FJARD VOL. 35, NO. 3. PP. 458-469 (2021)

Fayoum Journal of Agricultural Research and Development
ISSN:1110- 7790

Assessment and spatial distribution of some micronutrients within soils of ibshway district, Fayoum governorate, Egypt.

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ABSTRACT

The main objective of conducting this study is to assess the state, concentrations or levels of some plant micronutrients (Fe, Mn, Zn) in the soils of Ibshway District - Fayoum Governorate - Egypt.
It was found that the general mean of total and DTPA- extractable Fe, Mn, Zn were 42745.42 and 0.43 mg Fe/kg soil, 260.85 and 1.69 mg Mn/kg soil, and 51.85 and 0.23 mg Zn/kg soil, respectively.
Key words: micronutrients - iron - manganese - zinc - soil - Ibshway District – Fayoum.

Introduction:

Total Iron (Fe):

Shui-Sheng et al., 2016 mentioned that iron is the third greatest metal element in soils. The iron content in soils may vary between one and several hundred grams per kilogram depending on the type of parent materials. There are sixteen iron oxides, oxide hydroxides, and hydroxides known in the environment to date. Among these iron oxides, Fe_2O_3 (α and γ form), Fe3O_4, and FeOOH (α and γ form) are of interest and attracted the greatest amount of attention due to their good distribution in soils and industries.

In soil science, iron species can be generally classified into several groups, including organically bounding iron, amorphous iron, free iron, and total iron. Free iron is defined as the iron coated/adsorbed on the surface of soil but not counting in the lattice structure of the soil. For the basic soil analysis, free iron is the major analytical item because it is an important indicator for understanding the genesis of soil, soil classification, and soil the distribution behavior **Blume and Schwertmann, 1969 and McKeague and Day, 1966**. For example, the ratio of the amorphous iron and free iron is an important indicator to distinguish the weathering extent of the soil horizon. Deb was among the first to use sodium dithionite to measure the free iron oxide content of soils (Deb, 1950).

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Received: 27/10/ 2021
Accepted:1/11/ 2021

Iron (Fe) is an element relatively abundant in many cultivated soils with, on average, a total concentration of 20 to 40 g kg^{-1} **Cornell and Schwertmann, 2003**. In its ferrous (FeII) state, Fe is mainly present in primary minerals and some phyllosilicates; its oxidation to the ferric form (FeIII) leads to important changes in pedogenetic processes **Torrent and Cabedo 1986; Adriano 2001; Stucki et al. 2002** resulting in the formation of a series of "conjugate bases" where Fe is Among Fe pedogenetic forms of crystalline Fe (hydro) oxides, goethite (α-FeOOH) and hematite (α-Fe_2O_3) are the most abundant minerals in well-drained soil. Other Fe oxides may exist in poorly drained soil as crystalline minerals (lepidocrocite, maghemite, and magnetite), or short-range-ordered crystalline minerals (ferrihydrite and ferroxite) or noncrystalline precipitates **Schwertmann 1985; Cornell and Schwertmann 2003**.

DTPA- extractable Iron (Fe):

Soluble iron in soil pore spaces may be a useful parameter for evaluating potential toxicity or community effects for soil microfauna. For example, elevated iron in soil pore water may result in soil bacterial communities dominated by iron bacteria. The soil-water partition coefficient (Kd) for iron is pH-dependent. **Baes et al. 1984** reported Kd values ranging from 1.4 to 1,000 L/kg over a pH range of 4.5 to 9.0; a value of 25 is used for their modeling assumptions.

Available zinc and iron (DTPA extractable) was extracted with DTPA extractant (0.005 M Diethylene Triamine Penta Acetic acid + 0.1 M Triethanol amine + 0.01 M $CaCl_2$) at 1:2 soils to extractant ratio, shaken for two hours and filtered as described by **Lindsay and Norwell (1978)**. Zinc and Iron concentration in the filtrate was determined by Atomic Absorption Spectrophotometer under suitable measuring conditions **Page et al., 1982**.

The DTPA-Fe ranged from 3.2 to 34.6 mg kg^{-1} in different horizons of soil series and decreased with depth. The irregular distribution of Fe in the soils of Naurangpura series might be due to the weak pedogenic manifestation and alluvial nature of these soils **Sangwan and Singh 1993.** These results are in close agreement with the findings of **Sharma et at. 1985** and **Dhir 1977** in arid soils of Rajasthan. The DTPA-Mn varied from 6.1 to 31,6 mg kg^{-1} and decreased with depth in all the pedons. The higher content of Mn in surface soils could be attributed to the addition of organic matter and the chelating of organic compounds released during decomposition.

Total Manganese (Mn):

Behera and Shukla, 2014 reported that the contents of the total, as well as extractable Mn and Fe varied widely with extractants and soil series. However, the amounts of Mn or Fe extracted by diethylene triamine penta-acetic acid (DTPA), Mehlich 1, Mehlich 3, 0.1 mol L^{-1} HCl and ammonium bicarbonate DTPA (ABDTPA) were significantly correlated with each other ($P < 0.01$). Based on the DTPA-extractable contents and the critical limits (2 mg Mn kg^{-1} soil and 4.5 mg Fe kg^{-1} soil).

Systematic information regarding the distribution of total manganese under different cropping systems in major soils of India in general and Haryana, in particular, is scant **Narender et al., 2017**.

DTPA- extractable Manganese (Mn):

Renge 2015 reported that micronutrient availability in the rhizosphere is controlled by soil and plant properties, and interactions of roots with microorganisms and the surrounding soil. Plants exude a variety of organic compounds (carboxylate anions, phenolics, carbohydrates, amino acids, enzymes, etc.) and inorganic ions (protons, phosphate, etc.) to change the chemistry and biology of the rhizosphere and increase micronutrient availability.

Mahesh Kumar et al., 2011 noted that the DTPA extractable Mn was negatively correlated with pH in soils of Naurangpura, Molasar, Masitawali and Devas series. A significant negative correlation of calcium carbonate on DTPA-Mn was observed in soils of Molasar (r 0.460), Dune complex (r 0.448), Devas (r = 0.3\6) and Chirai series (r = 0.058). Micronutrient cations had a positive correlation with clay and a significant effect was found for DTPA-Fe, Mn and Zn. Higher the clay content in soils, more surface area available for ion exchange which finally contributes to the greater DTPA extractable forms of these micronutrients.

Total Zinc (Zn):

The range of total zinc concentrations in soils reported in the literature tends to show an overall mean total concentration of around 55 mg Zn kg^{-1}. **Kiekens 1995** reported a typical range of zinc in soils of 10-300 mg kg^{-1} with a mean of 50 mg Zn kg^{-1}.

Bertrand et al., **2002** identified a range of total zinc concentrations of 4-41 mg kg^{-1} in alkaline, non-calcareous (< 2% $CaCO_3$) arable soils in South Australia and Victoria, and 5-36 mg kg^{-1} in calcareous soils (>2% $CaCO_3$) in the same regions.

The results of **Rutkowska et al., 2015** indicated that zinc activity in the soil solutions was very high and comparable to the total concentration of zinc.The investigated soil properties significantly influenced the K_d, the total concentration of zinc, as well as the concentration of Zn^{2+} in the soil solution. The total concentration and activity of zinc in the soil solution increased with increasing Zn content in the soil and rising soil acidity while they decreased with increasing the content of organic carbon and clay particles.

Regmi et al., 2010 reported that more than 80 % of the total Zn content occurred in the relatively inactive and mineral-bound residual form (RES), whereas only a small fraction occurred in WS, EX, OM, AFe-OX, and CFe-OX fractions. Among all the fractions, water soluble and exchangeable (which are important for plant use) were higher in biological than conventional soils at both locations. Management systems, particularly biological practices, enhanced plant-available and total Zn pools in soils.

Total Zn in soils indicates the potential capacity of soils to supply Zn for crop production given the capacity of crop to exploit it. However, total Zn in soil doesn't indicate Zn availability to plants. Soil Zn fractions are influenced by different factors for e.g. **Adhikari and Rattan, 2007** reported that soil pH and organic matter level markedly alter the distribution of Zn among the plant available pools.

DTPA- extractable Zinc (Zn):

Dhaneshwar et al., 2016 tried to find out the relationship between physic-chemical properties and DTPA-extractable Zn (available Zn) content of rice soils. For this eighty- four (84) surface soil samples (0-20cm) were collected from three villages (viz. Saharapali, Nuagarh and Adgaon) of Bargarh district under the Hirakud Command Area of Odisha. Analytical observations revealed that the soils were slightly acidic in reaction with a moderately high content of soil organic carbon.

Abida et al., 2020 reported that the AB-DTPA-extractable Zn and soil pH was determined at 0, 7, 14, 28, 56 and 84 days of incubation. Results revealed that more extractable Zn was recorded in the low-limed soil as compared with high-limed soil. Further, more extractable Zn was detected in both soils when treated with PM (84.62%), followed by FYM (69.23%) and BC (52.56%) during 0–28 days as compared with control.

Ramiro et al., 2021 found that the initial DTPA-Zn increased with increased Olsen P (R2 = 0.41; $p < 0.001$) and with increased ratio of Fe in poorly crystalline to Fe in crystalline oxides (R2 = 0.58; $p < 0.001$). DTPA-Zn decreased with increased cumulative Zn uptake, but not in soils with DTPA-Zn < 0.5 mg kg^{-1}. Overall, the available Zn is more relevant in explaining Zn uptake by plants than applied Zn sulfate.

MATERIALS AND METHODS:

Soil samples were collected reached One hundred and seventeen from thirty-nine sites representing the Ibshway District area following the grid system at distances of 2 kilometers during June 2016. Locations of the studied sites were identified using a "GPS" (Model German).

Three soil samples were taken from each site: the first from the surface soil layer at a depth of (0 –30 cm) the second represented the subsurface soil layer at a depth of (30–60 cm) and third soil layer at a depth of (60 –90 cm). The collected soil samples were air-dried, crushed with a wooden hummer, passed through a 2 mm sieve and stored in plastic bottles. The collected soil samples were analyzed for total and DTPA- extractable iron 'Fe" manganese "Mn" and Zinc "Zn", organic matter, total $CaCO_3$, particle size distribution, ECe and pH using the following methods:

- Particle size distribution, by the hydrometer method (ASTM No. 152 H Temp.) using sodium hexameta phosphate - sodium carbonate as dispersing agents **Jacks, 1986**.
- Calcium carbonate content, volumetrically using Schreiber's calcimeter **Page et al., 1982**.
- Soil (pH) in soil paste using a pH -meter according to page et al., (1982).
- Electrical conductivity (ECe), in the saturation paste extract using EC- Meter according to Page et al., (1982).
- Available forms of iron 'Fe" manganese "Mn" and Zinc "Zn" in soil were extracted using diethylene triamine penta acetic acid (DTPA) at pH 7.3 and determined with Inductively Coupled Plasma (ICP), according to USDA, Soil Survey Lab Manual (2004).
- Total content of iron 'Fe" manganese "Mn" and Zinc "Zn"in soil samples (0.5 g each) were digested with 9.0 mL (HNO_3) and 3.0 mL hydrochloric (HCl) acids using Teflon flasks and determined with Inductively Coupled Plasma (ICP), according to **USDA, Soil Survey Lab Manual 2004**.
- Organic matter content according to Walkely and Black method as described by **Page et al., 1982**.

The obtained concentrations total and DTPA- extractable iron 'Fe" manganese "Mn" and Zinc "Zn" were classified into different categories (ranges), their geographical distribution throughout the whole area of Ibshway District were identified and mapped using the Geographic Information System (GIS) and Integrated Land and " ILWIS software" to produce colored soil maps for each tested component.

Results and discussion:

Total Iron (Fe):

Data in table (1) which illustrated by maps (1, 2 a, b and c) stated that the values total and DTPA- extractable iron in tested soils of Ibshaway District. It was clear that the amount of total and DTPA- extractable iron in surface layer (0 – 30 cm) ranged between 11485 and 70256 and 0.229 to 0.732 mg Fe/ Kg soil respectively. While, the subsurface layer (30 – 60 cm) ranged from 20305 to 59085 and between 0.229 and 0.770 mg Fe/ kg soil. On the other hand, the amount of total and DTPA- extractable iron in the third layer (60 – 90 cm) ranged between 21245 and 101056 and from 0.229 to 0.800 mg Fe/ kg soil respectively.

Table (1) Levels of total soil Iron (Fe) throughout Ibshway District area.

Depth	Range (mg/kg)	Area (Feddan)	% of area
	< 20000	42.19	0.11
0 -30	20000 - 50000	35517.54	92.59
	50000 - 100000	2775.70	7.30

	> 100000	0.00	0.00
30 - 60	< 20000	1.07	0.00
	20000 - 50000	36904.21	97.03
	50000 - 100000	1129.98	2.97
	> 100000	0.00	0.00
60 - 90	< 20000	0.11	0.00
	20000 - 50000	33538.45	88.18
	50000 - 100000	4497.00	11.82
	> 100000	0.00	0.00

Generally, the minimum values of total and DTPA- extractable iron in tested soils of Ibshaway District ranged from 11485 to 101056 and between0.229 and 0.800 mg Fe/ kg soil respectively. Also, the average values of total and DTPA- extractable iron were 42745.42 and 0.430 mg Fe/ kg soil**. Shui-Sheng et al., 2016** mentioned that iron is the third greatest metal element in soils. The iron content in soils may vary between one and several hundred grams per kilogram depending on the type of parent materials. There are sixteen iron oxides, oxide hydroxides, and hydroxides known in the environment to date. Among these iron oxides, Fe_2O_3 (α and γ form), Fe_3O_4, and FeOOH (α and γ form) are of interest and attracted the greatest amount of attention due to their good distribution in soils and industries.

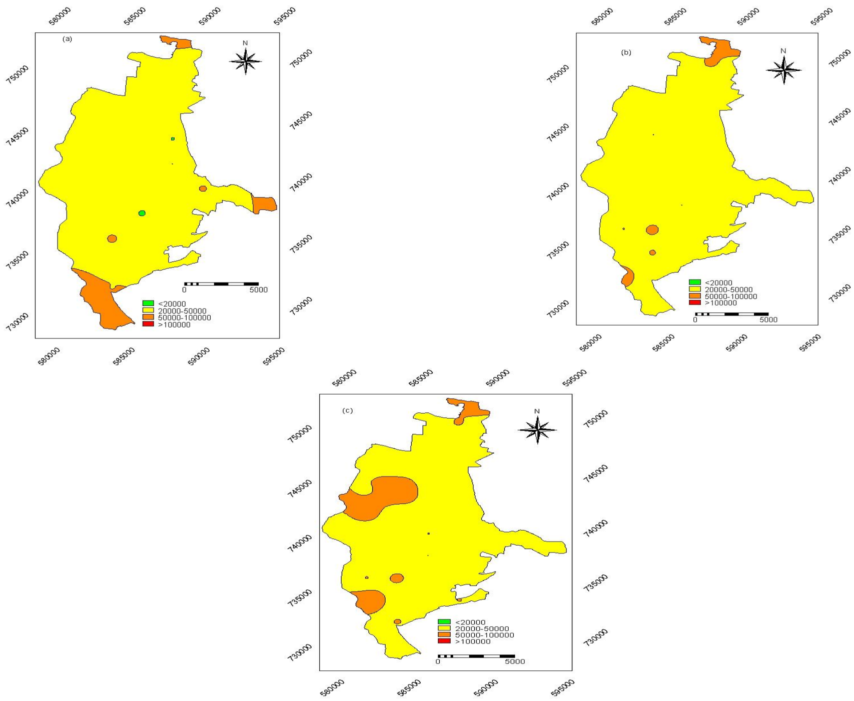

Fig. (1) Spatial distribution of total iron (Fe) content throughout Ibshway District area (soil depth 0-30, 30 -60 and 60-90 cm).

Table (2) Levels of extractable soil Iron (Fe) throughout Ibshway District area.

Depth	Range (mg/kg)	Area (Feddan)	% of area
0 -30	< 0.2	0.00	0.00
	0.2 – 0.4	16416.75	43.16
	0.4 – 0.6	19967.30	52.50
	> 0.6	1652.30	4.34
30 - 60	< 0.2	0.00	0.00
	0.2 – 0.4	16416.75	43.16
	0.4 – 0.6	19967.30	52.50
	> 0.6	1652.30	4.34
60 - 90	< 0.2	0.00	0.00
	0.2 – 0.4	11285.38	29.67
	0.4 – 0.6	26530.55	69.75
	> 0.6	219.21	0.58

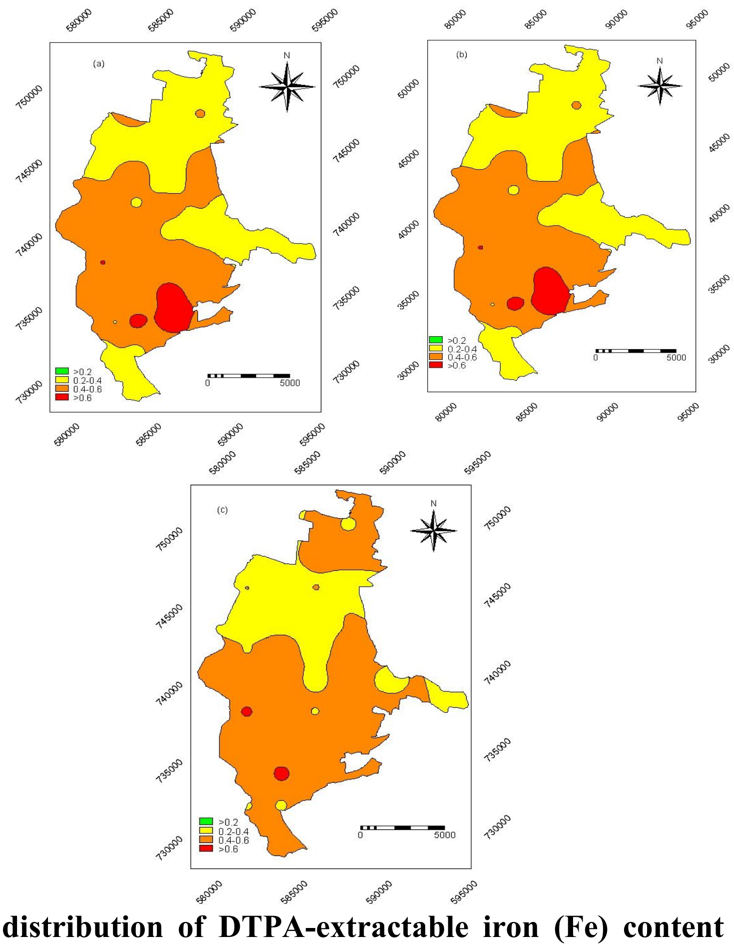

Fig. (2) Spatial distribution of DTPA-extractable iron (Fe) content throughout Ibshway District area (soil depth 0-30, 30 -60 and 60-90 cm).

Manganese (Mn):

Data in table (3 and 4) which is illustrated by maps (3 and 4 a, b and c) stated that the values total and DTPA- extractable manganese (Mn) in tested soils of Ibshaway District. It was clear that the amount of total and DTPA- extractable manganese (Mn) in surface layer (0 – 30 cm) ranged between 260 and 857 and from 1.388 to 2.440 mg Mn/ Kg soil respectively. While, the subsurface layer (30 – 60 cm) ranged from 275 to 926 and between 0.947 and 3.522 mg Mn/ kg soil. On the other hand, the amount of total and DTPA- extractable manganese (Mn) in the third layer (60 – 90 cm) ranged between 279 and 3583 and from 1.023 to 2.764 mg Mn/ kg soil respectively.

Table (3) Levels of total soil manganese (Mn) throughout Ibshway District area.

Depth	Range (mg/kg)	Area (Feddan)	% of area
0 -30	< 300	2.89	0.01
	300 - 500	2681.41	7.05
	500 - 800	35188.29	92.52
	> 8000	163.18	0.43
30 - 60	< 300	0.86	0.00
	300 - 500	1957.45	5.15
	500 - 800	35782.37	94.08
	> 8000	294.59	0.77
60 - 90	< 300	38035.47	100.00
	300 - 500	0.00	0.00
	500 - 800	0.00	0.00
	> 8000	0.00	0.00

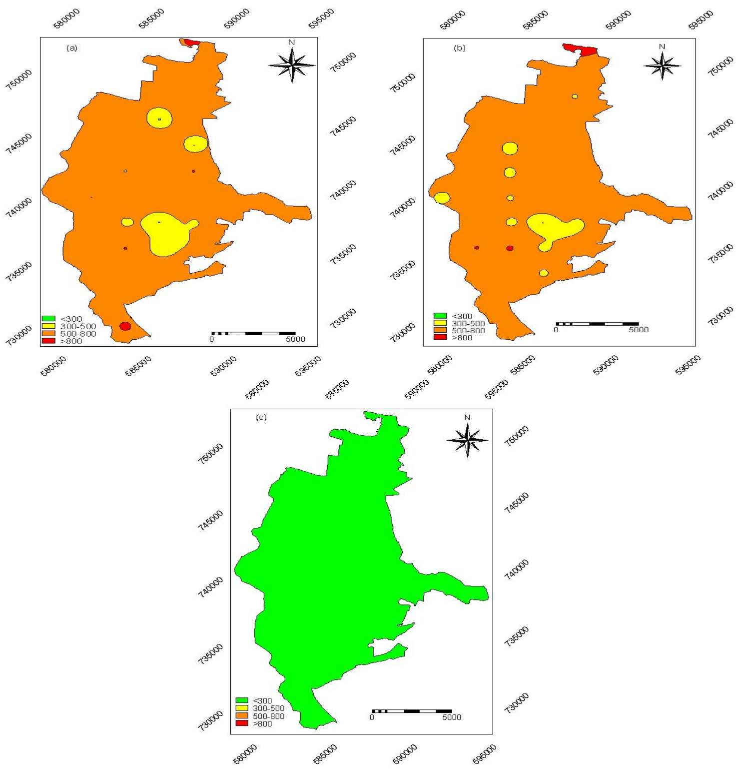

Fig. (3) Spatial distribution of total manganese (Mn) content throughout Ibshway District area (soil depth 0-30, 30 -60 and 60-90 cm).

Generally, the minimum values of total and DTPA- extractable manganese (Mn) in tested soils of Ibshaway District ranged from 11485 to 101056 and between0.229 and 0.800 mg Mn/ kg soil respectively. Also, the average values of total and DTPA- extractable manganese (Mn) were 42745.42 and 0.430 mg Mn/ kg soil.

Table (5) Levels of extractable soil manganese (Mn) throughout Ibshway District area.

Depth	Range (mg/kg)	Area (Feddan)	% of area
0 - 30	< 1.5	1589.60	4.18
	1.5 – 2.0	36177.48	95.12
	2 – 2.5	267.56	0.70
	> 2.5	0.00	0.00
30 - 60	< 1.5	946.90	2.49
	1.5 – 2.0	34551.72	90.84
	2 – 2.5	2361.70	6.21
	> 2.5	174.80	0.46
60 - 90	< 1.5	946.90	2.49
	1.5 – 2.0	34551.72	90.84
	2 – 2.5	2361.70	6.21
	> 2.5	174.80	0.46

The total amount of manganese in the soil is between 20 to 3000 ppm with an average values of 600 mg/kg. Divalent manganese is absorbed by clay minerals and organic material, and In terms of nutrition plant, divalent manganese ions (Mn^{2+}) is most important **Malakouti and Tehrani, 1999**.

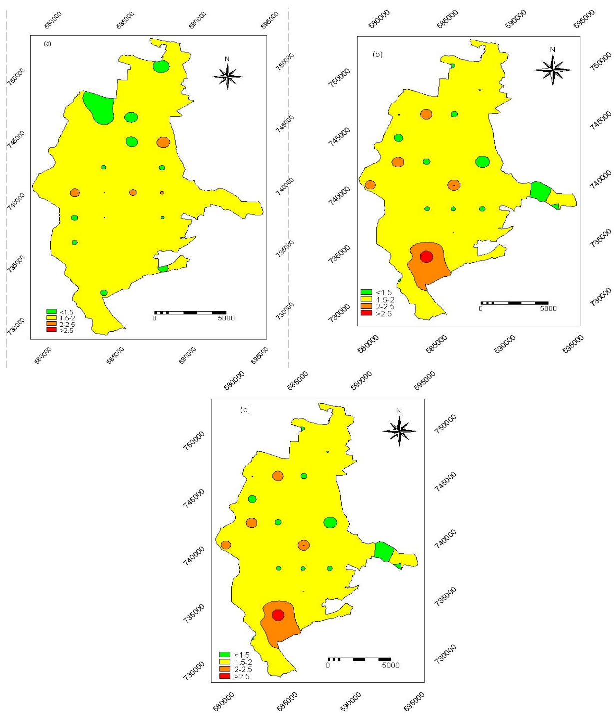

Fig. (4) Spatial distribution of DTPA -extractable manganese (Mn) content throughout Ibshway District area (soil depth 0-30, 30 -60 and 60-90 cm).

Zinc (Zn):

Data in table (5 and 6) which is illustrated by maps (5 and 6 a, b and c) stated that the values total and DTPA- extractable Zn in tested soils of the Ibshaway District. It was clear that the amount of total and DTPA- extractable zinc (Zn) in the surface layer (0 – 30 cm) ranged between 26.40 and 97.10 and from 0. 093 to 0.0.634 mg Zn/ Kg soil respectively. While, the subsurface layer (30 – 60 cm) ranged from 19.80 to 85.90 and between 0.110 and 0.698 mg Zn/ kg soil. On the other hand, the amount of total and DTPA- extractable zinc (Zn)in the third layer (60 – 90 cm) ranged between 24.50 and 90.90 and from 0.085 to 0.976 mg Zn/ kg soil respectively.

Table (5) Levels of total soil zinc (Zn) throughout Ibshway District area.

Depth	Range (mg/kg)	Area (Feddan)	% of area
0 - 30	< 30	6.64	0.02
	30 -60	29433	77.38
	60 - 90	8585.65	22.57
	> 90	9.21	0.02
30 - 60	< 30	23.84	0.06
	30 -60	33870.24	89.05
	60 - 90	4141.04	10.89
	> 90	0.00	0.00
60 - 90	< 30	48.32	0.13
	30 -60	34658.81	91.12
	60 - 90	3328.13	8.75
	> 90	0.11	0.00

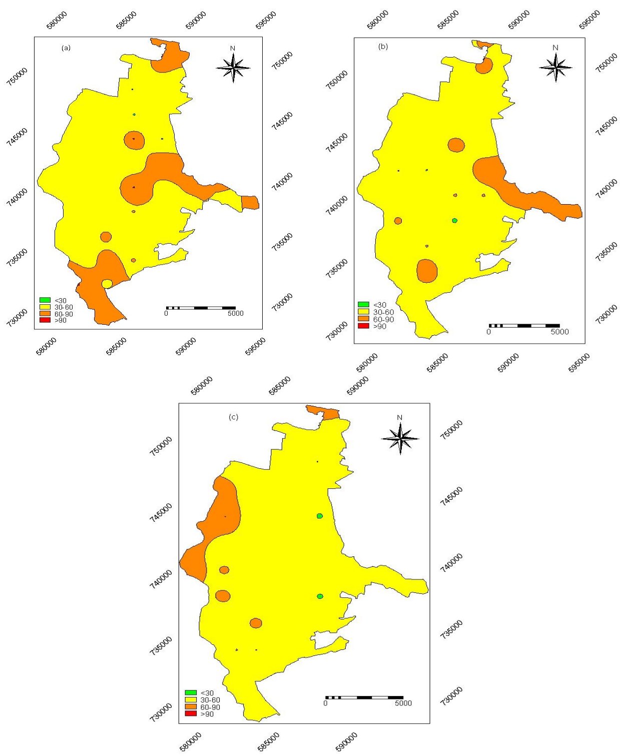

Fig. (5) Spatial distribution of total zinc (Zn) content throughout Ibshway District area (soil depth 0-30, 30 -60 and 60-90 cm).

Generally, the minimum values of total and DTPA- extractable zinc (Zn) in tested soils of Ibshaway District ranged from 11485 to 101056 and between 0.229 and 0.800 mg Zn/ kg soil respectively. Also, the average values of total and DTPA- extractable zinc (Zn) were 42745.42 and 0.430 mg Zn/ kg soil.

Table (6) Levels of extractable soil zinc (Zn) throughout Ibshway District area.

Depth	Range (mg/kg)	Area (Feddan)	% of area
0 - 30	< 0.1	2.41	0.01
	0.1 – 0.4	37583.36	98.81
	0.4 – 0.6	448.31	1.18
	> 0.60	1.39	0.00
30 - 60	< 0.1	0.00	0.00
	0.1 – 0.4	37839.08	99.48
	0.4 – 0.6	190.34	0.50
	> 0.60	6.05	0.02
60 - 90	< 0.1	263.22	0.69
	0.1 – 0.4	36572.89	96.16
	0.4 – 0.6	1094.12	2.88
	> 0.60	105.27	0.28

Total Zn in soils indicates the potential capacity of soils to supply Zn for crop production given the capacity of crop to exploit it. However, total Zn in the soil doesn't indicate Zn availability to plants. Soil Zn fractions is influenced by different factors for e.g. **Adhikari and Rattan, 2007** reported that soil pH and organic matter level markedly alter the distribution of Zn among the plant available pools.

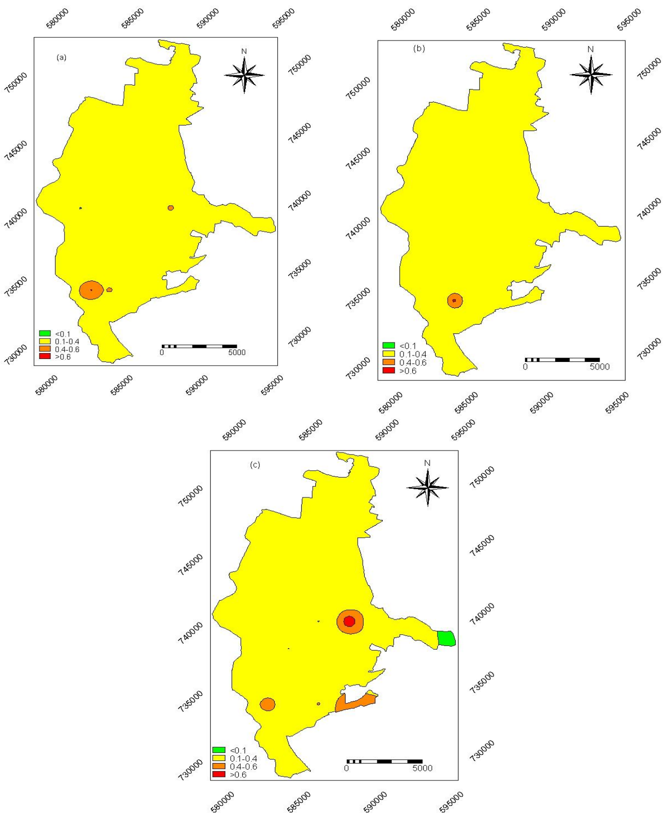

Fig. (6) Spatial distribution of DTPA-extractable zinc (Zn) content throughout Ibshway District area (soil depth 0-30, 30 -60 and 60-90 cm).

REFERENCES:

Abida Saleem; Dost Muhammad; Mumtaz Khan; Qudrat Ullah Khan; Muhammad Rizwan; Salma Shaheen Hamza Noor; Shiza Gul3; Muhammad Daud Khan and Shafaqat Ali 2020. Dynamics of AB-DTPA-extractable Zn in high and low limed calcareous soils amended with biochar and farmyard and poultry manures. Arabian Journal of Geosciences. 13: 145.

Adhikari T, Rattan RK 2007. Distribution of zinc fractions in some major soils of India and the impact on nutrition of rice. Communications in Soil Science and Plant Analysis 38, 2779-2798.

Adhikari T, Rattan RK 2007. Distribution of zinc fractions in some major soils of India and the impact on nutrition of rice. Communications in Soil Science and Plant Analysis 38, 2779-2798.

Adriano A.D. 2001. Trace elements in terrestrial environments: biogeochemistry, bioavailability, and risks of metals, Springer, New York Advances in Agronomy 99:183-225.

Baes III, C. F., R. D. Sharp, and A.L. Sjoreen. 1984. A Review and Analysis of Parameters for Assessing transport of environmentally released radionuclides through agriculture. ORNL-5786.

Behera S. K. and Shukla A. K. 2014. Total and Extractable Manganese and Iron in Some Cultivated Acid Soils of India: Status, Distribution and Relationship with Some Soil Properties. Pedosphere 24(2): 196–208, 2014.

Bertrand, L.J., R.E. Holloway, R.D. Armstrong and M.J. McLaughlin 2002. The rapid assessment of concentrations and solid phase associations of macro and micro nutrients in alkaline soils by mid-infrared diffuse reflectance spectroscopy. Australian Journal of Soil Research, 41: pp 61-76, 2003.

Blume, H. P. and Schwertmann, V. 1969. "Genetic evaluation of profile distribution of aluminum, iron and manganese oxides," SoilScience Society of America, Proceedings, vol. 33, no. 3, pp. 438–444.

Cornell R.M. and Schwertmann U. 2003. The iron oxides, 2nd edn. Wiley-VCH, Weinheim

Dhaneshwar Padhan; Arup Sen and Biplab Pal (2016). DTPA-Extractable Zinc in Rice Soils and Its Availability to Rice. Current World Environment Vol. 11(2), 662-669.

Dhir, R.P. 1977. Western Rajasthan Soils: Their characteristics and properties. In: Desertification and its contro/. pp. 102-115. ICAR, New Delhi, India.

Jacks, G., Olofsson, E. and Werme, G. (1986). An acid surge in a well-buffered stream. Ambio 15, 282-285.

Kiekens, L. 1995. Zinc, in Alloway, B.J. (ed.) Heavy Metals in Soils (2^{nd} edn.). Blackie Academic and Professional, London, pp 284-305.

Lindsay, W.L. and Norwell, W.A. 1978. Development of DTPA soil test for Zinc, iron, manganese and copper. Soil Sci. Soc. Am. J., 42: 421-428.

Mahesh Kumar, P. Raina and B. K. Sharma (2011). Distribution of DTPA extractable micronutrients in arid soils of Churu district, Rajasthan. Agropedology. 21 (I). 44-48.

Malakouti, M.J., M.H. Tehrani, 1999. Effect of micronutrients on the yield and quality of agricultural products: micro-nutrients with macro-effects. Tarbiat Modares University publication, Iran.

McKeague, J. A. and Day, J. H. 1966. "Dithionite- and oxalate-extractable Fe and Al as aids in differentiating various classes of soils," Canadian Journal of Soil Science, vol. 46, no. 1, pp. 13– 22.

Narender, R. S. MALIK and Shivakumar L. 2017. Kinetic release behavior of DTPA-extractable manganese in soils of different cropping systems and total manganese content associated with soil texture. Indian

Journal of Agricultural Sciences 87 (5): 603–6.

Page, A.L., Miller, R.H. and Kenay, D.R. 1982. Methods of soil analysis. Part-2 Soil Science of America, Inc. Publs. Madison, Wisconsin, USA.

Ramiro Recena; Ana M. García-López and Antonio Delgado 2021. Zinc Uptake by Plants as Affected by Fertilization with Zn Sulfate, Phosphorus Availability, and Soil Properties. Agronomy, 11, 390. https://doi.org/10.3390/agronomy11020390.

Regmi, B.; Rengel, Z. and H. Shaberi-Khabaz 2010. Fractionation and distribution of zinc in soils of biologically and conventionally managed farming systems, Western Australia. 19th World Congress of Soil Science, Soil Solutions for a Changing World 1 – 6 August 2010, Brisbane, Australia.

Renge Z. 2015. Availability of Mn, Zn and Fe in the rhizosphere. ournal of Soil Science and Plant Nutrition, 15 (2), 397-409.

Rutkowska, B.; Szulc,W.; Bomze, K.; Gozdowski, D.and Spychaj-Fabisiak, E. 2015. Soil factors affecting solubility and mobility of zinc in contaminated soils. Int. J. Environ. Sci. Technol. 12:1687–1694.

Sangwan. B.S. and Kuldeep Singh 1993. Vertical distribution of Zn, Mn, Cu and Fe in the semi-arid soils of Haryana and their relationship with soil properties. Journal of the Indian Society of SOIL Science 41, 463-467.

Schwertmann U. 1985. The effect of pedogenic environments on iron oxide minerals. Adv Soil Sci 1:172–200.

Sharma, B. K., Dhir, R. P. and Joshi, D. C. 1985. Available micronutrient status of some soils arid zone. Journal of the Indian Society of Soil Science 33, 50-55.

Shui –Sheng, Fan, Feng-Hsiang Chang, Hsin-Ta Hsueh and Tzu-Hsing Ko 2016. Measurement of Total Free Iron in Soils by H2S Chemisorption and Comparison with the Citrate Bicarbonate Dithionite Method. Journal of Analytical Methods in Chemistry Volume 2016, Article ID 7213542, 7 pages. http://dx.doi.org/10.1155/2016/7213542.

Stucki JW, Lee K, Zhang L, and Larson RA 2002. Effects of iron oxidation state on the surface and structural properties of smectites. Pure Appl. Chem 74:2145–2158.

Torrent J, Cabedo A 1986. Sources of iron oxides in reddish brown soil profiles from calcarenites in Southern Spain. Geoderma 37:57–66

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التوزيع الجغرافي لبعض عناصر المغذيات الصغرى في أراض مركز إبشواي- محافظة الفيوم – مصر.

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كان الهدف من هذه الدراسة هو تقييم مستويات بعض عناصر المغذيات النباتية الصغرى (حديد، منجنيز، زنك) الكلي والمستخلص في أراضي مركز إبشواي بمحافظة الفيوم بجمهورية مصر العربية.

وقد بينت النتائج أن المتوسط العام لكل من الحديد والمنجنيز والزنك الكلي المستخلص بمحلول ثنائي الإيثيلين ثلاثي الأمين خماسي حامض الخليك DTPA هي 42745.42 و 0.430 ملليجرام حديد/ كجم تربة، و260.85 و 1.69 ملليجرام منجنيز/ كجم تربة، و51.85 و 0.23 ملليجرام زنك/ كجم تربة على الترتيب.