# Assessing the Environmental Impacts of Nanotechnology on Organisms and Ecosystem Functions

***Jean-Claude Bonzongo***
***University of Florida, Gainesville, FL***

## Abstract

The goal of this project is to develop an understanding of the potentially complex interplay between manufactured nanomaterials (MN) and the health of organisms and ecosystems. Nanotechnology has been singled out by industry and governments to become the world's largest and fastest industrial revolution, and with regard to the environment, it carries the potential to substantially benefit environmental quality through pollution prevention, treatment, and remediation. However, nanotechnology could also lead to serious environmental problems. This is because it is largely unknown how MN will impact the environment. Meanwhile, as the use of nanotechnology increases, emissions of produced nanomaterials to the environment may also increase, creating a new class of environmental problems. Unfortunately, the environmental behavior and fate of engineered nanomaterials are not necessarily predictable from that of similar but larger compounds. The proposed research will evaluate the environmental impacts of MN. The driving research hypothesis is that chemical elements used in the production of MN could lead to environmental dysfunctions due to: (1) the potential toxicity of these elements and their derivatives; (2) the nanometer-sizes that make MN prone to bio-uptake/bioaccumulation; and (3) the large surface area which might lead MN to act as carriers/delivers of pollutants adsorbed onto them. To address this broad hypothesis, toxicological approaches at the organismal level in combination with experimental investigations at the system level will be used. In addition, the bioaccumulation tendency of MN with contrasting chemical and physical properties will be theoretically assessed by molecular modeling, which will assess possible damage to the cell membranes caused by MN and test the ability of MN to cross cell membranes.

The first approach will test the impact of MN at the "organismal level" and proposed experiments would be along the lines of classical environmental toxicology. Well-established small-scale toxicity tests or microbiotests including the Ceriodaphnia dubia acute toxicity test, the Selenastrum capricornutum chronic toxicity test, and the MetPLATE™ assay will be used. The potential for adverse reproductive developmental effects of MN will be assessed using the YES assay. In addition, molecular simulations will be used to develop a predictive tool for the assessment of the effects of MN on cell membranes by: (1) computing the free energy barrier for cell membrane permeation; (2) investigating the mechanisms of permeation of MN of various size, shape, and chemical composition through lipid bilayer membranes; and (3) assessing the potential damages that can be caused to the cell membranes by MN. Finally, the ability of MN to accumulate inside living cells by transfer through the cell membrane will be tested in laboratory experiments using unicellular algal cells grown in culture media containing fluorescent MN. Confocal and transmission electron microscopy will be used to detect the bio-accumulated MN. Data from these laboratory assays will be used to validate the predictions obtained from the developed model.

The second proposed approach will test the impact of MN at the "system level" to gain an understanding of their impacts on the network that binds the ecosystem components together. The driving idea being that the ability to qualitatively and/or quantitatively characterize any natural service provided by ecosystems can be used to assess the impact of pollutants on ecological functions. Therefore, by combining the flow of material/energy to the participation of biota, the series of reactions involved in sedimentary cycling of organic carbon and microbial respiration will be used to assess the potential impact of MN on basic ecological functions. To meet these objectives, we will combine batch experiments and soil/sediment column studies. The batch experiments will be used to assess: (1) the short-term impacts of MN on microbial driven sedimentary biogeochemical processes; and (2) the bioavailability of MN-bound pollutants. On the other hand, column studies will be used to determine: (1) the mobility and (2) the long-term effect of MN in sedimentary environments.

The proposed combination of toxicological, biogeochemical, and modeling expertise in the assessment of the potential impacts of MN on biota and the environment is anticipated to advance discovery as well as our understanding of the behavior, fate, and impact of MN in the environment. At the very least, our anticipated findings could provide arguments that would help avoid the dispersal of MN until more is known on their environmental implications.