Geophysical Research Abstracts, Vol. 8, 06025, 2006
SRef-ID: 1607-7962/gra/EGU06-A-06025

Sensitivity of eco-physiological indicators of soil quality with respect to agricultural and industrial impact

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Microbial activity is a driving force of mineralization processes and nutrient cycling in soil. Therefore microbial component is one of the key factors responsible for soil fertility and soil quality which is the integration of chemical, physical and biological features of soil.

Several eco-physiological quotients: RQ (the ratio of CO_2 evolution to O_2 uptake), qCO_2 (the ratio of basal respiration to microbial biomass) and C_{mic}:C_{org} (% microbial biomass-C per unit soil organic C), have been suggested as a quick and reproducible soil quality indicators (Dilly, 2001; Anderson, 2003). qCO_2 and C_{mic}:C_{org} reflect in some cases the availability of soil carbon and maintenance requirements of soil microbial community. Therefore the increase of qCO_2 and decrease of C_{mic}:C_{org} values indicate the soil quality degradation. The generality and sensitivity of such quotients to different anthropogenic impacts affecting soil quality such as agricultural use or industrial pollution has not been compared yet. Growth characteristics of soil microbes, such as specific growth rate (μ_m), may serve as an additional ecological indicator showing the dominating of K or r strategy in soil microbial community. Our goal was to compare sensitivity of qCO_2, C_{mic}:C_{org} and μ_m applied to the series of soils in long-term tillage and in gradient of industrial contamination. We studied the applicability of these characteristics for indication of soil humus degradation and level of soil pollution.

Chernozem soils in tillage during 10, 46, 76 years and soil under 100 years old forest (as undisturbed control) were chosen for monitoring of soil humus degradation under agricultural usage. Gradient of industrial pollution was studied in soils at 7, 20, 28,

100, 200 km distance from Monchegorsk Cu-Ni smelter.

Soil microbial biomass was determined by SIR-method, specific growth rates of soil microorganisms were estimated by kinetic respiration analysis in soils amended with glucose and mineral salts.

Soil humus content depended strongly on tillage duration of chernozems and declined from 9.2% in control to 6.04% in 76 years ploughed soil. C_{mic}:C_{org} ratio was the most sensitive parameter reflecting the process of humus degradation at high significance level ($P<0.001$). Significant correlation ($P<0.01$) was found also between μ_m –values and humus content in chernozems confirming that nutrient status of soil rather than the ecosystem maturity is responsible for K – r competition in soil microbial communities. The differences in qCO_2-values in long-term ploughed soils were insignificant showing the lower sensitivity of this parameter to total content of soil humus.

Values of qCO_2 were positively correlated whereas C_{mic}:C_{org} -values were negatively correlated with the level of industrial contamination. In this case qCO_2 was more sensitive to industrial gradient compared to C_{mic}:C_{org} ratio. Strongest negative relationship was found between μ_m – values and the level of soil pollution indicating that fast-growing microorganisms with r-strategy were more sensitive to industrial pollution than slow growing K-strategists.

Thus, C_{mic}:C_{org} ratio was more sensitive in respect to the humus degradation in arable soils, whereas qCO_2reflected better the degradation of soil quality under industrial pollution. Specific growth rates distinctly indicated functional changes in soil microbial communities both under agricultural and under industrial impact. Combined employment of these three parameters showed a good potential for soil ecological studies.

References:

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