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### A Substance Flow Model for Global Phosphorus

David A. Vaccari

*Stevens Institute of Technology*

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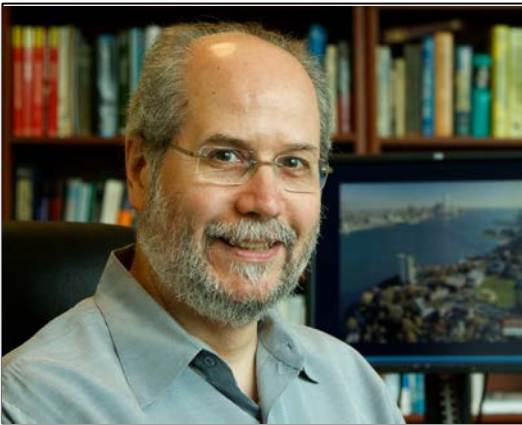
The MSU Sustainability Seminar Series Presents:

## A Substance Flow Model for Global Phosphorus

WHEN: March 1, 4:00 pm

WHERE: CELS 120 lecture hall

**Dr. David A. Vaccari, Ph.D., P.E., BCEE**  
**Stevens Institute of Technology**



Dr. Vaccari has thirty-five years of experience in the environmental field covering many diverse aspects. He has a B.S., M.S. and Ph.D. in environmental science and a M.S. in chemical engineering, all from Rutgers University. He is a licensed Professional Engineer, a Board-Certified Environmental Engineer, and is listed in the Who's Who in Environmental Engineering and Science. His specialties include stochastic modeling of wastewater treatment and biogeochemical cycling. His interest in the latter was initiated by work with NASA advanced life support for long-term space missions. He is the author of a Scientific American article on phosphorus resources, and the textbook "Environmental Biology for Engineers and Scientists."

A mechanistic model of phosphorus flows through the global food system was developed to address questions about the relative effectiveness of and interactions among potential conservation interventions. Phosphorus is required as a fertilizer for producing food, and there is no substitute. Most phosphorus used in agriculture is mined, and 75% of the world's reserves are controlled by a single country: Morocco. Thus the world's food supply is potentially vulnerable to geopolitical conditions. Although known reserves can satisfy current demand for several centuries, it is nevertheless the case that an essential resource is being used unsustainably. Only about 10% of the phosphorus used in agriculture reaches our plates. Losses along the way contribute to water pollution, causing eutrophication. In freshwater bodies this produces toxic drinking water and fish kills. In the coastal marine environment eutrophication causes hypoxic (low oxygen) zones, popularly called "dead zones, in many parts of the world. Thus conservation of phosphorus is of interest both to preserve the resource and to prevent pollution.

The conservation interventions considered include: population control; reduction in meat fraction in the diet (MFD); animal manure use efficiency (MUE); agricultural phosphorus use efficiency (PUE); the fraction of food supply that is wasted; the fraction of food waste that is recycled; the fraction of human waste that is recycled. The model shows that the meat fraction in the diet is the most sensitive of these factors, and this factor interacts with PUE and MUE. Furthermore, there is a minimum MFD below which it actually becomes necessary to mine more phosphorus. Another conclusion is that recycling is much less effective than reduction in conserving the resource.