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ARABIC SUMMARY		

SUMMARY

This investigation was focused on two different parts including a field survey; isolation and identification of microorganisms (fungi, arbuscular mycorrhizal fungi and bacteria) from agricultural fields near the superphosphate factory, Assiut, Egypt. The second part studies the direct and residual effect of compost at different levels (0, 2, 4 and 6 ton / fed) and inoculation with microorganisms on plants (carrot, spinach, peas, Jew's mallow, radish and cowpea) growth, transfer of Cd and Ni in tested plants and soil metal availability.

Part 1:

1- Soil texture of agricultural fields near the superphosphate factory varied from sandy loam to loamy sand of which clay, silt and sand ranged from 6.08 to 24.47%, 12 to 20 % and 61.45 to 81.92%, respectively.

2- The soils of the six sites were slightly alkaline with pH 7.00 to 8.50. The electrical conductivity values (EC) differed from 0.76 to 2.74 dS m^{-1} which could be considered non-saline soil.

3- According to international agricultural soil standards, the total contents of Mn, Cd and Ni were higher than the permissible limits (500, 1 and 20 mg kg^{-1}).

4- The accumulation of total heavy metals in the inspected soils could be arranged in descending order of which Fe > Mn > Zn > Ni > Cr > Cu > Pb > Cd.

5- DTPA-extractable Fe, Ni and Cr decreased with distance far from the factory, while DTPA-extractable Pb increased with distance. Concerning other studied metals, there is no clear relationship between levels of extractable Mn, Cu, Zn and Cd and the distance from the factory.

6- DTPA-extractable metals decreased in the order Fe > Mn> Cu > Zn >Pb > Ni > Cd > Cr of soil samples.

7- Seventeen fungal species and one species variety belonging to 11 genera in addition to some dark and white sterile mycelia were isolated during the present investigation from contaminated soil samples and mature compost on PDA medium and identified on CzDA, CzYA and PDA media.

8- Twelve mesophilic fungal species and one species variety belonging to eight genera were isolated from soil samples of 6 different sites at a different distance from the factory under study at 28 ±1º C. *Aspergillus* sp. was the most abundant genera in all the sampling sites then *Fusarium* sp., *Penicillium sp.*, *Rhizopus* sp., *Humicola* sp., *Epicoccum* sp. and *Cochliobolus* sp. The total counts of mesophilic fungi ranged from 1.46 x 10^4 to 3.2 x 10^4 CFU per g dry soil markedly lower than a "typical" temperate soil (10^5-10^6 CFU per g dry soil) as a result of pollution. Site No. 1 was the richest in mesophilic fungal population giving rise to 25.1% of total counts, whereas site No. 5 was the lowest in mesophilic fungal population represented by 11.5% of the total count.

9- Four thermotolerant and thermophilic fungal species and one variety belonging to 5 genera in addition to dark and white sterile mycelia were isolated from contaminated soil samples at 45 ±1° C. *Emericella nidulans* var. *nidulans* was the most common then *Thermomyces lanuginosus*, *Malbranchea sulfurea*, *Aspergillus fumigatus* and *Rhizomucor pusillus*. The total counts of thermotolerant and thermophilic fungi were 3.6 x 10^3 CFU per g dry soil. Site No. 3 was the richest in fungal population giving rise to 35.6% of total counts, whereas site No. 4 was the lowest in fungal population represented by 4.72% of the total counts.

10- Nine species of arbuscular mycorrhizal fungi were recovered from soil samples within 6 sites near the factory under study. In all sites, the dominant genus was *Funneliformis*, which comprised 47.3% of total spore density.

11- Based on spore density, the five dominant species in tested soils were *Funneliformis mosseae, Funneliformis geosporum, Glomus lamellosum, Acaulospora laevis* and *Rhizophagus clarus*, representing 34.2, 13, 12.3, 11.6 and 10.6% of total spore density, respectively.

12- Colonization by AM fungi was widely varied, ranging from 55 to 88 %, in which the highest value was recorded in site No. 2 and mycorrhizae were represented by all typical structures viz. hyphae, arbuscules and vesicles.

13- The total counts of mesophilic and thermophilic bacteria were 10.4 x 10^6 and 38.96 x 10^4 respectively. The total bacterial

14- count of contaminated soil was lower than a "typical" temperate soil (10^8-10^9 CFU per g dry soil). Site No. 2 was the richest in mesophilic bacterial population giving rise to 25.29% of total counts, whereas site No. 4 was the richest in thermophilic bacterial population yielding 40.29% of total counts.

15- Based on statistical analysis, there was a strong negative correlation between total microbial count and most heavy metals under study.

16- According to the microbial diversity, four fungal isolates (*Aspergillus niger, A. terreus, Penicillium funiculosum* and *Fusarium culmorum*) + one bacterial species (*Bacillus* sp.) and four species of arbuscular mycorrhizal fungi (AMF) (*Acaulospora bireticulata*, *Gigaspora margarit, Glomus lamellosum and Funneliformis mosseae*) were used as inoculum in the second part of the investigation.

Part II:

A- Carrot and Jew′s mallow experiments:

1- Results showed that the mycorrhizal colonization of Jew's mallow (residual effect) was higher than that of carrot (direct effect). The highest mycorrhizal colonization of carrot plants recorded at moderate compost rate (4 ton / fed) + AM. Whereas, the residual effect of CM (2 ton / fed) + M + AM treatment attained the maximum mycorrhizal colonization of Jew′s mallow plants.

2- Growth measurements of carrot plants were significantly ($p < 0.05$) increased as a result of direct application of compost and microorganisms. The highest values of root fresh weight and root dry weight were observed in CM (2 ton / fed) and CM (2 ton / fed) + M treatments, respectively. CM (zero) + M treatment realized the maximum values of shoot fresh weight and root length while CM (zero) + AM attained the highest values of shoot dry weight and shoot length.

3- The growth parameters of Jew′s mallow plants were highly significant ($p < 0.05$) increased as a result of residual effect of all the amendments. Where the residual effect of CM (zero) + AM treatment gave the maximum values of root and shoot fresh weight and shoot dry weight. However, the residual effect of CM (2 ton / fed) +M and CM (6 ton / fed) + M +AM treatments realized the highest values of root dry weight and plant height, respectively.

4- The maximum value of mycorrhizal dependency of carrot plants (28.22%) obtained at 2 ton / fed compost. While, the residual effect of CM (zero) + AM gave the highest (57.04%) value of mycorrhizal dependency in Jew′s mallow plants,

5- Cadmium contents decreased by 70 and 62.97%, respectively in roots and whole plants of carrot grown in polluted soil by using CM (6 ton / fed) + M + AM treatment. Whereas in shoots, the lowest level recorded 65.52% reduction in soil treated with CM (6 ton/ fed) + M. Concerning to Jew′s mallow, the residual effect of CM (2 ton / fed) + M + AM

gave maximum Cd reduction in roots and whole plants by 88.41 and 80.87%, respectively. On contrast, in shoots gave the lowest level with the residual effect of CM (6 ton / fed) and AM fungi by 86.48 %.

6- Data showed that using compost at 6 ton / fed with microbes and AM fungi positively decreased sharply Ni concentration by 94.35, 92 and 93%, respectively in roots, shoots and whole plants of carrot. On the other hand, Ni content of Jew's mallow plants was higher than carrot plants. The maximum reduction in Ni concentration in whole plant of Jew's mallow was detected in residual effect of CM (4ton / fed) + AM treatment.

7- DTPA extractable of Cd and Ni values in Jew's mallow soil after harvesting were higher than in carrot soil. The DTPA extractability of soil Cd and Ni were significantly decreased with increasing soil pH ($p < 0.05$). Soil pH increased significantly ($p < 0.05$) particularly when using AM fungi or M + AMF only or combined with compost and their residual effects. The soil availability of Cd and Ni were the lowest as application of compost and microorganisms. The lowest DTPA extractable of Cd and Ni observed with CM (6 ton / fed) + AM treatment with a reduction 17.19% and 18.58%, respectively at pH (7.16). While, The minimum DTPA extractable of Cd and Ni in soil of Jew's mallow was detected with residual effect of CM (zero) + AM treatment with a reduction 41.94% and 62.48%, respectively at pH (7.24).

8- The TF values of different treatments varied from 0.09 to 0.25 for Cd and 0.008 to 0.110 for Ni by carrot plants. Whereas, TF values of Cd and Ni varied from 0.34 to 1.75 and ND to 0.20 by Jew′s mallow plants.

B- Peas and radish experiments:

1- Pea plants treated with CM (2 ton / fed) + AM and CM (4 ton / fed) + M +AM, recorded the maximum values mycorrhizal colonization. While, the highest proportion of mycorrhizal colonization structure of radish plants in application of CM (6 ton / fed) + M+AM treatment**.**

2- Growth measurements of pea plants were significantly ($p < 0.05$) increased as a result of amendments. Results show that application of CM (4 ton / fed) + AM fungi treatment attained the highest values of fresh and dry weight of roots and shoots. Whereas, using CM (4 ton / fed) + M treatment gave the maximum values of pods weight, fresh and dry weight of peels and dry weight of seeds.

3- The residual effect of different compost levels and inoculation improved radish growth parameters. CM (4 ton / fed) + AM treatment attained the maximum values of root and shoot dry weight and radish branches. While, the highest values of root fresh weight, shoot fresh weight, root length and shoot height were detected in CM (2 ton / fed), CM (2 ton / fed) + AM, CM (zero) + AM and CM (6 ton / fed) + AM fungi treatments, respectively.

4- The direct and residual effect of CM at 4 ton /fed + AM treatment attained the highest value of mycorrhizal dependency of pea and radish plants recorded 37.22 and 41.02%, respectively.

5- The lowest content of Cd (75% reduction) in roots of peas was observed in CM (4 ton/fed) + M + AM treatment. Meanwhile, the minimum level of Cd in shoots, peels and seeds of pea plants was detected in CM (6 ton / fed) + M by reduction 65.33, 55.35 and 61.54%, respectively. The residual effect of the previous treatment reduced Cd concentration by 73.33, 81.5 and 78% for roots, shoots and whole plants of radish, respectively.

6- Application of compost at high level (6 ton / fed), microbes and mycorrhizal inoculations attained highly significant reduction for nickel content by 65.60 and 71.46 % in roots and seeds of peas, respectively. The lowest Ni values in shoots of peas were realized in plants treated with CM (6 ton / fed) + AM or M+ AM. Concerning radish plants, the lowest level of Ni was recorded in roots, shoots and whole plants of radish in CM (6 ton / fed) + AM treatment by reduction 75, 38.46 and 47.06%, respectively.

7- Soil cultivated with pea and treated with AMF always had the lowest amounts of DTPA-extractable Ni with all discussed compost treatments by reduction 32.34% at the pH (7.12). The lowest DTPA extractable Cd was recorded by reduction 24.31% at pH (7.14) in soil treated with CM at 6 ton / fed + M

+ AM fungi. DTPA extractable Cd and Ni in soil after harvesting radish were lower than in pea soil**.** The minimum Cd availability was observed in residual effect of AM fungi treatment recorded the highest value of soil pH (7.18) by reduction 22.83%. On contrast, the residual effect of CM (2 ton / fed) plus AM fungi attained the lowest level of DTPA extractable Ni at soil pH (7.16) by reduction 39.30%.

8- TF values at different treatments pea plants varied from 0.43 to 1.12 for Cd and 0.067 to 0.152 for Ni. However, the TF of Cd by radish plants varied from 0.18 to 0.72 and the TF of Ni varied from 0.089 to 0.148.

C- Spinach and cowpea experiments:

1- The highest mycorrhizal colonization structure in spinach plants was detected in CM (4 ton / fed) + M +AM treatment. On contrast, residual of CM (2 ton / fed) + M + AM attained the maximum values of hyphae, vesicles and arbuscular colonization in cowpea plants.

2- Data showed that the highest values of root fresh weight and dry weights of root and shoot of spinach were recorded in CM (4 ton / fed) + M + AM treatment. While, the maximum values of shoot fresh weight, plant height and branches number were detected in CM (6 ton / fed) + M + AM, CM (6 ton / fed) + AM and CM (zero) + AM treatments, respectively.

3- Results showed that no pods formed in cowpea plants. Data showed that the highest value of fresh and dry weight of root and shoot were attained at residual effect of high level of

compost (6 ton / fed) + AM fungi. The maximum value of the plant height was realized in plants inoculated with AM fungi only.

4- The highest value of mycorrhizal dependency (MD) for spinach plants detected at 4 ton / fed of compost inoculated with M + AM fungi recorded 38.83%. Concerning cowpea plants, the residual effect of AM fungi treated with 6 ton / fed of CM recorded the highest (34.49%) value of mycorrhizal dependency (MD) for dry weight of cowpea plants.

5- The minimum level of Cd (58.33% reduction) was observed in roots of spinach grown in polluted soil incorporated with CM at 4 ton/fed + AM, CM at 6 ton/fed, CM at 6 ton/fed + M, CM at 6 ton/fed + AM and CM at 6 ton/fed + M + AM. On contrast, the lowest level in cowpea roots was detected in CM at 2, 4, 6 ton / fed treatments combined with AM fungi by reduction 43.55%. Cadmium content decreased by 71.42% in shoots of spinach when using CM at 6 ton / fed with AM fungi and with M + AM while the metal content decreased by 80% in cowpea shoots as a result of the residual effect of CM at 4 and 6 ton / fed with AM fungi treatments.

6- The lowest level of Ni (92.5% reduction) was recorded in roots of spinach treated with CM (2 ton / fed) + AM. While, Ni level decreased by 81.81% for the corresponding organs of cowpea when using CM (4 ton / fed) + AM. Concerning shoots of spinach, Ni concentration reduced by 64.29% when soil treated with CM at (6 ton / fed) + AM fungi while the

minimum concentration (76.19% reduction) observed in cowpea shoots as a result of the residual effect of CM (4 ton / fed) + AM fungi.

7- Results showed that the DTPA extractable of Cd and Ni in cowpea soil were higher than in spinach soil. The lowest DTPA extractable of Cd and Ni in spinach soil was recorded at pH (7.14) in soil treated with CM (4 ton / fed) + AM and also, it decreased by 34.09% and 46.93% respectively. Whereas, the minimum Cd and Ni availability in cowpea soil was observed in residual effect of CM (6 ton / fed) + AM treatment recorded at soil pH (7.12) by reduction 31.95 % and 31.77 % respectively.

8- The TF values of different treatments varied from 0.46 to 1.33 for Cd and 0.064 to 0.19 for Ni by spinach plants while varied from 0.89 to 1.96 for Cd and 0.058 to 0.28 for Ni by cowpea plants.