Science of the Total Environment 644 (2018) 661–674

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

Meta-analysis of non-reactive phosphorus in water, wastewater, and sludge, and strategies to convert it for enhanced phosphorus removal and recovery

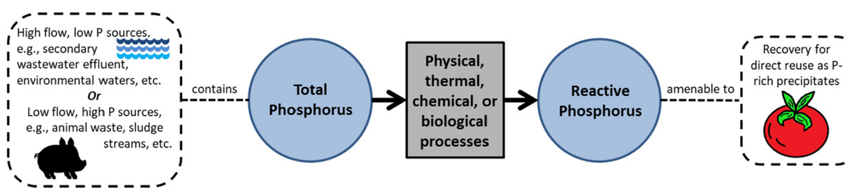
Kaushik Venkiteshwaran, Patrick J. McNamara, Brooke K. Mayer *

Department of Civil, Construction and Environmental Engineering, Marquette University, 1637 West Wisconsin Avenue, Milwaukee, WI 53233, USA

HIGHLIGHTS

- Meta-analysis reveals non-reactive P (NRP) comprises a substantial portion of total P.
- NRP must be physically, chemically, or biologically converted to soluble RP for recovery.
- No technologies have been implemented to recover soluble NRP from water matrices.
- P conversion processes must be specifically tested in water, wastewater, and sludge.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 8 May 2018
Received in revised form 28 June 2018
Accepted 29 June 2018
Available online xxxx

Editor: Zhen (Jason) He

Keywords:
Advanced oxidation processes (AOP)
Conversion
Hydrolysis
Organic phosphorus
Orthophosphates
Soluble reactive phosphorus (SRP)

ABSTRACT

Current and future trends indicate that mining of natural phosphorus (P) reserves is occurring faster than natural geologic replenishment. This mobilization has not only led to P supply concerns, but has also polluted many of the world's freshwater bodies and oceans. Recovery and reuse of this nuisance P offers a long-term solution simultaneously addressing mineral P accessibility and P-based pollution. Available physical, chemical, and biological P removal/recovery processes can achieve low total P (TP) concentrations (≤100 μg/L) and some processes can also recover P for direct reuse as fertilizers (e.g., struvite). However, as shown by our meta-analysis of over 20,000 data points on P quantity and P form, the P in water matrices is not always present in the reactive P (RP) form that is most amenable to recovery for direct reuse. Thus, strategies for removing and recovering other P fractions in water/wastewater are essential to provide environmental protection via P removal and also advance the circular P economy via P recovery. Specifically, conversion of non-reactive P (NRP) to the more readily removable/recoverable RP form may offer a feasible approach; however, extremely limited data on such applications currently exist. This review investigates the role of NRP in various water matrices; identifies NRP conversion mechanisms; and evaluates biological, physical, thermal, and chemical processes with potential to enhance P removal and recovery by converting the NRP to RP. This information provides critical insights into future research needs and technology advancements to enhance P removal and recovery.

© 2018 Elsevier B.V. All rights reserved.

* Corresponding author.
E-mail address: Brooke.Mayer@marquette.edu (B.K. Mayer).

https://doi.org/10.1016/j.scitotenv.2018.06.369
0048-9697/© 2018 Elsevier B.V. All rights reserved.

Contents

1. Introduction

1.1. Phosphorus as a critical nutrient and a pollutant

Paradoxically, phosphorus (P) is simultaneously an important non-renewable agricultural nutrient and an environmental pollutant. On one hand, modern human society depends on P to sustain the global food supply. Rapid increases in human population and the subsequent need for high agricultural productivity have led to substantial increases in fertilizer use. Currently, P is primarily obtained from subsurface mining of phosphate minerals. Unfortunately, these mineral P resources replenish on geologic time scales, making P an essentially non-renewable resource, characterized by rapidly depleting finite reserves. This, coupled with the fact that 90% of minable P is found in only five

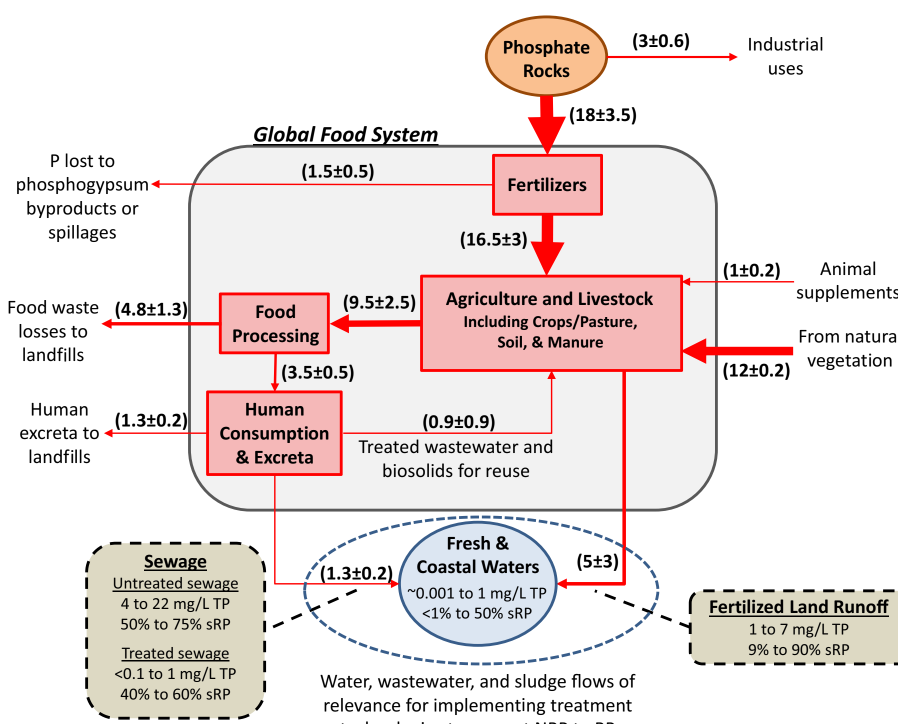


Fig. 1. Anthropogenic phosphorus (P) flows (million metric tonnes of P per year) for global food production, adapted from Cordell and White (2014). The thickness of each arrow indicates the relative magnitude of each P flow. The majority of mined P (18 ± 3.5 million tonnes of P per year) is used in fertilizers, approximately 35% (6.3 ± 3 million tonnes of P per year) of which is lost to surface waters. Soluble reactive P (sRP) accounts for a majority of total P (TP) in many waters, but a substantial proportion of the TP in point source sewage and sludge, non-point runoff, and environmental waters can consist of non-reactive P (NRP), which may be more difficult to remove and is not directly recoverable.

Download English Version:

https://daneshyari.com/en/article/8858640

Download Persian Version:

https://daneshyari.com/article/8858640

Daneshyari.com