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Phosphate dosing of mains water: Novel strategies for water loss reduction?

Researchers have recently shown that phosphate added to drinking water to reduce plumbosolvency may be lost to the environment through water mains leakage. Matthew Ascott of the British Geological Survey explores how the water industry might use phosphate to further reduce leakage and the economic and potential environmental significance of its loss.

Essential components of strategies to reduce water losses include detecting and tracing water leakages in the environment. Industry-standard techniques for tracing leaks include analysis for chlorine and trihalomethanes, but concentrations of these determinands can fall below detection limits due to their volatile nature. Consequently, further methods to trace leakage in the environment are a useful addition to the leakage manager's toolbox.

Plumbosolvency, the release of lead from pipework into drinking water, is a major health concern for water utilities. Dosing of mains water with phosphate (PO_4) has been shown to be highly effective in reducing concentrations of lead in drinking water to meet current public health standards. In the United Kingdom, more than 95 percent of water supplies are dosed at approximately 1 mg P/L (milligrams phosphate (as P) per liter), according to the Chartered Institution of Water and Environmental Management (CIWEM). In the United States, more than half of water supplies are dosed with phosphate, and other countries such as Ireland are currently considering dosing to reduce plumbosolvency. Given the extent of dosing, it's important to consider both whether the phosphate added to mains water could be a useful tracer of leakage and whether existing phosphate dosing could be incorporated into leakage policy to reduce water losses.

Recent work has shown the ratio of the stable isotopes of oxygen (^{18}O and ^{16}O) in the phosphate molecule (termed $\delta^{18}O_{PO4}$) to be a potentially useful tracer of phosphate in the environment. A team of researchers at the British Geological Survey and the University of Lancaster collaborated to assess the potential benefit of this novel isotope technique to leakage tracing by undertaking a program of mains water sampling in England and Wales. Recently published research in *Environmental Science and Technology*'s August 2015 issue[1] suggests for the first time that the isotopic signature of phosphate in tap water may be a useful tracer of water mains leakage.

Forty samples of mains water were taken across all of the major water utilities in England and Wales in addition to the source phosphoric acids used in dosing. The water samples fall into two categories based on the different source acids used. Of the samples tested, 70 percent were shown to have been dosed with acid Type A. As illustrated in Figure 1, Type A-dosed waters have a relatively distinctive isotopic fingerprint in comparison to other phosphate sources, such as fertilizer or sewage treatment effluent. This finding suggests that P in leakage from mains water dosed with Type A acid can be distinguished from other P sources. Potential exists for this technique to be incorporated into the standard suite of leakage tracing methods.

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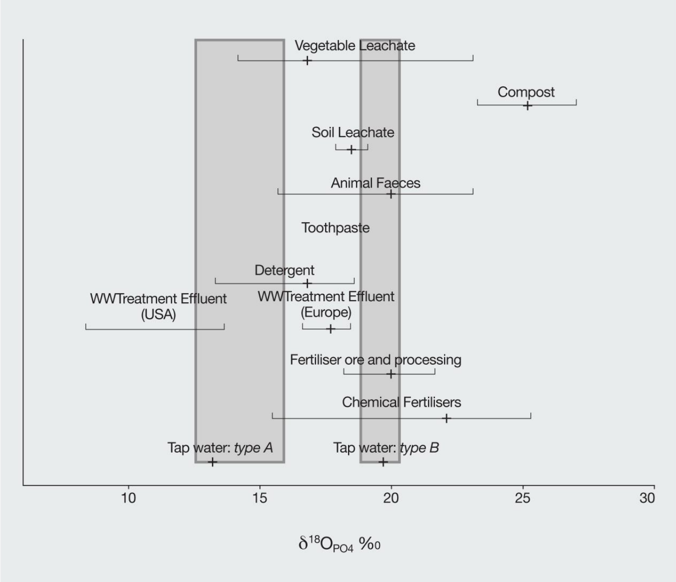
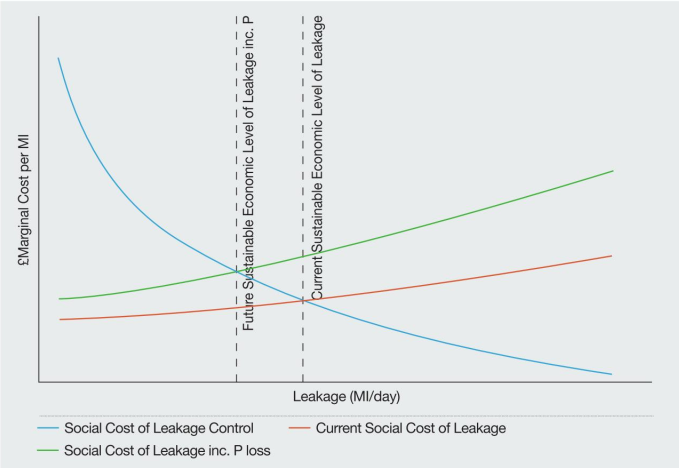
Whilst phosphate added to mains water may be a potentially useful tool for tracing leaks, this practice also has important cost implications. The authors used phosphate rock price trends, estimates of dosing concentrations, and national leakage rate data to quantify the cost of phosphate lost to the environment from leakage in England and Wales. From 1994 to 2014, the total cost was estimated to be US$ 9 million, with current annual operational costs in 2015 estimated to be $1 million per year. With limited alternatives to phosphate dosing and increasing costs of source phosphate rocks, the commercial cost of phosphate leakage is likely to continue to increase.

Phosphate lost from leakage has an additional environmental cost as a contributor to potential eutrophication. The authors quantified the environmental significance of the loss of P from leakage in the Thames catchment, England. Historic leakage rates provided by Thames Water, dosing concentrations, and extents[2] were used to derive the total flux of P and compared to published sewage treatment discharges[3]. In 2011,



(Right) Figure 1. The isotopic fingerprint ($\delta^{18}O_{PO4}$) of phosphate dosed tap water in England and Wales relative to other sources of phosphate.



Left: Figure 2: An example calculation of the sustainable economic level of leakage including and excluding additional environmental costs associated with leakage of phosphate (P)

> **Novel methods to trace leakage in the environment are helpful to reduce water losses – this work is a first step in the use of phosphate-oxygen isotopes as a tracer for mains leakage in the environment.**
>
> **Daren Gooddy, British Geological Survey**

the flux of P from mains leakage was estimated to be approximately 40 percent of current sewage treatment discharge. With future improvements to wastewater treatment resulting in reduced P inputs to surface waters from point sources, the contribution of mains leakage to the total environmental P loading will only increase if current dosing practices are continued.

UK water loss targets are set by calculating the Sustainable Economic Level of Leakage (SELL). The SELL is the level of water loss at which it would cost more to make further reductions in leakage than to produce the water from another source, taking into account benefits derived from both water savings and social/environmental improvements. To date, these calculations have included the environmental benefits of reduced water abstraction and chemical consumption due to lower leakage levels, but they do not take into account loss of P or the downstream ecological or amenity costs.

Figure 2 illustrates conceptually how the environmental effect of P losses from leakage could be incorporated into the SELL calculation through an additional environmental cost function. Implementation of policy instruments to incorporate this additional cost into the calculation would lower the SELL value toward lower water losses.

Author's Note

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