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Nutrient output from rural areas on the example of two catchments Skuterud and Zagożdżonka

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Abstract: *Nutrient output from rural areas on the example of two catchments Skuterud and Zagożdżonka.* In this paper, two rural catchment – the Zagożdżonka catchment in Poland and the Skuterud catchment in Aas, Akershus county in Norway are compared. In addition to the general description, more in particular information, runoff, $N\text{-}NO_3$ load, $P\text{-}PO_4$ load, total phosphorus and total nitrogen concentrations in streams are compared. The data compared are from 1993 to 1995 in Zagożdżonka catchment and from 1994–1996 from Skuterud catchment. The average concentration of $N\text{-}NO_3$ in Zagożdżonka River in the period was 0.85 $mg \cdot l^{-1}$ and the mean concentration of $P\text{-}PO_4$ was 0.13 $mg \cdot l^{-1}$. In the stream in Skuterud catchment the average concentration of $N\text{-}NO_3$ was 4.95 $mg \cdot l^{-1}$ and the mean concentration of $P\text{-}PO_4$ was 0.04 $mg \cdot l^{-1}$. For both catchments the same data were also compared for the 2008. In Skuterud catchment the highest concentration of nutrients occurred in November, March and April, which was connected to the higher runoff from agricultural areas during the snowmelt period. In Zagożdżonka catchment the highest concentration of nutrients was noted in March, April and in summer time, which was connected to periods with high amounts of precipitation. Comparison of the two rural catchments showed many differences in applied measurement methods for water sampling, water measurement, discharge measurement, runoff amounts and management practices, which had an effect on results of monitoring program. The compared data can be useful to predict the development of future environmental conditions for example water quality. It can also be useful for predict how nutrient runoff will be in future. What is more the different conditions for runoff in Skuterud and Zagożdżonka then different measures are needed.

Key words: rural catchment, runoff, agriculture, nitrogen, phosphorus, measurement method, monitoring program.

INTRODUCTION

Knowledge about nitrogen and phosphorus contents in water is important to assess the situation in rural area and prevent eutrophication of surface water. Agriculture contributes up to 50% of the nitrogen and 30% of the phosphorus delivery to rivers in Norway (Bechmann et al. 2009). The similar values were estimated in Poland, 50–60% of nitrogen and 30––40% of phosphorus inflow to Baltic sea comes from agricultural lands (Duer et al. 2004). The main factors responsible for nutrient loss to streams, rivers and lakes are related topography, soil types, meteorological conditions and agricultural activities. There are different pathways for nutrients and soil particles to open water courses. In Norway an important reason for transport to open water systems can be through the subsurface drainage runoff caused by excess rainfall. Another reason for transport of nutrients and soil particles is through surface runoff caused by excess rainfall on saturated soils or as snowmelt induced surface runoff on frozen soils. In Skuterud catchment, in Akershus county, one of the catchments in the Norwegian Agricultural Monitoring Programme, autumn and winter period with snowmelting is the most important runoff period. Snowmelt and rainfall on frozen or partly frozen soil can result in high surface runoff because of restricted infiltration. Soils, after long periods with rainfall which occurred during autumn, are characterized by near saturated conditions (Deelstra et al. 2009). The importance of autumn and winter period are different in different parts of Norway, this is the reason for having 10 catchments in the National Monitoring Programme. In western part of the country winter and frozen soil are less important than in eastern part represented by Skuterud. In Poland the eutrophication of open waters is also a huge problem. The water assessment, which was carried out in the years 2004–2007 showed that 62% of watercourses had a problem with eutrophication (Chief Inspectorate for Environmental Protection 2010). The implementation of the EU "Water Frame Directive" has led to increased focus on water quality and measures to improve the quality. Classification of the status of water quality has shown that 51% of Norwegian waterbodies are at no risk, 22% at possible risk, 25% at risk and 2% not defined (Snellingen et al. 2010).

In rural catchments runoff generation occurs mostly after the growing season (from September to March) during periods with excess precipitation (Deelstra et al. 2007). Crop yield is the major factor determining the nitrogen balance. Also the weather conditions during the growing season has a major effect on crop yields (Bechmann et al. 1998).

Nutrient losses are also highly correlated with changes in the yearly runoff and the monitoring results shown high variation in diffuse nutrient losses (Deelstra and Iital 2008). It is important to document losses of nutrients and to evaluate the implementation of mitigation methods. The countermeasures have high influence on nutrient losses from agriculture and effects on water quality. The mitigation methods include set of legislative, regulatory, economic incentives and information campaigns. In Norway farm policy strategy established rules which serve for mitigation of phosphorus from agriculture. They include soil management (inter alia reduce autumn tillage, contour ploughing or establish vegetated buffer zones and sedimentation ponds) and nutrient application (inter alia no manure application from 1st November to 15th February, phosphorus application plan based on soil phosphorus tests, reduced recommendations of fertilizer application) (Bechmann 2008). In order to motivate farmers to adopt conservation tillage practises, the agricultural authorities started to give support to those who leave the soil untilled during the winter period. This action was initiated in 1990 and has since then become more differentiated. In 2009 about 53% of the grain area is tilled only in spring, 42% ploughed in autumn and 5% harrowed in autumn and current support is given at rates of 50–180 Euro ha^{-1} per annum, varied according to erosion risk, with 90% of the support being given on areas with medium to extremely high erosion risk (Snellingen et al. 2010). In Poland mitigation methods are developed in lesser degree and they are mainly connected with economic incentives. The huge part in mitigation methods has also a Code of Good Agricultural Practice, which is an informative instrument for farmers. It contains many practical rules of how to reduce risk of water pollution (Ministry of Agriculture and Rural Development and Ministry of Environmental 2004). In Norway the national support regime was in 2005 changed to Regional Environmental Programmes. Each county develop (local authorities, farmers organisations, extension service involved) on their own environmental support program, both what measures should be given support and also the level of support. The programs are approved by the Agricultural Authorities. In 2009 about 1392 million Euro were given as environmental support for measures on 0.2 mill ha agricultural areas. Total area used for grain production were 0.3 mill ha. In some watersheds with specific problems with water quality there are specific rules and regulations on farming activities. Farmers have to implement certain mangement practices, like reduced tillage to obtain the subsidies and general production support. In this paper, two catchments Zagożdżonka in Poland and Skuterud in Norway are compared. The loads and concentration of nitrogen and phosphorus from 1993 to 1995 in Zagożdżonka catchment and from 1994–1996 in Skuterud catchment are compared with present situation and discussed in relation also to implemented measures in the catchments.

CATCHMENT CHARACTERISTICS LOCATION

The Skuterud catchment is located in Ås in Akershus county in Norway (Fig. 1). It is located approximately 30 km south from Oslo. Skuterud is one of the catchments in the Norwegian Agricultural Monitoring Programme – JOVA. Skuterud has measurements continuously from 1993 – ongoing. The area of Skuterud to Lake Østensjø is 449 ha and the elevation range amounts to 91–146 m asl. The average slope in the catchment is 3.6% (Deelstra et al. 2009). In the northern part of Skuterud catchment the Østensjø Lake is located. It is a shallow hypertrophic lake with capacity of 900 000 m^3 and area about 40 ha. The average depth is about 2.5 m with a maximum depth of 7 m (Borge 2009).

The Zagożdżonka catchment is located in Poland about 100 km south of Warsaw (Fig. 1). The total area of the tributary to the Vistula river is 56 850 ha, but the subcatchment to Płachty Stare gauging Station (area 8240 ha) has been considered in this study.

The catchment has a lowland character, typical for central Poland. The elevation range is from 148 till 185 m and with absolute relief 37 m (Banasik 1983). The river slopes in the area range from 0.25% to 0.35% (Popek et al. 2008). In northern part of Zagożdżonka catchment (about 2 km down the Płachty Stare gauge), the reservoir called "Staw Górny" is situated.

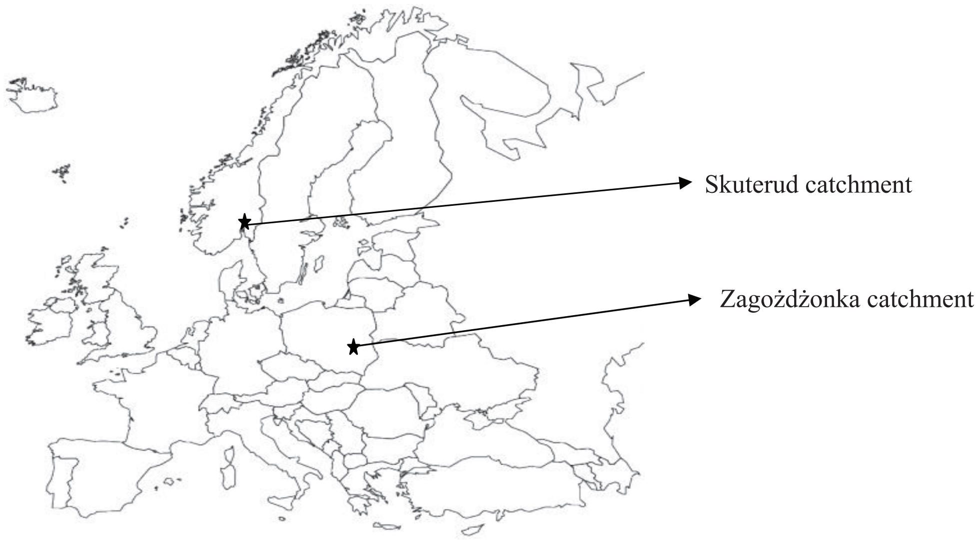

FIGURE 1. Catchment location

CLIMATE

The climate in Norway is temperate. In Ås the long term mean annual temperature amounts to 5.3°C. The highest temperature (16.8°C) is in July and the lowest (–4.8°C) at the turn of January and February (Deelstra and Iital 2008). In the period of 1994–1996, the highest precipitation (142.4 mm) was observed in December 1994 and the lowest (0.1 mm) in July 1994 (Tab. 1). In this period occurred also some months without rainfall (February and March, 1996). The precipitation in 2008 was 972.8 mm, while in the period of 1994-1996 average precipitation was 656 mm. The long term annual precipitation for Skuterud is 785 mm, so 2008 was a wet year (Pedersen et al. 2008).

Poland is situated in temperate climatic zone. In Zagożdżonka catchment the annual normal temperature amounts to 7.6°C, the average temperature in winter time ranges from 0.5°C to 1.0°C and in summer period is about 14.4° (Polish Hydrological Atlas 1986). The annual average precipitation in the period 1993–1995 was 236 mm. The highest precipitation (72 mm) was measured in November 1995 and the lowest (2.8 mm) in October 1995 (Tab. 1). In 2008 the precipitation was 537.3 mm, so it was a year with higher average rainfall than in previous compared period. The long term annual precipitation for Zagożdżonka was 611 mm.

Periods with high amounts of precipitation bring the largest runoff in the susceptible area, which is connected with the higher losses in agricultural areas. In 2008, the average annual runoff in Skuterud catchment was 631.2 mm, while in period 1994–1996 average runoff was 366.6 mm. Whereas in Zagożdżonka watershed in 2008 the average annual runoff was 56.3 mm, while in period 1993–1995 average runoff was 76 mm (Tab. 2) (Banasik 2009).

TABLE 1. The comparison of average precipitation and runoff in Zagożdżonka (Banasik 2009), and Skuterud catchments (Deelstra et al. 2005)

Zagożdżonka				Skuterud			
Year	Precipitation [mm]	Runoff [mm]	Runoff Coefficient [–]	Year	Precipitation [mm]	Runoff [mm]	Runoff Coefficient [–]
November 1993–October 1994	534	83	0.16	May 1994–April 1995	851.4	511.8	0.60
November 1994–October 1995	651	69	0.11	May 1995–April 1996	461.4	222.4	0.48
2008	537.3	76	0.14	2008	972.8	631.2	0.65

TABLE 2. The precipitation and runoff in Polish and Norwegian hydrological, 2008

Skuterud			Zagożdżonka		
Month	Precipitation [mm]	Runoff [mm]	Month	Precipitation [mm]	Runoff [mm]
May 2008	27.6	14.1	November 2007	43	5.2
June 2008	72.0	2.8	December 2007	11.5	4.7
July 2008	118.7	10.5	January 2008	50.4	6.0
August 2008	184.6	77.8	February 2008	13.2	5.6
September 2008	60.3	31.4	March 2008	60.3	7.5
October 2008	155.9	119.1	April 2008	38.6	6.7
November 2008	96.4	87.6	May 2008	62.7	5.6
December 2008	41.4	51.4	June 2008	26.2	2.7
January 2009	55.2	7.6	July 2008	53.0	2.3
February 2009	60.7	4.7	August 2008	74.3	2.2
March 2009	60.6	31.6	September 2008	59.9	3.3
April 2009	39.4	192.6	October 2008	44.2	4.5

In both catchments different assessment method of annual precipitation, runoff and nutrient loads were used. In Norway the period from the first day of May first year to the last day of April of the following year was considered, being an agro-hydrological year (Bechmann et al. 2009). The period coincides with then sequence in agricultural practices, including sowing, harvesting, tillage and time of using fertilizers. In Poland annual precipitation, runoff and nutrient loads were calculated for period from the first day of November of the first year to the last day of October the following year. It is connected with water balance in catchment and it is called hydrological year.

LAND USE AND SOILS

The main land use is agriculture covering 61% of the Skuterud area. Lands covered by forest are 29%, marshland constitutes 2% and the rest includes 8%. In period 1994–1996 oat constitute 32% of arable land and winter wheat 27%. During period 1994–1996, 41% of arable land is in stubble during winter, 35% have winter sown crops with autumn tillage. Other forms are autumn ploughed, autumn harrowed and grass. In Skuterud catchment the silty clay loam soils are dominant, but also loamy sand and silt occurs (Tab. 3) (Deleestra 2005).

The main form of land use in Zagożdżonka catchment is arable land taking up approximately 47% of the total area. The 40%, of the land is occupied by forest, 11% permanent pasture and the rest includes 2% (Banasik 1983). The most popular crops on arable land are rye, wheat-rye and oats. Potatoes occur also here quite often. In Zagożdżonka catchment sand is dominating soil type varying, from pure sand to loamy sands. In depressions areas also peaty soils occur (Tab. 3). There is information about husbandry and animals in the catchment, but in this area, the cows are grown only for milk for farmers household use in some farms.

FERTILIZERS APPLICATION

The fertilizer application in Skuterud catchment depends on crop type and varied during period from 1994 to 1996. In 1996 most of all phosphorus fertilizers utilized were on winter rye (31 $kg \cdot ha^{-1}$) and the least in 1994 on barley and oats (21 $kg \cdot ha^{-1}$). In 1996, most of all nitrogen fertilizer utilized on winter wheat (191 $kg \cdot ha^{-1}$) and the least in 1996 on oats (120 $kg \cdot ha^{-1}$) (Deelstra et al. 2005). Generally, in Skuterud watershed average applied N-fertilizers is 120 $kg \cdot ha^{-1}$ and P-fertilizers is 30 $kg \cdot ha^{-1}$ (Deelstra et al. 2008).

According to the Polish statistical yearbook, the consumption of mineral and chemical fertilizer in a term of pure phosphates in the Radomskie Voivodship were for as follow: 1994–6.1 $kg \cdot ha^{-1}$, 1995–12.1 $kg \cdot ha^{-1}$, 1996–16.1 $kg \cdot ha^{-1}$. The amount of N-fertilizers used in the Radomskie Voivodship was in 1994 – 22.5 $kg \cdot ha^{-1}$, in 1995 – 36.2 $kg \cdot ha^{-1}$ and in 1996 – 50.8 $kg \cdot ha^{-1}$ (Tab. 4) (Statistical Yearbook of the Republic of Poland 1997).

TABLE 3. Participation of soils in compared catchments (Deelstra et al. 2005; Banasik et al. 2005)

Soil Type	% of Zagożdżonka catchment area to Płachty Stare gauge	Soil type	% of Skuterud arable land area to Lake Østensjø
Light loamy sand	60.6	Marine and silty loams	75.4
Loamy sand	27.2	Sandy shore deposit	13. 6
Organic	12.1	Silty clay loams	11.0
Sand	0.1		

TABLE 4. The fertilizer application in compared catchments (Deelstra et al. 2008), (Statistical Yearbook of the Republic of Poland 1997)

Year	1994–1996	1994–1996
The average fertilizer application	Zagożdżonka (in the Radomskie Voivodship)	Skuterud
N-fertilizers [kg·ha^{-1}]	36.50	120
P- fertilizers [kg·ha^{-1}]	11.43	30

DISCHARGE MEASUREMENT AND SAMPLING METHODS

The Skuterud catchment is one of ten catchments in the National Environmental Monitoring Programme in Agriculture (Bechmann 2008). Monitoring was started in 1991 and the continuous time series with 20 years of data is a basis for trend analysis and development in land use, nutrient losses and water quality.

The Zagożdżonka catchment is a research catchment when the monitoring of hydometerological data is gathered since 1963 (Płachty Stare gauge station) but water quality parameters periodically (Hejduk et al. 2010).

In compared catchments different water sampling methods are applied. In Poland grab sampling system was used, which enables the researchers to determine the maximum, minimum and average concentration in samples (Hejduk and Banasik 2008; Hejduk et al. 2010). In Norway standard method used in the National Monitoring Programme is flow proportional composite water sampling. In this system the sampling intensity is determined by the discharge and composite sample represents only the average concentration of the sampling period. The water sample frequency is determined by the discharge intensity, which was recorded every 10s. Each time 500 m^3 of water passes through the discharge measurement structure and the preset water sample (100 ml) is taken. Small samples of water are gathered in the monitoring site in glass container with 20 l capacity at 5°C. Every fortnight samples are analyzed for nutrients, suspend sediments and pesticides, except periods with high runoff when samples are collected more frequently (Bechmann 2008).

RESULT AND DISCUSSION

In the period from 1994 to 1996 in Skuterud watershed losses of total nitrogen with runoff were 68.66 kg·ha^{-1} and losses of total phosphorus were 1.78 kg·ha^{-1}of arable land (Deelstra 2005). In 2008/2009 the first losses amounted 48.2 kg·N·ha^{-1} and the second were 2.7 kgP·ha^{-1}. The amount of yearly average total nitrogen losses was 4.01 kg·ha^{-1}. The highest nitrogen loss of 12.3 kg·ha^{-1} occurred in November while the lowest (0.1 kg·ha^{-1}) was in June. In the analyzed year the average total phosphorus load was 0.23 kg·ha^{-1}. The largest phosphorus loss occurred in April and amounted to 0.98 kg·ha^{-1}, which was connected to the snowmelt period. The lowest phosphorus loss (0.004 kg·ha^{-1}) was noted in June (Deelstra et al. 2005).

In period from 1993 to 1995 in Zagożdżonka watershed losses of nitrates with runoff were 2.79 kg·ha^{-1} and losses of orthophosphates were 0.41 kg·ha^{-1} (Tab. 5) (Banasik et al. 1999).

The data about the concentration of nutrients in water samples in 2008 in Skuterud are shown in Table 7. In streams of Skuterud catchment in November of 2008, the highest concentra-

TABLE 5. The nitrates and phosphates loads in Zagożdżonka catchment and the total nitrogen and the total phosphorus in Skuterud catchment

Zagożdżonka			Skuterud		
Year	$N\text{-}NO_3$ load [kg·ha^{-1}]	$P\text{-}PO_4$ load [kg·ha^{-1}]	Year	Total N [kg·ha^{-1}]	Total P [kg·ha^{-1}]
November 1993–October 1994	1.34	0.20	May 1994 – – April 1995	48.3	1.2
November 1994–October 1995	1.45	0.21	May 1995 – – April 1996	20.4	0.6

TABLE 6. Average concentration of nutrients in water samples

Zagożdżonka			Skuterud		
Year	$N\text{-}NO_3$ [mg·l^{-1}]	$P\text{-}PO_4$ [mg·l^{-1}]	Year	$N\text{-}NO_3$ [mg·l^{-1}]	$P\text{-}PO_4$ [mg·l^{-1}]
November 1993 – October 1994	0.77	0.12	May 1994 – April 1995	5.55	0.03
November 1994 – October 1995	0.93	0.15	May 1995 – April 1996	4.08	0.05
The average concentration in period from 1993 to 1995	0.85	0.13	The average concentration in period from 1994 to 1996	4.82	0.04

In period from 1993 to 1995 in taken samples (102) from Zagożdżonka River the average concentration of $N\text{-}NO_3$ was 0.85 mg·1^{-1} and the mean concentration of $P\text{-}PO_4$ was 0.13 mg·l^{-1} (Tab. 5) (Banasik 2009).

In 42 composite samples from stream in Skuterud catchment in period from 1994 to 1996 the average concentration of $N\text{-}NO_3$ was 4.82 mg·1^{-1} and the mean concentration of $P\text{-}PO_4$ was 0.04 mg·l^{-1} (Tab. 6) (Deelstra et al. 2005).

tion of total phosphorus (0.49 mg·l^{-1}) and $P\text{-}PO_4$ (0.17 mg·l^{-1}) occurred. Quite high concentration of total phosphorus (0.31 mg·l^{-1}) appeared also at the turn of March and April. The highest concentration of total nitrogen (10.10 mg·l^{-1}) was noted like in case of total phosphorus in November. In regard to $N\text{-}NO_3$ the highest concentration amounted to 4.52 mg·l^{-1} at the turn of September and October (Deelstra et al. 2005).

This situation was connected with the higher losses in agricultural areas in

TABLE 7. The average concentrations concentration of nutrients in water samples in 2008 in Skuterud catchment (Pederson et al. 2008)

Date	Time step [Day]	TP $[mg \cdot l^{-1}]$	$P–PO_4$ $[mg \cdot l^{-1}]$	TN $[mg \cdot l^{-1}]$	$N–N0_3$ $[mg \cdot l^{-1}]$
30.04–13.05.2008	14	0.06	0.01	2.70	2.55
13.05–29.05	16	0.03	0.01	2.50	2.00
29.05–6.06	8	0.06	0.03	1.90	1.00
6.06–30.06	23	0.10	0.04	2.20	1.50
30.06–9.07	9	0.18	0.05	4.20	3.10
9.07–29.07	19	0.08	0.02	1.80	1.10
29.07–19.08	21	0.07	0.04	3.90	2.70
19.08–21.08	2	0.29	0.08	4.50	3.52
21.08–11.09	21	0.22	0.09	5.00	3.53
11.09–30.09	19	0.08	0.04	4.80	3.10
30.09–16.10	16	0.30	0.08	6.70	4.52
16.10–7.11	22	0.20	0.06	5.70	3.80
7.11–21.11	14	0.49	0.17	10.10	3.30
21.11–10.12	17	0.14	0.04	3.80	3.20
10.12–19.12	9	0.17	0.06	5.00	3.70
19.12.2008–9.01.2009	21	0.29	0.08	5.20	2.20
9.01–26.01	17	0.11	0.04	3.00	2.10
26.01–19.02	24	0.05	0.02	3.00	2.10
19.02–8.03	17	0.09	0.04	2.40	1.50
8.03–24.03	16	0.07	0.04	2.20	1.50
24.03–7.04	14	0.31	0.04	1.80	0.85
7.04–23.04	16	0.22	0.05	4.20	1.50
23.04–7.05	17	0.16	0.04	2.90	2.10

November and with the snowmelt period with the highest runoff, which was taking place from March to April (Borge 2009).

The data about the concentration of nutrients in water samples in 2008 in Zagożdżonka are shown in Table 8. In 2008 in Zagożdżonka the highest concentration of total phosphorus (0.48 $mg \cdot l^{-1}$) was noted in March and the highest concentration of $P\text{-}PO_4$ (0.15 $mg \cdot l^{-1}$) occurred in the summer time. The highest concentration of total nitrogen (2.84 $mg \cdot l^{-1}$) and $N\text{-}NO_3$ (1.83 $mg \cdot l^{-1}$) appeared in April (Banasik 2009). This situation was connected to periods of high amounts of precipitation, which took place in March, with the snowmelt period occurring in April and with storm events, which bring the largest concentration of nitrogen and phosphorus in water. Compared data from 2008 concerning concentration of nutrient in water was presented in Figures 2–5.

TABLE 8. The concentration of nutrients in water samples in 2008 in Zagożdżonka catchment* (Banasik 2009)

Date	Time step [Day]	TP [mg·l^{-1}]	P-PO$_4$ [mg·l^{-1}]	TN [mg·l^{-1}]	N-NO$_3$ [mg·l^{-1}]
11.2007– 02.2008	Lack of data				
03.03.2008	7	0.42	0.07	1.56	0.91
10.03.2008	7	0.31	0.08	1.16	0.65
17.03.2008	7	0.48	0.13	2.01	1.37
25.03.2008	7	0.14	0.11	1.93	1.16
31.03.2008	7	0.38	0.10	1.96	1.17
07.04.2008	7	0.38	0.06	1.70	0.79
14.04.2008	7	0.10	0.08	1.53	0.70
21.04.2008	7	0.14	0.08	2.84	1.83
28.04.2008	7	0.11	0.03	1.53	0.76
05.05.2008	7	0.17	0.08	2.47	1.26
12.05.2008	7	0.17	0.08	1.60	0.57
19.05.2008	7	0.13	0.08	2.76	1.46
26.05.2008	7	0.12	0.10	1.42	0.55
02.06.2008	7	0.20	0.12	1.20	0.30
09.06.2008	7	0.13	0.08	1.39	0.19
16.06.2008	7	0.15	0.09	1.27	0.23
23.06.2008	7	0.15	0.09	1.58	0.19
30.06.2008	7	0.16	0.10	1.50	0.15
07.07.2008	7	0.19	0.11	1.60	0.14
14.07.2008	7	0.20	0.15	1.52	0.14
21.07.2008	7	0.20	0.12	1.35	0.16
28.07.2008	7	0.19	0.12	1.46	0.16
04.08.2008	7	0.22	0.15	1.44	0.18
11.08.2008	7	0.21	0.11	0.83	0.12
18.08.2008	7	0.17	0.11	0.93	0.11
25.08.2008	7	0.22	0.13	1.21	0.15
1.09.2008	7	0.17	0.09	0.99	0.11
8.09.2008	7	0.25	0.15	0.97	0.24
15.09.2008	7	0.15	0.08	0.79	0.10
22.09.2008	7	0.13	0.07	1.12	0.17
29.09.2008	7	0.12	0.07	1.01	0.14
6.10.2008	7	0.10	0.09	1.43	0.25
13.10.2008	7	0.11	0.08	0.76	0.12
20.10.2008	7	0.10	0.07	0.81	0.22
27.10.2008	7	0.08	0.06	0.85	0.20

* The result of examination covered by accreditation range PCA AB 140.

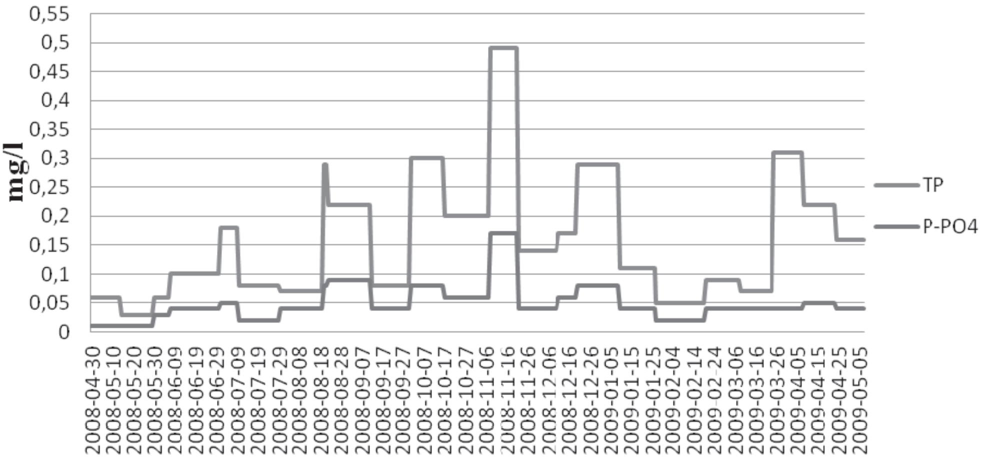

FIGURE 2. The average concentrations of total phosphorus and orthophosphates concentration change during 2008 in Skuterud

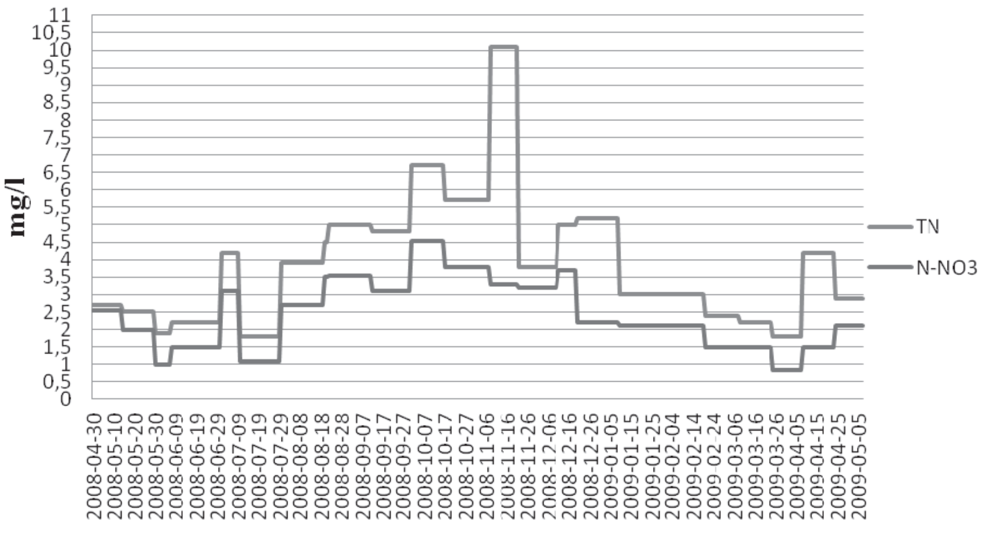

FIGURE 3. The total nitrogen and nitrates concentration change during 2008 in Skuterud

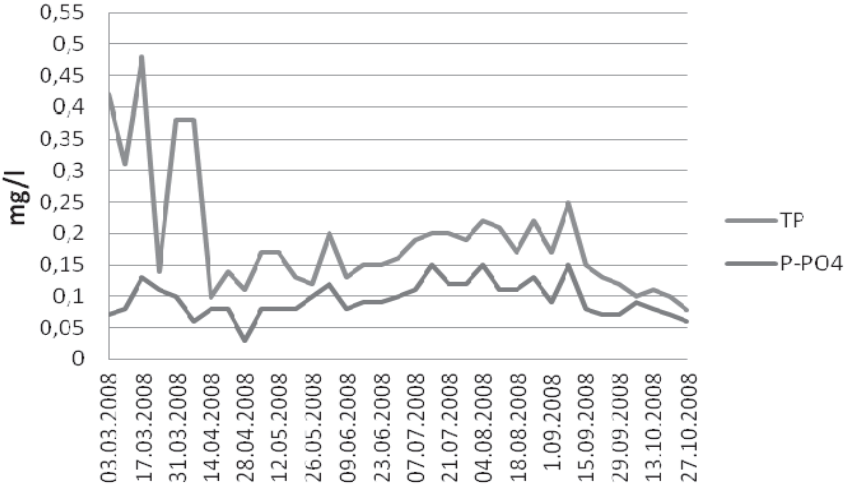

FIGURE 4. The total phosphorus and orthophosphates concentration change based on grab samples during 2008 in Zagożdżonka

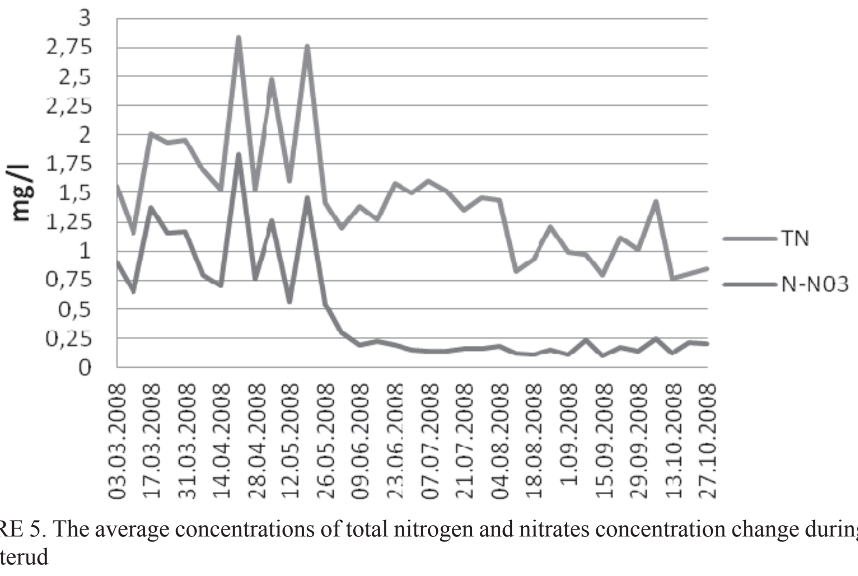

FIGURE 5. The average concentrations of total nitrogen and nitrates concentration change during 2008 in Skuterud

CONCLUSIONS

1. Comparison of two rural catchments showed many differences in hydro-meteorological parameters, soil types, applied measurement methods and data quality.
2. In Norwegian measurement system the research period (hydrological year) starts in May of first year and comes to the end in April of the following year, while in the Polish one it begins in November of the first year

and finishes in October of the following year what generate problems with comparison of the catchment.

3. The sampling methods are different in both catchments. In Norway the sampling enables the researchers to gain the average result but it is not possible to measure extreme, while in Poland the extremes maximum and minimum are easily reached but the average concentration has to be calculated. Both method is be useful depend on purpose of monitoring.
4. In compared catchments the average concentration of $N\text{-}NO_3$ (4.82 $mg \cdot l^{-1}$) was higher in streams of Skuterud (investigation period 1994–1996) and at the same time he mean concentration of $P\text{-}PO_4$ (0.13 $mg \cdot l^{-1}$) was higher in Zagożdżonka River.
5. In 2008 in compared catchments the highest concentration of total phosphorus (about 0.49 $mg \cdot l^{-1}$) and $P\text{-}PO_4$ (about 0.15 $mg \cdot l^{-1}$) were similar. The mean concentration of total nitrogen (10.10 $mg \cdot l^{-1}$) and $N\text{-}NO_3$ (4.52 $mg \cdot l^{-1}$) were higher in streams of Skuterud. However the different method of the sampling system (flow proportion in Norway and grab sampling in Poland) has probably influence on this results, what should be check by more precise method comparison.
6. Based on PL-Nor catchments comparison we found that the need of monitoring system to document changes and status as well as need of implementing more measures in agriculture to reduce eutrophication is one the most important issues.

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SNELLINGEN BYE A., AARSTAD A., LØVBERGET A.I., BERGE G., HOEM B. 2010: Jordbruk og miljø, Tilstand og utvikling.

Streszczenie: *Koncentracja biogenów w rolniczych zlewniach na przykładzie zlewni rzeki Skuterud i Zagożdżonki.* W artykule zostały porównane dwie rolnicze zlewnie, jedna zlokalizowana w Polsce – Zagożdżonka, druga w Norwegii – Skuterud. Poza ogólnymi opisami zlewni, porównywane informacje dotyczyły szczegółowych danych o opadach, spływie powierzchniowym, oraz stężeniach N-NO_3, P-PO_4, TP i TN w płynących wodach powierzchniowych. Dane ze zlewni Zagożdżonka pochodzą z lat 1993–1995, ze zlewni Skuterud z lat 1994–1996. Średnie stężenie N-NO_3 w w badanym okresie w rzece Zagożdżonka wynosiło 0,85 mg·l, zaś średnie stężenie P-PO_4 było równe 0,13 mg·l. W ciekach zlewni Skuterud średnia koncentracja N-NO_3 wynosiła 4,95 mg·l, zaś P-PO_4 oscylowała około 0,04 mg·l. W obydwu przypadkach te same analizy były przeprowadzone i porównane dla roku 2008. Wyniki pokazały, że dla cieków zlokalizowanych w Skuterud najwyższa koncentracja nutrientów wystąpiła w listopadzie, marcu i kwietniu. Zaistniała sytuacja ma związek z wysokim spływem powierzchniowym z terenów rolnych podczas upraw ziemi oraz z okresami roztopów. W zlewni Zagożdżonki najwyższe stężenie nutrientów w rzece odnotowano w marcu, kwietniu oraz w okresie letnim, co miało związek z dużymi opadami w tym okresie. Porównanie dwóch rolniczych zlewni pokazało wiele różnic, między innymi w stosowanych metodach pomiarowych, systemie monitoringowym i otrzymanych wynikach. Mimo wielu różnic przeprowadzona analiza może być przydatna w prognozowaniu przyszłych zmian warunków środowiskowych.

Słowa kluczowe: zlewnia rolnicza, stężenie azotu i fosforu w wodzie, metody pomiarowe

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