The emerging field of nano-environmental science

MICHAEL F. HOCHELLA, JR.[1,2] AND YI YANG[3]

[1]NanoEarth, Virginia Tech, Blacksburg, VA 24061 USA, hochella@vt.edu

[2]Energy and Environment Directorate, Pacific Northwest National Laboratory, Richland, WA 99352 USA, michael.hochella@pnnl.gov

[3]School of Geographic Sciences, East China Normal University, Shanghai 200241 China, yyang@geo.ecnu.edu.cn

The field of nano-environmental science is advancing rapidly. Results from this kind of science can be highly impactful, when just a few years ago, we would have had little hope of this. Our best example to date started four years ago and unfolded very slowly. At that time we decided to study a coal ash spill that occurred from an ash impoundment pond into the Dan River, North Carolina, USA. This damaging event provided us with an opportunity to study the significance and role of naturally occurring, engineered, and incidental nanomaterials associated with contaminant distribution (mostly As, but other metals) from a large-scale, acute aquatic discharge event. We found that the As was principally carried downstream sorbed to ferridyrite nanoparticles that we determined to be a secondary nanomaterial that formed in the coal ash impoundment. We also came across TiO_2 nanoparticles which could be natural or of engineered origin, but also rare non-stoichiometric titanium oxide nanoparticles (Magneli phases) that at first seemed inconsequential. After nearly a year, we conclusively determined that these Magneli phases were incidental nanoparticles produced during industrial coal burning. We now have multple lines of evidence that strongly suggest that these phases are distributed world-wide and that they may have deleterious human health consequences. The upshots: First, we still are not aware of all of the important pollutants in our environment. This is particularly true for nanomaterials in the environment that can be very difficult to find and understand. Nanoparticles are often ephemeral, changing their composition, key aspects of their atomic structure, and their size and shape with time. Even subtle variations can dramatically change their properties and the way they interact with living things, as demonstrated particulary well in this study. Stociometric titanium dioxides and Magneli phases, which are nearly identical chemically and structurally, have dramatically different electronic properties, and due to that, environmental (and human) consequences.