



Lina BAGDŽIŪNAITĖ-LITVINAITIENĖ

**RESEARCH AND ASSESSMENT OF CHANGES
IN BIOGENIC SUBSTANCES IN THE WATER OF
RIVERS**

Summary of Doctoral Dissertation

**Technological Sciences, Environmental Engineering and
Landscape Management (04T)**

0000

Vilnius „Technika“ 2005

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

Lina BAGDŽIŪNAITĖ-LITVINAITIENĖ

**RESEARCH AND ASSESSMENT OF CHANGES
IN BIOGENIC SUBSTANCES IN THE WATER OF
RIVERS**

Summary of Doctoral Dissertation

Technological Sciences, Environmental Engineering and
Landscape Management (04T)

Vilnius „Technika“ 2005

Doctoral dissertation was prepared at Vilnius Gediminas Technical University in 2001 – 2005

Scientific Supervisor

Assoc Prof Dr Antanas LUKIANAS (Vilnius Gediminas Technical University, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

The Dissertation is being defended at the Council of Scientific Field of Environmental Engineering and Landscape Management at Vilnius Gediminas Technical University:

Chairman

Prof Dr Habil Dmitrijus STYRO (Vilnius Gediminas Technical University, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

Members:

Prof Dr Habil Brunonas GAILIUŠIS (Lithuanian Energy Institute, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

Prof Dr Habil Donatas BUTKUS (Vilnius Gediminas Technical University, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

Habil Dr Saulius VAIKASAS (Lithuanian University of Agriculture, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

Assoc Prof Dr Petras PUNYS (Lithuanian University of Agriculture, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

Opponents:

Prof Dr Habil Algimantas ČESNULEVIČIUS (Vilnius University, Geography – 06P)

Assoc Prof Dr Valentinas ŠAULYS (Water Management Institute of Lithuanian University of Agriculture, Technological Sciences, Environmental Engineering and Landscape Management – 04T)

The dissertation will be defended at the public meeting of the Council of Scientific Field of Environmental Engineering and Landscape Management in the Senate Hall of Vilnius Gediminas Technical University at 10 p. m. on 16 December 2005.

Address: Saulėtekio al. 11, LT-10223 Vilnius-40, Lithuania

Tel. +370 5 274 49 52, +370 5 274 49 56, fax +370 5 270 01 12,

e-mail doktor@adm.vtu.lt

The summary of the doctoral dissertation was distributed on 00 January 2005

A copy of the doctoral dissertation is available for review at the Library of Vilnius Gediminas Technical University (Saulėtekio al. 14, Vilnius, Lithuania)

VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Lina BAGDŽIŪNAITĖ-LITVINAITIENĖ

**BIOGENINIŲ MEDŽIAGŲ KAITOS UPIŲ
VANDENYJE TYRIMAI IR ĮVERTINIMAS**

Daktaro disertacijos santrauka

Technologijos mokslai, aplinkos inžinerija ir kraštotvarka (04T)

Vilnius „Technika“ 2005

Disertacija rengta 2001 – 2005 metais Vilniaus Gedimino technikos universitete.

Mokslinis vadovas

doc. dr. Antanas LUKIANAS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T).

Disertacija ginama Vilniaus Gedimino technikos universiteto Aplinkos inžinerijos ir kraštovarkos mokslo krypties taryboje:

Pirmininkas

prof. habil. dr. Dmitrijus STYRO (Vilniaus Gedimino technikos universitetas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T).

Nariai:

prof. habil. dr. Brunonas GAILIUŠIS (Lietuvos energetikos institutas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T),

prof. habil. dr. Donatas BUTKUS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T),

habil. dr. Saulius VAIKASAS (Lietuvos žemės ūkio universitetas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T),

doc.dr. Petras PUNYS (Lietuvos žemės ūkio universitetas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T).

Oponentai:

prof. habil. dr. Algimantas Česnulevičius (Vilniaus universitetas, geografija – 06P),

doc. dr. Valentinas Šaulys (Lietuvos žemės ūkio universiteto Vandens ūkio institutas, technologijos mokslai, aplinkos inžinerija ir kraštovarkla – 04T).

Disertacija bus ginama viešame Aplinkos inžinerijos ir kraštovarkos mokslo krypties tarybos posėdyje 2005 m. gruodžio 16 d. 10 val. Vilniaus Gedimino technikos universiteto Senato posėdžių salėje.

Adresas: Saulėtekio al. 11, LT-10223 Vilnius-40, Lietuva.

Tel. +370 5 274 49 52, +370 5 274 49 56, faksas +370 5 270 01 12,

el. paštas doktor@adm.vtu.lt

Disertacijos santrauka išsiuntinėta 2005 m. sausio 00 d.

Disertaciją galima peržiūrėti Vilniaus Gedimino technikos universiteto bibliotekoje (Saulėtekio al. 14, Vilnius, Lietuva)

VGTV leidyklos „Technika“ 0000 mokslo literatūros knyga

Description of the research problem

Expanding human economic activity has an increasing impact on nature. Increasing exploitation of natural resources disturbs the equilibrium of natural processes.

Lithuania is rich in water resources: it has 772 rivers longer than 10 km, 2850 lakes bigger than 0.5 ha, 434 ponds with the surface area of each exceeding 5 ha. It is essential to protect these natural assets from pollution and irrational exploitation. Water protection is one of those environmental fields that cause great concern.

Implementing the restructurisation of the national economy it is important to adopt preventive measures that forward the improvement of the quality of all surface and underground waters, as they to a large extent contribute to the cleanness of the Curonian Lagoon and the Baltic Sea.

In 1995, by expressing its wish to accede to the EU, Lithuania undertook the obligation to harmonise its policy, including water policy, with the EU legal requirements. Moreover, it is necessary to take account of Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy. Its purpose is to establish a framework for the protection of inland surface waters, coastal waters and groundwater. It is also necessary to follow the requirements of Directive 91/676/EEC. The objective of this directive is to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution. Currently agriculture in Lithuania is a fourth important branch of economy (preceded by industry, retail trade, and transport and communication) and economic interests often outweigh the environmental ones. Thus the EU Water Framework Directive demands to produce enough information in sufficient detail on the actual status of every river basin. With regard to all river basins, the information is necessary on land use, farms, pollution by nitrogen and phosphorus compounds from point sources and precipitation. Besides, this directive provides for the optimisation of sampling frequencies and demands to ensure the level of reliability and precision. Sampling frequencies is selected which take account of the variability in parameters resulting from both natural and anthropogenic conditions. The times at which monitoring is undertaken shall be selected so as to minimize the impact of seasonal variation on the results, and thus ensure that the results reflect changes in the water body as a result of changes due to anthropogenic pressure.

Object of the research

The thesis analyses the concentration of biogenic substances and their changes in the water of 10 rivers located in different hydrologic areas of Lithuania.

Topicality of the problem

To forecast and monitor the ecological status of aquatic ecosystems, major attention should be paid to finding out factors that reduce concentrations of biogenic substances by assessing long term trends both as a result of changes in natural conditions and through anthropogenic activity. Concentrations and inflow of the main biogenic substances (mineral nitrogen and mineral phosphorus) in natural geosystems are influenced by physical-geographical conditions, climate and anthropogenic activity.

The analysis of the changes in the river quality should be carried out sticking to the principle of a basin as this is the only way to find out the factors that have influence on the upward trend in the concentration of biogenic substances and on their interaction.

Aim and tasks of the work

To define the relation between the water yield in rivers and changes in biogenic substance concentrations taking account of physical-geographical conditions of and anthropogenic changes in river basins of Lithuania; the analysis covers the last three decades (1974–2003 m.). This will create potential for foreseeing further trends of changes in hydro-chemical status of water. The following tasks were solved to achieve the above-mentioned goal:

- carrying out of the analysis of the data of river flow and biogenic substance concentrations:
 - assessment of the dependence of changes in biogenic substance concentrations on debits in the years of varying water yield;
 - finding out of patterns of exceeding maximum permitted levels of biogenic substances;
- finding out of the trends of changes in point and diffuse pollution in 1974–2003 in the basins of the rivers concerned and assessment of a possible impact on the chemical status of surface waters;
- comparison of methods for calculation of biogenic substance flows;
- finding out of opportunities for optimisation of the number of water samples based on analytical and experimental tests;
- analysis of changes in biogenic substances in the longitudinal profile of the Žeimena river with the help of ATV-DVWk water quality model.

Scientific novelty

Assessment of long term changes in levels of biogenic substances and their amount, with regard to water yield and intensity of anthropogenic activity, in the water of different hydrological areas of Lithuania. Comparative analysis of methods for calculation of biogenic substance flows. Establishment of possibility to reduce frequency of water sampling.

ATV-DVWk water quality model was for the first time in Lithuania used for forecasting of the changes in the water quality in the longitudinal profile of a river.

Practical value

The obtained research results extend an analysis of long term changes in levels of biogenic substances with regard to water yield and intensity of anthropogenic activity. Finding out of methodical peculiarities of calculation of biogen flows. Recommendations on possibilities to reduce sampling frequency. ATV-DVWk modelling programme that is widely used in Europe was used under Lithuanian conditions.

Defended propositions

Results of the thesis were presented in 3 international conferences and 4 national scientific conferences.

Three articles on the subject of the thesis were published in scientific publications.

The scope of the scientific work

The thesis consists of an introduction, five chapters, conclusions, a list of author's publications and references. Arbitrary marks and symbols are also included. The thesis text is given in 133 pages, which contain 40 figures and 29 tables. The list of references contains 114 entries.

Description of the thesis

1. Review of literature

The analysis of scientific works enables to state that researched on hydrochemical changes in the river water and its dependence on possible impacting factors in most cases were short-term and covered only individual impacting factors. Changes in the level of biogenic substances show a complex relation of natural and anthropogenic processes in the river basin. The impact of water yield in rivers has insignificant impact on water pollution.

2. Research object and methodology of research

Ten rivers (the Merkys, the Šventoji, the Žeimenė, the Neris, the Lėvuo, the Šešupė, the Venta, the Akmena, the Jūra, the Šešuvis) located in different hydrologic areas of Lithuania were chosen for the researches. They are basins with distinct anthropogenic activity and physical-geographical conditions.

Assessment of changes in anthropogenic activity. Changes in human economic activity were assessed taking account of total industrial production growth and agricultural production intensity, as well as use of fertilisers.

Assessment of changes in water yield. To define the change, daily hydrological characteristics were used throughout the period of research. Annual water yield of rivers was assessed taking account of the average annual

debit, annual flow volume and modular factor and drawing integral curves of deviation of modular factors of the annual flow from the average value. Statistical parameters of the period of the research and flow distribution by seasons were calculated. Correlation coefficient was calculated by defining the dependence of the levels of biogenic substances on water debits on the day of sampling throughout the period of the research; besides, relations between concentrations and modular factors in the periods of different water yield were determined.

Statistical analysis of characteristics under research. The analysis was carried out with the help of the Statistical Package for the Social Sciences. The statistical programme carried out dispersion analysis applying linear regression model. Monofactorial dispersion was applied when the change in biogenic substances was being analysed with regard of time and two stages of the intensity of anthropogenic activity (1974–1990 and 1991–2003). Multiple regression in joint regression model was applied when analysing all factors related to the change in biogen concentrations, i.e. a debit of a sampling day, periods of different intensity of anthropogenic activity, seasons and water yield phases.

Methods for calculation of biogenic substance flows. Four methods were applied for calculation of biogenic substance flows. The first method was applied for calculation of biogenic substance flows when the concentration of biogens recorded during one measurement per month was available, while the volume of river flow was calculated taking account of the monthly average debit. The second method was used to find out the arithmetical average of the levels of biogens calculated from the data of two adjacent measurements, while the volume of river flow was calculated taking account of the average debit throughout the period between two adjacent dates of water samplings. The third method was used to calculate biogenic substance flows when the levels of biogens determined during one measurement per month were available, while the volume of river flow was calculated taking account of the average debit throughout the period which was presumed to start 15 days before the date of sampling and 15 (or 16) days after it.

The fourth method was used to calculate the flows of biogenic substances using the following formula:

$$S_4 = \frac{Q_1 t \left(C_1 + \frac{\Delta C}{n} j \right) + Q_2 t \left(C_1 + \frac{\Delta C}{n} j \right) + Q_3 t \left(C_1 + \frac{\Delta C}{n} j \right) + \dots + Q_j t \left[C_1 + \frac{\Delta C}{n} j \right]}{1000}, \quad (2.1)$$

where: Q_j – the average daily debit, m^3/s ; t – time, s ; C_1 – the primary level of biogens during the period of research, mg/l ; ΔC – the difference between the final and the initial levels, mg/l ; j – the number of the day row, 1, 2 ... (n – 1); n – a number of days during the period of research;

The fourth method (the same as the second) is based on the principle of linear interpolation. All intermediate values of biogen concentration in the period between two adjacent measurements were calculated based on the presumption that the change in the concentration was linear throughout that period. This method was chosen for the comparison with the above-mentioned three projects.

Finding possibilities to reduce the frequency of sampling. To find possibilities to reduce the frequency of sampling, mathematical statistics methods were used. Statistical parameters of biogen concentrations – variation coefficients when the data of 12, 8, 6 and 4 measurements per year are available – were calculated. Based on these data and analysing the change in biogen concentrations, when a number of measurements is not more than 12 per year, the appropriate months were selected considering the volume of flow: January, March, April, May, July, October, November, and December when a number of measurements is 8; April, May, July, October, December, and January when the data of 6 measurements are being analysed; April, July, October, and December when the data of 4 measurements per year are analysed.

Experimental tests. Experimental tests were carried out to assess the dependence of biogenic substances on the water yield of rivers. In the summer 2002 (July, August) and the spring (March, April) and summer (May, June, July, August) 2003 the frequency of sampling in 4 rivers located in the Southeast Lithuania was increased to 3 times per month.

Mathematical modelling of water quality in the longitudinal profile of the Žeimena river was carried out with the help of ATV-DVWk model. The model analyses the section of the Žeimena 78.6 to 13.7 km from the river mouth.

Calculation of nitrogen compounds and changes in debits in the longitudinal profile in the spring, summer, autumn and winter was carried out with the help of ATV-DVWk.

3. Changes in biogenic substance concentrations and the influencing factors

Changes in anthropogenic activity in 1974–2003

The recent three decades were unsettled with regard to Lithuanian industry, agriculture, and urbanisation. Analysing changes in total industrial production two distinct stages could be singled out, i.e. before 1990 and after it. Before 1990, industrial production was undergoing rapid growth, while starting with 1991 the growth slowed down. After 1994 industrial production started slightly growing. Changes in intensity of agriculture during the researched periods are evidenced by agricultural areas and a number of animals and poultry in all category farms. According to the dynamics of changes in human

economic activity, for further analysis the period was divided into 2 stages: before 1990 and after 1991.

Patterns of changes in water yield

The annual flow is the main characteristics indicating total water yield and potential water resources of a river basin in question. Distribution of the annual flow of every river depends on climatic, physical-geographical and morphological conditions of a river basin. Drawing of accumulated integral curves revealed the phases of water yield of the rivers in question. In most rivers, a low water yield was seen in 1974–1979, except the Šventoji, the Merkys, and the Žeimena where the phase of a low water yield continued till 1997, 1986 and 1989 respectively. The phase of a high yield of most rivers started in 1980 and lasted till 2003.

The influence of the intensity of human agricultural activity

Reasons for changes in concentrations of biogenic substances are multiple and interrelated. Naturally, human agricultural activity is one of the key elements of the influence. At the beginning, all the researched period was divided into three stages: 1974–1990, 1991–1996, 1997–2003, so that comparison of the change in biogen concentrations before and after a radical economical and political break were possible. The stage when the intensity of anthropogenic activity was lowest which resulted in lower pollution, i.e. 1991–1996, was chosen as a reference. Monofactorial dispersion analysis showed that there was no need to divide the researched period into 3 periods, as the reference period 1991–1996 and the period 1997 to 2003 had no significant differences. This means, that the significant economic break in 1990–1991 has impact on the last years, too. Therefore, further only two stages of different intensity of anthropogenic activity will be analysed: before 1990 and after 1991.

During the first stage the highest amplitude of changes in nitrate concentrations was recorded in the Akmena (0,030 to 4,858 mg/l), the Venta (0,044 to 3,964 mg/l) and the Šešuvis (0,040 to 2,845 mg/l) (Figure 3.1). In other rivers this amplitude was slightly lower - 0,00 to 2,86 mg/l. In the second stage, the amplitude of concentration changes in some rivers (the Neris, the Šventoji, the Jūra, the Akmena) became lower, however, in most rivers it increased. Analyses of the trends of samples that exceeded the maximum permitted level showed that in the rivers of the Southeast Lithuania concentration of nitrates in 1974 to 1990 was only 0–3%, while in 1991 to 2003 it went up to 4%. In the rivers of the Central Lithuania, in the first stage nitrates exceeded the maximum permitted level by 0–1%, while in the second stage by 21–25%. In the rivers of the Western Lithuania, a number of samples exceeding the maximum permitted level amounted to 14 % (of the total number of samples), while after 1991 it amounted to 4– 28%.

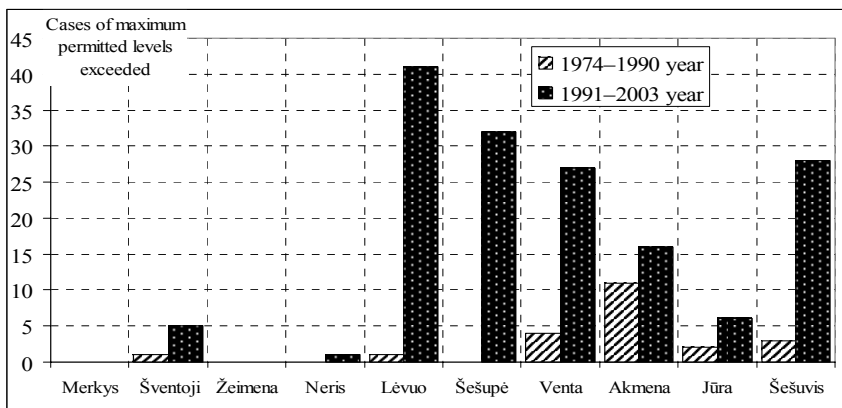


Figure 3.1. The number of times the nitrate concentrated exceeded the maximum permitted level

The maximum permitted levels of phosphates were more often exceeded in the first stage (1974 to 1990). In the rivers of the Central Lithuania, the number of samples exceeding the maximum permitted level amounted to 69–72% of the total number of samples. In the water of other rivers in the first stage the maximum permitted level was often exceeded, too – in the rivers of the Southeast Lithuania this indicator was 35–65%, while in the rivers of the Western Lithuania it was 14–66%.

In the second stage, exceeding of the maximum permitted level reduced but still was frequent. The highest one was recorded in the rivers of the Central Lithuania – in the Šešupė it amounted to 70%, it was also rather frequent in other rivers – in the Neris it amounted to 47%, in the Lėvuo it amounted to 32%. Exceeding was rarer in the Žeimena, the Šventoji, the Jūra – 3, 6, and 8 % accordingly.

Analysis of dependence of biogenic substance concentrations on the water yield of rivers

Analysis of the dependence of concentrations of nitrates, mineral nitrogen, and phosphates on the water yield during two stages of distinct intensity of economic activity reveals that in the first stage the strongest relation between mineral nitrogen and phosphates and the water yield was recorded in the Akmena (correlation coefficients were $-0,57$ or $-0,8$ accordingly) and between mineral nitrogen and the water yield in the Merkys (correlation coefficient was $-0,45$). The trend of the decrease in concentrations of mineral nitrogen with the increase in the water yield was noticed in the waters of other rivers (except the Neris and the Žeimena) but correlation coefficients were low: varying from –

0,09 to -0,31. The correlation relations of the dependence of phosphate concentration on the water yield is even weaker – correlation coefficients vary from 0,14 to -0,31. In the second stage, the strongest relation between mineral nitrogen and the water yield was recorded only in the Merkys and the Žeimena; correlation coefficients were -0,47 and 0,46 accordingly; in other rivers it varied from 0,09 to -0,47. The strongest relation between phosphates and the water yield was recorded in the Merkys (correlation coefficient was 0,45). Thus, although in the second stage human economic activity was less intensive, an insignificant trend of increase in concentration of mineral nitrogen and decrease in phosphates with the increasing water yield was observed. Dependences of biogenic substance concentrations on the water yield of rivers in low and high water yield phases set taking account of differential integral curves of river flow in the stages of anthropogenic activities of different intensity (1974–1990 and 1991–2003) were found out.

As this analysis integrates many potential factors influencing changes in biogen concentrations, these factors are analysed as monofactorial parameters, because then the significance of the interaction among the parameters could not be established.

To find out the patterns of hydrological regime and biogenic substance concentrations, the probability of the annual debit in the years of different water yield was calculated by singling out the most characteristic debits in the years of high (probability up to 33%), medium (probability up to 66%), and low (probability higher than 66%) water yield.

In the rivers of the Southeast Lithuania, the dependence of nitrogen compounds on the water yield became vivid when the water yield was high. Of the researched rivers of the Central Lithuania, in the Šešupė the change in nitrate and mineral nitrogen concentrations when the water yield was high depended on the river debit. In the rivers of the Western Lithuania, correlation coefficients revealing a relation between nitrogen compounds and water yield were low (the maximum value R in the Venta in the year of high water yield reached only 0,53). Phosphate concentrations have no influence on changes in water yield.

Results of modelling of changes in biogenic substances in longitudinal profile

With the help of ATV-DVWk, concentration of ammonium ions and nitrates in the Žeimena section 78,6 to 13,7 km (distance from the mouth) in 2000-2001 hydrological years was simulated. Modelling in 2000-2001, without singling out seasons or months and without having a possibility to introduce intermediate real values of biogen concentrations that would enable to get more precise results, showed that simulated biogen concentrations differ from the real

ones by 10 to 76 %. Four month of the summer season singled out by very close values of simulated concentrations of nitrates and ammonium ions and the real values found out by measurement. The same as in the summer season, in autumn and winter (October, November, December, January, February) simulated concentrations of biogenic substances in question to a large extent differed from the values obtained by direct measurement. The difference reached as much as 38%. The obtained results enable to make a conclusion that concentrations of biogenic substances found out with ATV-DVWk corresponded to the values obtained by direct measurement in the summer season. This could be explained by a low change in debit and a vegetation period of plants during which nitrogen compounds were accumulated in biota.

4. Comparison of methods for calculation of biogen flows in the years of different water yield

The thesis analyses the methods for calculation of biogenic substance flows in the spring and summer seasons of years of different water yield; after their comparison, absolute differences between individual methods and relative values in percentage were calculated. Figure 4.1. gives mineral nitrogen flows calculated using different methods in the spring season of the year of high water yield.

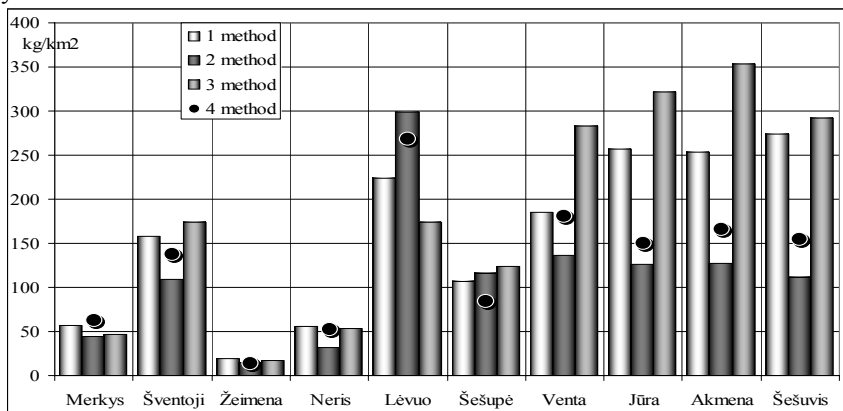


Figure 4.1. Flows of mineral nitrogen calculated applying different methods in the spring season of the year of high water yield.

The given data reveal that the values of mineral nitrogen flows calculated with the fourth method are close to the values calculated with the second method. Flow values differed from 8 to 27%. The values of flows of the Central and Western Lithuania calculated using the third method were most distant from the results of the fourth method. In the years of medium water yield of the

rivers of the Southeast Lithuania, the values of mineral nitrogen flows obtained using the fourth method were closest to the values calculated using the third method. They differ from 4,75 to 37,9 kg/km², while the flows of substances researched in the rivers of the Central and Western Lithuania calculated using the fourth method are closest to the first or second method. In the years of low water yield, the flows of substances researched in the rivers of all hydrological areas are closest to the results of the second method. Calculation of the flows of mineral nitrogen in the summer seasons using all the four methods in the years of various water yield revealed that the values obtained using the fourth method were closest to the values calculated using the second method.

Comparing the values of phosphate flows calculated using the fourth method with the results of the rest three methods, it turned out that in the years of different water yield in the spring season in all hydrological areas of Lithuania they were closest to the flows calculated using the first method. In the years of high water yield, the values of substance flows in the rivers of the Southeast Lithuania varied 0,6 to 5,5 %, in the rivers of the Central Lithuania – 13 to 48 %, while in the Western Lithuania – 3 to 15 %. In the years of medium water yield, the values of phosphate flows calculated using the first and fourth methods in the rivers of the Southeast Lithuania differed 7 to 12 %, in the rivers of the Central Lithuania – about 7%, while in the rivers of the Western Lithuania – 3 to 6%. In the years of low water yield in the rivers of the Southeast Lithuania, the values of phosphate flows varied 1 to 43 %, in the rivers of the Central Lithuania – up to 31%, in the rivers of the Western Lithuania – up to 27%. The analysis of biogenic substance flows calculated using three different methods in the years of high, medium and low water yield in the spring and summer seasons and comparison of the obtained results with the method, that was mathematically most precise, allow making conclusion that the values of mineral nitrogen were closest to the values obtained using the first (when one value of concentrations per month is available and when the flow volume is calculated taking account of the monthly average debit) and the second (when the arithmetical average value of two adjacent concentrations is available and when the flow volume is calculated taking account of the average debit throughout the period between two adjacent dates of sampling) method.

The values of phosphate flows, comparing the three methods with the fourth one, reveal that in the spring season they are closest when calculated using the first method, while in the summer season – using the second method.

To prove these conclusions we analysed the data of biogenic substances calculated using different methods and taking account of experimental tests (when the frequency of water sampling is up to 3 times). Bigger differences between the flows of mineral nitrogen calculated using different methods were

recorded in the Šventoji and the Neris. Comparing the values of the fourth method with the values of other three methods we found out that the lowest relative difference in the Šventoji was recorded between the first and the fourth method (up to 14%), while in the Neris the difference between the second and fourth method amounted to 27%. Analysis of the data of mineral nitrogen flows of these rivers in the summer season revealed that the closest results of all calculation methods were recorded between the second and fourth methods – the relative differences are 5,9% and 12,8% accordingly. Analysis of differences in phosphate flows calculated using different methods showed that in the spring season the biggest differences between the methods were recorded in the Šventoji (differenced reached 47,86%), while the lowest in the Merkys (differences did not exceed 5,86%). In the summer season the highest difference between the methods was recorded in the Šventoji (up to 24,75%), while the lowest in the Žeimena (not exceeding 7,26%). Analysis of the data using different methods revealed that in the spring season the values of flows calculated using the second method were close to the value calculated using the fourth method, while no clear pattern was seen in the summer season, although the results of the first method were usually close to the results of the fourth method that was mathematically most precise. When 3 water samples per month were available, the values of mineral nitrogen in the Žeimena and Merkys in the spring season, calculated using different methods, hardly differed (0,61 to 1,69 kg/km² and 0,31 to 3,97 kg/km² accordingly). The lowest differences of the flows in the Žeimena were recorded between the fourth and second method, while in the Merkys – between the fourth and third methods (Figure 4.2).

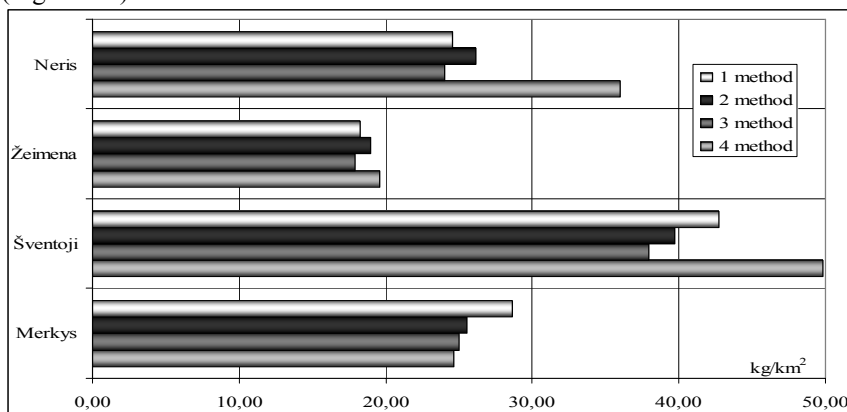


Figure 4.2. Changes in mineral nitrogen in the spring season of 2003 when 3 water samplings were available

However, completely opposite results were obtained analysing the data in the summer season. The values of mineral nitrogen flows in the Merkys calculated using the fourth method were closer to the first method, while in the Žeimena they were closer to the third method.

Values of phosphate flows in the spring season were closest to the second and fourth methods.

To assess the level of information and precision of more frequent sampling, the values of biogenic substance flows were compared and calculated using different methods and with one or three monthly sampling data available.

5. Possibilities to optimise the number of water samplings

Optimisation of a number of river water samplings is a relevant issue. Although in Lithuania a national programme of monitoring for the year 2005-2010 has been drafted and approved by resolution of the Government (7 July 2005, No. 130), which provides 12 samplings per year, the problem related to the optimisation of a number of samplings, taking account of financial and informative significance, still remains.

Coefficients of variations in mineral nitrogen concentrations underwent the lowest changes in the Lėvuo (0,81 iki 0,88), in the Venta – 0,73 to 0,82, in the Akmena – 0,45 to 0,54, while the highest changes in variation coefficients were recorded in the Žeimena – 0,47 to 0,61.

The analysis of the changes in phosphate concentrations revealed that the lowest fluctuation in variation coefficients was recorded in the Lėvuo – they were 1,37 to 1,38; while the greatest fluctuations were recorded in the Šventoji – 0,50 to 0,86.

The comparative analysis of variation coefficients was carried out, i.e. variation coefficients of every river were calculated with 12 water samples per year available – this value was taken as a reference used for the comparison with other variation coefficients when a number of water samplings was lower per year.

A reduced number of water samplings results in the loss of part of information on the water quality. To answer the essential question in which river a number of measurement could be reduced, we based on the criterion that variation coefficients of biogen concentrations obtained using different calculation must be close to each other. The critical value was chosen to be 5%. Figure 5.1 gives the analysis results.

Presuming that the critical value does not exceed 5%, a number of mineral nitrogen sampling could be reduced to 8 only in the Šešupė. Phosphate sampling could be reduced to 8 in the Merkys and the Žeimena, to 6 in the Akmena, to 4 in the Neris, Lėvuo and Šešupė.

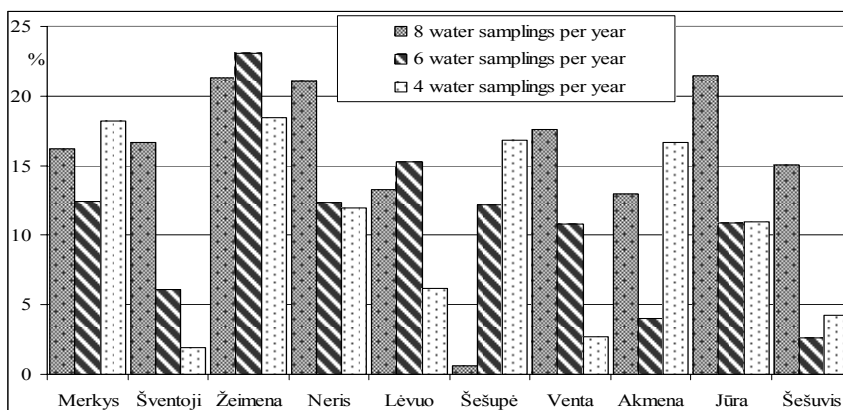


Figure 5.1. Percentage of the ratio of the values of comparison of variation coefficients of mineral nitrogen concentrations with the reference variation coefficient

Conclusions

1. Unevenness coefficients calculated with regard to all rivers in question revealed that the flow in the rivers of the Southeast Lithuania was most even (unevenness coefficients of the flow varied 0,13 to 0,3), it was less even in the rivers of the Western Lithuania (unevenness coefficients of the flow varied (33 to 0,51), while in the rivers of the Central Lithuania it was most uneven (unevenness coefficients of the flow varied 0,4 to 0,53).

2. Multiple regression analysis, assessing the intensity of human economic activity and the water yield (debit changes in 1974-2003 and seasonal changes) revealed that in all researched rivers the relation of biogenic substance concentrations and debits on water sampling days and the intensity of anthropogenic activity was statistically reliable. In all researched rivers, except the Šventoji, the trend of decreasing nitrogen concentration with the increasing debits on the days of sampling was observed, although no close relation was seen. It was determined that phosphate concentration did not depend on the changes in debit values.

3. Analysis of the dependence of biogenic substances on the water yield of rivers during two stages of economic activity of different intensity showed that the strongest relation between mineral nitrogen, nitrates and water yield was recorded in the Akmena, the Merkys and the Neris. Correlation coefficient showing the dependence of nitrate concentrations on the water yield does not exceed 0.46, while concentrations of mineral nitrogen go down with the decrease in the water yield. Correlation relation of the dependence of phosphate concentrations on the water yield is even weaker.

4. Summarising modelling results it could be stated that ATW-DVWk model could be used for the analysis of changes in biogenic substances in the rivers of Lithuania. The difference between the values of biogens obtained during modelling and the values obtained during direct measurement does not exceed 38%. More precise results were obtained when modelling change in biogens in individual seasons.

5. Comparative analysis of the fourth methods used to calculate the flows of biogenic substances in the spring and summer seasons of the years of high, medium and low water yield revealed that flows could be calculated in sufficient precision in the following ways: monitoring of substance concentrations once per month and calculation of the flow volume taking account of the monthly average debit or averaging two adjacent monitorings of biogenic substances and calculating the flow volume taking account of the average debit value throughout the period between two adjacent dates of water sampling.

6. Analysis of both mineral nitrogen and phosphate flows revealed that the change in their values taking account of the seasons was similar to the river flow distribution per year. It was found out that the biggest amount of mineral nitrogen was transmitted in the autumn and winter season. In the rivers of the Southeast Lithuania, on the average 51,7% of the annual value of flows are transmitted in this season; in the Central Lithuania – 51,9%, in the Western Lithuania – 65,4%. The smallest part falls to the summer season. In summer flows in the river in the above-mentioned hydrological areas were 13,7; 13,1 and 7,2 % accordingly. In spring the flows were 34,6; 35,0 or 27,4 % of the annual value accordingly.

7. Comparison of the values of biogenic substances, when the date of two or three monthly samplings were available, revealed that the amplitude of changes in relative differences was very wide and reached up to 100%. Relative differences of mineral nitrogen were lower in spring, while those of phosphates were lower in summer.

8. Analysis of changes in variation coefficients of concentrations of biogenic substances throughout the long period of the research, when a number of water samplings per year varied, revealed that, when calculating mineral nitrogen, water sampling only in the Šešupė could be carried out only in characteristic months 8 times per year; in other rivers a number of sampling could not be reduced. To assess changes in phosphates, 8 annual samplings would be sufficient in the Merkys and the Žeimena, 6 times in the Akmena, 4 times in the Šešupė, the Lėvuo and the Neris.

Publications and conferences

Articles in publications included in the list approved by the Department of Science and Studies under the Ministry of Education and Science

1. Bagdžiūnaitė-Litvinaitienė Lina; Lukianas Antanas. Fluctuations of nitrogen and phosphorus compounds concentrations in river water. Water management Engineering, Nr. 25(45), 2004, p. 99-110. (in Lithuanian). ISSN 1392-2335.
2. Bagdžiūnaitė-Litvinaitienė Lina. Change dynamics of biogenic matter in river waters of southeast Lithuania during periods of different wateriness // Journal of Environmental Engineering and Landscape Management, Vilnius Gediminas Technical University, Vol. XII, No. 4, 2004, p. 146-152. ISSN 1648-6897.
3. Bagdžiūnaitė-Litvinaitienė Lina. Fluctuations of mineral nitrogen and phosphate in river water during periods of various wetness. Journal of Environmental Engineering and Landscape Management, Vilnius Gediminas Technical University, Vol. XIII, No. 3, 2005, p. 132-140. ISSN 1648-6897.

Articles included into digests of reports of international conferences held in Lithuania

1. Bagdžiūnaitė-Litvinaitienė Lina. Mineral nitrogen and phosphorus changes in rivers of Lithuania. Youth seeks progress 2003: paper collection of scientific conference of Ph.D students. Lithuanian university of agriculture. Kaunas: Akademija, 2003. p. 338-342. (in Lithuanian). ISBN 9955-9633-2-8.
2. Bagdžiūnaitė-Litvinaitienė Lina; Lukianas Antanas. River flow rate influence on changing concentration of biogenic materials. International scientific conference „Protection and management of water bodies“. October 29, 2004.: Proceedings, 2004. p. 20-26. (in Lithuanian). ISBN 9955-448-28-8.

Articles included in the digests of reports of conferences held by international science organisations in Lithuania

1. Bagdžiūnaitė-Litvinaitienė Lina, Lukianas Antanas. Studies on Biogenic Pollution of Lithuanian Rivers Water. The 6th International Conference. Environmental Engineering. Selected Papers. Vilnius Gediminas Technical University, 2005. p. 319-326. ISBN 9986-05-850-3.

Reports included in the digests of reports of conferences held in Lithuania

1. Bagdžiūnaitė-Litvinaitienė Lina. Priorities in controlling the purification of river waters with regards to waters policy of the European Union. In: Proceedings of the V Conference of Lithuania Junior Scientists „Lithuania without science – Lithuania without future“, held in Vilnius on 21 March, 2002. Environmental protection engineering. (5-osios Lietuvos jaunųjų mokslininkų konferencijos „Lietuva be mokslo - Lietuva be ateities“, įvykusios Vilniuje

2002 m. kovo 21, pranešimų medžiaga: Aplinkos apsaugos inžinerija) Vilniaus: Technika, 2002. p. 78-82 (in Lithuanian). ISBN 9986-05-564-4.

2. Bagdžiūnaitė-Litvinaitienė Lina. Dynamics of concentrations and amount of biogenic substances in the southeastern Lithuanian rivers during the time of minimal flow In: Proceedings of the VI Conference of Lithuania Junior Scientists „Lithuania without science – Lithuania without future“, held in Vilnius on 20 March, 2003. Environmental protection engineering. (6-osios Lietuvos jaunųjų mokslininkų konferencijos „Lietuva be mokslo - Lietuva be ateities“, įvykusios Vilniuje 2003 m. kovo 20, pranešimų medžiaga: Aplinkos apsaugos inžinerija) Vilniaus: Technika, 2003. p.87-95. (in Lithuanian). ISBN 9986-05-645-4.

3. Bagdžiūnaitė-Litvinaitienė Lina. Upių vandens kokybės kaita hidrobiologiniu aspektu // VI-osios Lietuvos jaunųjų hidroekologų konferencijos „Vandens ekosistemų įvairovė, funkcionavimas ir valdymas“, įvykusios Vilniuje 2003 m. spalio 4 - 5d., pranešimų santrauka. (in Lithuanian). ISBN 9986-15-578-0. p. 11-12.

4. Bagdžiūnaitė-Litvinaitienė Lina. Tendencies of biogenic matter concentrations in river waters in the context of anthropogenic activities. In: Proceedings of the VII Conference of Lithuania Junior Scientists „Lithuania without science – Lithuania without future“, held in Vilnius on 25 March, 2004. Environmental protection engineering. (7-osios Lietuvos jaunųjų mokslininkų konferencijos „Lietuva be mokslo - Lietuva be ateities“, įvykusios Vilniuje 2004 m. kovo 25, pranešimų medžiaga: Aplinkos apsaugos inžinerija) Vilniaus: Technika, 2004. p. 403-410 (in Lithuanian). ISBN 9986-05-755-8.

Information of the author

Lina Bagdžiūnaitė-Litvinaitienė was born in Švenčionys on 3 September 1977. In 1999, she graduated from Vilnius Pedagogical University (the speciality of natural sciences). In 2001, she was awarded a Master's Degree at the Faculty of Environmental Engineering of Vilnius Gediminas Technical University. In 2001 – 2005, she was a student of doctoral studies at Vilnius Gediminas Technical University. Since 2001, the author has been working as an assistant at the Department of Hydraulics of Vilnius Gediminas Technical University. In 2004, Lina Bagdžiūnaitė-Litvinaitienė was a trainee at Dresden University of Technology.