Sustainable use of phosphorus

Capturing the philosopher's stone

de Boer, M.A.

Publication date
2019

Document Version
Other version

License
Other

Preface

Phosphorus is an essential element for life. It is a crucial component of our DNA, bones and teeth. Moreover, it is a major nutrient in our food. In order to feed the world population, phosphorus-based fertilizers are desperately required. This demand will continue to rise with the world's expanding population and growing prosperity. Even though phosphorus is a scarce element, most phosphorus is lost in water bodies after consumption, leading to extreme algae growth and water pollution. On top of that, it is important to note that the European Union has hardly any reserves, and mainly depends on import from Morocco, Russia and the Middle East. All in all, a more sustainable use of this precious element is urgently needed since phosphorus cannot be replaced and there is no synthetic substitute.

In this PhD thesis entitled "Sustainable use of phosphorus: capturing the philosopher's stone" several essential aspects for converting our current linear P economy to a circular P economy will be discussed, with a focus on the current status quo, the quality and recovery potential of secondary phosphates, and the stimuli and hurdles of such a phosphate transition.

Thesis outline

Chapter **one** includes an overview of the status quo of the phosphorus market, reserves and commonly used industrial production methods. This overview

describes the type of processes used for phosphate beneficiation and the quality of phosphate rock, which is dependent on the ore type, level of radioactivity and hazardous metal content.

The following two chapters focus on struvite, which is a new, secondary phosphate source that can be harvested from urban mines. Chapter **two** contains a comparison of the micro-pollutants in and chemical characteristics of struvite generated from communal wastewater or manure, since one of the main concerns of using secondary phosphorus resources is the possible presence of contaminants. This chapter highlights that the majority of struvite produced is of high purity. In chapter **three**, we describe that even when pharmaceutical micro-pollutants are present in struvite and the sorbent-based fertilizers, zeolite and biochar, the health risk is insignificant, as these contaminants are not transferred into tomato crop fruit.

In chapter **four,** the recovery potential of phosphates from wastewater at wastewater treatment plants in The Netherlands has been mapped out. We have calculated that the Netherlands can be self-sufficient in its phosphate supply by using its own urban mines when the recovered phosphates are also efficiently recycled.

In chapter **five**, we address the barriers and drivers of phosphate recovery from urban mines from a political, economic, social, technical, legal and environmental point of view. The main barriers found are the different and unclear characteristics of struvite compared to common fertilizers and the end-of-waste status of struvite

that hinders free market trade. The main driver is the reduction of maintenance costs of the wastewater treatment plants.

In the **sixth** and final chapter, the congruence of actors and networks within the phosphate transition using the multi-layered perspective and institutional entrepreneurship as a frame is described to gain new insights in the development, prerequisites and realization of sustainable transitions and the role of proactive institutional entrepreneurs.