

Material Flow Analysis – A Tool for Nutrient Resource Management

Nutrient recycling from human waste for production of animal feed provides an alternative to the use of chemical fertilisers and commercial animal feed. It also contributes to minimising water and soil pollution. Nga Do-Thu¹, Antoine Morel^{2,3}, Phuc Pham-Duc⁴, Hung Nguyen-Viet^{3,5,6}, Thammarat Kootatpet²

Hoang Tay and Nhat Tan

The study site comprises the two neighbouring communes of Hoang Tay and Nhat Tan, Kim Bang district, Hanam province, Vietnam. The 16 293 inhabitants (in 2008) are spread over a total area of 8.61 km². Livestock, paddy fields and sanitation systems are the main sources of nutrient generation. The study site has no wastewater treatment plant, and wastewater from households and livestock etc. is discharged via the sewage systems directly into the water channels or fishponds. Some of the solid waste is collected and disposed of in an uncontrolled landfill.

Method

The adapted MFA [1] was first applied to this rural area of Vietnam. The simplified model, visualising all the current human activities focuses on some key activities, with their main input and output flows, including their interactions [2]. Necessary data was obtained from available sources, such as statistics, local and international research reports and scientific literature, and complemented by experts' views. Model parameters were determined by an acquired understanding of the system and based on a nutrient balance concept. Moreover, conducting plausibility and parameter assessments could solve data uncertainty and scarcity. Alternatively, model simulations were used to quantify nutrient

flows and identify their corresponding key parameters illustrated in a flow diagram. Moreover, the effects of potential mitigation measures could then be calculated and discussed for different scenarios by adjusting their respective parameters.

Results

The main annual N input to the study site originated from chemical fertilisers applied to rice paddy fields (177 ± 7 tonnes), and from commercial fish and animal feed (245 ± 11 tonnes). The main output into water bodies and soil/groundwater originated from drainage systems (42 ± 3 tonnes) and paddy field runoffs (116 ± 6 tonnes). Yet, it is important to note that large amounts of nutrients could be recycled as animal feed or fertiliser. For example, 214 ± 56 tonnes of N from wastewater, faecal sludge or manure (53 % of total N), as well as from organic solid waste are generated annually by households, markets and crop residues. Only 30 % of total N from markets and household organic solid waste were recycled to feed animals, pigs and poultry. Yet, only 49 % of the manure was reused as fertiliser. Therefore, 51 % of total N from manure and wastewater was discharged into water bodies and soil/groundwater, equalling 216 ± 6 tonnes – an amount exceeding the chemical fertilisers used (177 ± 7 tonnes). Consequently, reuse of wastewater and manure to fertilise rice paddy fields was an economical way to reduce the use of chemical fertilisers (Photo 1).

Two scenarios for the study site were created based on the developed MFA model. Firstly, by 2020, if sanitation systems and farming habits of local communities remain the same, the amount of N from wastewater is expected to increase by 50 %. The amount of N from faecal sludge and organic solid waste could triple compared to the 2008 status (Scenario 1). Secondly, by 2020, if on-site sanitation systems were improved by increasing the annual emptying frequency factor of septic tanks or pour-flush latrines, N could be re-

duced five times, once from biogas and 0.3 times from pit latrines to almost reach the 2008 status (Scenario 2). If wastewater, pig manure and organic solid waste were recycled, and on-site sanitation systems improved as aforementioned, the amount of N could be reduced significantly.

Conclusions

The adapted MFA method is an ideal technical basis for planning and decision-making, especially in developing and emerging countries with limited technical and financial resources. The visualisation results obtained also raised the awareness of local populations regarding the critical local pollution situation. Moreover, based on the scenarios described, local authorities could also develop nutrient recycling strategies instead of continuing to damage soil, groundwater or Nhue river water.

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- [2] Brunner, P.H., Rechberger, H. (2004): Practical Handbook of Material Flow Analysis. Advance Methods in Resource and Waste Management. Lewis Publishers.



Photo 1: Livestock manure is fed into a biogas reactor and effluent is then used in agri/aquaculture.

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