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Assessment of Sewage Sludge Application on Microbial Diversity, Soil Properties and Quality of Wheat Plants Grown in A Sandy Soil

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A FIELD trail was carried out on a sandy soil in El-Kata village, Giza governorate, to probe the consequences of enriching the soil with diverse rates of sewage sludge (10, 20 and 30 tons/fed) on microbial diversity, soil properties, growth and yield of wheat plants. The results indicated a significant rise in soil fertility level, as far as biological, chemical and physical features are considered. Wheat yield under the high rate of sewage sludge application (30 t fed^{-1}) was significantly higher than that gained under chemical fertilization while, wheat yield under chemical fertilization was significantly higher than that harvested under the low rate of sewage sludge application (10 t fed^{-1}).

The differences in wheat yield between chemically fertilized plots and those receiving 20 tons fed^{-1} of sewage sludge were not significant. It is worthy to mention that the concentrations of K, Zn, Mn, Cu, Cd and Pb did not increase in seeds or straw subsequent to sewage sludge application. EDTA-extractable Cu, Zn, Pb and Cd concentrations in soil increased with increasing rates of sewage sludge application. However, the accumulation of K, Zn, Mn, Cd, and Pb in soil as a result of sewage sludge use at wheat harvested was barely visible. It is concluded that the use of sewage sludge in agriculture as a partial substitute of mineral fertilizers and as an ameliorating agent for soil physical and biological properties might be seen as a common practice as. Eventual assessment of the accumulation of potential toxic elements in soil is highly recommended.

Keywords: Enzymatic activities, Microbial diversity, Sandy soil, Sewage sludge, Wheat plant.

It is well acknowledged that sandy soils lack factors crucial for fertility, as being differentiated by their very low moisture equivalent, ion exchange capacity and scarcity of organic carbon and nitrogen. These factors exercise synergic effects in warning soil productivity; low moisture equivalent necessitates frequent irrigation at short intervals, low ion exchange capacity permits rapid washing out of plant nutrients from soil. This enlightens the low efficiency of chemical fertilization experimented in these soils. The expansion of soil management practices that restore and/or improve crop production through lessening negative environment impacts has been studied by several authors (Dick, 1994 and Attia, 2003).

Application of sewage sludge to sandy soils is widely skillful as means of inexpensive waste disposal to improve soil properties (Sauerbeck, 1987). This amendment is rich in organic matter that stimulate native soil biodiversity, and thus, reactive biogeochemical nutrient cycles (Abdel Karem *et al.*, 2000 and Pascual *et al.*, 1999). Extensive studies to manage sewage sludge application for different crops, soils and climates are badly needed.

The overall ambition of the present work aims at assessing the application of different rates of sewage sludge to a sandy soil on their microbial diversity besides certain qualitative and quantitative measures of wheat plants.

Experimental Methods

A field trail was carried out in a sandy soil at El Kata village, Giza governorate, Sewage sludge compost was obtained from the Abou-Rawash Wastewater Treatment Plant. The mechanical analysis of the sandy soil revealed that it contains 79.83% sand, 5.85% silt and 14.32% clay. The main characteristics of soil and sewage sludge compost are listed in Table 1.

The trail covers three treatments, *i.e.,* mineral fertilization with NPK (100 kg N + 30kg P_2O_5 +50kg K_2O fed^{-1}), organic fertilization with sewage sludge (10, 20 and 30-tons air-dried sewage sludge fed^{-1}) as well as untreated soil. Sewage sludge was mixed with surface soil using disc harrow just prior wheat sowing. Seeds of wheat (Sakha 69, variety) were sowen at the rate of 60kg fed^{-1}. The area of each plot was 1/2 fed (2100 m^2). In plots receiving chemical fertilization, superphosphate and potassium sulphate were added during the preparation of the soil for cultivation, while nitrogen fertilizer as ammonium sulphate was added at 5 equal doses after 15, 30, 45, 60 and 75 days from sowing. Rhizosphere soil samples were collected, at wheat tillering, from each treatment for microbiological analysis. Plant samples were gathered at harvest and separated to grain and straw for chemical analysis. Sewage sludge and sewage sludge treated soil samples were taken before planting and at harvest time for chemical and biological analyses.

Microbiological analyses

Plants were carefully uprooted and thoroughly washed with tap water. Serial dilution technique was carried to count bacteria, aerobic spore-formers, actinomycetes and fungi in rhizosphere soil. One ml of homogenate soil suspension was plated in one of the following media nutrient agar, tryptone-glucose-yeast extract agar, martin agar, malt agar, selective medium (Jensen agar and Kusten Willioams's agar media) to isolate *Bacillus*, aerobic spore forming, fungi, *Trichoderma* and actinomycetes respectively (Camobell *et al.*, 1997). The plates were incubated at 30° for bacterial cultures, 28° for fungi and yeasts and 30° for actinomycetes. Bacteria, fungi, and actinomycetes were counted after 2,5 and 7 days of incubation, respectively. Mycorrhizal spores were counted according to Kormanik & McGraw (1982) and the number of spores was expressed to g dry $soil^{-1}$.

Enzymatic analyses

Dehydrogenase activity was determined by Garcia *et al.* (1993) method, and expressed as µg INTF/g dry soil. Urease activity was measured according to the method of Nannipieri *et al.* (1980) and expressed as µmol of NH^+_4-N/g soil/h. Phosphatase activity was determined according to the method of Tabatabai & Bermner (1969) and expressed as µmol of P-niteophenol (PNP)/g dry soil/24hr.

Physical and chemical analyses

Total N, P and K were determined in both soil and wheat plants according to the methods described by Kalra & Maynard (1991). EDTA extractable Fe, Zn, Mn, Cu, Cd and Pb were determined according to the methods given by Fujii & Cory (1986). Atomic abosorption spectrophotometry was used for analyses of heavy metals. Total organic carbon (TOC) was determined by method described by Yeomans & Bremner (1989). The soil physical properties were carried according to Kalra & Maynard (1991).

Statistical analysis

Results were statistically analyzed using the SPSS 10.0 (Statistical Package for the Sciences System). Spore and microbial counts were transformed by log X. Mean separation among the treatments was done by Duncan's Multiple Range Test at $P < 0.05$.

Results and Discussion

The addition of sewage sludge enriched the sandy soil with the three main macronutrients, *i.e.*, NPK, despite the increase in potassium was not that much (Table 1).Results revealed that always the higher the rate of sewage sludge application the higher the increases in macronutrients. On the other hand, EDTA extractable metals were somewhat increased with sewage sludge application. Worth mentioning, available iron, cupper, zinc and manganese in soils amended with sewage sludge were distinguishably higher than in the control treatment. Tsadilas *et al.* (1995) confirmed similar attitudes of micronutrients in sewage sludge amended soils, and reported a close correlation of decreasing availability of Mn with the incidence of organic amendment in soil. Interaction between Mn and organic matter was intense and complex as it is associated with certain secondary reactions of manganese that might affect micronutrient availability (Hue *et al.*, 1988).

After sewage sludge incorporation with soil, the soil pH was slightly reduced from 7.8 to 7.7, 7.6 and 7.5 as a result of addition of sewage sludge at rates of 10, 20 and 30-ton fed^{-1}, respectively as shown in Fig. 1. These values remained, fairly constant till wheat harvest. Several authors had reported a decrease of soil pH following sewage sludge application (Gasco *et al.*, 2002 and Valarini *et al.*, 2002). The decreased in pH was probably caused by the production of organic acids during sewage sludge decomposition and/or by NH^+_4-N nitrification.

TABLE 1. Concentrations of total elements in sewage sludge and sewage sludge treated soils before sowing.

Elements*	Sewage sludge	Soil treated with sewage sludge 0	10t fed^{-1}	20t fed^{-1}	30t fed^{-1}
Organic-C %	33.800	0.113	0.406	0.705	1.007
NH_4-N %	0.050	0.0006	0.001	0.0015	0.002
NO_3-N %	0.0200	0.0008	0.001	0.0012	0.0015
Organic-N %	2.470	0.026	0.049	0.074	0.097
Macronutrients (%)					
Total-N	2.540	0.028	0.510	0.077	0.101
Total-P	1.420	0.008	0.022	0.035	0.056
Total-K	0.120	0.019	0.021	0.022	0.024
Available-P (mg kg^{-1})	200	2	8	10	12
Heavy metals [EDTA extractable (mg kg^{-1})]					
Fe	1260	170	290	410	520
Zn	72	18	22	26	32
Mn	60	49	51	54	56
Cu	28.00	0.18	0.26	0.32	0.46
Cd	1.00	0.16	0.18	0.22	0.24
Pb	0.600	0.060	0.018	0.02	0.03

*Oven dry basis.

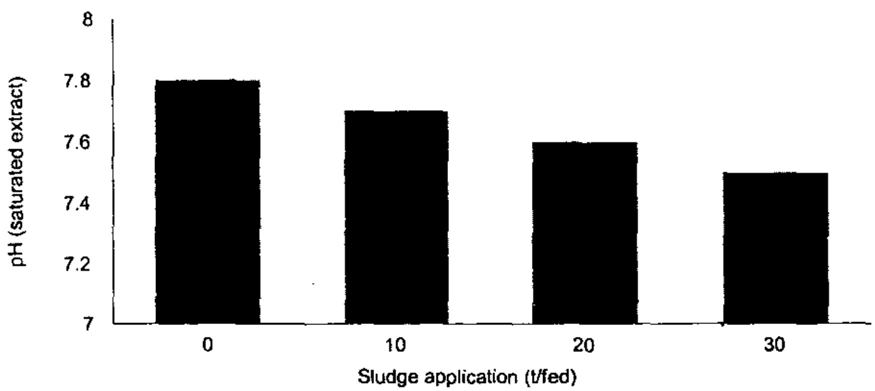

Fig.1. Effect of sewage sludge application rates on pH of sandy soil.

Electrical conductivity (EC) increased slightly with increasing the rate of sewage sludge application as shown in Fig. 2. The electrical conductivity ranged between 1.25 dSm^{-1} in untreated soil to 1.35 dSm^{-1} in soil treated with 30-ton fed^{-1} of sewage sludge. Application of 60 Mg/ha/yr for five years of limed sewage sludge to Port Byron silt loam in Minnesota (Duncomb *et al.*, 1983) increased the EC in the 0-15 cm soil depth from 0.32 to 0.46 dSm^{-1}, and in the 15-30 cm soil depth, from 0.30 to 0.43 dSm^{-1}. Despite sludge contains large quantities of salt, it might increase the electrical conductivity in soil solution.

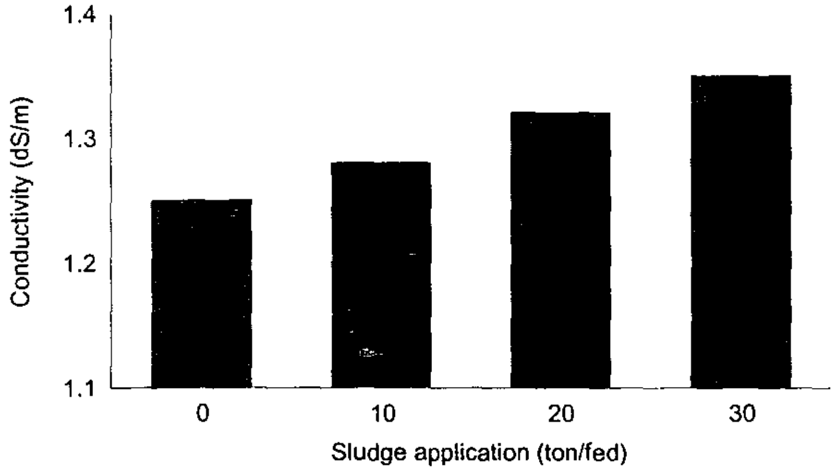

Fig. 2. Effect of sewage sludge application rates on electric conductivity in sandy soil.

Results of hydraulic conductivity shown in Fig. 3 exhibit a decrease associated with increasing sewage sludge application. Hydraulic conductivity decreased from 40cm hr in untreated soil to 25 cm hr in soil receiving 30-ton fed^{-1}. The increase in water retention at various metric potentials of sewage sludge-treated soils is probably due to the increase in total porosity, storage pores, and the water absorption capacity of organic matter (Filizola *et al.*, 1998). Treatments with sewage sludge positively affected cation exchange capacity (CEC) and water content (Tokeshi *et al.*,1997; Valarini *et al.*, 1997, 2002; Filizola *et al.*, 1998 and Frighetto *et al.*, 1998).

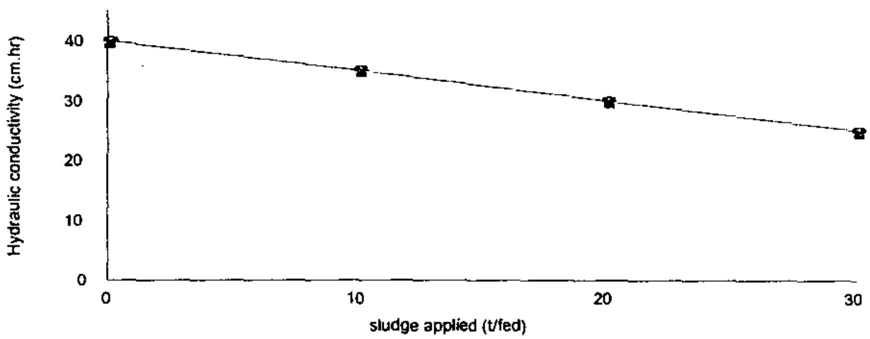

Fig. 3. Effect of sewage sludge application rates on hydraulic conductivity of sandy soil.

Results presented in Table 2 illustrate the population intensities of bacteria, spore-formers, actinomycetes and fungi in the rhizosphere of wheat plants. The population densities of studied microorganisms were increased significantly at $P<0.05$ in case of enriching the rhizosphere with 20-ton/fed or more of sewage sludge. These fast increases in the microbial intensities indicates a high nutritive value of sewage sludge present particularly nitrogen and phosphorus. Sewage sludge application to the sandy soil generally raised the activity of soil microorganisms through enriching soil organic matter (Dick, 1992 and Dick & Tabatabai, 1992). The increase of microbial density associated sewage sludge application might be ascribe to both now microbial biomass incorporated in the organic residues as well as the simulative action of added nutrients (Perucci, 1993; Diaz *et al.*, 1994 and Garcia *et al.*, 1998).

TABLE 2. Change in microbial intensities in the rhizosphere soil of wheat in accordance to sewage sludge application.

Sewage sludge rate	Mean per gram root dry weight			
	Bacteria ($x10^6$)	Spore forming ($x10^3$)	Actinomycetes ($x10^4$)	Fungi ($x10^4$)
Untreated soil	71a	8.4a	1.2a	3.4a
NPK	108a	12.8b	1.7a	3.7a
10t sewage sludge	216b	28.6c	3.4b	6.2ab
20t sewage sludge	401c	34.7c	4.4bc	9.3bc
30t sewage sludge	514c	46.4d	5.3c	10.3c

Numbers followed by the different small letter significant at level $P < 0.05$
NPK=100kg N+30kg P_2O_5+ 50kg K_2O fed^{-1}

Data given in Table 3 illustrate that *Bacillus* spp., *Streptomyces*, *Aspergillus* and *Trichoderma* were the common cellulolytic micro-flora found in soils receiving sewage sludge. The higher the rate of enrichment with sewage sludge the higher the intensities of cellulotytic microorganisms.

TABLE 3. Change in cellulolytic microorganisms in wheat rhizosphere soil in accordance to sewage sludge application .

Sewage sludge rate	Mean per gram root dry weight			
	Bacillus ($x10^5$)	Streptomyces ($x10^4$)	Aspergillus ($x10^4$)	Trichoderma ($x10^4$)
Untreated soil	5.58a	5.41a	2.16a	4.33a
NPK	5.74a	5.70a	3.65b	4.89a
10t sewage sludge	7.48b	6.97ab	4.11bc	6.47b
20t sewage sludge	7.80bc	7.48b	4.63c	7.55bc
30t sewage sludge	8.89c	8.64c	4.92c	8.21c

Numbers followed by the different small letter significant at level $P < 0.05$
NPK=100kg N+30kg P_2O_5+ 50kg K_2O fed^{-1}

Intensities of asymbiotic nitrogen fixing bacteria and phosphate solubilizing microorganisms were increased in soils treated with sewage sludge and were higher in soil enriched with high dose of sewage sludge (Table 4) . Furthermore, numbers of arbuscular mycorrhizal fungi (AM fungi) in rhizosphere of wheat plants were higher in soil treated with sewage sludge compared to untreated control (Table 4).

TABLE 4. Change in non-symbiotic nitrogen fixing bacteria, phosphate solubilizing microorganisms and spores of AM fungi in wheat rhizosphere soil in accordance to sewage sludge application.

Sewage sludge rate	Mean per gram root dry weight			
	Azotobacter ($x10^5$)	Aspergillus ($x10^3$)	Bacillus ($x10^4$)	AM fungi (spore 100 g dry soil)
Untreated soil	1.00a	1.04a	1.67a	3.0a
NPK	1.51a	1.51a	1.71a	4.0a
10t sewage sludge	2.85b	2.74b	2.30b	8.0b
20t sewage sludge	3.38b	3.11c	2.98bc	28.5c
30t sewage sludge	4.17c	3.84c	3.61c	48.0d

Numbers followed by the different small letter significant at level $P < 0.05$
NPK=100kg N+30kg P_2O_5+ 50kg K_2O fed^{-1}

A noticeable increases in enzymatic activities were evident in rhizosphere soils enriched with up to 20t fed^{-1} of sewage sludge (Table 5). Enzymatic activities were always higher in soils receiving 30t fed^{-1} sewage sludge. Results indicated that dehydrogenase activity was positively affected under all tested rates of sewage sludge application. Greatest enzymatic activity was observed when sewage sludge was applied at the rate of 20t fed^{-1}. Maximum urease activity in soil rhizosphere was found in soils receiving 20t $fed^{-1}$of sewage sludge. Measured activities of phosphatase were higher in all treated soils. The most significant values of the enzyme was recorded in soil amended with 20t fed^{-1} of sewage sludge. On the other hand, it is worthy to state that some authors indicated a decrease in the activity of dehydrogenase (Reddy & Faza, 1989), urease, and phosphatase (Reddy *et al.*, 1987) following soil enrichment with sewage sludge.

No effect of sewage sludge application on urease activity was detected, whereas phosphatase activity decreased only at high rates of sewage sludge. Brookes *et al* (1984) also reported that phosphatase activity was not affected by A noticeable increases in enzymatic activities were evident in rhizosphere soils enriched with up to 20t fed^{-1} of sewage sludge Table 5. Enzymatic activities were always higher in soils receiving 30t fed^{-1} sewage sludge. Results indicated that dehydrogenase activity was positively affected under all tested rates of sewage sludge application. Greatest enzymatic activity was observed when sewage sludge was applied at the rate of 20t fed^{-1}. Maximum urease activity in soil rhizosphere was found in soils receiving 20t fed^{-1} of sewage sludge. Measured activities of phosphatase were higher in all treated soils. The most significant values of the enzyme was recorded in soil amended with 20t fed^{-1} of sewage sludge. On the other hand, it is worthy to state that some authors indicated a decrease in the activity of dehydrogenase (Reddy & Faza, 1989), urease, and phosphatase (Reddy *et al.*, 1987) following soil enrichment with sewage sludge. No effect of sewage sludge application on urease activity was detected, whereas phosphatase activity decreased only at high rates of sewage sludge. Brookes *et al.* (1984) also reported that phosphatase activity was not affected by elevated soil metal concentrations due to sewage sludge application. Increases in biological activities caused by sewage sludge application is ascribed to high available carbon and moisture.

TABLE 5. Some enzymatic activities in wheat rhizosphere soil treated with different levels of sewage sludge .

Sewage sludge rate	DH-ase	Urease	Phosphatase
	*u*gINTF/g soil	Umol NH_4-N/g soil/h	*u*mol PNP/g soil/h
Untreated soil	132	1.8a	77a
NPK	151a	2.3b	93b
10t sewage sludge	193b	2.8c	141c
20t sewage sludge	237c	3.4d	182d
30t sewage sludge	282d	4.2e	255e

*Numbers followed by the different small letter are significant at level $P < 0.05$
NPK=100kg N+30kg P_2O_5+ 50kg K_2O fed^{-1}, DH-ase = dehydrogenase

Data in Table 6 reveal that the sewage sludge application surpassed chemical fertilizer treatment. The higher the dose of sewage sludge the higher increase in seed and straw yields of wheat. However, no significant differences were calculated between chemical fertilizer treatment and intermediate sewage sludge application rate. Seeds and straw yields of wheat increased significantly with increasing rate of sewage sludge application. Wheat yield under the high rate of sewage sludge application (30t fed^{-1}) was significantly higher than that gained under chemical fertilization. However, wheat yield under chemical fertilization was significantly higher than that harvested under the low rate of sewage sludge application (10t fed^{-1}). The difference in wheat yield between chemical fertilization and intermediate rate of sewage sludge was not significant. De Haan (1983) suggested that the most functional parameter in organic manures, including sewage sludge is the co-called organic matter effect, *i.e.,* increase in soil productivity arising from more than the available nutrients content. Increase over fertilized control plots might be attributed to an increase in soil water holding capacity, resulting from higher organic matter levels, as well as from the slow release of N and P from sewage sludge.

Tsadilas *et al.*(1995) studied the influence of sewage sludge application on some soil properties and growth of wheat. They measured the shoot/root ratios under various mixing ratios of soil and sewage sludge and found them to increase with increasing the rate of sewage sludge application. The Shoot/Root ratios in wheat plants grown in soils enriched with sewage sludge were higher than control, indicating that the shoot length was more than the root length.

TABLE 6. Effect of sewage sludge application on yield components of wheat grown in sandy soil .

Sewage sludge rate	Seed yield (kg fed^{-1})	Straw yield (kg fed^{-1})	Harvest index	Seed index (g)
	621 a	827 a	42.9 a	37.8 a
Untreated soil	1550 c	1520 b	49.5 b	41.2 b
NPK	1136 b	1412 b	44.6 a	40.6 b
10t sewage sludge	1660 c	1620 bc	50.6 b	41.5 b
20t sewage sludge	1970 d	1830 c	51.8 b	42.0 b
30t sewage sludge				

*Numbers followed by the different small letter are significant at level $P< 0.05$

NPK=100kg N+30kg P_2O_5+ 50kg K_2O fed^{-1}.

As mentioned before, data in Table 7 indicate that the concentrations of N, P, and Fe were increased in seeds and straw of wheat by sewage sludge application. On the other hand, the concentration of K, Zn, Mn, Cu, Cd, and Pd did not increase in seeds and straw by sewage sludge application compared to the control treatment. However, no significant differences in concentrations of N, P and K between chemically fertilized wheat and that receiving a high rate of sewage sludge. The increases in the metal concentrations were more pronounced in plots received 30t fed^{-1} sewage sludge. Results in Table 7 show also that cumulative sewage sludge application exhibited a high significant effect on Cd concentration in wheat plants particularly at the rate of 30t fed^{-1} sewage sludge. Cadmium has drawn the most attention because of related potential health hazard. Results showed that application of 30t fed^{-1} sewage sludge initiated an increase in Cd concentration in wheat plant tissues. However, Cd concentrations in wheat plants grown under all the sewage sludge treatments tried were below the phytotoxic levels of 5 mg/kg for Cd sensitive crops (Kim, 1988).

Table 8 shows the EDTA extractable metals increased in soil after wheat harvest in plots receiving sewage sludge. Their increase was parallel to the increase in sewage sludge rate. The El Kata soil was found to be poor in plant available nutrients specially Cu, and Zn Table 1. Sewage sludge might be a good source providing nutrients for plants. Increasing the rates of sewage sludge application increased the accumulation of nutrient elements in soil. However, the accumulation of K, Mn, Cd, and Pb were not that much in soils treated with sewage sludge in accordance to their low concentrations in sewage sludge. On the other hand, accumulation of organic C, N, P, Fe, and Cu was pronouncedly high.

TABLE 7. Effect of sewage sludge applications on elements concentration in seeds and straw of wheat.

Sewage sludge rate	N	P	K	Fe	Zn	Mn	Cu	Co	Cd	Pb
	Concentration of elements									
	%			Mg kg^{-1} plant material						
				Seeds						
Untreated soil	1.82a	0.25a	0.18a	50a	25b	12ab	0.2a	0.08a	0.04ab	0.02a
NPK	2.15b	0.32b	0.22b	54a	20a	10a	0.1a	0.06a	0.02a	0.01a
10t sewage sludge	2.05b	0.28b	0.20b	62b	26bc	12ab	0.2a	0.10a	0.04ab	0.02a
20t sewage sludge	2.12b	0.30b	0.22b	74c	28c	14b	0.2a	0.10a	0.04ab	0.02a
30t sewage sludge	2.20b	0.32b	0.22b	82d	28c	14b	0.2a	0.10a	0.06b	0.02a
				Straw						
Untreated soil	0.89a	0.14ab	0.20a	180a	28ab	24a	1.1a	0.10a	0.08ab	0.02a
NPK	1.15b	0.16b	0.22a	172a	25a	22a	1.0a	0.08a	0.06a	0.01a
10t sewage sludge	1.11b	0.12a	0.20a	200b	28ab	24a	1.1a	0.10a	0.08ab	0.02a
20t sewage sludge	1.21b	0.14ab	0.20a	220c	30b	24a	1.2a	0.10a	0.10b	0.02a
30t sewage sludge	1.30c	0.16b	0.22a	240d	30b	24a	1.2a	0.10a	0.10b	0.02a

*Numbers followed by the different small letter are significant at level $P < 0.05$
NPK=100kg N+30kg P_2O_5+ 50kg K_2O fed^{-1}.

TABLE 8. Concentration of accumulated elements in soil treated with different rate of sewage sludge (after wheat harvest).

Elements*	Soil treated with sewage sludge 0	10t fed^{-1}	20t fed^{-1}	30t fed^{-1}
Organic-C %	0.082	0.273	0.449	0.547
NH_4-N %	0.0004	0.0006	0.0010	0.0014
NO_3-N %	0.0006	0.0010	0.0012	0.0016
Organic-N %	0.020	0.037	0.058	0.078
	Macronutrients (%)			
Total-N	0.021	0.039	0.060	0.081
Available-P	0.001	0.0015	0.002	0.002
Total-P	0.006	0.018	0.028	0.049
Total-K	0.18	0.20	0.021	0.023
	Heavy metals (EDTA extractable (mg kg^{-1}))			
Fe	160	270	380	500
Zn (mg kg^{-1})	16	18	22	26
Mn (mg kg^{-1})	45	47	50	52
Cu (mg kg^{-1})	0.16	0.22	0.28	0.40
Cr (mg kg^{-1})	0.60	1.30	1.70	1.90
Cd (mg kg^{-1})	0.15	0.17	0.20	0.22
Pb (mg kg^{-1})	0.010	0.016	0.020	0.026

*Oven dry basis

References

Abdel Karem, H.; Radwan, S.M.A. and Attia, M. (2000) Impacts of certain biofertilizers on cowpea plants in sewage sludge amended sandy soil. *Pakist. J. Biol. Sci.* **3**, 423.

Attia, M. (2003) Impacts of arbuscular mycorrhizal fungi and *Pseudomonas putida* on distribution of some heavy metals in soils and faba bean plants. *Egypt. J. Microbiol.* **38,** 55.

Brookes, P.C.; McGrath, S.P.; Klein, D.A. and Elliott, E.T. (1984) Effects of heavy metals on microbial activity and biomass in field soils treated with sewage sludge. pp. 574-583, Environ. Contamin. CEP Ltd, Edinburgh, UK.

Camobell, C.D.; Grayston, S.J. and Hirst, D.J. (1997) Use of rhizosphere carbon sources in sole carbon source tests to discriminate soil microbial communities. *J. Microbiol. Methods,* 30, 33.

De Haan, S. (1983) General comments on the organic value of sludge. In: *"The Influence of Sewage Sludge Application on Physical and Biological Properties of Soils".* G. Catroux, P. L'Hermite, E. Suess and D. Reidel (Ed.), pp. 62-63, Publ. Co., Dordrech, Holland.

Diaz, E.; Roldan, A.; Lax, A. and Albaladejo, J. (1994) Formation of stable aggregates in degraded soils by amendment with urban refuse and peat. *Geoderma,* 63, 277.

Dick, R.P. (1992) A review: long-term effects of agricultural systems on soil biochemical and microbial parameters. *Agric. Ecosyst. Environ.* 40, 25.

Dick, R.P. (1994) Soil enzyme activities as indicators of soil quality. In: *"Proceedings of a Symposium Defining Soil Quality for a Sustainable Environment".* Doran, J.W.; D.C. Coleman; D.F. Bezdicek and B.A. Stewart (Ed.), pp. 107-124, Minneapolis, *Soil Sci. Soc. Am.* (SSSA Specia; Publ. 35).

Dick, R.P. and Tabatabai, M.A. (1992) Potential uses of soil enzymes. In: *"Soil microbial ecology: Applications in Agricultural and Environmental Management",* Metting Jr., F.B. (Ed), pp. 95-127, New York, Marcel, Dekker,

Duncomb, D.R.; Clapp; C.E. Dowdy; R.H. Larson W.E. and Polta R.C. (1983) The effect of limed sewage sludge on soil properties and maize production. In: *"Utilization of Sewage Wastes on Land. Research progress report"*,St. M.N. Paul (Ed), pp. F.1-F.12, USDA-ARS, University of Minnesota,

Filizola, H.F.; Valarini, P.J. and Tokeshi, H. (1998) Environmental impact of irrigated conventional farming systems. Test of biodynamical farming system In: *"World Congress of Soil Science", Summaries.* Montpellier, Guaira, Sao Paulo State, Brazil.

Frighetto, R.T.S.; Valarini, P.J.; Tokeshi, H.; Filizola, H.F.; Felipe, A. and Oliveira, D.A. (1998) Effects of management practices on soil physico-chemical, biochemical and microbial parameters under irrigated agriculture. In: *Conferencia Internacional,* IFOAM 98, S9. No. 158.

Fujii, R. and Cory, R.B. (1986) Estimation of isotopically exchangeable Cd and Zn in soils. *Soil Sci. Soc. Am. J.* 50, 306.

Garcia, C.; Hernandez, T.; Costa, F.; Ceccanti, B. and Masciandaro, G. (1993) The dehydrogenase activity of soil as an ecological marker in processes of perturbed system regeneration. In *Proceeding of the XI International Symposium of Environmental Biochemistry* , J. Gallardo-Lancho (Ed.), pp 89-100, Salamanca, Spain,

Garcia, C.; Hernandez, T.; Albaladejo, J.; Castillo, V. and Roldan, A. (1998) Revegetation in semiarid zones: influence of terracing and organic refuse on microbial activity. *Soil. Sci. Am. J.* 62, 670.

Gasco, G.; Vicente, MA.; Martinez-Inigo, MJ.; Sastre, I.; Yebenes, L.; Guerrero, A. and Lobo, MC. (2002) Nitrogen dynamic in an olive grove amended with sewage sludge. In *Proceeding of the third International Congress Man and Soil at the Third Millennium* , J.L. Rubio; R.P.C. Morgan; S. Asins and V. Andreu (Ed.), pp. 1097-1105, Geoforma Ediciones, Logrono.

Hue, N.V.; Silva, J.A. and Arifin, R. (1988) Sewage sewage sludge soil interactions as measured by plant and soil chemical composition. *J. Environ. Qual.* 17, 505.

Kalra, Y.P. and Maynard, D.G. (1991) *Methods Manual for Forest Soil,* pp.23-33, Forestry Canada Northern Forestry Centre.

Kim, S.J. (1988). Relative concentration of Cd and Zn in tissue of selected foot plants grown on sewage sludge treated soils. *J. Environ. Qual.* 17,568.

Kormanik, P.P. and McGraw, A.C. (1982) Quantification of vesicular-arbuscular mycorrhiza in plant roots. In: "*Methods and Principles of Mycorrhizal Research*", N.C. Schenck (Ed.), pp. 37- 45, AM Phytopathol. Soc. St. Paul. Minn.

Nannipieri, P.; Ceccanti, B.; Cervelli, S. and Matrese, E. (1980) Extraction of phosphatase, urease, protease, organic carbon and nitrogen from soil. *Soil Sci Soc Am J.* 44, 1011.

Pascual, J.A.; Garcia, C. and Hernandez, T. (1999) Lasting microbiological and biochemical effects of the addition of municipal soild waste to an arid soil. *Biol. Fertil. Soils.* 30, 1.

Perucci, P. (1993) Enzyme activity and microbial biomass in a field soil amended with municipal refuse. *Biol. Fert. Soil* 14, 54.

Reddy, G.B. and Faza, A. (1989) Dehydrogenase activity in sewage sludge amended soil. *Soil Biol. Biochem.* 21, 327.

Reddy, G.B.; Faza, A. and Bennett, R. Jr. (1987) Activity of enzymes in rhizosphere and non-rhizosphere soils amended with sewage sludge. *Soil Biol. Biochem.* **19**, 203.

Sauerbeck, D.R. (1987) Effects of agricultural practices on the physical, chemical and biological properties of soils: Part II. Use of sewage sludge and agricultural wastes. In: "*Scientific Basis for Soil Protection in the Eropean Community* ", H. Barlin and P.L. Hermite (Ed.), pp. 181-210.

Tabatabai, M.A. and Bermner, J.M. (1969) Use of *p*-nitrophenol phosphate in assay of soil phosphatase activity. *Soil Biol. Biochem.* 1, 301.

Tokeshi, H.; Alves, M.C.; Sanches, A.B. and Harada, D.Y. (1997) Control of *Sclerotinia sclerotiorum* with effective microorganisms. *Phytopathol.* 23, 146.

Tsadilas, C.D.; Matsi, T.; Barbayiannis, N. and Dimonyiannis, D. (1995) Influence of sewage sludge application on soil properties and on the distribution and availability of heavy metal fractions. *Commun. Soil Sci. Plant Anal.* **26**, 2603.

Valarini, P.J.; Garrido, M.S.; Fernandez-Santander, A. and Romero, C. (2002) Evaluation of biological parameters as indicators of the integral soil health after organic treatments. Comparison with phsico-chemical parameters. *Proceedings of the Third International Congress Man and Soil at the Millennium,* J.L. Rubio; R.P.C. Morgan; S. Asins and V. Andreu (Ed.), pp. 923-928, Logrono.

Valarini, P.J.; Frighetto, R.T.A.; Tokeshi , H. and Oliveira, D.A. (1997) Action of effective microorganisms (EM) in soil of intensive agricultural system in Brazil. In: *"International Conference on Kyusei Nature Farming"*, pp.15-16, Bangkok, Thailand.

Yeomans, J.C. and Bremner, J.M. (1989) A rapid and precise method for routine determination of organic carbon in soil. *Comm. Soil Sci. Plant Anal.* 19, 1467.

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تقييم إضافة الحمأة على التنوع الميكروبى وخواص التربة ونوعية نباتات القمح النامية فى تربة رملية

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أجريت تجربة حقلية على تربة رملية فى قرية القطا محافظة الجيزة لتقييم تخصيب التربة بمعدلات مختلفة من الحمأة (١٠، ٢٠، ٣٠ طن للفدان) على التنوع الميكروبى ونمو ومحصول نباتات القمح.

أظهرت النتائج زيادة معنوية فى مستوى خصوبة التربة وكذلك الخواص الكيميائية والفيزيائية والإحيائية للتربة. حيث أعطى المعدل العالى (٣٠ طن/للفدان) من الحمأة زيادة عالية فى البذور وقش القمح بالمقارنة بالأسمدة الكيماوية بينما أعطت الأسمدة الكيماوية زيادة معنوية فى محصول القمح بالمقارنة بالمعدل المنخفض من الحمأة (١٠ طن للفدان). وعلى الرغم من أن الاختلافات فى محصول القمح بين المعاملات المسمدة بالأسمدة الكيماوية وتلك المضاف إليها بـ٢٠ طن للفدان حمأة فلم يظهر بينيهما فروق معنوية. ومن الجدير بالذكر أن تركيز البوتاسيوم والزنك و المغنسيوم والنحاس والكاديوم والرصاص لم تزد فى بذور أو قش القمح نتيجة التسميد بالحمأة.

وقد أظهر تحليل التربة بعد حصاد القمح زيادة بعض العناصر بزيادة التسميد بالحمأة وعلى الرغم من ذلك كان تراكم البوتاسيوم والزنك والمغنسيوم والكاديوم والرصاص فى التربة بعد الحصاد كنتيجة للتسميد بالحمأة ضئيلا.

مما سبق يمكن استنتاج أن استعمال الحمأة فى الزراعة كبديل مميز للأسمدة المعدنية وكوسيلة لتحسين الخواص الطبيعية والإحيائية للتربة الرملية مع متابعة رصد تراكم العناصر الثقيلة بها كل حين.