Closing the Phosphorus Loop in Hanoi, Vietnam

In Hanoi, Vietnam, water bodies are polluted by high levels of nutrients, which are discharged in wastewater. At the same time, farmers in and around the city use artificial fertilisers. A nutrient accounting tool indicates where to set priorities to enhance nutrient recovery, and in this way reduce water pollution and the mining of limited phosphorus reserves. The analysis in this article focuses on phosphorus.

Material flow analysis

EAWAG/SANDEC and its partners in Vietnam have developed a tool to estimate and visualise water and nutrient flows in a region. The tool links urban organic waste/wastewater management and urban agriculture. Concretely, it consists of a computer model made up of a series of Excel-based nutrient accounting sheets. The user enters various parameters, such as the number of inhabitants, type of sanitation system, area under cultivation and livestock population. The model subsequently estimates, for instance, phosphorus inputs into surface waters and phosphorus recovery for agricultural use. The model is designed to support local actors in analysing the impact of different measures on fertiliser need and nutrient discharge in the environment.

The tool is based on material flow analysis (MFA). This method studies the fluxes of resources used and transformed as they flow in a specified region. In industrialised countries, MFA proved to be a suitable instrument for the early recognition...
of environmental problems and development of countermeasures (Baccini and Brunner, 1991). It can also be applied in rapidly developing cities in the South to evaluate the impact of changes in consumption patterns, solid waste and wastewater treatment infrastructure, periurban agricultural production, and waste and wastewater reuse practices on resource consumption and environmental pollution.

**Phosphorus supply and demand in Hanoi**

In Hanoi, like in many other cities in developing countries, high population growth, industrialisation and economic development have led to increased resource consumption and environmental degradation. Periurban agriculture is of key importance in the supply of food and provision of income, especially to the poorest section of the population. However, rapid urbanisation also creates pressure on the land. Farmers tend to use more fertilisers in an attempt to enhance yield and maximise benefit from their decreasing land area. A better balance between nutrient supply in urban waste products and nutrient demand in periurban food production could be the key to reducing resource consumption and environmental pollution (Montangero et al., 2007).

The MFA tool was applied to demonstrate the effects of selected extreme scenarios on phosphorus inputs into the river and on phosphorus recovery for agricultural use. For this purpose, the effects of various parameters, such as the type of sanitation system, area under cultivation and livestock population were simulated.

**The impact of urine diversion toilets**

To illustrate the model, this article looks at the impact that the type of sanitation system has on phosphorus recovery (more information and different scenarios can be found in Montangero et al., 2007 and Montangero and Belevi, 2008).

In Hanoi, most buildings are connected to septic tanks, which collect wastewater from toilets. Most of the phosphorus contained in toilet wastewater leaves the septic tank in the pre-treated effluent (septic tanks do not retain phosphorus efficiently). Effluent from septic tanks and greywater (laundry, kitchen and bath wastewater) reach surface waters via roadside drainage channels. Together, they account for 94 per cent of the total phosphorus load in Hanoi's water bodies. Only a small proportion of this phosphorus load is recovered for use in food production.

Urine diversion toilets offer crucial advantages over septic tanks with regard to phosphorus recovery, since these toilets have two compartments, keeping urine and faeces separate. Urine leaves the toilet through a pipe / tube. Faeces are stored directly beneath the toilet. After defecation, dry soil, ash or sawdust is spread over the faeces, controlling odour and absorbing moisture. There are generally two chambers for faeces used alternatively. When one of the chambers is full, the other is used and the faeces/ash mixture is stored in the first compartment for about a year. During this period, pathogenic microorganisms die off, substantially reducing the health risks associated with reuse of the mixture as a fertiliser in agriculture. The urine, meanwhile, possibly diluted, can be used for irrigation. This system makes it possible to retain all the nutrients contained in human excreta – apart from a small amount of nitrogen volatilising during urine storage. These nutrients could subsequently take the place of some of the artificial fertilisers used in agriculture. It is interesting to note that this kind of system was formerly widespread in North Vietnam.

The extent to which phosphorus recovery could potentially be increased was quantified. Assuming, for example, that all septic tanks in Hanoi were replaced by urine diversion toilets, the amount of artificial phosphorus fertiliser required could be reduced from 2800 to 1200 tonnes per year – a 57 per cent decrease! This is one step towards closing the phosphorus loop.

**Need for an integrated planning approach**

To further develop scenarios such as that involving urine diversion for Hanoi (or other cities), more information is needed on users' perceptions of new sanitary facilities, the costs and whether these are acceptable to users, longer term market analysis, etc. MFA could be used as a tool in integrated planning that involves all stakeholders.

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**References**