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Elemental Concentration of Selected Soil and Water Samples from Al-Madinah Area, Saudi Arabia.

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Abstract. As a part of an extensive soil and water evaluation project, soil and water samples were collected from ten sampling sites in Al-Madinah area in Saudi Arabia. The objectives were: (1) to investigate the elemental concentrations of the samples and to compare them with the existing standards, (2) to enter the data in a data base to be utilized as a ground for future research projects for agricultural and urban development purposes.

Ten soil sampling sites were selected in the Al-Madinah area. Five individual locations were selected within each sampling site. Each sample processed and passed through a 2 mm sieve. A 0.5 g sub-sample was digested in concentrated analar HNO_3 and analyzed for B, Co, Cu, Fe, Mn, Pb and Zn and for Ca and Mg. Organic matter contents, total soluble salts and pH were determined. Five replicate water samples were collected from five locations.

The organic matter contents of the soil samples vary between 0.02 and 0.86%. The total soluble salts fluctuate between 0.03 and 0.66% and the soil pH vary between 7.01 and 7.55. The concentrations of Ca are the highest followed by the concentrations of Mg and Fe. Boron concentrations are low. Mean Ca contents are similar to previous findings by other researchers.

The mineral concentrations of the water samples are similar to those of the unbottled drinking waters according to the international and Saudi Arabian Standards organizations.

Introduction

Contaminations of soil and water bodies by major and trace elements may be caused by natural processes or through human activities in the environment. The basic natural processes are physical and chemical weathering of rocks and leaching of the resulting unconsolidated materials. The man made causes include disposal of industrial wastes, application of fertilizers, metal sheets, wire and pipes etc., and the burning of coal and wood in the environment [1-3].

Physical or chemical changes in water, like change of pH and concentration of soluble salts or presence of organic particles in water reduce the solubility of the heavy metals and convert them into suspended particles. Organic residues absorb and hold them in an insoluble form [4].

Elevated levels of major and trace elements in soils and waters are of a major concern in today's world because of the economic and health reasons. It is important to have a record of the level of elemental concentrations and if possible their source of occurrence. Availability of such records enables the responsible agencies to plan for the clean up of the polluted soil and water bodies and protect the agricultural products from losses and the members of the communities from health problems.

As part of an extensive soil and water evaluation project, a number of soil and water samples were collected from ten sampling sites in Al-Madinah area in Saudi Arabia. The first objective of the study was to investigate the elemental concentrations of the soil and water samples and to compare the results with the existing standards such as those established by international organizations like the WHO, or those established by local regulatory agencies in Saudi Arabia [5;6]. The second objective was to enter the data into a data base to be compared with data available from other study areas in Saudi Arabia [7;8] and to use the data as a ground for future research projects in soil and water for agricultural, environmental and urban development purposes.

Materials and Methods

Ten sampling sites were selected in the Al-Madinah area (24′ 18″ N, 39′ 36″ E) (Fig. 1). Five individual locations were selected within each sampling site. The purpose for this method of sampling was to evaluate the variations among the sampling locations within a particular site. One soil sample was collected from each individual location, dried, crushed and passed through a 2 mm sieve. A 0.5 g sub-sample was digested in concentrated analar HNO_3 according to the method proposed by the Saudi Arabian Standards Organization [9]. The resultant solution was analyzed for B, Co, Cu, Mn, Pb, Fe and Zn using a Perkins-Elmer model 603 atomic absorption spectrophotometer and for Ca, Mg, using a Pye Unicom SP^9 equipped with a SP^9 computer. Organic matter contents, total soluble salts (TSS) and pH were determined according to techniques explained by Black *et al.* [10].

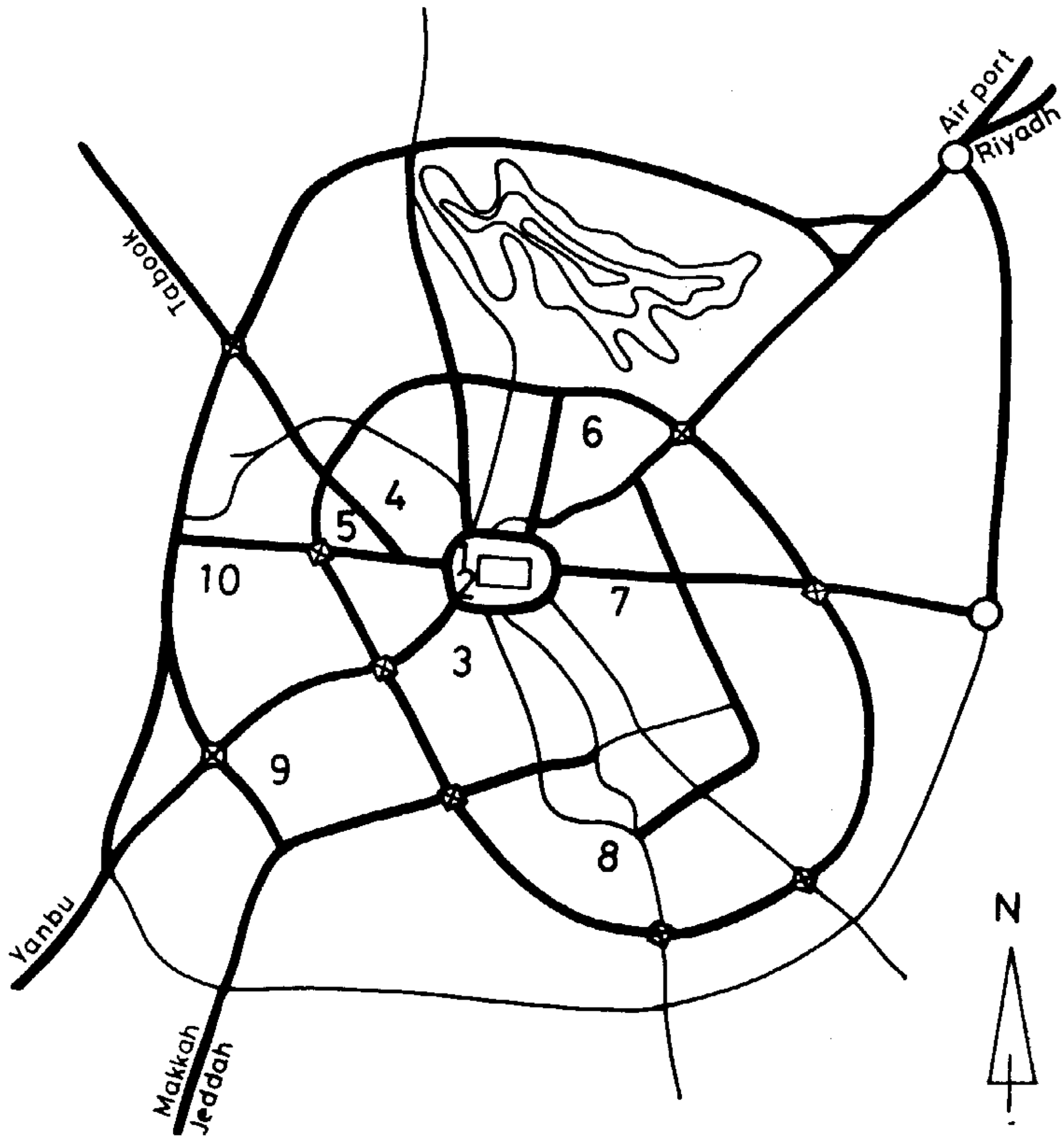

Fig. 1. A map of Al-Madinah area showing collection sites.
(1,2, Al-Haram; 3, Al-Khulfa'a; 4, Al-Khandaq; 5, Al-Khandog; 6, Uhod; 7, As-Salam; 8, Quba'a; 9, A'Abar Ali; 10, Al-Azizeyyah)

The methods for collecting the water samples were similar to those described by Saudi Arabian Standards Organization [6]. Samples of water were collected in 100-ml polyethylene plastic bottles with screw caps. The bottles were washed thoroughly with distilled water and dried prior to sample collections. Five locations were sampled and five replicate samples were collected for each sampling location. The samples were kept in a refrigerator at 10°C until water analyses were performed.

Results and Discussions

The organic matter contents of the soil samples vary between 0.02 and 0.86% (Table 1). The TSS fluctuates between 0.03 and 0.66%. There is no appreciable difference in the soil pH values that vary between 7.01 and 7.55, that is within the neutral alkaline range. The concentrations of Ca are the highest followed by the concentrations of Mg and Fe (Table 2).

Table 1. Organic matter, total soluble salts and pH values of tested soil samples

Sample source*	Organic matter %	Total soluble salts %	pH value
1	0.02	0.04	7.03
2	0.03	0.12	7.01
3	0.06	0.03	7.27
4	0.19	0.08	7.08
5	0.57	0.61	7.19
6	0.08	0.43	7.36
7	0.61	0.59	7.23
8	0.81	0.66	7.55
9	0.75	0.59	7.43
10	0.86	0.63	7.75

* According to Fig. 1.

Boron concentrations are low, but fluctuate within the ranges reported worldwide for natural conditions [11;12]. Boron is not uniformly distributed in the earth's crust and is known to be the most mobile micro element in the soils of warm humid, and semi arid regions [12]. It is likely to concentrate in surface horizons and its status has been extensively investigated throughout the world [11]. Mean calcium contents in the earth's crust are higher than that of most of other essential elements. Calcium concentrations vary between 0.25 to 0.35 % that is similar to previous findings [7].

In the earth's crust Co has a high concentration in ultra mafic rocks (100-220 μg/g) compared to its presence in acid rocks (1-15 μg/g). The Co abundance in sedimentary rocks range from 0.1 to 20 μg/g and seems to be associated with clay minerals or organic matter [12]. The cobalt content of surface soils of different countries ranges from 0.8 to 122 μg/g [7; 13; 14]. In the present study Co content of tested soils ranged from 0.96 to 2.51 μg/g.

Table 2. **Mineral contents ($\mu g/g$) of tested soil samples obtained from various localities in the Al-Madinah area (n=5, $\bar{\chi}$ ± standard deviation)**

Element	Sample source*									
	1	2	3	4	5	6	7	8	9	10
Boron	1.45±0.28	0.98±0.11	1.11±0.09	0.81±0.08	1.22±0.08	1.43±0.19	0.66±0.01	1.27±0.61	0.93±0.08	1.01±0.12
Calcium	2890±2.81	3010±3.11	3120±2.71	3300±4.81	2930±2.39	3001±3.01	3200±1.98	3190±2.81	3190±2.81	3039±2.93
Cobalt	2.51±1.11	0.96±0.01	2.12±0.01	2.09±0.06	1.87±0.11	2.11±0.08	1.09±0.13	1.72±0.11	1.89±0.09	2.00±0.19
Copper	9.01±1.01	8.97±1.08	11.91±1.01	8.09±1.28	11.11±1.07	8.31±0.99	10.16±1.13	8.11±1.83	11.18±1.07	13.11±1.91
Iron	20.1±1.11	18.6±1.01	25.31±2.19	20.11±1.06	18.11±1.09	24.09±1.91	22.11±1.19	19.6±1.03	26.0±1.05	23.19±1.19
Magnesium	1989±3.11	2630±4.01	2280±3.06	2110±2.91	2480±2.89	2330±3.19	2640±2.89	2410±2.17	2390±3.01	2591±3.17
Manganese	2.98±0.11	1.18±0.20	1.29±0.66	2.00±1.01	2.11±0.91	0.98±0.01	1.91±0.61	0.71±0.11	1.11±0.69	0.63±0.05
Lead	1.01±0.06	0.71±0.03	1.2±0.08	0.91±0.11	1.02±0.17	0.89±0.08	1.01±0.03	0.86±0.09	1.23±0.11	0.66±0.05
Zinc	8.11±0.91	6.31±1.02	8.03±0.17	9.91±1.03	8.01±1.19	7.92±0.91	9.01±0.28	10.11±0.89	7.01±1.01	6.38±0.81

* According to Fig. 1

The concentrations of Cu in the tested soils are in agreement with earlier findings [7; 15; 16]. Soils analyzed for iron contained low amounts of this element. The Fe contents of the tested soils are within the range reported for alkaline soils [17, pp. 449-461; 18, pp. 145-163; 19, pp. 473-474]. Iron concentrations in the present study are similar to earlier findings in other Saudi Arabian soils [7;8].

Magnesium is present in the soils in fairly high amounts and ranges between 170 and 400 μg/g [20], although the levels can vary considerably and values between 17 to 13000 μg/g have been reported [20]. Mg is one of the most abundant trace elements in the lithosphere, and its common range in rock is 350 to 2000 μg/g. Its highest concentrations are usually associated with mafic rocks [11]. Magnesium concentrations in the tested soils are similar to the earlier findings of Hashem [7] in other Saudi Arabian soils, which range from 2060 to 3361 μg/g.

The abundance of Mn in the soil is reported to range from 25 to 2200 μg/g [11], while the Mn content in the present study of the tested soils ranged from 0.61 to 2.98 μg/g. Throughout the world, calcareous soils are often low in Mn [13]. Lead in the top horizons of different soils from various countries ranges from 3 to 189 μg/g [21; 22], while in the present study concentrations range from 0.66 to 1.23 μg/g. Hashem [8] found the lead content of soils of other parts of Saudi Arabia to be higher than those found in the present study.

The mean Zn contents in surface soils of different countries range from 17 to 125 μg/g [23; 24], but the Zn contents in the present investigation ranged from 6.31 to 10.11 μg/g. This is in agreement with earlier findings in some Saudi Arabian soils [7;8]. Element concentrations of tested water samples were also in agreement with earlier findings [7;8] in other Saudi Arabian water samples. Table 3 shows that the mineral concentrations of the water samples are similar to those of the unbottled drinking waters (Table 4) according to the international and Saudi Arabian Standards Organization.

The water authority of Al-Madinah depends heavily on the desalinized water from Yanbu that constitutes about 60% of the needed water. Ten per cent of the required water is supplied by the authority's wells, and the remaining 30% is purchased from the farm wells around the city. This water, however, has an unpleasent salty taste which might be attributed to the mixing of irrigation water with the city's main distribution system in order to eliminate water shortages. The concentration of the elements measured in the present study are in the levels similar to previous observations [7; 8; 25; 26], proven to be below the maximum permisible concentration for drinking water. Although the total dissolved solids in most samples (except sample number 4 which is treated water [health water]), were slightly high according to WHO, no evidence of health effects due to using water with total dissolved solids (TDS) in excess of 1000 mg/L [27;28] was reported. However, high TDS is important

Table 3. Mineral contents (mgL^{-1}) of water samples obtained from various localities in the Al-Madinah area (n=5, $\bar{\chi}$ ± standard deviation)

Element	Sample source*									
	1	2	3	4	5	6	7	8	9	10
Boron	1.45±0.01	0.89±0.03	1.15±0.01	1.05±0.06	1.00±0.11	1.15±0.06	1.20±0.03	1.0±0.02	1.30±0.03	1.55±0.05
Calcium	98.11±0.8	64±1.9	55±2.0	60±2.0	55±1.9	65±1.9	65±1.0	50±3.0	67±2.6	91±2.1
Cobalt	0.11±0.03	0.01±0.003	0.01±0.003	0.01±0.001	0.03±0.004	0.05±0.001	0.02±0.001	0.04±0.002	0.05±0.001	0.05±0.002
Copper	0.01±0.001	0.03±0.001	0.01±0.002	0.01±0.001	0.04±0.001	0.02±0.001	0.01±0.001	0.01±0.003	0.04±0.001	0.02±0.001
Iron	0.03±0.002	0.11±0.001	0.06±0.001	0.05±0.002	0.32±0.01	0.02±0.003	0.20±0.01	0.23±0.04	0.02±0.001	0.02±0.001
Magnesium	64±1.1	36±1.0	29±1.0	25±1.0	35±0.9	30±0.1	36±2.0	27±0.9	56±2.5	42±1.4
Manganese	0.06±0.001	0.01±0.003	0.01±0.001	0.07±0.002	0.031±0.003	0.01±0.003	0.06±0.001	0.013±0.002	0.02±0.001	0.01±0.001
Lead	b.d	b.d	b.d	b.d	b.d	b.d	b.d	b.d	b.d	b.d
Zinc	0.53±0.01	0.35±0.02	0.35±0.03	0.34±0.02	0.27±0.05	0.41±0.09	0.38±0.01	0.20±0.06	0.53±0.08	0.37±0.06
pH	7.64	7.64	7.53	7.44	7.55	7.44	7.74	7.52	7.68	7.61
T.D.S.	1728	1043	896	288	966	915	992	800	1312	1504

* According to Fig. 1 T.D.S. = Total Disolved Solids b.d. = below detection

Table 4. Limits of mineral contentration of unbottled drinking water (according to Saudi Arabian Standards Organization and international standards of drinking water)

Element	Optimum (Mg^{-1})	Maximum (Mg^{-1})
Boron	—	5
Calcium	75	200
Copper	0.05	1.5
Iron	0.1	1.0
Magnesium	30	150
Manganese	0.05	0.5
Lead	—	0.01
Zinc	5	15
pH	7-8.5	9.2
T.D.S.	300-900	<1200

because of its economic effect due to its associations with corrosion damage to the water system. The pH values reported in the present study show that the majority of the samples tested were slightly alkaline.

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المحتوى المعدني لعيّنات مختارة من تربة منطقة المدينة المنوّرة ومياهها بالمملكة العربية السعودية

عبدالوهاب رجب هاشم بن صادق وعوض متيريك الجهني
كلية العلوم، جامعة الملك سعود، ص.ب ٢٤٥٥،
الرياض ١١٤٥١، المملكة العربية السعودية
(سُلِّمَ في ٢٢/٦/١٩٩٢م، وقُبل للنشر في ٩/٢/١٩٩٤م)

ملخص البحث. تّم في هذا البحث جمع عيّنات من التربة والماء من منطقة المدينة المنوّرة وحُلّلت لقياس محتواها المعدني. وكانت نتائج تحليل التربة أنها تختلف من موقع لآخر بينما كانت نتائج تحليل الماء متقاربة في جميع المواقع.