Phosphate flow in Japan

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Abstract

To evaluate phosphate flow in Japan in 1997, I constructed a framework then estimated and evaluated it. Phosphate input to farmland was 4.3 times larger than output, and the largest in input was chemical fertilizers, 79% of input. Outflow as water-soluble phosphate from farmland was small; therefore, a large amount of phosphate has remained in the farmland soil and has accumulated year by year. Livestock excreta production was about half that of chemical fertilizer, though 38% of livestock excreta was not utilized.

Though available phosphate in farmland has been surveyed several times systematically, total phosphate has not been surveyed. Understanding total phosphate resources in farmland and active use of livestock excreta is important for resource management and for reducing environmental risk.

1 Introduction

Phosphate is an essential element for crop production. Although phosphate is a limited resource on the earth, a much larger amount of phosphate is used because of its low fertilization efficiency. As a result, it has been speculated that high accumulation of phosphate on farmland occurs in Japan. Kawasaki [1] summarized that available phosphate (Truog P) had increased from 1974 to 1982 by high input of phosphate for improving and increasing soil fertility, though he emphasized a further increase of total phosphate would occur.

Excess phosphate does not cause much damage and Japanese soils have high phosphate absorption; especially in the Andosol, which occupies half the total area of Japanese farmland [2], high input of phosphate has continued. As a result, crops were damaged by excessive phosphate application, with an imbalance of other elements, in some areas [3,4,5,6]. It was thought that these problems were caused by inappropriate application of phosphate.
In this study, I estimate the phosphate flow in Japan in 1997 and evaluate it.

2 Method

2.1 Framework of phosphate flow

The framework of phosphate flow is shown in Figure 1. Farmland receives phosphate as chemical fertilizer, a part of livestock excreta, and from crop residue. These are inputs. Crops and crop by-products are the outputs from farmland. Some phosphate flows out from farmland. Inputs minus outputs and outflow is the phosphate remaining in farmland. Another part of livestock excreta is disposed to the environment as non-utilized livestock excreta. The sum of residual phosphate and non-utilized livestock excreta is considered to be an excessive resource of phosphate.

2.2 Estimation of phosphate flow

2.2.1 Chemical fertilizer

Application of chemical fertilizer phosphate for each of 71 crops per area basis was obtained from "Agricultural Production Environmental Statistics" conducted...
by the Statistics and Information Department, Ministry of Agriculture Forestry and Fisheries (MAFF). This survey covered more than 16,000 farms from a total of 3,291,480 farms. The total amount of chemical fertilizer applied to crops was obtained by calculating the total planted area for crops multiplied by the chemical fertilizer applied to the crops per area.

2.2.2 Use and discharge of livestock excreta
The total amount of livestock excreta for each type of livestock (dairy cattle, beef cattle, pigs, layers, and broilers) was estimated from numbers and growth stages of livestock [7] and excreta production unit per head at various growth stages [8].

The utilization rate of livestock excreta as manure of each type of livestock was obtained from the Statistical Information Department MAFF [9]. The remaining part of livestock excreta was assumed to be non-utilized livestock excreta.

2.2.3 Estimation of crops, crop by-products and plowed crop residues
Estimation of each of the 71 crops’ phosphate was obtained from the crops’ yield [7] and their phosphate content [10]. Estimation of crop by-products was obtained from the crops to crop by-products rate [11] and their phosphate content [10]. Some part of crop by-products was used for manure production or feed for livestock. The remaining part of crop by-products was assumed to have been plowed to farmland.

2.2.4 Estimation of outflow phosphate
Estimation of outflow phosphate from farmland was as follows. Tokutome and Matsumori [12] measured the total amount of water-soluble phosphate in Koisegawa basin (220km²; farmland occupied 36% of total area) and Nanjo [13] described farmland contributes about 4.5% of total phosphate outflow in the river. From this information, I estimated phosphate load unit per farmland, then estimated total phosphate flow out with using the farmland area of Japan.

3 Results

3.1 Verification of the results
The result is shown in Figure 2. There was good coincidence between the application of phosphate for farmland, estimated as 594,683t, and market demand (592,430t [14]). Production of livestock excreta and production of crops were 319,707t and 123,113t respectively in 1997. Ukita and Nakanishi [15] estimated them as 321,000t and 102,000t, respectively in 1990. These indicate that farther differences are not observed even with a different estimation method.
3.2 Evaluation of phosphate flow in Japan

The largest input was chemical fertilizer, which was 69% of total input. Livestock excreta production (319,907 t) was about half of chemical fertilizer, though 38% of it was not utilized and was disposed of as non-utilized livestock excreta and became an environmental risk.

The remaining phosphate in farmland was 666,336 t. This would be largely due to about 4.3 times higher input than output and small outflow.

Phosphate outflow from farmland was relatively small compared with the other flows.

4 Discussion

In 1997, the application of phosphate was much larger than the accumulation by crops and crop by-products, and the remaining phosphate was 666,811 t. This would be largely due to chemical fertilizer input because about 80% of phosphate is thought to remain [13]. Though the remaining phosphate is a large pool in farmland, it might be utilized later. Phosphate has low fertilization efficiency, and is accumulated by soil, especially Ando soil, which covers about half of the farmland in Japan, and easily becomes unavailable for plants. For these reasons,
the amount of remaining phosphate became large.

On the other hand, in highly phosphate accumulated farmlands, vegetables grew with low or no input of phosphate [16,17,18,19]. This indicates enough available phosphate appears in some areas.

Accumulated phosphate sometimes runs off as a suspended solid on sloped land or by rainfall, and therefore the environmental risk caused by accumulated phosphate would not shrink [20,21]. Sharpley et al. [22] described that to evaluate the environmental capacity by amount of accumulated phosphate on farmland and weighted on land shape. In this study, only water-soluble phosphate was accounted for by runoff. Therefore, this value might be an underestimate, because suspended solid phosphate was not counted.

Soils are not infinite sinks for phosphate [22] and application of livestock excreta for farmland is limited by phosphate level for preservation of ground water quality in the Netherlands [23]. In Japan, the effect of phosphate on ground water quality will be low. This would be largely due to the difference of soil type. However, a large amount of phosphate remains per year and enough or more phosphate is added to farmland. This may indicate wasteful use of phosphate. Although available phosphate (Truog P) in farmland soil has been surveyed several times systematically, total phosphate has not been surveyed in Japan. Understanding the phosphate resource in farmland in Japan, a systematic and sequential survey of total phosphate would be needed, because a huge amount of phosphate is remaining year by year in farmland.

Although livestock excreta production was about half of chemical fertilizer application, 38% of it was not utilized. This non-utilized livestock excreta would be an environmental risk. Therefore, active use of livestock excreta is important to reducing environmental risk.

The appearance of excess damage by phosphate with imbalance of other elements in some areas indicates the importance of soil diagnosis, and the amount of livestock excreta was about half of chemical fertilizer application. Application of appropriate amount of chemical fertilizer phosphate and active use of livestock excreta would be important for effective use of phosphate and would be important for effective resource management.

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References


