Assessing nutrient fluxes in a Vietnamese rural area despite limited and highly uncertain data

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Material flow analysis (MFA) is a useful methodology to describe and quantify complex systems based on the law of mass conservation. It was further adapted to suit the specific conditions in developing countries where the available data is scarce and uncertain. The 'adapted MFA' methodology optimises the number of parameters, describes these parameters as probability distributions and assesses the accuracy and uncertainty of the model values by Monte Carlo simulation. This study illustrates the first successful application of the 'adapted MFA' methodology in a small and low-income area including two neighbouring communes in rural northern Vietnam, where environmental sanitation and traditional agricultural practices are strongly interlinked and have an impact on the surrounding environment. Moreover, data on this area is typically scarce and uncertain. The obtained results reveal that the agricultural system was a significant source of nutrients (nitrogen (N) and phosphorous (P)), which affect the surrounding environment mainly due to the overuse of chemical fertilizers. Every year, there were 103 +/- 39 tonnes of N released into the atmosphere, 25 +/- 3 tonnes of N leached to the surface water and 14 +/- 2 tonnes of P accumulated in the soil, all originating from the applied chemical fertilizers. In addition, the sanitation system was also a critical source of nutrients that enter the surface water. 69 +/- 6 tonnes of N and 23 +/- 4 tonnes of P came from households through effluents of onsite sanitation systems (such as latrines and septic tanks) and were directly discharged to surface water every year. Moreover, the whole system annually generated a large nutrient source (214 +/- 56 tonnes of N; 58 +/- 16 tonnes of P) in the form of wastewater, faecal sludge, animal manure and organic solid wastes. The validated MFA was used to model different scenarios for the study site. The first scenario demonstrated that if nutrient management is not improved. wastewater as well as faecal sludge and organic solid waste are expected to double in the year 2020 as compared to that in 2008. The second and third scenario revealed possible strategies to significantly reduce environmental pollution and reuse nutrient sources predicted to be available in the year 2020.

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