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Reuse of third generation industrial waste

As global consumption of finite raw materials continues to rise, so too does the amount of waste produced. In Europe for example, each citizen consumes an average of 15 tonnes of raw materials and produces on average 5 tonnes of waste every year. This places huge pressure on the environment, with increasing pollution of air, water and soil, and contributes significantly to climate change. In order to reduce the twin problems of consumption and waste production, the circular economy promotes reuse of so called ‘waste products’ to extend their life cycle for as long as possible. Very often however, it can be difficult to find a suitable use for these waste products without causing additional damage to the environment.

In this study we collected waste alum sludge residuals from a water treatment plant, and waste bauxite residue, commonly referred to as ‘red mud’ from an Aluminum processing plant. We then simulated their use, firstly in filter drains to capture excess Phosphorus in the drain flows (recycle 1), and then, once saturated with Phosphorus, applied them to a range of agricultural soils (recycle 2) to act as a slow release fertiliser. While Phosphorus is a key plant nutrient in soils, excessive amounts can leach through or along the soil, or be transported in surface runoff to streams and rivers after rainfall events. Such Phosphorus laden flows are a main cause of pollution to rivers and streams globally – this is termed eutrophication. The purpose of our study was to assess whether or not application of these residuals as fertiliser would increase the pollution risk of phosphorus from different soil types with a range of initial phosphorus concentrations over a 6-month period when subjected to repeated and onerous rainfall conditions.

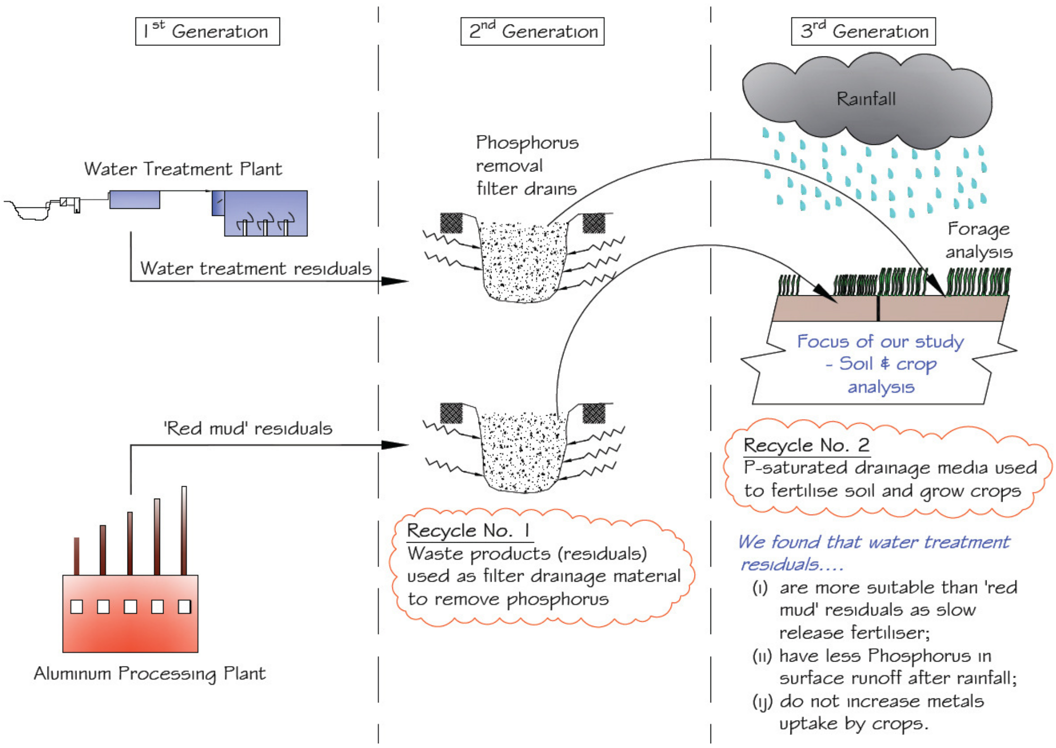

Fig. 1. Schematic overview of study.

Our study found that when the residual materials were mixed with the soils, the waste alum sludge from the water treatment plant was more successful than the red mud residuals at reducing pollutant flows from a wide range of phosphorus enriched soils. Then when we applied the Phosphorus enriched waste alum sludge and red mud residuals to the surfaces of grassed soils, we found that the polluting phosphorus loads did not increase above those of the natural occurring soils under repeated rainfalls. These were important findings because they meant that the waste products displayed an ability to bind in the available Phosphorus and release it slowly into the soil, at a rate more suited to plant uptake requirements. The key phosphorus binding mechanisms in the red mud residuals were its high calcium deposits, which attracted phosphorus ions, while the relatively high aluminium deposits in the water treatment residuals explained its ability to bind in the available phosphorus. The potential therefore of both products to act as a slow release fertiliser is promising. We then examined metal uptake concentrations in the plants over the study period to evaluate if these were affected by application of the residuals, which contained a variety of trace metals. Encouragingly, we found that there were only negligible differences in metal concentrations between plants taken from the soils which had received the residuals and those which had not; with the water treatment residuals impacting the least and therefore performing better. Our overall conclusion was that water treatment residuals have a more promising prospect as a slow release fertiliser than red mud residuals, and our future research will be to further validate this finding on a longer term basis and at a larger scale.

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Publication

Soil phosphorus dynamics following land application of unsaturated and partially saturated red mud and water treatment residuals
R B Brennan, J G Murnane, A N Sharpley, S Herron, K R Brye, T Simmons
J Environ Manage. 2019 Oct 15