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STRATEGIC DETERMINATION of ORGANIC WASTE RECYCLING OPPORTUNITIES

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ABSTRACT

Many criteria must be considered when evaluating the application of organic wastes to land. Among these considerations is the nutrient status of the soil relative to crop nutrient needs and waste nutrient content. This study evaluated the long-term, or strategic, opportunities for applying animal wastes to land in the Republic of Ireland. Using a mass balance methodology based on the phosphorus needs of crops, it was demonstrated that phosphorus surpluses exist in all counties in the Republic of Ireland. These findings have implications for the continued use of land as a receptor for both animal wastes and other organic wastes, particularly the rates at which these wastes are applied.

INTRODUCTION

The landscape is regarded as the most logical receptor for the recycling of organic wastes (*i.e.*, animal manures, *etc.*) from agriculture. Nevertheless, application of these materials at the incorrect rate (or time) can lead to unacceptable levels of pollution risk. In particular, excessive levels of phosphorus (P) in the soil resulting from over-application of organic wastes (and / or other P sources) can lead to eutrophication of non-saline receiving waters. Among others, Sharpley *et al.* (1994) showed that the loss of dissolved P in surface overland flow is strongly and positively correlated with soil test phosphorus (STP) concentrations. There also is evidence (*e.g.*, Grant *et al.*, 1996) that high concentrations of P in the soil can result in leaching losses of dissolved P.

STP concentrations can increase whenever inputs of P exceed outputs, as shown in the elementary mass balance equation for a conservative element in any closed system:

$$\text{Inputs} = \text{Outputs} + \text{Storage} \quad (1)$$

Due to the positive correlation between STP concentration and environmental losses of P from the soil, it is desirable to match the inputs of P to a soil-crop system as closely as possible with beneficial outputs (*e.g.*, crop and animal products). Although, this principle does not hold true for soils of low fertility, where it is agronomically beneficial to apply P in excess of short term crop demands in an effort to increase soil fertility (and therefore productivity), it is a prudent operational goal for soils with adequate fertility. In Ireland, a 4-point index system is used to rank soils according to their nutrient content, and therefore, the likely crop response to added nutrients. The Morgan's soil test is used for determining agronomically available P; the indices are shown in Table 1.

Table 1. Irish Soil Fertility Indices for P (Morgan's Text)

Index	Soil P concentration, mg/l by the Morgan's Test	Likely crop response to additional P
1	0 – 3.0	Definite response
2	3.1 – 6.0	Response likely
3	6.1 – 10.0	Response unlikely
4	> 10.0	No response

This research was conducted to identify areas in Ireland where the "potentially best" opportunities for organic waste application to the landscape exist. Although a variety of criteria actually govern the acceptability of a given waste application site, for purposes of this study "potentially best" sites were defined as those that had the capacity to assimilate phosphorus in excess of current supplies.

METHODOLOGY

A mass balance analysis was performed using published data on crop and animal production, assumed soil P levels, and other reported data (such as P fed to animals in concentrates and other animal feeds, and commercial P fertiliser consumption). Scenarios with and without taking account of animal manure recycled to grassland, and with and without inputs of industrial and municipal biosolids were examined using two assumed distributions of STP, as described below:

- Scenario 1: Inputs of P in animal manure were ignored, as was P uptake by grassland, to simulate total recycling of manure P within grassland systems. National consumption of commercial fertiliser P was distributed according to the percentages of tillage crops and grassland in each country relative to the national total. Crop demand for P by tillage crops was assumed to be in accord with crops produced on soils that were all at Soil Index 3. No municipal or industrial P sources were included.
- Scenario 2: As for Scenario 1, but a 50:50 mix of soils at Index 2 and Index 3 was assumed when calculating P demand by tillage crops.
- Scenario 3: Inputs of P in animal manure and grassland P uptake was included with tillage crop P uptake, but all soils were assumed to be at Soil Index 3 for P. National consumption of commercial fertiliser P was distributed according to the percentages of tillage crops and grassland in each country relative to the national total.
- Scenario 4: Same as Scenario 3, but a 50:50 mix of soils at Index 2 and Index 3 were assumed.
- Scenario 5: Same as Scenario 4, but P inputs from municipal and industrial sources were included.

Data for the study were gathered from the Department of Agriculture and Rural Development, Teagasc (The Agriculture and Food Development Authority), the Irish Central Statistics Office, the National Dairy Board, and the Irish Feed and Grain Association.

RESULTS AND DISCUSSION

There is a scarcity of data in Ireland of the types and / or at the spatial scales necessary to conduct an in-depth mass balance on phosphorus in agriculture. The highest resolution at which it was possible to make reasonably intelligent calculations was a county, of which there are 26 in the Republic. At this resolution, reliable data regarding crop and animal production are available from the Irish Central Statistics Office (CSO). From these enumerated data, it was possible to make a reasonable apportionment of relevant data that only exist at a national level (*e.g.*, chemical P fertiliser consumption). No reliable data were available for unbiased estimates of the distribution of STP levels in Irish agricultural soils. What data do exist regarding STP levels come from soil samples sent by farmers, home gardeners, *etc.* to national soil laboratories for nutrient analysis or from special, localised research. In either case, these data are highly biased and cannot be considered to be representative of the actual distribution of P levels in Irish soils.

Because of such data limitations, our results are only indicative of the true situation. Nevertheless, our analysis showed that phosphorus surpluses exist in all counties in the Republic of Ireland. The magnitude of the surpluses varied with the assumptions used about the distribution of soil P levels (and, therefore, phosphorus demand by crops). Table 2 describes the mass balance for P on a national basis for the 5 scenarios examined. (For detailed county-based results see O'Regan, 2000).

Table 2. Inputs, beneficial outputs and surpluses of phosphorus in Irish agriculture.

Region	P Inputs, kg	Beneficial P Outputs, kg	Surplus P (Inputs minus Beneficial Outputs), kg	P Surplus per ha, 1997 UAA (4,431,600 ha)
Scenario 1 , no animal manure P in inputs, no grass P uptake, soils at Index 3				
Republic	67,803,800	30,295,000	37,508,800	8.46
Scenario 2 , no animal manure P in inputs, no grass P uptake, 50% / 50% soils at Index 2 / 3				
Republic	67,803,800	33,558,300	34,245,500	7.73
Scenario 3 incl. animal manure P in inputs, incl. grass P uptake, all soils at Index 3				
Republic	165,069,200	62,184,700	102,884,500	23.22
Scenario 4 , incl. animal manure P in inputs, incl. grass P uptake, 50% / 50% soils at Index 2 / 3				
Republic	165,069,200	83,221,200	81,848,000	18.47
Scenario 5 incl. industrial and municipal P & animal manure P in inputs, incl. grass P uptake, 50% / 50% soils at Index 2 / 3				
Republic	168,562,600	83,221,200	85,341,400	19.26

In retrospect, Scenarios 3, 4 and 5 above probably overstate the magnitude of the P imbalance, because to an extent these scenarios "double count" a significant amount of P. In particular, some of the P in concentrates fed to livestock and poultry is the same P that is in their manure; both concentrates P and animal manure P were enumerated as inputs in Scenarios 3, 4 and 5. Scenarios 1 and 2 negate this double counting by excluding from the analysis animal manure P on the input side of the equation. However, Scenarios 1 and 2 *perhaps* under-estimate beneficial P outputs by excluding from consideration P uptake of some inorganic (fertiliser) P by grassland.

As a check against the projections summarised in Table 2, we also tried to replicate a methodology used previously for calculating a national mass P balance in Ireland Tunney (1990). In contrast to Tunney, however, we aggregated county-specific data wherever possible to determine national totals. Using 1998 animal and crop census data, we derived a P surplus of 48,622,000 kg by this approach. This is, for all practical purposes, identical to a similar assessment made by the Irish Environmental Protection Agency (Scenario 1 in Brogan, Crowe and Carty, 2001).

CONCLUSIONS AND IMPLICATIONS

Although the lack of data with the desired spatial resolution limits the precision of our analyses, there is, nevertheless, little doubt that a P surplus exists for Ireland as a whole, and on a county-by-county basis. Anecdotal evidence, such as EUROSTAT data on nutrient consumption in Ireland, lends further support to this conclusion. The true magnitude of the surplus is likely to be somewhere between that projected in Scenarios 2 and 4.

These projections highlight the need for a national strategy regarding the use of land as a receptor for organic wastes from agriculture, as well as the need for more precise data about the current soil P status. In those counties with the most severe P surpluses, a very strong educational programme should be focused regarding the use of agricultural wastes on the landscape. In the short term, national and local government in areas where P surpluses are particularly excessive should evaluate aggressive measures to restrict the use of P-bearing materials on the landscape. This restriction might be accomplished by taxing non-organic sources of P, by requiring nutrient management plans from all farms, by requiring training for all persons that apply P amendments to the soil, by giving tax credits for the efficient use of P, or by a number of other economic and / or regulatory instruments.

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