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Soil enzyme activities as affected by anthropogenic alterations: intensive agricultural practices and organic pollution

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Abstract

The activity of a range of enzymes related to the cycling of the main biologically important nutrients C, N, P and S was investigated in cultivated and non-cultivated soils from various parts of Europe. Two agricultural sites from North Italy under continuous corn (*Zea mays* L.) with and without organic fertilization were compared. Two other agricultural sites from South Italy under hazel (*Corylus avellana* L.) never flooded or repeatedly flooded over by uncontrolled urban and industrial wastes were investigated. The non-cultivated soils were from Middle and South Europe with different pollution history such as no-pollution and pollution with organic contaminants, which is phenanthrene and other polycyclic aromatic hydrocarbons (PAHs).

Agricultural soils showed significant differences in some of physical–chemical properties (i.e. organic C, total and labile phosphate contents, available Ca and Mg) between the two sites studied. Enzyme activities of hazel sites periodically flooded by wastes were mainly higher than in the hazel sites never flooded. Sites under many years of continuous corn showed dehydrogenase, invertase, arylsulphatase and β-glucosidase activities generally lower than the soils under hazel either flooded or not by wastes.

As compared to agricultural soils, non-cultivated soils heavily or moderately polluted by organic contaminants displayed much lower values or complete absence of enzymatic activities.

Dissimilar, contradictory correlations between soil enzyme activities and the majority of soil properties were observed separately in the two groups of soils. When the whole set of enzyme activities and soil properties were considered, all significant correlations found separately for the groups of soils were lost. The overall results seem to confirm that no direct

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cause–effect relationships can be derived between the changes of a soil in response to a given factor and both the variations of the activity and the behaviour of the enzymes in soil.

Keywords: Enzyme activities; Agricultural soils; Non-cultivated soils; Anthropogenic alterations; Organic pollution

1. Introduction

Soil is a living dynamic, non-renewable, resource and its conditions influence food production, environmental efficiency and global balance (Dick, 1997; Doran and Parkin, 1994; Doran and Zeiss, 2000).

The quality of soil depends in part on its natural composition, and also on the changes caused by human use and management (Pierce and Larson, 1993). Human factors influencing the environment of the soil can be divided into two categories: those resulting in soil pollution and those devoted to improve the productivity of soil (Gianfreda and Bollag, 1996).

Unusual management of the soil, such as intensive cultivation without crop rotation (Reeves, 1997), or accidental/deliberate contamination by municipal and industrial wastes (Edwards, 2002), are major causes of land degradation and reduced soil productivity.

The determination of the quality-related properties of soil (which are sensitive to changes caused by management practices and environmental stress) may help to monitor the changes in its sustainability and environmental quality. This is especially true for the agricultural management and recovery of soil, and to assist into the establishment of policies for the use of land.

Soil enzymes activities have been suggested as suitable indicators of soil quality because: (a) they are a measure of the soil microbial activity and therefore they are strictly related to the nutrient cycles and transformations; (b) they rapidly may respond to the changes caused by both natural and anthropogenic factors; (c) they are easy to measure (Gianfreda and Bollag, 1996; Drijber et al., 2000; Calderon et al., 2000; Colombo et al., 2002; Nannipieri et al., 2002). Moreover, as claimed by several authors (Dick and Tabatabai, 1993; Dick, 1997, van Beelen and Doelman, 1997, Trasar-Cepeda et al., 2000), soil enzymes activities may be considered early and sensitive indicators to measure the degree of soil degradation in both natural and agro-ecosystems, being thus well suited to measure the impact of pollution on the quality of soil.

Among soil pollutants, major environmental concerns are heavy metals and polycyclic aromatic hydrocarbons (PAHs) (Smreczek et al., 1999). The presence of heavy metals in the soil may influence the biochemical processes by affecting both microbial proliferation and enzyme activities. Heavy metals may inhibit enzyme activities by masking catalytically active groups, having denaturing effects on the conformation of proteins, or competing with the metal ions involved in the formation of enzyme–substrate complexes (Gianfreda and Bollag, 1996 and references therein).

As multi-ring by-products of the incomplete combustion of several organic pollutants, PAHs are considered hazardous soil contaminants. In soil, they may have different fates. The sorption of organic contaminants by natural soil colloids (organic and inorganic) often limits their bioavailability as substrates, thus affecting their microbial degradation rate in the soil (Grosser et al., 2000). When bio-available, PAHs may strongly affect the biological and biochemical activity of soil.

In the present study we have measured the activity of a range of enzymes, related to the cycling of the main biologically important nutrients (C, N, P, S) in soils of two typologies: agricultural and non-cultivated soils. The selected soils were characterized by different origins, properties and history. We studied four soils from two large agricultural sites located in North and South Italy and characterized by different management practices (continuous monoculture cultivation and accidental overflooding with polluted wastewater), and four non-cultivated sites polluted by organic and inorganic pollutants located in different parts of Europe. Attempts were made to find some cause–effect relationships, if any, between soil properties, depending on their management and/or pollution, and enzyme activity levels.