Humic-based polyelectrolyte complex: effect on soil properties and ecotoxicity

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Interpolyelectrolyte complexes (IPECs), the products of interaction between two oppositely charged polyelectrolytes (PEs), have been suggested for soil structure stabilization. An ability of IPECs to improve soil hydrophysical properties, prevent soil erosion and act as soil conditioners have been studied in our previous works [1]. The efficacy of IPECs was dependent both on chemical composition of IPEC and soil properties. Using humic substances as the polyanionic ingredient of IPEC is a prospective approach to develop environmental-friendly and effective formulations.

In this study we used a positively charged IPEC prepared from the commercial polymers: cationic poly(diallyldimethylammoniumchloride) (PDDA) and anionic biopolymer lignohumate (LH), a humic-based plant growth stimulator. The objective of the study was to assess the effects of the three PEs on soil properties and toxicity to a number of standard test-species. The results obtained for cationic IPEC were compared with the ones for anionic LH and cationic PDDA.

Soil experiments were conducted in a small-plot trial. The results showed, that humic-based IPEC drastically reduced the share of large soil aggregates and prevented the formation of small aggregates, thereby significantly increasing the content of agronomically valuable aggregates (0.25-10 mm). Application of IPEC in concentrations of 1-5% did not lead to a significant change in the amount of exchangeable cations, except for potassium. Soil treatment with IPEC promoted plant growth and development in the extend comparable to the effect of LH, humic plant growth stimulator.

The toxicity was evaluated in bioassays using bacteria *Escherichia coli*, ciliates *Paramecium caudatum*, mammalian cell (bull spermatozoa *Bos taurus*) *in vitro*, and three plant species *Sinapis alba*, *Raphanus sativum* and *Triticum durum*. Test responses were assessed (1) in an aqueous matrix at direct contact with PEs and (2) after polymer interaction with a soil matrix. In water matrix, PDDA and IPEC were highly toxic to bacteria and ciliates in all tested concentrations and less toxic to the mammalian cells. Higher plants were less sensitive to the polymers with a progressive decrease of the toxicity in a row PDDA-IPEC-LH. In soil matrix, the phytotoxicity of PDDA and IPEC significantly decreased. In environmentally relevant concentrations, used for the anti-erosion polymer-soil crust formation, no toxicity of both polymers was detected in phytotests. Being introduced in soil matrix, cationic polymers bound to organic and mineral components that resulted in mitigation of the polycation's toxicity.

The results of the work show that LH in the polycomplex retains its biostimulant properties and a humic-based IPEC can be used to create productive artificial soils.

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References

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