Fractionation of Micronutrients in Selected Soils from Saudi Arabia

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ABSTRACT. Fractionation of micronutrients into 5 fractions was carried out on ten selected soils in Saudi Arabia (Tessier *et al.* 1979). The ranges for different micronutrient fractions were: 0 - 796, 0 - 105, 0 - 75 and 0 - 59942 ug g^{-1} for Mn, Zn, Cu and Fe, respectively. The residual fraction constitutes the absolute majority of all fractions and the order of the 5 fractions was: Residual > Fe-Mn Oxide bound > CO_3 bound > organic bound > exchangeable.

The DTPA extractable micronutrients ranged from 1.56 - 16.30 ug g^{-1} for Mn, 0.09 - 2.20 ug g^{-1} for Zn, 1.51 - 17.7 ug g^{-1} for Fe and 0.07 - 2.73 ug g^{-1} for Cu extraction of micronutrients with DTPA showed strong relationship with micronutrients estimated by using different fractionation schemes. Therefore, it is considered a good estimation for the availability of micronutrients in the studied soils.

Deficiency of micronutrients is a problem worldwide and is more severe in calcareous soils. In Saudi Arabia, calcareous soils represent a very significant proportion of agricultural soils. The agricultural soils of Saudi Arabia are generally coarse to medium textured with low organic matter and a pH of 7.5 to 8.5 (Bashour *et al.* 1983).

Prasad *et al.* (1984) studied the availability of micronutrients in some selected Saudi soils and concluded that available Fe and Zn are low in many of the soils studied while Mn and Cu are present in adequate amounts. In another study, El-Fouly (1983) indicated that Mn availability in arid soil was affected by oxidation-reduction conditions in the soil. He suggested that Mn deficiency will occur in well aerated alkaline and calcareous soils irrespective of texture, organic matter contents and electrical conductivity of the saturation extract (EC_e). Similar views were also shared by other

93

workers (Hagen and Tucker 1982, Sillanpaa 1982).

While the total concentration of micronutrients may not be a limiting factor, the availability of these micronutrients to plants is largely limited in calcareous and alkaline soils. Knowledge of how the metal ions are bound to the complex soil structure is important for understanding the mobility, solubility, uptake and the potential modes of transport of metal ions.

Several fractionation schemes have been developed over recent years in order to address this problem. One of the widely used procedures for the fractionation studies is that developed by Tessier *et al.* (1979). This procedure fractionates soil metals into five fractions *viz*: exchangeable, carbonate bound, Fe-Mn oxide bound, organic bound, and residual. However, the review of literature indicated that many researchers have used different fractionation schemes utilizing different extractants (McLaren and Crawford 1973, Wagemann *et al.* 1977, Shuman 1979, 1983, 1985).

Previous research on Saudi Arabian soils was mainly directed towards providing a general framework for understanding the soils and their potentialities for micronutrients status (Bashour *et al.* 1983). The fractionation of Saudi soils using sequential extraction, to our knowledge, has never been attempted. The objective of this study is to fractionate some typical soils of Saudi Arabia and determine the distribution of micronutrients in these fractions.

Materials and Methods

A total of 10 soil samples were taken from different regions representing various soil types and covering important agricultural regions of the Kingdom. Placement of the sampled profiles in family groups in Soil Taxonomy (Soil Survey Staff 1975) and the Parent Material of each are given in Table 1. Soil samples were air dried, ground to pass through a 2 mm sieve and stored for subsequent analyses. The electrical conductivity (EC_e), pH, carbonate content, soil texture and organic carbon were determined (USDA, Handbook No. 60, 1954) and presented in Table 2.

The fractionation scheme of Tessier *et al.* (1979) was used in this study. This scheme involves a separate extraction step for the CO_3 bound fraction and is best suited for our purpose. Plant available micronutrients were determined using DTPA extraction procedure (Lindsay and Norwell 1978) for all soils.

All glassware used in this study was previously soaked in 8% (v/v) HNO_3 for 24 hours and rinsed several times with distilled deionized water. The selective extractions

Table 1. Family groups and parent material of the soil samples

Soil No.	Location	Family Group	Parent Material
1*	Al-Qassim	Typic Haplargid, Clayey, Hyperthermic.	Medium-texture Alluvium Sediment Originated from Metaphoric Rock.
2	Al-Kharj	Typic Torrifluvent, Fine-silty, Hyperthermic	Medium-textured Alluvium (Sedimentary Rock)
3	Al-Kharj	Typic Torrifluvent, Fine-silty, Hyperthermic	Medium-textured Alluvium (Sedimentary Rock)
4**	Liyyah	Typic Haplargid, Loamy, Thermic	Medium-textured Alluvium (Metamorphic Rock)
5**	Al-Hada	Typic Torrifvent, Coarse Loamy Thermic	Coarse-textured Alluvium (Metamorphic Rock)
6	Haradh	Typic Torrifuvent, Coarse Loamy Thermic	Coarse-textured Alluvium, Derived from (Sedimentary Rock)
7	Hail	Typic Torrifuvent, Coarse Loamy Thermic	Coarse-textured Alluvium, Derived from (Sedimentary Rock)
8	Wadi Dawasir	Typic Torripsamment, Sandy, Hyperthermic	Coarse-textured Alluvium, Derived from (Sedimentary Rock)
9	Al-Kharj	Typic Torripsamment, Sandy, Hyperthermic	Coarse-textured Alluvium, Derived from (Sedimentary Rock)
10	Haradh	Typic Torripsamment, Sandy, Hyperthermic	Coarse-textured Alluvium, Derived from (Sedimentary Rock)

* Soil derived from sediments of metamorphic rock.

** Soil derived from metamorphic rock.
   All others derived from sedimentary rocks.

Table 2. Some physical and chemical properties of the soils used for chemical fractionation studies

Soil No.	Location	EC_e (dSm^{-1})	pH	CO_3-	Org-C	Sand %	Silt %	Clay %	Textural Class
1	Al-Qassim	6.93	7.62	9.5	0.73	50	16	34	Sandy clay loam
2	Al-Kharj	2.47	7.48	30.7-	0.11	57	18	25	Sandy clay loam
3	Al-Kharj	1.84	7.63	35.7	0.11	43	25	32	Clay loam
4	Liyyah	5.24	7.63	9.7	0.92	50	31	19	Loam
5	Al-Hada	1.30	7.56	5.0	1.05	58	31	11	Sandy loam
6	Haradh	3.22	7.35	24.8	0.10	79	10	11	Sandy loam
7	Hail	1.7	7.84	14.0	0.12	81	8	11	Loamy sand
8	Wadi Dawasir	2.81	7.66	13.2	0.24	87	8	5	Sand
9	Al-Kharj	3.02	7.56	19.0	0.10	92	2	6	Sand
10	Haradh	1.22	7.72	11.6	0.10	97	0	3	Sand

EC_e = Electrical Conductivity of a Saturation Extract.

were conducted in polypropylene bottles of 250 ml capacity. Between consecutive extractions, the soil and the extractant was centrifuged (Sorvall medel 101) at 10,000 rpm for 30 minutes. The supernatent solution was removed with an autopipette, filtered, and analysed for micronutrients. The residue was washed with deionized water and again centrifuged for 30 minutes. The supernatent solution was added to the extraction solution after filtration.

The sequential fractionation scheme used in this study is outlined below:

(1) *Exchangeable:–* To a 5g soil sample, 40 ml of 1M magnesium chloride ($MgCl_2$) at pH 7.0 was added and the contents were shaken continuously for 1 hour at room temperature. After centrifuging, the supernatent solution was filtered and saved for analysis. The residue was washed with 20 ml water and the washings discarded.

(2) *Carbonate Bound:–* The residue from (1) was agitated continuously for 5 hours with 40 ml of 1M sodium acetate (NaOAc/ACOH at pH 5.0). After agitation, the supernatent solution was filtered and stored for analysis. After extraction, residue was washed with 20 ml of water and the washings discarded.

(3) *Iron-Manganese Oxide Bound:–* To the residue from (2), 100 ml of 0.04 M hydroxylamine hydrochloride. (NH$_2$OH.HCl) was added in 25% (v/v) HOAc and the extraction was carried out at 95 ± 2°C in a water bath with occasional agitation for 6 hours. After centrifuging, the residue was washed with the required amount of water (20 ml) and the washings were combined with the original extract after filtration to make up a total volume of 100 ml.

(4) *Organic Bound:–* The residue from (3) was first treated with 15 ml of 0.02M nitric acid (HNO$_3$) and 25 ml of 30% hydrogen peroxide (H$_2$O$_2$) (pH 2 with HNO$_3$) for 24 hours at 85 ± 2°C in a water bath. A second 15 ml aliquot of 30% H$_2$O$_2$ was then added and the contents heated again to 85°C for 3 hours with intermittent agitation. After cooling, 25 ml of 3.2 M ammonium acetate (NH$_4$OAC) in 20% (v/v) HNO$_3$ was added and agitated continuously for 30 minutes. After centrifuging, the residue was washed with 20 ml of water and the washings added to the extracted solution after filtration to make up a final volume of 100 ml.

(5) *Residual:–* For this study, 1 g of sample was taken from (4) and treated with 2 ml of 70% perchloric acid (HClO$_4$) and 10 ml of hydrogen floride (70%HF) in a platinum crucible. The contents were digested on a hot plate and when the residue became paste, a second addition of 1 ml of HClO$_4$ and 10 ml of HF was made. Again, the contents were digested to near dryness. Finally 1 ml of HClO$_4$ was added and evaporated again until the appearance of white fumes. The contents were then dissolved in 6N hydrochloric acid (HCl), filtered, and made up to 100 ml for analytical work. The metal content in each fraction was analysed using a Perkin-Elmer Model 503 Atomic Absorption Spectrophotometer and the flameless atomic absorption (Varian Specter AA 30). Each soil sample was analysed in triplicate.

Results and Discussion

Manganese concetrations in the various fractions are given in Table 3 and these ranged from 0 to 0.5% for exchangeable, 3 to 29% for CO$_3$ bound, 1 to 5% for the organic bound, 10 to 38% for the Fe-Mn oxide bound and 49 to 81% for the residual fractions. In general, coarse textured soils contained less Mn in almost all the fractions than the medium or fine-textured soils (r values ranged from 0.154 to 0.754). Only 4 soils out of the 10 studied soils contained Mn in the exchangeable fraction and these 4 soils also had high proportion of Mn in the residual fraction. The amount of Mn in the exchangeable fraction showed an increase with an increase in Mn concentration in the Fe-Mn oxide fraction (r = 0.681).

As expected, DTPA extractable Mn decreased with a corresponding decrease in exchangeable Mn (r = 0.965). The poor correlation (r = 0.006) shows that the CO$_3$ contents of soils had no relationship with the CO$_3$ - bound Mn contents of soils and the

Table 3. Mn content (ug g^{-1}) of the different fractions in the soils

Soil No.	Exchangeable	CO$_3$- Bound	Fe-Mn Oxide Bound	Organic Bound	Residual
1	3.4	35.5	228.9	32.4	353
	0.5b	5.4	35.0	5.0	54
	0.591c	0.64	1.58	1.124	5.46
2	N.D.a	36.8	153.1	10.2	205
	0.0	9.1	37.8	2.5	50.7
	0.0	1.06	5.77	0.00	10.11
3	N.D.	49.9	170.0	8.0	221.4
	0.0	11.1	37.8	1.8	49.3
	0.0	1.248	0.363	0.00	49.3
4	1.0	32.9	129.7	24.2	796.5
	1.0	3.3	13.2	2.5	80.9
	0.080	1.05	0.153	0.208	18.23
5	1.8	73.0	206.7	20.3	964.2
	0.1	5.8	16.3	1.6	76.2
	0.630	1.27	5.77	0.611	16.62
6	N.D.	18.9	20.0	2.0	152.8
	0.0	9.8	10.3	1.3	78.9
	0.0	0.412	0.379	0.473	78.9
7	N.D.	11.2	126.2	10.2	202.4
	0.0	3.2	36.1	2.0	57.8
	0.0	0.03	5.294	0.379	2.19
8	0.54	19.2	71.6	5.6	222.8
	0.2	6.0	22.4	1.8	69.7
	0.046	0.00	2.94	0.600	9.38
9	N.D.	35.0	23.3	2.0	61.2
	0.0	28.8	19.2	1.7	50.4
	0.0	2.96	3.46	0.00	8.41
10	N.D.	9.8	9.2	1.0	48.2
	0.0	14.4	13.4	1.5	70.7
	0.0	0.98	0.60	0.379	5.66

a = N.D.: None detected.

b = Percentage of the total concentration.

c = Standard deviation (±) for each estimation.

same is true for the other Mn fractions of soils. It is possible that Mn from MnO_2 is solubilized by a strong reducing agent, such as hydroxylamine hydrochloride (Jenne 1968).

The soils derived from metamorphic rocks were similar with respect to Mn contents. Moreover, soils high in organic carbon had comparatively high Mn contents in the organic bound fraction ($r = 0.839$). The residual Mn contents of soils derived from metamorphic rock were found to be at least two to three times higher than the soils derived from sedimentary rocks.

Table 4 shows the Zn contents in the various fractions of the soils studied. There was no detectable zinc in the exchangeable fraction. Although CO_3 and pH are considered to be important factors which determine the carbonate-bound contents of Zn in soils, the poor correlation ($r = 0.179$) indicates that CO_3 - bound Zn was not related to CO_3 and pH of the soils in the present study. The CO_3 - bound contents of Zn ranged from 0.3 to 2.1 ug g^{-1} in different soils. The results do not agree with the findings of Mustafa *et al.* (1988) who found a strong relationship between CO_3 - bound Zn contents of soil and the $CaCO_3$ contents of soil. This difference could be attributed to the difference in Zn contents of soil and method of experimentation. The soils as studied here were low in Zn contents.

The Fe-Mn oxide bound Zn was by far the largest among all the fractions, except residual. This is expected because both Zn and Cu are preferentially adsorbed on Fe-oxide surfaces in soils. The coarse-textured soils had a lower amount of Zn in the Fe-Mn oxide bound fraction than the medium textured soils ($r = 0.660$). With exception of soils, which are derived from metamorphic rocks, organic bound Zn could be related to the organic carbon contents of the soils ($r = 0.929$). A similar finding was reported by Mandal and Mandal 1986 who compared repeated H_2O_2 extraction of Zn with a single extraction and reported that repeated extraction of Zn with H_2O_2 did not show any effect on single extracted Zn. Therefore, they suggested that a single H_2O_2 extraction was sufficient for solubilizing organic matter in the soils which they studied. Zinc in the residual fraction was comparatively higher than in other fractions, compared to other metals. The soils high in clay contained high amounts of residual Zn. This may be due to the fact that Zn has a strong preference for adsorption on clay minerals (Ghanem and Mikkelsen 1987). The order of occurrence of Zn in the various fractions was Residual > Fe-Mn oxide > CO_3 > Organic > Exchangeable except for soils No. 1 and 4, where the order of occurrence is Residual > Fe-Mn oxide > Organic > CO_3 > Exchangeable.

No exchangeable Cu was detected in any of the soils (Table 5). A low value of correlation coefficient indicates that the CO_3 contents of the soils were not strongly related to the Cu contents of the soils. The values of correlation coefficients (r) were 0.438, 0.164, - 0.532, and 0.434 for CO_3, Fe-Mn oxide, Organic bound and residual fractions, respectively.

Table 4. Zn content (ug g^{-1}) of the different fractions in the soils

Soil No.	Exchangeable	CO$_3$-Bound	Fe-Mn Oxide Bound	Organic Bound	Residual
1	N.D.b	0.3	7.1	0.7	90.7
	0.0a	0.3	7.2	0.7	91.8
	0.0c	0.00	0.46	0.11	5.52
2	N.D.	0.6	5.9	0.4	67.1
	0.0	0.8	8.0	0.5	90.7
	0.0	0.00	0.125	0.00	13.01
3	N.D.	0.9	5.6	N.D	94.2
	0.0	0.9	5.6	0.0	93.6
	0.0	0.066	0.00	0.0	6.72
4	N.D.	0.4	6.1	1.0	105
	0.0	0.4	5.4	0.9	93.4
	0.0	0.046	0.12	0.0	4.52
5	N.D.	2.1	11.5	1.6	101.9
	0.0	1.8	9.8	1.4	87.0
	0.0	0.046	0.12	0.00	7.42
6	N.D.	1.0	1.4	N.D.	49.6
	0.0	1.9	2.7	0.0	95.4
	0.0	0.006	0.00	0.0	11.03
7	N.D.	0.9	5.1	0.4	69.6
	0.0	1.2	6.7	0.5	91.6
	0.0	0.049	0.31	0.00	0.42
8	N.D.	0.8	3.8	0.3	59.9
	0.0	1.2	5.9	0.5	92.4
	0.0	0.00	0.00	0.115	3.55
9	N.D.	0.9	3.3	N.D.	54.1
	0.0	1.5	5.7	0.0	92.8
	0.0	0.046	0.42	0.0	2.05
10	N.D.	0.7	1.9	N.D.	40.7
	0.0	1.6	4.4	0.0	94.0
	0.0	0.044	0.12	0.0	2.05

a = N.D.: None detected.

b = Percentage of the total concentration.

c = Standard deviation (±) for each estimation.

Table 5. Cu content (ug g^{-1}) of the different fractions in the soils

Soil No.	Exchangeable	CO$_3$- Bound	Fe-Mn Oxide Bound	Organic Bound	Residual
1	N.D.a	0.6	2.3	0.7	38.3
	0.0b	1.4	5.5	1.7	91.4
	0.0c	0.043	0.115	0.100	2.06
2	N.D.	1.3	4.3	0.3	26.8
	0.0	4.0	13.2	0.9	82.0
	0.0	0.03	0.12	0.06	0.70
3	N.D.	1.5	4.9	N.D	27.5
	0.0	4.4	14.5	0.0	81.1
	0.0	0.05	0.14	0.0	0.57
4	N.D.	0.7	2.1	1.9	56.3
	0.0	1.2	3.4	3.1	92.3
	0.0	0.05	0.12	0.12	0.92
5	N.D.	0.8	6.0	6.9	75.0
	0.0	0.9	6.8	7.8	48.6
	0.0	0.05	0.40	0.31	0.64
6	N.D.	2.2	2.4	N.D.	20.4
	0.0	8.8	9.6	0.0	81.6
	0.0	0.05	0.20	0.0	0.46
7	N.D.	1.6	4.1	0.2	24.7
	0.0	5.2	13.2	1.0	80.5
	0.0	0.12	0.10	0.01	0.49
8	N.D.	1.4	3.3	0.3	18.3
	0.0	6.0	14.2	1.3	78.5
	0.0	0.00	0.12	0.12	2.29
9	N.D.	1.2	1.9	N.D.	7.5
	0.0	11.3	17.9	0.0	70.8
	0.0	0.075	0.14	0.14	0.71
10	N.D.	2.0	2.2	N.D.	8.5
	0.0	15.8	17.3	0.0	66.9
	0.0	0.06	0.12	0.0	0.71

a = N.D.: None detected.

b = Percentage of the total concentration.

c = Standard deviation (±) for each estimation.

The order of different metals in Fe-Mn oxide fraction was Fe > Mn > Zn > Cu. However the percentage of the ions in this fraction was Mn > Cu > Fe > Zn. It is possible that part of the Fe and Mn extracted from this fraction could be derived from the parent oxide minerals during extraction with Hydroxylamine hydrochloride (Jenne 1968). The order of the metals in the CO_3 bound fraction was Mn > Fe > Cu > Zn and their percentage in the CO_3 fraction was Mn > Cu > Fe. The order of ions in the residual fraction was the same as their order in the Fe-Mn oxide fraction Fe > Zn > Mn > Cu. This fraction constitutes the absolute majority and ranged between 88 - 99% for Fe; 70 - 93% for Cu; 87 - 94% for Zn and 49 - 81% for Mn. The presence of a higher percentage of Mn in the Fe-Mn oxide fraction lowered the percentage of Mn in the residual fraction if compared with the other 3 metals.

The data indicate that total contents of the metals under study was the highest in the soils of metamorphic origin. Total contents of metals was in the following order Fe > Mn > Zn > Cu. This is the same order of residual and Fe-Mn-oxide bound metals. Copper in the organic bound fraction is related to the organic carbon contents of the soils (r = 0.803) and residual Cu was higher in the fine-textured soils.

Exchangeable Fe was not detected in any of the soils (Table 6). In spite of the fact that the Fe concentration was higher than that of the other metal ions, 88 - 89% of the Fe was in the residual fraction. However, Fe was comparatively lower in the CO_3-bound fraction and was found in appreciable amounts in the Fe-Mn oxide fraction. It is possible that Fe from the oxides in soils had been solubilized during extraction with hydroxylamine hydrochloride. The poor correlation (r = 0.256) shows that CO_3 levels of soils had no significant effect on the CO_3 bound Fe contents. The two soils with high organic C content also had higher Fe content in the organic bound fraction than the other soils.

DTPA - Extractable Micronutrients

Table 7 shows content of DTPA extractable micronutrients to range from 1.56 to 16.30 ug g^{-1} for Mn, 0.09 to 2.20 ug g^{-1} for Zn, 0.07 to 2.73 ug g^{-1} for Cu and 1.51 to 17.70 ug g^{-1} for Fe in the soils. According to Lindsay and Norwell (1978) critical levels, of the 10 soils studied, 7 soils were found deficient in Fe, 9 soils deficient in Zn, one deficient in Cu and none deficient in Mn. Soils of similar nature to those used in the present study, were reported to be adequate in Mn (Prasad *et al.* 1984). Organic-bound Cu was related to DTPA-extractable Cu (r = 0.934). The correlation between DTPA extractable Cu and Fe-Mn bound Cu was relatively poor (r = 0.240). DTPA extractable Zn was highly correlated with the ZN amount of in the CO_3- bound fraction (r = 0.819), the Fe-Mn oxide fraction (r = 0.854), and the organic-bound fraction (r = 0.836) which suggests that the 3 Zn fractions are readily available to plants. Whereas, DTPA-extractable Zn was poorly correlated with the amount Zn in the residual fraction (r = 0.569). DTPA-extractable Mn was also highly correlated with the amount of Mn in

Table 6. Fe content (ug g^{-1}) of the different fractions in the soils

Soil No.	Exchangeable	CO$_3$-Bound	Fe-Mn Oxide Bound	Organic Bound	Residual
1	N.D.a	1.7	565.7	15.3	23704
	0.0b	0.01	2.3	0.06	97.6
	0.0c	0.13	21.88	1.10	630.16
2	N.D.	2.7	447.8	19.3	17173
	0.0	0.02	2.7	0.11	97.2
	0.0	0.20	15.10	2.85	289.91
3	N.D.	4.3	522.3	N.D	19004
	0.0	0.02	2.7	0.0	97.3
	0.0	0.79	5.52	0.0	364.16
4	N.D.	1.4	566.4	51.9	43870
	0.0	0.00	1.3	0.01	98.6
	0.0	0.17	7.07	2.00	410.23
5	N.D.	3.5	1288.7	50.0	59942.5
	0.0	0.1	2.1	0.08	97.8
	0.0	0.09	15.95	14.49	593.26
6	N.D.	14.7	179.7	10.7	4003
	0.0	0.4	4.3	0.3	95.1
	0.0	0.17	6.13	2.38	95.1
7	N.D.	6.1	868.8	9.0	8324
	0.0	0.1	9.4	0.1	90.4
	0.0	0.38	25.16	0.55	90.4
8	N.D.	4.6	596.2	7.0	4401
	0.0	0.1	11.9	0.14	87.9
	0.0	0.43	3.38	2.00	191.20
9	N.D.	13.0	668.7	9.0	13450
	0.0	0.1	4.7	0.1	95.1
	0.0	0.95	3.89	1.41	998.99
10	N.D.	6.1	286.7	9.8	3765
	0.0	0.15	7.1	0.2	92.6
	0.0	0.47	10.41	1.27	92.6

a = N.D.: None detected.

b = Percentage of the total concentration.

c = Standard deviation (±) for each estimation.

Table 7. DTPA -extractable micronutrient contents of the soils

Soil No.	Mn	Zn	Cu	Fe
			(ug g^{-1})	
1	16.30	0.48	1.26	8.70
2	1.98	0.25	0.63	2.85
3	3.07	0.36	0.60	3.05
4	10.20	0.39	1.45	4.50
5	11.60	2.20	2.73	17.70
6	1.85	0.17	0.17	1.51
7	3.84	0.26	0.43	3.40
8	5.10	0.31	0.36	3.35
9	2.68	0.23	0.36	2.90
10	1.56	0.09	0.07	2.00

The DTPA- extractable critical levels of micronutrients as reported by Lindsay and Norwell (1978) are 4.50 ug g^{-1} for Fe, 0.80 ug g^{-1} or Zn, 1.00 ug g^{-1} for Mn, and 0.20 ug g^{-1} for Cu.

exchangeable (r = .965), organic bound (r = 0.944), and Fe-Mn oxide (r = 0.719) fractions. The amount of Mn present in the CO_3 - bound (r = 0.453) and residual (r = 0.694) fractions were not closely correlated with the DTPA-extractable Mn contents of soils. DTPA-extractable Fe was highly correlated with the amount of Fe determined in the Fe-Mn oxide (r = 0.808) and organic-bound (r = 0.650) fractions. However, the Fe contents found in the CO_3- bound (r = 0.391) and residual (r = 0.495) fractions showed a poor relationship with the DTPA - extractable Fe contents of soils.

Therefore, it can be concluded that in the studied soils, extracting Fe, Zn, Mn, Cu in DTPA solution as outlined by Lindsay and Norwell (1978) give a good estimation for the availability of these elements to plants.

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التحليل التجزيئي للعناصر الدقيقة لعينات تربة منتقاة

من مناطق مختلفة بالمملكة العربية السعودية

علي عبدالله الجلعود و محمد رافي و عصام بشور

مدينة الملك عبدالعزيز للعلوم والتقنية

ص .ب (٦٠٨٦) – الرياض ١١٤٤٢ – المملكة العربية السعودية .

حللت عدد (١٠) عينات تربة مختارة من مناطق زراعية مختلفة بالمملكة تحليلاً جزئيًا لمعرفة تراكيز الأشكال الكيميائية المختلفة (خمس أشكال) للعناصر الدقيقة حسب طريقة Tessier وآخرون ١٩٧٩م . تتراوح التراكيز المختلفة للأشكال الكيميائية من صفر – ٧٩٦ ، صفر – ١٠٥ ، صفر – ٧٥ ، صفر – ٥٩٩٤٢ ميكروجرام / جرام للمنجنيز والزنك والنحاس والحديد على التوالي يكون الشكل المتبقي هو الجزء الأكبر من الأشكال الخمسة وكان ترتيبها كالتالي المتبقي المرتبط بأكاسيد الحديد و الزنك > المرتبط بالكربونات > المرتبط بالمادة العضوية > المتبادل .

يتراوح تركيز العناصر المستخلصة بمحلول DTPA معبراً عنها بالميكروجرام / جرام بين ١ , ٥٦ – ١٦ , ٣٠ للمنجنيز و ٠٩ , – ٢ , ٢ للزنك و ١ , ٥١ – ١٧ , ٧ للحديد و ٠٧ , – ٢ , ٧٣ للنحاس . وجد علاقة قوية بين العناصر المستخلصة بمحلول DTPA وطريقة التحليل الجزئي المستخدمة بهذه الدراسة .

لهذا فإن إستخلاص العناصر الدقيقة بمحلول DTPA طريقة جيدة لمعرفة تراكيز هذه العناصر الدقيقة الميسرة للنبات في عينات التربة المدروسة .