

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

Rasa RUMINAITĖ

RESEARCH AND EVALUATION
OF THE ANTHROPOGENIC ACTIVITY
IMPACT ON THE RIVER RUNOFF
AND WATER QUALITY

SUMMARY OF DOCTORAL DISSERTATION

TECHNOLOGICAL SCIENCES,
ENVIRONMENTAL ENGINEERING (04T)



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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Rasa RUMINAITĖ

ANTROPOGENINĖS VEIKLOS ĮTAKOS
UPIŲ NUOTĖKIUI IR VANDENS KOKYBEI
TYRIMAI IR VERTINIMAS

DAKTARO DISERTACIJOS SANTRAUKA

TECHNOLOGIJOS MOKSLAI,
APLINKOS INŽINERIJA IR KRAŠTOTVARKA (04T)



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Introduction

Topicality of the problem

Lately, quite much attention is paid to the researches and assessment of the influence of the anthropogenic activity on the environment and surface water quality, but the water quality of river in karst regions is not investigated and analyzed in such a comprehensive way. In karst areas, various contaminants (organic and mineral fertilizers, pesticides etc.) quite easily get to open waters along with the surface and underground water runoff through subsidence pits and porous ground and these contaminants worsen the river water quality. So in the highly pollution sensitive karst region it is very important to investigate negative changes of the environmental factors caused as a result by the anthropogenic activity.

Object of the work – the Lielupė river basin district (RBD) is an international and the second biggest one in Lithuania, wherein the karst areas covers a large basin territory.

Aim and tasks of the work

The key aim of this work is to evaluate the trends of the anthropogenic activity in the Lielupė river basin district (RBD) and its influence on the river runoff and water quality dynamics by the analytical, experimental and mathematical simulation methods, considering the environmental requirements of the directives of the European Union, laws of the Republic of Lithuania and sublegal acts on the water quality.

The tasks of the work:

1. To submit a review of the studies of other authors in river flow and water quality subject.
2. To establish the alternation of the drainage areas in the Lielupė river basin district within the period 1960–2009 and evaluate the influence of drainage on the river runoff. Also analyze the alternation in the river wateriness.
3. To find the most hazardous sources of pollution, tendencies of the alternation in the scattered and point pollution within the analyzed period of 1992–2009 and evaluate their influence on the river water quality.
4. To carry out the analysis of the nutrient dynamics in the river water and estimate the tendencies of their alternation.

5. To evaluate the influence of small rivers assigned to the risk and potential risk waters on the total pollution of the Lielupē RBD by performing experimental researches.
6. To compile the model of the Mūša river subcatchment by using FYRIS water quality model, which allow evaluating the changes conditioned in water quality caused by the scattered and point pollution of the main rivers of the subcatchment in an integrated way.

Methodology of research

The influence of the drainage areas on the river runoff mode was evaluated by using the methods of analytical researches and mathematic statistics. The influence of small rivers on the total pollution of the Lielupē RBD was evaluated on the basis of the results of experimental researches. The sources of the scattered and point pollution were identified and the river pollution with total nitrogen and total phosphor was evaluated by performing mathematical simulation.

Scientific novelty

In the Lielupē RBD, the influence of the wetland drainage on the river runoff in the karst region was evaluated.

The most dangerous sources of the scattered and point pollution having the biggest influence of the water quality of the Lielupē RBD were established.

The influence of small rivers (basin areas up to 200 km²) on the total pollution of the Lielupē RBD was established by performing experimental researches. These rivers are especially sensitive to any changes in the natural factors and anthropogenic activity and not subjected to the national monitoring.

Practical value. The performed researches have supplemented scientific knowledge about the dynamics of nitrogen and phosphor compounds in the river water subject to the climate factors, river runoff and alternation of the anthropogenic activity. In the work, the most important sources of pollution were established and the contribution of the scattered and point pollution to the total pollution of the Lielupē RBD waters was calculated. It will help to improve planning, forecasting and controlling of the quality of the water resources of this basin and to establish the maximum admissible pollution loads so as not to violate the environmental requirements. The results of these researches will be useful for improving the plans of management of the Lielupē river basin district.

Defended propositions

1. The areas of drained lands which were too wet do not have an essential influence on the any changes of the runoff amount in different seasons. In the spring season, in the period of snow melting, the water excess is faster derived to the rivers through drainage systems; however, it does not impact the runoff flow in the summer season.
2. River pollution levels depend from these main anthropogenic factors: agriculture and stock-raising intensity (ascending or descending), modernization level of the water treatment equipment and implementation or not the advanced environmental measures.
3. Small rivers, on which cleanness of the water in big rivers also depends, are especially sensitive to the changes in the anthropogenic factors.
4. The biggest amount of nitrogen and its compounds in rivers comes from scattered sources, and the biggest amount of phosphorus compounds – from point sources of pollution.

The scope of the scientific work. The scientific work consists of the general characteristic of the dissertation, 6 chapters, conclusions, recommendations, list of literature, list of publications. The total scope of the dissertation – 166 pages, 67 pictures, 33 tables and 158 sources of literature.

1. Analysis of the river runoff and water quality researches

In this chapter, the researches by foreign and Lithuanian scientists in the field of the river water quality are analyzed. The evaluation by various authors related with the influence of the anthropogenic factors (degree of drainage of the river basin, preparation of ponds and adjustment of runoff and alternation of landed property) on the river runoff and water quality is analyzed. The environmental problems of the karst region in northern Lithuania are overviewed. A big attention is paid to the analysis of the alternation in the water quality by using mathematical models.

According to the review of literature sources, it is to notice that only the data of a short period when a small part of the wetland had been drained, was analyzed in these researches. Most researches evaluating the influence of drainage systems on the hydrologic mode of the rivers were performed in the river basins in the Middle Lithuania and the results received were evaluated ambiguously. Thus, it was decided to evaluate how the wetland drainage impacts the alternation in the river runoff in the northern part of Lithuania (Lielupė RBD).

It was also decided to establish and evaluate the processes of the alternation in the river water quality in a specific and highly pollution-sensitive karst region in the context of the alternation in the anthropogenic activity. It is purposeful to use both analytical researches and mathematical simulation, also experimental researches on which basis it would be possible to evaluate the way of influence of small rivers to total pollution of the Lielupė RBD.

2. Characteristic of the research object and methodology of work

In the chapter, a comprehensive characteristic of the research object and methodology of analytical, experimental researches and mathematical simulation are presented.

The international Lielupė river basin district in the northern part of Lithuania was chosen for the researches where the conditions of the surface water pollution are complicated because of happening karst processes (Fig. 1). The area of the Lielupė RBD is 17600 km²: 8662 km² belong to Latvia (49 %) and 8938 km² – to Lithuania (51 %). Used methodology of the analytical, statistical, mathematical simulation and experimental researches is presented in the chapter.

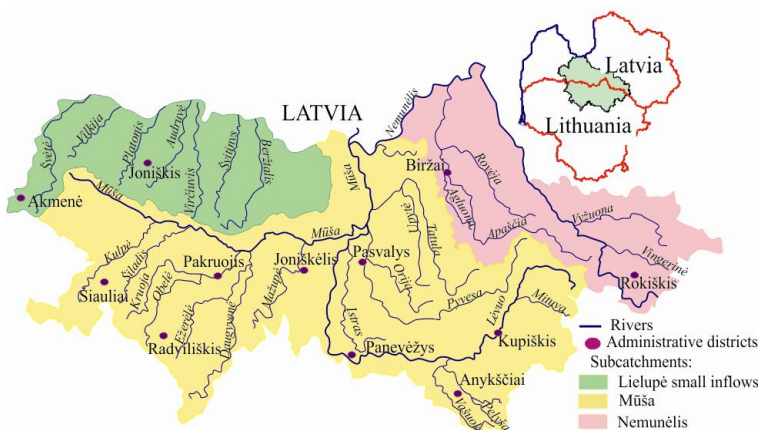


Fig. 1. Lielupė river basin district

The alternation of the drained areas (% of the territory of the basin and the wetland area) was established by using the data of the wetland cadastre. The data was collected according to the borders of the territories of the municipalities and later recalculated for the river basin district by establishing what part of the territory of the basin is covered by the wetland and drainage

areas. In order to analyze the alternation of the river wateriness, the data of the long-termed water debit gauging accumulated in the Hydrometeorology Service of Lithuania (period of 1960–2009) was used. According to this data, the tendencies of the alternation in the river runoff depth within the year, spring and summer seasons and those of the alternation in the maximum spring and summer debit modules while changing the drainage areas were analyzed.

The changes in the water quality in the Lielupė RBD were evaluated according to the dynamics and seasonal changes of the alternation in the concentrations of nitrogen and phosphor compounds including determination of the average weight concentrations. The concentrations of contaminants show the level of the river water pollution and the load evaluates the extent of pollution. To evaluate the extent of pollution, the average yearly loads of nitrogen and phosphor compounds consisting of the scattered and point pollution sources were calculated.

To evaluate the reliability of the results and to establish the statistical relationship between the variables, the methods of mathematic statistics are used and the main statistical parameters are calculated.

To evaluate the influence of small rivers assigned to the risk waters and not subjected to the national monitoring on the Lielupė RBD and to find out more about the real concentration of contaminants, natural experimental researches were performed. The water samples were taken in the mouth of the rivers Šiladis, Mažupė and Įstras in spring when the river wateriness is at the highest level and in summer and autumn when it is at the lowest level.

In order to assess the influence of the pollution sources of nitrogen and phosphor on the Mūša subcatchment and to forecast the changes in the water quality, the conceptual FYRIS model was chosen. The qualitative part of the model enables evaluating the river water quality exactly enough, to establish the influence of the scattered and point pollution sources and to evaluate the alternation of the amounts of contaminants in the researched basin.

In order to find out if the results obtained from FYRIS model coincide with the observed ones, and evaluate the reliability of the obtained values, the efficiency coefficient of the model E was calculated (Nash and Sutcliffe 1970):

$$E = 1 - \frac{\sum_{i=1}^n (\Theta_{stb,i} - \Theta_{mod,i})^2}{\sum_{i=1}^n (\Theta_{stb,i} - \Theta_{stb}^{vid})^2}, \quad (1)$$

where n – number of observations in units; Θ_{stb}^{vid} – means of all the concentrations of total nitrogen and total phosphor in the river water established

during the observations in mg/l; $\Theta_{stb,i}$ and $\Theta_{mod,i}$ – observed and simulated concentrations of total nitrogen and total phosphor in the river water in mg/l.

The efficiency coefficient of the model $E = 1$, it means the observed and simulated concentrations of contaminants coincide ideally. In case $E > 0.5$ – the efficiency of the model is very good; in case E falls between 0.4 and 0.5 – the efficiency of the model is good and in case it falls between 0.3 and 0.4 – it is satisfactory. In case $E < 0.3$, it is necessary to increase the line of the observation data or look for mistakes in the data. In case $E = 0$, it means the simulation data only coincides with the mean of the observed data (according to the direct dependence).

3. Influence of the land drainage on the river runoff

In this chapter, the results of researches of the land drainage evolution and of influence on the distribution of the yearly and seasonal river runoff (within many years) are presented.

The evolution and influence of drainage of too wet lands in the Mūša, Lēvuo, Tatula and Nemunēlis basins located in the Lielupē RBD on the river runoff in the period of 1960–2009 was analyzed. It was determined the wetland areas in the Mūša, Lēvuo and Nemunēlis basins exceed 70 % and those of the Tatula basin – even 90 % of the total basin area. Before 1961, the drainage areas covered only 4–7 % of the territory of the basin and in 2000 these areas covered already 58–80 %. Lately, any new drainage systems almost are not developed, so the drainage areas have changed little.

When increasing the drainage areas in the basins of the researched rivers, there is no clear tendency of the alternation in the maximum debit modules of the spring or summer floods. The correlation coefficients between these values are very low; they vary from 0.25 to 0.35 in spring and from 0.05 to 0.11 in summer months.

After analyzing the dependency of the river runoff alternation on the drainage area, it was established that the increasing of drained areas has no essential influence on the river runoff alternation of the researched rivers neither during the spring flood season nor that during the summer flood season. The correlation dependency between the river runoff depth in the spring and summer season and the drainage area is very low or low (Fig.2 and 3). During the spring season, the correlation coefficients vary from 0.17 to 0.22 and in summer – from 0.04 to 0.44.

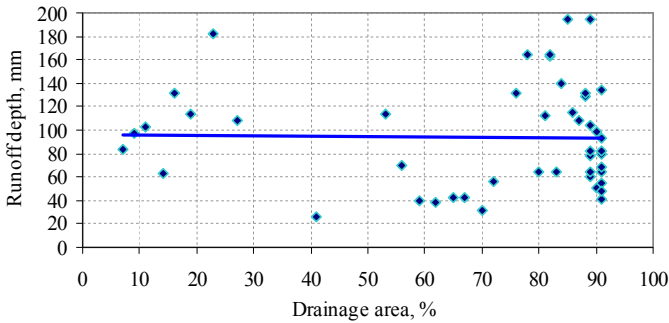


Fig. 2. Relationship between the spring runoff depth of the Tatula River and drained area in the river basin (in percent of wetland area)

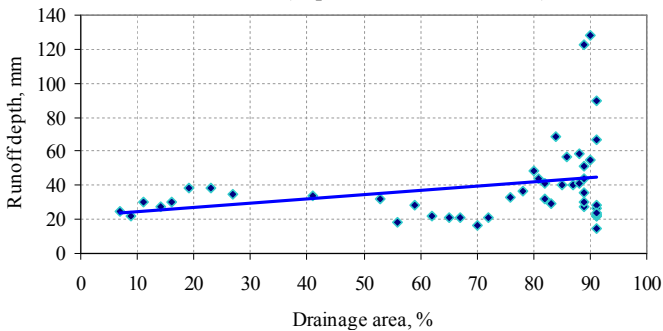


Fig. 3. Relationship between the summer runoff depth of the Tatula River and drained area in the river basin (in percent of wetland area)

While spring and summer seasons, excess water through the drainage systems quickly run off into rivers, but increasing the drainage areas, no essential yearly changes in the alternation of the runoff were determined. One of the key factors causing the runoff depth is precipitation. Maximum runoff observed when the rainfall is higher than the multi-annual rainfall. So the research analysis shows there are cycle fluctuations characteristic to the alternation of the runoff conditioned by the climatic factors and not by the land drainage.

4. Anthropogenic activity and nutrients changes

In this chapter, the analysis of the alternation in the anthropogenic activity and nutrients is presented.

The alternation in nutrients was analyzed during the period of 1992–2009 which was variable in the industrial and agricultural fields of Lithuania.

The number of companies impacting the surrounding environment and water quality in the territory of the researched Lielupė RBD decreased by more than 16 % from 1992 to 2009. The number of farms and companies undertaking the agricultural activity in the Lielupė RBD decreased from 336 (1992) to 135 (2009), i. e., by 40 %, and the average density of livestock decreased from 60.4 (1992) to 33.2 (2009) animals per one hectare of the basin. When decreasing the number of functioning enterprises, farms and companies undertaking the agricultural activity and density of livestock, there also was a decrease in the anthropogenic load causing the scattered and point pollution falling to the surface waters. The other factor determining less pollution of the surface waters in the last decade is the modernization and reconstruction or new construction of the waste water treatment plants with the higher capacity and extra nitrogen and phosphorus removal.

These changes have led to the decrease of amounts of contaminants discharged to the surface waters of the Lielupė RBD from the water treatment plants in the period from 1992 to 2009. For that period, it was established the load of total nitrogen decreased by 29 % or 636 t/year, that of total phosphorus and ammonium nitrogen – by 27 and 13 % or respectively by 95 and 411 t/year, that of nitrite nitrogen – by 10 %, and that of nitrate nitrogen – by 32 %. It was established when decreasing the number of animals in the basin, the loads of pollution arising along with animal droppings and getting to the soil have also decreased proportionally. During the researched period, 39.70 kg/ha of total nitrogen and 6.74 kg/ha of total phosphorus got to the soil on the average. Decreasing of the livestock volume by 55 % during the period from 1992 to 2009, the load of total nitrogen and total phosphorus from stock–raising farms has decreased by 51 %.

The tendency of decreasing pollution was also established by analyzing the alternation in the concentrations and loads of contaminants. After renewing the waste water treatment plants and decreasing of the livestock volume. In 2009 the percentage of the samples exceeding the maximum admissible concentration (MAC) in the researched basin decreased compared with 1992 as follows: ammonium nitrogen – by 7–10 %, nitrite nitrogen – by 2–3 %, phosphate phosphorus – by 5–10 %. In 2009 the number of samples exceeding of the maximum admissible concentration of nitrate nitrogen was higher by 10 % than in 1992. The load of ammonium nitrogen falling to the rivers of the Lielupė RBD decreased by 1–4.9 fold, that of nitrite and nitrate nitrogen decreased by 2.6 times and that of phosphate phosphorus – by 2–2.4 times compared with 1992.

5. Researches of the water quality in small rivers of the Lielupė river basin district

In the chapter, the results of experimental-natural researches of the water quality of small rivers of the Lielupė RBD are presented.

The rivers Šiladis, Mažupė and Įstras are little watery; therefore any contaminants getting to the river water are little diluted and their high concentrations are found during the researches which often exceed the maximum admissible concentration (Fig. 4 and 5).

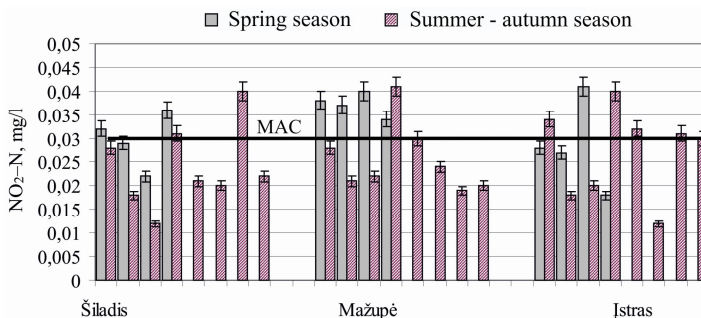


Fig. 4. Alternation in the concentrations of nitrite nitrogen in the water of the researched rivers during the spring and summer–autumn seasons

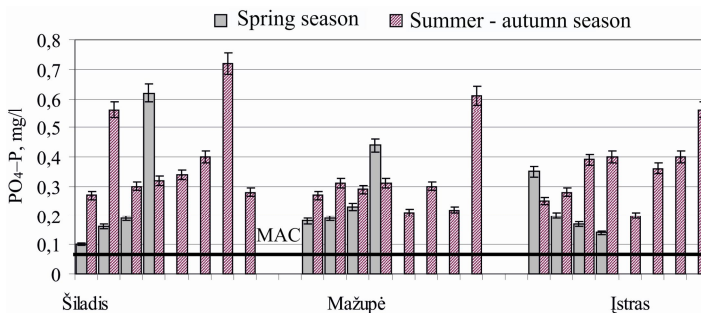


Fig. 5. Alternation in the concentrations of phosphate phosphor in the water of the researched rivers during the spring and summer–autumn seasons

The data analysis shows the concentrations of nutrients exceeded the maximum admissible concentration during the total researched period many times: nitrogen compounds – from 33 to 100 % and phosphor compounds – even by 100 % of the total number of samples. The excess of nitrogen and

phosphor compounds appears in the basins of small rivers because of intensively developed agricultural activities as the agricultural areas cover the major territory of the basin. It is estimated that the decrease of the areas of ploughed land by 30 % would result in the decrease of the average yearly concentrations of nitrogen compounds by up to 0.015–0.07 and those of phosphor compounds – up to 0.1 mg/l.

6. Mathematical simulation of water pollution with total nitrogen and total phosphorus in the Mūša river subcatchment

In this chapter, the results of mathematical simulation of pollution of the Mūša subcatchment river water with total nitrogen (N) and total phosphorus (P) and possibilities of decreasing that pollution are analyzed. The qualitative part of the module enabled to evaluate the river water quality exactly enough, establish the influence of the scattered and point pollution sources on the river water quality and also to evaluate the yearly and seasonal alternation of the amounts of total nitrogen and total phosphorus in the researched subcatchment.

The arable land covered 63 % and towns and developed territory – just 4 % of the territory of the subcatchment. The total subcatchment of the Mūša river was divided into seven smaller subcatchments (Fig. 6) with the water quality observation stations.

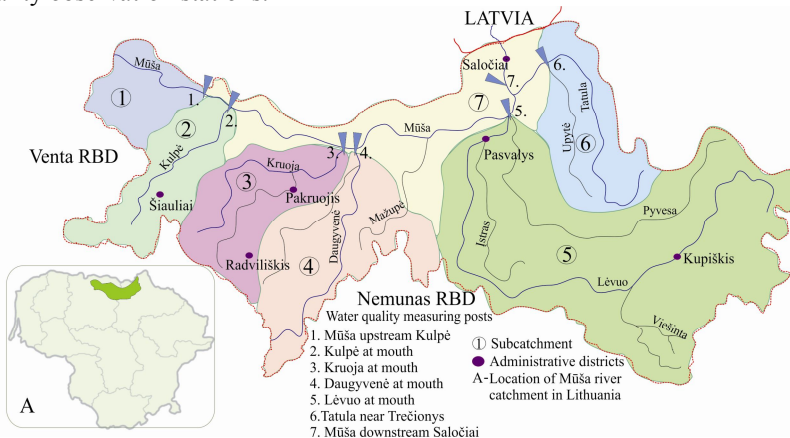


Fig. 6. Subcatchments of Mūša river basin and water quality monitoring posts

After calibrating FYRIS model (Fig. 7 and 8), the efficiency coefficient of the model was $E = 0.46$ when simulating total nitrogen and $E = 0.49$ when simulating total phosphorus.

The landed property covered more than 50 % of the territory of the Mūša subcatchment, so pollution of its environment and water depends on the soil culture, farming and use of land. The results of the simulation confirmed most nitrogen (about 87 %) got to all the distinguished subcatchments from the arable land and most total phosphor (49 %) – from the treatment plants, households and developed territories. Just a little more than 3 % of total nitrogen and 15 % of total phosphor to the subcatchment falling from the forestall territory and pastures.

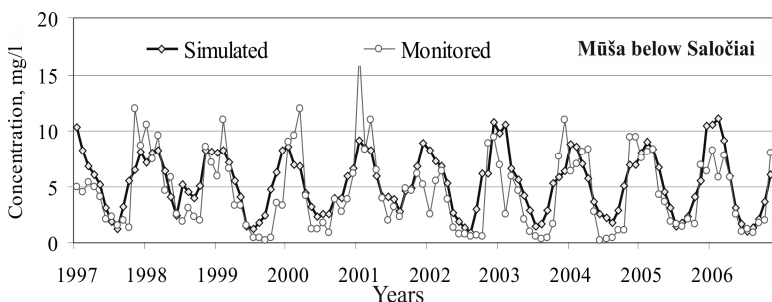


Fig. 7. Time series simulation of total nitrogen concentration in Mūša below Saločiai subcatchment

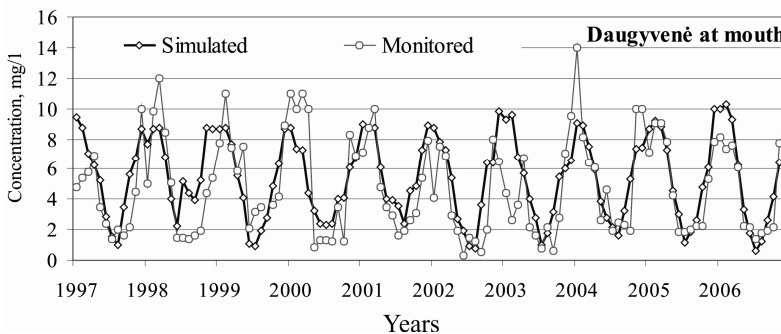


Fig. 8. Time series simulation of total nitrogen concentration in Daugyvenė at mouth subcatchment

After performing the mathematical simulation, it was established the average loads of total nitrogen conditioned by the scattered pollution in the total Mūša subcatchment vary from 2.11 to 0.54 t/km² a year and those of total phosphor – from 0.015 to 0.004 t/km². Meanwhile, the loads of total nitrogen conditioned by the point pollution vary from 0.11 to 0.05 t/km² and those of

total phosphor – from 0.011 to 0.005 t/km² a year. It was established high fluctuations of the loads are determined by intensive farming and high scour of contaminants. Fluctuations of the loads of the point pollution are determined by water discharged from the treatment plants. After decreasing the farming intensity and reconstructing and modernizing the waste water treatment plants, the loads of pollution have remarkably decreased.

Seasonal dependability of the runoff and of the concentrations of nutrients determine an uneven amount of nutrients scoured from the subcatchments during a year. The analysis of the results of simulation shows the seasonal amounts of scoured total phosphor and total nitrogen were different within the period of 1997–2006. Their highest amounts got to the rivers during the winter season – 36 % of total nitrogen and about 34 % of total phosphor falling to the subcatchment, when there is no vegetation processes. In spring, in the period of snow melting, one third, i. e., 31 % was scoured because of a higher runoff to the researched subcatchment, and in the summer and autumn seasons, respectively, 16 and 17 % of all nitrogen falling to the subcatchment. Little less of total phosphor compared with total nitrogen, but also in almost even parts, gets in the summer and spring seasons (26 % each). The lowest amounts of phosphor get to the Mūša subcatchment in the autumn season (14 % of all phosphor falling to the subcatchment).

The highest loads of total nitrogen and phosphor from the scattered pollution sources are formed in the Mūša subcatchment in the winter and spring seasons (32–38 %) and from the point pollution sources – in the summer and winter seasons – 32–39 %.

In order to be able to reach a good ecological condition (HELCOM action plan), it is necessary to decrease the amounts of contaminants getting to the rivers. During the simulation, it was established the average yearly load of total nitrogen in the Mūša subcatchment would be decreased by 225 t or 5 % and that of phosphor – by 15 t or 17 % if the cleaning equipment would be improved so that the concentrations of phosphor and nitrogen in discharged sewage did not exceed admissible ones. Chemically removing phosphorus from the cleaning equipment, his loads would decrease 21 t or 23 %. If the areas of ploughed land would be decreased by 30 %, the average yearly load of total nitrogen would decrease by 28 % and that of phosphor – by 11 %.

General conclusions

1. It was established that the drainage areas in the Lielupē RBD during 1960–2009 period expanded to 80 % from the basin area. The data analysis shows that the increase drained areas has no influence on the alternation of the river runoff during the spring or summer season. The

data analysis shows there are stable cycle fluctuations characteristic to the alternation of the runoff in case of increasing the drainage areas in the river basins.

2. It was established that the amounts of contaminants discharged to the surface waters of the karst Lielupē RBD and its soil during the 1960–2009 period differed depending on the intensity of anthropogenic activities. After renewing the waste water treatment plants, the load of total nitrogen decreased by 29 %, total phosphor and ammonium nitrogen – by 27 and 13 %, nitrite nitrogen – by 10 % and nitrate nitrogen – by 32 %. Decreasing of the livestock volume by 55% the load of total nitrogen and phosphorus getting into the soil with manure decreased by 51%.
3. It was determined, that during the 18 year period, decreased quantity from point sources of pollution released (10–32%) and livestock manure derived pollutants (51%) as well as loads of nitrogen compounds 3–9 and phosphorus compounds 2–4 times decreased. It shows that exchange of economic-industrial activity pollution load is changing.
4. Small rivers in Lithuanian karst region, on which cleanness of the water in big rivers also depends, are especially sensitive to the changes in the anthropogenic factors. The data of experimental researches of the water quality in small rivers shows the number of samples with the concentration of $\text{NH}_4\text{-N}$ exceeding the admissible one was 92–100 %, $\text{NO}_2\text{-N}$ – 33–42 %, $\text{NO}_3\text{-N}$ – 58–67 %, o $\text{PO}_4\text{-P}$ – 100 % from the total number of samples during the period of 2008–2009.
5. Data obtained from the mathematical model as well as the analysis of the national monitoring shows that the rivers pollution decreased during the analyzed period. By using the mathematical model FYRIS it was established the highest load (9874 t/year) of total nitrogen of all the pollution sources in the Mūša subcatchment was in 1998 and the lowest (2117 t/year) assessed in 2003. The highest load of phosphor (137 t/year) was in 1998 and the lowest load (47 t/year) – 2006.
6. During the simulation, it was established on the average 90 % of all nitrogen got to the Mūša subcatchment from the scattered pollution sources. It included 87 % of the arable land and just a little more than 3 % of the forest territory and pastures. 10 % of all nitrogen of the subcatchment got from the point pollution sources. The highest amounts of all phosphor of the Mūša subcatchment got to the subcatchment from the point pollution sources (about 49 %), ploughed

land – 36 % and just a little more than 15 % from the forestall territory and pastures.

7. During the simulation, it was established that the highest amounts of total nitrogen (about 36%) and total phosphorus (34%) got to the Mūša subcatchment during the winter season, when there is no vegetation processes and when with the snow melt water from the soil surface washed the unused fertilizer.

Recommendations

1. It is proposed to apply the ecologic farming system more widely in the Lielupē river basin district, where the agricultural areas cover the major part of the basin in order to decrease the river water pollution with nitrogen and phosphor compounds; it is proposed to decrease the farming intensity (improved land only organic fertilizers, using crop rotation, conservation of biological diversity), converting ploughed land to meadows. It is also proposed to conserve the bank protection zones of the surface waters located in the territories of intensive farming.
2. To decrease getting phosphor and its compounds to the rivers from the point pollution sources, it is proposed to renovate old sewage cleaning equipment functioning not under the total capacity and implement the biological phosphorus removal. As well as an additional tool to install the chemical phosphorus removal and tertiary treatment unit with membrane filters.

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ANTROPOGENINĖS VEIKLOS ĮTAKOS UPIŲ NUOTĖKIUI IR VANDENS KOKYBEI TYRIMAI IR VERTINIMAS

Mokslų problemos aktualumas

Pastaruosiu metu nemažai dėmesio skiriama antropogeninės veiklos poveikio aplinkai ir paviršinių vandens telkinių kokybės tyrimams, tačiau karstinio regiono upių vandens kokybė nėra taip plačiai tiriama ir analizuojama. Karstiniuose plotuose su paviršiniu ir požeminiu vandens nuotėkiu per smegduobes ir poringą gruntą į atvirus vandens telkinius gana lengvai patenka įvairūs teršalai (organinės ir mineralinės trąšos, pesticidai ir kt.), kurie blogina upių vandens kokybę. Todėl ypatingai jautriame taršai karstiniame regione svarbu išsamiai ištirti antropogeninės veiklos sukeltus neigiamus aplinkos veiksnių pokyčius.

Tyrimų objektas – tarptautinis, antrasis pagal dydį Lietuvoje – Lielupės upių baseinų rajonas (UBR), kurio išskirtinis bruožas – didelę baseino teritoriją užimantys karstiniai plotai.

Darbo tikslas – analitiniais, eksperimentiniais ir matematinio modeliavimo metodais įvertinti antropogeninės veiklos karstiniame Lielupės upių baseinų rajone kaitos tendencijas ir įtaką upių nuotėkiui bei vandens kokybės dinamikai, atsižvelgiant į gamtosauginius ir Europos Sąjungos direktyvų, Lietuvos Respublikos įstatymų ir poįstatyminių aktų reikalavimus vandens kokybei.

Darbo uždaviniai

1. Pateikti kitų autorių atliktų tyrimų upių nuotėkio ir vandens kokybės klausimais analizę.
2. Nustatyti Lielupės upių baseinų rajone drenažu nusausintų žemių kaitą, išanalizuoti upių vandeningumą per 1960–2009 m. laikotarpį ir įvertinti sausinimo įtaką upių nuotėkiui.
3. Nustatyti pavojingiausius taršos šaltinius, pasklidosios ir sutelktosios taršos kitimo tendencijas per nagrinėjamą 1992–2009 m. laikotarpį.
4. Atlikti biogeninių medžiagų dinamikos upių vandenyje analizę, nustatyti jų kaitos tendencijas.
5. Eksperimentiniais tyrimais įvertinti kaip mažos upės, priskirtos rizikos ir potencialiems rizikos vandens telkiniams, įtakoja Lielupės UBR užterštumą.

6. Panaudojant FYRIS vandens kokybės modelį sudaryti Mūšos upės pabaseinio modelį, leidžiantį integruotai įvertinti pagrindinių pabaseinyje esančių upių pasklidosios ir sutelktosios taršos sąlygotus vandens kokybės pokyčius.

Tyrimų metodika

Drenažu nusausintų žemių įtaka upių nuotėkio režimui įvertinta panaudojant analitinių tyrimų ir matematinės statistikos metodus. Mažų upių poveikis bendram Lielupės UBR užterštumui vertinamas remiantis eksperimentinių tyrimų rezultatais. Pasklidosios ir sutelktosios taršos šaltinių indentifikavimas ir upių tarša bendruoju azotu ir bendruoju fosforu įvertinta atliekant matematinį modeliavimą.

Mokslinis naujumas

Lielupės UBR įvertinta šlapių žemių sausinimo drenažu įtaka karstinio regiono upių nuotėkiui.

Nustatyti pavojingiausi pasklidosios ir sutelktosios taršos šaltiniai turintys didžiausią įtaką Lielupės UBR vandens kokybei.

Eksperimentiniais tyrimais nustatyta, kaip mažos (baseinų plotai iki 200 km²) upės, kurios yra ypatingai jautrios gamtinių veiksnių ir antropogeninės veiklos pokyčiams ir kuriose nevykdomas valstybinis monitoringas įtakoja bendrą Lielupės UBR užterštumą.

Praktinė vertė. Atlikti tyrimai papildė mokslo žinias apie azoto ir fosforo junginių dinamiką upių vandenyje priklausomai nuo klimato veiksnių, upių nuotėkio ir antropogeninės veiklos kaitos. Darbe nustatyti svarbiausi taršos šaltiniai, apskaičiuotas sutelktosios ir pasklidosios taršos indėlis į bendrą Lielupės UBR vandens telkinių taršą. Tai padės geriau planuoti, prognozuoti ir valdyti šio baseino vandens išteklių kokybę, nustatyti didžiausias leistinas taršos apkravas, kad nebūtų pažeisti aplinkosauginiai reikalavimai. Tyrimų rezultatai bus naudingi tobulinant Lielupės upių baseinų rajono valdymo planus.

Ginamieji teiginiai

1. Nusausintų pernelyg šlapių žemių plotai neturi esminės įtakos nuotėkio dydžio atskirais metų sezonais pokyčiams. Pavasario sezonu, sniego tirpimo laikotarpiu, vandens perteklius drenažo sistemomis į upes nuvedamas greičiau, tačiau tas procesas neįtakoja vasaros sezono nuotėkio dydžio.
2. Upių užterštumo lygis priklauso nuo šių pagrindinių antropogeninių veiksnių: žemdirbystės ir gyvulininkystės intensyvumo (didėjimo ar

- mažėjimo), vandenvalos įrenginių modernizavimo lygio bei pažangių aplinkosauginių priemonių įgyvendinimo ar netaikymo.
3. Mažos upės, nuo kurių priklauso ir didelių upių vandens švarumas, ypatingai jautrios antropogeninių veiksnių pokyčiams.
 4. Didžiausi azoto ir jo junginių kiekiai į upes patenka iš pasklidusių taršos šaltinių, o didžiausi fosforo ir jo junginių kiekiai – iš sutelktųjų taršos šaltinių.

Darbo apimtis. Darbą sudaro bendra darbo charakteristika, 6 skyriai, išvados, rekomendacijos, literatūros sąrašas, publikacijų sąrašas. Bendra disertacijos apimtis – 166 puslapiai, 67 paveikslai, 33 lentelės, 158 literatūros šaltiniai.

Pirmame disertacijos skyriuje analizuojami kitų autorių atlikti tyrimai upių nuotėkio ir vandens kokybės klausimais.

Antrame disertacijos skyriuje pateikiama tyrimų objekto charakteristika ir darbo metodika.

Trečiame disertacijos skyriuje analizuojama žemių sausinimo drenažo įtaka upių nuotėkiui.

Ketvirtame disertacijos skyriuje nustatoma antropogeninės veiklos ir biogeninių medžiagų kaita.

Penktame disertacijos skyriuje analizuojami atliktų mažų upių vandens kokybės eksperimentinių tyrimų rezultatai

Šeštame disertacijos skyriuje pateikiami Mūšos pabaseinio bendruoju azotu ir bendruoju fosforu matematinio modeliavimo rezultatai.

Bendrosios išvados

1. Per 1960–2009 m. laikotarpį drenažu nusausintų žemių plotai Lielupės UBR padidėjo iki 80 % nuo baseino teritorijos. Duomenų analizė rodo, kad nei pavasario, nei vasaros sezonų metu nusausintų plotų didėjimas neturi įtakos sezoniniam upių nuotėkiui. Upių baseinuose didėjant nusausintų žemių plotams išlieka nuotėkio kaitai būdingi cikliniai svyravimai.
2. Nustatyta, kad į paviršinius karstinio Lielupės UBR vandenį ir dirvožemį išleisti teršalų kiekiai per 1960–2009 m. laikotarpį kito priklausomai nuo antropogeninės veiklos intensyvumo. Atnaujinus vandenvalos įrenginius bendrojo azoto kiekiai sumažėjo 29 %, bendrojo fosforo ir amonio azoto – 27 ir 13 %, nitritų azoto – 10 %, o nitratų azoto – 32 %. Auginamų gyvulių skaičiui sumažėjus 55 % su gyvulių mėšlu į dirvožemį patekančio bendrojo azoto ir fosforo apkrova sumažėjo 51 %.

3. Nustatyta, kad per tiriamą 18 metų laikotarpį sumažėjus iš sutelktųjų taršos šaltinių išleidžiamų (10–32 %) bei su gyvulių mėšlu patekusių teršalų (51 %) kiekiui azoto junginių apkrovos sumažėjo 3–9, o fosforo 2–4 kartus. Tai rodo, kad kintant ūkinės – pramoninės veiklos apimtims ženkliai kinta ir taršos apkrovos.
4. Lietuvos karstiniame regione mažos upės, nuo kurių priklauso ir didelių upių vandens švarumas, ypatingai jautrios antropogeninių veiksmų pokyčiams. Tai parodė eksperimentiniai tyrimai, kuriais nustatyta, kad per 2008–2009 m. laikotarpį DLK viršijusių mėginių skaičius sudarė: $\text{NH}_4\text{-N}$ – 92–100 %, $\text{NO}_2\text{-N}$ – 33–42 %, $\text{NO}_3\text{-N}$ – 58–67 %, o $\text{PO}_4\text{-P}$ – 100 % nuo bendro mėginių skaičiaus.
5. Tiek duomenys, gauti atlikus matematinį modeliavimą, tiek valstybinio monitoringo duomenų analizė rodo, kad upių tarša per nagrinėjamą laikotarpį mažėja. Matematinio modeliu FYRIS nustatyta, kad didžiausia bendrojo azoto apkrova (9874 t/metus) iš visų Mūšos pabaseinyje esančių taršos šaltinių buvo 1998 m., mažiausia tarša (2117 t/metus) nustatyta 2003 m. Didžiausia fosforo apkrova (137 t/metus) buvo 1998 m., o mažiausia (47 t/metus) – 2006 m.
6. Modeliuojant vandens taršą nustatyta, kad vidutiniškai iš pasklidusių taršos šaltinių į Mūšos pabaseinį patenka 90 % viso pabaseiniui tenkančio azoto (iš ariamos žemės – 87 %, iš miškingos teritorijos ir ganyklų – 3 %). Iš sutelktųjų taršos šaltinių patenka 10 % viso pabaseiniui tenkančio azoto. Didžiausi bendrojo fosforo kiekiai į pabaseinį patenka iš sutelktųjų taršos šaltinių (apie 49 %), iš ariamos žemės – 36 %, o iš miškingos teritorijos ir ganyklų – vos daugiau kaip 15 % viso Mūšos pabaseiniui tenkančio fosforo.
7. Modeliuojant nustatyta, kad žiemos sezonu, nevykstant vegetacijos procesams ir kai su sniego tirpsmo vandeniu nuo dirvų nuplaunamas nesunaudotų trąšų perteklius, į Mūšos pabaseinį patenka didžiausi bendrojo azoto (apie 36 %) ir bendrojo fosforo (34 %) kiekiai.

Rekomendacijos

1. Lielupės upių baseinų rajone, kuriame žemės ūkio naudmenų plotai užima didelę baseino teritoriją, siekiant sumažinti upių vandens užterštumą azoto ir fosforo junginiais iš pasklidusių taršos šaltinių, siūloma: plačiau taikyti ekologinę ūkininkavimo sistemą (žemę gerinant tik organinėmis trąšomis, taikant sėjomainą, išsaugant biologinę įvairovę), mažinant žemdirbystės intensyvumą, t. y. mažinant ariamos žemės ir didinant pievų bei ganyklų plotus, taip pat skatinti pakrančių apsaugos juostų išsaugojimą.

2. Fosforui ir jo junginių patekimui į upes iš sutelktųjų taršos šaltinių sumažinti siūloma modernizuoti senus ir veikiančius ne pilnu pajėgumu nuotekų valymo įrenginius, t. y. įdiegiant biologinį fosforo šalinimą, taip pat kaip papildomą priemonę įdiegti cheminę fosforo šalinimo grandį bei tretinio valymo grandį su membraniniais filtrais.

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IMPACT ON THE RIVER RUNOFF AND WATER QUALITY

Summary of Doctoral Dissertation

Technological Sciences, Environmental Engineering (04T)

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