Supplementary Information: Phosphorus in Ontario's economic sectors: mapping flows and assessing recovery and recycling potential

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1. Phosphorus recovery processes

1.1. Scaling CAFOs phosphorus recovery processes

We refer the reader to Martín-Hernández et al. (2021) for a detailed description on estimating the phosphorus recovery costs of processes from phosphorus recovery from livestock facilities. Capital costs are annualized through the application of an annual capital charge ratio ($ACCR$) as defined by Towler and Sinnott (2013), shown in Eq. 1, assuming a typical interest rate i of 5% and a plant lifetime n of 20 years.

$$ACCR = \frac{i\,(1+i)^n}{(1+i)^n - 1} \tag{1}$$

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1.2. Scaling municipal wastewater phosphorus recovery processes

Data on processes for phosphorus recovery from municipal wastewater is taken from Egle et al. (2016). We assume that, similarly to other industrial activities (Dysert and Pickett, 2005), the phosphorus recovery cost from municipal wastewater in function of the plant capacity shows an exponential behavior. In consequence, the cost-to-capacity method (Baumann, 2014) is used to estimate phosphorus recovery cost from municipal wastewater in function of the plant capacity, as shown in Eq. 2, where x denotes the scale factor 'facility 2' refers to the facility which cost is required while 'facility 1' denotes the facility whose data is known. The scale factor x is estimated based on the data for different capacities reported by Egle et al. (2016) through the transformation of Eq. 2 by applying natural logarithms to both sides of the equation, as shown in Eq. 3. The scale factor obtained are shown in Table 1. The capacity magnitude has been normalized to the mass of phosphorus recovered.

Table 1: Estimation of scale factors for municipal wastewater phosphorus recovery systems.

Inflow	Technology	Type	P recovery potential (% related to inflow)	P inflow (kg P/year)	Annual processing cost (EUR)	Scale factor x
WWTPs (liquid phase)	Crystalactor	Struvite/Calcium phosphate	38	65700 328500	305920 795893	0.59
	Ostara Pearl	Struvite	20	65700 328500	130856 235234	0.36
	P-RoC	Calcium phosphate	27	65700 328500	75970 266025	0.78
	REM-NUT	Struvite	47	65700 328500	977933 4417171	0.94
	AirPrex	Struvite	15	65700 328500	74195 137693	0.38
	PRISA	Struvite	18	65700 328500	186923 371578	0.43
WWTPs	Stuttgart process	Struvite	40	65700 328500	581730 2419407	0.89
	Gifhorn process	Struvite	40	65700 328500	400384 1491509	0.82
	PHOXNAN	Struvite	51	65700 328500	891667 3468902	0.84
	Aqua Reci	Calcium phosphate	61	65700 328500	939605 3529595	0.82
	MEPHREC	P rich slag	68	65700 657000	1154473 4715866	0.61

$$\frac{\text{Cost}_{\text{facilitiy 2}}}{\text{Cost}_{\text{facilitiy 1}}} = \left(\frac{\text{Capacity}_{\text{facilitiy 2}}}{\text{Capacity}_{\text{facilitiy 1}}}\right)^x \tag{2}$$

$$x = \frac{\ln\left(\frac{\text{Cost}_{\text{facilitiy 2}}}{\text{Cost}_{\text{facilitiy 1}}}\right)}{\ln\left(\frac{\text{Capacity}_{\text{facilitiy 2}}}{\text{Capacity}_{\text{facilitiy 1}}}\right)} \tag{3}$$

2. Slaughter industry

Table 2 collects the number of animals slaughtered and the phosphorus in slaughterhouse waste in the province of Ontario for year 2019.

Table 2: Truncated normal distribution fitting parameters for the distribution of cAFOs sizes in regions of the Great Lakes area.

	Cattle	Swine	Sheep	Rabbit	Poultry	Total
Animals slaughtered in federally licensed facilities (heads, 2019)	628,366	4,010,926	84,721	Not available	238,979,246 (total)	244,663,410
Animals slaughtered in provincially licensed facilities (heads, 2019)	99,561	368,267	266,946	225,377		
P flows through slaughterhouse waste in t (2019)	2,222	621	42	7.3	904	3,796.6

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