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SOURCE APPORTIONMENT AND RETENTION OF NUTRIENTS AND ORGANIC MATTER IN THE MERKYS RIVER BASIN IN SOUTHERN LITHUANIA

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Abstract. The assessment of the type of human activity in a basin area that may cause an impact on the status of a water body is needed for successful implementation of the EU Water Framework Directive. Lack of necessary information often makes it difficult to perform the task. Therefore, the statistical MESAW model based on export coefficients approach has been used in this study for evaluation of the impact of different sources of nutrients and organic matter on the water quality in the Merkys River in southern Lithuania. The model was tested on the basis of data from 5 water quality monitoring sites with corresponding subbasin data on land use, point sources and atmospheric deposition. Nonlinear regression was used for simultaneous estimation of the export coefficients and retention.

The results revealed that the impact of anthropogenic sources accounted for 73% of COD, 56% of BOD, 90% of N_{tot} and 78% of P_{tot} loads measured in the Merkys River. Forest and wetlands contribute from 9.5 to 44% to the corresponding load. The retention in the Merkys River, Basin was found to be high for nitrogen and phosphorus and low for organic matter.

Keywords: source apportionment, retention, MESAW, nutrients, organic matter, the Merkys River.

1. Introduction

The Water Framework Directive (2000/60/EC) introduces new criteria and measures for managing Europe's waters under an integrating ecosystem-based approach. The Directive aims at good ecological and chemical quality status for all waters (surface, underground and coastal) by means of pollution-control measures that have to be planned at the hydrologic river basin level. With regard to point and diffuse sources of pollution the Water Framework Directive requires Member States to identify significant human pressures and evaluate their impacts on water quality. The characterization of water status, the description of pollution sources impact, the establishment of monitoring programs and the implementation of river basin management plans require an analysis of the current basin status and estimates of the relative significance of different sources of pollution (Kronvang *et al.* 2004).

Nutrient source apportionment is generally performed through inventories of point and diffuse sources. An alternative approach is source apportionment based on statistical analysis of observed river nutrient transport. This methodology can be divided into two categories: regression analysis between observed concentration and water discharge and regression analysis between observed load and basin characteristics (Behrendt 1996, 1999). Due to the development of dynamic process-based models new possibilities for source apportionment of organic matter and nutrients in large river basins become available. Considering the necessity for integrated management and the scale of planned application, models are indispensable tools (Olsson and Andersson 2007; Cai 2008).

A large number of water quality models have been developed to estimate the pollution loadings into water bodies. These models range from simple regression-based ones such as SPARROW (Alexander *et al.* 2002) and ESTIMATOR (Cohn *et al.* 1992) to conceptual and physically-based models such as CREAMS, GLEAMS, WEPP, AGNPS, EPIC, SWAT, MONERIS, QUAL2E, HBV-N, DUFLOW and MIKE-BASIN. Process-based models allow forecasting and a better understanding of processes; however, they need much detailed information on river basins, which is very often not available. Therefore, a large number of water bodies without water quality monitoring excludes the possibility of using sophisticated models. For decision-makers and scientists faced with a specific water management problem, it is therefore essential to choose a method which meets the often limited available input data, gives the wanted results and is economically feasible (Lidén *et al.* 1999).

Simplified models addressing the problem of water quality are proposed in literature and based on the export-coefficient approach (Johnes 1996; Worrall and Burt 1999; Grizzetti *et al.* 2005; Shrestha *et al.* 2008).

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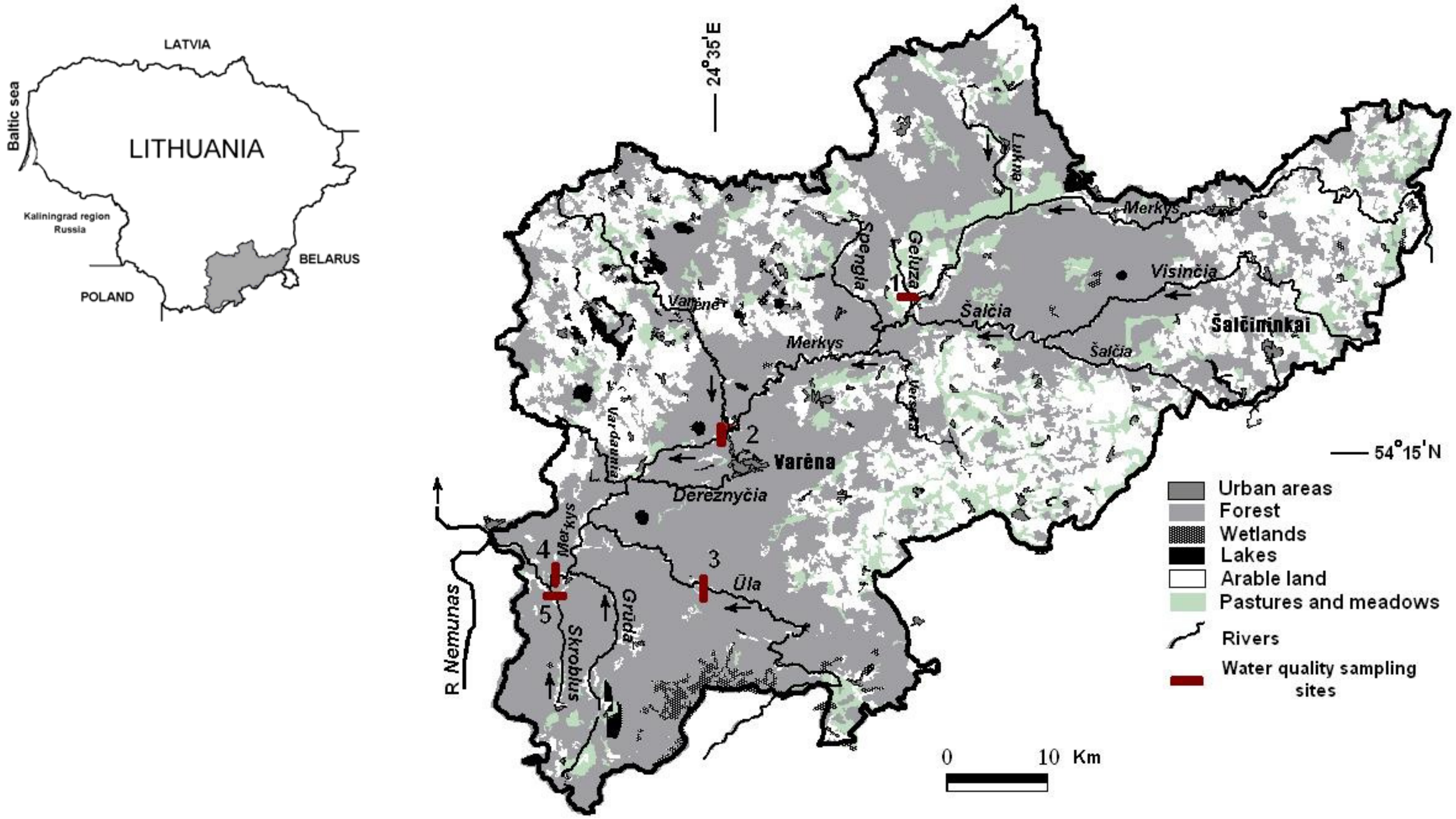

Fig. 1. Location map and water quality sampling sites in the Merkys River Basin

Table 1. Land use and drainage area of subbasins above water sampling sites

Subbasin	Agriculture, %	Forest, %	Grassland, %	Lakes, %	Wetlands, %	Urban, %	Other, %	Total area, km^2
Geluža	21.9	48.4	24.3	0.8	0.3	2.2	2.2	54.8
Merkys-V*	24.7	42.5	19.7	0.9	9.3	1.3	1.5	2815.3
Ūla	0.4	79.1	0.2	0.4	14.4	0.1	5.4	576.0
Merkys-P♣	3.1	84.6	2.6	0.7	1.4	0.8	6.7	846.2
Skroblus	0.7	93.9	1.3	0.1	2.0	0.1	1.8	76.2

*Merkys River upstream Varėna town; ♣Merkys River downstream Puvočiai settlement

This approach is based on the idea that nutrient load exported from a basin is the sum of losses from individual sources and on the assumption that specific land use will yield characteristic quantities of organic matter and nutrients to a receiving water body. However, large differences in export coefficients for the same land use categories have been mentioned in literature (Smith *et al.* 1997; McFarland and Hauck 1999; Lepistö *et al.* 2006). A variety of export coefficients in different regions of Lithuania were also reported (Šileika *et al.* 2006; Šmitienė 2008). Hence, export coefficients must be estimated for each region on the basis of available measurements.

The objective of this study is therefore to estimate export coefficients as well as to assess the contribution of different sources to the load of organic matter and nutrients in the Merkys River by means of statistical model MESAW. The waters of the Merkys River Basin represent a valuable resource contributing to agricultural and recreational activities. The lower reaches of the Basin have been taken by forests with very little human activity, however, the upper and middle ones have been much more affected by agriculture and urbanization. This Basin is a favorable area for the assessment of relative significance of human-induced and natural factors on water environment.

2. Study area and data

The study was made in the Merkys River Basin situated in southern Lithuania (Fig. 1). The total area of the Basin is 4416 km^2, 635 km^2 of which belong to Belarus. The length of the River is 203 km. It flows 13 km through the northern territory of Belarus, 5 km – along the Belarus-Lithuanian border, and the remaining 185 km – through Lithuania before disgorging into the Nemunas River. Average annual amount of precipitation in the Basin is about 680 mm, and the annual air temperature is 6 °C. Highly water-permeable sand and sandy loam soils, absorbing snow and rain water, are widely spread (67% of the area) there. Therefore, the water supply from large groundwater aquifers makes up to 50% of annual runoff volume. Average annual specific discharge at different sites within the Basin varies from 7.5 to 8.5 $l \cdot s^{-1} \cdot km^{-2}$ (Gailiušis *et al.* 2001) Forest (57%) and agricultural land (31%) are dominating land use classes in the Basin. Lakes and wetlands cover 0.8 and 8% of the total area, respectively. The density of population is 15.3 inhabitants per km^2. Urbanized areas cover 1% of the Basin and comprise 32.2% of population.

Monthly water quality sampling data of organic matter (BOD_7 and COD_{Cr}), total nitrogen (N_{tot}) and total phosphorus (P_{tot}) for the period 1993–2006 from 5 sites were used in this study. According to the data availability, the following subbasins were analysed: the Geluža River at the outlet (site 1 in Fig. 1); the Merkys River upstream Varėna (2); the Ūla River at Kašėtos (3); the Merkys River downstream Puvočiai (4) and the Skroblus River at Dubininkas (5). The sampling and chemical analyses were performed by the Lithuanian Environmental Agency. The same institution also provided with digital information for delineation of subbasins and a database on the point source emissions and atmospheric deposition. The latter data were set to 950 kg km^{-2} for N and 170 kg km^{-2} for P. The digital CORINE land cover map was used to derive land use statistics for each of the 5 subbasins. The analysed areas cover 4368.4 km^2 or 99% of the total Merkys River Basin. A brief description of the sites is presented in Table 1. Schematic representation of the connectivity of subbasins is shown in Fig. 2.

The load of each water quality constituent was calculated as a function of daily concentration of the constituent and the stream discharge. Daily concentrations were estimated by linear interpolation between the values measured at two sampling events. Annual loads were obtained by accumulating the daily load values. Average annual loads for the period 1993–2006 were further used in the MESAW model.

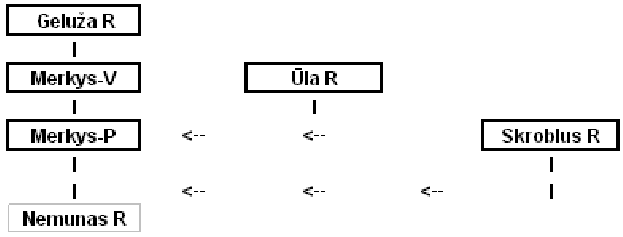

Fig. 2. Connectivity of subbasins

Daily data on continuous measurements of water discharge were provided by the Lithuanian Hydrometeorological Service. Daily discharge at the sites that lacked measurements was obtained from linear regression using the data from the most adjacent sites with flow measurements.

3. Methodology

The MESAW model is a statistical model for source apportionment of the riverine transport of pollutants (Grimvall and Stålnacke 1996). This model approach uses non-linear regression for simultaneous estimation of source strength (i.e. export coefficients to surface waters) for different land use or soil categories and retention coefficients for pollutants in a river basin. The basic principles and major steps in the procedure are as follows: (1) estimation of riverine loads at each water quality monitoring site; (2) subdivision of the entire drainage basin into subbasins, defined by the monitoring sites for water quality and their upstream-downstream relationships (describing the river system); (3) derivation of statistics on e.g. land use, lake area, point source emissions and other relevant data for each subbasin; (4) using a general non-linear regression expression with loads at each subbasin as the dependent/response variable and subbasin characteristics as covariates/explanatory variables (French *et al.* 2003).

Load at the outlet of an arbitrary subbasin is estimated from the following general expression (Vassiljev and Stålnacke 2005; Vassiljev *et al.* 2008):

$$L_i = \sum_{j=1}^{n}(1-R_{i,j})L_j + (1-R)S_i + (1-R)P_i + (1-R)D_i + \varepsilon_i, \quad (1)$$

where L_i – load at outlet of subbasin i; L_j – load at outlet of nearest upstream subbasin j; $R_{i,j}$ – retention on the way from outlet of subbasin j until outlet of subbasin i; n – number of subbasins located nearest upstream; S_i – total losses from soil to water in subbasin i; P_i – point source discharges to waters in subbasin i; D_i – atmospheric deposition on surface waters in subbasin i; R – retention in subbasin i; ε_i – statistical error term.

The load at each subbasin is decomposed into contributions from sources located in subbasins further upstream (the first term in Equation 1) and contributions from sources located within the subbasin under consideration (the S_i, P_i and D_i terms). The parameterisation of the model is flexible and can be study-area specific. The model is fitted by minimising the sum of squares for the difference in observed and estimated load. In this study, P_i and D_i was assumed to be known and S_i was assumed to be a simple function of land use according to

$$S_i = \beta_1 a_{1i} + \beta_2 a_{2i} + \beta_3 a_{3i}, \quad (2)$$

where a_{1i}, a_{2i} and a_{3i}, respectively, denote the area of agricultural land (arable land, pastures and meadows), forests and wetlands and other land in the subbasin i; and β_{1-3} are unknown emission/export coefficients for the land use categories. The point source emission, P_i, and atmospheric deposition, D_i, were allocated to the respective subbasin.

Organic matter and nutrients are normally retained temporally or permanently in watercourses. Therefore, retention in the model is expressed as a summary expression for all the hydrological and biogeochemical processes that may decrease the transport or losses of nutrients. It can be parameterized by any empirical function. In this study, retention was best estimated according to the equation:

$$R = 1 - \frac{1}{1 + (PAR \cdot A)}, \quad (3)$$

where PAR – unknown parameter estimated by the model (Table 2) and A is the drainage area of subbasin.

Table 2. Estimated *PAR* values* for the Merkys River Basin

Constituent	*PAR*
COD_{Cr}	$2.55 \cdot 10^{-4}$
BOD_7	$3.71 \cdot 10^{-5}$
N_{tot}	$2.09 \cdot 10^{-3}$
P_{tot}	$6.49 \cdot 10^{-4}$

*significance level p<0.01

Retention from an arbitrary subbasin m to the river mouth R_{mouth} is derived from:

$$R_{m,mouth} = 1 - \prod_{j=1}^{k}\left(1 - R_j\right), \quad (4)$$

where $R_{m,mouth}$ is retention from the outlet of the subbasin m on the way to the mouth of the whole river; k is the number of subbasins downstream sub-basin m; R_j are the values of retention within the different subbasin downstream subbasin m.

The estimated export coefficients β_{1-3} and the retention parameters are finally used to calculate the contribution from each source and subbasin to the riverine load at the outlet. The advantage of the method is that the export coefficients and retention are evaluated simultaneously.

4. Results

4.1. Estimation of loads

Water quality during the study period at sampling sites was changing from good to moderate and occasionally to bad (Table 3). Consequently, the results of an annual load, varying from 302 to 22000 tons for COD_{Cr}, 42–3215 tons for BOD_7, 2–103 tons for P_{tot} and 14–1479 tons for N_{tot}, were obtained. The lowest loads were observed in the Skroblus River and the highest ones in the Merkys River downstream Puvočiai.

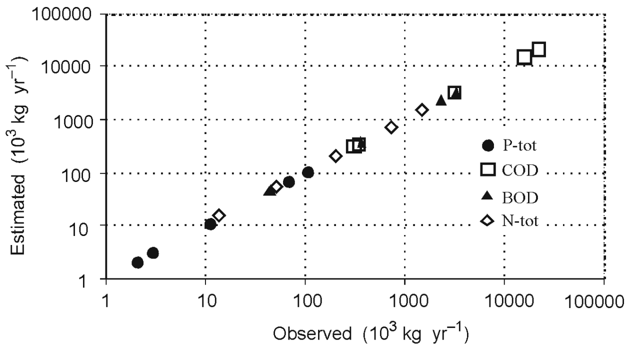

Fig. 3. Observed load of constituents against estimated values (log scale)

The MESAW model performed well in estimating the loadings. Absolute values of deviation between observed and estimated loads made less than 10% from the line of equivalence (Fig. 3). In turn, the loads of each water quality constituent from each subbasin were set as dependent variables to derive source strength (i.e. export coefficients) and retention.

4.2. Export coefficients

To estimate the loading, contribution for each land use type multiple regression analysis described in the MESAW methodology, was applied. The dependent variables were the annual loads of constituents, and the independent variable was the land use proportion in each subbasin.

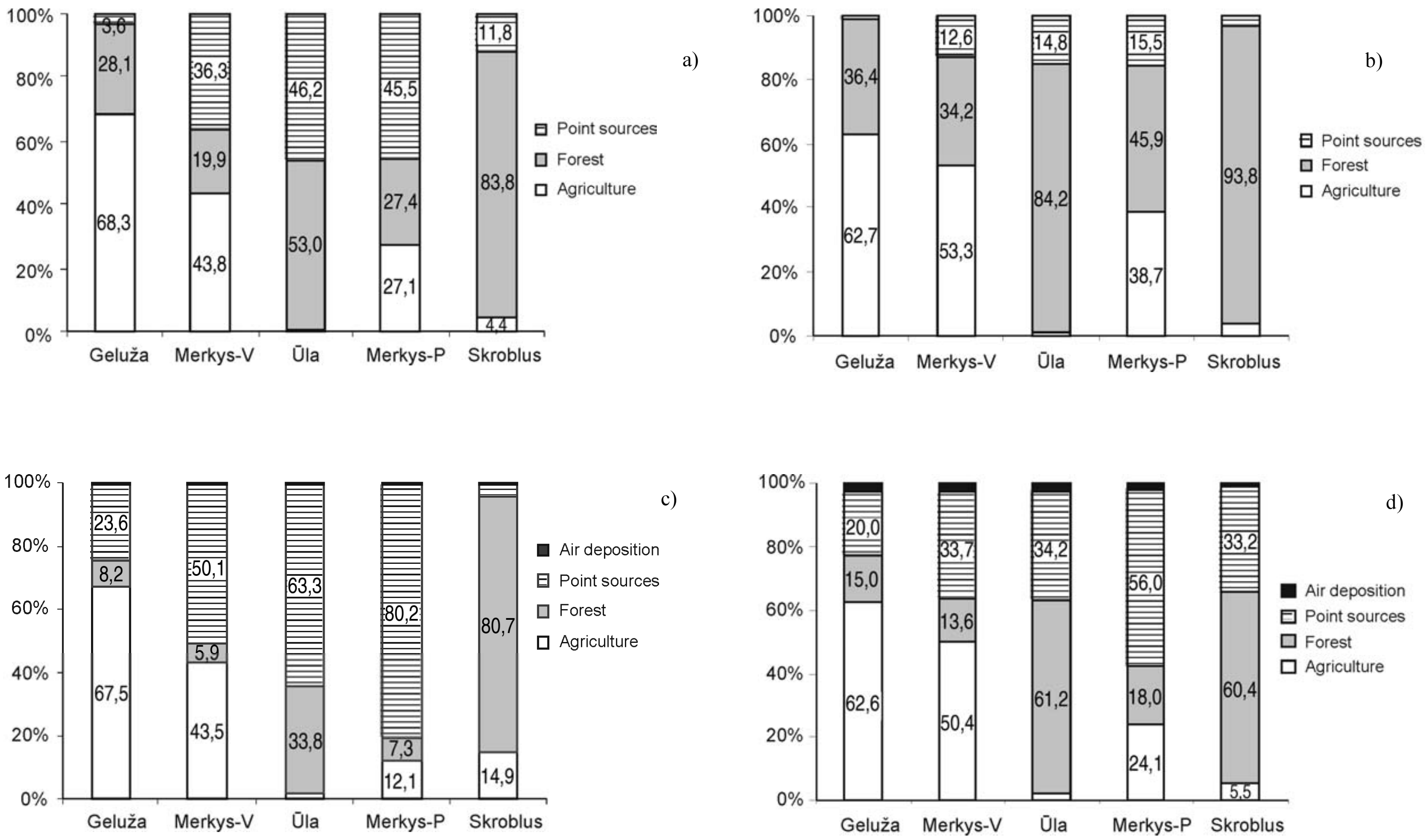

Fig. 4. Source apportionment of COD (a), BOD (b), total nitrogen (c) and total phosphorus (d) in studied subbasins

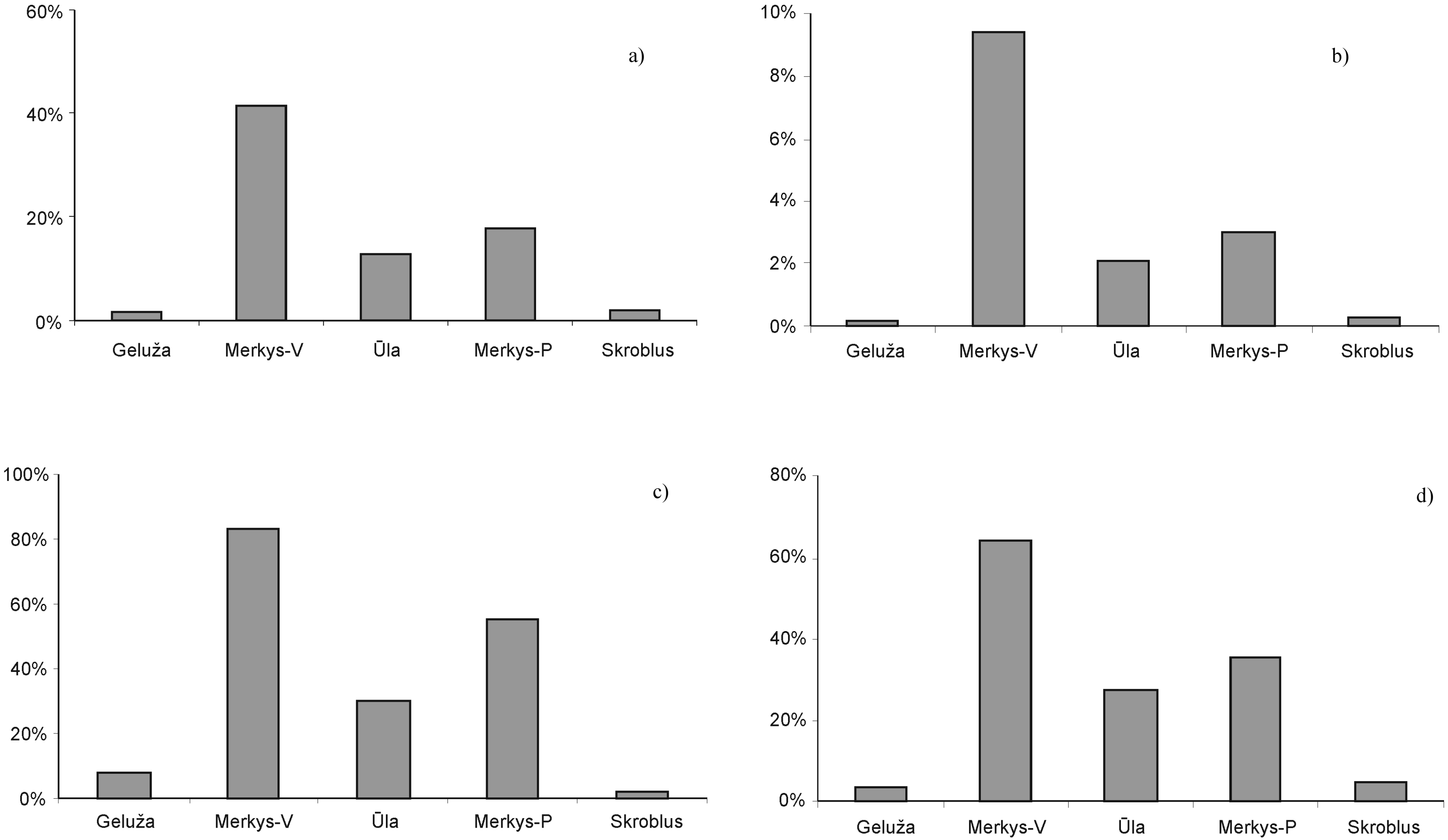

Fig. 5. Retention of COD (a), BOD (b), total nitrogen (c) and total phosphorus (d) in studied subbasins

Table 3. Observed riverine concentrations of water quality constituents at sampling sites (mg l^{-1})

Subbasin	COD_{Cr}		BOD_7		N_{tot}		P_{tot}	
	Min	Max	Min	Max	Min	Max	Min	Max
Geluža	9.0	27.0	1.50	4.3	0.81	2.0	0.026	0.23
Merkys-V	11.0	38.0	0.90	8.7	0.50	3.0	0.040	0.56
Ūla	9.2	25.0	1.50	3.5	1.10	1.7	0.080	0.16
Merkys-P	11.6	40.0	0.90	7.5	0.60	3.4	0.040	0.23
Skroblus	8.0	28.0	0.60	5.2	0.05	2.5	0.023	0.20
Standards*	Good	Bad	Good	Bad	Good	Bad	Good	Bad
	undefined		≤3.0	>4.1	≤2.6	>3.9	≤0.11	>0.21

*Particular concentration for water quality evaluation approved in Lithuania

Table 4. Export coefficient estimates (kg ha^{-1} yr^{-1})

Land use	COD_{Cr}	BOD_7	N_{tot}	P_{tot}
Agriculture	90.9	10.6	14.4	0.728
Forest and wetlands	35.5	5.85	1.67	0.173

The results of the analysis are summarized in Table 4. They represent estimated export coefficients from diffuse sources for the average conditions of two land use classes within the basin. The estimated export coefficients for point sources were 24.3, 0.81, 0.19 and 0.041 kg ha^{-1} yr^{-1} for COD_{Cr}, BOD_7, N_{tot} and P_{tot}, respectively. All the coefficients are significant at $p<0.01$. This indicates that the land use categories used as independent variables explained a large proportion of the variability in loadings.

Although a large number of data was taken from monitoring sites, it still represents a relatively small dataset (5 sites) from a statistical perspective. In general more sites are necessary to provide adequate power to the regression analysis approach of estimating export coefficients. For this reason there was no possibility to distinguish between source strength of each individual land use type defined in Table 1. Therefore, the land use of arable land, pastures and meadows as well as urban areas (apart from point sources) were combined into one group designated as agriculture, and the land use of forest and wetlands comprised the other one. The grouping was made by considering the prior knowledge of typical values of pollutant export coefficients derived from small basins with a single dominating land use category (Zobrist and Reichert 2006).

The results showed that the losses from agricultural land of almost all the riverine organic compounds (COD_{Cr}) were higher more than 2.5 times, and the losses of easily degradable (biologically oxidized) organic compounds (BOD_7) were 1.8 time higher than the corresponding losses from forested land. The losses of nitrogen and phosphorus revealed the same comparable pattern. The export from agriculture was higher 9 and 4 times, respectively. This indicates that agricultural land in the Merkys River Basin conditions much higher emission rates of nutrients and organic matter than the natural areas.

4.3. Source apportionment and retention

The relative contribution to the river export by each constituent source was estimated. The comparison between the constituent source apportionment of the basin input and of the river load can give an insight into basin behavior and help to identify the sources that most affect the water quality. The source apportionment estimate for the 5 subbasins in the Merkys River Basin is shown in Fig. 4.

In all the subbasins, the input of organic matter (COD_{Cr} and BOD_7) and nutrients (N_{tot} and P_{tot}) is dominated by agricultural and point sources except the Skroblus subbasin, where forest and wetlands contribute from 60.4 to 93.8% to the total riverine load. Forest areas significantly (53.0–84.2%) contribute to the input of organic matter and phosphorus in the Ūla River as well. The load of all the constituents in the Geluža River is highly influenced (62.6–68.3%) by agricultural sources. Agriculture is also dominating factor in the Merkys River subbasin upstream Varėna town. The nitrogen loads in the Ūla and the Merkys upstream Puvočiai subbasins depend mainly on point source inputs. Point sources contribute from 20 to 56% to the total phosphorus load in each subbasin. The Merkys River stretch in between Varėna and Puvočiai sites is the most distinguished for point inputs of phosphorus.

In general, human activity (agriculture and point sources) in the Merkys River Basin contributes by 73%, 56%, 90% and 78% to the total riverine load of COD_{Cr}, BOD_7, N_{tot} and P_{tot}, respectively. Natural areas (forest and wetlands) contribute to a less extent – by 27%, 44%, 9.5% and 19.4%, accordingly. Atmospheric deposition is responsible for 0.5% of the riverine load of nitrogen and 2.1% of phosphorus.

The contribution of different sources to the total riverine load depends on the inputs and on the ability of a basin to retain organic matter and nutrients during its transport into hydrographic network. The estimate values of retention in each Merkys River subbasin are shown in Fig. 5. The results indicate substantial retention for both nitrogen and phosphorus. In different subbasins the retention varies from 7.6 to 83.5% for N and from 3.4 to 64.4% for P. The total estimated retention (Equation 4) in the Merkys River Basin accounts for 79% of the load for nitrogen and 64% for phosphorus. High levels of retention can be attributed to instream processes. Furthermore, retention in lakes affects the decrease of nutrient transport from each subbasin to the whole river outlet. However, the capabilities to retain organic matter within the basin are rather low. The total retention of organic compounds accounts for 9.7 and 42.3% of the load for BOD_7 and COD_{Cr}, respectively. In particular, easily oxidized organic compounds (measured as BOD_7) are lowly retained (0.2–9.4%) in the basin.

The results revealed that larger basin areas conditioned higher retention. Therefore, due to a longer water residence time and a larger portion of lakes the highest retention of constituents was estimated in the large Merkys River subbasin located upstream Varėna town.

5. Discussion

The MESAW model based on multiple regression methodology was adopted in this study to estimate source apportionment, retention and export coefficients of organic matter and nutrients in the Merkys River Basin having heterogeneous land use types.

The estimated export coefficients of BOD_7, N_{tot} and P_{tot} for agriculture and forest land use agree with published values (McFarland and Hauck 1999; Grizzetti *et al.* 2005; Šileika *et al.* 2006; Shrestha *et al.* 2008; Šmitienė 2008; Vassiljev *et al.* 2008). However, a very limited information on organic matter export as regards COD was available. The reported emission rates (Wallace *et al.* 1997; Shrestha *et al.* 2008) were less compared to those obtained in this study. The differences can be attributed to the specific Basin characteristics for loading and storage of organic matter. The Merkys River flows along a hilly forested area with highly permeable soils. A low water-holding capacity along with the processes of breakdown of forest litter and podzolization conditions higher release of soluble organic compounds into water. Moreover, agriculture and point inputs considerably contribute to increased emissions of COD (Fig. 4a).

Low overall contribution (9.5%) from forested areas for N_{tot} was estimated in the Basin. From this point of view the Merkys River Basin has not been an exceptional area. In Finland, forestry contributes on average 9%, with increasing dominance towards eastern and northern parts of the country (Lepistö *et al.* 2006). "Background" N export from forests in Finland contributes 27% on average; in northern basins it may contribute from 40% up to 90% of the total load. The corresponding N export from the Skroblus subbasin in the Merkys Basin having a large proportion of forest (>90% of the total area) contributed by 80.7%.

Although the Merkys River Basin is considered as lowly influenced by human activity, the range of measured concentrations of BOD_7 and P_{tot} (Table 3) indicates the causative link to the activity. The activity does not cause persistent excess of any river pollutant, nevertheless, the results reveal that agriculture sensibly affects the load of BOD in the Merkys. The point sources mainly contribute to the riverine load of nitrogen and phosphorus.

There are 1693 settlements including Šalčininkai (6558 inhabitants) and Varėna (10387) towns and 19 wastewater treatment plants operating in the Basin. Most settlements are situated beside the Merkys River and its tributaries. Eight settlements with more than 500 residents each have no wastewater treatment plants installed. The housing of about 43% of population living in the Basin has not been connected to wastewater treatment facilities (Nemuno upių baseinų... 2007). Therefore, the stream water in the upper and middle reaches of the Basin (upstream Varėna town) has been affected by the discharges from Jašiūnai, Matuizos, Valkininkai, Vydeniai, Senieji Trakai, Rūdiškės, Eišiškės, Dargužiai, Baltoji Vokė, Rūdninkai and other settlements.

The Merkys River stretch downstream Varėna town receives the inflow from the Vardaunia, Derežnyčia, Derežna, Grūda and Ūla tributaries along with the impact from Varėna, Perloja, Mardasavas, Milioniškė, Mantonai, Rudnia, Žiūrai, Kabeliai, Kašėtos and Puvočiai settlements and Grybaulia fish ponds. Due to this, the loads of N and P in the Merkys River downstream Varėna have been affected by point inputs even to a higher extent.

Surprisingly a high degree (33.2%) of contribution from point P sources was estimated in the Skroblus River. It has been supposed that the water quality in the River represents the natural background (reference) conditions. However, this proposition has raised doubts due to the increased P concentrations in the River (Povilaitis 2004, 2006). The results of this study imply that the inputs of phosphorus from Margionys, Kapiniškiai, Rudnia and Dubininkas settlements affect the concentrations. Hence, the decision on the River's fulfilment of reference conditions has to be revised.

In the Nordic-Baltic region the retention of nutrients is generally regarded as high. It has been reported that up to 80% of nitrogen input is retained in river basins (Vassiljev and Stålnacke 2005). In southern Sweden it is estimated that 48% of the nitrogen losses from arable land is removed during the transport to surface waters. The research done in Estonia indicates that 33% of nitrogen and 35% of phosphorus is retained in lakes. The instream retention is lower – 11 and 14%, respectively (Vassiljev and Stålnacke 2005). The study made by Trepel and Palmeri (2002) in Germany shows that nitrogen removal efficiency in surface flow wetlands varies between 22 and 77%.

There was no possibility to distinguish between the retention in lakes and rivers in this study. Nevertheless, the obtained results revealed a high total retention of nutrients (79% N and 64% P) in the Merkys River Basin. The upper and middle reaches of the Basin are distinguished by the highest retention potential. It is most likely that a lot of lakes and ponds situated in the area determine the retention. Nutrient retention in the river network also contributes. This assumption can be supported by the results obtained in Finland. It has been reported (Lepistö *et al.* 2006) that, of the total N input to Finnish river-systems, 0% to 68% is retained in surface waters, with a mean retention of 22%. The highest retention of N (36–61%) was observed in basins with the highest lake percentages. The lowest retention (0–10%) of N was in basins with practically no lakes.

Nitrogen retention is the effect of several biogeochemical and physical processes, including plant uptake, denitrifcation and sedimentation. There is no doubt that lakes act as nutrient sinks. Regarding riverine retention the most important factors are assimilation by algae and aquatic macrophytes and especially gaseous losses via denitrification. Phosphorus is removed by adsorption onto streambed sediments, sedimentation and through uptake by algae and aquatic macrophytes. The adsorption onto bed sediments is regarded to be the major mechanism for P retention.

6. Conclusions

1. The approach based on export coefficients is very useful for estimating the total annual loads of constituents (organic matter and nutrients) to a water body from diffuse sources and therefore serves as an important tool for source apportionment, particularly in the circumstances when limited data are available for assessment.

2. The MESAW model showed to be a simple but reliable tool for simultaneous estimation of sources and retention in the Merkys River Basin due to a simple structure of the model and the fact that information from all water quality monitoring sites is used in an optimal way.

3. Agriculture and point sources account for 73% of COD, 56% of BOD, 90% of N_{tot} and 78% of P_{tot} load measured in the Merkys River. Forest and wetlands contribute from 9.5 to 44% to the corresponding load. Atmospheric deposition is responsible for 0.5% and 2.1% of the riverine load of N_{tot} and P_{tot}, respectively.

4. The retention in the Merkys River Basin was found to be high for nitrogen (79%) and phosphorus (64%), however, it showed to be low for organic matter (9.7% BOD and 42.3% COD).

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SKIRTINGŲ ŠALTINIŲ POVEIKIS BIOGENINIŲ IR ORGANINIŲ MEDŽIAGŲ PERNAŠAI IR SULAIKYMUI MERKIO UPĖS BASEINE PIETŲ LIETUVOJE

A. Povilaitis

S a n t r a u k a

Įgyvendinant vandensaugos uždavinius turi būti įvertintas konkretaus upės baseino vandens taršos lygis ir numatytos priemonės, padėsiančios pasiekti gerą būklę. Kiekvienos upės baseinas yra sudėtinga ekosistema, kurioje susipina gamtiniai ir antropogeniniai veiksniai. Jie veikia kompleksiškai, todėl analizuojant vandens terpėje migruojančias medžiagas sunku įvertinti kiekvieno jų įtaką.

Gamtinių ir antropogeninių veiksnių poveikiui biogeninių ir organinių medžiagų srautams bei jų sulaikymui Merkio upės baseine įvertinti buvo pritaikytas statistinis MESAW modelis. Jis pagrįstas emisijos koeficientų nustatymu įvertinant baseino žemėnaudą, taškinius taršos šaltinius ir atmosferines iškritas. Taikant netiesinės regresijos metodus nustatytas skirtingų veiksnių poveikis upės vandens kokybei.

Rezultatai parodė, kad antropogeninių šaltinių poveikis sudaro 73 % ir 56 % (pagal $ChDS_{Cr}$ ir BDS_7) bendro pernešamo organinių medžiagų kiekio Merkio upėje. Žmogaus veikla lemia 90 % pernešamo metinio bendrojo azoto ir 78 % bendrojo fosforo kiekio. Miško poveikis biogeninių ir organinių medžiagų srautams sudaro nuo 9,5 % iki 44 %. Bendrojo azoto ir bendrojo fosforo sulaikymas upės baseine siekia 79 % ir 64 %. Organinių junginių sulaikymas mažas – 9,7 % pagal BDS_7 ir 42,3 % pagal $ChDS_{Cr}$.

Reikšminiai žodžiai: biogeninės ir organinės medžiagos, šaltinių pasiskirstymas, medžiagų sulaikymas, MESAW modelis, Merkio upė.

РАСПРЕДЕЛЕНИЕ И ЗАДЕРЖАНИЕ БИОГЕННЫХ И ОРГАНИЧЕСКИХ ВЕЩЕСТВ В БАССЕЙНЕ РЕКИ МЕРКИС В ЮЖНОЙ ЧАСТИ ЛИТВЫ

А. Повилайтис

Р е з ю м е

При решении задач по водоохране должна быть учтена степень загрязненности воды каждого конкретного бассейна реки и намечены меры по улучшению его состояния. Бассейн каждой реки является сложной экосистемой, на которую комплексное воздействие оказывают разные природные и антропогенные факторы, определить влияние каждого из которых довольно трудно. Для оценки воздействия природных и антропогенных факторов на потоки биогенных и органических веществ и их задержание в бассейне реки Меркис была применена статистическая модель MESAW, основанная на определении коэффициентов эмиссии. Результаты показали, что воздействие антропогенных источников составляет 73% общего объема химического потребления кислорода (ХпК), 56% биохимического потребления кислорода (бпК), 90% общего количества азота и 78% общего количества фосфора, измеренных в реке. Воздействие лесов и болот на поток биогенных и органических веществ составляет от 9,5% до 44% общего объема веществ. Было установлено, что в бассейне реки Меркис задерживается много азота (79%) и фосфора (64%) и мало органического вещества (9.7–42.3%).

Ключевые слова: биогенные вещества, органическое вещество, распределение источников, задержание веществ, модель MESAW, река Меркис, Литва.

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