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DETERMINATION OF BORON LEVELS IN SOME DIFFERENT EGYPTIAN SOILS

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ABSTRACT

The current study is mainly carried out to through light on the background levels of total and available boron contents in different types of Egyptian soils, as it is one of the essential micronutrient elements for plant grown. Thirteen soil profiles were collected from different governorates of Egypt to represent the Nile alluvial, sandy, calcareous and lacustrine soils.

The obtained data showed that, the total boron content was varied from 48.1 to 71.9 µg g^{-1} in alluvial soils and from 14.3 to 26.7 µg g^{-1} in sandy soils. While in calcareous and lacustrine soils these values ranged from 25.7 to 44.1 and from 69.3 to 189.7µg g^{-1}, respectively. The highest total contents are found in lacustrine soils, especial at El-Tina plain soils. In general, boron values can be arranged according to the Egyptian soil types in the following order: Lacustrine > Nile alluvial > calcareous > sandy soils.

Available boron as hot water soluble boron values (HWB) were recorded a wide variation in their contents in different soil types. These values varied from 0.6 to 2.0; 0.9 to 1.7; 0.4 to 0.9 and from 2.9 to 7.3 µg g^{-1} in the Nile alluvial, sandy, calcareous and lacustrine soils, respectively.

Factors affecting total and available boron in the different studied soil types, the correlation coefficients were calculated. The values reveal that the total and available boron contents are almost dependent on soil parent material and its main properties.

The statistical measurements, i.e. weighted mean (W), trend (T) and specific range (R) of total boron were computed and interpreted in terms of soil genesis and formation.

Key words:HWB,Specific range, Trend, Total boron, Weighted mean

INTRODUCTION

Boron well enough known as essential micronutrient required for plant grown and uptake by grown plants depends mainly on its concentration in soil, soil pH, silt and clay particles concentrations and many other soil variables as well as soil environments (**Kaplan *et al.*, 1990**) .

Boron is a light non- metal. In the jargon of geochemistry B^{+3} is a lithophile element, this Greek word means that B^{+3}occurs dominantly in silicate minerals. The small ionic size of B^{+3} together with high positive charge and tendency to form covalent bonds mean that this element occur chiefly in Oxy – anions.Boron is present in all types of soils in the whole world. However, its content and status vary considerably from one soil to another and even in the subsequent layers of the same soil profile. These variations are surely controlled by several soil factors and environments. Soils differ widely in their total boron content according to the types of rock or parent material from which they were derived. Magmatic rocks are generally poor, containing only 1.5 to 3 µg g^{-1} B, whereas marine sediments and metamorphic rocks of marine origin are highly rich in B. Sea water contains appreciable amounts of B, being 5 µg g^{-1} on the average. The high concentration of B in sedimentary deposits is due to the fact that much of their B content has been deposited from marine sources. Also, boron accumulation in arid soils, especially in those subjected to salinization, is generally experienced, and toxic boron concentrations have been found in the water saturation extracts of some salt affected soils. It is necessary, therefore, to consider the soluble boron concentration in the soil as a factor in the diagnosis and reclamation of saline and alkali soils, **Richards (1954)**. Boron like most anions, are preferentially adsorbed on colloidal soil particles that carry a positive charge. Problems concerning plant nutrition with boron are experienced in soils of both arid and humid regions. In arid soils, the problem is the accumulation of boron in the soil up to the concentration of being considered toxic for plants, whereas in the soils of humid regions, the problem is the shortage in available B, as a result of the active leaching or the inactivation due to heavy liming (**Evans and Sparks, 1983**).Soil properties that may influence boron availability to plants include pH, exchangeable-Ca, soil texture, organic matter, hydrous oxides of Fe and Al, and soil salinity **(Kern and Bingham, 1985).**

In Egypt, **El-Sewi and El-Malky (1979)**, reported that the total boron content is 113 µg g^{-1} on the average, the average being twice as high in clay samples as in sandy samples. **El-Toukhy (1987)** in his study on the soils located south Idko lack reported that the total boron content ranged from 146 to 900 µg g^{-1} with an average of 335.9 µg g^{-1}. **Hassona (1999)** showed that total boron content in the soils of El-Tina plain ranged between 15.3 and 397 µg g^{-1}, while hot water soluble boron ranged from 0.1 and 7.4 µg g^{-1}.**Hassanin *et al*., (2012)** in their studies of total and available boron in different type of Egyptian soils, they reported that, the regional or lateral distribution of total boron increased upon passing from South to North. However, local conditions, topography, chance of variation within the parent material and sedimentation regime contribution to the chance in boron content along the study area.

The purpose of the present investigation is to throw light on the distribution of total and available boron values in some Egyptian soils and the statistical relationships between these values and some soil properties.

MATERIALS AND METHODS

1- Field work

Forty three soil samples from thirteen soil profiles were selected to represent some soil groups encountered in Egypt from different locations, i.e., Nile alluvial, sandy, calcareous and lacustrine soils. Soil profiles were dug deep down to 150 cm depth unless opposed by hardpan, bedrock or water table. Profiles 1, 2, 3 and 4 were represented Nile alluvial soils from El- Kanater El- Khyria, Qalub, Bilbays and El-Zagazig, respectively. Sandy soils were represented by profiles 5, 6and 7 which collected from Suez, Ismailiya and Port Said, respectively. Soil profiles 8, 9 and 10 were represented the calcareous soils from King Marut, El- Nobariya and El- Salloum, respectively. Soil profiles 11,12 and 13 were represented the lacustrine soils from El- Tina plain, El- Manzala and Idko soils, respectively.

The collected soil samples were air-dried, sifted and sieved through a 2 mm sieve to get the fine particles, then kept in plastic bottles for analyses.

2- Laboratory analyses:

- Particle size distribution by the international pipette method according to **(Piper, 1950).**

- Soil texture classes were determined using the texture triangle diagram (**USDA, 2004).**

- Determination of organic matter contents according to (**USDA, 2004)**.

- Soil reaction (pH) of saturated soil paste and electrical conductivity (EC) were determined according to **(Page *et al.*, 1982)**.

- Total carbonate content was determined volumetrically using Collin's calcimeter **(Jackson 1973)**. while cation exchange capacity was determined by Hissink's method as modified by **Gohar (1954)**.

- Total boron was determined in 1 g portions digested with HF-$HClO_4$ acids mixture in a platinum crucible **(Jackson, 1973)**. Available boron was extracted by boiling a suspension of 20 g soil and 40 ml distilled water under reflux for 5 minutes as described by **Page *et al.*, (1982)**. After cooling and filtration, determination of total and available boron was carried out colormetrically by curcumin method **(Dible *et al*., 1954)**.

3- Statistical methods:

Independent variables were determined for simple and multiple liner regression models at the 95 and 99 % confidence levels ($p < 0.05$ and 0.01, respectively) according to **Pankhurst and Appelo (1999)**.

RESULTS AND DISCUSSION

Soil characteristics:

Nile alluvial soils

Data presented in **Table (1)** showed that the Nile alluvial soils location which are represented by profiles Nos.1, 2, 3 and 4 from El- Kanater El- Khyria, Qalub, Bilbays and El-Zagazig, respectively revealed that, soil texture class variable from clay, clay loam and silty clay where, clay texture was dominant throughout the other different representative soil profiles depth, the clay particles percentage was found more than 48.5% as particle size distribution, Soil reaction is slightly to moderately alkaline where pH values varied from 7.46 to 7.84. These soils are characteristics with non-saline to very slightly saline soils as indicated by EC values which varied from 1.25 to 2.68 *dS*/m. Organic matter content was ranged from 1.22 to 3.11 % with higher contents in the surface layers. $CaCO_3$ content is very low and in a narrow range, it was varied from 0.57 to 3.29 % with an irregular distribution pattern with depth. Cation exchange capacity (CEC) values were vary between 39.9 and 58.2 Cmol kg^{-1}. The highest values of (CEC) were found in Qalub soils which has a relatively high contents of clay and organic matter. These results are coordinate with those in Nile alluvial soils of Egypt, reported by **Hassanin *et al*., (2012)** who concluded that (CEC) values of Kafr El- Dawar, Abou Homass, Damanhor, El-Mansoura and El-Zagazig soils as Nile Alluvial soils were ranged from 23.4 to 54.6 Cmol kg^{-1}.

Sandy soils

In case of sandy soil locations which are represented by profiles Nos. 5, 6 and 7 from Suez, Ismiliya and Port Said soils respectively. These soils are very poor in organic matter contents.

Soil texture class ranged between sand to sandy loam where, the sand texture was dominant throughout the different soil profiles depth, the sand particle percentage was found more than 74.8%. Where, coarse sand ranged from 18.7 to 30.3 %, while fine sand from 49.6 to 70.5 %, as shown in (Table 1).

With regard to the chemical properties, data in **Table (1)** showed that, these soils were slightly to moderately alkaline soil reaction where pH values varied from 7.56 to 8.02. These soils are characteristics with very slightly saline to slighty saline soils. EC values were ranged from 2.35 to 4.89 *dS*/m. Organic matter content was very poor and it ranged from 0.39 to 0.71 %. The hot climatic zone, besides the absence of natural vegetation are the main factors affecting the reduction of soil organic matter. $CaCO_3$ content was varied from 1.98 to 3.46 %. Cation exchange capacity (CEC) of sandy soils was very low and it have values varied from 2.8 to 6.1 Cmol kg^{-1}. The

Table1. Some chemical and physical properties of the studied soil profiles.

Location	Prof. No.	Depth (cm)	ECe dS/m	pH	O.M %	$CaCO_3$ %	Particle size distribution%				Textural class	CEC Cmol / kg
							C.Sand	F.Sand	Silt	Clay		
	Nile alluvial soils											
El-Kanater El-Khyria	1	0 – 30	1.67	7.56	2.84	0.98	0.4	18.6	17.8	63.2	C	52.3
		30 – 75	1.95	7.59	2.53	0.57	0.7	11.3	22.4	65.6	C	54.5
		75 – 110	2.11	7.84	1.93	0.72	0.5	21.3	18.5	59.7	CL	47.1
		110 - 150	1.86	7.76	1.22	0.84	0.9	17.1	13.6	68.4	C	55.7
Qalub	2	0 – 35	1.25	7.62	3.11	1.03	1.1	5.3	22.4	71.2	C	58.2
		35 – 80	1.48	7.71	2.99	1.16	0.8	11.2	20.9	67.1	C	56.7
		80 – 100	1.39	7.79	2.36	1.22	0.9	5.4	28.9	64.8	C	52.9
		100 - 150	1.33	7.68	2.12	1.18	1.6	12.4	31.7	54.3	C	46.8
Bilbays	3	0 – 25	2.11	7.56	1.98	2.55	3.5	21.3	26.7	48.5	C	39.9
		25 – 70	2.45	7.59	1.67	3.29	3.8	22.7	19.8	53.7	SiC	44.6
		70 – 90	2.68	7.84	1.25	2.58	2.9	23.1	22.4	51.6	C	42.5
		90 - 140	2.43	7.76	1.29	2.94	2.1	14.1	23.6	60.2	CL	46.8
El- Zagazig	4	0 – 30	1.28	7.46	2.15	1.18	1.2	10.8	18.7	68.4	C	54.3
		30 – 75	2.08	7.59	1.82	1.68	0.8	12.1	16.2	70.9	CL	50.3
		75 – 100	1.98	7.84	1.54	1.45	0.9	11.2	21.6	66.3	C	47.7
		100 - 140	2.27	7.76	1.39	1.67	0.6	19.9	22.8	65.7	C	45.8
	Sandy soils											
Suez	5	0 – 25	3.12	7.88	0.64	2.90	26.3	66.5	5.4	1.8	S	3.9
		25 – 70	4.24	7.91	0.52	1.98	24.3	59.8	12.7	3.2	LS	5.7
		70 – 150	2.99	7.86	0.50	2.11	28.8	63.1	6.4	1.7	S	2.8
Ismailiya	6	0 – 20	2.35	7.72	0.68	2.88	20.6	69.4	7.1	2.9	S	3.1
		20 – 75	2.88	7.93	0.71	2.14	25.2	49.6	22.8	2.4	SL	4.6
		75 – 140	3.56	8.02	0.59	2.26	18.7	70.5	8.3	2.5	S	4.8
Port Said	7	0 – 30	4.03	7.56	0.48	2.66	29.8	62.6	5.9	1.7	S	3.0
		30 – 80	4.45	7.64	0.39	3.18	30.3	58.7	8.6	2.4	LS	6.1
		80 – 150	4.89	7.83	0.50	3.46	24.2	67.2	6.4	2.2	S	4.5

Cont: Table(1)

	Calcareous soils											
Marut	8	0 – 20	3.66	7.45	0.83	22.8	1.4	48.7	17.8	32.1	SCL	14.5
		20 – 60	5.12	7.52	0.76	17.4	0.9	69.8	22.1	7.2	LS	6.2
		60 – 95	6.37	7.61	0.55	29.5	1.2	29.5	26.7	42.6	C	15.8
El-Nobariya	9	0 – 25	2.42	7.68	0.98	18.7	3.9	65.6	14.7	15.8	SL	11.3
		25 – 80	1.99	7.72	0.79	20.1	5.2	53.6	29.4	11.8	SL	9.7
		80 – 140	2.89	7.63	0.80	28.6	9.8	65.4	18.7	6.1	LS	5.2
El- Salloum	10	0 – 15	5.78	7.59	0.28	26.7	5.4	70.5	15.9	8.2	LS	7.1
		15 – 65	7.03	7.67	0.54	31.9	6.7	49.9	13.6	29.8	SCL	13.4
		65 – 130	6.91	7.81	0.57	29.0	7.3	47.2	40.2	5.3	SL	6.9
	Lacustrine soils											
El-Tina plain	11	0 – 25	4.8	7.75	1.38	4.21	0.8	20.2	17.8	61.2	C	45.3
		25 – 60	11.9	7.69	1.11	3.02	0.7	17.8	22.9	58.6	C	39.8
		60 – 110	14.3	7.63	1.03	2.84	1.1	20.6	28.5	49.8	C	31.6
El- Manzala	12	0 – 20	2.8	7.58	2.11	3.12	3.1	23.5	32.9	40.5	CL	28.9
		20 – 70	16.7	7.49	1.85	2.99	2.9	21.3	41.2	34.6	CL	26.7
		70 – 130	23.5	7.62	1.32	1.96	2.8	2.9	48.1	46.2	SiC	30.5
Idko	13	0 – 15	35.6	7.70	1.43	2.37	12.5	14.4	33.4	39.7	CL	24.6
		15 – 55	17.1	7.72	0.99	2.58	11.3	8.5	22.4	57.8	C	38.7
		55 – 100	15.9	7.68	0.85	3.12	8.9	6.9	21.0	63.2	C	47.8

Texture_: S: sand LS: loamy sand SL: sandy loam SCL: sandy clay loam
C: clay SiC: silty clay CL: clay loam

lowest values of (CEC) for sandy soils than all studied soil types may be attributed to these soil have very low clay percentage and very poor in organic matter contents. These results are in agreement with those in sandy soils of Egypt, reported by **Hassanin *et al*., (2012)** who mentioned that (CEC) value of El-Salhiya soil ranged from 1.9 to 8.1 Cmol $kg^{-1}$and in Rashied sandy soil varied between 2.6 and 5.1 Cmol kg^{-1}

Calcareous soils

Regarding to the physical and chemical properties of the calcareous soil which are represented by profiles8,9 ana10 as shown in **(Table1)**, data revealed that, soil texture class variable from clay, to loamy sand . Soil reaction is slightly to moderately alkaline and pH values varied from 7.45 to 7.81. These soils are characteristics with non-saline to slightly saline soils as indicated by EC values which ranged from 1.99 to 7.03 *dS*/m. Organic matter content not exceeded 0.98 % with higher contents in the surface layers. $CaCO_3$ content is very high and varied from 17.4 to 31.9 % with an irregular distribution pattern with soil profiles depths. CEC values were vary between 5.2 and 15.8 Cmol kg^{-1}. The lowest value characterizes the deepest layer of profile No. 9 at (El-Nobariya soil), while the highest value is detected in the deepest layer of profile No. 8 at (Marut soil).

Lacustrine soils

Physical and chemical analyses of the lacustrine soils which are represented by profiles Nos. 11, 12 and 13 from El- Tina plain, El-Manzala and Idko soils, respectively. For mechanical composition, the data in **Table (1)** revealed that texture classes of the lacustrine soils are considered to be clayey in spite of the variations in its clay content which varies from about 34.6 to 63.2 %. Soil texture class variable from clay, clay loam and silty clay where, the silt percentage was found between 17.8 and 48.1% and clay percentage was detected between 34.6 and 63.2% as particle size distribution.

pH values varied from 7.49 to 7.75.This indicate that, these soil subject to slightly alkaline. Soils of this group are characteristics with very slightly saline to strongly saline soils as indicated by EC values which ranged from 2.8 to 35.6 *dS*/m. Organic matter content was ranged from 0.85 to 2.11 % with higher contents in the surface layers. $CaCO_3$ content is varied from 1.96 to 4.21 % with an irregular distribution pattern with depth. Cation exchange capacity (CEC) values of lacustrine soils were vary between 24.6 and 47.8 Cmol kg^{-1}. The highest value was recorded in the deepest layer of profile No. 13 at (Idko soil) which has a relatively high content of clay. While the lowest value was found in the top layer of the same soil profile.

Total and available boron contents in Egyptian soils:

Data presented in **Table (2)** showed that the total and available boron(HWB) completely differ contents and varied considerably from one soil profile to another and also within the different layers of a profile. The different values of total and available boron in different Egyptian soils may be due to the texture variations as clay percentage, organic matter contents, many soil factors reduced the availability of boron contents, environment factors as well as the types of rock or parent material from which they were derived.

Nile alluvial soils:

Data in **Table (2)** showed that total boron contents in the Nile alluvial soils were considered the higher values after lacustrine soils. Total boron contents in the Nile alluvial soils varied from 48.1 to 71.9 µg g^{-1}. The highest values of total boron were characteristic in the surface layer of Bilbays soil (prof.No.3). While, the lowest value was found in the deepest layer of Qalub soil (prof.No.2) which recorded 48.1 µg g^{-1}.In general, the highest values of total boron are usually found in the surface of these Nile alluvial soil profiles, the distribution trend of total boron indicates a discontinuity in boron throughout the entire depth of soil profile except for the soils of profile No.2 where boron tends to decrease with depth.

Statistical analysis as shown in **(Table 3)** showed that total boron contents in the Nile alluvial soils is positively significant correlated with the OM % (r = 0.573*). In contrast, total boron content is negatively highly significant correlated with pH (r = - 0.644**). These results are coordinated with those reported by **Hassanin *et al*., (2012)** in Nile alluvial soils of Egypt.

The values of available boron (HWB) in the Nile alluvial soils profiles were ranged from 0.6 to 2.0 µg g^{-1}. The lowest value was found in Bilbays soil (prof.No.3). While, the highest content was found in the surface layer of profile No.2 (Qalub soil). The amounts of HWB in the Nile alluvial soils may be mainly rendered to the texture variations,$CaCO_3$% and organic matter contents. The ratios between HWB/total boron in the alluvial soils ranges from 0.99 to 3.60 %.

Data in **(Table 3)** showed that statistical analysis reveals, positively significant correlation between available boron and $CaCO_3$% (r = 0.549**).

Sandy soils:

Total boron contents of the sandy soils as shown in Table (2) observed that, sandy soils were poor in total boron, it ranged between 14.3 and 26.7 µg g^{-1}. The lowest value was detected in the deepest layer of profile No.7 (Port Said soils), while the highest content was found in the deepest layer of profile No.5 (Suez soil). These results are coordinated with those reported by **El-Sewi and El-Malky (1979)**. The most striking feature of the boron content in sandy soil profiles is that the

Table 2. Total and available boron contents of the studied soil profiles.

Location	Prof. No.	Depth (cm)	Boron μg g^{-1} Total	Available	% of total
		Nile alluvial soils			
El-Kanater El-Khyria	1	0 – 30	68.4	1.4	2.05
		30 – 75	59.7	1.1	1.84
		75 – 110	61.6	1.2	1.95
		110 - 150	50.9	0.9	1.77
Qalub	2	0 – 35	58.5	2.0	3.60
		35 – 80	55.6	1.8	3.57
		80 – 100	51.3	1.0	2.08
		100 - 150	48.1	1.3	2.53
Bilbays	3	0 – 25	71.9	0.8	1.11
		25 – 70	62.7	0.8	1.28
		70 – 90	59.1	0.7	1.18
		90 - 140	60.8	0.6	0.99
El-Zagazig	4	0 – 30	58.8	1.2	2.04
		30 – 75	61.4	1.3	2.12
		75 – 100	57.2	0.9	1.57
		100 - 140	49.9	0.7	1.40
		Sandy soils			
Suez	5	0 – 25	19.7	1.5	7.61
		25 – 70	15.5	1.3	8.39
		70 – 150	26.7	1.7	5.99
Ismailiya	6	0 – 20	20.4	1.5	7.35
		20 – 75	19.9	1.4	7.04
		75 – 140	24.3	1.6	7.00
Port Said	7	0 – 30	20.6	1.2	5.83
		30 – 80	16.1	1.1	6.83
		80 – 150	14.3	0.9	6.29

Cont: Table(1)

		Calcareous soils			
Marut	8	0 – 20	44.1	0.9	1.75
		20 – 60	35.6	0.7	1.40
		60 – 95	38.1	0.8	2.10
El-Nobariya	9	0 – 25	28.7	0.7	1.39
		25 – 80	30.9	0.5	1.62
		80 – 140	25.7	0.6	2.33
El- Salloum	10	0 – 15	33.4	0.5	2.10
		15 – 65	29.8	0.4	1.68
		65 – 130	26.8	0.6	2.24
		Lacustrine soils			
El- Tina plain	11	0 – 25	174.2	6.4	3.67
		25 – 60	164.1	6.5	3.96
		60 – 110	189.7	7.3	3.85
El- Manzala	12	0 – 20	92.5	3.7	4.00
		20 – 70	90.7	4.8	5.30
		70 – 130	88.5	4.3	4.86
Idko	13	0 – 15	78.9	3.9	4.94
		15 – 55	80.4	3.1	3.86
		55 – 100	69.3	2.9	4.18

deepest layers were contained the highest total boron, except for the soil profile No.7 of (Port Said soils) whose total boron in the surface layer is higher than that of the deepest one.

Depthwise distribution of total boron content in the sandy soils does not portray any specific pattern with depth, except for the soil of profile No. 7 where boron content tends to decrease with depth.

To substantiate the relationship between total boron and the factors that possibly control its behavior in the studied sandy soil profiles, correlation coefficients were computed. The obtained coefficients as shown in **(Table 3)** indicates that total boron in the sandy soils is positively significant correlated with the $CaCO_3$% (r = 0.673*). Also, it had a non-significant correlation with the others soil variables.

Values of available boron (HWB) for the investigated sandy soil profiles as shown in **(Table 2)**, data showed that, HWB ranges from 0.9 to 1.7 µg g^{-1}. The higher amounts of available boron were strictly associated with the deepest layer of profile No. 5 (Suez soil), while the lower amounts were detected in the deepest layer of profile No.7 (Port Said soils). This may be taken as an indication of the unique origin of sediments in these localities which is manifested by the relative enrichment in boron bearing minerals. The percentage between HWB/total B ranges from 5.83 to 8.39 %, this ratio is very high comparing with those in case of Nile alluvial soils. This may be due to the texture variations as clay percentage, organic matter contents, all these factors reduced the availability of boron content. These variations are surely controlled by several soil factors and environments. Soils differ widely in their total and available boron contents according to the types of rock or parent material from which they were derived.

Statistical analysis in **Table (3)** showed that HWB in the sandy soils is non-significant correlation with the studied soil variables.

Calcareous soils:

Data presented in **Table (2)** clear that total boron contents in the calcareous soils which are represented by profiles Nos.8, 9 and 10 from King Marut, El- Nobariya and El- Salloum soils respectively, ranged from 25.7 to 44.1 µg g^{-1}. King Marut soil (profile No. 8) detected the highest contents of total boron, spatially in the surface layer. While the lowest values were found in El- Nobariya soil (profile No. 9) and spatially in the deepest layer,

Statistical analysis as shown in **Table (3)** showed that total boron content is positively significant correlated with both CEC (r = 0.692*) and silt content (r = 0.721*). On the other hand, the total boron is negatively significant correlated with fine sand content (r = -0.677*).

Available boron contents (HWB) for the investigated calcareous soils, data in **Table (2)** revealed that, it ranged from narrow limit between 0.4 and 0.9 µg g^{-1}. Available boron came with the same distribution of total boron values, where King Marut soil (profile No. 8) recorded the highest values of (HWB) specially in the surface layer, while El- Salloum soil (profile No. 10) detected the lowest values. The variations encountered in HWB throughout this soil types may be due to several factors such as total boron content, soil variables as well as local environments in each locality. The percentage between HWB/total B varied from 1.39 to 2.33 %.

The statistical evaluation of HWB in relation to soil variables indicates that the HWB is positively significant correlated with $CaCO_3$% content (r = 0.681*). In contrast, HWB boron contents are negatively significant correlated with with fine sand content (r = - 0.693*).

Table 3. Correlation coefficient between some soil properties and Total and HWB contents for the studied soil profiles.

Soil properties	Nile alluvial soils		Sandy soils		Calcareous soils		Lacustrine soils	
	Total B	HWB Cont.	Total B	HWB Cont.	Total B	HWB Cont.	Total B	HWB Cont.
EC *dS*/m	0.028	0.106	0.063	- 0.198	- 0.462	0.451	0.372	0.076
pH	- 0.644**	- 0.298	- 0.125	0.271	- 0.039	- 0.198	0.364	- 0.668*
O.M %	0.573*	0.329	- 0.051	- 0.010	0.488	0.271	0.195	0.773*
$CaCO_3$ %	0.473	0.549*	0.673*	0.295	0.225	0.681*	0.169	- 0.692*
CEC *Cmol* / kg	0.465	0.311	0.162	0.197	0.692*	- 0.472	-0.672*	- 0.281
C. Sand %	- 0.039	- 0.073	- 0.066	- 0.073	0.045	0.128	0.512	- 0.303
F. Sand %	- 0.164	0.275	0.098	0.075	- 0.677*	- 0.693*	0.257	- 0.316
Silt %	0.098	0.082	- 0.043	0.255	0.721*	0.094	0.091	0.409
Clay %	0.127	0.259	0.319	- 0.24	0.441	- 0.249	-0.546	0.284
* Significant ** H. Significant	(r) at 5% = 0.497 (r) at 1% = 0.623		(r) at 5% = 0.666 (r) at 1% = 0.798					

Lacustrine soils:

Total boron contents of the studied soil profiles Nos 11,12 and 13 which represented the lacustrine soils collected from El-Tina plain, El-Manzala and Idko soils, respectively, consider the highest total boron values of all studied soils, where it ranged from 69.3 to 189.7µg g^{-1} with an irregular distribution pattern with depth. Idko soils recorded the lowest contents of total boron, while El- Tina plain soils recorded the highest ones. These results are coordinated with those reported by **Hassona (1999)** studies on boron distribution in relation to some variables in El- Tina plain soils of Sinai

Considering the lateral distribution of total boron in lacustrine soils as shown in **Table (2)**, data indicated that boron content recorded the highest level in the lacustrine sediments of El- Tina plain soils then decreased upon passing west direction to El-Manzala then Idko soils where sub-deltaic and wind-blown sands started to interfere. Total boron tends to increase as shown in the profiles representing El-Tina plain soils which are possibly of Nile alluvium origin intermixed to some extent with lacustrine deposits.

The statistical analysis as shown in **Table (3)** showed that, total boron content in the lacustrine soils was negatively significant correlated with CEC (r = - 0.672*)

With regard to available boron in the lacustrine soils, data in **Table (2)** showed that, HWB content varied from 2.9 to 7.3 µg g^{-1}. The highest values were associated with the soils of El-Tina plain soils (profile No. 11), while the lowest amounts characterized the soils of Idko (profile No. 13). The higher amounts of HWB in the lacustrine soils of El-Tina plain soils may be ascribed to the possible intermixing of lacustrine sediments with the alluvial deposits, rich in boron in this particular locality. The percentage of HWB/total boron ranges from 3.67 to 5.3 %.

To figure out the individual effect of each soil variables on the HWB content, simple correlation was computed, data present in **Table (4)** showed that, HWB content in the lacustrine soils was positively significant correlated with OM % (r = 0.773*). While in contrast, HWB content was negatively significant correlated with both $CaCO_3$ content (r = -0.692*) and pH (r = - 0.668*)

With regard to total and available boron distribution in different types of Egyptian soils, we regard that, there are many soil variables controlled, among of them the percentage of clay particles, also the type of clay soil formation, it differ from one soil clay to another. These results are coordinate with several investigators such as **El-Demerdashe *et al*., (2012)** studies on adsorption of boron (B^{3+}) on some Egyptian soils, they reported that, adsorption of boron increase by increasing soil clay particles, also it differs from one soil clay to another, being in the order: Clay of calcareous soil > clay of lacustrine soil > clay of alluvial soil.

Regarding to the HWB contents in the studied soil types, data summarized by **Aubert and Pinta (1977)**, they showed that the average concentration of HWB in soils, worldwide basis, ranges from 0.1 to 2.0 µg g^{-1}, while soils of arid and semi-arid environmental contrition contain from 5 to 16 % of total B in the HWB form. Data indicated that HWB only ranged up to 15.9 % of the total.

According to **Richards, (1954)** boron concentration in saturation extract below 0.7 µg g^{-1} is safe for sensitive crops, while 0.7 to 1.5 µg g^{-1} is marginal and more than 1.5 µg g^{-1} is unsafe.

Comparing the obtained levels of HWB with the critical levels for sensitive crops by **(Richards, 1954)**, data revealed that, the most of the studied soil samples of lacustrine soils as well as El-Suiz soils and Ismailiya soils contain high concentrations of available boron which are unsafe levels caused death of crops and plants. Therefore, the course of reclamation should be continued by leaching process for reducing the unsafe levels.

Also, the ratio between HWB and total boron contents could be used as a criterion for soil differentia. According to this ratio, the studied soil types could be arranged in the order: sandy > lacustrine > Nile alluvial > calcareous.This ratio also indicates that total boron controls, to a large extent the amounts of HWB in the studied soil profiles.

Depthwise distribution of total boron:

Oertal and Gilles (1963) suggested three measures for element content, namely the weighted mean (W), trend (T) and specific range (R). These measures could be written as follows:

1- Weighted mean was calculated as the element concentration of each sample horizon multiplied by the thickness of the horizon or layer and divided the sum of these products by the total thickness of all layers.

2- $T = (W-S)/ W$ when $W > S$

$T = (W-S)/ S$ when $S > W$

Where W = weighted mean

S = the concentration in the surface layer

T = trend

Values of (T) lie in the range from -1 to +1 and are more symmetrical distribution when T is small.

3- $R = (H-L) / W$

Where R = specific range

H = the highest concentration.

L = the lowest concentration.

W = weighted mean

Data in **Table (4)** showed that, weighted mean (W), trend (T) and specific range (R) of total boron in the studied soil profiles representing the soil types.

Weighted mean (W) of total boron in the studied soil profiles varies widely between 17.92 and 87.2 µg g^{-1}. The lowest values of (W) are associated with the sandy soils which has the low percent of silt and clay fractions. The highest values of (W) characterized the soils derived from fine textured representing lacustrine soils. The wide variations encountered within or between soil profiles may reflect the variations in parent materials as affected by both geogenic or pedogenic processes. On the other hand, the relatively low content as designated by the weighted mean of sandy soil profiles may be attributed to the nature of parent material from which the soils are derived.

In brief, the weighted mean (W) of total boron for the studied soil profiles representing the soil types follows the descending order: Lacustrine > Nile alluvial > calcareous > sandy soils.

Table 4. Weighted mean (W), trend (T) and specific range (R) of total boron in the studied soil profiles.

Location	Prof. No.	Weighted mean (W)	Trend (T)	Specific range (R)
	Nile alluvial soils			
El-Kanater El-Khyria	1	54.8	- 0.16	0.19
Qalub	2	49.5	- 0.13	0.22
Bilbays	3	52.6	- 0.09	0.26
El- Zagazig	4	57.4	- 0.11	0.11
	Sandy soils			
Suez	5	22.70	- 0.24	0.47
Ismailiya	6	17.92	0.18	0.39
Port Said	7	19.11	- 0.10	0.21
	Calcareous soils			
King Marut	8	39.8	- 0.02	0.09
El-Nobariya	9	44.1	- 0.04	0.11
El- Salloum	10	41.5	- 0.01	0.15
	Lacustrine soils			
El- Tina plain	11	72.3	- 0.08	0.10
El- Manzala	12	81.1	- 0.05	0.11
Idko	13	87.2	- 0.04	0.06

To work out a reliable comparison within and between the studied soil profiles, the values of trend (T) were calculated. These values are negative and vary from (-0.09) to (-0.16); (-0.10) to (-0.24); (-0.01) to (0.04) and (-0.04) to (-0.08) in the Nile alluvial soils, sandy soils, calcareous soils and lacustrine soils, respectively. The values of trend (T) indicate that the boron trend (T) for the Nile alluvial soils follows the symmetrical distribution of boron as: Bilbays soils > El-Zagazig soils > Qalub soils > El-Kanater El-Khyria soils. While, studied sandy profiles could be arranged according to the symmetrical distribution of boron as follows: Port Said soils > Ismailliya soils > Suez soils. On the other hand, the values of trend (T) for the lacustrine soils showed that the soils of Idko soils was highly symmetrical distribution of total boron than the other soil profiles.

Considering the trend (T) for the calcareous soils, the values presented in **Table (5)** showed that the computed trend of soil profiles representing El-Salloum soils and King Marut soils are more symmetrical boron distribution than El- Nobariya soil profiles.

With regard to specific range (R) data in **Table (4)** revealed that the specific range for total boron varied from 0.06 to 0.47. The highest value was recorded in the sandy soils (profile No. 5); while the lowest one was found in the lacustrine soils (profile 13). Also, in the Nile alluvial soils, the specific range of profiles Nos. 1 and 2 are homogeneous regarding boron content, whereas the other profiles 3 and 4 are probably formed from heterogeneous soil materials. In the sandy soils, profiles Nos. 5,6 and 7 are heterogeneous regarding boron content,

In the calcareous soils, data in **Table (4)** reveal that the specific range (R) of the soil materials of profiles Nos.8 and 9 are formed of homogeneous materials, while the soil materials of profiles 10 is constituted from heterogeneous soil materials. The values of specific range for soil profiles representing the lacustrine soils indicate that the soil of profiles Nos.11, 12 and 13 are homogeneous soil materials.

Commenting on the statistical measures of boron, it is quite clear that the wide variation in the weighted mean which is considered the most satisfactory measure of boron status, indicated a multi-origin and/or multi-depositional regime of the studied soil types as well as variable pedogenic processes exerted by the prevailing soil environments. On the other hand, the various and non-unique trends (T) and specific range (R) are rendered to pedogenic processes alone.

Notwithstanding that the cultivation of lands and discontinuity of layers within each profile are also involved in such variations. It seems evident that the depositional mode and environments played a paramount role in soils formation. This is truly reflected on the status of boron as indicated by the statistical measures.

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تقدير مستويات البورون لبعض الأراضى المصرية المختلفه

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تم أختيار ثلاثه واربعين عينه تربه من ثلاثه عشر قطاعا إرضي ممثلة للأراضى المصريه المختلفه من مناطق مختلفه حيت تمثل الأراضى الرسوبيه النهريه والرملية والجيرية والبحيريه وذلك لألقاء الضوء على عنصر البورون الكلى والميسر والمستخلص بواسطة الماء الساخن (HWB) فى هذه الأراضي حيث قدرت الخواص الطبيعية والكيميائية وكذلك تم تقدير البورون الكلي والميسر

وتشير نتائج الدراسة إلى ما يلى:

محتوى التربه من البورون الكلى يختلف اختلافا كبيرا حيث يتراوح ما بين (48,1 – 71,9) ، (26,7–14,3) ، (44,1–25,7) ، (189,7–69,3) ملليجرام/جرام فى الأراضى الرسوبية النهريه و الرملية والجيرية والبحيريه على الترتيب.

حيث كان ترتيب الأراضى المصريه تحت الدراسه من حيث محتواها من البورون الكلى كالتالى:

الأراضى البحيرية > الأراضى الرسوبية النهريه > الأراضى الجيرية > الأراضى الرملية

بينما المحتوى الميسر من البورون والمستخلص بالماء الساخن (HWB) يختلف اختلافا واضحا حيث تراوحت الكميات المستخلصة ما بين (0,6 – 2,0) ، (0,9– 1,7) ، (0,4– 0,9) ، (2,9– 7,3) ملليجرام/جرام فى كل من الأراضى الرسوبية النهريه و الرملية والجيرية والبحيريه على الترتيب.

وبمقارنة الكميات المستخلصة فى الأراضى المختلفة مع الحد الحرج لهذا العنصر تبين أن الأراضى البحيرية تحتوى على تركيز عالى من البورون الميسر مما قد يسبب موت النباتات لزيادته عن الحد المسموح به.

وقد أجرى التحليل الأحصائى لتحديد مدى الارتباط بين الكمية الكلية والميسرة من البورون وبعض متغيرات التربة فى الانواع المختلفة من الاراضى تحت الدراسة وقد أظهرت النتائج أن الكمية الكلية والميسرة ترتبط بمادة الاصل وصفاتها الاساسية.

تم حساب المقاييس الاحصائية والتى تشتمل على المتوسط الوزنى (W) والاتجاه (T) وكذلك النطاق النوعى (R) للمحتوى الكلى لعنصر البورون فى الانواع المختلفة من الاراضى تحت الدراسة وقد نوقشت نتائج هذه المقاييس الاحصائية لتحديد اصل ومنشأ ومدى تجانس وتكوين هذه الأراضى.