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Microbial growth and biofilm formation in the capillary fringe above the groundwater table

Soil and groundwater are naturally inhabited by a vast variety of prokaryotes. It was estimated that 2.5 x 1029 microorganisms live in the top 8 m of the terrestrial subsurface and at least 2.5 x 1030 microorganisms below 8 m depth, either suspended in the water phase or immobilized as a biofilm on organic and mineral compounds. Capillary fringes (CFs) form the interface between groundwater-saturated soil and the unsaturated underground and may be as thin as a few centimetres but can also span over more than one meter above the water table. Microbial life in the vadose zone (zone above permanent water saturation) requires adaptive strategies to cope with unfavorable conditions such as dryness, growth-limiting moisture content or inadequate supply of carbonaceous compounds and oxygen or other electron acceptors. Human activity may cause severe local pollution associated with surplus substrate supply, toxicity or other harmfull effects for the soil bacteria. As a consequence of the highly variable presence of water that is essential for bacterial growth and a variable supply of growth substrates, surface-attached growth and life in biofilms is an appropriate strategy for survival. Biofilm formation in an oligotrophic, groundwater-saturated underground and in the capillary fringe (CF) above the water table is however a very slow process due to severe nutrient limitation. Because of low groundwater flow rates, non-motile and motile bacteria have sufficient time to passively or actively attach to mineral surfaces at places or in the vicinity of a growth-supporting environment to form a stationary and permanent biofilm. The thickness of a biofilm depends on the continuity of nutrient supply, the nutrient concentration and the electron availability for aerobic, anoxic or anaerobic respiration/fermentation. The formation of a biofilm may cause changes in the flow behavior of the groundwater due to narrowing of pore diameters or changes of surface properties of the overgrown soil minerals. Bacteria in the biofilm at the surface of soil particles are surrounded by a thick layer of extracellular polymeric substances (EPS) which form a hydrogel. EPS functions as absorbant for nutrients and supplies moisture for the bacteria in the biofilm when the CF is dehydrated during long-lasting droughts with decreasing groundwater levels. Part of it may slowly be degraded when no ohter carbon sources are available. Harmless soil bacteria in biofilms of groundwater-saturated soil may mutate and get antibiotic-resistant when exposed to antibiotic resistence bacteria or antibiotic resistence genes that were found in polluted groundwater and are absorbed by EPS of biofilms.

Biography

Josef Winter is a Chemist and Microbiologist with research experience of more than 30 years in the Field of Aerobic and Anaerobic Wastewater and Waste Treatment, Soil Remediation and Groundwater Pollution. He has published more than 100 articles in peer-reviewed journals and is a member of different professional NGOs. He retiered in the year 2016.

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