Nutrients in urine: energetic aspects of removal and recovery

M. Maurer*, P. Schwegler and T.A. Larsen

EAWAG, Environmental Engineering, Überlandstrasse 133, CH-8600 Dübendorf, Switzerland

* Author to whom all correspondence should be addressed

Abstract The analysis of different removal and recovery techniques for nutrients in urine shows that in many cases recovery is energetically more efficient than removal and new-production from natural resources. Considering only the running electricity and fossil energy requirements for the traditional way of wastewater treatment and fertiliser production, the following specific energy requirements can be calculated: 45 MJ $kg^{-1}{}_N$ for denitrification in a WWTP, 49 MJ $kg^{-1}{}_P$ for P-precipitation in a WWTP, 45 MJ $kg^{-1}{}_N$ for N-fertiliser and 29 MJ $kg^{-1}{}_P$ for P-fertiliser production. These numbers are higher than the values derived for thermal volume reduction of urine (35 MJ $kg^{-1}{}_N$ for eliminating 90% water) or production of struvite (102 MJ $kg^{-1}{}_N$, including 2.2 kg P). Considering only the electricity and fossil energy for the traditional way of wastewater treatment and fertiliser production, the energy value of 1 PE urine is 0.87 MJ $PE^{-1}d^{-1}$ (fertiliser value: 0.44, wastewater treatment: 0.43 MJ $PE^{-1}d^{-1}$).

A more detailed life cycle assessment (LCA) of the entire urine collection system, including the required materials and the environmental burden, support the energy analysis. The LCA compares conventional denitrification in a wastewater treatment plant with collecting urine in households, reducing the volume by evaporation and using it as a multi-nutrient fertiliser. The primary energy consumption for recovery and reuse of urine, including the nutrients N, P and K, is calculated with 65 MJ $kg^{-1}{}_N$, compared with 153 MJ $kg^{-1}{}_N$ derived for the conventional ‘recycling over the atmosphere’.

Keywords Energy requirements; LCA; nitrogen; phosphorus; urine source separation

Water Science and Technology **Vol 48 No 1 pp 37–46**

Introduction

In regions with sensitive surface waters, the costs for wastewater treatment are dominated by the conversion and elimination of nitrogen and phosphorus. The introduction of nitrification, a prerequisite for enhanced nitrogen elimination, into an activated sludge plant increases the reactor volume significantly and leads to higher energy consumption of approximately 60 to 80%. The elimination of phosphorus requires either the addition of chemicals and subsequent disposal of inorganic sludge or an increase of reactor volume for enhanced biological phosphorus removal (EBPR). At the same time, the elements N and P are essential for agriculture and have to be produced technically from natural resources. Phosphorus is gained from rock phosphates, which deplete in quantity and quality (USGS, 2002). Nitrogen fixation is determined by the cost and availability of fossil fuels. The idea is compelling that by recovering the nutrients from wastewater streams and reusing it for agricultural purposes, the costs of extensive wastewater treatment could be avoided and resources saved.

Several removal and recovery techniques have been investigated (Brett *et al*., 1997; Maurer *et al*., 2002). However, currently only very limited information is available to decide which route, removal or recovery, should be taken. This article gives an overview over the possible technologies for nutrient recovery from liquid wastes, compares them with the current practice, and discusses the feasibility of recovery. Energy data for the various technologies are compiled and give an important decision guideline for removal or recovery.