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Humic substances and nature-like technologies

Learning from nature: understanding humic substances structures and interactions for the development of environmentally friendly, nature-like technologies

Irina V. Perminova[1] · José-María García-Mina[2] · Heike Knicker[3] · Teodoro Miano[4]

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Humic substances (HS) are viewed as an inherent component of soil organic matter, which plays multiple life-sustaining functions in the environment. The complexity of the molecular ensemble of humic substances is reflected in singular physicochemical features and results in uniquely broad and diverse interactions with both abiotic components and living organisms directed towards adaptation of life to its abiotic environment. The reported examples of mediating roles of HS in soil range from the transport of available nutrients in soil solution (Olaetxea et al. 2018) to the remediation of contaminated soils (Perminova and Hatfield 2005). Still, the major problem remains in transferring the molecular engineering of nature into the technology world. This problem gave rise to the topic of the Fourth International Conference on Humic Innovative Technologies (HIT) "From molecular analysis of humic substances - to nature-like technologies," which was organized by the CIS chapter of the International Humic Substances Society on October 15–20, 2017, in Moscow, Russia (www.humus.ru/hit-2017). The papers presented at that conference formed the basis for this special issue of the *Journal of Soils and Sediments.*

✉ Irina V. Perminova
iperm@org.chem.msu.ru

[1] Department of Chemistry, Medicinal Chemistry and Fine Organic Synthesis Division, Lomonosov Moscow State University, Leninskie Gory 1-3, Moscow, Russian Federation 119991

[2] Biological and Agricultural Chemistry Group, Universidad de Navarra, 31080 Pamplona, Spain

[3] Geoecología, Biogeoquímica y Microbiología Ambiental, Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Avda. Reina Mercedes, 10, 41012 Sevilla, Spain

[4] Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, Via Amendola, 165/A, 70126 Bari, Italy

The authors of the papers described above rely on very well-known facts that the humus content in soil is directly related to soil fertility and that HS extracted from different substrates (peat, lignite, soil) are capable of improving crop yields and fruit quality (Rose et al. 2014). Recent studies point out that this beneficial action of humic substances might also involve a complementary action of soil microbiota (Olaetxea et al. 2018). This very important issue is addressed in this special issue by Bezuglova et al. (2019) who showed that the beneficial action in wheat involves complementary effects including high pesticide degradation, high microbial activity of exudates, and improvements in plant mineral nutrition. In this line, other studies deal with the transformation of humic substances in soils and their biological activity (Fedoseeva et al. 2019; Sachkova et al. 2019; Tikhova et al. 2019) as well as with the influence of other organic soil amendments, like Biochar, on the transformation of soil organic matter (Orlova et al. 2019). Finally, Kalinichenko et al. (2019) reported the effects of humic substances on soil properties and Pb concentration in waters. Of particular importance is the study of Karpukhina et al. (2019) that describes a rapid and consistent methodology to evaluate humic substance concentration in fertilizers. This issue is of special relevance since many products marketed as humic substances are not true humic substances but, instead, are other types of organic matter residues in solution.

The collection of the presented papers provides the state-of-the-art on the complexity of abiotic-biotic interactions involving humic substances, fosters a deeper view into the problems and perspectives of nature-like technology developments, and pushes forward a concept of eco-adaptive chemistry and technology (Perminova 2019)—a logical consequence of green chemistry principles applied to the transfer of nature machinery and of its sophisticated tools, and the best example of those are humic substances.

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