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Desalination 226 (2008) 222–230
DESALINATION
www.elsevier.com/locate/desal

Source apportionment of nutrients in Estonian rivers

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Received 18 December 2006; revised accepted 2 February 2007

Abstract

Eutrophication caused by excess nutrient loads is the main problem for Estonian surface waters. The assessment of the type of human activity on the catchment area that may cause an impact on the status of a water body is needed for successful implementation of the Water Framework Directive. The lack of necessary information often makes it difficult to perform this task. The simple export coefficients approach has been used in this investigation for evaluation of the impact of different sources of nutrients on the water quality in Estonian rivers. Attention has mainly been concentrated on the diffuse pollution sources (natural and anthropogenic). Non-linear regression was used for the estimation of the export coefficients and retention of nutrients. Results revealed that the export coefficients vary within a wide range of limits even in such a small country as Estonia. Soil type, topography, climatic conditions and water flow are the main natural factors influencing export coefficients. It was demonstrated that the use of export coefficients estimated for other regions may lead to wrong conclusions about the impact of different diffuse sources on the water body status.

Keywords: Diffuse sources; Export coefficients; MESAW; Nutrients; Water Framework Directive

1. Introduction

The European Union Water Framework Directive (WFD) [1] requires assessment of the pressures from human activity, which, combined with the information on the sensitivity of the receiving water body to the pressures, will identify those water bodies at risk of failing to meet the environmental objectives of the Directive. The size typology given in the Water Framework Directive implies that the status of all rivers with catchment areas greater than 10 km^2 must be assessed [2]. It means that the impact of different pollution sources on the water quality status of the river must be estimated for hundreds of rivers in Estonia. Lack of hydrochemical data

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Presented at the 10th IWA International Specialized Conference on Diffuse Pollution and Sustainable Basin Management, Istanbul, Turkey, 18–22 September 2006.

0011-9164/06/$– See front matter
doi:10.1016/j.desal.2007.02.108

for most of the rivers requires a methodology for the evaluation of the potential danger of pollution sources for the rivers without measurements. The purpose of the paper was to examine a simple approach to accomplish the assessment of unmonitored water bodies.

Eutrophication is one of the most serious problems related to the pollution of surface waters in Estonia. The nutrient concentrations exceed permitted level in many rivers. In order to effectively manage nutrient pollution reductions, it is important to estimate the influence of different nutrient sources on water quality in rivers. The Guidance Document No. 3 [3], which states a common strategy for the implementation of the WFD, proposes to use analysis of the pressures and impacts before elaboration of water protection measures. It is demonstrated in the paper that such analysis requires different methods for estimation of point and diffuse sources.

The impact of point sources may be calculated on the basis of information on pressures and river characteristics. This approach is very simple, though some questions can arise in the performance of the task. The situation is more complex with diffuse pollution. Sophisticated models need much detailed information on watershed, which is not available at present and will not be in the foreseeable future. Therefore, the large number of water bodies without hydrochemical monitoring practically excludes the possibility of using sophisticated models. According to the WFD guidance [3], the evaluation of diffuse sources may be done also with the help of the export coefficients (EC) of nutrients. This simple approach is based on the idea that the nutrient load exported from a catchment is the sum of the losses from individual sources and on the assumption that, for a given climate, specific land-use will yield characteristic quantities of nitrogen and phosphorus to a receiving water body [4]. Despite its simplicity, the export coefficient model was successfully tested in the modelling of long-term nitrate losses from catchments (e.g., [5] and [6]). However, Smith et al. [7] note the variability of export coefficients for the same land-use classes. Large differences in export coefficients for same land-use categories have been mentioned also in Arheimer and Brandt [8], Baginska et al. [9], Haggard et al. [10], Pieterse et al. [11]. Table 1 contains empirical export coefficients for different types of land-use [12]. It is evident that differences between minimal and maximal values are very large.

Table 1
Empirical data on nitrogen and phosphorus export coefficients (kg/ha/y)

	Nitrogen		Phosphorus	
	Min	Max	Min	Max
Agriculture	2.1	53.2	0.08	5.4
Urban	1.5	38.5	0.19	6.23
Forest	1.37	7.32	0.01	0.83

Large differences between values of export coefficients available from published studies prevent direct use of them. Hence, export coefficients must be estimated (or at least controlled) for each region on the basis of measurements. In this paper, simple statistical methods have been used for the estimation of export coefficients for Estonian rivers.

2. Description of the method

As was mentioned above, the problem is that we have to evaluate the potential impact of different pollution sources on the status of hundreds of water bodies without hydrochemical monitoring data. The method used for such evaluation is described below in more detail.

The key stages of evaluation of potential impact as laid down in the WFD are [3]:

- Identifying driving forces and pressures;
- Identifying the significant pressures;
- Assessing the impacts;
- Evaluating the likelihood of failing to meet the objective (good status by the year 2015).