Endangered species? Should cheap phosphorus be first on an elemental 'Red List?'

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Should the periodic table bear a warning label in the 21st century or be revised with a lesson about elemental supply and demand? If so, that lesson could start with one element considered a staple of life – but growing endangered, like the Asiatic dhole – phosphorus.

Why is phosphorus pivotal? Phosphorus is in the DNA of all plants and animals. It is a key ingredient in fertilizer, but high quality phosphate deposits for mining are limited in both quantity and locality. Indeed, there are increasing concerns that with 85% of the resource limited to three countries in the world, inexpensive phosphorus may become a vestige of the past.

What could happen then? That's a question that scientists James Elser, a professor at Arizona State University, and Elizabeth Bennett, a researcher at McGill University in Canada, want to tackle sooner rather than later. In their commentary "The phosphorus cycle: a broken biogeochemical cycle" published in the Sept. 6 issue of *Nature*, the duo examine the lack of public and governmental discourse about the plight of the element phosphorus – and the potential social consequences of inaction.

Elser and Bennett in North America, and researchers Dana Cordell and Stuart White with Institute for Sustainable Futures in Australia, are just a few of the rising tide of scientific voices calling for early environmental attention and action. Awareness is a critical piece that needs to be addressed, along with better global accounting and technological innovation, the researchers say, to build pre-emptive, sustainable solutions for this broken biogeochemical cycle.

In the United States, for example, the strategic dimensions of a limited phosphorus supply are just beginning to be recognized and reported. On the other hand, Morocco, which possesses the largest phosphorus reserves in the world, is already planning for the inflow of millions of dollars – a white gold – that could result from global phosphorus shortfalls.

"Right now we have natural resources people, agricultural people, wastewater people, pollution people, and others largely working on their own. We could all be more effective if our efforts and knowledge were coordinated to develop best practices," Elser says.

"We also need to better ways to quantify the P resources and movements going on out there," he adds. "We should question the huge shifts in numbers that result from voluntary and proprietary reports, for example. More than that, simply identifying where and how much of the resource exists isn't enough. We need to examine the costs involved in extracting the element from different sources and advocate for policy measures that connect the P-supply issues to the P-pollution issues."

Elser points out that phosphorus is already out of reach for poor farmers in many countries, and, as history's economic lessons have shown, the costs of any monopolized resource can skyrocket. He is also concerned about the institutional vacuum regarding governance: "Who will establish regulations and incentive structures with regard to phosphorus use and waste given its impacts on food security?"

Besides a shortfall of information, improving phosphorus sustainability is complicated by factors like soil type, which can heavily influence how much phosphorus is needed in a particular area and how available the element is to crops. And while tailoring crops by breeding and engineering can help improve phosphorus use in some situations, such complications mean there is no single solution.

There's a lot that needs to be done and half-measures won't work," says Elser. "What we need, and what we call for in our Nature piece, is a comprehensive network of nutrient sustainability research centers, connected closely to policy makers and farmers and the public."

Elser has pushed for public and institutional awareness in the United States since first reading early research that suggested that phosphorus would follow the path of peak oil in his lifetime. In response, Elser co-founded the ASU Sustainable Phosphorus Initiative in 2010, with ASU collaborators Mark Edwards, a professor with ASU's W.P. Carey School of Business and Morrison School of Management and Agribusiness, Dan Childers, an associate director of the Global Institute of Sustainability, and doctoral student Jessica Corman.

The ASU collaborative developed a Sustainable Phosphorus Summit in 2011 that brought together more than 100 researchers, engineers, teachers, students and entrepreneurs to discuss how to recycle, reclaim, reuse and more sustainably manage this limited resource, with support from the National Science Foundation and others. Two book projects have emerged from the summit. To be published by Oxford Press, the first, "Phosphorus, Food, and Our Future," with ASU doctoral students Corman and Karl Wyant, seeks to engage natural and social scientists, policy analysts and regulators and professionals involved in agriculture, food production and sanitation. The second project is a trade book by Elser, titled "P is for People."

Elser is best known for his pioneering work on ecological phosphorus limitation and biological stoichiometry, a field that studies the relationships among carbon, nitrogen and phosphorus in living systems, including topics a diverse as tumors, lakes subjected to air pollution, microbial evolution in hot spring, and, now, global agricultural systems.

Elser's work has taken him to Norway, Mexico, Argentina, China and Japan. In 2011, he's received a Fulbright to study Andean lakes and a $900,000 grant from the National Science Foundation to continue his work in Cuatro Cienegas, Mexico, with Valeria Souza, a microbial evolutionary ecologist with National Autonomous University of Mexico (UNAM). As with his work and interest in phosphorus sustainability, public awareness is central to this project. Their collaboration will include the development of a high tech, bilingual planetarium to help get young students from the United States and Mexico excited about microorganisms and their roles and function in the Earth's systems, with support from Deirdre Meldrum, a professor with the Ira A. Fulton School of Engineering and director of the Center for Biosignatures Discovery Automation in ASU's Biodesign Institute, and Janet Siefert, a statistician with Rice University.

"Humans control the global phosphorus cycle, more than carbon, more than nitrogen," says Elser. "Looking at how we're doing with P, I'd have to say: this is no way to run a biogeochemical cycle. We need to clean up our lakes, our oceans and our act!"

More information: www.nature.com/nature/journal/ … 67/full/478029a.html

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