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EDITORIAL

In recognition of Mike Hedley: fate of fertiliser in soil and mobilisation of recalcitrant nutrients

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Mike Hedley's career

This special issue brings together papers that examine topics studied during the career of Professor Mike Hedley, a soil scientist now retired and living on the shores of Lake Taupo in New Zealand. Mike's career began when after a BSc Hons in Biochemistry at the University of Leeds, he relocated to New Zealand in 1975 to undertake a PhD on the Biological availability of particulate phase phosphorus (P), supervised by Professors Keith Syers and Neil Macgregor at Massey University in Palmerston North. During this time, the research group focussed on studying the impact of agriculture on water quality and consequently trained several prominent scientists including Professor Andrew Sharpley (formerly of the USDA-ARS and recently retired from the University of Arkansas).

After completing his PhD in 1978, Mike took up a post doc with John W.B. Stewart at the University of Saskatchewan in Canada. During his time in North America, Mike attended the American Society of Soil Science meeting in Denver Colorado where he was inspired to blend the Massey, Saskatchewan, and Colorado P fractionation techniques to improve the characterisation of soil organic P decline in cultivated wheat soils. In 1980, Mike spent 1.5 years as a post doc at the University of Oxford in the UK, working with Drs Peter Nye and Bob White on how plant roots solubilised soil P and it was here in 1982 that Mike published his seminal P fractionation paper (see next section). He then returned to Massey University to the then Fertilizer and Lime Research Centre (FLRC) and spent the next few decades researching fertiliser quality, the properties of reactive phosphate rock, resin soils tests, and P, S and K cycling in pasture soils. In 1998, Mike became director of the FLRC where he supervised hundreds of students and supported world leading research on cadmium, fluoride, biochar, and nitrous oxide emissions. Mike's role in research on nutrient loss in intensive pasture systems and associated mitigation options such as effluent management, duration-controlled grazing, the use of new pasture species and opportunities for N attenuation in soil and groundwater has had a fundamental impact on New Zealand's agricultural industry. Mike retired from the FLRC (now Farmed Landscapes Research Centre) and Massey University in 2018 but continues to advise on national and international issues.

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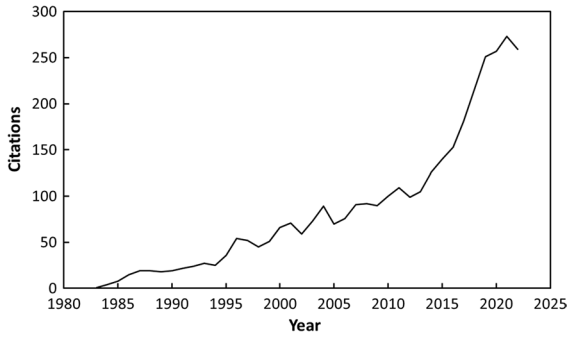

Fig. 1 Citation statistics for Hedley et al. (1982), showing a total of 1797 direct citations to 2022. Data sourced from Web of Science

Seminal P fraction paper

By far Mike's most cited study is his 1982 paper "Changes in inorganic and organic soil phosphorus fractions induced by cultivation practices and by laboratory incubations" (Hedley et al. 1982) (Fig. 1). In it the authors built on previous work that used the sensitivity of a range of chemicals to quantify changes in soil P induced by cultivation. Thousands of studies have used the technique often inferring specific aluminium iron or calcium compounds are extracted. Recent work showing that fractions do not neatly isolate specific P compounds has called for the technique to be abandoned (Barrow et al. 2021). However, the original paper referred to fractions as chemically extractable P (e.g., Resin-P), not specific P forms; furthermore, several reviews and commentaries have called for the presence of specific compounds to be confirmed by other techniques such as X-ray absorption near edge structure spectroscopy or ^{31}P nuclear magnetic resonance spectroscopy (Condron and Newman 2011; Gu and Margenot 2021; Negassa and Leinweber 2009). Using

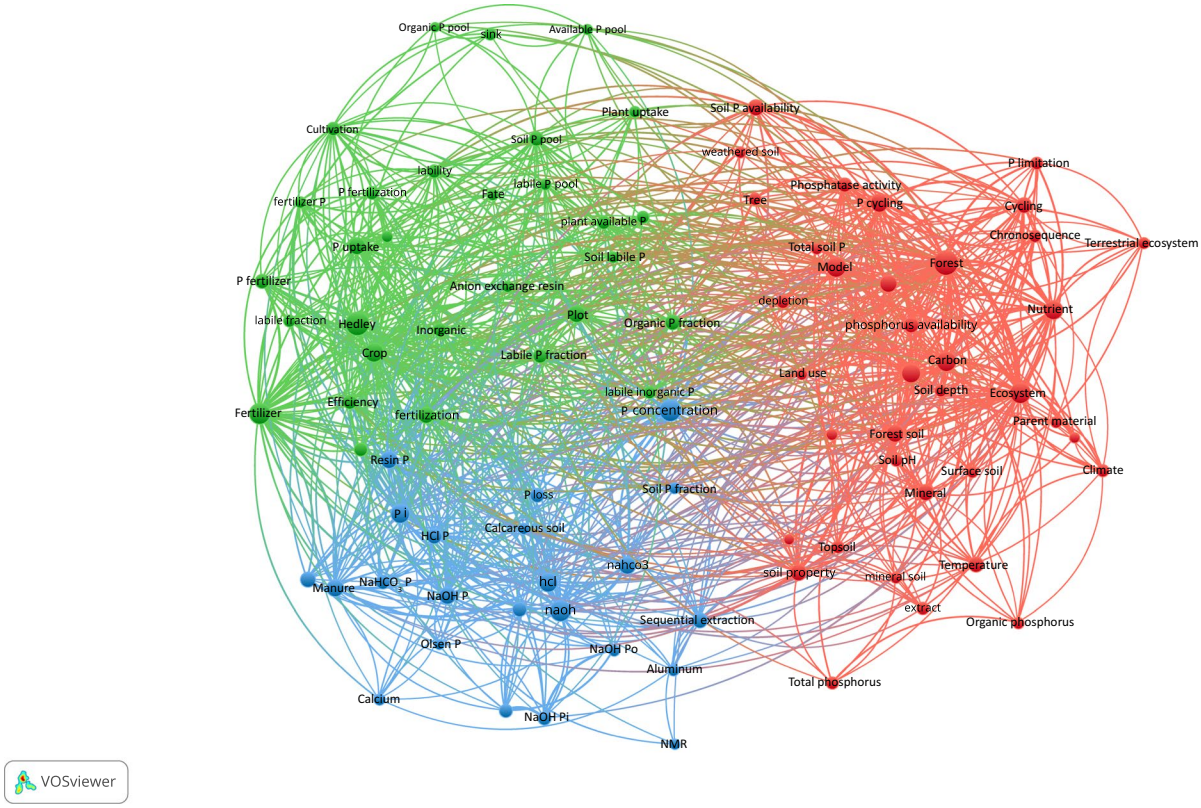

Fig. 2 Visualization of terms appearing in titles and abstracts of papers identified using search words of Hedley and fraction* or method*created with VOSviewer (https://www.vosviewer.com/). The search identified 90 terms and 3 main clusters. The number of times a particular term appears is indicated by the size of the labels and circles. Different colours reflect the different clusters of related terms. The lines represent how these citations are linked. Irrelevant or generic scientific terms were excluded from the analysis

Mike's P fractionation technique or subsequent modifications, advances have been made in assessing the fate of P during soil pedogenesis (Yang and Post 2011), the storage of long term manure or fertiliser P additions (Blake et al. 2003), and the soil's vulnerability to lose P from land to water (McDowell et al. 2001). Despite its deficiencies, the technique has enabled thousands of researchers to test hypotheses where other techniques or equipment was either unavailable or too expensive. Interestingly, references to Mike's original 1982 paper rapidly increased between 2013 and 2019 and references to the term 'Hedley fractionation' or similar now total 13,578 citations, helped by key reviews and papers by Cross and Schlesinger (1995), Sharpley and Moyer (2000), and Wang et al. (2010). An analysis of terms appearing in titles and abstracts of papers identified using search words of 'Hedley fractionation' or similar, shows that the method has been extensively used in research relating to forests, ecosystems, fertilizer, carbon, and modelling (Fig. 2). The Hedley fractionation method or variants of, is widely used around the world, with the most common citations occurring in papers from the USA and China.

This special issue collates several papers that we submitted in response to a call in 2021. All the papers are focused on P and have often used the P fractionation technique. However, much like the diversity of topics covered over Mike's career, these papers cover topics such as: minimising P losses from fertiliser to water (Wang et al. 2022); improving the efficiency of P use in grassland and cropping systems (Bilotto et al. 2022; Bouray et al. 2022; Hu et al. 2022; Schwerdtner et al. 2022; Touhami et al. 2022), assessing the effect of different amendments on the availability of P in the soil (Brownrigg et al. 2022; Kruse et al. 2022); and fertiliser value of waste streams (Battisti et al. 2022).

All the papers have practical applications. This not only fits well with the Journal's aim for published work to have practical applications but also of Mike's intent for his work to have bettered farming practice. We hope you enjoy reading them.

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