EFFECT OF NATURAL CLAY DEPOSITS ENRICHED WITH SOME NUTRIENTS ON SOME SANDY SOIL CHARACTERISTICS AND NUTRIENT LEVELS

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ABSTRACT

Sandy soils are amongst the most extensive soil in the new reclaimed lands of Egypt. Zeolite and bentonite minerals are naturally present in different geologic environment and bentonite was reported to be extensively found in sedimentary environment in Egypt. This study aims to evaluate the role of zeolite and bentonite minerals as amendments and characterize that ability for improving the status of micronutrients in sandy soil. Results showed that saturation of zeolite and bentonite with Zn, Fe, and Mn increased dramatically the available level extracted by DTPA. Results of incubation experiment indicated that treating sandy soil with Zn or Mn and or Fe saturated zeolite or bentonite increased significantly the level of these nutrients after 30 days of incubation when compared with the untreated sandy soil. The increase was more pronounced in case of application bentonite when compared with zeolite treatments. Results indicated also significant increase in the concentrations of these nutrients in maize tissue in the case of application nutrient saturated minerals. These results may be of good potential for improving the available levels of Zn, Mn, and Fe in sandy soils and bentonite was more efficient than zeolite in that regards. Such finding could be important under Egypt conditions since bentonite deposits are wide spread in huge quantities in the different regions.

INTRODUCTION

Zeolite and bentonite minerals are naturally present in different geologic environment.where the Bentonite was reported to be found in sedimentary environment under Egyptian conditions.However Zeolite is a crystalline, hydrated aluminosilicate of alkali and alkaline earth cations having an infinite, open, three dimensional structures (Akbar et al., 1999 and Sasdkova et al., 2005). More than forty types of zeolites have been reported by different research groups. Among these minerals, analcime, clinoptilolite, erionit, chabazite, mordenite, and philipsite are well known ((Polat et al., 2004) .Zolites have slow release fertilizers in soil reservoirs for K^+ (Hershey et al., 1980) and for $NH_4{}^+$ (Lewis et al., 1984). Zeolites added to fertilizers help to retain nutrients and, therefore, improving the long term soil quality by enhancing its absorption ability. It concerns the most important plant nutrients such as nitrogen (N) and potassium (K), and also calcium, magnesium and microelements (Flanigen and Mumpton, 1981; Mumpton, 1981). Absorbed cations are relatively mobile due to their weak attraction, and can be replaced using the standard ion exchange techniques, making zeolites good ion exchangers (Mumpton, 1999). Zeolites are used to promote better plant growth by improving the value of fertilizers, it can aslo hold great potential for the sorption of several metal cations, e.g. Co^{+2}, Cu^{+2}, Zn^{+2} and Mn^{+2} (Erdem et al., 2004). Applications of zeolite to soil change number of parametesr such as surface area, pH and hydraulic conductivity (Mahabadi et al, 2007). More recently, Zahedi et al (2009) showed that zeolite application in lands which are exposed to drought stress can maintain soil water content and improve plant growth and production. The Egyptian bentonite deposits have high clay content, high percentage of montmorillonite clay mineral, high surface area and high CEC. These characteristics improve the physical and chemical properties of sandy soils and enhance their fertility and productivity (El-Hady and El-Sherif ,1988). The addition of bentonite improved soil texture of sandy soil, and consequently soil –water – plant interrelationships (Abou-Gabel et al, 1989). Bentonite application resulted in a highly significant increase in soil porosity and available water content and controlled water movement but the bulk density values were significantly decreased (Al-Omran et al., 2002), The authors added that natural benonite were useful in improve hydrophysical properties of the sandy calcareous soil, it reduced infiltration losses and increase available water capacity (AWC). Suganya and Sivasamy (2006) mentioned that the way to increase the low CEC of sandy soils over the long time is to apply high CEC material such as clay mineral. Therefore, this research was carried out to study the effect of using natural zeolite and bentonite deposits for improving soil characteristics and evaluate their potential for improving micronutrient levels in sandy soil.

MATERIALS AND METHODS

Bentonite and zeolite samples were collected from different sources and characterized in order to select the most appropriate sample for this study. The selected zeolite and bentonite samples were supplied from Delta Biotc Company and ICMI Company, respectively. The selected samples were prepared for mineralogical analysis using X-ray diffraction technique and the relevant physical and chemical characteristics were determined following the standard procedures described in Page et.al. (1982). A surface soil sample (0-30 cm) was collected from a private farm east of Cairo- Alexandria desert road at Km 84. The collected soil sample was air dried, crushed using a wooden roller, sieved in 2mm sieve and kept in plastic bottles for analyses. The main physical and chemical characteristics are soil texture, ECe, soil pH, soluble cations and anions and CEC were determined. Available nutrients were also measured using the standard methods described in Page et.al. (1982). The selected zeolite and bentonite samples were prepared for the experiments and then saturated with Zn, Mn and or Fe using sulphate salts (Flata et al 2002) as follows: 1N solution of zinc sulfate ($ZnSO_4$), manganese sulfate ($MnSO_4$) and ferrous sulfate ($FeSO_4$) were prepared using pure sulphate salts. Each solution was added to either zeolite or bentonite sample using 1:10 (w/v) ration (mineral: solution). The mixtures were then shacked on mechanical shaker for 24 hours and centrifuged (2000 cycle/Min.) for 10 minutes. The above step was repeated two times in order to saturate the sample with the selected ion. The samples were washed once using distilled water followed by several washings with ethyl alcohol until the sulphate test in the latchet gave negative test. The moist samples were then dried at 40^{o}C then, grinded in porcelain cup and sieved by using 0.125mm sieve. The prepared samples were kept for the following experiment.

Incubation experiment: A pot experiment was carried out under the laboratory conditions by mixing different rates of either zeolite or bentonite clays with the sandy soil. Distilled water was added to the mixture to reach the field capacity at laboratory conditions. Twenty five treatments were considered in this experiment. The treatments were as follows:

1- Control "soil without zeolite or bentonite addition".
2- Soil + Untreated bentonite at rates of 0.1g, 0.5 g and 1g /kg soil
3- Soil + Zn-bentonite at rates of 0.1g, 0.5g and 1g /kg soil
4- Soil + Mn -bentonite at rates of 0.1g, 0.5 g and 1g /kg soil
5- Soil + Fe-bentonite at rates of 0.1g, 0.5 g and 1g /kg soil
6- Soil+ Untreated zeolite at rates of 0.1g, 0.5 g and 1g /kg soil
7- Soil +Zn-Zeolite at rates of 0.1g, 0.5 g and 1g /kg soil
8- Soil + Mn-Zeolite at rates of 0.1g, 0.5 g and 1g /kg soil
9- Soil +Fe-Zeolite at rates of 0.1g, 0.5 g and 1g /kg soil

Each treatment had three replicates. The pots were incubated under laboratory conditions for 30 days. Six wetting and air dry cycles were carried out to allow sufficient mixing of nutrients and soil, by weight each pot and add the missing water until reaching the field capacity level during the whole experiment every five days. After incubation a representative soil sample from each treatment were collected and subjected to analysis. Available Zn, Mn, and Fe were extracted using DTPA solution and then measured using Atomic Absorption Spectrophotometer (AAS) as described by (Lindsay and Norvell 1978).

Pot experiment was planted with maize (Tri-hybrid 311) two seeds in each pot and was kept for 3 weeks under the laboratory condition .Pots were irrigated every other day with distilled water only without adding fertilizer nutrient solution. After the three weeks plants were collected and plant sample weighted and dried at 70 ^{o}C for 48hrs and weighed. Representative 0.5 g samples of plant materials were wet digested according to (Cottene 1982) then Zn, Mn, and Fe were measured in all plant samples using AAS (Lindsay and Norvell 1978). Analysis of variance ANOVA and was done according to (Snedecor and Cochran 1976) using SAS program and Tukey's HSD (Honestly Significant Difference) test (SAS Institute, 1982).

RESULTS AND DISCUSSION

Data inTable 1 show some of the relevant characteristics of the collected bentonite and zeolite samples. It indicates that zeolite sample is mostly clinoptilolite mineral with quartz, feldspar and mica as accessory minerals. The texture of the sample is clay having over 75%

clay + silt fraction. The sample was very low in salt content where the dominant cation was Ca followed by K, Na and Mg. The soluble anions were dominated by Cl, SO_4 and HCO_3 ions. The dominant exchangeable cations are Na followed by K, Ca and Mg. On the other hand, cation exchange capacity was relatively high and represent about 122 meq/100g zeolite data also indicates a relatively high available Zn and Mn while other micro and macronutrients are relatively low. These data may reflect the possible role of zeolite for sandy soil improvements as a result of the high CEC, high SP and the presence of relatively high exchangeable K and available Zn. The collected soil sample was low in salinityand have sandy texture with 3.1% clay, and the dominant soluble Na followed by Ca, Mg and K. CEC value was very low where also the available macro and micro nutrients were low. Bentonite sample is mostly montmorillonite mineral with kaolinite, quartz, feldspar and mica as accessory minerals. It has clay texture with clay + silt content above 86%. It was very low in salt content where the dominant cation was Na followed by Ca, K and Mg. The soluble anion was dominated by Cl, ions. The dominant exchangeable cation was Na followed by K, Mg and Ca. On the other hand, the cation exchange capacity was high and represent about 83 meq. /100g bentonite. Data also indicated that relatively high available Zn and Mn while other micro and macronutrients were relatively low.

Table(1)Some physical and chemical characteristics of soil, bentonite and zeolite samples.

Material	Clay +silt	minerolgy	EC_e (dS/m)	CEC (meq/100 g soil)	Exchangeable cations (meq/100gsoil)				Available Nutrient (ppm)		
					Ca	Mg	Na	K	Zn	Mn	Fe
Soil	17.6	———	4.6	3.8	1.00	0.75	0.85	0.90	0.5	1.2	1.0
Zeoilite	75	Clinoptilolite, Felspare	0.68	122.5	11.8	7.10	52.5	50.1	12.0	5.7	2.7
Bentonite	86	Montomoronite, Kaolinite,qurtze	2.3	83	2.20	20.0	58.0	2.50	9.4	5.6	1.7

Material	Sp%	Soluble Ions (meq/L)							
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	$SO_2^{=}$
Soil	15	4.12	4.00	33.50	3.00	-	4.25	37.81	2.60
Zeolite	85	2.30	1.88	2.16	2.24	-	2.95	2.76	2.82
Bentonite	780	2.82	0.50	19.00	0.67	-	1.10	18.50	1.80

Data in Table 2 indicated that saturation of zeolite and bentonite samples with Zn, Fe, and Mn increased dramatically the available contents of these nutrients which was extracted by DTPA. The extent of the increase depends on nutrient not on the clay mineral. The available Mn increased by saturating the two studies clay minerals more than Zn and Fe. The available nutrient values increased 4183, 5748 and 1362 ppm for Zn ,Mn and Fe respectively using zeolite whereas The available nutrient values were increased 5184, 5331 and1414 ppm for Zn ,Mn and Fe respectively by using bentonite.

Table (2) available Zn, Mn, and Fe level (ppm) in nutrient saturate zeolite and bentonite .

nutrient / clay mineral	Extracted DTPA(PPM)					
	Zn		**Mn**		**Fe**	
	before saturating	after saturating	before saturating	after saturating	before saturating	after saturating
Zeolite	12.00	4195	5.7	5754	2.70	1365
Bentonite	9.40	5194	5.6	5337	1.73	1416

Data in Table 3 indicated the effect of applicati on different levels of zeolite and bentonite to the sandy soil on the availability of the study nutrient. It showed that application of natural zeolite or bentonite to sandy soil led to increase the available Zn level but the increase was not significant. On the other hand, treating sandy soil with Zn saturated either zeolite or bentonite led to significantly increase the level of available Zn after 30 days of incubation when compared with the untreated sandy soil. The increase was more pronounced with Zn saturated bentonite in comparison with Zn zeolite treatments. It was also clear that saturated bentonite sample was more effective for increasing Zn availability than all the studied treatments. Data also indicated that application of natural zeolite or bentonite to sandy soil increased significantly than the non- treated samples the available Mn level. Also, application of Mn saturated zeolite or bentonite to sandy soil led to significantly increase the level of available Mn after 30 days of incubation when compared with the untreated sandy soil. These resulted were more pronounced with Mn saturated than Mn zeolite treatment. These results reflect the importance of bentonite as a good carrier for Mn than the zeolite for increasing available Mn in sandy soil. Data showed that Fe level in untreated soil was deficient even after the application of untreated zeolite or bentonit although the level was increased significantly with the increase the application rate of either zeolite or bentonite. On the other hand, the application of Fe saturated zeolite or bentonite to sandy soil led to increase significantly the level of available Fe after 30 days of incubation in comparison with the untreated sandy soil. These results are more pronounced with Fe saturated bentonite than Fe zeolite treatments.

The obtained results could be of good potential for improving the available level of Zn, Mn, and Fe in sandy soils where the bentonite seems be more efficient than zeolite. Such finding could be important under Egypt conditions wher the bentonite deposits are wide spread in huge quantities in the different regions and it can be used more efficiently in that regards.

Table (3) Available Zn, Mn and Fe levels (mg Kg^{-1}soil) in zeolite and bentonite treated or untreated.

treatment	control	0.1gKg^{-1}soil	0.5gKg-^{1}soil	1.0g Kg^{-1}
Available Zn (ppm)				
Zeolite	0.41 G	0.51 G	0.55 G	0.65 G
Zn zeolite	0.41 G	2.22 F	8.3 D	12.75 B
Bentonite	0.41 G	0.66 G	0.73 G	0.93 G
Zn bentonite	0.41 G	3.53 E	9.81 C	19.06 A
Available Mn (ppm)				
Zeolite	1.67 G	3.66 F	4.58 E	7.30 D
Mn zeolite	1.67 G	4.58 E	7.70 DC	9.74 B
Bentonite	1.67 G	4.38 FE	5.26 E	8.51 C
Mn bentonite	1.67 G	4.78 E	9.57 B	13.2 A
Available Fe (ppm)				
Zeolite	1.95 I	3.07 H	3.87 FG	4.47 E
Fe zeolite	1.95 I	3.55 HG	5.49 D	6.65 B
Bentonite	1.95 I	3.75 G	4.58 E	5.71 D
Fe bentonite	1.95 I	5.28 D	7.08 C	10.77 A

the same letter are not signification
HSD* Zn (0.5492) , Mn (0.898), Fe (0.6621)
*Tukey's HSD (Honestly Significant Difference) test

Data in Table (4) show the content of Zn, Mn and Fe, in maize plants as affected by different mineral types and different application rate of either zeolite or bentonite, Generally, data illustrate that application of different rates of minerals caused gradual significant increase in the concentrations of the three studied micro nutrients in maize plants, which reflect the level of available nutrient present in the soils. On the other hand, application of Zn-bentonite, Mn-bentonite or Fe-bentonite, led to significantly increase the concentrations of these nutrients in comparison with the application of bentonite only. The same trend was obtained in the case of zeolite with different absolute values. Iron concentration was significantly increased in maize tissue as a result of Fe-zeolite or Fe-bentonite application to the studied soil and the increase was quite high in the highest application rate (1.00 g kg^{-1} soil).

TABLE(4) Nutrient concentration in maize plant after three weeks of plantation under treated and un treated sandy soils .

treatment	control	0.1g Kg-1 soil	0.5gKg1soil	0.1g Kg -1soil
Concentration of Zn mg kg-1 (ppm)				
Zeolite	32.46 H	43.50 GF	51.83 E	62.80 D
Zn zeolite	32.46 H	85.43 B	91.03 B	104.00 A
Bentonite	32.46 H	41.80 G	54.26 EF	62.50 D
Zn bentonite	32.46 H	46.70 G	60.00 D	74.46 C
Concentration of Mn mg kg-1 (ppm)				
Zeolite	44.8 0 F	52.53 EF	69.10 E	127.90 CB
Mn zeolite	44.80 F	65.30 E	109.73 CD	140.33 AB
Bentonite	44.80 F	58.65 EF	106.90 D	119.96 CD
Mn bentonite	44.80 F	64.20 E	112.70 CD	151.23 A
Concentration of Fe mg kg-1 (ppm)				
Zeolite	129.53 I	205.9 H	292.56 G	358.96 E
Fe zeolite	129.53 I	314.63 GF	747.80 B	853.50 A
Bentonite	129.53 I	180.76 IH	352.43 EF	440.90 D
Fe bentonite	129.53 I	352.46 C	617.80 C	880.76 A

the same letter are not signification
HSD* Zn (7.1), Mn (18.86), Fe (51.75).
*Tukey's HSD (Honestly Significant Difference) test

From the above results, it is that there was a beneficial effect for the application of natural minerals such as zeolite and bentonite as amendments to sandy soils. Such beneficial effect was more pronounced if the minerals were saturated with nutrients such as Zn, Mn and Fe. Application rate of the micronutrient saturated minerals are critical and as low as 0.1g/kg soil could be suitable to raise the deficient level of Zn, Mn and Fe in the maize plants grown on the sandy soil.

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تأثير رواسب الطين الغنيه ببعض المغذيات على خواص الاراضى الرمليه ومستوى العناصر بها

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توجد الاراضى الرمليه على نطاق واسع فى مصر ومن طرق استصلاح هذه الار اضى اضافه المترسبات الطبيعيه للاراضى المستصلحه ، حيث تتواجد معادن الزيوليت والبنتونيت فى المترسبات الجيولوجيه الطبيعيه بينما يتواجد البنتونيت بوفره فى المترسبات الموجوده فى مصر

حيث يهدف البحث الى معرفه دور كل من معادن الزيوليت والبنتونيت كمحسنات طبيعيه ومدى تأثيرها على تحسين حاله العناصر الصغرى فى الاراضى الرمليه عند تشبيع كل من الزيوليت والبنتونيت بالزنك والمنجنيز والحديد مما ادى الى حدوث زياده معنويه فى مستوى العناصر الصغرى بعد 30 يوم من التحضين عند المقارنه بالاراضى الغير معامله وكان هناك زياده ملحوظه فى حاله العناصر الصغرى فى البنتونيت عنها فى حاله الزيوليت

وتشير النتائج ايضا الى ان هناك زياده فى تركيز المغذيات فى انسجه الذره المزروع بعد عمليه التحضين نتيجه لتحسين مستوى العناصر من الزنك والمنجنيز والحديد فى الاراضى الرمليه المعامله بهذه العناصر

ونظرا لنتائج البنتونيت الملحوظه يمكن استخدام البنتونيت تحت الظروف المصريه نظرا لتوفره بكميات كبيره وباماكن عديده فى مصر