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CHARACTERIZATION OF THE ORGANIC MATTER POOL IN MANURE

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ABSTRACT

The increasing number of industrial farms without soil nearby represents a new opportunity to reuse manure for agricultural purposes, especially in arid and semiarid areas. However, the nature, stability and dynamics of the industrial manure are very heterogeneous, regarding the organic pool. In this experiment, different types of animal manure were evaluated on organic matter, total organic carbon (C_{ot}), total N, C/N ratio, water-soluble organic carbon (C_w), organic N (N_{org}), carbohydrates, C_w/N_{org} ratio, humic acid-like carbon (C_{ha}), fulvic acid-like carbon (C_{fa}), humification index ((C_{ha}/C_{ot})x100) and C_{ha}/C_{fa} and NH_4^+-N/NO_3^--N ratios.

Compared to other organic wastes like sewage sludge and urban refuse, commonly used as organic fertilizers, these materials had a similar organic matter content. Due to their high content of total nitrogen, the C/N ratio was low. The study of the different fractions of organic matter showed, as it was indicated by its higher concentration of total organic C, that the horse and pig manures had the greatest content of mineralizable organic matter. However, the fraction of easily biodegradable organic compounds (water-soluble C) was higher in the turkey manure. The study also showed that, in most cases, the percentage of fulvic acid-like C was greater than that of humic acid-like C. This fact indicates that the organic matter of these wastes is not completely humificated. This fraction of humic substance-like was higher in calf manure and more polymerizated in sheep manure. Regarding the parameters related to the organic matter stability such as, C_w, carbohydrates and C/N, C_w/N_{org} and NH_4^+-N/NO_3^--N ratios, it had been assessed that the organic matter of these materials is not completely stabilized. The results show that the values of these parameters in the cow manure converge to the limits set for organic wastes with an acceptable degree of maturation (C_w<0.5%, carbohydrates < 0.1%, C/N<12, C_w/N_{org}<0.7 and NH_4^+-N/NO_3^--N<0.16).

INTRODUCTION

The decrease in organic matter content in Mediterranean soils is one of the most important causes of degradation (Garcia et al., 1992). Animal manure application to soils in arid and semiarid areas was a traditional source of nutrients and organic matter for soil-plant systems but the scarcity of these biosolids in the second part of the century reduced their use in the south-east of Spain. Now, the increase of the number of industrial farms without soil nearby represents a new opportunity to reuse these materials for agricultural purposes. However, the nature, stability and dynamics of this type of residual are very heterogeneous, specially regarding the organic pool. On this account a sustainable use of animal manure for fertilizing purposes must start with a complete characterization of the discussed aspects to avoid rapid release of nutrients, and to reduce negative environmental impacts, such as of contamination of subsurface water due leaching nitrates. The problem is that considerable information concerning compost from animal manure is available but it is limited in the case of fresh residues and highly decomposable materials.

The aims of this experiment were i) the characterization of the different organic matter pools ii) quantification of the humic substances-like and finally iii) the evaluation of organic matter stability in animal manure.

MATERIAL AND METHODS

Forty-four manure samples from horse, cow, calf, pig, sheep, goat, rabbit and fowl such as, chicken, turkey and ostrich were collected from different farms of the south-east of Spain. All samples were dried in a stove of forced air at 60°C and ground to 0.5 mm for analysis. Organic matter (OM) was determined by loss on ignition at 430°C for 24 h (Navarro et al., 1993), total organic carbon by oxidizing with $K_2Cr_2O_7$ in H_2SO_4 according to Yeomans and Bremner (1989), total nitrogen (N_t) by Kjeldahl method and carbohydrates by the antrone method (Brink et al., 1960). After oxidation with $K_2Cr_2O_7$, the 0.1 M $Na_4P_2O_7$-extractable organic carbon (C_{ex}), fulvic acid-like carbon (C_{fa}), the latter after precipitation of the humic acid-like carbon (C_{ha}) at pH 2.0, and water soluble organic carbon (C_w) were measured by determining of Cr^{+3} spectrophotometrically (Sims and Haby, 1971). The C_{ha} was calculated by subtracting the C_{fa} from the C_{ex}. NH_4^+-N was extracted with 2 M KCl and determined colourimetrically (Honeycult et al., 1991), NO_3^--N by second-derivative spectroscopy method (Sempere et al., 1993; Simal et al., 1985). Organic nitrogen (N_{org}) was calculated as the difference between N_t and inorganic nitrogen (sum of NH_4^+-N and NO_3^--N).

RESULTS AND DISCUSSION

The results of the analyzed manures are summarized in Table 1. The OM average contents ranged from 45.7 % to 71.3 %, the turkey and ostrich manures being the wastes with the highest and lowest OM concentrations, respectively. However, all manures had similar quantities of OM compared to those found in sewage sludges and composts made from municipal solid waste by Cegarra et al. (1993).

Regarding the different fractions of organic matter, the horse and pig manures showed the highest levels of C_{ot}. The N_t concentrations were high in all manures producing a low C/N ratio. Therefore, the wastes with higher C_{ot} contents will have lower nitrogen losses, by NH_3-volatilization, during their degradation into the soil. The concentration of easily biodegradable organic compounds was greater in turkey manure, as it was indicated by its higher C_w value. The C_{fa} and C_{ha} average values were between 0.93 % and 2.97 % and 0.40 % and 1.34 %, respectively. In most cases, the C_{fa} percentage was greater than that of C_{ah}, which indicated that the organic matter of these wastes is not completely humificated. This little fraction of humic substance-like was higher in calf > sheep > chicken > goat > horse > cow > pig > ostrich > rabbit > turkey manure, as it was assessed of humification index (HI) values, calculated as $(C_{ha}/C_{ot})x100$. However, the humic-like fraction was more polymerizated in sheep > horse > cow > goat > calf > pig > chicken > rabbit > ostrich > turkey manure according to polimerization ratio values, calculated as C_{ha}/C_{fa}.

The organic matter of these manures might have undergone the beginning of the biodegradation process during their storage in heaps at outskirts of the farms. So parameters related to the organic matter stability were studied. The C/N ratio was low in all manures excepting the manures of chicken and turkey that had values of this ratio lower than 12, which is the limit accepted for mature composts prepared with a wide range of organic wastes (Bernal et al., 1998). The C_w, carbohydrates and NH_4^+-N/NO_3^-- N ratio average values ranged from 0.78 % to 2.46 %, 0.08 % to 0.20 % and 0.15 to 1.65 respectively. The cow manure had values of these parameters more close to the limits set

for municipal waste composts (C_w < 0.5 % and carbohydrates < 0.1 % (Garcia et al., 1992)) and composts from different organic wastes (NH_4^+-N/NO^{3-}- N < 0.16 (Bernal et al., 1998)). However, the cow and pig manures had C_w/N_{org} ratio values < 0.7, the value considered as indicating a mature compost suggested by Hue and Liu (1995).

CONCLUSIONS

According to the results obtained, it can be concluded that all studied manures can be used as amendments in agricultural soils, both for their elimination and for improvement of soil properties, due to their notable organic matter content. However in most cases, the organic matter stabilization process will start after its application to soil, only cow manure showed values of the parameters related to the organic matter maturity within the established limits for mature organic material.

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Table 1. Different fractions and stability parameters of organic matter in the studied manures (dry weight basis). OM: Organic matter; C_{ot}: total organic C; N_t: total N, C_w: water-soluble organic C; N_{org}: organic N; C_{fa}: fulvic acid-like C; C_{ha}: humic acid-like C; HI: humification index.

Manure	nº	OM (%)		C_{ot} (%)		N_t (%)		C/N		C_w (%)		Carbohydrates (%)	
		A.V.*	Range	A.V.	Range	A.V.	Range	A.V.	Range	A.V.	Range	A.V.	Range
Horse	4	63.9	59.5-77.6	40.7	34.1-47.3	2.1	1.9-2.3	20.2	15.1-25.2	2.12	1.87-2.50	0.14	0.12-0.18
Cow	4	53.3	25.1-67.5	22.5	13.2-38.8	1.9	0.9-2.4	14.2	12.5-16.0	0.78	0.25-1.68	0.08	0.02-0.16
Calf	3	47.1	42.9-51.2	29.5	18.1-41.7	1.8	1.2-2.2	16.8	14.7-19.3	2.11	1.18-2.85	0.20	0.15-0.32
Pig	6	67.8	61.9-72.7	40.7	37.7-42.8	2.2	1.8-2.7	19.1	14.2-24.1	1.17	0.63-1.90	0.12	0.08-0.19
Sheep	4	51.3	38.9-58.2	31.4	21.5-38.5	1.9	1.5-2.6	17.7	13.4-26.2	1.37	0.64-1.96	0.11	0.06-0.14
Goat	4	54.7	45.6-67.7	29.5	26.4-38.1	2.2	2.0-2.4	13.2	11.4-16.0	1.97	1.16-2.64	0.13	0.06-0.18
Rabbit	6	65.0	58.8-68.5	36.5	34.7-39.3	1.8	1.7-1.9	20.4	19.8-20.7	1.24	0.98-1.59	0.13	0.11-0.15
Chicken	4	52.5	45.9-62.6	32.6	28.2-38.6	3.1	2.5-4.2	11.1	6.7-14.7	2.16	1.93-2.63	0.19	0.17-0.20
Turkey	3	71.3	59.8-73.4	35.6	26.7-39.3	4.0	3.1-4.5	9.0	7.5-16.3	2.46	2.03-2.96	0.20	0.15-0.24
Ostrich	6	45.7	36.7-53.8	28.1	23.3-31.0	1.7	1.4-1.9	17.1	16.1-19.2	1.13	0.76-1.47	0.10	0.06-0.15

Manure	nº	C_w/N_{org}		C_{fa} (%)		C_{ha} (%)		HI (%)		C_{ha}/C_{fa}		NH_4^+-N/NO_3^--N	
		A.V.	Range	A.V.	Range	A.V.	Range	A.V.	Range	A.V.	Range	A.V.	Range
Horse	4	1.11	1.05-1.17	1.33	1.20-1.40	1.34	1.27-1.45	3.48	2.68-4.27	1.03	0.96-1.09	0.75	0.20-1.30
Cow	4	0.46	0.22-0.71	0.93	0.40-1.71	0.55	0.10-0.97	2.85	0.77-6.28	0.98	0.15-2.44	0.32	0.10-0.45
Calf	3	1.27	1.01-1.41	1.66	1.46-2.05	1.20	1.01-1.35	4.07	3.24-5.58	0.72	0.65-0.76	0.57	0.36-0.70
Pig	6	0.55	0.37-0.90	1.45	0.70-2.47	0.80	0.50-1.00	1.86	1.16-2.43	0.69	0.37-1.18	0.89	0.31-2.42
Sheep	4	0.82	0.41-1.41	1.33	0.57-2.12	1.18	0.91-1.59	3.80	3.01-4.25	1.10	0.49-1.61	0.48	0.35-0.69
Goat	4	1.01	0.84-1.16	1.80	0.90-2.19	1.02	0.64-1.60	3.56	2.37-6.07	0.74	0.29-1.79	0.15	0.04-0.25
Rabbit	6	0.74	0.61-0.88	1.61	1.32-1.99	0.56	0.35-0.74	1.15	0.56-1.87	0.29	0.11-0.48	1.20	1.01-1.50
Chicken	4	0.78	0.48-0.94	2.55	2.20-3.13	1.14	0.72-1.59	3.62	2.15-5.64	0.46	0.27-0.71	1.01	0.68-1.37
Turkey	3	0.65	0.60-0.70	2.97	2.66-3.09	0.40	0.29-1.50	1.12	1.09-3.82	0.14	0.11-0.49	1.65	1.01-1.68
Ostrich	6	0.70	0.59-0.79	2.10	1.57-2.50	0.42	0.15-0.73	1.51	0.57-2.41	0.22	0.06-0.44	0.36	0.19-0.49

*A.V.: Average value