Factors affecting the water extractable phosphorus from compost

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Phosphorus (P) is recognized to be essential for plant growth, being the second nutrient for importance only to nitrogen (N). Most of the P utilized in agriculture comes from the mining of rock phosphate (about 80% from Morocco and North-west Africa), which is a not-renewable resource [1]. In this frame the recovery-recycling of P from organic waste for plant nutrition can play a key role in the reduction of the rock phosphate dependency for agricultural uses.

Composts have been deeply studied for their N content and availability for plant while fewer are the studies about their capacity to furnish available P. Composts can have very high quantity of P, there is a general imbalance of the N/P ratio for plant nutrition, in this scenario it is possible distribute to the soils very high quantity of P being its potential plant availability unknown. Water soluble P is generally recognized to be the most suitable parameter for assessing potential fast plant available P from compost [2]. Beside to the few information about the water soluble P from compost, few are the studies assessing the factors affecting this traits. The factors playing a role in the water extractability of P from compost appears to be the stability level, the content of calcium (Ca), beside to the presence of aluminium (Al) and iron (Fe).

Therefore the objectives of this work were: (*i*) the assessment of the water extractable P, and (*ii*) the study of the main factor affecting this feature. To this aims in this work 26 composts from different origin and stability level were compared for their water extractable P (inorganic: *Pi* and organic: *Po*). Moreover the relationships between extractable P, the stability level and the content of the above cited element (Ca, Al, and Fe) were investigated by means of the principal component analysis (PCA).

Materials and Methods

Twenty-six compost from different origin [organic fraction of municipal solid waste (also anaerobically digested), sewage sludge, green waste and their mixtures], were collected from many different composting facilities in the northern Italy region. On fresh samples were determined the main characteristics (pH, EC, NH_4^+-N NO_3^--N, dissolved organic carbon), besides to the stability level by means of the measurements of the oxygen uptake rate (OUR) [3].

On the air-dried and milled sample were determined the content of P and trace elements via Atomic Emission Spectroscopy Inductively Coupled Plasma (AES-ICP) after microwave assisted acid digestion ($HCl + HNO_3 + H_2O_2$). The total inorganic P was determined via Murphy and Riley method after 0.5M H_2SO_4 extraction (overnight). The water extractable P was determined on the dried and milled samples after 2 h extraction: *Pi* was determined via Murphy and Riley method. Total water extractable P was determined via AES-ICP after $H_2SO_4 + H_2O_2$ hot digestion. The water soluble organic P (*Po*) was determined as difference between total water extractable P and *Pi*. The relationships between *Pi,* *Po* and other variables were assessed via PCA.

Results and discussion

Different compost samples showed a wide range of stability level (from 2 up to 80 mmol O_2 kg^{-1} VS h^{-1}), representing the whole range of stability level according to Veeken et al. [4]. The total P content varied from 2.6 up to 8.3 mg g^{-1} showing an average content of 4.6 mg g^{-1}. Total inorganic P (extractable in 0.5M H_2SO_4) showed a range comprise between 35 and 85% of total P. The water soluble P showed lower range with respect to the 0.5M H_2SO_4 extractable P, being the *Pi* comprise between 0 and 13% of total P (4.6% on average). Organic P in the water extract ranged between 0.5 and 7 %.

As shown in Table 1, the first PC (PC 1) showed 28.5% of recovered variance, this was mainly formed by Al (0.85) and Fe (0.84), in addition to **Pi H2SO4** (-0.60) and the stability level (-0.42). This PC showed the relationship existing between the total inorganic P from different composts and their stability levels; it appears therefore in different composts the lower was the stability level the higher was the acid extractable inorganic P. Moreover it appears from this PC (PC1) the possible role of "sequestration" played by Al and Fe which very likely blocked the native P in precipitated hydro-oxides being unavailable to microbial growth.

Table 1. Factor loadings and recovered variance of the three extracted principal components (unrotated).

Variable	PC 1	PC 2	PC 3
OUR	-0.42		-0.56
P_i H2SO4	-0.60		0.58
Ca		0.81	
Fe	0.84		
Al	0.85		
pH		0.45	0.47
P_i		-0.85	
P_o			0.66
Variance (%)	28.5	22.3	18.7

From the second PC (PC 2) which recovered a further 22.3% of variance, clearly appeared the negative relationships between the total content of Ca (0.81), and the water soluble inorganic phosphorus in different compost: P_i (-0.85). At last PC 3 which recovered a further 18.7% of variance (total 69.5%), showed the negative relationship of P_o with the OUR. In other words at the lower stability level lower was the water soluble organic P. At the same time P_o increased depending also by the presence of total inorganic P (**P_i H2SO4**; 0.58).

Conclusion

Composts deserve attention for their very interesting amount of P which can be partially available for plant nutrition. From the data analyzed in this work it appears that unstable compost are rich of inorganic P, this can be very likely immobilized by microorganisms during the composting process. Inorganic P available to microorganisms appears to be negatively related to high levels of flocculating agents such as Al and Fe. In fact greater quantity of water soluble organic P are related to higher initial inorganic P. Water soluble inorganic P, the most suitable for plant nutrition, appears to be related only to the presence of Ca: high quantity of Ca reduce the extractability of P in water.

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