and factors. Minitab-for-Windows program was used in statistical analysis for all results obtained in this investigation.

Results

The characteristics of soil samples collected from different sites of Gizan region, Saudi Arabia are given in Table 1. The mechanical fraction percentage of the soil samples tested shows that the soil texture class is sandy. The percentage of organic matter for the soils ranged between

Tabel 1.

Soil characteristics of different localities from Gizan region (n = 5)

Soil Locality	Mechanical fraction %			Texture class	Organic matter %	pH	T.S.S %	NO3 %
	Sand	Silt	Clay					
Abdullah street	89.0	5.8	5.2	Sand	0.66	9.1	0.29	0.011
Al-Merjan coast	98.3	0.9	0.8	Sand	0.97	9.4	0.82	0.023
Aramco camp	92.6	1.2	6.2	Sand	0.89	9.3	2.34	0.015
Central market	91.3	3.3	5.4	Sand	0.13	9.4	0.23	0.008
Covered market	90.5	4.1	5.4	Sand	0.60	9.6	0.04	0.011
Fish market	90.6	4.2	5.2	Sand	0.11	9.2	0.82	0.023
Hyatt Regency hotel	89.0	3.3	7.7	Sand	0.21	9.9	0.47	0.004
Military camp	88.9	4.4	6.7	Sand	0.08	9.1	0.48	0.016
Sports stadium	90.0	3.9	6.1	Sand	0.52	9.3	0.46	0.005
The Airport	91.1	2.1	6.8	Sand	0.04	9.0	0.79	0.031
The Beach	98.1	0.9	1.0	Sand	0.49	9.3	0.02	0.010
The Port	89.6	6.2	4.2	Sand	0.34	9.7	1.30	0.020
Vegetables market	89.5	5.1	5.4	Sand	0.02	9.3	0.69	0.012

0.02 % and 0.97 %, while in all the soils from different places the soil reaction was alkaline. The pH ranged between 9.0 in the airport soil and 9.9 in the soil from the Hyatt Regency hotel. In general, with the exceptions of the covered market and the Beach soils (0.04 and 0.02 % of T.S.S respectively), the soil samples had a high content of T.S.S. The highest percentage of T.S.S was observed in the soil from the Aramco camp, which was 2.34 %, followed by the Port soil with 1.30 %. The Airport soil had the highest nitrate concentration (0.031 %) and the lowest nitrate concentration was recorded in Hyatt Regency hotel soil (0.004 %).

The results of heavy metal contents of different localities are presented in Table 2. The soils from the thirteen

Tabel 2.

Total metals content of the soil samples collected from different localities of Gizan region (n = 5, ± SD)

Soil Locality	Heavy metal content (μ g / g)					
	Al	Co	Cu	Fe	Pb	Zn
Abdullah street	259 ± 7.9	54 ± 0.7	7 ± 0.5	152 ± 3.9	11 ± 0.9	46 ± 3.2
Al-Merjan coast	261 ± 8.4	53 ± 1.0	5 ± 0.4	160 ± 4.2	11 ± 2.1	22 ± 1.1
Aramco camp	353 ± 7.6	83 ± 1.0	10 ± 1.0	226 ± 12	29 ± 4.1	56 ± 2.5
Central market	196 ± 9.1	51 ± 8.0	15 ± 1.0	197 ± 9.2	45 ± 2.0	109 ± 17
Covered market	305 ± 4.4	65 ± 0.8	10 ± 0.3	171 ± 5.7	20 ± 2.5	37 ± 1.6
Fish market	411 ± 9.3	84 ± 2.4	18 ± 1.0	227 ± 9.2	10 ± 1.2	50 ± 2.2
Hyatt Regency hotel	505 ± 7.1	91 ± 10	20 ± 2.0	255 ± 7.8	77 ± 10.1	184 ± 12
Military camp	242 ± 5.2	55 ± 7.0	5 ± 1.0	157 ± 6.7	14 ± 1.8	22 ± 1.5
Sports stadium	172 ± 3.6	30 ± 2.1	1 ± 1.2	105 ± 9.1	2 ± 0.	17 ± 1.1
The Airport	386 ± 7.5	60 ± 0.3	10 ± 0.7	225 ± 5.4	26 ± 3.1	32 ± 1.4
The Beach	323 ± 3.2	41 ± 0.3	8 ± 0.5	198 ± 6.6	7 ± 1.1	22 ± 1.0
The Port	264 ± 9.9	60 ± 0.9	6 ± 1.2	133 ± 9.9	18 ± 2.2	23 ± 1.3
Vegetables market	256 ± 5.6	61 ± 1.2	7 ± 1.1	137 ± 8.9	12 ± 3.1	27 ± 1.8

localities differ in their mineral composition. The Hyatt Regency hotel soil had the highest concentration of heavy metals, while the lowest concentration occurred in the Sports stadium soil.

Altogether 39 fungal species were isolated from thirteen localities and identified at species level (Table 3). The predominated genus in the soil localities studied was *Aspergillus* with frequency 84 - 100 %, followed by

Table 3. Fungal isolates from different localities of the Gizan soils. (No. of colonies per gram of soil).

Fungi species	Soil Locality													
	Abdullah street	Al-Merjan coast	Aramco camp	Ceneral market	Covered market	Fish market	Regency hotel	Military camp	Sports stadium	The airport	The beach	The port	Veg. market	Freq. %
Alternaria Total count	10	8	5	14	4	3	3	11	16	15	4	10	12	
A. alternata (Fr.) Keissler	3	1	-	3	1	-	1	4	3	2	-	1	3	76
A.chlamydosporo Mouchacca	4	3	2	2	-	1	-	1	2	2	1	5	4	84
A.humicola Oudem	1	2	1	6	-	1	1	2	2	6	1	1	2	92
A.phragmospora van Emden	-	1	1	1	2	1	-	3	4	2	1	1	3	84
A.tenuissima (Fr.) Wiltshire	2	1	1	2	1	-	1	1	5	3	1	2	-	84
Aspergillus Total count	55	34	18	67	15	12	5	62	75	67	14	55	62	
A. apica Mehrotra & Basu	1	8	2	5	1	1	1	8	19	7	1	3	4	100
A. candidus Link ex Fries	2	3	-	3	1	2	-	9	2	12	1	12	2	84
A. clavatus Desm	5	-	2	2	1	1	-	7	1	3	1	1	8	84
A. flavus Link ex Fries.	8	1	1	7	2	2	1	2	13	16	1	3	9	100
A. Fumigatus Fries.	4	5	2	8	2	1	2	3	7	1	2	1	1	100
A. nidulans (Eidam) Winter	7	1	1	9	1	1	-	6	8	8	1	1	5	92
A. niger van Teighem	4	-	3	10	1	1	-	7	1	5	1	4	2	92
A. ochraceous Withelm	1	-	1	5	2	-	1	9	4	2	2	9	4	84
A. oryzea (Ahlburg) Cohn	5	2	3	1	2	2	-	8	12	1	1	5	10	92
A. raperi Stolk & Meyer	8	6	2	8	1	1	-	2	2	3	2	9	8	92
A. terreus Thom	10	8	1	9	1	-	-	1	6	9	1	7	9	84
Chaetomium spirale Zoph	4	3	-	7	-	-	-	5	11	6	-	3	4	61
Curvularia Total count	6	7	2	8	3	2	-	4	12	10	1	5	4	
C. intermedia Boedijin	2	1	-	1	-	1	-	-	4	6	1	1	2	69
C. tuberculata Jain	2	3	2	3	-	-	-	2	5	2	-	1	2	69
C. Pallescens Boedijin	2	3	-	4	3	1	-	2	3	2	-	3	-	69
Fusarium Total count	9	6	4	10	2	2	-	9	13	10	4	8	9	
F. solani (Mart.) Sacc.	-	2	-	5	-	-	-	1	5	3	1	1	4	61
F. oxysporum Schlecht.	4	2	4	3	2	1	-	-	-	3	-	3	-	61
F. coeruleum (Lib.) Sacc.	5	-	-	1	-	-	-	1	6	4	2	2	2	61
F. ciliatum Link	-	2	-	1	-	1	-	7	2	-	1	2	3	61
Mucor Total count	7	8	6	11	4	3	2	10	10	3	7	9	6	
M. pusillus Lindt	-	-	-	-	4	3	2	-	-		5	3	-	46
M. mucedo L. ex Fr.	3	2	3	7	-	-	-	-	-	-	-	3	4	46
M. hiemalis Wehmer	-	-	3	-	-	-	-	5	7	-	2	3	2	46
M. racemosus Fres.	4	6	-	4	-	-	-	5	3	3	-	-	-	46
Penicillium Total count	45	24	10	50	10	7	3	42	55	47	14	35	50	
P. lanosum Westl.	-	9	-	-	2	-	-	17	-	8	2	11	7	53
P. notatum Westl.	8	5	1	9	-	-	-	6	13	-	2	8	9	69
P. citrimum Thom	12	-	3	15	-	-	-	10	16	-	-	5	6	53
P. nigricans (Bain.) Thom	7	-	-	-	2	3	1	-	-	16	-	9	4	53
P. expansum Link	-	4	2	7	-	4	2	-	-	8	3	-	-	53
P. frequentans Westl.	6	3	4	19	2	-	-	-	14	-	-	1	14	61
P. chrysogenum Thom	-	1	-	-	2	-	-	4	-	5	5	1	10	53
P. islandicum Sopp	12	2	-	-	2	-	-	5	12	10	2	-	-	53
Stachybotrys Total count	6	5	2	11	2	1	3	4	8	9	2	3	4	
S. kamplensis Hansford	2	-	1	2	-	1	3	-	1	2	-	1	-	61
S. bisbyi (Srin.) Barron	4	3	1	4	1	-	-	-	5	4	1	1	2	76
S. atra Corda	-	2	-	5	1	-	-	4	2	3	1	1	2	69

Alternaria with frequency 76 - 92 %, *Curvularia* with frequency 69 %, *Fusarium* with frequency 61 % and *Penicillium* with frequency 53 - 69 %, while the frequency of *Mucor* spp was 46 %. No growth of *Curvularia* and *Fusarium* genera was observed in Hyatt Regency hotel soils.

Correlation coefficients between chemical and biological properties of Gizan soils are presented in Table 4. The fungal numbers were negatively correlated with Co, Cu, Al and Fe elements (highly significant). Fungal numbers decreased as the concentration of heavy metals increased. This indicates negative correlations between fungal numbers and some heavy metals. The results exhibited no correlation between fungal numbers and any other physical or chemical variables measured during this study. Therefore, heavy metals may be the more important limiting factor of

Table 4. Correlation coefficients matrix between chemical and biological properties of Cizan soils (r_{xy}); *: Significant, **: Highly significant at 0.01.

	Fungi	Bacteria	O.M	T.S.S	NO3	Al	Co	Cu	Fe	Pb	Zu
Fungi											
Bacteria	**0.03**										
O. matter	**0.00**	**-0.17**									
T.S.T	**-0.12**	**-0.83****	**0.26**								
NO3	**-0.32**	**-0.60***	**-0.10**	**0.38**							
Al	**-0.91****	**-0.05**	**-0.17**	**0.19**	**0.19**						
Co	**-0.65***	**-0.25**	**-0.11**	**0.45**	**0.16**	**0.81****					
Cu	**-0.56***	**0.19**	**-0.36**	**-0.03**	**-0.06**	**0.74****	**0.76****				
Fe	**-0.78****	**0.08**	**-0.18**	**0.18**	**0.16**	**0.85****	**0.72****	**0.85****			
Pb	**-0.28**	**0.27**	**-0.23**	**0.04**	**-0.30**	**0.56***	**0.59***	**0.73****	**0.65***		
Xn	**-0.25**	**0.36**	**-0.21**	**-0.08**	**-0.44**	**0.56***	**0.57***	**0.80****	**0.64***	**0.95****	

Sports stadium soil had the highest total counts of fungi with 24.5 x 10^3 followed by the Central market soil with 23.9 x 10^3. Hyatt Regency hotel soil recorded the lowest number of fungi (0.8 x 10^3). Copper was highly significant correlated with all heavy metals tested. Aluminium and cobalt were highly significant correlated with Fe and Cu. In general, most of the heavy metals were highly significant correlated with each other, while some of them was significantly correlated with the other elements. Therefore, heavy metals in Gizan soil were correlated with one another. The results show that there was no correlation between heavy metal concentrations and both of physical and chemical measurements of the soil. Bacterial flora of Gizan soil was correlated significantly with nitrate concentration and of highl significant correlation with T.S.S. But, there was no correlation between heavy metal concentrations and bacterial counts. In fact, bacterial numbers are more closely correlated with T.S.S., suggesting that this may be a more important limiting factor than metals. On the other hand mycoflora growth in Gizan soil than physical or chemical properties. As a result a high content of heavy metals in Gizan soil may have caused the marked reduction in fungal numbers.

It appears that Al had the greatest effect on soil mycoflora (r = -0.91) followed by Fe (r = -0.78). As a result, the genera of *Curvularia* and *Fusarium* were not detected in the Hyatt Regency hotel soil, because it has the highest concentration of Al. Similar result was obtained in other Saudi Arabian soils [26]. The results of previous investigations showed that copper is toxic to most microorganisms even at low concentrations [9,10]. A recent study, about the effect of heavy metal toxicity on the growth of *Penicillium*, *Aspergillus* and *Fusarium* spp In vitro, showed that lead had the greatest effect on Penicillium and *Aspergillus* spp. [27] while the fungus *Fusarium* spp was affected by cobalt [28]. Also *Penicillium* and *Aspergillus* could tolerate up to 400 of Zn. Al had the greatest effect on *Penicillium* spp. [26].

The differences in counts of soil actinomycetes, bacteria, nitrifying bacteria and fungi are shown in Fig. 2. The Beach soil had the highest total counts of actinomycetes, bacteria and nitrifying bacteria with 1.1 x 10^4, 2.2 x 10^5 and 1.0 x 10^5, respectively. Total bacterial counts at five sites exceeded 1.4 x 10^5 per gram of soil; these localities are the Central market, Hyatt Regency hotel, Covered market, the Beach and Military camp. Aramco camp soil recorded the lowest number of bacteria (1.3 x 10^2). No growth of soil actinomycetes or nitrifying bacteria was observed in the soils collected from the Port and the Aramco camp.

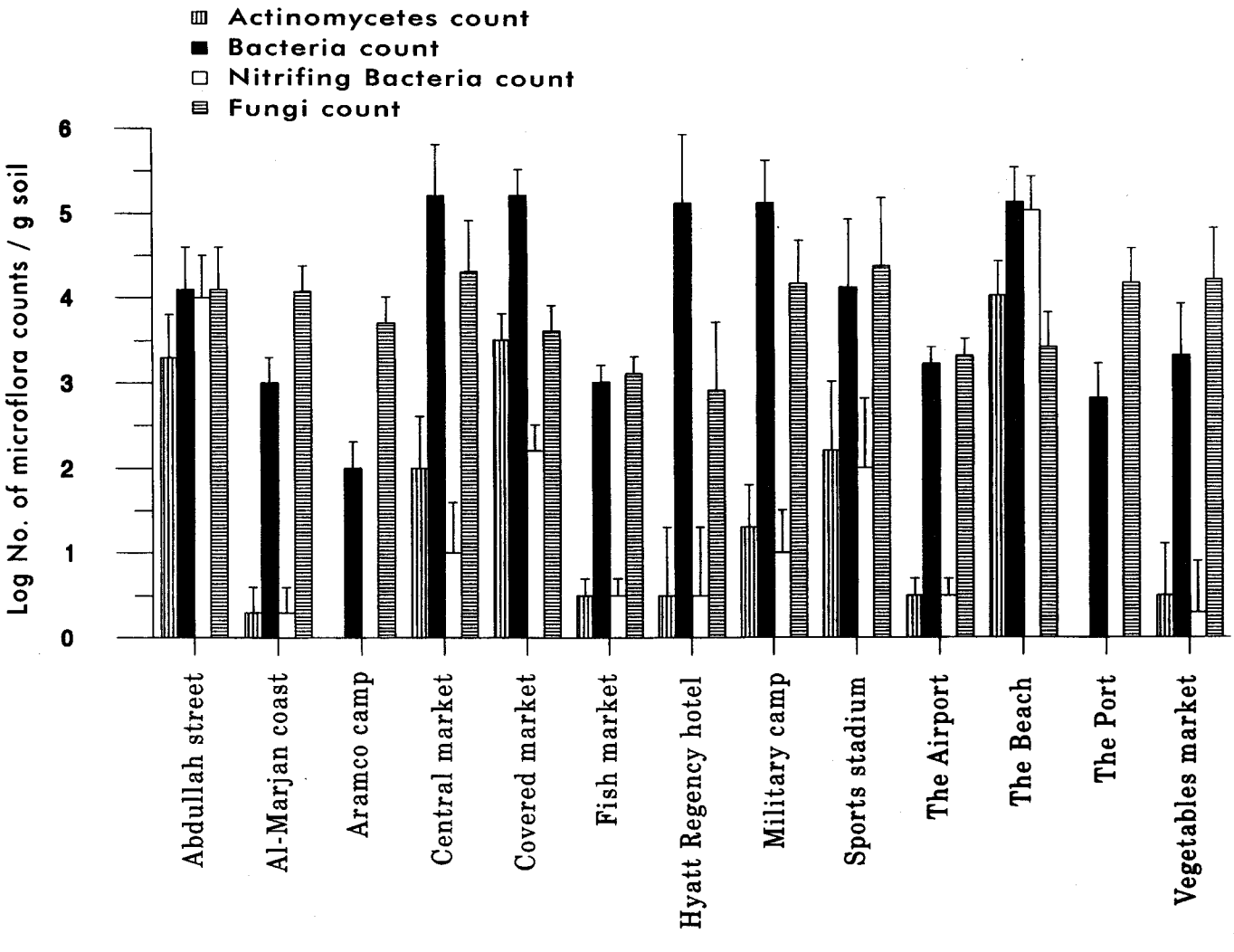

Fig 2.

Soil microflora total counts of the soil samples collected from different localities of Gizan area.

Discussion

Impact of soil characteristics on mycoflra

The effects of organic matter and nitrate in the samples were probably negligible, since all soils contained low percentages, consistent with the findings of previous studies on Saudi Arabian soils [4, 29, 30].

In all tested soils the soil was alkaline, with pH ranging from 9.0 to 9.9. Microflora grown in soils with high concentrations of salts and tolerant of these pH values are halophiles [13, 30]. Soil pH probably contributed to the dramatic decline in total counts of soil actinomycetes, bacteria and nitrifying bacteria as well as the total absence of the fungal genera *Curvularia* and *Fusarium* in Hyatt Regency hotel soil.

Most of the soil samples tested had a high percentage of total soluble salts. However the Beach and the Covered market soils reached the lowest percentage of T.S.S, such

that there was a marked decline in fungal numbers in these cases. The results show that there was no correlation between fungal density and total soluble salts; a similar relationship between salt content and number of fungi in the soil were reported earlier in Egyptian soils by Sabet [31] and Tolba et al [32], in Iraqi soils by Al-Doory et al [33] and in Saudi Arabian soils by Hashem [8].

Since the nitrate concentration represents the final product of the nitrification process carried out mainly by soil microflora, so the small amount of nitrate recorded in Gizan soils reflects the effects of heavy metal toxicity and soil alkaline on nitrifying bacteria and soil fungi. Overall, the disturbance in density of nitrifying bacteria and fungi may contribute to the trace amount of nitrate found in the Gizan soils.

Impact of heavy metals on soil mycoflora

The mean Zn content in surface soils of different countries has been reported to range from 17 to 125 *ug* g^{-1} [5], while in some Saudi Arabian soils ranged from 6 to 14 *ug* g^{-1} [8, 34], but Zn content in the present study ranged from 17 to 184 *ug* g^{-1}. Lead in the top horizon of different soils from various countries ranges from 3 to 189 *ug* g^{-1} [5]. In the present study Pb concentration of analysed soils ranged from 2 to 77 *ug* g^{-1}, while Pb content in different Saudi Arabian soils ranges from 1.6 to 31 *ug* g^{-1} [5, 8, 26]. The concentration of Cu in the present study resembles the earlier findings [5] from Poland, Russia and Saudi Arabian soils. The concentrations of Al, Co and Fe in the soil localities studied from Gizan area were 4-8 times higher than reported from other soils of Saudi Arabia [5]. The content of Al, Co and Fe recorded here for different soils ranged from 172 to 505, 30 to 91 and 105 to 255 *ug* g^{-1} respectively, whereas in different surface soils of Saudi Arabia the concentrations of Al ranges from 81 to 270 *ug* g^{-1}, Co ranges from 6 to 25 *ug* g^{-1} and Fe ranges from 19 to 43 *ug* g^{-1} [5, 26, 31]. The estimated concentration of Al recorded here was similar to an earlier finding for aluminium rich soil in the Hail region of Saudi Arabia [26]. Throughout the digestion process same amount of HNO3 (20 ml) was used in order to avoid the biological-available heavy metals.

In the present study, the degree of metal toxicity on the distribution of fungal flora varied from one metal to another. It appears that the high concentrations of Al, Co and Fe elements in Gizan soil samples affected the distribution of *Curvularia* spp. and Fusarium spp., such that there was no growth of these two genera in the Hyatt Regency hotel soil. As a result the genera of *Curvularia* and *Fusarium* were considered as sensitive to heavy metal toxicity, because they were found confined to soils with less concentrations of metals. Among the fungi isolated, aspergilli followed by dematiaceous hyphomycetes representing *Alternaria, Curvularia, Fusarium, Penicillium* and others have dominated the soils investigated. However members of mucorales were least represented from the view point of dominance. Soil samples collected from Fish market, Hyatt Regency hotel and the Beach were found to be harboured by less number of fungal species than other soils in Gizan area. Hence these soil localities had only 20, 11 and 28 fungal species isolated, respectively, thus clearly indicating impact of heavy metals on the fungal flora of Fish market, Hyatt Regency hotel and the Beach soil.

The frequency of *Fusarium solani, Penicillium nigricans* and *Penicillium citrinum* were almost similar to earlier findings by other workers in Saudi Arabian soils. *Penicillium nigricans* and *P. citrinum* were 53 % and that of *Fusarium solani* was 61 %. Other studies in Saudi Arabian soils reported that the frequency of *Penicillium nigricans, P. citrinum* and *Fusarium solani* were 52, 50 and 60 % respectively [8, 30, 35].

On the whole *Aspergillus* genera have dominated the Gizan soils reflecting its tolerance to the high levels of metals. In the present findings, interestingly species of *Aspergillus apica, A. flavus* and *A. fumigatus* (frequency 100 %) have maintained their dynamic equilibrium both in soils with high metal contents and soils containing low concentrations of heavy metals indicating their detoxification and ecological adaptation. Similar behaviour of *Aspergillus* spp. towards heavy metals has been observed in Indian soil [37].

However, the growth and distribution of soil fungi was inhibited by heavy metal toxicity in some soil localities in the Gizan area, such that there was no growth of *Fusarium solani, F. ciliatum, Penicillium lanosum, P. chrysogenum* and *Stachybotrys atra* seen in the Abdullah street, Aramco camp and Hyatt Regency hotel soil, because they have the highest concentration of Al, Co and Fe elements. Also the number of colonies of most fungi isolated per gram of soil

were few in most samples. In conclusion, the heavy metals are the prime inhibitory factor of soil mycoflora.

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