

Molecular weight and humification index as predictors of adsorption for plant- and manure-derived dissolved organic matter to goethite

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Summary

Sorptive retention of organic matter is important in maintaining the fertility and quality of soils in agricultural ecosystems. However, few sorption studies have been conducted that use dissolved organic matter (DOM) characteristic of agricultural amendments. We investigated the sorption to goethite (α -FeOOH) of DOM extracted from: (i) above-ground biomass of wheat straw (*Triticum aestivum* L.), maize residue (*Zea mays* L.), soybean residue (*Glycine max* (L.) Merr.), and hairy vetch residue (*Vicia villosa* L.); (ii) below-ground biomass from maize, soybean, canola (*Brassica napus* L.), and green bean (*Phaseolus vulgaris* L.); and (iii) beef, dairy, poultry, and pig animal manures. The apparent molecular weight (MW_{AP}) of the DOM was measured by high performance-size exclusion chromatography and ranged from 312 to 1074 g mol⁻¹. The carboxyl-group content of the DOM measured by potentiometric titration ranged from 4.84 to 21.38 mmol₍₋₎ g⁻¹ carbon. The humification index (*HIX*) determined by fluorescence spectrometry varied from 1.15 to 4.33. Sorption was directly related to both MW_{AP} and *HIX* values of the DOM. Molecular weight analysis of the solution prior to and after sorption indicated that the DOM molecules > 1800 g mol⁻¹ were preferentially sorbed, resulting in fractionation of the DOM upon reaction with goethite. The multiple regression equation, based only on MW_{AP} and *HIX* parameters, explained 76% of the variance in amount of DOM sorbed. The results indicate that MW_{AP} and *HIX* are important factors in controlling the sorption of DOM to mineral surfaces. Amendment with materials that release DOM of higher molecular weight and greater humification will result in enhanced initial sorption of DOM to soil solids, thereby contributing to accumulation of a larger soil organic C pool.

Introduction

Plant biomass is the primary precursor for soil organic matter (Kögel-Knabner, 2002; Kaiser & Guggenberger, 2000). In managed systems where animal manure is utilized as a nutrient source, the carbon released from manure can lead to significant increases in both dissolved and solid phase soil organic matter (Ohno *et al.*, 2005). Immediately after amendment of soils with plant residue or animal manure, soluble soil C is augmented with the water-soluble fraction of the carbon-rich substrate (Ohno *et al.*, 2000). The dissolved organic matter (DOM) released from fresh materials such as plant and animal residues is believed to be less effectively stabilized than soil-derived DOM. However, the generally labile nature of DOM

results in this operational fraction being the most mobile and, presumably, the fraction most directly involved in reactions such as complexation with ions and sorption to soil particle surfaces (Zsolnay, 1996).

Sorption often involves the formation of stable complexes between surface cationic metal and polar or acidic functional groups of the organic molecules, which suggests that sorption is sensitive to both the chemical structure of the sorbing DOM and the surface properties of the minerals (Kaiser & Guggenberger, 2000). Metal oxy-hydroxides, with their preponderance of surface hydroxyl groups, have been shown to contain high affinity sorption sites for DOM (Baldock & Skjemstad, 2000). In addition, the molecular weight and functional group content of humic substances have been shown to be important factors in controlling DOM sorption to soil minerals (Gu *et al.*, 1994, 1995; Balcke *et al.*, 2002; Guo & Chorover, 2003). The preferential adsorption

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of higher molecular weight fractions of humic substances has been well documented (Jardine *et al.*, 1989; Wang *et al.*, 1997; Meier *et al.*, 1999; Chorover & Amistadi, 2001; Hur & Schlautman, 2004), and recent work on extracellular biomolecules also indicates a preference for high molar mass constituents (Omoike & Chorover, 2005). The adsorption of organic matter to mineral surfaces proceeds via multiple mechanisms. Ligand exchange reactions involving carboxyl and hydroxyl groups of natural organic matter and surface hydroxyl groups of solid components have been reported to be the predominant mechanism for DOM sorption onto metal oxy-hydroxides (Gu *et al.*, 1994; Chorover & Amistadi, 2001).

Fluorescence spectroscopy has been used to characterize DOM because of its ability to distinguish different classes of organic matter (Senesi, 1992; Alberts & Takacs, 2004). Fluorescence spectroscopy methods have been proposed that quantify the extent of humification on the basis of the extent of the shift in emission spectra towards longer wavelengths (Cox *et al.*, 2000; Kalbitz *et al.*, 2000). The humification index (*HIX*) is, thus, a measure of the complexity and the condensed (aromatic) nature of the dissolved organic matter.

Although the DOM isolated from leaf litter (Shotyk & Sposito, 1990; Brown & Sposito, 1991) and organic forest soil horizons (Chorover & Amistadi, 2001; Rennert & Mansfeldt, 2003) have been studied, research into DOM of amendments relevant to agronomic management practices has been limited. There is a strong need for studies that pertain to the fate of organic C derived from agricultural amendments because judicious management of these resources could potentially lead to enhanced soil quality and C sequestration. In this study, we characterized the DOM isolated from crop shoot biomass, root biomass and animal manures, and we conducted sorption experiments with these DOM extracts using goethite as a model sorbent. Goethite was selected due to its prevalence in soils and as a representative of the broader class of Fe oxy-hydroxides that constitute important surfaces for DOM sorption. The objective of the work was to test whether the sorption of DOM was related to the chemical characteristics of DOM molecules as reflected in measurements of molar mass, *HIX*, molar absorptivity, and acidity.

Materials and methods

Aqueous extracts

Above-ground plant biomass was represented by field-grown wheat straw (*Triticum aestivum* L.), maize residue (*Zea mays* L.), soybean residue (*Glycine max* (L.) Merr.), and hairy vetch residue (*Vicia villosa* L.) grown in Kansas and Iowa, USA. Below-ground plant biomass was represented by the roots from maize, soybean, canola (*Brassica napus* L.) and green bean (*Phaseolus vulgaris* L.) grown in Maine, USA. The samples were air-dried prior to mechanical grinding to pass a 1-mm aperture sieve. The beef, dairy, poultry and pig manures used were described by Griffin & Honeycutt (2000). The manure

samples were air-dried and sieved through a 2-mm aperture sieve. Distilled-deionized water (DI-H₂O) was used for all solutions and extractions. The plant materials and animal manures were extracted at a 40:1 water to solid mass ratio at 4°C for 16 hours with periodic hand shaking. Suspensions were then centrifuged at 900 g for 25 minutes prior to vacuum filtering through 0.4 µm aperture polycarbonate filters (Nucleopore; Whatman Corporation, Florham Park, NJ, USA).

Chemical analysis

The concentration of total soluble C (C_{TS}) in the extracts was determined using a Shimadzu TOC 5000 analyser (Shimadzu Corporation, Columbia, MD USA). Fluorescence measurements were obtained using a Hitachi F-4500 spectrofluorimeter (Hitachi Corporation, San Jose, CA, USA). Excitation (EX) and emission (EM) slits were set to 5 nm; response time was 8 s; and scan speed was 240 nm minute⁻¹. The EM spectra were obtained by using 254 nm for EX, and EM was recorded from 280 to 500 nm. The *HIX* value was calculated as:

$$HIX = (\sum I_{435 \rightarrow 480}) / (\sum I_{300 \rightarrow 345}), \quad (1)$$

where *I* is the fluorescence intensity at each wavelength (Ohno, 2002).

Potentiometric titrations of the extracts were conducted in a capped, glass reaction beaker at 25.0 ± 0.1°C to determine the carboxyl group content of the DOM (Ohno & Cronan, 1997). The solutions were bubbled with humidified 99.9% purity N₂ to minimize CO₂ contamination and a Ross combination electrode was used (Orion 81-02 U; Thermo Electron Corporation, Waltham, MA, USA). Extracts were passed through a H⁺-saturated cation exchange resin column to remove cations prior to titration. The extracts were diluted to 240 mg C_{TS} litre⁻¹ for the titration. The ionic strength of the solution was set to 20 mM by the addition of KCl to be representative of typical soil solutions (Campbell *et al.*, 1989). Because of the difficulty in determining equivalence points in the titration of DOM, operational beginning and end points of pH 3 and 8 were selected for carboxyl groups. Titrations of 20 mM KCl solutions were used for blank correction.

Molecular weight analysis

High performance size exclusion chromatography (HPSEC) was used to estimate the apparent molecular weight (MW_{AP}) distributions of DOM in aqueous solutions. The HPSEC system consisted of a Hewlett Packard 1100 Series high performance liquid chromatography unit (Agilent Technologies, Palo Alto, CA, USA) equipped with a G1311A quaternary pump, a G1314 auto-sampler, and a G1315A photodiode array detector. A Waters Protein Pak 125 stainless-steel HPSEC column with a Waters guard column was used. The mobile phase consisted of 100 mM NaCl buffered with 5 mM phosphate buffer to pH 6.8. Samples were matched to the mobile phase matrix

by adding 0.1 ml of 1 M NaCl solution (phosphate buffered to pH 6.8) to 0.9 ml of sample. Calibration of molar mass to retention time was accomplished using polystyrene sulfonate (PSS) standards (2.0 mg PSS ml⁻¹) with nominal molecular masses of 4.6, 8.0 and 18.0 kDa and polydispersity values less than 1.2 (Polymer Standards Service, Silver Spring, MD, USA). Acetone and salicylic acid were used as the lowest molecular mass standards in the calibration. The injection volume for all samples and standards was 100 µl and flow rate was 1.0 ml minute⁻¹ with detection at 254 nm. All standards and samples were run in duplicate.

The relative frequency histogram distribution of the DOM MW_{AP} was determined by summing the detector response in 0.1-minute increments between 6.0 and 14.5 minutes and then dividing the signal response for each interval by the total sum of signal response from 6.0 to 14.5 minutes. The weight-averaged elution time (ET_{AVG}) was calculated as:

$$ET_{AVG} = \sum rf(ET_{6.0 \rightarrow 14.5}), \quad (2)$$

where rf was the relative frequency value of the associated elapsed time (ET) defined as the mid-point value of the interval increment. The MW_{AP} value was obtained from the standard curve using the linear regression of log MW_{AP} as a function of elution time.

Goethite synthesis

Synthetic goethite was used in this study because the primary intent was the comparative assessment of which chemical properties of DOM from a variety of common soil amendments are the controlling factors in sorption. Use of laboratory-synthesized goethite (as opposed to natural soil particles) also avoided confounding sorption results by the desorption of native organic matter into DOM solutions. The goethite was synthesized by modifying a method described by Schwertmann & Cornell (1991). Briefly, 13.9 g of FeSO₄·7H₂O were added to 1 litre of de-aerated DI-H₂O. One hundred and ten ml of 1 M NaHCO₃ solution were then added, and air was bubbled through the reaction vessel at 35 ml minute⁻¹ for 48 hours. The suspension was then centrifuged at 900 g for 30 minutes and the supernatant discarded. The remaining solid was washed three times with DI-H₂O and dried at 40°C for 24 hours. The specific surface area was 58.3 m² g⁻¹ as measured by triple point N₂ adsorption.

DOM adsorption

The extent of adsorption was evaluated using a single-point adsorption index at an initial concentration of 50 mg litre⁻¹ C_{TS} reacted with laboratory-synthesized goethite. The adsorption index was determined by reacting 0.150 g of the goethite with 15 ml of plant biomass or manure extract solution containing 50 mg litre⁻¹ C_{TS} in 50-ml glass Erlenmeyer flasks covered with Parafilm. The pH of the extracts was initially

adjusted to pH 5.8 by the addition of 0.1 N NaOH or HCl. Triplicate samples for each DOM source were placed on an orbital shaker at 120 revolutions minute⁻¹ for 24 hours at 4°C to minimize microbial degradation of the DOM during the sorption period (Zhou & Wong, 2000). The suspensions were transferred to a centrifuge tube, centrifuged at 900 g for 25 minutes, and filtered through 0.40 µm aperture polycarbonate filters. The pH values of the supernatants were measured and the pH change from the initial value was <0.35 unit increase. The C_{TS} concentration was determined as described above and the quantity adsorbed was calculated by difference from the initial solution. The final solution was also analysed for MW_{AP} as described above.

Statistical analysis

Principal component analysis (PCA) was conducted to determine relationships between the DOM samples by means of MATLAB Release 14 (The MathWorks, Natick, MA, USA) running PLS_Toolbox version 3.5 (Eigenvector Research, Manson, WA, USA).

Results and discussion

DOM chemical characteristics

The DOM extracted from the plant biomass and animal manures in this study are materials typically incorporated into soils in sustainable agricultural systems. The MW_{AP} , carboxyl-group content, HIX , and ultraviolet absorptivity at 280 nm of the individual 12 DOM extracts are shown in Table 1. Inspection of the individual values shows no strong differences between groupings of amendment material types, with the exception of animal manure carboxyl-group content (17.8 ± 4.9 mmol₍₋₎ g⁻¹ C), which is greater than that for the above-ground plant biomass DOM (8.1 ± 2.9 mmol₍₋₎ g⁻¹ C) and below-ground plant biomass (6.5 ± 1.5 mmol₍₋₎ g⁻¹ C) (Table 1). The carboxyl-group content for the plant biomass DOM is within the range found for soil fulvic acids (5.2–11.2 mmol₍₋₎ g⁻¹ C), while the animal manure DOM has a greater carboxyl-group content than soil fulvic substances (Sposito, 1989).

The range of HPSEC-determined MW_{AP} values (312–1074 g mol⁻¹ MW_{AP}) of the DOM derived from organic soil amendments in this study are slightly less than those reported for a variety of other soil organic matter types. Aiken & Gillam (1989) found literature values for soil humic substances to range between 900 and 1684 g mol⁻¹. Water-extracted DOM from an Oa horizon of a forest floor layer was reported to have a mean number-averaged molecular weight of 750 Da (Kaiser & Zech, 1999). Although the MW_{AP} values used in this study are less than reported for soil humic materials, they are in the range of the MW_{AP} values of wheat straw fulvic acid, which was reported to be c.600 g mol⁻¹ (Grossl & Inskeep, 1996). The HIX values for the DOM extracts ranged from 1.15 to 4.33 (Table 1). This

Table 1 The apparent molecular weight (MW_{AP}), carboxyl-group content (COOH), humification index (HIX) and molar absorptivity of the dissolved organic matter extracted from the amendment materials

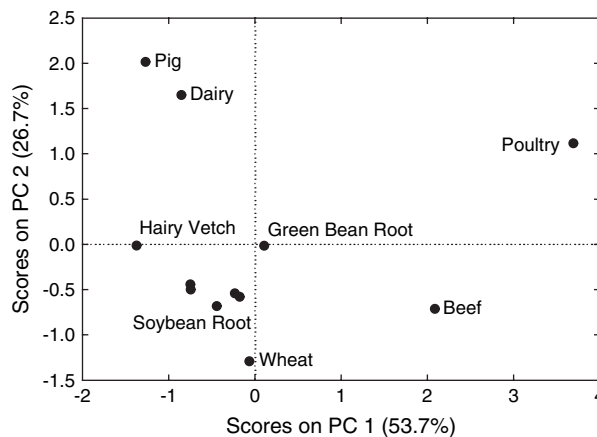
Material	$MW_{AP}/g\ mol^{-1}$	COOH/mmol ₍₋₎ g ⁻¹ C	HIX	Molar absorptivity/litre mol ⁻¹ cm ⁻¹
Above-ground biomass				
Wheat straw	745	4.6	2.17	74.2
Maize residue	614	8.0	1.99	90.8
Soybean residue	905	11.6	1.61	65.1
Hairy vetch residue	312	8.3	1.55	53.9
Below-ground biomass				
Maize root	394	5.5	1.59	118
Soybean root	515	5.9	2.08	81.2
Canola root	374	5.8	1.95	85.7
Green bean root	422	8.8	2.46	127
Animal manures				
Beef	1074	11.2	2.45	234
Dairy	365	20.1	1.73	63.8
Poultry	653	17.2	4.33	328
Pig	361	22.7	1.15	63.5

was the expected range as HIX values of DOM from the maize extract and from the soil:water extract were 1.33 and 5.38, respectively (Ohno, 2002). Thus, all of the values for HIX in Table 1 are less than that for water-soluble organic matter extracted from mineral soil. Molar absorptivity (a) at 280 nm, frequently used as measurement of the aromaticity of DOM (Chin *et al.*, 1994), ranged from 53 to 328 litre mol⁻¹ cm⁻¹ (Table 1). The plant biomass DOM gave rise to molar absorptivity values that are significantly less than those values reported for humic substances (Chin *et al.*, 1994) and forest floor leachates (Chorover & Amistadi, 2001), which, along with the HIX data, indicates that these DOM solutions are likely to be enriched in polysaccharides and other weakly chromophoric biomolecules. The largest values for molar absorptivity are observed for beef and poultry manure. While HIX and molar absorptivity values reported in Table 1 were strongly correlated ($r = 0.89$, $P < 0.001$), each of these variables exhibited poor correlation with MW. The latter is in contrast with Chin *et al.* (1994), who observed strong correlation between MW and molar absorptivity for aquatic humic substances.

One of the goals of this study was to determine whether there were general differences in chemical properties of DOM deriving from plant above-ground biomass, below-ground biomass and animal manures. Cropping systems studies have shown that management rotations that have animal manures as a component have increases in both total and dissolved soil organic matter concentrations, while those rotations that rely on green manures (leguminous plant species) do not increase organic matter concentrations (Ohno *et al.*, 2005). Animal manures were also associated with greater phosphorus (P) availability. These differences in organic matter build-up and P availability as a result of differing management systems could be related to the chemical characteristics of the DOM released from the amendment materials.

Principal component analysis was conducted on the data set shown in Table 1 to put the DOM source materials into groups that are similar to each other and the resulting score-plot of the first two principal components is shown in Figure 1. Scores in PCA reflect how samples relate to each other (Beebe *et al.*, 1998). The score-plot of the two PCA components captures 80% of the variation and clearly shows that the plant-derived DOM clusters together, irrespective of whether it derives from above-ground or below-ground tissue (Figure 1). This suggests that plant-derived DOM is chemically similar, in terms of the measurements employed in this study, regardless of tissue source.

The PCA results highlight the differences in DOM chemical properties between animal manures and plant derived-DOM, as well those within the animal manure grouping (Figure 1). This dissimilarity amongst the animal manures might reflect the differences in the chemical properties of feed materials for the different animals, as well as the differing digestive processes of the

**Figure 1** Principal component analysis scores for components 1 and 2 of the chemical property data shown in Table 1.

animals. This result suggests that results from manure studies might be specific to the manure-type being investigated and not be applicable to all manure sources.

DOM sorption to goethite

The quantity of DOM sorbed onto goethite at a single-point initial concentration of $50 \text{ mg litre}^{-1} C_{TS}$ was normalized to surface area and is shown in Figure 2. Although the use of a single-point sorption index precludes estimation of maximum sorption capacity and bonding affinity, it does provide relative sorption affinities for the different DOM materials studied. The extent of sorption was dependent on DOM source, which suggests that the chemical properties of the DOM are an important factor in determining the extent of sorption. Comparison of sorption densities with other studies is hindered by differences in solution:mineral ratio, organic matter type and pH, which all affect the degree of sorption. However, a sorption study using DOM from an Oa horizon of a forest soil was conducted under similar conditions (Kaiser & Zech, 1999). These authors reported 341 mmol kg^{-1} DOM sorption under the following conditions: 371 mmol kg^{-1} of DOM addition (416 mmol kg^{-1} for this study); $0.19 \text{ g goethite per } 15 \text{ ml solution}$ ($0.15 \text{ g per } 15 \text{ ml}$), and pH range of $6.0\text{--}6.2$ ($5.8\text{--}6.2$). Sorption in our study ranged from 114 mmol kg^{-1} to 280 mmol kg^{-1} , which indicates that our sorption densities were somewhat less than those observed for DOM extracted from an organic forest floor soil.

The MW_{AP} ($r = 0.72$), HIX ($r = 0.69$) and molar absorptivity ($r = 0.77$) were all significantly correlated ($P = 0.01$) with the amount of DOM sorbed (Figure 3). Conversely, adsorption was

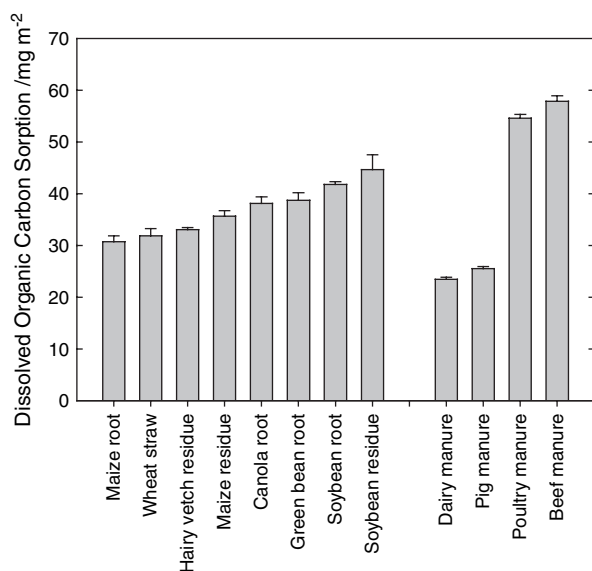


Figure 2 Sorption of dissolved organic matter derived from above- and below-ground plant biomass and animal manures. Error bars show standard error, $n = 3$.

relatively insensitive to carboxyl group content ($r = -0.13$) (Figure 4). The lack of statistical significance between sorption and carboxyl-group content for the DOM set was surprising because ligand exchange of carboxylate at surface hydroxyl groups is generally accepted as a principal mechanism for DOM sorption onto metal oxy-hydroxides. Two DOM extracts, dairy and pig manures, which grouped together in the PCA scores plot (Figure 1), lie outside the cluster of data points for the other materials for the relationship between DOM sorption and carboxyl-group content (Figure 4). The correlation between carboxyl group content and sorbed mass improves upon removal of the dairy and pig manures from the data set ($r = 0.79$, $P < 0.01$). Although these two manures have the two largest values for carboxyl-group content, they also

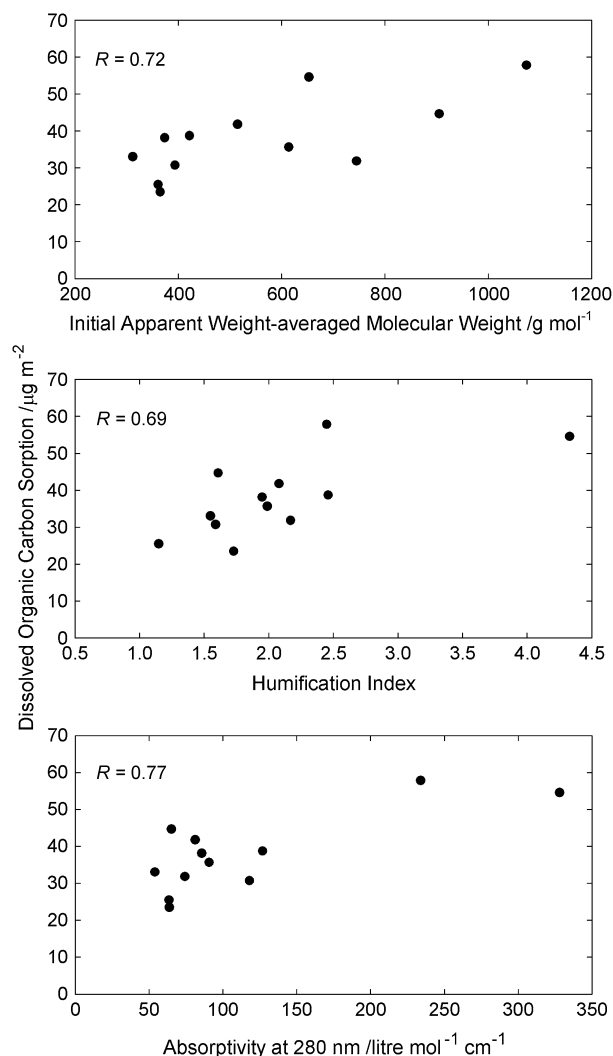


Figure 3 Correlation between initial apparent molecular weight, humification index and absorptivity at 280 nm with dissolved organic matter adsorption on goethite ($P < 0.01$). The initial dissolved organic matter concentration was $50 \text{ mg } C_{TS} \text{ litre}^{-1}$ and the goethite concentration was 10 g litre^{-1} .

have small values for MW_{AP} , HIX and molar absorptivity (Table 1). The small amount of sorption found for dairy and pig manures, despite the large carboxyl-group content, suggests that MW_{AP} , molar absorptivity and HIX are more important as primary, predictive parameters for DOM sorption to goethite and that the carboxyl-group content might be of secondary importance.

Apparent molecular weight and HIX or molar absorptivity were used as independent variables in a multiple regression analysis to predict the sorption of DOM from all 12 sources onto goethite. The regression equations were:

$$\text{Sorption } (\mu\text{g C m}^{-2}) = 10.51 + 6.72(HIX) + 0.024(MW), R^2 = 0.76 \quad (3)$$

$$\text{Sorption } (\mu\text{g C m}^{-2}) = 18.12 + 0.072(\text{absorptivity}) + 0.021(MW), R^2 = 0.78 \quad (4)$$

The predictive regression equations were significant at the 1% level, indicating that variation in molecular mass together with either molar absorptivity or HIX , is able to explain most of the variability in DOM sorption extent across a wide range of organic agricultural amendments.

The results from this study show that fractionation of the DOM occurs upon sorption due to preference for the higher molecular weight components of the DOM. This process is shown for wheat DOM where sorptive fractionation resulted in a decrease in relative frequency of higher MW_{AP} (early eluting) fractions remaining in solution, as well the concurrent increase in the relative frequency of the lower MW_{AP} (late eluting) fractions (Figure 5). Sorption results in nearly 100% removal of the $> c.1800 MW_{AP}$ fractions, which indicates a very strong preference for sorption of the higher MW_{AP} fraction.

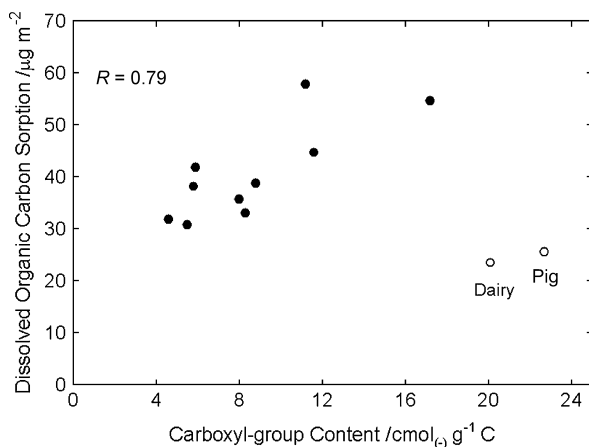


Figure 4 Correlation between carboxyl-group content with dissolved organic matter adsorption on goethite ($P < 0.01$). The initial dissolved organic matter concentration was $50 \text{ mg } C_{75} \text{ litre}^{-1}$ and the goethite concentration was 10 g litre^{-1} .

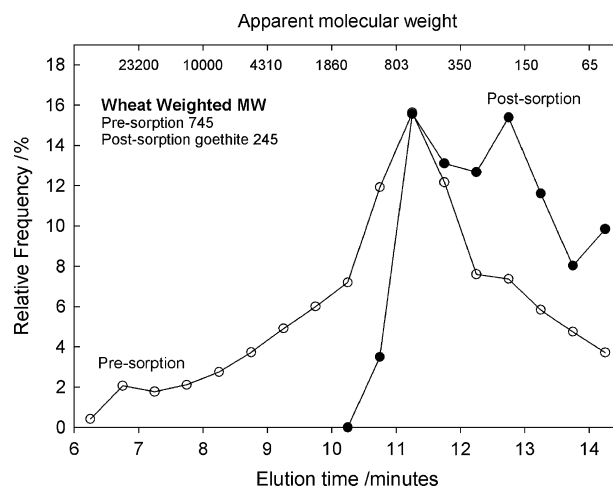


Figure 5 Molecular weight frequency distribution of the initial wheat straw dissolved organic matter extract and the dissolved organic matter remaining in solution after equilibrium sorption onto goethite. The bottom x -axis shows elution time and the top x -axis shows apparent molecular weight.

The percentage decrease in MW_{AP} of DOM, expressed as $\{[(\text{pre-sorption } MW_{AP} - \text{post-sorption } MW_{AP})/\text{pre-sorption } MW_{AP}] \times 100\}$, after a sorption reaction with goethite is shown in Table 2. The preferential sorption of the higher molecular weight DOM components shown in Figure 2 for wheat was also found for all other DOM sources, as evidenced by the percentage decrease in MW_{AP} , which ranged from 33% for canola root to 77% for beef manure. Furthermore, in all cases except for dairy manure, the HIX values of the DOM remaining in solution were less than the initial values, thus indicating preferential sorption of the more 'humified' material (Table 2).

Table 2 The percentage decrease in apparent molecular weight (MW_{AP}) and humification index (HIX) of the dissolved organic matter extracted from the amendment materials after sorption onto goethite

Material	% MW_{AP} decrease	% HIX decrease
Above-ground biomass		
Wheat straw	70	32
Maize residue	55	28
Soybean residue	64	29
Hairy vetch residue	40	22
Below-ground biomass		
Maize root	36	23
Soybean root	61	44
Canola root	33	6
Green bean root	34	17
Animal manures		
Beef	77	34
Dairy	35	+ 2
Poultry	48	19
Pig	34	30

Conclusions

The objectives of this study were to determine selected chemical properties of water-extractable DOM derived from plant biomass and animal manures, which are common soil amendments employed in sustainable agricultural systems, and to assess the relationship of these parameters to sorption onto goethite. Principal components analysis of the DOM indicated similarity in chemical properties of DOM extracted from plant shoots and roots. Animal manure-derived DOM grouped differently from the plant-derived materials in PCA analysis, and this grouping also exhibited a significant effect of animal source. While the 12 sources of DOM utilized in this study may not adequately represent the entire family of carbon-rich materials that are used as soil amendments, the results show that DOM sorption is influenced by the molecular weight and 'humification' (the latter as measured by *HIX* or molar absorptivity at 280 nm) of the DOM. The results from this work indicate preferential sorption to goethite of the high molecular weight components of biomass- and manure-derived DOM, analogous to what is observed for humic substances that have received more study by other investigators. The results of this study of DOM sorption for common soil amendments have implications for both the maintenance of soil quality and nutrient availability. Specifically, the data suggest that amendment with materials that release DOM of higher molecular weight and greater humification will result in enhanced initial sorption to soil solids, thereby contributing to accumulation of a larger soil organic C pool.

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