**PROJECT TITLE:** Lignin-coated fertilizers for phosphate control

**I. PROJECT STATEMENT**

This proposed project will provide a real-world test of a novel, bio-based, fertilizer coating that slows nutrient release to reduce nutrient runoff from agricultural fields. Anthropogenic phosphorus pollution is reaching dangerously high levels in freshwater basins around the world, with mineral phosphate fertilizers from cereal grain farming being among the largest contributing sources1. Phosphorus is a common component of both mineral and manure fertilizers because it is necessary to achieve high crop yields necessary to support conventional family farms in Minnesota. However, a large portion of phosphorus applied as fertilizer is not taken up by plants, and either builds up in the soil or washes into rivers, lakes and coastal seas. Minnesota has implemented policies aimed at reducing agricultural runoff through wetlands preservation and increased buffer strips around fields. Another way to reduce fertilizer runoff is to coat fertilizer particles in a material that controls water diffusion so that the nutrients are released slowly over time, giving the crop roots a chance to absorb the fertilizer before percolation and runoff can remove the product. There has been work on developing slow release fertilizers, but there remains a need to address issues of cost, performance, and effective implementation by farmers2.

We are developing a technological solution to address this need. We have created a slow-release fertilizer coating made from lignin, a byproduct of cellulosic ethanol production. This form of lignin has properties that allow it to be processed like a plastic, yet it is a 100% natural and biodegradable material made from wood. We have developed formulations with this material that can be coated onto granulated fertilizers to control the rate of dissolution and thereby maintain a constant nutrient supply in fields without the need to over application. When the fertilizer is used up from a coated particle, the lignin coating becomes part of the slow-turnover carbon pool in the soil. Therefore, implementation of this technology throughout the agricultural sector has the potential both to decrease eutrophication and increase carbon sequestration.

At the end of this project, we will have demonstrated the scale-up of the coating process and have acquired necessary real-world data on the efficacy of this coating material to bring it to market. NRRI is working with the University of Minnesota Technology Commercialization office to patent the technology and identify commercialization partners. Likely partners would include Minnesota-based fertilizer distributer Mosaic for agricultural markets and Ohio-based Scotts for lawn and golf course markets. The results from this research program are essential to attracting high-profile commercialization partners such as these.

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1 Title:** Scale-up of lignin-material coated fertilizer and performance testing.  **Description:** *We will purchase 500 kg of granulated high phosphate fertilizer and apply our best-performing lignin-based coating, developed in collaboration with colleagues from the Technical University of Cologne, Germany. This work will be done at NRRI’s prototype laboratory using a pilot spheronizer. We will produce sufficient quantities for all greenhouse testing in year 1. We will make formulation adjustments based on findings from greenhouse studies during scale-up for field production. We will contribute to greenhouse and field trials with chemical and statistical analyses and reporting.*  **ENRTF BUDGET: $ 145,939** | |  |
| **Outcome** | **Completion Date** |
| *1. Sample coated fertilizer for greenhouse testing* | *December 2020* |
| *2. Measurements of phosphate dissolution rate and comparison with uncoated fertilizers* | *December 2020* |
| *3. Scaled-up production of fertilizer* | *April 2021* |
| *4. Analyze samples and data from greenhouse and field performance* | *June 2022* |

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| **Activity 2 Title:** Assess high lignin coating impact on soils in greenhouse  **Description:** *A replicated (4 x) and repeated (2X) greenhouse experiment will assess the ability of lignin-coated fertilizer to provide P to agronomic an agronomic crop(s) as indicated by plant biomass accumulation at 30 days after planting. At the end of the study the amount of extractable P in the soil will be determined.*  **ENRTF BUDGET: $54,015** | | |  |
| **Outcome** | **Completion Date** |
| *1. Greenhouse testing of lignin coated fertilizer* | *April 2021* |
| *2. Chemical analysis of extractable phosphorus from greenhouse study* | *July 2021* |

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| **Activity 3 Title:** Replicated field trialsof lignin-coated fertilizer  **Description:** *Replicated plot-scale field testing will assess agronomic crop (s), wheat or corn response to incorporated lignin coated P fertilizer. The study will be repeat in space (at least 3-locations). Crop biomass and yield will serve as plant response indicators. Soil samples will be collected at two depth increments (0-15; 15-30 cm) at the end of the and assessed for extractable P.*  **ENRTF BUDGET: $79,428** | |  | |
| **Outcome** | **Completion Date** | |
| *1. Plot-scale field testing to assess agronomic crop response* | *August 2021* | |
| *2. Soil sampling and processing* | *October 2021* | |
| *3. Extractable phosphorus determination.* | *December 2021* | |

**III. PROJECT PARTNERS AND COLLABORATORS:**

**A. Partners receiving ENRTF funding**

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| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| Jane Johnson | Research Soil Scientist | USDA-ARS North Central Soil Conservation Research Laboratory | Field trial leader |

**B. Partners NOT receiving ENRTF funding**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| Mike Riebel | Vice President | Attis Innovations | Consultation |
| Dr. Stéphan Barbe | Professor | TH Köln | Consultation |

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:**

A key program deliverable is a product that will be sold into the agricultural fertilizer market. We will consult with Attis Innovations to develop a business plan to bring this into widespread use.

**V. PROJECT TIMELINE:**

This project will be completed in 2 years

1. Mekonnen MM, Hoekstra AY. Global Anthropogenic Phosphorus Loads to Freshwater and Associated Grey Water Footprints and Water Pollution Levels: A High-Resolution Global Study. *Water Resour Res*. 2018;54(1):345-358.

2. SHAVIV A, MIKKELSEN RL. Controlled-Release Fertilizers to Increase Efficiency of Nutrient Use and Minimize Environmental Degradation - a Review. *Fertilizer Research*. 1993;35(1-2):1-12.