Effects of Low Molecular Weight Humic Substances on Microorganisms

Humic substances increase the growth rate of many forms of beneficial microorganisms in part, by stimulating enzyme activities (Vissera, 1985, Pouneva, 2005, Burkowska and Donderski, 2007). This is true for both aerobic and anaerobic microorganisms (Hartung, 1992).

Humic substances assist in the nutrition of microorganisms by complexing and delivering trace elements like iron to microbial cell surfaces. (Chen and Wang, 2008).

Humic substances act as an electron shuttle to help anaerobic organisms grow by helping them to reduce organic compounds and metals (Lovley et al. 1996; Finneran et al. 2002).

Humic substances also increase the growth rate and populations of beneficial microorganisms around plant roots, and the activity of soil enzymes like catalase and phosphatase (Sellamuthu and Govindaswamy, 2003).

Studies indicate that humic substances may represent a stimulatory component of the soil environment with respect to both ectomycorrhizal and arbuscular mycorrhizal fungi, which form associations with plants and enhances the uptake of water and nutrients (Gryndler et al. 2005, Hrselová et al. 2007).

Humic substances retard the growth of pathogenic bacteria, while enhancing the growth of beneficial microorganisms. Specific growth rates, growth yield, and enzyme activity of pathogenic organisms decreased markedly with increasing concentrations of humic and fuvic acids (Alexander et al. 2008; Imai et al. 1999a; Imai et al. 1999b; Loffredo et al. 2008.).

Humic substances have also been used to increase the longevity and survival rate of various plant growth-promoting bacteria inoculum stored for future use on crops (Young et al., 2006).

Humic substances not only reduce the toxic effects of metals, hydrocarbons and other chemicals on microorganisms (Lipczynska-Kochany and Kochany, 2008; Feificova et al. 2005), but they can directly catalyze the oxidation of toxic compounds by both anaerobic and aerobic microorganisms (Bradley et al. 1998, Larsson et al. 1988, Wang et al. 2009). This is accomplished by humic substances acting as electron shuttles (Larsson et al. 1988, Luu et al., 2003, Aulenta et al. 2010).

References

Alexander K. T., Kirschner J. S., Andreas H. F., Romana H., Beate Süß, Beate G., Alois H. and B. Reitner. 2008. **Rapid Growth of Planktonic *Vibrio cholerae* Non-O1/Non-O139 Strains in a Large Alkaline Lake in Austria: Dependence on Temperature and Dissolved Organic Carbon Quality.** Appl. and Environ. Microbiol., 74: 2004-2015

Aulenta, Federico; Di Maio, Veronica; Ferri, Tommaso and Mauro Majone. 2010. **The humic acid analogue antraquinone-2,6-disulfonate (AQDS) serves as an electron shuttle in the electricity-driven microbial dechlorination of trichloroethene to cis-dichloroethene.** Bioresource Technology, Article in Press, Corrected Proof.

Bradley P. M., Chapelle F. H., and D. R. Lovley. 1998. **Humic Acids as Electron Acceptors for Anaerobic Microbial Oxidation of Vinyl Chloride and Dichloroethene.** Appl Environ Microbiol., 64(8): 3102–3105.

Burkowska, A. and W. Donderski. 2007. **Impact of humic substances on bacterioplankton in eutrophic lake.** Polish J. of Ecol. 55 (1): 155-160.

Chen, Min and Wen-Xiong Wang. 2008. **Accelerated uptake by phytoplankton of iron bound to humic acids.** Aquatic Biol., 3: 155–166.

Feificova, D. Snajdr, J. Siglova, M. Cejkova, A. Masak, J. and V. Jirku. 2005. **Influence of Humic Acids on the Growth of the Microorganisms Utilizing Toxic Compounds (Comparison between Yeast and Bacteria),** CHIMIA International Journal for Chemistry, 59 (10): 749-752.

Finneran, K. T., Forbush, H. M., Gaw VanPraagh ,C. V. and D. R. Lovley. 2002. **Desulfitobacterium metallireducens sp. nov., an anaerobic bacterium that couples growth to the reduction of metals and humic acids as well as chlorinated compounds.** Internatl. J. of Systematic and Evolutionary Microbiol., 52: 1929-1935, by Society for General Microbiology.

Gryndler M., Hršelová H., Sudová R., Gryndlerová H., Řezáčová V. and V. Merhautová. 2005. **Hyphal growth and mycorrhiza formation by the arbuscular mycorrhizal fungus Glomus claroideum BEG 23 is stimulated by humic substances.** Mycorrhiza, 2005,15 (7): 483-488.

Hartung, H.A. 1992. **Stimulation of anaerobic digestion with peat humic substance.** Science of The Total Environment, 113 (1-2) pp 17-33.

Hrselová H., Soukupová L., and M. Gryndler M. 2007. **Humic acid-like material from sewage sludge stimulates culture growth of ectomycorrhizal fungi in vitro.** Folia Microbiol (Praha).52(6):627-30.

Imai, A., Fukushima, T., and K. Matsushige. 1999a. **Effects of Aquatic Humic Substances on the Growth of the Cyanobacterium *Microcystis aeruginosa*** (a toxic algae). Japan Soc. on Water Environment, 22(7): 555-560.

Imai, A., Fukushima, T., and K. Matsushige. 1999b. **Effects of iron limitation and aquatic humic substances on the growth of Microcystis aeruginosa.** Can. J. Fish. Aquat. Sci. 56 (10): 1929-1937.

Larsson P., Okla L. and L Tranvik. 1988. **Microbial degradation of xenobiotic, aromatic pollutants in humic water.** Appl. Environ. Microbiol.; 54(7): 1864-1867

Lipczynska-Kochany, Ewa and Jan Kochany . 2008. **Humic substances in bioremediation of industrial wastewater—Mitigation of inhibition of activated sludge caused by phenol and formaldehyde.** J. of Environmental Sci. and Health, Part A, 43(6): 619 – 626.

Loffredo E., Berloco M., Casulli F. and N. Senesi. 2007. **In vitro assessment of the inhibition of humic substances on the growth of two strains of *Fusarium oxysporum.*** Biol. and Fertility of Soils, 43 (6): 759-769.

Loffredo E., Berloco M. and N. Senesi. 2008.**The role of humic fractions from soil and compost in controlling the growth in vitro of phytopathogenic and antagonistic soil-borne fungi.** Ecotoxicology and Environ. Safety, 69 (3), 350-357.

Lovley , D. R., Coates J. D., Blunt-Harris E. L., Phillips E. J. P. & J. C. Woodward. 1996. **Humic substances as electron acceptors for microbial respiration.** Nature 382: 445 – 448.

Luu Y, Ramsay B.A., and J. A. Ramsay 2003. **Nitrilotriacetate Stimulation of Anaerobic Fe(III) Respiration by Mobilization of Humic Materials** in Soil. Appl. and Environ. Microbiol., 69 (9):. 5255-5262.

Pouneva, I. 2005. **Effect of Humic Substances on the Growth of Microalgal Cultures.** Russian Journal of Plant Physiology, 52 (3). pp. 410-413

Sellamuthu K. M. and M. Govindaswamy. 2003. **Effect of fertiliser and humic acid on rhizosphere microorganisms and soil enzymes at an early stage of sugarcane growth.** Sugar Tech, 5(4): 273-277.

Vissera. 1985.**Physiological action of humic substances on microbial cells.** Soil Biol. and Biochem., 17(4): 457-462.

Wang, Yibo; Wu, Chunyuan; Wang, Xiaojing; and Shungui Zhou. 2009. **The role of humic substances in the anaerobic reductive dechlorination of 2,4-dichlorophenoxyacetic acid by Comamonas koreensis strain CY01.** J. of Hazardous Materials, 164 (2-3): pp 941-947.

Young, C.-C., Rekha, P., Lai, W.-A. and A. Arun. (2006), **Encapsulation of plant growth-promoting bacteria in alginate beads enriched with humic acid**. Biotech. and Bioengineering, 95: 76–83.