International Journal of Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (4): 385-390, 2007
ISSN 1816-4897

Comparison of Physico-Chemical Properties of Tunisian Activated Sludge and Produced Compost

[1]Mohamed Anis El hammadi, [2]Melika Trabelsi, [2]Amel Jrad,
[2]Habib Gannouchi and [1,2]Belgacem Hanchi
[1]Faculté des Sciences-Campus Universitaire-Tunis-1060-Tunisie
[2]Centre International des Technologies de l'Environnement de Tunis (CITET),
Boulevard de l'Environnement, 1080 Tunis

Abstract: In Tunisia, we have an increasingly growing sewage sludge production. Therefore, evaluation of its valorisation is essential. Composting has emerged as a valuable route for the disposal of urban waste, with the prospect of applying composts on arable fields as organic amendments. A comparative study was made for major nutrient elements or macronutrients (include carbon, nitrogen, phosphorous, potassium) and the micronutrient elements mostly used (manganese and magnesium) present in the activated sludge taken from the municipal wastewater plant of Charguia in the capital of Tunisia and the produced compost made from the above sludge (13.37 C/N ratios). K, Fe and Mn concentrations were more important in the maturity compost. The original sludge shows a higher C, N, P, Ca and Mg contents. An important observation was that the amount of heavy metals and *E. coli* present in the final product is lower than the amount mentioned for the waste compost use in French norms, showing that the final compost was not toxic.

Key words: Sewage sludge, compost, nutrients, heavy metals

INTRODUCTION

The upgrading and expansion of wastewater treatment plants in Tunisia have increased the volume of sludge generated. Wastewater treatment plants are in Tunisia annually producing more than 1,300,000 m^3 of fresh sewage sludge, around 30,000 m^3 of dried sludge, of which 55% are used for land application. Sewage sludge is mainly aerobically stabilized and then dried on beds; in a few plants, anaerobic digestion is provided or the sludge is extracted from lagoons once dried (Bahri, 2000). Sewage sludge is a source of organic matter and plant nutrients (Martinez *et al*., 2003a), since it can improve soil physical and chemical properties (Caravaca *et al*., 2002; McKay and Moffat, 2001). Tunisian soils often have low organic contents for high agricultural production. At present, sewage sludge is mainly used for agricultural production. Sludge agricultural use presents potential environmental risks, as heavy metal and organic contaminants accumulation in soils, as well as the discharge of nutrients, especially N and P, to surface and groundwater (Martinez *et al*., 2003a).

Composting could stabilize the organic matter concentration of sewage sludge and by this way decrease the risks of heavy metals and salts leaching (Garcia *et al*., 1990; Planquart *et al*., 1999). It is a biological process of aerobic decomposition that degrades labile organic matter to carbon dioxide, water vapour, ammonia, inorganic nutrients to obtain a stable organic material (compost) containing humic-like substances and to eliminate pathogens (Inbar *et al*., 1993). The major nutrient elements or macronutrients in the compost include carbon, nitrogen, phosphorous and potassium. The micronutrient elements mostly used are cobalt, manganese, magnesium, copper and zinc.

Corresponding Author: Mohamed Anis El hammadi, Faculté des Sciences-Campus Universitaire-Tunis-1060-Tunisie
Tél: 216-2276-4522, 216-7730-4346

Micronutrients are essential for the growth and development of microorganisms, zinc and copper are essential for many microorganisms in the compost while toxic metals are not (Parvaresh *et al*., 2004).

Compost contains major plant nutrients such as N, P and K, micro nutrients such as Cu, Fe and Zn and humic substances which improve the physical properties of soils such as aeration and saturation capacity (Wong *et al*., 1995). In addition, the use of other organic wastes with large C/N ratios (such as green wastes) in mixture with sewage sludge can reduce the rate of nitrogen mineralization that first decrease its leaching risks (McKay and Moffat, 2001) and second provide a durable release to plants. Yet, compost amendment has been frequently shown to increase soil fertility (Caravaca *et al*., 2002; Martinez *et al*., 2003a), plant biomass (Guerrero *et al*., 2001; Moreno-Peñaranda *et al*., 2004) and plant nutrition (Moreno *et al*., 1996). In the last years and with the environmental risks of sludge agricultural use, more effort was made in Tunisia to develop low cost and high efficient composting technologies according to Tunisia's conditions. Composting is coming increasingly under consideration in Tunisia. Because it has several advantages over current disposal strategies, but the sludge compost quality with respect to agricultural use depends on its nutrient element contents.

The aim of the physico-chemical analyses in the present study is to conduct an analytical survey of nutrient elements and to compare their contents in selected sewage sludge and the produced compost.

MATERIALS AND METHODS

A laboratory research was conducted in the laboratory of Tunis International Center for Environmental Technologies. This work was commencing in September 2005.

Sampling

Activated sludge was collected from the wastewater treatment plant of Charguia in Tunis town. This sludge is used in the north of Tunisia as organic amendment to increase soil fertility. Preservation of the sludge was conducted prior to experimental run. The Typical characteristics of sludge used in the composting process are shown in detail in Table 1. The mature sludge compost was produced from the above sludge with green wastes (1/2 volume) and municipal sewage sludge (1/2 volume) following the Aerated Pile Method (Wilson *et al*., 1980). This compost met the French norm on composts made with materials of water treatment for pathogenic microorganisms and heavy metals (NF U 44-095). Characteristics of compost are shown in Table 1.

Physico-chemical Analysis

Nitrogen was determined by the Kjeldahl method (NF ISO 11261), the organic matter by Gravimetry (Rodier 8th edition). Total organic carbon is measured according to Colorimetry method (ISO 14235); Fe, K_2O, CaO, MgO, P_2O_5 were analyzed by emission spectrometry -ICP (NF EN ISO 11885). The elements Cd, Cu and Mn were analyzed by emission spectrometry-ICP (NF EN ISO 11885). Mercury was determined by atomic absorption analysis (NF EN 1483).

Table 1: Typical characteristics of the sludge and the produced compost of Charguia (results expressed in dry basis)

Properties	Sludge	Final compost
OM (g kg^{-1} DW)	522	251
TKN (g kg^{-1} DW)	38.3	14.8
C/N (g kg^{-1} DW)	8.85	13.37
TOC (g kg^{-1} DW)	339	198
Cd (mg kg DW)	1.95	<0.6
Cu (mg kg DW)	140	23.1
Hg (mg kg DW)	<0.091	<0.091
Escherichia coli (colony Forming units g^{-1} fresh material)	1.7×10^5	<30

OM: Organic Matter, TKN: Total Kjelahl Nitrogen, TOC: Total Organic Carbon, Cd: Cadmium, Cu: Cuivre, Hg: Mercury

RESULTS AND DISCUSSION

The comparative concentrations of specific nutrients in the two types of compost are of interest. Sludge and sludge compost showed variability in total C, N and organic matter (Table 1) as well as P, K, Ca, Fe, Mn and Mg (Fig. 1). The total C content in the sludge was 339 g kg^{-1} DW, decreased in the produced compost to 198 g kg^{-1} DW. The decrease of C during composting indicates that microorganisms use these compounds as source to build their own structures and to alter other more resistant carbon fractions. New water soluble carbon compounds of microbial origin may be formed during composting, since composting is a synthesis process (Charest *et al*., 2003). The bioavailable C in the mixture was transformed by microbes into CO_2 and H_2O and resulted in the loss of organic matter that concentrated nutrient contents. The organic matter in the produced compost (251 g kg^{-1} DW) was lower compared with the sewage sludge (522 g kg^{-1} DW). Bertoldi *et al*. (1991) reported that bacteria and pathogenic organisms can generally metabolize readily assimilable organic matter such as alcohols and sugars whereas they cannot multiply on complex compounds such as cellulose, lignin and humic substances. Stone *et al*. (2001) showed that compositional changes during composting are similar to those observed during natural wood decomposition: carbohydrates were degraded more rapidly than lignin and the organic matter was degraded relatively nonselectively. Complex organic compounds like lignin are mainly degraded by thermophilic micro-fungi and actinomycetes. During composting, the immature compost material is mineralized and humified to more complex organic matter (Garcia *et al*., 1991). Initially, The N content in the sludge was 38.3 g kg^{-1} DW. The N content decreased in the final compost (14.8 g kg^{-1} DW). This data showed that the obtained compost did not supply N as effectively as the sewage sludge because of the greater N losses during composting (Bertran *et al*., 2004). The total N is affected by the action of proteolytic bacteria and temperature. At high temperatures, N is lost in the atmosphere. It could be necessary to

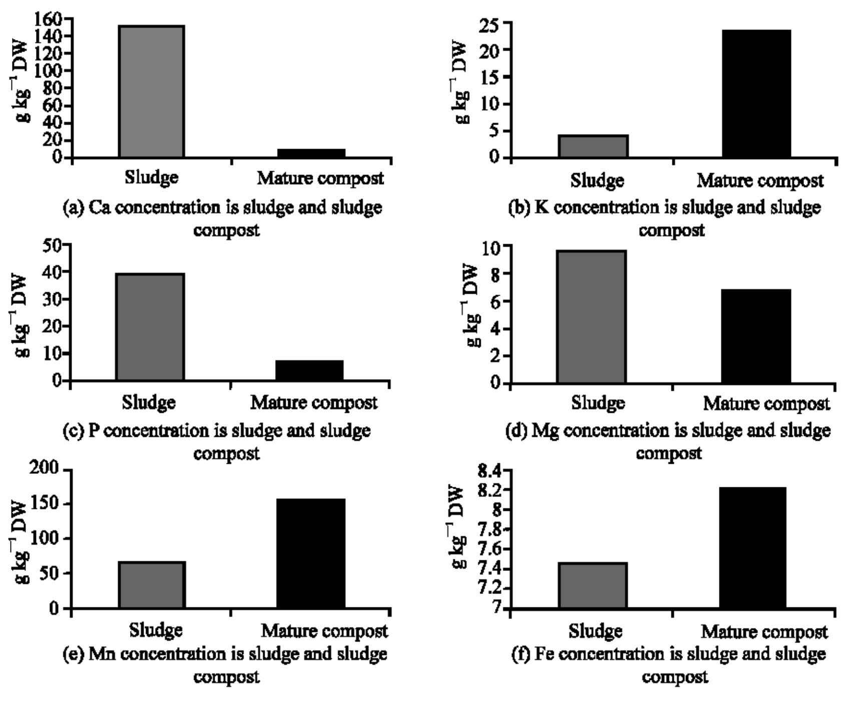

Fig. 1: Concentrations of nutrients in sludge and sludge compost

supplement the compost with inorganic sources of N depending on soil nutrient status and crop requirement (Egrinya Eneji *et al*., 2001). Archibold (1995) notes that N may be the one of the most limiting elements for plant growth in Mediterranean ecosystems have critical importance in plant nutrition. The concentration of K in the sludge is 4.35 g kg^{-1} DW, in the mature compost, there is a high amount of K (69.4 g kg^{-1} DW). In fact, Sewage sludge contains relatively small amounts of K because most of the K present in the influent readily passes through the wastewater treatment facility and is discharged with the effluent (Warman *et al*., 2004). When sewage sludge is applied to agricultural land, the sludge usually does not provide enough K to meet the requirements for forage and corn growth even though the availability of K in sewage sludge is rated very high (Warman, 1986). The final compost had high level of K compared with those found by Cegarra *et al*. (1993) and Moreno-Caselles *et al*. (2002) in composts, made from municipal solid wastes and manures, respectively, which are used commonly as organic fertilisers. P, Mg and Ca concentrations were lower in the produced compost compared with the sewage sludge. Sewage sludge is generally high in Ca since lime is typically added during wastewater treatment. The sewage sludge entering compost composition comes from a sewage plant that applies a dephosphatation process to sewage. Consequently, P is concentrated in the residual sludge, Sewage sludges are known to be a source of P when used as a fertilizer (Lisk *et al*., 1992).

So, compost application must be mineralized to release enough available P and Ca, which is often a slow process in newly amended soils. The final product shows a higher Mn and Fe content than in sewage sludge. Generally, the sludge compost can be notably higher in Fe (Lisk *et al*., 1992).

Also, this compost showed potentially toxic heavy metal contents lower than the limits established by the second draft on Biological Treatment of Biowaste of the European Commission (European Commission, 2001) for compost and stabilized biowaste.

CONCLUSION

This study represented a multi-facetted evaluation of the agronomic value of a waste material and the corresponding produced compost. The results obtained indicate that the composting can be an environment-friendly alternative to the recycling of municipal sludge and that it can help to solve the disposal problem of this waste, but, there was considerable difference in the fertilizer value of the activated sludge and the final product. The nutrient elements in the mature compost were low compared to the native sludge and other mineral fertilizers; in particular total N, P and Ca contents that were likely to be growth limiting for microorganisms or plants because they are capital for plant growth. Hence, N and P are the limiting factor for this sludge compost use and in a lesser extent P. In consequence, sludge compost composition and rates must be well studied and defined before any agricultural use. In addition, more effort should be made in Tunisia to study the environmental impact of heavy metals and contaminants of compost in the long term.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Belgacem Hanchi for his invaluable help in this work. This work was supported by the CITET (Tunis International Center for Environmental Technologies).

REFERENCES

Archibold, O.W., 1995. Mediterranean Ecosystems. Ecology of world vegetation, Chapman et Hall, London, pp: 131-164.

Bahri, A., 2000. Document provided by the water resources management group of the world bank presented at the Water Week 2000, World Bank, April, 2000.

Bertoldi, M., F. Zucconi and M. Civilini, 1991. Temperature, Pathogen Control and Product Quality. In: The Sta_ of BioCycle (Ed.), The BioCycle Guide to the Art and Science of Composting. The JG Press, Emmaus, PA, USA., pp: 195-199.

Bertran, E., X. Sort, M. Soliva and I. Trillas, 2004. Composting winery waste: Sludges and grape stalks. Biores Technol., 95: 203-208.

Caravaca, F., C. Garcia, M.T. Hernandez and A. Roldan, 2002. Aggregate stability changes after organic amendment and mycorrhizal inoculation in the afforestation of a semiarid site with *Pinus halepensis*. Applied Soil Ecol., 19: 199-208.

Cegarra, J., A. Roig, A.F. Navarro, M.P. Bernal, M. Abad, M.D. Climent and P. Arago´n, 1993. Caracterý´sticas, compostaje y uso agrý´cola de residuos so´ lidos urbanos. Proceeding Jornadas de Recogidas Selectivas en Origen y Reciclaje. Spain: Co´rdoba, pp: 46-55.

Charest, M.H., H. Antoun and C.J. Beauchamp, 2003. Dynamics of watersoluble carbon substances and microbial populations during the composting of de-inking paper sludge. Biores. Technol., 91: 53-67.

Egrinya, E.A., Y. Sadahiro, H. Toshimasa and I. Akihiro, 2001. Physico-chimical changes in livestock feces during composting. Commun. Soil Sci. Plant Anal., 32: 3-4.

European Commission. Working Document on Biological Treatment of Biowaste. Available from http://www.europa.eu.int/comm./environment/ waste/facts_en.htm, 2001.

Garcia, C., T. Hernandez and F. Costa, 1990. The influence of composting and maturation processes on the heavy-metal extractability from some organic wastes. Biol. Wastes., 31: 195-219.

Garcia, C., T. Hernandez and F. Costa, 1991. Changes in carbon fractions during composting and maturation of organic wastes. Environ. Manage., 15: 433-439.

Guerrero, C., I. Gomez, R. Moral, J. Mataix-Solera, J. Mataix-Beneyto and T. Hernandez, 2001. Reclamation of a burned forest soil with municipal waste compost: Macronutrient dynamic and improved vegetation cover recovery. Bior. Technol., 76: 221-227.

Inbar, Y., Y. Hadar and Y. Chen, 1993. Recycling of cattle manure: The composting process and characterization of maturity. J. Envion. Qual., 22: 857-863.

Lisk, D.J., H. Walter, T. Rutzke, M.H. Kuntz and G.J. Doss, 1992. Composition of Toxicants and other constituents in yard or sludge composts fromthe same community as a function of time-of-waste-collection. Arch. Environ. Contam. Toxicol., 22: 380-383.

Martinez, F., G. Cuevas, R. Calvo and I. Walter, 2003a. Biowaste effects on soil and native plants in semiarid ecosystem. J. Environ. Qual., 32: 472-479.

McKay, M. and A.J. Moffat, 2001. GB experience in the last decade: From research to practice. Biosolids utilisation in forestry (INRA), Internat Worksh, 29-30 March 2001.

Moreno-Caselles, J., R. Moral, M. Pe´rez Murcia, A. Pe´rez Espinosa and B. Rufete, 2002. Nutrient value of animal manures in front of environmental hazards. Commun. Soil Sci. Plant Anal., 33: 23-32.

Moreno, J.L., C. Garcia, T. Hernandez and J.A. Pascual, 1996. Transference of heavy metals from a calcareous soil amended with sewage-sludge compost to barley plants. Biores. Technol., 55: 251-258.

Moreno, P.R., F. Lloret and J.M. Alcañiz, 2004. Effects of sewage sludge on plant community composition in restored limestone quarries. Restor Ecol., 12: 290-296.

Parvaresh, A., M.R. Shahmansouri and H. Alidadi, 2004. Determination of carbon/nitrogen ratio and heavy metals in bulking agents used for sewage composting. Iran J. Publ. Health, 33: 20-23.

Planquart, P., G. Bonin, A. Prone and C. Massiani, 1999. Distribution, movement and plant availability of trace metals in soils amended with sewage sludge composts: Application to low metal loadings. Sci. Tot. Environ., 241: 161-179.

Stone, A.G., S.J. Traina and H.A.J. Hoitink, 2001. Particulate organic matter composition and pythium damping-off of cucumber. Soil Sci. Am. J., 65: 761-770.

Warman, P.R., 1986. Effects of fertilizer, pig manure and sewage sludge on timothy and soils. J. Environ. Qual., 15: 95-100.

Warman, P. and W.C. Termeer, 2004. Evaluation of sewage sludge, septic waste and sludge compost applications to corn and forage: Yields and N, P and K content of crops and soils. Biores Technol., 96: 955-961.

Wilson, G.B., J.F., Parr, E. Epstein, P.B. March, R.L. Chaney, D. Colacicco, W.D. Burge, L.J. Sikora, C.F. Tester and S.B. Hornick, 1980. Manual for composting sewage sludge by the Beltsville aerated pile method. Joint USDA/EPA Spec. Rep. EPA-600/8-80-022. US Government Printing O_ce, Washington.

Wong, J.W.C., S.W.Y. Li and M.H. Wong, 1995. Coal fly ash as a composting material for sewage sludge: Effects on microbial activities. Environ. Technol., 16: 527-537.