Effect of Reclaimed Wastewater Irrigation on Groundwater Phosphorus Concentrations

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Introduction

This study investigates groundwater loading of phosphorus (P) to Priest Lake (ID) and the feasibility of P leaching from wastewater treated irrigation fields.

Priest Lake is a historically pristine and oligotrophic lake in northern Idaho. Residents around Priest Lake have been noticing increases in algal growth, a key indicator of eutrophication. Groundwater (GW) has become an increasingly recognized pathway for phosphorus (P) transport with P being a known limiting nutrient in oligotrophic systems. Hydrologic conditions in the area allow for fast infiltration and GW movement increasing the feasibility of nutrient transport.

Twenty years ago, a new wastewater treatment facility that irrigates primary treated effluent onto forest land was constructed. There is a 60 cm ash cap thought to be capable or removing large amounts of P but below that is a coarse gravel glacial outwash till (Tindall, 2016).

Wastewater Irrigation Field and Groundwater Sampling Locations

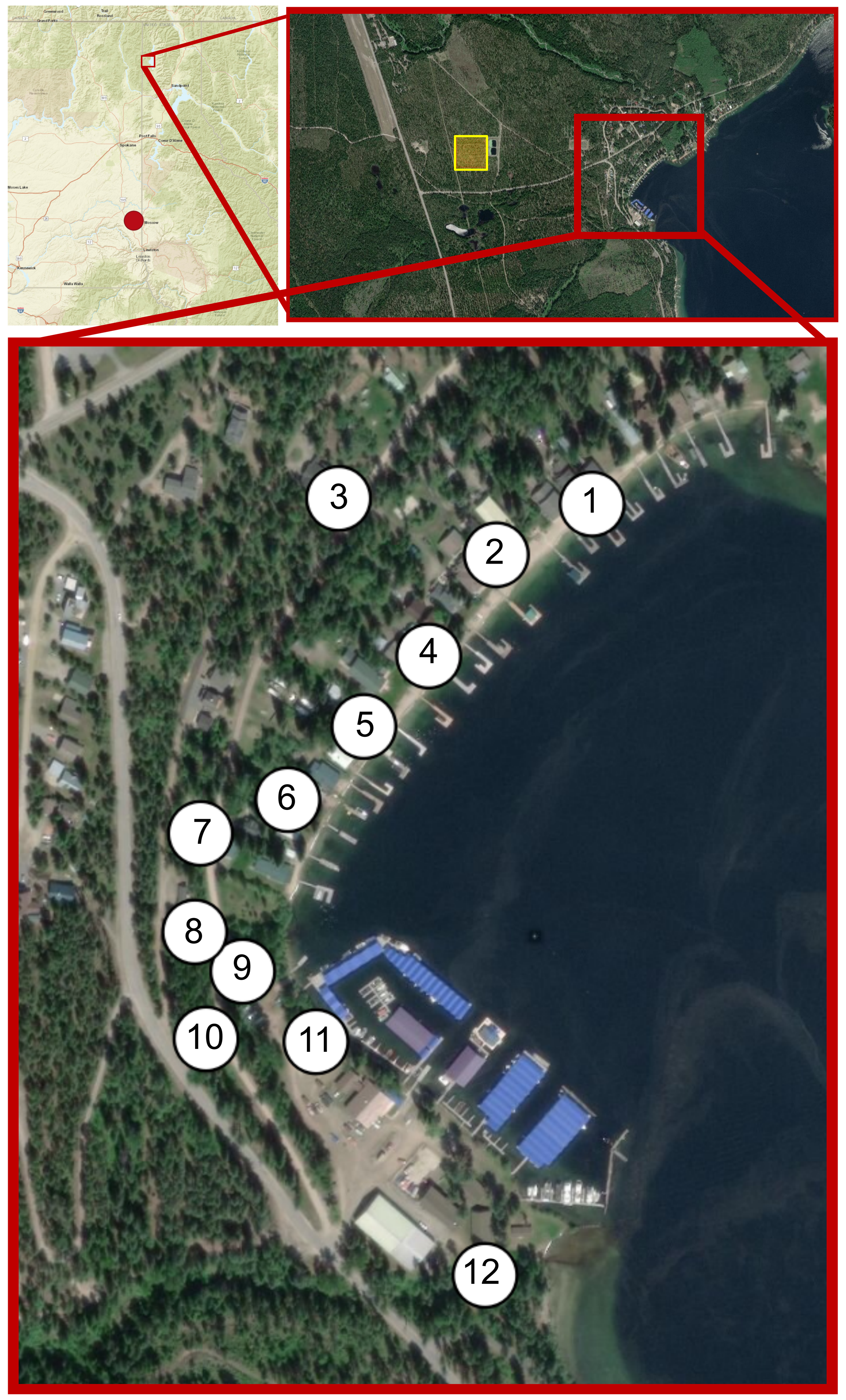

Figure 1. Kalispell Bay Study site. The yellow shaded box indicates the wastewater irrigation site. White circles indicate groundwater sampling points.

Identifying Potential Phosphorus Sources

GW test wells were constructed, and sampling points were established to quantify nutrient loading to the lake. The following parameters were analyzed in GW samples collected from 2018-19:

- Pharmaceuticals to identify anthropogenic influence
- GW and precipitation isotopes to generate mean transit times (MTT) for the GW sources
- TP to diagnose a nutrient flux into Kalispell Bay

Background signals for TP were also collected from the surrounding area from GW and surface water sources to act as a baseline.

Determining the Feasibility of P Leaching

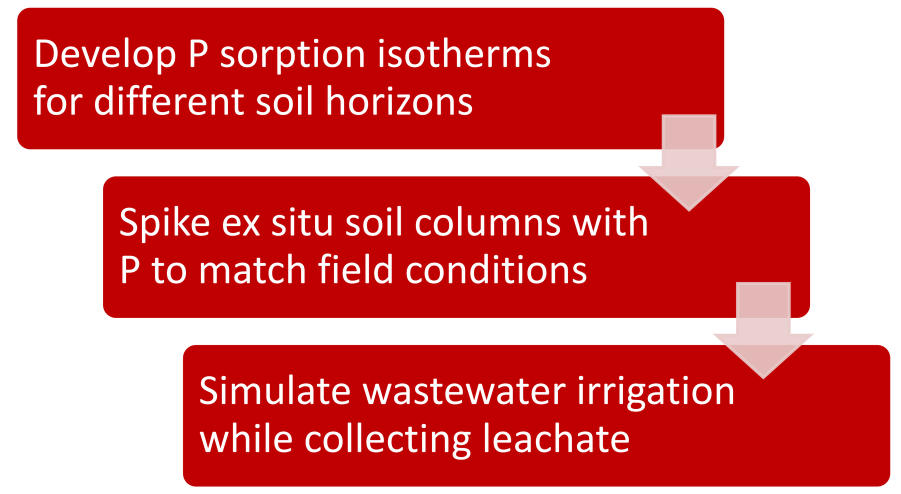

Table 1. Select GW Source Indicators

Location I.D.	1	3	6	11	12
Caffeine (µg/L)	None Detected	5.51	74.43	18.46	8.40
MTT (Days)	402	530	614	345	292
TP (mg/L)	0.011	0.015	0.037	0.080	0.023

GW Phosphorus Concentrations

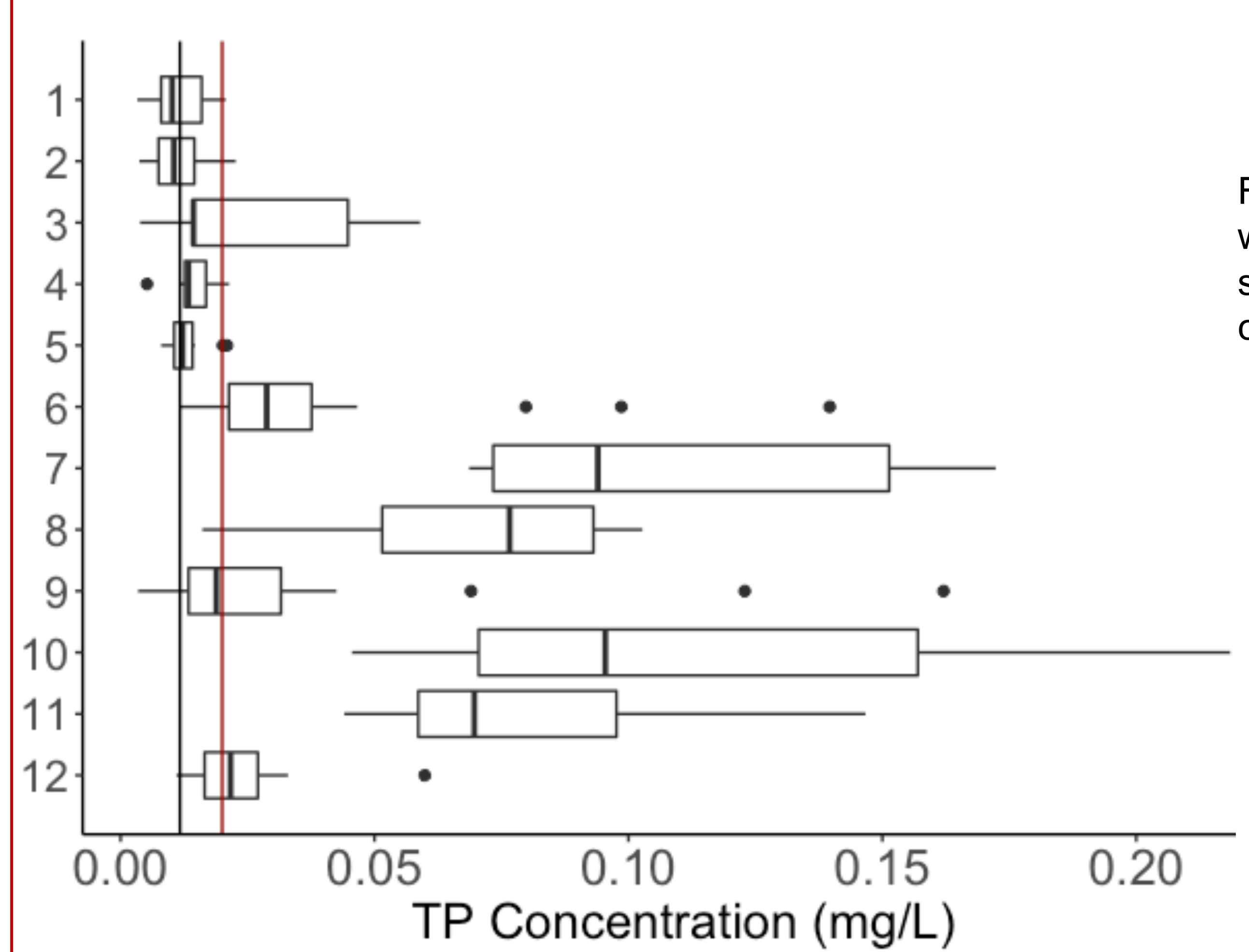

Figure 2. TP concentrations aligned vertically to corresponding sampling points in Figure 1. Red line is known eutrophication concentration; black line is the GW TP background concentration.

P Sorption Isotherms for Various Soil Depths

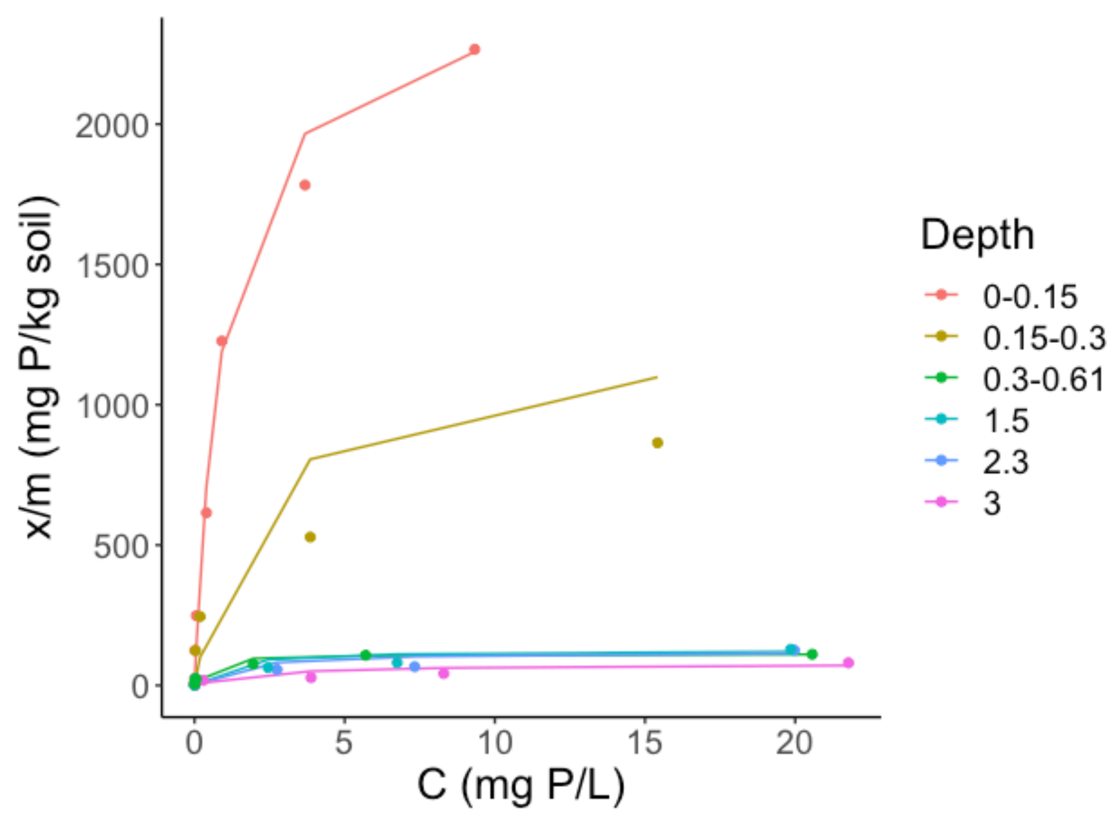

Figure 3. P sorption isotherms were developed for the soil depths (m) as shown. Data was best fitted to a Langmuir Isotherm.

Soil Column Leachate P Concentrations

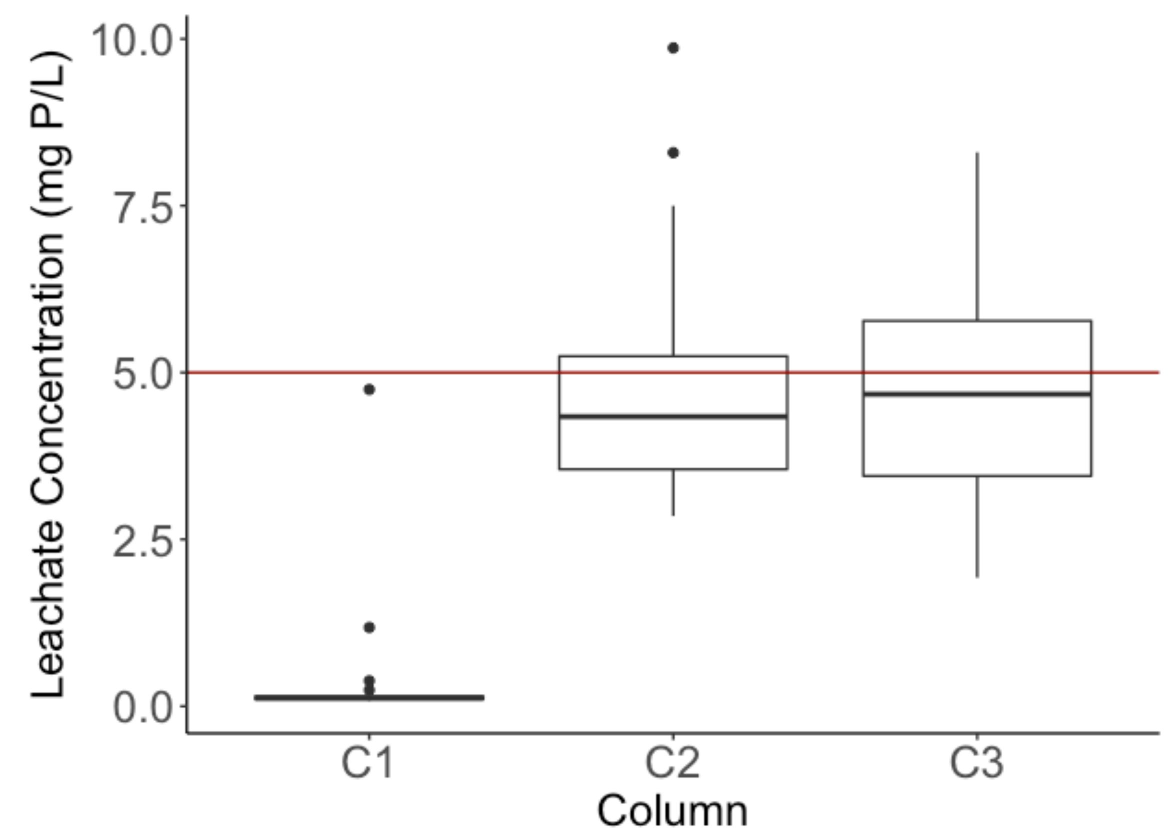

Figure 4. Leachate collected from soil columns during simulated wastewater irrigation. C1 is the control. C2 and C3 represent spiked columns. The red line is marked at the influent concentration. Columns shown below.

GW Testing Implications

P concentrations in shallow groundwater were found at concentrations capable of causing eutrophication in an oligotrophic system. A plume was identified, as shown in Figure 2, in the southwest corner of the bay with boundary conditions at or below the background TP concentrations.

With the positive results from the pharmaceutical analysis along with the low background P concentrations, it can be assumed that there is an anthropogenic influence on the groundwater (Buszka et al., 2002). The MTT provides an upper boundary for how far away the source resides for which the wastewater irrigation field is within.

Phosphorus Leaching Implications

Initial Irrigation

- Control and initial soil P test data show little P in system
- Initial high potential for P sorption in topsoil layer, as shown in Figure 3

P Accumulation over Time from Irrigation

- With no major P removal mechanism, P remains in system

Soil P Saturation and Leaching

- Isotherms in Figure 3 identify P sorption limits
- Olsen P test data available fall into sorption maximum range (Accurate Testing Labs, 2016)
- P has accumulated to maximum soil capacity and leaches out high P concentrations

Future Column Experiments

There is a P plume entering Priest Lake at Kalispell Bay via GW at concentrations able to cause eutrophication. The source is most likely anthropogenic wastes which indicate wastewater sources. **The irrigation field at which wastewater is applied near Kalispell Bay has accumulated enough P to leach out P increasing the GW load.** These findings suggest wastewater irrigation can contribute to GW nutrient loading should be considered as potential sources for eutrophication.

Future columns experiments will use DI water to simulate snowmelt and precipitation. The columns will be dissected, and soils will be analyzed for Olsen-P for quality assurance on the irrigation studies. P transport to GW will be modeled using Hydrus-1D.

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References

Tindall, John. Kalispell Bay Sewer District, Staff Analysis for Draft Reuse Permit M-052-05, Municipal Recycled Water Facility. **2016**.

Buszka, P. M.; Yeskis, D. J.; Kolpin, D. W.; Furlong, E. T.; Zaugg, S. D.; Meyer, M. T. Waste-Indicator and Pharmaceutical Compounds in Landfill-Leachate-Affected Ground Water near Elkhart, Indiana, 2000–2002. *Bull Environ Contam Toxicol* **2009**, *82* (6), 653–659.

Accurate Testing Labs, Certificate of Analysis. 2016.

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