LASER GRANULOMETRY OF COLLOIDAL ORGANIC MATTER EXTRACTED FROM COMPOSTS

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ABSTRACT

The objective of this work was to characterize the particle size distribution (psd) of water soluble colloids from composts in relation to their maturity and their interaction with soil.

Compost of green waste and sewage sludge were used at two different stages of maturation: “fresh compost” issued from 6 weeks of composting and “mature compost” sampled after 6 months of maturation Amended and non-amended soils came from an experimental field at Feucherolles, near Paris. The colloidal fraction was extracted with water from soils and from composts by shaking at 20°C and using pressurized hot water at different temperatures. Hot water allowed the increase of extraction yields by partial hydrolyse and extraction of more hydrophobic compounds .

Amended and non-amended soils extracts were characterized by their psd ranged from 0.040 to 0.300 µm, independently of the extraction temperature. Colloidal fraction extracted from composts had psd depending on temperature: their psd moved from 0.04 to 0.80 µm at low temperature and from 0.04 µm to 0.20 µm when temperature increased from 20°C to 175°C. Colloidal particle extracted from composts at 20°C and 175°C were added to the soil. Adsorption modified psd of the non adsorbed colloids, showing adsorption of the largest colloids extracted at 20°C. On the contrary, the colloids extracted at high temperature were more adsorbed with a disappearance of the finest colloids from the solution.

INTRODUCTION

A fraction of compost organic matter is water soluble, consisting of a complex mixture of polymeric materials with colloidal properties (Gigliotti et al, 1997). They are dynamic colloids characterized by a complex and a miscellaneous nature, containing superficial charges explaining their dynamic behavior (Lyklema et al, 2000). A criteria defining the colloids is the very small size between 1 nm to 1 µm (Kretzschmar et al., 1995 ; Wilkinson et al., 1997). This fraction could play an important role when composts are applied to the soil. Specially, it could be a mobile fraction through the soil profile, therefore becoming a potential vector of pollutants.

The objective of this work was to characterize the colloidal fraction extracted from composts and from soils through their particle size distributions (psd) using laser granulometry based on LALLS principle (Low Angle Laser Light Scattering). This technique allows to measure size distributions of particle diameters > 0.040 µm. The effects of interactions between colloids and soils was studied on the balance of dissolved C and changes in particle size distributions (psd) occurring when part of colloids are adsorbed to the soils.

MATERIALS AND METHODS

A compost made of green waste and sewage sludge was sampled at two different stages of maturation: “fresh compost” after 6 weeks of composting under enforced aeration and “mature compost” after 6 months of maturation in outdoor piles.

Amended and non amended soils were sampled in March 2003 in a field experiment at Feucherolles, near Paris, France. The “mature compost” was applied three times in October 1998, September 2000 and 2002. Each time, the equivalent of 4 Mg of C ha^{-1} was applied. Soil coming from the non-amended plots was used as reference In this soil, the average organic carbon and the average nitrogen amounts were 11,1 g kg^{-1} et de 1.09 g kg^{-1} respectively, and 150 $g.kg^{-1}$ of clay, 783 $g.kg^{-1}$ of silt et 67 $g.kg^{-1}$ of sand. The CEC was 9.4 cmol kg^{-1} and pH (in 1:1 soil water ratio) was 6.9.

Colloid particles were extracted from soils and from composts by shaking in water at 20°C during 24 hours and by pressurized water extraction at 50°C, 125°C and 175°C, using a Dionex ASE 200 (Accelerated Solvent Extractor). Three replicates of the extraction of each soil and compost samples were realized. The organic C content was measured after extractions with a Total Organic Carbon Analyzer Shimadzu TOC-5050A, ASI-5000A.

The organic colloidal fractions extracted from soils and composts were characterized by their particle size distributions (psd). Based on the diffraction of particles suspensions, laser granulometry is a technique used to measure psd of soils fractions (Muggler et al., 1997 ; Dur et al., 2004). The apparatus is a LS-230 Beckman-Coulter laser grain-size analyzer, with a range from 0,04 to 2000 µm, divided into 116 fractions. The samples circulate in a 130 ml cell, lit by a low-intensity laser beam. Samples are sonified for 15 min then diluted in milliQ (Millipore) water in order to obtain 50% obscuration. Psd data are obtained under soft agitation in the measuring cell. The refractive indexes are 1.6 or 1.5 and the absorption coefficients of 0.2 or 0.1 were used for compost extracts and soil extracts, respectively. All the replicates were measured in laser granulometry. Data are expressed by the particle diameters from 0.04 to 2000 µm, in log scale permitting a better representation of the smaller particles, distributed in 116 fractions. Because compost and soil extracts are made of very fine and poly-dispersed particles (smaller than 1 µm), psd are expressed in Number frequency (% of total particles called % Number). The main statistical parameter is the “mode” which is the particle diameter value (in µm) when the intensity of psd is the highest.

Adsorption of compost extracts on the non-amended reference soil was carried out according to batch technique: 6 g of soil was mixed with 10 ml of the fresh compost extracts (20°C and 175°C). The soil suspensions were agitated at 20°C for 24 hours, then centrifuged 30 min at 1000 g**.** Supernatants were then analyzed by laser granulometry. In the same time, organic C concentrations were quantified in the supernatants (mg L^{-1}) before and after adsorption on the soil.

RESULTS AND DISCUSSION

Colloidal fractions extracted from composts

The colloids extracted from composts at 20°C were characterized by a psd going from 0.040 µm to 0.800 µm, with modes at 0.120 µm and 0.170 µm for the fresh compost and the mature compost, respectively (Figure 1A). No difference was observed between the colloids extracted from the fresh and mature composts at 125 and 175°C (Figure 1C and 1D) and the psd ranged from 0.04 µm and 0.2 µm, with a primary mode at 0.055 µm and a secondary mode at 0.150

µm, at 175°C. The increase of the extraction temperature increased the extraction yields in soluble organic matter (Table 1) and the extracts had a more hydrophobic character because of the decrease of the dielectric constant of water when temperature increased. However, the equivalent diameters of colloidal particles decreased when the extraction temperatures increased.

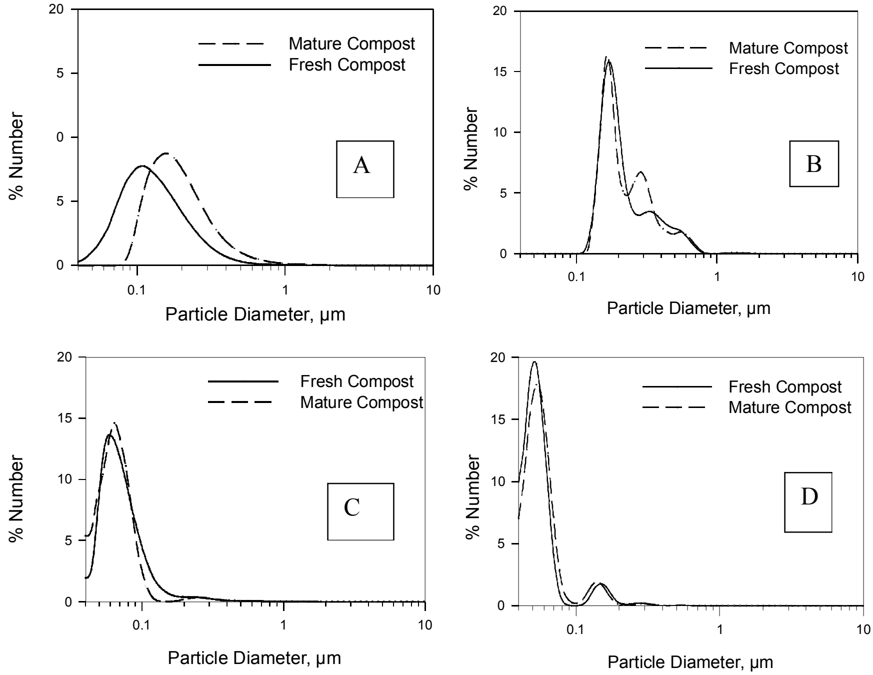

__Figure 1__. Particle-size distributions, in µm, related to the % Number of particles of composts extracts. Fresh and matures composts were extracted at 20°C (A) and by pressurized water at 50°C (B), 125°C (C) and 175°C (D).

Sorption of colloids on soil

Sorption of colloids extracted at 20°C on the non-amended soil was characterized by the loss of 14% of Organic Carbon (Table 1). Simultaneously, adsorption caused a shift of the psd with a decrease of the mode. Adsorption selected the largest particles, and the colloids from compost remaining in solution had a similar psd that the colloids extracted directly from the reference soil. (Figure 2A).

__Table 1__. Organic Carbon concentrations of fresh compost extracts, extraction at 20°C and by pressurized water at 50°C, 125°C and 175°C, before and after sorption on the non amended soil. Three replicates and standard deviation of 0.3 mg/L.

Fresh Compost Extracts Extraction temperature °C	Before Sorption Organic Carbon mg/L	After Sorption Organic Carbon mg/L	% Sorbed
20	149	127	14
50	698	461	34
125	1184	722	39
175	2222	1403	38

Simultaneous, sorption of colloids extracted with pressurized hot water was characterized by the loss of most very fine particles, i.e. < 0.060 µm which were present in the compost extracts before sorption. Indeed, the psd moved towards coarser particles after sorption but not as far as the psd of the soil extract itself (Figure 2B). This can indicate that 38% of adsorbed organic carbon selected the finest particles (Table 1). In addition, it was not possible to discard the formation of new associations between colloids and fine clay particles of soils. On the other hand, the amount of extracted C highly increased with the temperature. However, the proportion of adsorbed organic carbon remained similar whatever the amount of extracted C.

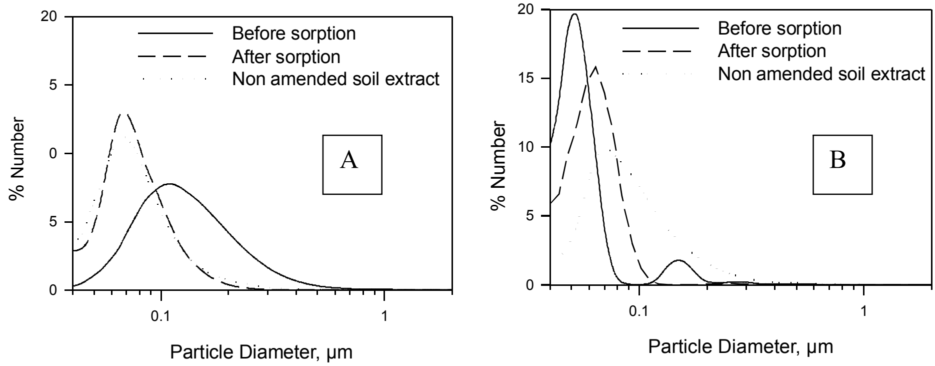

Figure 2. *Particle-size distributions, in µm, related to the % Number of particles of compost extracts adsorbed on the soil. The compost extract at 20°C (A) and the compost extract at 175°C (B) were adsorbed on the non amended soil.*

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