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EVALUATION OF SEWAGE SLUDGE AS A SOIL CONDITIONER FOR NEWLY RECLAIMED SANDY CALCAREOUS SOILS OF EGYPT

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ABSTRACT

Two pot experiments were conducted during two successive seasons of 1998 and 1999 to evaluate the influence of sewage sludge applied to sandy calcareous soils on physical and chemical properties of the soil, plant growth, dry matter yield, water consumption, water use efficiency, elemental content as well as uptake of N, P, K and Pb by *Casuarina equistifolia* seedlings which used as windbreaks and wooden trees.

The studied soil was treated by different rates of sewage sludge namely, 0, 1, 2, 3, 4, 5 and 6%. The changes in chemical properties of the treated soil before and after cultivation were measured. Also, the soil content of total N, available P, K and DTPA Pb was determined after cultivation.

The obtained results showed that application of sewage sludge to sandy calcareous soils, improved hydro-physical and chemical properties of the soil.. Plant growth, dry matter yield, water use efficiency, concentration and uptake of N, P, K and Pb by plants were increased.

The rate of increase percent in different treatments for NPK uptake by plants relative to control (100%) were 394.3%, 353.1%, 249.5% and 390.2%, 431.9%, 306.9% in the two successive seasons, respectively.

The results showed that the application of sewage sludge to newly reclaimed sandy soil improved soil chemical properties before and after cultivation and nutrients status of the soil after cultivation.

The most outstanding beneficial effect was obtained as a result of adding sewage sludge to sandy calcareous soils at the rate of 4% (40 ton/fed). So, one can conclude that sewage sludge can be considered as a good soil conditioner for improving coarse textured soils properties and planting wooden trees in the desert as windbreaks and as a source of wood production.

INTRODUCTION

In the A.R. Egypt, population is increasing more rapidly than natural resources. The agricultural cultivation area in the Nile Valley is limited. The cultivation of new areas of sandy and sandy calcareous soils represents a neccessity to increase the agricultural production in Egypt.

To cultivate sandy and sandy calcareous soils successfully, one should overcome many problems such as the poor physical, chemical and nutritional properties of these soils. It is a known fact that the low water holding capacity, cation exchange capacity, level of available nutrients as well as the poor structure, all are directly related to the coarse texture and low level of organic matter in these soils. Moreover, it is frequently found under dry conditions that such soils contain high concentration of $CaCO_3$, which in turn, adds more nutritional problems to plants. These problems can be solved by applying some organic manures.

As organic manures are limited in Egypt, attention has been focused in the last few years to the subject of using some local waste materials as substitutes of the manures to solve most of the above mentioned problems of sandy and calcareous soils.

Sewage sludge is a potentially valuable resource of essential macro and micro elements to plants. It also serve as a good natural soil conditioner due to its high content of organic matter which ranges from 30 to 60% (Abdel-Naim *et al.*, 1982 and Mohamed, 1991). Addition of some natural wastes and/or synthetic materials to the coarse textured soils improved soil physical and chemical properties and increased the plant growth, water use efficiency and uptake of N, P and K by plants grown in the treated soils (Ham and Dowdy, 1978; Saouma, 1978; El-Dawwey, 1982; Morsy *et al.*, 1982; El-Sokkary and El-Keiy, 1989; Anand, 1992; Sakr *et al.*, 1992 and Morsy and El-Dawwey, 1999). However, unwise use of sewage sludge produce effects on both the growing plants, feeding animals and consequently human health...Meanwhile, there is no hazards (due to the accumulation of heavy metals) on human being when using sewage sludge as soil conditioner for planting the windbreaks and wooden trees.

The current work has been planned to find out the possibilities of using sewage sludge for improving the physical, chemical and nutritional properties of sandy calcareous soils, as well as improving the wooden trees growth in desert soils as a windbreaks and as a source of wood production.

MATERIALS AND METHODS

Representative surface soil samples (0-30 cm depth) were collected from the newly reclaimed desert land located at West Samalout, El-Minia Governorate.

The soil samples were air dried, crushed and sieved through a 2mm sieve, thoroughly mixed and then kept in a plastic pottles for analysis. The main physical and chemical properties of the studied soil (for the two seasons) are given in Table (1). Soil samples were analyzed according to the standard procedures, described in Black (1965), Jackson (1973), Lindsay and Norvell (1978) and Page *et al.* (1982).

Total porosity was calculated according to the following equation : Porosity % = (1- Bulk density/Real density) x 100.

Hydraulic conductivity (cm/min) was determined by using plastic columns (5.2 cm in diameter and 30 cm in height). The amount of soil was calculated and filled in the column to obtain bulk density of 1.7 g/cm^3. The hydraulic conductivity was determined according to Singh (1980).

Pot Experiment:

Sewage sludge samples were air dried, crushed and sieved through a 2mm sieve, thoroughly mixed with the used soil at rates of 0, 1, 2, 3, 4, 5 and 6%. Thirty kg of the treated soil was placed in plastic pots (25 cm in diameter and 60 cm in height). Five seeds of ***Casuarina equistifolia*** were sown in each pot (at 1st week of March) and after germination, the plants were thinned to one per pot. Each pot received a basal dose of chemical fertilizers at the equivalent rates/feddan as follows: 100 kg of ammonium nitrate (33% N), 200 kg of superphosphate (15.5% P_2O_5) and 50 kg of potassium sulfate (48-52% K_2O). Each treatment was replicated five times.

The plants were irrigated every three days to keep the soil moisture content around the field capacity. Plant height (cm) and water consumption (L/seedling) were recorded through the growth period. The plants were harvested six months after sowing (at 1st week of September), and the fresh weight of plants was registered. The plants were washed, oven dried at 70°C and the dry weight of plants was recorded.

Table (1): Some physical and chemical characteristics of the used soil for the two seasons.

Characters	1st season	2nd season
Particle size distribution		
Coarse sand %	27.37	28.05
Fine sand %	69.06	69.63
Silt %	3.06	1.26
Clay %	0.51	1.06
Texture grade	Sandy	Sandy
Real density, g/cm^3	2.80	2.77
Bulk density, g/cm^3	1.70	1.74
Total porosity %	39.29	37.18
Hydraulic conductivity cm/min	1.17	1.03
Field capacity %	13.45	13.65
Wilting point %	4.65	4.52
Available water %	8.80	9.13
pH (1:2.5)	8.16	8.27
EC (dS/m)	1.46	1.52
CEC (C mol/kg)	5.90	6.12
$CaCO_3$ %	12.60	13.24
Organic matter %	0.23	0.24
Total N%	0.01	0.01
Available P, ppm (Olsen)	0.25	0.20
Available K, ppm (ammonium acetate)	6.10	5.95
DTPA-Fe, ppm	2.30	2.57
DTPA-Zn, ppm	0.45	0.40
DTPA-Mn, ppm	2.60	1.85
DTPA-Cu, ppm	0.20	0.30
DTPA-Pb, ppm	0.16	0.14

The tested amendment (sewage sludge) was collected from the Waste Healthy Drainage Station of El-Minia City.

The dry plant material was ground in stainless steel mill and then digested in H_2SO_4 and H_2O_2 according to standard methods (Peach and Tracey, 1986) to determine N, P, K and Pb in the digestion. The uptake of these nutrients by plants was calculated by multiplying the dry matter yield by concentration of each nutrient. Water use efficiency was calculated as gram production of total dry matter/L of the irrigation water. The changes in soil pH, EC, $CaCO_3$ %, CEC and organic matter as well as the content of total N, available P, available K and Pb in the used soil after cultivation were determined. Statistical analysis was carried out according to the method of Snedecor and Cochran(1973).

RESULTS AND DISCUSSION

1. Chemical characteristics of the sewage sludge:

The analytical results in Table (2) show that the organic matter content of the sewage sludge are relatively high (FAO, 1982). It is highly considered an important soil amendment, for improving the soil physical and chemical properties.

The fact of relatively high levels of macro and micro nutrients (Table 2) represents the sludge as a promising organic fertilizer in addition to its property as soil conditioner. The presence of high levels of available Fe, Zn, Mn, Cu and Pb will not represent harmful effect on soil and plants when sludge is applied on the sandy calcareous soil due to the high pH value of these soils (Pietz *et al.*, 1983 and El-Sokkary and El-Keiy, 1989).

Table (2): Some chemical characteristics of the sewage sludge sample in the two successive seasons.

Characters	1st season	2nd season
pH (1:2.5)	6.74	6.91
EC (dS/m)	7.65	8.13
CEC (C mol/kg)	142.00	151.00
$CaCO_3$ %	4.10	3.80
Organic matter %	36.52	37.41
Total N%	2.10	2.22
Available P, ppm (Olsen)	1.95	2.17
Available K, ppm (ammonium acetate)	75.00	81.00
DTPA-Fe, ppm	22.60	26.40
DTPA-Zn, ppm	8.90	8.15
DTPA-Mn, ppm	26.10	29.50
DTPA-Cu, ppm	6.77	6.40
DTPA-Pb, ppm	7.04	7.28

2. Particle size distribution and texture grade:

Data given in Table (3) show no clear effect of sewage sludge application on particle size distribution. Content of fine fractions (silt + clay %) was slightly increased due to sewage sludge application, however, the texture grade of the treated soilremained the same.

Similar results were obtained by Christonsen (1986) as well as Martens and Frankenberger (1989).

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3. Real density, bulk density and total porosity:

Both real and bulk densities were decreased due to sewage sludge application, however, positive increase in total porosity was obtained. It is worthy to mention that the changes in total porosity were increased, in most cases, with increasing the application rate of sewage sludge.

The changes in density and subsequently in porosity of the soil after sewage sludge application are due to the increases in aggregate size and stability as a result of increasing organic matter and soil conditioning. The sewage sludge improves soil aggregation, where new aggregates or micro aggregates were created. Binding of these aggregates together may form new aggregates of bigger size, which have lower density and subsequently the porosity increases.

Similar results were obtained by Walter (1978); Abdel-Naim *et al.* (1986); Abdel-Mottaleb *et al.* (1989) and Tester (1990).

4. Hydraulic conductivity (HC):

Data given in Table (3) show that the addition of sewage sludge to coarse textured soils improved their physical properties, so the water has moved slowly through their pores.

The hydraulic conductivity value of the untreated sandy calcareous soil was 1.17 cm/min, the high value of HC was due to the open texture of the untreated soil. The addition of sewage sludge improved the HC, which decreased from 1.17 cm/min to 0.66 cm/min.

The improvement in the hydraulic conductivity could be attributed to the increase in soil micro-porosity, and in turn, the increase in the hydraulic resistively of the treated sandy calcareous soil. Also, the improvement in HC of the treated soil may be attributed to the high content of organic matter and organic colloids in sewage sludge.

Similar results were obtained by Spotswood and Raymer (1973); Shehata *et al.* (1985) and Williams *et al.* (1987).

5. Field capacity, wilting point and available water:

Data in Table (3) show that the addition of sewage sludge at various rates obviously improved the field capacity, wilting point and available moisture content of sandy calcareous soil. However, due to the fact that the increase in water retained at wilting point is far beyond that at field capacity, the available water increased.

The enhancing effect of sewage sludge on available water might be attributed to its important role for increasing the amount of colloids and consequently the number of microspores and also due to its positive action like supersponge on increasing the absorbing and storing available water in the root media.

The obtained results are in agreement with those reported by Abdel-Naim *et al.* (1986); Abdel-Mottaleb *et al.* (1989); Mbagwu and Piccolo (1990b) and Tester (1990).

Table (4): Effect of sewage sludge on some growth parameters and water use efficiency by *Casuarina* seedlings in the two successive seasons.

Application Rate %	First season 1998					Second season 1999				
	Plant height, cm	Fresh weight, g/s*	Dry weight, g/s	Water consumption, L/s**	Water us efficiency, g/L	Plant height, cm	Fresh weight, g/s	Dry weight, g/s	Water consumption, L/s	Water use efficiency, g/L
0 00	47.0	21.43	5.10	85.00	0.06	61.6	23.12	5.22	87.0	0.06
1.00	78.0	39.00	9.26	93.71	0.10	82.2	39.40	10.84	96.2	0.11
2.00	105.7	48.42	12.53	95.30	0.13	114.3	59.32	14.88	102.0	0.15
3.00	126.8	61.93	14.72	98.44	0.15	123.7	62.44	15.80	105.8	0.15
4.00	137.0	62.08	14.83	99.37	0.15	142.1	71.92	16.82	106.1	0.16
5.00	144.0	63.87	15.15	97.42	0.16	147.6	72.18	17.50	106.5	0.17
6.00	145.5	64.09	15.28	98.05	0.16	148.0	72.50	17.55	106.8	0.17
L.S.D at 5%	8.4	2.25	0.60	2.16	0.01	7.7	1.13	0.70	1.6	0.01

*** g/s : gram/seedling**
**** L/s : litre/seedling**

6. Growth Parameters:

Data given in Table (4) revealed that treating the studied soil with sewage sludge generally increased plant height, fresh and dry weights of *Casuarina* tree seedlings grown in the treated soil, compared with the untreated one. The increase in all the studied growth parameters was almost proportional to the increase in application rates of sewage sludge.

7. Water Consumption and Water Use Efficiency:

It is clearly shown from Table (4) that the amount of water consumed by *Casuarina* seedlings grown in the treated soil was increased due to the high increase in growth of *Casuarina* plants.

The water use efficiency refers to the amount of dry seedling materials produced by a unit of water. As the dry matter yield of the seedlings grown in the treated soil with sewage sludge was much higher than in the untreated one (Table 4), it could be seen that the water use efficiency was significantly increased.

The increase in water use efficiency due to soil treatment with sewage sludge in the first and second seasons could be attributed to the effect of this material on increasing the water holding capacity and consequently, decreasing the water infiltration rate into the soil surface, hence it increased the available water to the seedlings. The available water will be used in producing more plant materials and then more water use efficiency.

Similar results were obtained by El-Kadi (1978); El-Nashar (1985); Sadic *et al.* (1988); Aboulroos *et al.* (1989); El-Sokkary and El-Keiy (1989) and Morsy and El-Dawwey (1999).

8. Concentration and uptake of N, P, K and Pb:

Careful examination of the data presented in Table (5) show that the concentration and uptake of all the studied elements were increased with treating the studied soil with sewage sludge, compared with the untreated one.

Table (5): Effect of sewage sludge on concentration and uptake of N, P, K and Pb by *Casuarina* seedlings grown in the studied soil before and after cultivation in the two successive seasons.

Application Rate %	First season 1998								Second season 1999							
	N		P		K		Lead		N		P		K		Lead	
	%	Uptake, mg/s*	%	Uptake, mg/s	%	Uptake, mg/s	ppm	Uptake, mg/s	%	Uptake, mg/s	%	Uptake, mg/s	%	Uptake, mg/s	ppm	Uptake, mg/s
0 00	0.90	45.90	0.12	6.12	1.00	51.0	32.1	0.16	0.85	44.4	0.11	5.74	1.10	57.4	34.8	0.18
1.00	1.10	101.9	0.14	12.96	1.05	97.2	33.2	0.31	0.96	104.1	0.12	13.00	1.20	130.1	35.9	0.39
2.00	1.30	162.9	0.17	21.30	1.10	137.8	34.8	0.44	1.25	186.0	0.15	22.32	1.31	194.9	36.4	0.54
3.00	1.55	228.2	0.19	27.97	1.25	184.0	36.2	0.53	1.38	218.0	0.18	28.44	1.42	242.4	39.3	0.62
4.00	1.75	259.5	0.22	32.63	1.33	197.2	38.2	0.57	1.44	242.2	0.21	35.32	1.50	252.3	40.1	0.67
5.00	1.90	287.9	0.23	34.85	1.42	215.1	40.8	0.62	1.51	264.3	0.24	42.00	1.62	283.4	41.6	0.73
6.00	1.95	298.0	0.24	36.67	1.55	236.8	42.6	0.65	1.66	291.3	0.24	42.12	1.70	298.4	44.3	0.78
Mean	1.62	226.9	0.20	27.73	1.28	178.0	37.6	0.52	1.37	217.7	0.19	30.53	1.46	233.6	39.6	0.62
L.S.D at 5%	0.15	23.6	0.01	2.35	0.08	11.3	2.1	0.02	0.05	21.8	0.01	2.46	0.07	13.5	2.4	0.02

*** mg/s : milligram/seedling**

Through studying Table (5) the following stricking observations can be cited:

1. The concentration and uptake of N, P, K and Pb by *Casuarina* seedlings grown in the treated soil with sewage sludge were significantly increased, in the two seasons, compared with control.
2. The increase in N, P, K and Pb concentration and uptake was proportional to the increase in the application rate of sewage sludge.
3. The most obvious improvement in concentration and uptake of these elements by *Casuarina* seedlings was resulted from the fourth rate (4%) of the sewage sludge, where the differences between this rate and the two higher rates were not significant .
4. The percent increase in N concentration and N uptake by *Casuarina* seedlings in the first season, relative to control were 71.67% and 394.3%, respectively. However, the increase percent in the second season relative to control were 60.18% and 390.21%.
5. The percent increase in P concentration and P uptake by *Casuarina* seedlings in the first season, relative to control were 62.28% and 353.10%, respectively. However, the increase percent in the second season relative to control were 72.73% and 431.94%, respectively.
6. The percent increase in K concentration and K uptake by *Casuarina* seedlings in the first season, relative to control were 28.33% and 249.05%, respectively. However, the increase percent in the second season relative to control were 32.58% and 306.94%, respectively.
7. The percent increase in Pb concentration and Pb uptake by *Casuarina* seedlings in the first season, relative to control were 17.24%

and 225.0%, respectively. However, the increase percent in the second season relative to control were 13.79% and 245.37%, respectively.

Similar results were obtained by Abdel-Naim *et al.* (1982, 1986); El-Nashar (1985); Shehata *et al.* (1985); Sadic *et al.* (1988); Aboulroos *et al.* (1989); El-Sokkary and El-Keiy (1989); Anand (1992) and Morsy and El-Dawwey (1999).

Generally, the increase in nutrients uptake may be due to one or more of the following reasons:

One. The high content of nutrients in the tested amendment (Table 1 and 2).

Two. The increase in dry weight of plants grown in the treated soil (Table 4).

Three. The increase in ion mobility due to the increase in the retained water in the treated sandy soil.

Four. The improvement in soil structure which reflected on holding water and decreasing nutrient losses by leaching and deep percolation.

Five. The decomposition of sewage sludge increases the organic acids, hence, it reduce P fixation which in turn, increases available P in soil and P uptake by plants.

Six. The decomposition of organic materials in soil liberates the organic nitrogen and increases its availability to plants.

9. The effect of sewage sludge on some chemical properties of the studied soil before and after cultivation:

Data given in Table (6) show the following :

1. Addition of sewage sludge to sandy calcareous soil slightly decreased the pH value before and after cultivation. The slight decrease in the pH values may be attributed to the effect of low pH value of sewage sludge, as well as the effects of organic acids produced from the decomposition of the used material and root residues in the soil.
2. Addition of sewage sludge to sandy calcareous soil increased the EC values of the soil before and after cultivation. The increase in EC values of the treated soil with sewage sludge may be attributed to its content of salts (Table 2).
3. Application of the tested amendment to the studied soil had no effect on $CaCO_3$ percent in the soil either before or after cultivation.
4. Addition of sewage sludge to sandy calcareous soil slightly increased the CEC before cultivation, however, it was significantly increased after cultivation. The increase in CEC values of the treated soil with sewage sludge may be attributed to its highly content of organic matter (Table 2).
5. The organic matter percent in the treated soil was significantly increased before and after cultivation, compared with the untreated one.

The results are in harmony with those obtained by Koreak *et al.* (1979); El-Toukhy (1982); Shehata *et al.* (1985); Fawzi (1986); Mahmoud (1988); Aboulroos *et al.* (1989); Tester (1990); Mohamed (1991); Anand (1992) and Morsy and El-Dawwey (1999).

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10. Content of some elements in the studied soil after cultivation:

Data given in Table (7) show that the application of sewage sludge to the studied soil increased the total nitrogen, available phosphorus, available potassium and DTPA lead in the soil after cultivation, in the two successive seasons.

The high increase in available phosphorus content in the treated soil with sewage sludge compared with control may be attributed to the decomposition of the used material and producing organic acids, which decreased phosphorus fixation and increased the available phosphorus.

Table (7): Effect of sewage sludge on content of total N, available P, available K and DTPA Pb in the studied soil after cultivation of *Casuarina* tree seedlings in two successive seasons.

Application Rate %	First season 1998				Second season 1999			
	Total N%	Available P, ppm	Available K, ppm	DTPA Pb,ppm	Total N%	Available P, ppm	Available K, ppm	DTPA Pb,ppm
0 00	0.010	0.25	6.10	0.16	0.012	0.22	6.00	0.14
1.00	0.011	0.30	8.23	0.18	0.014	0.25	7.95	0.15
2.00	0.013	0.34	9.83	0.22	0.019	0.29	8.90	0.19
3.00	0.015	0.51	10.65	0.25	0.022	0.36	10.15	0.23
4.00	0.018	0.63	11.70	0.29	0.025	0.44	11.30	0.25
5.00	0.022	0.69	12.45	0.31	0.0-27	0.53	12.40	0.29
6.00	0.026	0.71	13.10	0.32	0.029	0.61	12.95	0.30
L.S.D at 5%	N.S	0.03	0.05	0.03	N.S	0.05	0.30	0.02

Sewage sludge, usually have high levels of trace elements, including Pb .Page (1974) indicated that enrichment of plant tissues by sludge-borne Pb was unlikely. Additional studies indicate, while the soil might be enriched by sludge-borne Pb , its uptake by crops would seldom be of major concern as far as the food chain is concerned (Dowdy and Lareson, 1975 and Soon *et al*.1980). It has been concluded that, since Pb added to soils is usually not readily available to crops, accumulation of this element in crops would not limit the application of sludge to land (Adriano,1986).

Similar results were obtained by Webber (1972); El-Keiy (1983); El-Sokkary and El-Keiy (1989); El-Nashar (1985); Shehata *et al.* (1985); Sadic *et al.* (1988); Aboulroos *et al.* (1989) and Morsy and El-Dawwey (1999).

Generally, the improvement in growth parameters, water use efficiency and concentration and uptake of nitrogen, phosphorus and potassium of the *Casuarina* seedlings could be attributed to the effect of sewage sludge on the improvement in physical and chemical properties of the treated soil.

CONCLUSION

Economically, the most outstanding beneficial effect was obtained as a result of adding the sewage sludge as a soil amendment for newly reclaimed sandy calcareous soil at the rate of 4%. Therefore, it is concluded that sewage sludge can be considered as a good soil conditioner for improving the physical and chemical properties of coarse textured soils . Meanwhile, there is no hazards (due to the accumulation of heavy metals) on human being when using sewage sludge for planting wooden trees in the desert as windbreaks and as a source of wood production.

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تقييم مخلفات الصرف الصحى (الحمأه) كمحسن للأراضى الرملية الجيرية حديثة الاستصلاح فى مصر

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- أجريت تجربتى أصص خلال موسمى 1998 ، 1999 بهدف تقييم تأثير مخلفات الصرف الصحى (الحمأه) المضافة للأراضى الرملية الجيرية على بعض الخواص الطبيعية والكيميائية للتربة وكذلك النمو ومحصول المادة الجافة ومعدل استهلاك المياه وكفاءة استعمال المياه وتركيز وامتصاص عناصر النيتروجين والفوسفور والبوتاسيوم والرصاص بواسطة شتلات الكازوارينا التى تستخدم كمصدات رياح وكأشجار خشبية .
- أضيفت الحمأه الى التربة بتركيزات صفر ، 1 ، 2 ، 3 ، 4 ، 5 ، 6% ، وتمت دراسة التغيرات فى الخواص الكيميائية للتربة المعاملة قبل وبعد الزراعة وكذلك محتوى التربة من العناصر الغذائية بعد الزراعة .
- أظهرت نتائج هذه الدراسة أن استخدام الحمأه فى الأراضى حديثة الإستصلاح أدى الى مايلى :

- حدوث تحسن واضح فى الخواص الطبيعية والكيميائية للتربة بزيادة تركيز الحمأه المضافة .
- حدثت زيادة معنوية فى نمو النباتات ووزن المادة الجافة وزيادة كفاءة إستعمال المياه وكذلك تركيز وامتصاص عناصر النيتروجين والفوسفور والبوتاسيوم الممتص بواسطة نباتات الكازوارينا وذلك خلال فترة النمو فى الموسمين .
- معدل الزيادة النسبية للمعاملات المختلفة فى عنصر النيتروجين والفوسفور والبوتاسيوم الممتص بواسطة النباتات مقارنة بالكنترول (100%) فى الموسم الأول كانت 394.3% ، 353.1% ، 249.5% على التوالى ، بينما كانت فى الموسم الثانى 390.2% ، 431.9% ، 306.9% على التوالى .
- حدث انخفاض غير معنوى فى رقم الـ pH ، $CaCO_3$ فى التربة سواء قبل أو بعد الزراعة فى حين حدثت زيادة معنوية فى درجة التوصيل الكهربى (EC) ونسبة المادة العضوية والسعة التبادلية الكاتيونية (CEC) للتربة قبل وبعد الزراعة .
- تحليل التربة بعد الزراعة أظهر حدوث زيادة غير معنوية فى محتوى التربة من عنصر النيتروجين ، فى حين حدثت زيادة معنوية فى محتوى التربة من عنصرى الفوسفور والبوتاسيوم وذلك بزيادة تركيز الحمأه المضافة للتربة .
- إقتصادياً تبين من نتائج هذه الدراسة أن إضافة الحمأه الى الأراضى الرملية الجيرية حديثة الإستصلاح بمعدل 4% قبل الزراعة (40 طن/فدان) قد أعطى أفضل النتائج فيما يتعلق بتحسين خواص التربة والحالة الغذائية للنباتات نظراً لأن الزيادة الناتجة عن إستعمال المعدلين الأعلى (5% ، 6%) كانت زيادة غير معنوية إحصائياً .
- أخيرا يمكن القول أن مخلفات الصرف الصحى (الحمأه) تعتبر محسنا جيدا لتحسين خواص الأراضى خشنة القوام وتحسين نمو شتلات الكازوارينا التى تزرع فى الأراضى الصحراوية كمصدات رياح وكمصدر لإنتاج الخشب .

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Table (3): Effect of sewage sludge on some physical properties of sandy calcareous soil.

Application Rate %	Particle size distribution %											
	Coarse sand	Fine sand	Silt	Clay	Texture grade	Real density, g/cm^3	Bulk density, g/cm^3	Total porosity %	Hydraulic conductivity, cm/min	Field capacity %	Wilting point %	Available water %
0 00	27.37	69.06	3.06	0.51	Sandy	2.80	1.74	37.85	1.17	13.45	4.65	8.80
1.00	26.38	69.60	3.37	0.65	Sandy	2.71	1.66	38.75	0.99	14.92	4.95	9.97
2.00	25.35	69.68	3.85	1.12	Sandy	2.66	1.62	39.10	0.86	15.30	4.98	10.32
3.00	25.23	70.16	3.42	1.19	Sandy	2.62	1.59	39.31	0.78	15.83	5.08	10.75
4.00	23.20	70.35	4.93	1.52	Sandy	2.60	1.54	40.77	0.71	16.90	5.28	11.62
5.00	22.89	70.42	4.94	1.75	Sandy	2.59	1.47	43.24	0.69	17.85	5.45	12.40
6.00	22.45	71.54	4.06	1.95	Sandy	2.58	1.40	45.74	0.66	18.58	5.81	12.77

Table (6): Effect of sewage sludge on pH, EC, $CaCO_3$, CEC and organic matter in the studied soil before and after cultivation in the two successive seasons.

Application Rate %	pH		EC(dS/m)		$CaCO_3$ %		CEC (Cmol/kg)		Organic matter%	
	Before cultivation	After cultivation	Before cultivation	After cultivation	Before cultivation	After cultivation	Before cultivation	After cultivation	Before cultivation	After cultivation
1st season, 1998										
0 00	8.16	8.16	1.46	1.38	12.60	12.60	5.90	5.92	0.23	0.25
1.00	8.12	8.10	1.60	1.54	12.64	12.60	6.10	6.35	0.81	0.85
2.00	8.10	8.06	1.65	1.60	12.69	12.65	6.70	6.90	0.95	1.00
3.00	8.03	8.00	1.74	1.68	12.70	12.70	7.85	7.80	1.10	1.15
4.00	7.95	7.92	1.85	1.75	12.78	12.70	8.15	8.25	1.20	1.26
5.00	7.90	7.85	1.92	1.84	12.80	12.70	9.20	8.90	1.40	1.48
6.00	7.88	7.81	2.10	1.96	12.80	12.72	10.32	9.85	1.50	1.55
L.S.D at 5%	N.S	N.S	0.05	0.05	N.S	N.S	0.87	0.75	0.12	0.13
2nd season, 1999										
0 00	8.27	8.25	1.52	1.44	13.24	13.20	6.12	6.44	0.24	0.24
1.00	8.25	8.21	1.64	1.58	13.20	13.15	6.90	7.25	0.76	0.80
2.00	8.21	8.17	1.76	1.64	13.30	13.32	7.40	7.80	0.88	0.92
3.00	8.17	8.12	1.81	1.70	13.30	13.40	7.95	8.15	1.10	1.22
4.00	8.01	7.94	1.86	1.73	13.32	13.36	8.30	8.95	1.22	1.25
5.00	7.96	7.91	1.94	1.80	13.30	13.40	9.25	9.80	1.35	1.41
6.00	7.95	7.87	2.00	1.90	13.35	13.40	10.50	10.95	1.40	1.46
L.S.D at 5%	N.S	N.S	0.04	0.04	N.S	N.S	0.75	0.87	0.10	0.10