Journal of Ecological Engineering
Volume 15, No. 1, Jan. 2014, pp. 26–31
DOI: 10.12911/22998993.1084172

Research Article

SEASONAL CHANGES OF NITROGEN AND PHOSPHORUS CONCENTRATION IN SUPRAŚL RIVER

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Received: 2013.11.24
Accepted: 2013.12.14
Published: 2014.01.15

ABSTRACT
The purpose of the study was to determine seasonal changes of ammonia nitrogen, nitrate nitrogen, total nitrogen, phosphate and total phosphorus in the years 2003–2009 in the river Supraśl. For this purpose a monitoring network was created with selected three control points on the basis of which the assessment was made. Control points were located near Gródek, Nowodworce and Dzikie. The research results were averaged for each month. On this basis the assessment of seasonal changes of nitrogen and phosphorus forms in the river Supraśl has been carried out. Research and analysis showed that the concentration of nitrogen and phosphorus in waters of Supraśl were characterized by a clear seasonal variation, the highest concentration of nitrogen was observed in January and February and the lowest in June in each of the analyzed points, the course of changes in the concentration of nitric and total nitrogen in March were different from the general course of reigning changes in their concentrations in surface waters.

Keywords: nitrogen, phosphorus, seasonality, river.

INTRODUCTION

Chemical composition of surface waters is very diverse and depends on the type of surrounding areas usage. In case of small agricultural catchment, main components that run across rivers are nutrients, mainly in forms of nitrogen and phosphorus [Koc 2006, Czyżyk et al. 2008, Sapek 2008]. A number of changes associated with a decrease or increase in the concentration of each nutrient is associated not only with human activity, but also with the processes of natural mineral components migration into surface waters as a result of the prevailing climatic conditions.

The succession of the seasons is an important factor influencing on the chemistry of surface waters. Individual periods are characterized by different intensity of environmental factors, which in conjunction with the development cycles of organisms affect the intensity of their life processes, and therefore, the uptake, release and migration of nutrient elements [Vymazal 1995, Gergel et al. 1999, Bucka and Wilk-Woźniak et al. 2002].

Air temperature is not without significance, it directly affects the temperature of water in a given period. Water temperature, in turn, determines the rate of the natural changes occurring in the aquatic environment, including the ability of rivers self-purification [Jarosiewicz 2007, Kozłowski 2009].

Supraśl River is located in north-eastern Poland in the poviat of Białystok. Its catchment area is about 1800 km^2. Supraśl catchment includes such tributaries as: Sokołda, Płoska, Dzierniakówka, Pilinica, Biała, Czarna, Grzybówka i Słoja. The river (Supraśl) is located among the areas used primarily for agricultural purposes. In the catchment area small settlement units are located and there is no industry that might affect significantly the qualitative changes of the aquatic environment [Skorbiłowicz 2003].

The purpose of this paper was the determination of seasonal changes in the concentration of nitrogen and phosphorus in waters of Supraśl over six years research cycle.

RESEARCH METHODS

To assess the concentration changes of nitrogen and phosphorus forms the research results conducted by the Regional Inspectorate for Environmental Protection in Bialystok from 2003 to 2009 were used. Examination of water samples was performed in three control points located in the vicinity of: Gródek (CP 1), Nowodworce (CP 2) and Dzikie (CP 3) (Figure 1). Arithmetic mean and standard deviation (SD) of test results for each month in the period 2003–2009 were calculated using the statistical packet Statistica 10 for each control point.

The water samples were studied for the following components: ammonium nitrogen, nitrate nitrogen, total nitrogen, phosphates and total phosphorus, in addition air temperature was measured. Different parameters in the water samples were indicated by an UV-VIS spectrometry in accordance to the following standards and research procedures:

- ammonium nitrogen – PN-ISO 7150-1:2002,
- nitrate nitrogen – PN-82/C-04576.08,
- total nitrogen – PB–52 ed. 4 from day 04.06. 2007, in accordance to PN-73/C-04576/14,
- phosphates – PN-EN ISO 6878:2006,
- total phosphorus – PN-EN ISO 6878:2006.

RESULTS AND DISCUSSION

From the average temperature distribution (Figure 2), during the period of the study, results that the lowest temperature was observed in each of the control points in January, and the highest in July. The temperature distribution achieved in the measurements, is characteristic for Polish lowland areas (Web portal: poland.gov.pl).

The highest concentrations of ammonia nitrogen were observed in January, while the lowest in June. Comparing the average monthly temperature (Figure 2), with changes of ammonium nitrogen (Figure 3), a pattern can be noted. Namely, the concentration of this component in water increases with simultaneous temperature of ambient air decrease, which also was pointed by Blanket (2006), Sojka et al. (2007) and Czyżyk et al. (2008). The concentration of nitrate nitrogen (Figure 4) underwent changes, as the concen-

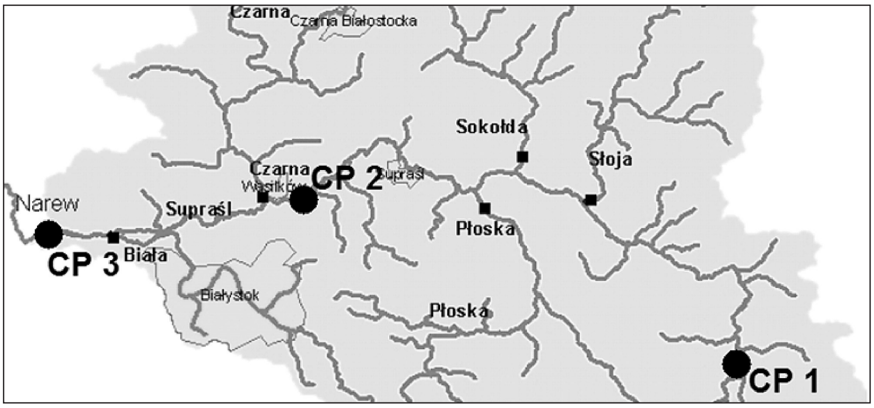
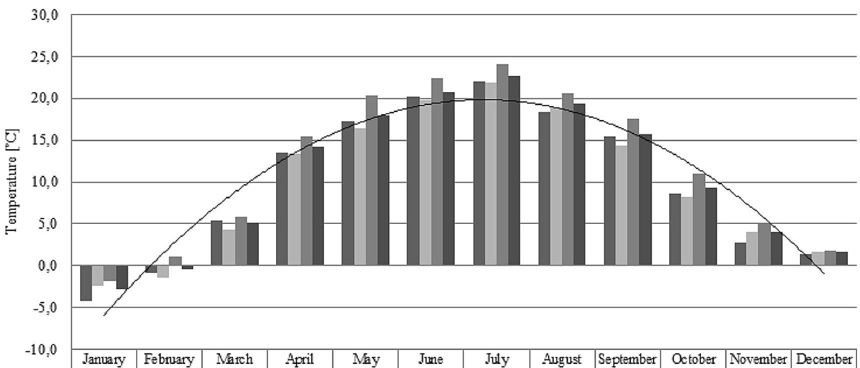


Figure 1. Location of control points on the river Supraśl [Ocena… WIOŚ 2010]



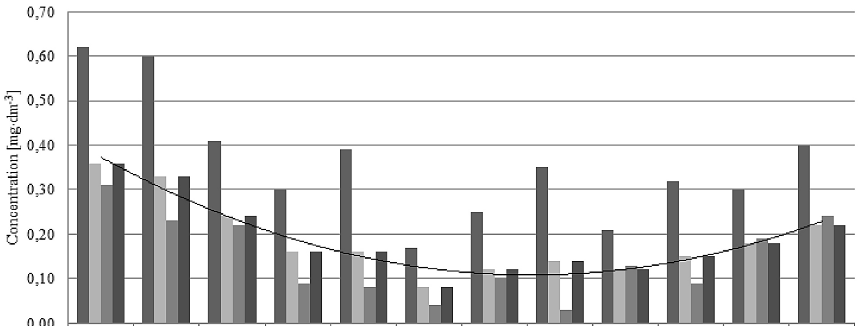
	January	February	March	April	May	June	July	August	September	October	November	December
CP 1	-4,2	-0,8	5,4	13,5	17,3	20,2	22,0	18,4	15,4	8,6	2,8	1,4
CP 2	-2,3	-1,4	4,2	13,4	16,4	19,7	21,9	18,9	14,3	8,2	4,0	1,7
CP 3	-1,8	1,1	5,9	15,5	20,3	22,4	24,0	20,6	17,5	11,0	5,2	1,9
Mean	-2,8	-0,4	5,2	14,1	18,0	20,8	22,6	19,3	15,7	9,3	4,0	1,6

Figure 2. Average temperature distribution of atmospheric air at control points on the river Supraśl [Dane... WIOŚ]

tration of ammonia nitrogen in the same period. Maximum concentration of this component was observed in March and a minimum in July. The exception from the general trend of increased concentrations is the results achieved in all control points in March. Possibly in this case, the overall variability of nitrate nitrogen concentration was disturbed by external (anthropogenic) source of this component in the studied waters. The spring period, which begins in March, is characterized by increased runoff from agricultural fields. Those waters are enriched in increased amounts of nitrate nitrogen unused by plants, as indicated in studies carried out by Banaszuk et al. [2009].

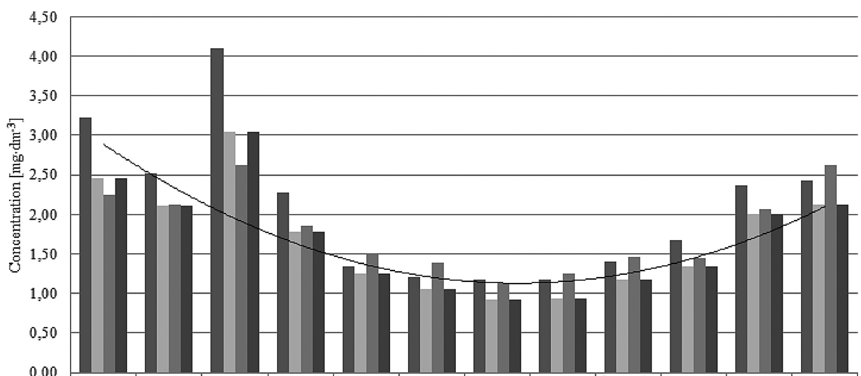
The concentration of total nitrogen (Figure 5) was characterized by a similar trend of changes as the nitrate nitrogen. Maximum concentration of total nitrogen was observed in March and a minimum in August. The concentration changes rhythm of total nitrogen is related to concentration changes of nitrate nitrogen. Phosphate concentration (Figure 6) was the highest in July and lowest in November. A characteristic changes trend was observed in all control points- the gradual increase in the concentration of phosphates with its beginning in May and ending in July.

The concentration of total phosphorus (Figure 7) showed an analogical changes trend as the concentration of dissolved phosphorus in the water. The maximum concentration of total phosphorus was observed in all control points in July, while the minimum in April. The data collected in CP 1 (Figure 3–7) indicate, the greatest concentration of nitrogen present in the winter and in the first decade of the spring – January, February, March. In the rest of the analyzed period, the nitrogen concentration has not changed significantly. It is strictly related to changes of atmospheric air temperature and oxygen conditions improvement in watercourse occurring during the period of temperatures above 0 ˚C [Koc 2006, Sojka et al. 2007, Czyżyk et al. 2008]. In the phosphorus case, high-



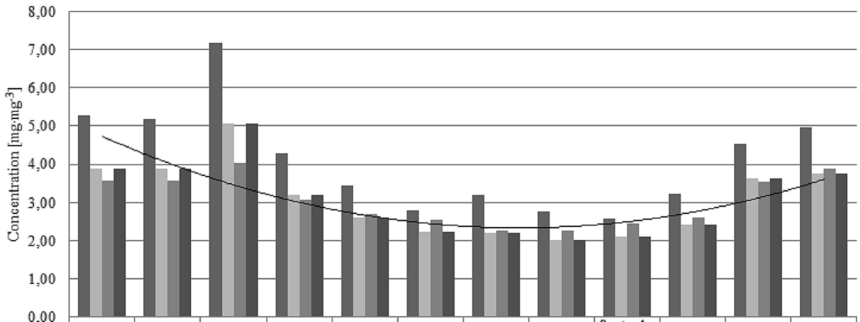
	January	February	March	April	May	June	July	August	September	October	November	December
CP 1	0,62	0,60	0,41	0,30	0,39	0,17	0,25	0,35	0,21	0,32	0,30	0,40
CP 2	0,36	0,33	0,24	0,16	0,16	0,08	0,12	0,14	0,12	0,15	0,18	0,22
CP 3	0,31	0,23	0,22	0,09	0,08	0,04	0,10	0,03	0,13	0,09	0,19	0,24
Mean	0,36	0,33	0,24	0,16	0,16	0,08	0,12	0,14	0,12	0,15	0,18	0,22

Figure 3. The concentration of ammonia nitrogen in the river Supraśl [Dane... WIOŚ]



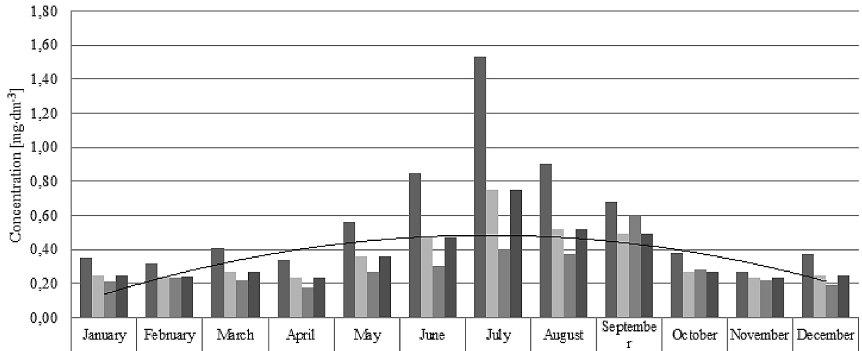
	January	February	March	April	May	June	July	August	September	October	November	December
CP 1	3,23	2,52	4,10	2,27	1,34	1,20	1,17	1,18	1,40	1,68	2,37	2,42
CP 2	2,45	2,11	3,05	1,78	1,25	1,06	0,92	0,93	1,18	1,34	2,01	2,13
CP 3	2,24	2,13	2,62	1,85	1,49	1,39	1,13	1,25	1,47	1,45	2,06	2,62
Mean	2,45	2,11	3,05	1,78	1,25	1,06	0,92	0,93	1,18	1,34	2,01	2,13

Figure 4. The concentration of nitrate nitrogen in the river Supraśl [Dane... WIOŚ]



	January	February	March	April	May	June	July	August	September	October	November	December
CP 1	5,26	5,19	7,16	4,27	3,45	2,79	3,20	2,77	2,57	3,22	4,54	4,96
CP 2	3,88	3,88	5,07	3,18	2,61	2,22	2,21	2,02	2,10	2,41	3,64	3,76
CP 3	3,57	3,57	4,04	3,07	2,70	2,53	2,26	2,26	2,46	2,59	3,53	3,87
Mean	3,88	3,88	5,07	3,18	2,61	2,22	2,21	2,02	2,10	2,41	3,64	3,76

Figure 5. The concentration of total nitrogen in the river Supraśl [Dane... WIOŚ]



	January	February	March	April	May	June	July	August	September	October	November	December
CP 1	0,35	0,32	0,41	0,34	0,56	0,85	1,53	0,90	0,68	0,38	0,27	0,37
CP 2	0,25	0,24	0,27	0,23	0,36	0,47	0,75	0,52	0,49	0,27	0,23	0,25
CP 3	0,21	0,23	0,22	0,18	0,27	0,30	0,40	0,37	0,60	0,28	0,22	0,19
Mean	0,25	0,24	0,27	0,23	0,36	0,47	0,75	0,52	0,49	0,27	0,23	0,25

Figure 6. The concentration of phosphorus in the river Supraśl [Dane... WIOŚ]

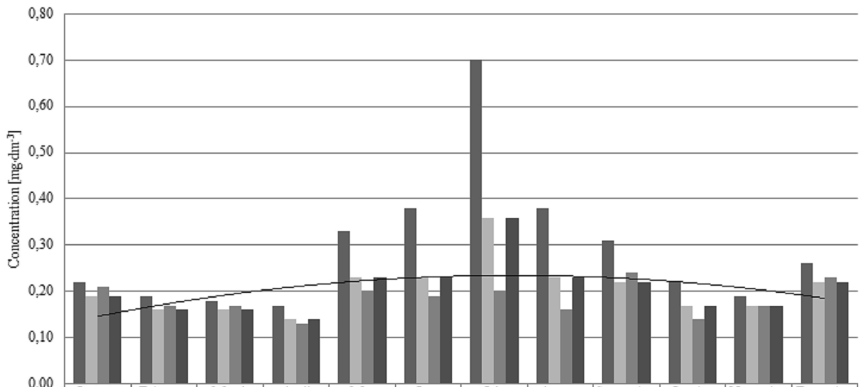
est concentration was recorded in July. Then, a gradual increase in the concentration of phosphorus was observed, which begins in May and ends in October. As pointed by Banaszuk [2009] and Sapek [2011] the highest concentration of studied forms of phosphorus occurs in July.

The data collected from CP 2 (Figures 3–7), shows that the greatest concentration of nitrogen is observed in winter and early spring, and phosphorus in July – as in CP 1. Average monthly concentrations of the individual indicators are lower than in CP 1. It is worth mentioning that the area between points CP 1 and CP 2 is largely covered with forests. Therefore, the nutrient supply from anthropogenic origin is relatively small. In comparison to the results obtained from CP 2 samples it can be concluded that a significant part of the ingredients introduced to Supraśl in CP 1 is bioremediated in this stretch. Research carried out by Kozłowski [2009] confirms the above described mechanism.

Total phosphorus concentration in the control point CP 3 is not significantly different in any of the analyzed months. Phosphate levels in the studied waters, as in other points reaches their maximum in July. The concentration of phosphate in the waters of CP 3 was increased during the growing season. The data presented in Figures 3–7 that the concentration of various forms of nitrogen are characterized by a similar trend of changes-maximum occurrence was observed in winter and early spring, while the lowest concentration was observed in July, which is also indicated by Dąbrowska [2008]. Concentrations of phosphates and phosphorus are the highest during the growing season, which is typical for a small agricultural catchment according to Kuźniar et al. [2008].

From the results summarized in Table 1, the largest dispersion in standard deviations occurs in increased concentrations periods of each indicator.

Similar results were achieved by Skorbiłowicz [2005], who showed that seasonal changes in selected components of the waters of Narew were primarily dependent upon climatic factors such



	January	February	March	April	May	June	July	August	September	October	November	December
■ CP 1	0,22	0,19	0,18	0,17	0,33	0,38	0,70	0,38	0,31	0,22	0,19	0,26
■ CP 2	0,19	0,16	0,16	0,14	0,23	0,23	0,36	0,23	0,22	0,17	0,17	0,22
■ CP 3	0,21	0,17	0,17	0,13	0,20	0,19	0,20	0,16	0,24	0,14	0,17	0,23
■ Mean	0,19	0,16	0,16	0,14	0,23	0,23	0,36	0,23	0,22	0,17	0,17	0,22

Figure 7. The concentration of total phosphorus in the river Supraśl [Dane... WIOŚ]

Table 1. The standard deviations (SD) of test results from the years 2003–2009

Indicator	Point	January	February	March	April	May	June	July	August	September	October	November	December
Temperature ˚C	CP 1	10.11	4.52	2.86	3.72	5.70	5.58	5.07	2.38	5.28	4.13	5.00	4.05
	CP 2	9.56	6.56	2.93	3.49	9.85	3.56	3.16	2.84	3.32	4.97	3.79	4.35
	CP 3	9.53	5.08	2.91	3.56	7.22	4.45	5.05	4.42	4.05	3.60	2.93	4.33
Ammonium nitrogen mg N×dm^{-3}	CP 1	0.47	0.38	0.35	0.12	0.25	0.11	0.34	0.42	0.10	0.08	0.15	0.18
	CP 2	0.08	0.06	0.10	0.10	0.02	0.04	0.04	0.03	0.03	0.11	0.02	0.01
	CP 3	0.20	0.11	0.32	0.09	0.06	0.05	0.12	0.03	0.17	0.00	0.72	0.86
Nitrate nitrogen mg N×dm^{-3}	CP 1	0.75	0.23	2.13	0.46	0.20	0.66	0.59	0.43	0.29	0.33	1.14	1.20
	CP 2	0.30	0.11	1.15	0.41	0.16	0.17	0.19	0.26	0.35	0.11	0.52	0.06
	CP 3	0.32	0.38	0.78	0.39	0.26	0.58	0.46	0.81	0.44	0.43	0.20	1.36
Total nitrogen mg N×dm^{-3}	CP 1	0.48	1.55	2.48	0.69	0.58	0.50	1.06	0.45	0.63	0.17	1.13	1.36
	CP 2	0.28	0.61	1.56	0.57	0.10	0.33	0.24	0.50	0.41	0.58	0.78	0.11
	CP 3	0.51	0.60	0.89	0.65	0.42	0.78	0.76	0.90	0.71	0.84	0.80	2.26
Phosphates mg PO_4×dm^{-3}	CP 1	0.20	0.16	0.36	0.06	0.12	0.28	1.10	0.59	0.28	0.09	0.04	0.21
	CP 2	0.04	0.02	0.05	0.05	0.01	0.08	0.09	0.13	0.05	0.03	0.04	0.03
	CP 3	0.02	0.07	0.08	0.05	0.03	0.07	0.08	0.14	1.08	0.17	0.06	0.02
Total phosphorus mg P×dm^{-3}	CP 1	0.15	0.07	0.10	0.05	0.07	0.13	0.52	0.24	0.12	0.05	0.03	0.13
	CP 2	0.10	0.02	0.05	0.05	0.03	0.03	0.05	0.06	0.03	0.08	0.06	0.06
	CP 3	0.09	0.04	0.07	0.06	0.10	0.10	0.05	0.05	0.34	0.05	0.10	0.21

as air temperature and precipitation, and that the concentration of nitrate nitrogen was characterized by the largest seasonal variability.

Research carried out by Kulbika and Kowalik [2002] also showed that nitrate concentrations in rivers are reaching the summer minimum (July and August) and two winter maxima (January and March).

Dąbkowski and Pawlata-Zakrzywaj [2003] studied the river Raszynka and found that the purity status changed during each month of the research year. The growing rate of quality changes in the hydrological year pointed to that. Their research showed maximum concentration of nitrogen in the period January-April (snow melt), and the minimum- in the period July-October (full vegetation and low outputs).

According to the results obtained by the Trender [2010] and Pulikowski et al. [2011] nitrogen concentrations show a similar trend of changes taking place in other streams of surface water. In small agricultural catchments nitrogen concentration reaches its maximum mostly in February or March. In case of phosphorus maximum is observed most commonly during the growing season [Kiryluk 2011].

CONCLUSIONS

1. The concentration of nitrogen and phosphorus in waters of Supraśl were characterized by a notable seasonal variation.
2. The largest concentration of nitrogen was observed in January and February and the lowest in June in each of the analyzed points.
3. The changes course of nitrate and total nitrogen concentrations in March was different from the generally prevailing changes course of their concentrations in surface waters.
4. Probably in some areas the concentration of phosphorus in surface waters increases with the beginning of the growing season and decreases thereafter.

Acknowledgement

The project was funded by S/WBiIŚ/4/2011.

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