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Impact of the agrarian reform on nutrient run-off in Lithuania

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Abstract

Fertilisation on agricultural farmland was identified as an important source of nutrient losses to the environment in the second half of the 20th century. There is only very few data available about the efficacy of the nutrient input in countries of transition where dramatic changes in agricultural production are still in progress. As a result of the reduced fertiliser input the concentration of phosphorus and ammonium nitrogen (NH_4-N) in Lithuanian rivers decreased significantly from 1990 to 2001. The phosphorus concentration declined below the eutrophication level of 0.05 mg L^{-1}. The NH_4-N concentration is below the critical threshold of 0.39 mg L^{-1}. In general, nitrate nitrogen (NO_3-N) concentrations in waters increased with decreasing agricultural production. In Lithuania the NO_3-N concentration increased until 1993 and is at the moment on a higher level than before 1990. The NO_3-N load is highest in areas of intensive agricultural production, but never exceeded a value of 700 kg N km^{-1} yr^{-1}. Despite the increase of NO_3-N concentrations and total N loads, these values are low compared to the nitrogen load in countries with intensive agriculture. The results revealed that losses of nitrogen by leaching at low fertilisation rates depended on management factors rather than fertiliser practices. About 60.000 new farmers without farming knowledge and experience started agricultural production with the transition in 1989. Large quantities of NO_3-N might have been lost because of poor manure handling and disturbance of well-established nutrient balances in the soil.

In 2001 567 t NH_4-N, 10,679 t NO_3-N and 420 t PO_4-P were discharged to the Baltic Sea. The NH_4-N load discharged to the Baltic Sea declined by factor 3.1 and the phosphate (P_2O_5) load by factor 6.7 from 1986 to 2001. During this period the NO_3-N load increased 1.5-fold.

Key words: Baltic Sea, eutrophication, land use, nutrient losses

Zusammenfassung

Einfluss der Agrarreform auf den Nährstoffaustrag in Litauen

Düngung auf landwirtschaftlichen Flächen ist eine der bedeutendsten Ursachen für Nährstoffverluste in die Umwelt. Es gibt bislang nur wenige Untersuchungen für sog. 'Countries in Transition', in denen noch immer drastische Veränderungen in der Landwirtschaft stattfinden. Bedingt durch den zurückgegangen Einsatz von Mineraldüngern konnte von 1990 - 2001 eine signifikante Abnahme der Phosphor- und Ammonium-Konzentrationen in den Flüssen Littauens beobachtet werden. Die Phosphor- und Ammonium-Konzentrationen fielen dabei unter die kritischen Grenzwerte von 0.05 mg P L^{-1} und 0.39 mg NH_4-N L^{-1}. Mit zunehmender Intensität der landwirtschaftlichen Produktion steigt in der Regel die Nitratkonzentration in Gewässern an. In Litauen wurde bis 1993 ein Anstieg der Nitratkonzentrationen beobachtet. Momentan entspricht die Nitratkonzentration jedoch der von 1990. Die Nitratfracht war mit Werten bis zu in 700 kg N km^{-1} yr^{-1} in Gebieten mit intensiver Landwirtschaft am höchsten. Trotz des Anstiegs der Nitrat-Konzentrationen und –frachten, sind die Werte gering im Vergleich zu Ländern mit intensiver Landwirtschaft. Diese Daten zeigen, dass Stickstoffverluste durch Auswaschung bei geringer Düngungsintensität von der Art der Bewirtschaftung abhängen. Schätzungsweise 60.000 neue Betriebe mit Leitern ohne landwirtschaftliche Grundkenntnisse und -erfahrungen wurden 1989 im Zuge der Agrarreform gegründet. Hierdurch kam es möglicherweise zu einem hohen Verlust an Nitrat, bedingt durch unsachgemäße Lagerung von Wirtschaftsdüngern und Störung der Nährstoffgleichgewichte im Boden.

In 2001 wurde die Ostsee mit insgesamt 567 t NH_4-N, 10.679 t NO_3-N and 420 t PO_4-P befrachtet. Von 1986 bis 2001 nahmen die Nährstofffrachten in die Ostsee für Ammonium um den Faktor 3.1 und für Phosphor um den Faktor 6.7 ab. Im gleichen Zeitraum stiegen die Nitratkonzentrationen um das 1.5-fache.

Schlüsselworte: Ostsee, Eutrophierung, Landnutzung, Nährstoffverluste

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1 Introduction

Agricultural management practices and fertilisation were the major sources of nutrient losses in the second half of the 20th Century (Kremser and Schnug, 2002). The reduction of nutrient run-off from diffuse sources is difficult because of the dispersion in large territories.

Large quantities of nitrogen and phosphorus from urban and agricultural areas are deposited in lakes and marine water. The annual total nitrogen and phosphorus input into the Baltic Sea is estimated to be about 10^6 t N and $5 \cdot 10^4$ t P, respectively (Kremser and Schnug, 2002). In 1988 the HELCOM Ministerial Declaration was adopted with the aim to reduce the overall nutrient load to the Baltic Sea by 50% with reference to the level from 1987 until 1995. However, the Interim Status Report on Implementation of the Declaration revealed that none of the Contracting Parties achieved the target (Helsinki Commission, 1997).

The main prerequisite for the development of prevention measures that would substantially reduce nutrient losses at low costs is profound knowledge about nutrient pathways from soil/plant and animals to rivers, lakes and marine waters in dependence on soil and climatic conditions. This, however, is a complex task as a variety of factors influence the behaviour of nutrients in the environment.

Many investigations were carried out and a lot of results published on improvement of nutrient management in market economy countries with high and stable agricultural production (Rekolainen, 1989; MAFF, 1993; Vinten and Smith, 1993; Johnsson and Hoffmann., 1998; Nordic Council of Ministers, 2001), but there is very few data available about the nutrient efficiency in countries of transition where dramatic changes in agricultural production are still in progress (Lofgren et al., 1999; Nordic Council of Ministers, 2001, Jansons et al., 2002).

A widespread method to reduce surface water pollution is the restriction of fertiliser use and limitation of stocking densities. Such recommendations are included in the legislation of many developed countries.

A central question still is if nutrient losses in agriculture mainly depend on productivity and fertilisation. The answer to this question is not so simple as it seems at first glance. Water pollution in countries of transition occurs in different ways. Nutrient run-off is not only dependent on fertiliser rate or stocking density of livestock.

This contribution aims at analysing the long-term variation of nutrient flow from agricultural land during the agrarian reform in Lithuania. Additionally, the impact of agricultural production on the pollution of rivers in relation to changing agricultural activity during the period of transition from central planned to market economy was evaluated.

2 Agricultural situation

Reforms during the transition resulted in significant changes in the agricultural sector in Lithuania. Since 1989 the agricultural production declined drastically (Table 1). In 2001, the volume of agricultural goods was 49 % of the production in 1989, and the corresponding values for crop and livestock production were 69 % and 44 %, respec-

Table 1:
Production of agricultural goods in Lithuania (10^3 tons)

	1989	1991	1993	1995	1997	1999	2001
Crop production							
Grain	3272	3347	2708	1954	3052	2112	2398
Sugar beet	1075	811	855	692	1002	870	880
Potatoes	1927	1508	1773	1594	1830	1708	1054
Livestock production							
Milk	3235	2916	2067	1819	1950	1714	1794
Meat (slaughter weight)	534	450	276	208	201	193	171
Number of livestock (at the end of the year)							
Cattle	2435	2322	1701	1152	1054	923	748
Incl. dairy cows	850	842	738	615	590	538	438
Pigs	2705	2436	1359	1260	1128	1159	856
Change in agricultural production, %	100	86	54	50	72	52	49
Source: Anon (2002a)							

Table 2:
Cropping on agricultural farmland in Lithuania (103 hectares)

Type of crops	1990	1993	1995	1997	1999	2001
Cereals and leguminous plants	1084	1289	1053	1214	1062	972
Sugar beets	32	35	24.3	35.2	30.6	26.9
Flax	23	4.5	13.2	6.1	8.8	10.2
Potatoes	113	122	124	121	121.1	102.5
Vegetables	16	25	25.8	26.8	24.9	21.1
Fodder crops	933	1204	1100	1134	1088	998
Other crops	12.9	2.1	7.2	15.3	64.3	40.1
Total sown area	2213.9	2681.9	2359.2	2562.3	2421.3	2186.1

Source: Anon (2002a)

Table 3:
The use of fertilisers in Lithuania (kg of active substance per ha of cropped area)

	1990*	1991*	1992*	1993*	1994**	1995**	1996**	1997**	2001**
Nitrogen	123.9	85.0	56.3	45.8	40.3	35.8	41.1	51.4	97.7
Phosphorus	77.9	60.0	36.4	18.3	12.7	13.5	14.9	17.5	41.6
Potassium	132.6	105.6	66.5	29.2	20.3	14.9	16.5	20.0	56.4

Source: * Anon (1996); **Anon (2002a)

tively. The production of meat and milk per capita dropped by more than 64 % in the same period. Agriculture accounted for about 6.9 % of the gross national product (GNP) in 2001 and employs today about 19 % of the labour force.

The land reform started in 1990 and privatisation in 1991. By March 31, 1993 previous collective and state farms were transformed into 3760 agricultural companies and enterprises. Most of the companies accepted meanwhile self-liquidation and are bankrupt. 963 agricultural companies continued farming on 4.3 % of the total agricultural land. The share of private and household farms in the total agricultural production increased from 48.3 % in 1991 to 79.3 % in 2001. Private farms produced 78.9 % of the total grain and 91 % of the total milk production in 2001. 67.500 full-time private farms assessed land ownership in 2001.

Agricultural production export was important before the transition. Before 1990 about 40 % of the Lithuanian agricultural products were sold to eastern countries. Today, the possibilities for export are limited mainly because Lithuanian products are too expensive for eastern markets. There also exist unsolved problems with customs and other risks connected with financial operations due to the economic situation in Russia. Lithuania is continuously integrating into European economy. Lithuanian export to EU countries accounts for 45.9 % of the total Lithuanian export.

2.1 Development trends of the agricultural sector

Most likely, the fluctuation in agricultural production has not ceased yet, because processes towards stabilisation and development did not start before 1997 when the area of agricultural farmland increased. The total area of agricultural farmland declined in 2001 again to 85 % of the area in 1997 (Table 2). About 696,000 hectares of arable land (24 % of the total arable land) remained as set-aside land.

The expenditure of mineral and organic fertilisers is presented in Table 3. High increases in the prices of mineral fertilisers drastically decreased its use due limited financial resources of farmers. Only about 30-40 % of the required minimum amount of mineral fertilisers for an average production level is now being used. Application rates of fertilisers, however, increased again after 1995.

There is no data available about fertiliser use from 1998-2000, but the data of 2001 shows that mineral fertiliser use increased rather significantly.

3 Investigated area

The Nemunas River basin was identified in the Baltic Sea Joint Comprehensive Environmental Action Programme (JCP) as an Agricultural Hot Spot in the Baltic Sea catchment area because of a significant pollution from agricultural and livestock production (HELCOM, 1993). The total area of the Nemunas River basin is 98.200 km^2.

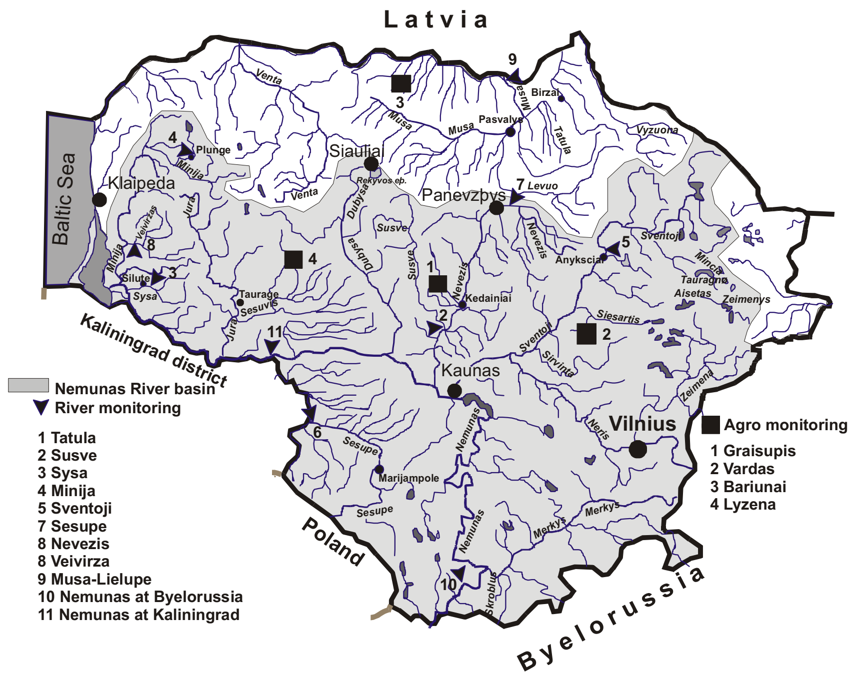

Fig.1:
Nemunas River basin and location of monitoring locations in rivers and agricultural watersheds

Almost half of the basin (46,650 km^2) is in Lithuanian territory. The Nemunas river basin covers about 71.4 % of Lithuania (Fig. 1).

Nitrogen and phosphorus long-term monitoring data as well as water flow data in the upper course of the rivers Tatula, Susve, Sysa, Minija, Sventoji, Sesupe, Nevezis, Veivirza, Levuo and the Nemunas River at the border to Byelorussia and the Kaliningrad district (Russian Federation) were used for the assessment of temporal changes in the water quality from 1986 to 2000.

Monitoring data for the upper courses of the rivers were mainly influenced by agricultural and natural run-off as the NO_3-N concentration in the small stream Graisupis within an agricultural watershed of 14.2 km^2 size reveals. The Graisupis stream is the third rank tributary of the Nevezis River. The Nevezis River basin is in the Lithuanian Middle Plain where agriculture is most developed and agriculture is most productive. The soils in the Graisupis watershed are loam and sandy loam. About 48 % of the farmland is arable land, 27 % forests and 16 % pasture. There is no point source pollution in the Graisupis watershed. Hydrological observations and water quality investigations have been carried out in the Graisupis stream since 1996.

Relevance of conclusions is based on statistical analysis. A t-test was performed in order to verify changes in nutrient loads with the data set being split in two periods: 1986 - 1991 and 1992 - 2000. The Null hypothesis was that nutrient loads (nitrate, ammonium and phosphate) are equal between these periods. Data set was assumed as having unequal variances and unequal size.

4 Results

The use of mineral fertilisers and the number of animals declined considerably in Lithuania from 1990 to 2001 (Tables 2 and 3) and so did the concentration of phosphorus and NH_4-N in Lithuanian rivers (Fig. 2).

The phosphorus concentration dropped below the eutrophication level (0.05 mg P L^{-1}). The NH_4-N concentration is meanwhile below the critical threshold of 0.39 mg NH_4-N L^{-1} (Lithuanian Ministry of Environment, 2002). In comparison, the NO_3-N concentration increased distinctly (Fig. 2).

Nitrate nitrogen concentrations from 1992 to 2001 were generally on an extended level. Even the lowest measured

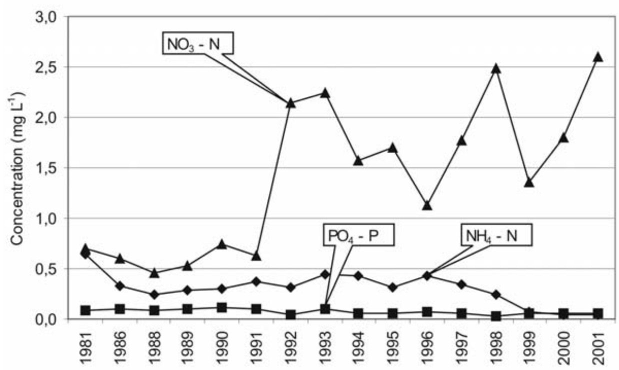

Fig. 2:
Variation of nutrient concentrations in the upper courses of the Lithuanian rivers Tatula, Susve, Sysa, Minija, Sventoji, Sesupe, Nevezis, Veivirza and Levuo.
Source: Anon (2002c)

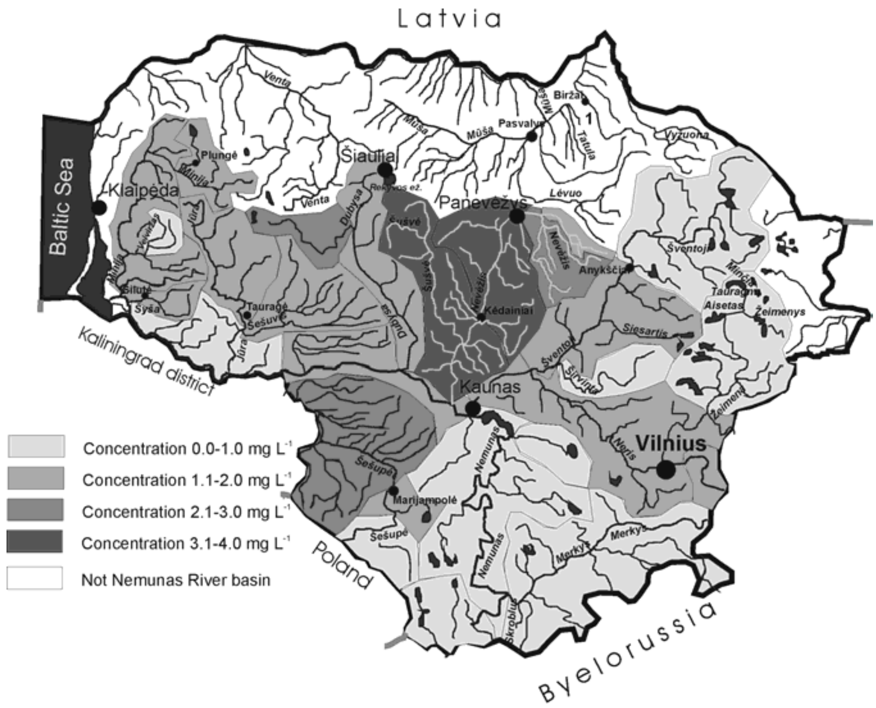

Fig. 3:
Mean NO_3-N concentration (1997-2001) in rivers of the Nemunas basin.
Source: Anon (2002c)

concentration during this period was higher than before 1992. Since 1993, the nitrate nitrogen concentration started to decrease. An increase of the NO_3-N concentration in rivers was registered again in 1997 when agricultural production increased and average NO_3-N concentration reached the level of medium polluted rivers (2.5 mg NO_3-N L^{-1} in 1998 (Lithuanian Ministry of Environment, 2002).

The most intensive agricultural production is in the basins of the rivers Nevezis and Sesupe where the most fertile soils provide best conditions for agricultural production. The analysis of the regional distribution of NO_3-N in rivers of the Nemunas River basin shows that concentrations are critical in areas with intensive agriculture (Figure 3). The mean NO_3-N concentration of the last five years was 2.1 - 4.0 mg NO_3-N L^{-1}in the rivers of the Nevezis River basin.

Though the rivers are polluted with nitrate, ammonia and phosphate, the extent is not critical (no more than 700 kg N and 45 kg P km^{-1} yr^{-1}). The nutrient loads were used to evaluate the variation of nutrient losses. Annual fluctuations of the nutrient load in the upper course of the rivers Tatula, Susve, Sysa, Minija, Sventoji, Sesupe, Nevezis, Veivirza and Levuo are presented in Fig. 4.

The variation of phosphorus, NH_4-N and NO_3-N loads to the lower course of the Nemunas River at the Kaliningrad border and to the upper course of Lithuanian rivers in agricultural regions was determined (Fig. 5). A decrease of phosphorus and NH_4-N loads in the upper course of the rivers was closely related to the nutrient load in the lower course of the Nemunas River at the border to Kaliningrad.

The question is whether or not nutrient loads to the upper course of the rivers derive from agricultural sources. To answer this question the relationship between NO_3-N concentrations in the Graisupis stream which is situated in an agricultural watershed and the Nevezis River was established (Fig. 6).

Nutrient discharges to the Graisupis watershed are dynamic because a small stream reacts faster to hydrological and meteorological condition changes. Nevertheless a weak, but significant linear correlation was found. The coefficient of determination was 46 % for the NO_3-N concentration in both water bodies (Fig. 7). This data clearly shows that agriculture is the main source of pollution in the upper course of rivers.

A comparison of the specific nutrient load to the Nemunas River and upper courses of other rivers revealed a negative influence of agriculture in the sense of increasing NO_3-N loads to the Nemunas River from 1986 onwards (Fig. 8). An increase of the load to rivers in intensive agricultural areas caused an increase of the NO_3-N load to the lower course of the Nemunas River at the border to Kaliningrad and the Baltic Sea. The relationship between the NO_3-N concentration in the upper course of rivers and the lower course of the Nemunas river (Fig. 9) was even closer than that between the agricultural watershed stream Graisupis and upper course of rivers (Fig. 7).

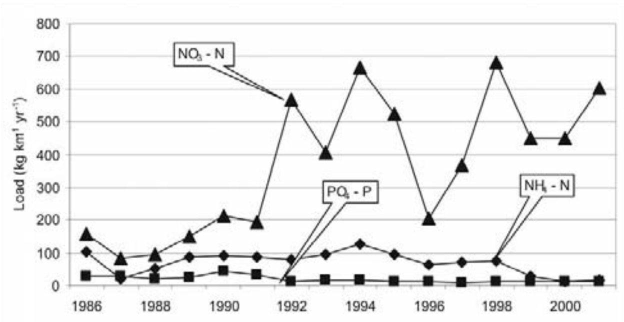

Fig. 4:
Annual variations of the nutrient load in the upper courses of the rivers Tatula Susve, Sysa, Minija, Sventoji, Sesupe, Nevezis, Veivirza and Levuo.
Source: Anon (2002b)

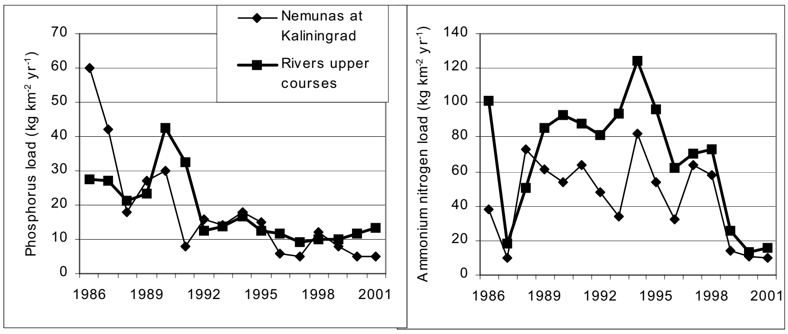

Fig. 5:
Variation of the phosphorus and ammonium nitrogen loads to the lower course of the Nemunas River at the border to Kaliningrad (Russia) and in upper reaches of Lithuanian rivers in agricultural regions.
Source: Anon (2002c)

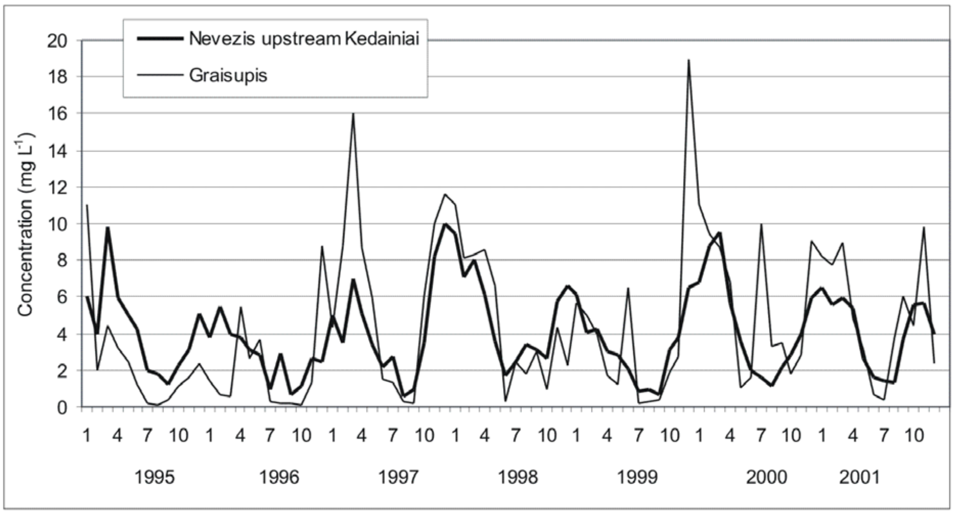

Fig. 6:
Variation of the nitrate nitrogen concentration in the Nevezis River and in the Graisupis stream (1994-2002).
Source: Anon (2002c) and Anon (2002d)

The calculations were made for the nutrient loads at the outlet of the river Nemunas. The specific nutrient load at the border to Kaliningrad was a main parameter for calculating the total load from the Nemunas River basin in the territory of Lithuania, which covers an area of 46,650 km^2. A decrease of phosphorus and NH_4-N loads to the upper course of the rivers was reflected in the nutrient loads to the lower course of the Nemunas River at the border to the Kaliningrad district and to the Baltic Sea. From 1986 to 2001 the NH_4-N load to the Baltic Sea decreased 3.1 times and that of PO_4–P 6.7 times. At the same time the NO_3-N load increased 1.5 times.

In order to determine whether pollution increased during the agrarian reform the nutrient loads in the upper courses of rivers in the periods of 1986-1991 and 1992-2000 were divided in table 5.

The statistical analysis reveals that the NO_3-N load to the upper course of the rivers significantly differed between periods before and after the agricultural reform.

Table 4:
Calculated nutrient load to the Baltic Sea from the Nemunas River basin in Lithuania from 1986 to 2001

Year	NH_4-N load (t)	NO_3-N load (t)	PO_4-P load (t)
1986	1773	7137	2799
1987	467	4712	1959
1988	3405	7231	840
1989	2846	6578	1260
1990	2519	6998	1400
1991	2986	6858	373
1992	2239	13155	746
1993	1586	10496	653
1994	3825	15628	840
1995	2519	11989	700
1996	1493	5645	280
1997	2986	9517	233
1998	2706	18753	560
1999	1003	9228	446
2000	514	12969	282
2001	567	10679	420

Source: Anon (2002c)

The NO_3-N load was significantly lower from 1986 to 1991 than after the agrarian reform. The strongest increase was observed in the rivers Susve, Sysa, Nevezis and Veivirza. In comparison the NO_3-N load to the river Sesupe did not change despite the fact that this river is located in a region with intensive agriculture and therefore this phenomenon should be a target of future investigations.

A different situation was found for NH_4-N and phosphorus loads. The mean NH_4-N load did not change within time. The NH_4-N load to rivers is, however, not consistent. The mean load of phosphorus decreased in most rivers.

5 Discussion

The monitoring data of rivers in Lithuania include natural and agricultural run-off as well as municipal and industrial pollution. The average five-year (1996 - 2001) NO_3-N load upstream to the Nevezis River with two large cities was 826 kg NO_3-N km^{-2} yr^{-1} while it was downstream 951 kg NO_3-N km^{-2} yr^{-1}. The NO_3-N load to the Nevezis River entering from two cities makes up only 13 %. This proves that in territories of intensive agriculture nitrate mainly enters rivers by diffuse sources.

Rivers are polluted by NO_3-N mainly form agriculture and natural sources (see Fig. 6) which is shown by the similar data for NO_3-N concentrations upstream of the Nevezis River and to a small stream in an agricultural watershed (14.2 km^2) which is in the same Nevezis River catchment. Only peak concentrations are higher in the small stream during floodings. The retention of nitrogen in the main rivers yielded about 20 to 50 % lower nitrogen loads than in the stream of an agricultural watershed. The retention includes denitrification, nitrogen uptake by water growth, sedimentation and other processes, which results in decreasing nitrogen concentrations in the water. For example, the average NO_3-N load upstream to the Nevezis River of the city Kedainiai (34,000 inhabitants) was 936 kg NO_3-N km^{-2} yr^{-1} while the load to an agricultural stream was 1407 kg NO_3-N km^{-2} yr^{-1} during the same period (1997-2001).

Despite the increase of NO_3-N concentrations in rivers and increasing nutrient loads, these values are low com-

Table 5:
Nutrient loads to the upper course of rivers and significance of its changes between periods before and after the agrarian reform in Lithuania

River / Nutrient species	Mean nutrient load (t)		Significance of *t - test* at $p<0.05$
	1986 - 1991	1992 - 2000	
Nitrate nitrogen (NO_3-N)			
Tatula	294	904	*
Susve	146	691	*
Sysa	106	649	*
Minija	122	394	*
Sventoji	154	258	*
Sesupe	121	127	-
Nevezis	169	612	*
Veivirza	96	351	*
Levuo	123	343	*
Mean	*148*	*481*	*
Ammonium nitrogen (NH_4-N)			
Tatula	69	117	-
Susve	59	40	-
Sysa	90	139	-
Minija	129	101	-
Sventoji	52	84	-
Sesupe	35	41	-
Nevezis	45	76	
Veivirza	141	109	-
Levuo	29	62	*
Mean	*72*	*85*	-
Phosphate phosphorus (PO_4-P)			
Tatula	49	25	-
Susve	22	6.9	*
Sysa	45	12	*
Minija	29	13	*
Sventoji	15	17	-
Sesupe	14	8.1	-
Nevezis	22	10	*
Veivirza	48	10	*
Levuo	16	8	*
Mean	*29*	*12*	*

Note: * - significant; (ns) - not significant

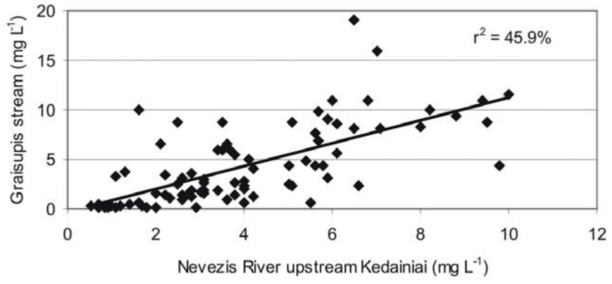

Fig. 7:
Relationship between nitrate nitrogen concentration in Graisupis and Nevezis rivers upstream Kedainiai (data from fig. 6).

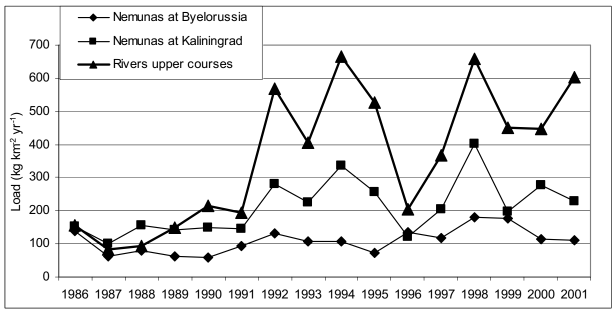

Fig. 8:
Variation of nitrate nitrogen loads to the the Nemunas River and in upper courses of the rivers in agricultural regions.
Source: Anon (2002c)

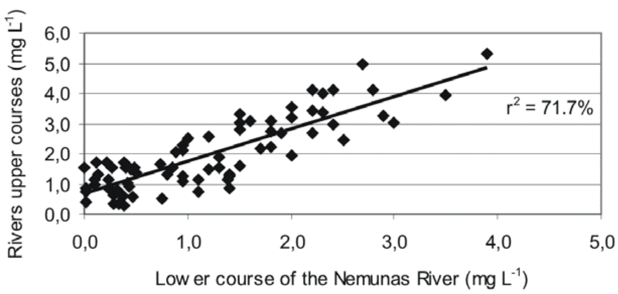

Fig. 9:
Relationship between nitrate nitrogen concentrations in the lower course of theNemunas River and the upper courses of the rivers in regions with intensive agricultural production (data from fig. 8).

pared to nitrogen loads in countries with intensive agriculture (Fig. 10).

Values for diffuse nitrogen loads to rivers in Ostrobotnia (1990-1994), Schleswig-Holstein (1990-1999) and Fyn (1990s) ranged from 500 to 1900 kg N km^{-2} (Sustainable Agriculture and Forestry, 2000), while the load to the Nemunas River at the border to Kaliningrad was only 263 kg km^{-2} yr^{-1} during this period. This data shows that the diffuse nitrogen transport in Schleswig-Holstein (Germany) and Fyn (Denmark) watercourses was 5-6 times higher than that to Nemunas River.

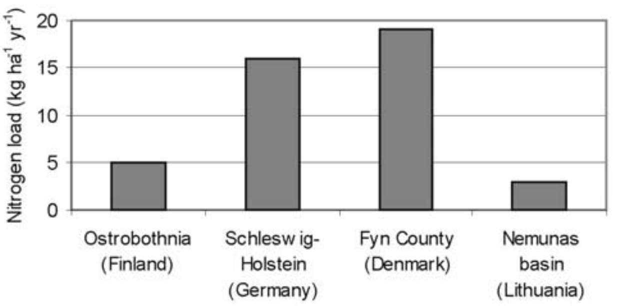

Fig.10:
Nitrogen load from diffuse sources to rivers of Finland, Germany, Denmark and Lithuania.
Source: Sustainable Agriculture and Forestry (BERNET Report), 2000 and Anon (2002c)

Hydrological and meteorological conditions during the period of 1996-2000 varied largely. In some years the annual rainfall was higher than the long-term average and in other years lower. It is important to note that the river flow rate and rainfall in different physical-geographic zones varied differently. The annual rainfall was on average 10 % lower in Central Lithuania (according to observations in Dotnuva meteorological station) during the period of 1986-1991 than in the period from 1992-2000. In contrast, in Western and Eastern Lithuania (Laukuva and Ukmerge meteorological stations) precipitation was 5-10 % higher during the first period. Long-term observations of Lithuanian rivers' flow (up to 180 years in the Nemunas River) (Gailiusis et al. 2001) show that a dryer phase has started since 1991 compared to the period of 1978-1990. But again, the flow decreased not in all rivers, e.g. rivers' flow in the Baltic Highlands, Northern Lithuania and Western Lithuania did not change. The flow in the rivers in the Central Lithuania slightly decreased. The average run-off coefficient (ratio between mean annual discharge during the investigated period and mean long-term annual discharge) of annual flow was 1.15-1.20 in 1978-1990 and 0.85-0.95 in 1991-2000 with a high fluctuation between years. Thus the period from 1991 to 2000 can be considered dryer (the run-off coefficient for the Nemunas River was 0.94) than that from 1978 to 1990.

There was only a weak correlation between total nitrogen concentration and water discharge in the Graisupis stream over a 7 years period of observation with monthly data (r^2 = 13 %). Differences for run-of coefficients of Lithuanian rivers' flow were only small between the two periods. Therefore, it can be assumed that hydrological conditions did not have a significant influence on nitrogen losses.

The results further reveal that a decreasing input of mineral and organic fertilisers will not automatically result in decreased nitrate nitrogen losses. Fertiliser use was, however, related to phosphorus and to some extent ammonium losses. Increasing nitrates losses were determined during the implementation of the agrarian reform in Lithuania, which caused tremendous changes in land use, the dismantling of cattle and pig farms, the establishment of new farms with about 60.000 new farmers who had only poor environmental knowledge. It is difficult to evaluate the impact of these factors on nitrogen losses to the environment. It might be that large quantities of NO_3-N were mineralised in soils and finally leached, because of different farm management practices.

Important is on a long-term basis that it can be expected that the run-off of nitrates will decrease significantly after the agrarian reform has been completed. Should the intensity of agricultural production and use of fertilisers, however, increase, this might yield a higher pollution of water bodies. The results of this study reveal that sudden changes in farming operations increase surface water and ground water pollution.

Conclusions

1. Phosphorus and ammonium loads from Lithuanian territory to the Baltic Sea decreased by more than 50 % within the last10 years.
2. Generally, the NO_3-N concentration in the Nemunas River is low, but run-off from agriculture in the basin of the Nevezis River contributes to regionally higher nitrogen loads.
3. The annual variation of hydrologic conditions was not related to increased NO_3-N losses.
4. In the course of the agrarian reform changing land use and farm management practices possibly yielded undesired nitrogen losses through higher mineralisation rates.
5. Leaching of nitrate in countries of transition is related to handling of manure, ploughing of pastures, abandonment of arable land and cultivated meadows, crop rotations, application of fertilisers and soil cultivation and therefore research and transfer of knowledge into advisory systems needs to be continued.

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