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Sommario/riassunto Half a century ago, soil microbiologists reached the conclusion that a full understanding of the growth and activity of microorganisms in soils and sediments would require quantitative observations at spatial scales as near as possible to the size of the organisms themselves. Back then, this type of observation was not feasible at all, unfortunately. The development of electron microscopes in the 60s and 70s provided qualitative insight into microscopic parameters that controlled the activity of bacteria, archaea, and fungi in pore spaces, but produced no quantitative information. It is only with the technological advances in X-ray computed micro-tomography (µCT), first at synchrotron facilities in the 90s, then with commercial table-top scanners in the early 2000s, that quantitative, micrometric data on the geometry of the pore space has become available. In the last decade, different methods have also been developed to measure the spatial distribution of microorganisms at fine resolution in thin sections, as well as to map the composition of organic soil constituents or the nature of nitrogenous compounds at micrometric or even nanometric scales. Finally, a number of computational approaches have been adopted successfully to model mathematically the various physico-chemical processes occurring within pores, which affect the growth and activity of microorganisms. After these novel techniques became available, an initial stage in the

research has consisted of identifying and resolving the problems associated with their use to elucidate microbial processes in heterogeneous soils and sediments. Significant progress has been achieved in this respect, for example in the development of objective (operator-independent), local segmentation techniques adapted for X-ray µCT images, in terms of improvements of hybridisation (FISH) technologies to locate bacterial and archaeal cells in soil thin sections, or in the in elaboration of statistical tools to interpolate 2-D measurements to produce 3-D data. All of this progress enables us to now enter with confidence into a second stage of the research, where different techniques will be combined to apprehend more completely the characteristics of microhabitats in terrestrial systems. A number of research groups around the world are trying to quantify the physical and (bio)chemical features of these microhabitats, as well as to describe as thoroughly as possible the composition and biodiversity of microbial populations they contain. Within the next few years, increasing focus will be placed on this integration of techniques, and progress in this respect will likely be fueled very significantly by the development of an array of new techniques, e.g., single-cell metabolomics or X-rays produced by plasma wave accelerators, which offer great promise for the research on soils and sediments.