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Improve Physico- Chemical Properties of Poor Soil at Toushka Area Using Lake Nasser Sediments

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ABSTRACT

It is well known that the problem associated with the construction of Aswan High Dam is trapping the sediments upstream the dam in Lake Nasser. Sedimentation reduces reservoir storage capacity, increase of bed levels at the reservoir entrance and formation of a new delta. For this reason, periodical dredging of Lake Nasser sediments have been necessary. These dredged sediments can be utilized for reclaiming poor lands around the Lake. Some area of Toushka land suffers from deficient of nutrients, clay and organic matter content, therefore sediment from Lake Nasser can be added to this soil to improve their physico- chemical properties. Since the annual floods from the Nile River no longer occur, the sediments and silt that were carried all throughout the region are trapped in Lake Nasser.The lack of natural fertilizer has resulted in an increase in erosion of the river and Nile Delta, and an increase in the use of chemical fertilizers. The chemical fertilizers contain high levels of Nitrogen and Phosphorous which are harmful because they flow from the cropland to the water. Both of these elements are known to cause an increase in algae and algal blooms.The main objective of this work is to provide simple guidelines for using Lake Nasser sediments as natural fertilizers in Toushka area.

To achieve this goal, sediment samples were collected from the sedimentation area of Lake Nasser. Also soil sample was collected from the selected poor land in Toushka. Sediment and soil are mixed with different percentage (40, 60 and 80%).Sediment, soil and different mixtures samples were subjected to analysis for pH, Electric conductivity, Calcium Carbonate, Cation exchange capacity, Organic matter , Nitrogen, Phosphorus, Potassium and some heavy metals (Fe, Mn, Cu Pb, Cd, Ni and Zn).The results showed that soil texture at Toushka area is silty loam and poor in their content of available Nitrogen, Phosphorous and Potassium (NPK), organic matter, clay and have low Cation exchange capacity. While Lake Nasser sediment classified as clay and rich in their content of the most analyzed parameters.Also the results of physico- chemical properties for mixture samples showed that, the concentrations of the most analyzed parameters increase as the amount of mixed sediment-soil increase except soil pH and Calcium carbonate percentage. The paper concluded that, Lake Nasser sediment can be utilized as soil amendment for Toushka area with different mixtures which contain sufficient amount of nutrients, organic matter, clay and minimum amount of available heavy metals and salts as well as optimum pH value. Therefore, it is recommended to implement a pilot project to evaluate the characteristic of sediment for reclaiming poor areas of Toushka land and define the optimum acceptable ratio of soil sediment mixture.

Key words: Lake Nasser sediment, Toushka land, physico- chemical properties, Land reclamation

Introduction

Toushka area lies at the southern west of Egypt and adjacent to Lake Nasser at its northern west direction. This area is one of the most prospective areas for sustainable agriculture development in south valley. Therefore, Egypt starting national project for cultivating these lands to get clean agriculture production (free from pollution). Although most of Toushka lands are considered good for cultivation, there are some areas have mainly sandy texture soil and poor of clay content, organic matter and available nutrients. Therefore, these lands need to improve their physico- chemical properties by adding sediments as a soil amendment. Natural fertilizers are those formed through decomposition, while chemical fertilizers are manmade or mined. Natural fertilizers improve the texture of the soil and increase the amount of beneficial microorganisms. Ho *et al.*, (2000) studied the yield and heavy metal concentration of white cabbage and beet cultivated in soil amended with River-sediment from Hanoi, Vietnam. The author concluded that yield of white cabbage and beet was definitely affected by addition of the river-sediment, which was collected from Tolich River, Hanoi, to the agricultural soil taken at the farm of Hanoi Agricultural University. The yield was highest at 30% addition of the sediment to the soil, indicating the fertilizer effect of the sediment. Effect of addition of the sediment on the total heavy metal concentration in crops was not clear, but tendency of accumulation of Cd was noticed. Parkpian *et al.*, (2002) assessed the benefits and risks of using River sediment for Vietnamese Agriculture: A case study of the Nhieu

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Loc Canal in Ho Chi Minh City. The applications of sediment to cabbage field have caused an increase in concentration of heavy metals in soil, especially substantial amount of Zn (over 100 kg/ha) and Pb (14.66 Kg/ha). From short-term observation, it was found that application of Nihieu Loc sediment to cabbage farm is safe but further study should be carried out to find long-term effect, if the application of this sediment is still practice by farmers at the higher rates (28-42 ton/ha). All plants need nitrogen, phosphorus and potassium to grow. Without enough of any one of these nutrients, a plant will fail. Nitrogen is largely responsible for the growth of leaves on the plant. Phosphorus is largely responsible for root growth and flower and fruit development. Potassium is a nutrient that helps the overall functions of the plant performs correctly. There is a wide variety of beneficial uses of sediment as a soil amendment, depending on the physical and chemical properties of sediment. Sediment is added to soil both as sources of fertilizer and conditioner for the soil, since they contain useful amounts of plant nutrients and organic matter. The organic matter in the applied sediment enhances the soil's structure by reducing plasticity and bulk density and improving granulation, porosity and water-holding capacity (Liu *et al*., 1999). In addition, nutrient in sediment, increase cation exchange capacity which, measures the ability of a soil to retain cations. The objective of this work is to provide simple guidelines for using Lake Nasser sediments as natural fertilizers in Toushka area.

Materials and Methods

Sampling and site description:

Sediment sampling was collected from the top layer (5 cm) of bed sediments at six sites along the Lake, started from Arkeen (km 333.3) to Masmas (km 237) which represent sedimentation area (Figure 1). Soil samples were also collected from land of Toushka at El- Mostqble village E (031, 33, 46) & N (22, 24, 21).
The sediment sample mixed with soil by different percentage: mixture (1) [40% (40 gm sediment: 60 gm soil)], mixture (2) [60% (60 gm sediment: 40 gm soil)] and mixture (3) [80% (80 gm sediment: 20 gm soil)].

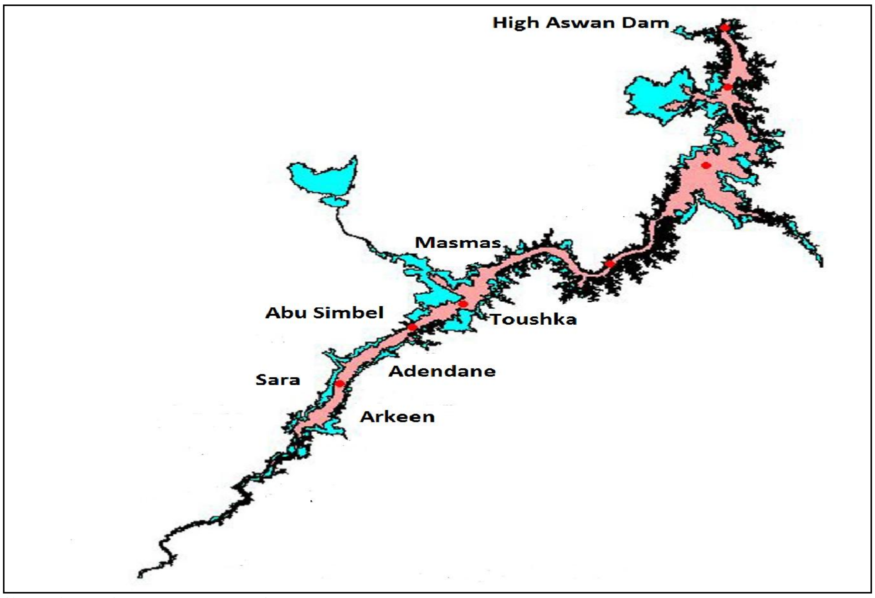

Fig. 1: Sampling sites along Nasser Lake

Analytical procedures:

The collected sediments and soil samples were air dried crushed and sieved through a 2 mm sieve and subjected to the following analysis at laboratory:
The mechanical soil analysis was carried out as described by Baruah and Barthakur (1997).
Soil reaction (soil pH) was determined in the soil suspension (1:2.5 soils) using pH meter (Jackson, 1973).
Calcium Carbonate content was measured volumetrically using Collin's Calcimeter, Jackson, (1973).
Organic matter content was determined by Welkey and Black method, (Black, 1982).
Cation exchange capacity was determined according to Black, 1982.
Electric conductivity (EC) was determined according to Jackson, 1973 (1:2) soil water ratio.
Available Nitrogen was determined by micro-kjeldahel method (Black, 1982).

Available macro and micronutrients P, K and some trace metals (Fe, Mn, Cu Pb, Cd, Ni and Zn) were extracted according to the method of Chester *et al.,* (1985) and determined by inductively coupled plasma spectrometer (ICP plasma 400).

Results and Discussion

The data obtained for different physico- chemical analysis of sediment samples from Lake Nasser, soil samples from Toushka and different mixture of (sediment- soil) are graphically represented in Figures (2 - 10) and the data of some trace metals are presented in Table (1). The observations and interpretation about these data are discussed as follows:

Grain Size Distribution

Figure (2) showed the results of the grain size distribution in bed sediments, Soil and different mixture (sediment + soil) samples. The grain size of sediment, mix.2 (60%) and mix.3 (80%) samples are classified as clay. The soil sample collected from Toushka is classified as silty loam, while, mix.1 (40%) sample is classified as clay loam. It is clear from the above result that, the addition of sediment to the soil by the lowest studied ratio 40% (Mix.1) leads to acceptable increase of clay content in soil. Clay is a naturally occurring, inorganic component of most soils with a chemical formula called aluminosilicates [$Al_4Si_4O_{10}(OH)_8$] which carry negative charges and have a large surface area. Large surface area and negative charges of this clay lead to adsorb a positively charged ion that important as plant nutrients, such as ammonium, calcium, magnesium and potassium. The clay/silt fraction has high surface area and because of its surface chemistry is more likely to adsorb organic and heavy metal (Shuzhen, *et al*., 2002).

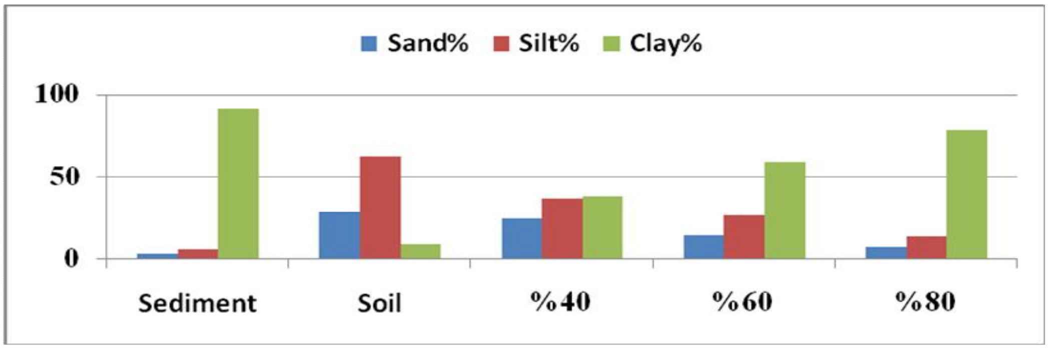

Fig. 2: Grain size distribution

Hydrogen ion concentration (pH)

The results presented in Figure (3) show that the pH recorded values of 6.42 and 7.16 in sediment and soil sample, respectively. However its values in different mixture ranged from 6.55 in Mix.3 (80%) to 6.87 in mix.1 (40%). It is clear that the addition of sediment to soil lead to decreases in the pH values in different mixture except mix.1 (40%) that was found to be close to neutral state and therefore it is suitable for the availability of most nutrients. It was found that soil pH affects the availability of nutrients and how the nutrients react with each other. If the soil is more alkaline than pH 8, phosphorous, iron and many trace elements become insoluble and unavailable for plant uptake. The phosphorus is most available for plant uptake at pH 6.0 to 6.8. It is worth to mention that, when the pH value is greater than 7.5, calcium can tie up phosphorus, making it less available to plants (NSW. Agriculture, 2000 and Fernandez & Robert, 2012). Also the availability of certain nutrients (iron, manganese, and copper) for plant uptake increase as pH decreases. The same nutrients could become unavailable (chemically tied up) at pH 7.0 or above. Additionally, alkaline soils cause zinc deficiencies that lead to stunted plants, poor growth and reduced yields in some crops and pastures. The changes in the availability of nutrients cause the major effects on plant growth attributed to acid soils (NSW. Agriculture, 2000). The pH of soil will change over time influenced by factors including parent material, weathering and current agricultural practices. It will also fluctuate through the year. (NSW. Agriculture, 2000).

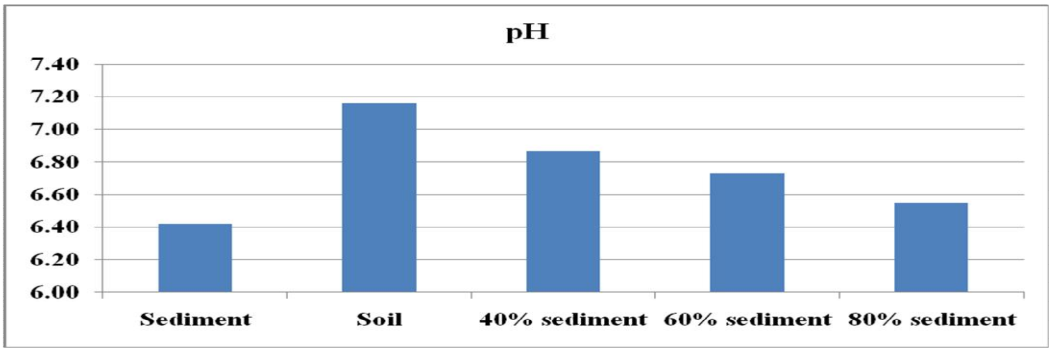

Fig. 3: pH values

Electric conductivity

The maximum conductivity value (6.32 ds m^{-1}) was recorded in sediment sample while, the minimum value (2.35 ds m^{-1}) was recorded in soil sample (Figure 4). It is clear that the addition of sediment to soil lead to increase of EC values in different mixtures (40, 60 & 80%) where the values were 2.46, 2.58 & 3.51 ds m^{-1} respectively as shown in Figure (4). According to Smith and Doran (1996), silty loam to clay loam soil with EC value ranged from 1,4 to 2.5 is consider slightly saline soil. Therefore EC value of Mix.1 (40%) considered slightly saline soil and suitable for reclaiming poor areas of Toushka land than other mixtures.

Soil electrical conductivity (EC) is a measure of the amount of salts in soil (salinity of soil). Although EC does not provide a direct measurement of specific ions or salt compounds, it has been correlated to concentrations of nitrates, potassium, sodium, chloride, sulfate, and ammonia. It is an important indicator of soil health which affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms. Increases in EC lead to decline microorganism activity and hinder plant growth by affecting the soil-water balance (Adviento- Borbe *et al*., 2006).

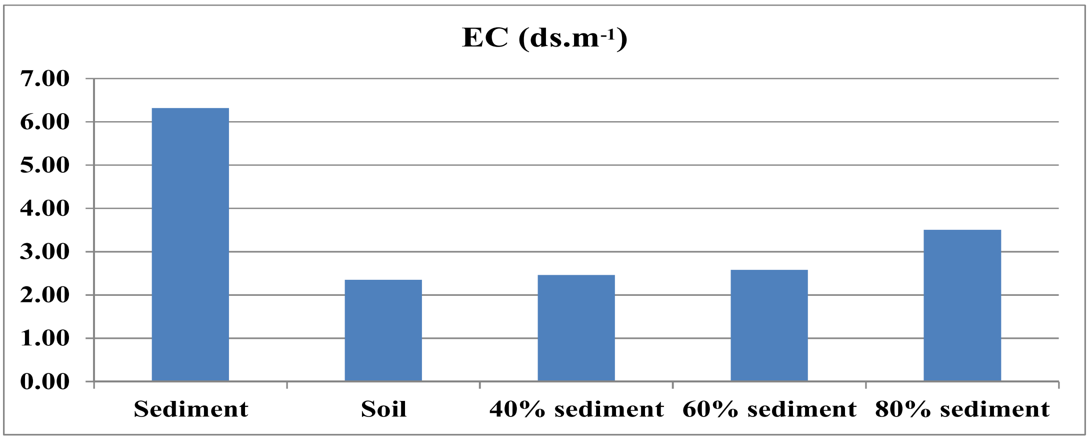

Fig. 4: Electrical Conductivity values

Nutrients (Nitrate, Phosphate and Potassium (NPK)):

Nitrate:

The results presented in Figure (5) showed that the nitrate concentration of soil sample increase by adding sediment. The maximum value (177.5 mg kg^{-1}) was recorded in sediment sample ,while the minimum value (76.5 mg kg^{-1}) was recorded in soil sample. It is worth to mention that, mix.1 (40%) and mix.2 (60%) recorded the same value (164 mg kg^{-1}) of nitrate concentration. Therefore mix.1 (40%) can be consider suitable for the availability of nitrogen as nitrate in soil.

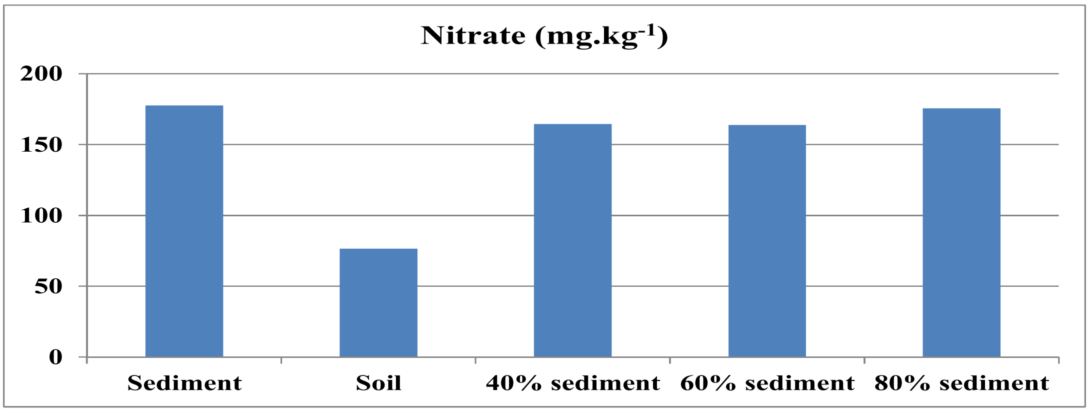

Fig. 5: Nitrate concentrations

Phosphate

The highest phosphate concentration (2011.5 mg kg^{-1}) was recorded in sediment sample while, the lowest value (805.5 mg kg^{-1}) was recorded in soil sample. However, the phosphate concentration in different mixtures showed gradually increase as the sediment percentage increase and recorded values of 1168.5, 1769.5 and 1786 mg kg^{-} respectively (Figure 6). Therefore, mix.1 (40%) showed increase in phosphate concentration of soil by 45% which considered suitable for phosphate availability in soil. Since nitrogen and phosphorus are essential elements for plant growth and being recognized as primary nutrients. A high level of phosphorus in soil was reported to suppress the uptake of zinc micronutrients or vice versa high zinc in soil will induce deficiency of phosphorus (Adriano, 1992). Phosphorous is common in most of the soils and application of phosphatic fertilizer is considered crucial for crop production (Memon, 1996). Phosphorus stimulates flourishing and seed formation.

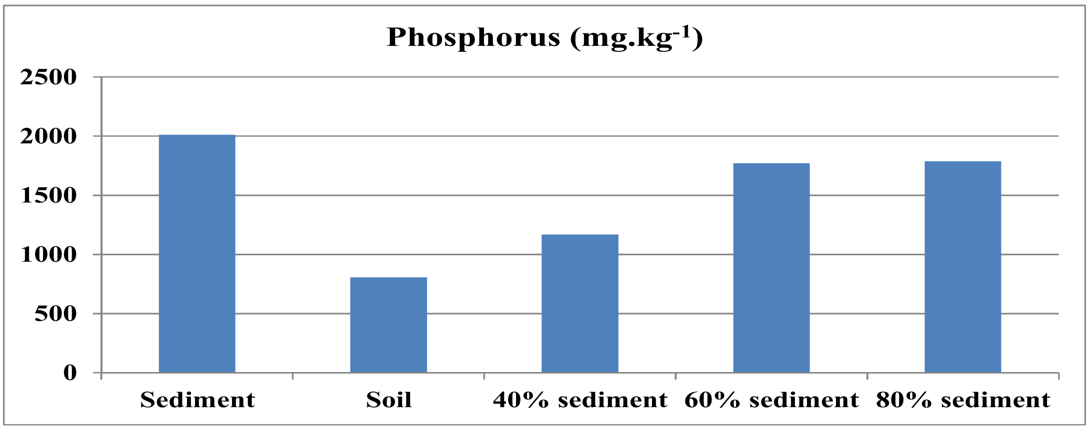

Fig. 6: Phosphate concentrations

Potassium

Potassium recorded the highest value of 1200 mg kg^{-1} in sediment sample while, the lowest value (580 mg kg^{-1}) recorded in soil sample. However, the potassium concentration showed slightly increase in different mixtures (40, 60 & 80%) and recorded values of 740, 760 & 780 mg kg,$^{-1}$ respectively (Figure 7). Therefore mix.1 (40%) could be considered suitable for potassium availability in soil.

Potassium (K+) is of unusual significance because of its live role in biochemical functions of the plant like activating various enzymes, improvement of protein, carbohydrates and fat concentration, developing tolerance against drought and resistance to frost, lodging, pests and disease attack (Marschner, 1995).

Nutrients availability can be impacted by soil physical and chemical properties, including parent material and naturally occurring minerals, amount of organic matter, depth to bedrock, sand, or gravel, permeability, water holding capacity and drainage. In addition, environmental conditions and crop characteristics have an important impact on nutrient availability (Fernandez &Robert, 2012). Supplementary amount of nutrients can be added to soil inform of inorganic fertilizer to correct inadequate supply of nutrients to the crop (Dirk and Hogarth,1984) and to increase the biological productivity of various ecosystems as well as the microbial activity in soil (Barabasz, *et al*.,2002).

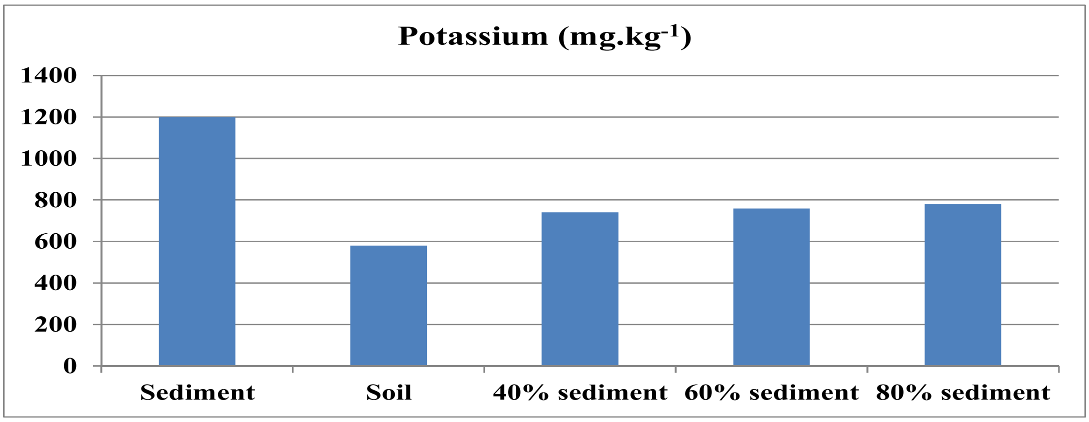

Fig. 7: Potassium concentrations

Calcium carbonate Percentage

Calcium carbonate percentage recorded the highest value (19.9%) in soil sample while, the lowest value (3.3%) recorded in sediment sample. It is worth to mention that as, the sediment percentage increase in the mixture, the carbonate percentage decrease (Figure 8). It is clear that adding the Nasser Lake sediment to silty Loam soil from Toushka land decrease the percentage of Ca- carbonate content, which lead to improve soil texture. It was mention that the availability of plant nutrients is influenced by the amount of calcium carbonates that has a direct effect on soil pH. The availability of phosphorus is reduced by the high levels of calcium which is associated with carbonates. In addition, iron, zinc, and manganese deficiencies are common in soils that have a high calcium carbonate equivalent. In some climates, the change in soil Ca- carbonate content caused changes in soil erodibility (wind erosion). Soil texture modification due to Ca- carbonate content was the main factor affecting soil erodibility due to the indirect effect on the particle size distribution (Khalid & Moatasim, 2012).

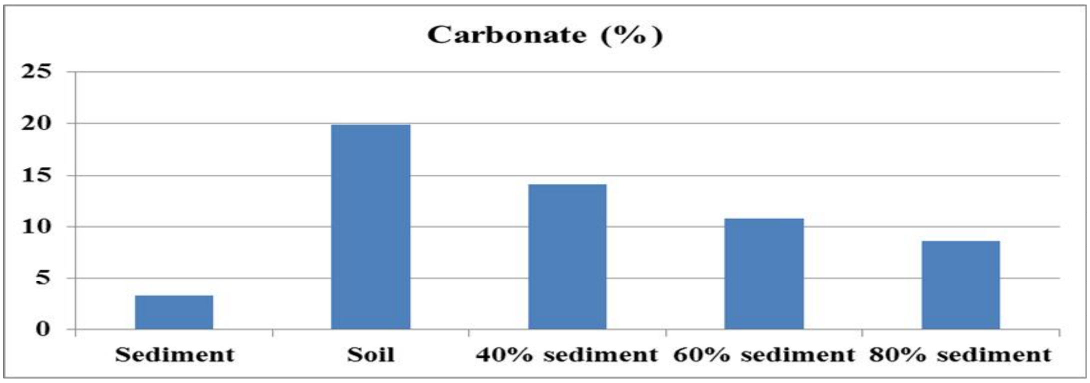

Fig. 8: Calcium carbonate percentage

Organic matter (OM)

The organic matter contents recorded the highest values (3.6 %) in sediment sample, while the lowest value (1.7 %) recorded in soil sample. The results showed, slightly increases in organic matter content in different mixtures (40, 60 & 80%) which recorded values of 2.2, 2.6 & 2.8% respectively (Figure 9). Therefore mix.1(40%) can be consider suitable for organic matter contents in soil.Sediment used in agriculture has a great potential to meet the needs of organic matter in soil. The organic matter in the applied sediment enhances the soil structure by reducing plasticity and bulk density and improving granulation, porosity and water-holding capacity (Liu *et al*., 1999).

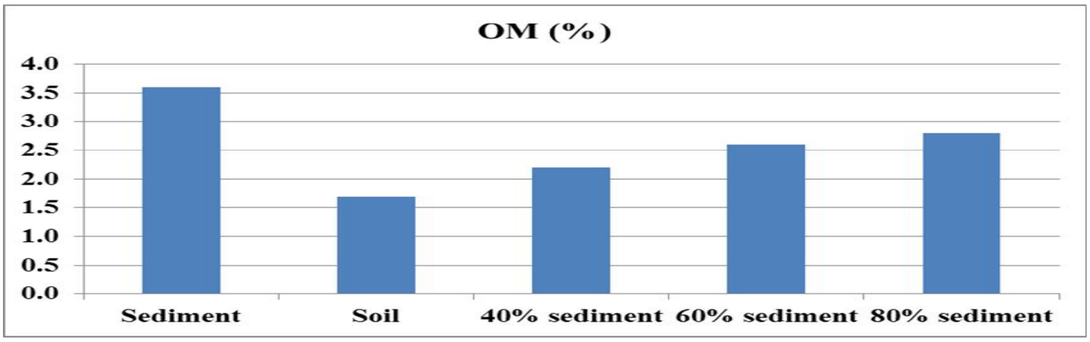

Fig. 9: Percentage of Organic Matter

Cation Exchange Capacity (CEC)

The CEC recorded the highest value of 66.3 meq (100 gm)$^{-1}$ in sediment sample while, the lowest value (9.78 meq (100 gm)$^{-1}$) of CEC recorded in soil sample. The results revealed that as sediment in mixture increased, the CEC increased and recorded values of 31.14, 43.3 & 53.88 meq (100 gm)$^{-1}$ in different mixtures (40, 60 & 80%) respectively (Figure 10). These results indicated that mix.1 (40%) have a low cation-exchange capacity than other mixtures.

Chemical elements exist in solution as cations (positively charged ions) or anions (negatively charged ions). In the soil solution, the plant nutrients Ca, K, Fe, Mn, Zn, and Cu exist as cations. Cation exchange capacity (CEC) is a measure of the amount of attraction for the soil with these chemical elements that facilitates retention of positively charged chemical elements from leaching. Soils that have a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils that have a high cation-exchange capacity. However soils that have high cation-exchange capacity have the potential to retain cations, which reduces the risk of the pollution of ground water (Fernandez & Robert, 2012).

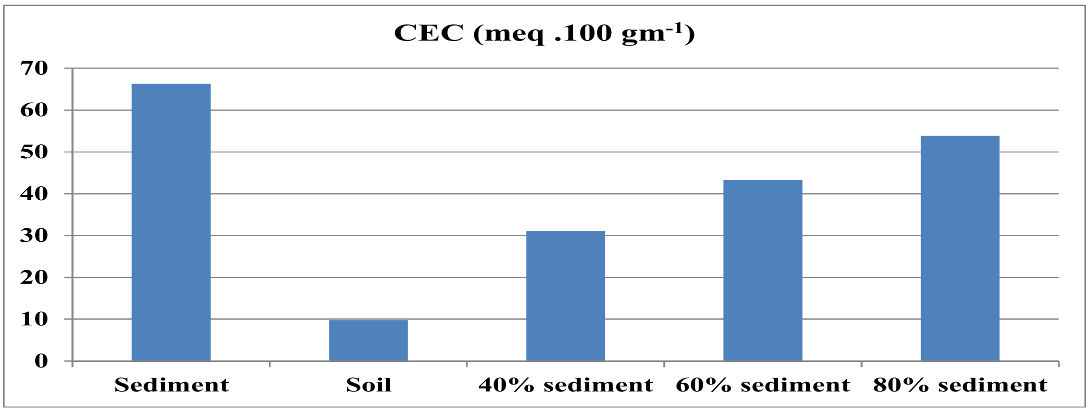

Fig. 10: Cation Exchange Capacity (CEC)

Available Heavy Metals

The results of measured available heavy metals concentrations revealed that the highest values recorded in sediment sample, while the lowest values were recorded in soil sample (Table 1). The results also showed that, as sediment percentage in the mixture increase, the concentration of measured available heavy metals gradually increased. A high percentage of clay in bottom sediment along Nasser Lake increases the ability of sediments to adsorb the heavy metals cations. Therefore, mix.1 (40%) contains minimum heavy metals concentrations and can be considered suitable for metal available. Generally, available heavy metals concentrations in all used samples recorded low value as compared with the Agricultural land use target (Canadian environmental quality guidelines 2002).In this study available heavy metals concentration were measured because total metal concentration in sediment does not give adequate data about metal origin and it also does not provide any data about metal solubility (Bryan and Langston, 1992). Certain trace elements are essential in plant nutrition (micronutrients). Trace element uptake by roots depends on both soil and plant factors (e.g., source and chemical form of elements in soil, pH value, organic matter, plant species, and plant age). However, plants growing in a polluted environment can accumulate trace elements at high concentrations causing a serious risk to human health when plant base food-stuffs are consumed and have heightened public concern (Smith *et al*., 1996). Clay/silt fraction has high surface area and because of its surface chemistry is more likely to adsorb heavy metal.

In general, this paper gives simple guidelines for the importance of using Lake Nasser sediments as natural fertilizers which contain sufficient amount of nutrients, clay and organic matter.

Table 1: Available Heavy Metals Concentration in mg kg^{-1}

Sample	Zn	Fe	Mn	Cu	Pb	Cd	Ni
Agr. Land Use Target	200	-	-	63	70	1.4	50
Sediment	57.00	860.50	162.80	7.960	10.840	1.140	4.880
Soil	1.10	1.86	11.10	0.788	2.540	0.115	0.670
mixture1 (40% sediment)	6.40	368.55	95.80	6.105	1.745	0.285	4.310
Mixture2 (60% sediment)	18.20	392.15	141.85	7.095	2.770	0.302	4.945
Mixture3 (80% sediment)	22.12	665.00	158.10	7.835	2.670	0.350	4.925

Conclusion

Sediment extracted from the bed of Lake Nasser enriches the silty loam soil in Toushka area with organic matter and nutrients (NPK) in addition to improve its structure and physical properties. The concentration of bioavailability heavy metals increase as sediment in mixture with silty loam soil increased, but still very low compared with agricultural land use target. The paper concluded that, Lake Nasser sediment can be utilized as soil amendment for Toushka area with different mixtures which contain sufficient amount of nutrients, organic matter, clay and minimum amount of available heavy metals and salts as well as optimum pH value.

Recommendation

It is recommended to implement a pilot project to evaluate the characteristics of sediment as a soil amendment for reclaiming poor areas of Toushka land and to identify how the sediments affect the crop yields and define the optimum acceptable ratio of soil sediment mixture.

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