FOLIA OECOLOGICA – vol. 36, no. 2 (2009). ISSN 1336-5266

Concentrations of phosphate phosphorus and total phosphorus in the water in different biotopes of the Nature Reserve Alúvium Žitavy

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Abstract

Noskovič, J., Palatická, A., Porhajašová, J., Kováčik, P. 2009. Concentrations of phosphate phosphorus and total phosphorus in the water in different biotopes of the Nature reserve Alúvium Žitavy. *Folia oecol*., 36: 125–133.

Over the years 2006–2008 the concentrations of P-PO_4^{3-} and $P_{Tot.}$ were evaluated as dependent on the time and site of sampling in the water of the Nature Reserve (NR) Alúvium Žitavy which is situated in the southwestern part of the Slovak Republic. According to the results obtained, we can calculate the concentration of phosphate phosphorus over the whole monitored period in water of the Nature Reserve was 0.44 mg dm^{-3}. It represented 60.27% of total phosphorus, other forms of phosphorus represented the rest of total phosphorus. Dependent on the sampling site we found out the highest mean P-PO_4^{3-} concentrations over the whole monitored period in summer with the maximum being in August and the lowest in February and March. As dependent on the sampling site mean P-PO_4^{3-} concentrations slightly decreased from the first to the last sampling site. We found out statistically significant influence of all three qualitative factors (sampling year, sampling month, sampling site) in value changes of this form of phosphorus by analysis of variance. The total phosphorus over the whole monitored period was 0.73 mg dm^{-3}. Generally, the lowest mean values over the whole monitored period were in the winter season with minimum being in February. Absolutely, the lowest mean $P_{Tot.}$ concentration was measured in this month in 2008. Analogous to P-PO_4^{3-}, mean $P_{Tot.}$ concentrations in the water generally slightly decreased from the first to the last sampling site. Influence of sampling site was also confirmed statistically. That finding demonstrates the purifying ability of wetland habitats being situated in the nature reserve.

Key words

nature reserve, phosphate phosphorus, total phosphorus, wetland

Introduction

Phosphorus is a limiting factor for production processes in water ecosystems (Lellák et Kubíček, 1991). This phosphorus in the surface water can be dissolved or undissolved in the organic and inorganic form. The inorganic dissolved phosphorus is mainly in the form of phosphate phosphorus (DeBusk, 1999). The algae and bacteria during photosynthesis are making use of phosphate phosphor and its compound is going to incorporated into biomass. For necrotic organisms phosphate phosphor is going to released into the aquatic environment or is fixing to insoluble (aerobic conditions, alkaline environment) form of calcium, magnesium, iron salts. These forms are accumulated in the sediments (Lellák et Kubíček, 1991). Phosphorus is also excreted by animals into the water and then it is used by bacteria and algae (Ambrožová, 2003).

Major processes affecting retention, cycling and release of phosphorus in wetlands are diffusion, plant uptake, litter fall, sedimentation, decomposition of organic matter, sorption and burial and peat accretion. The capacity of wetlands for phosphorus removal is limited compared to their nitrogen removal capacity. There is no permanent loss mechanism for phosphorus in wetlands that is analogous to denitrification; therefore, phosphorus tends to accumulate in wetlands at a higher rate than does nitrogen (DeBusk, 1999).

Material and methods

Research area

The Nature Reserve (NR) Alúvium Žitavy is situated in the cadastral land of the town Hurbanovo and the village of Martovce in the southwestern part of the Slovak Republic (Krajinno-ekologicky plán obce Martovce, 2006). Its area covers 32.53 hectares and it was established as the Nature Reserve in 1993. Aluvium lies in interperineal area of the river Žitava, from its present estuary of the river Nitra to the village Veľký Vék (assumed air line) (Szabóová, 1989). It is closed to surrounding agrocenosis with the remainders of meanders of the original water course of the rivers Nitra and Žitava. There is an open water line of the canal with dense bank vegetation in the central part of the Reserve. The northern part enlarges and there is continuous vegetation of riverine forest. Wetland ecosystems are situated mainly in terrain depression at the edge of the alluvium of the river Žitava (Bridišová et al., 2006).

Its larger part is flooded in the course of the year, but especially in spring. There are different biotopes, aquatic, wetland and riverine vegetation. Riverine forests, particularly, willow stands, almost along Alúvium provide suitable ecological conditions both for nesting of avifauna and hiding places as well. There are more than 76 bird species occurring in this area (Prírodná rezervácia Alúvium Žitavy, 2006). Furthermore, for conservation of fauna and flora genetic resources are very important (Štátny zoznam osobitne chránených častí prírody a krajiny Slovenskej republiky, 2007).

The NR Alúvium Žitavy is a part of the Protected Landscape Area Dunajské luhy (Krajinno-ekologický plán obce Martovce, 2006). The protection objective is biotopes of European importance (riverine willow-poplar and alder wood forests) and species of European importance (*Proterorhinus* sp., *Rhodeus amarus*, *Gobio albipinnatus*, *Bombina bombina*, *Lutra lutra*, *Citellus citellus*, species of national importance *Microtus oeconomus*) (Bridišová et al., 2006). Concurrently, NR Alúvium Žitavy is a part of the Special Protection Area SKSPA 005 Dolné Považie where also belongs a proposed habitat of European importance 0159 Alúvium Žitavy (Krajinno-ekologický plán obce Martovce, 2006). The rarest species of avifauna are, for example *Ardea* sp., *Remiz* sp., *Botaurus* sp., *Circus* sp., *Anas* sp., *Acrocephalus* sp., *Charadrius* sp., *Locustella* sp., etc. In term of protected flora, there are *Leucojum aestivum* vegetated almost in the whole area of the NR and *Nuphar lutea* on water level. *Ceratophyllum* sp., *Lemna minor* and *Lemna trisulca* form a typical green cover on the water level. Along the interperineal area of the river Žitava, there is wetland vegetation from which communities of *Phragmites australis*, *Typha latifolia*, *Carex* sp. and *Scirpus* sp. are dominant (Prírodná rezervácia Alúvium Žitavy, 2006).

Sampling and processing of the material

Taking of water samples was carried out from 6 sampling sites in the NR (see Fig 1). Water samples were taken regularly during the years 2006–2008, on the 15th day each month. The sampling sites were proposed to obtain the best possible data for the evaluation of changes in $P\text{-}PO_4^{3-}$ and $P_{Tot.}$ concentrations in water as dependent on sampling time and site. We have established the following 6 sampling sites:

Sampling site No. 1 (47°51'88" N, 18°09'89" E, 121 meters above sea level) (see Fig 2) – inflow of the river Žitava into the Alúvium. *Phragmites australis* and *Salix* sp. grow along the river Žitava. The average depth is 0.32 metres.

Sampling site No. 2 (47°51'92" N, 18°09'25" E, 111 meters above sea level) (see Fig 3) and **No. 3.** (47°51'83" N, 18°09'25" E, 117 meters above sea level) (see Fig 4) – these sampling sites are typical wetland ecosystems. There is a very dense vegetation of *Phragmites australis* and *Salix* sp. in this part of the NR. Water level is covered by *Lemna minor*. Water in these sites flows very slowly and the height of its level is chaning in the course of the year as dependent on weather in dependence on weather during the year. The average depth is 0.30 meters.

Sampling site No. 4 (47°51'58" N, 18°08'38" E, 129 meters above sea level) (see Fig 5) – is situated near the bridge on which there is a road to the village Martovce. It is also the narrowest part of Alúvium; therefore, water flow reaches the highest speed in the river Žitava. There are typical vegetation of *Phragmites australis*, *Salix* sp. and *Alnus* sp. on the banks of the river Žitava. The average depth is 0.40 meters.

Sampling site No. 5 (47°51'09" N, 18°07'99" E, 116 meters above sea level) (see Fig 6) and **No. 6** (47°50'81" N, 18°07'67" E, 121 meters above sea level) (see Fig 7) – typical wetland ecosystems. The river Žitava flows out of its watershed here while rapid snow melting in spring months and intensive precipitation amount in summer months. Compared to the second and the third sampling site, the river floods the whole area between two slopes. The water level decreases about few meters during dry weather in summer. This part of Alúvium is represented mainly by an open water area. *Typha latifolia*, *Phragmites australis*, *Alnus sp.* and *Salix sp.* grow along the river. The water level in sampling site No. 6 is covered with *Lemna* sp. which forms a typical green cover. Beyond this sampling site the river Žitava flows into the river Nitra. The average depth in sampling site No. 5 is 0.26 meters and 0.39 meters in sampling site No. 6.

In the samples taken, $P\text{-}PO_4^{3-}$ concentrations were determined colorimetrically by stannous chloride and $P_{Tot.}$ colorimetrically by ammonium molybdate.

Fig 1. Ortho-photo map of the Nature Reserve Alúvium Žitavy with marked sampling sites

Fig 2. Sampling site No. 1

Fig 3. Sampling site No. 2

Fig. 4. Sampling site No. 3

Fig 5. Sampling site No. 4

Fig 6. Sampling site No. 5

Fig 7. Sampling site No. 6

The results obtained were graphically processed in term of sample time and sample site, consequently processed statistically. All the statistical analyses were consequently conducted by the statistic system Statgraphics Plus 5.0. The basic statistical characteristics of each data file were calculated for all monitored indicators (see Table 1). The statistical differences based on three qualitative factors (sampling year, sampling month, sampling site) were tested by analysis of variance. LSD test for statistical contrasts testing was used on significance level of 95% and 99%. Pearson for bilateral correlation relationships was used to evaluate indicators observed.

Table 1. Basic statistical characteristics

Indicator	$P\text{-}PO_4^{3-}$ [mg dm^{-3}]	$P_{Tot.}$ [mg dm^{-3}]
Count (n)	216	216
Average	0.44	0.73
Minimum	0.01	0.10
Maximum	0.94	2.10
Median	0.46	0.67
Mode	0.34	0.57
Variance	0.026	0.060
Standard deviation	0.161	0.244
Standard error	0.011	0.017
Range	0.93	2.00
Coefficient of variation [%]	36.644	33.420

Results and discussion

The mean phosphate phosphorus concentration in the water of the NR over the whole monitored period was 0.44 mg dm^{-3} (Fig 8). It represented 60.27% of total phosphorus, other forms of phosphorus represented the rest of total phosphorus. The relationship between $P\text{-}PO_4^{3-}$ and $P_{Tot.}$ is shown in Fig 9. Kuníková et al. (2005) found out that in 2002–2003 the mean concentration of $P\text{-}PO_4^{3-}$ in Anakonda wetland was 0.042 mg dm^{-3}.

Dependent on sampling time (see Fig 10), over the whole monitored period the lowest $P\text{-}PO_4^{3-}$ values were in the early spring with its minimum value being in March (0.24 mg dm^{-3}), the second lowest mean value (0.25 mg dm^{-3}) was in February. The decrease of $P\text{-}PO_4^{3-}$ values in this time is related to unsuitable temperature conditions for decomposition of substances containing organic phosphorus form. According to Palatická (2009) there is a positive correlation dependence between water temperature and the concentration of $P\text{-}PO_4^{3-}$.

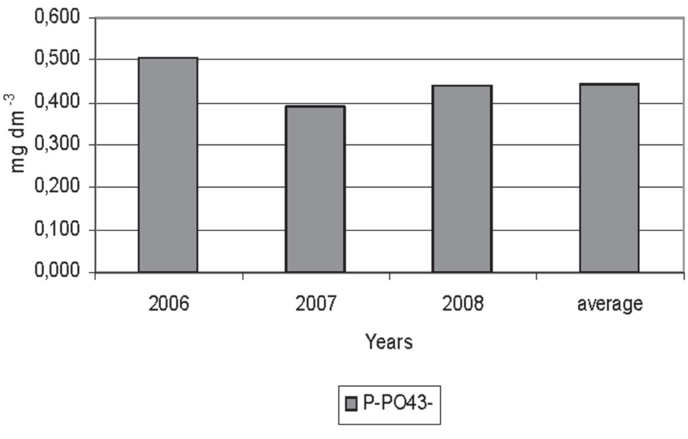

Fig 8. The mean concentrations $P\text{-}PO_4^{3-}$ [mg dm^{-3}] in the years 2006–2008

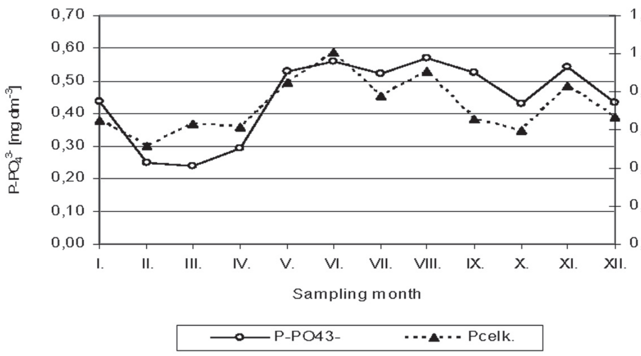

Fig 9. Relationship between mean concentration of $P\text{-}PO_4^{3-}$ and $P_{Tot.}$

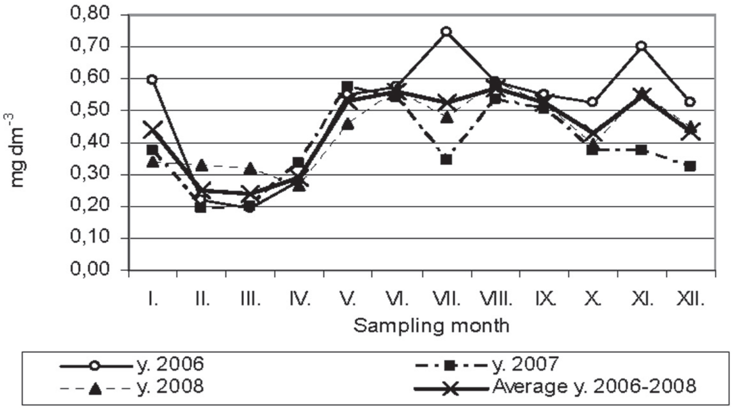

Fig 10. The mean $P\text{-}PO_4^{3-}$ concentrations in dependence on sampling time

Mean concentrations of phosphate phosphorus over the whole monitored period were gradually increasing from March to summer. Its maximum mean concentration was in August (0.57 mg dm^{-3}). Sozanský et Noskovič (2002) found the water course Cabajský creek similar seasonal dynamics and Beňačková (2007) in the water Nature Reserve Žitavský luh. According to Pitter (1999), high $P\text{-}PO_4^{3-}$ concentrations in summer are due to decomposition of organic substances which is in progress more intensively in higher temperature and under aerobic conditions. During the decomposition dissolved oxygen in water is consumed. Lellák et Kubíček (1991) if oxygen depletion occurs, Fe^{3+} in sediments reduces to dissolved Fe^{2+}, so blocked phosphates are partly released into water above the sediments. Documented by the results Palatická (2009), was found a negative correlation between reliance $P\text{-}PO_4^{3-}$and the dissolved oxygen content.

From the diagram of mean $P\text{-}PO_4^{3-}$ concentrations as dependent on sampling site (see Fig 11) it can be seen that its values slightly declined and varied from 0.48 mg dm^{-3} in sampling site No. 3 to 0.38 mg dm^{-3} in sampling site No. 6.

The change of concentrations was most significantly influenced by the year of taking samples of this indicator. The highest difference was achieved between the first and the second sampling year. The influence of sampling month and the site of the change of $P\text{-}PO_4^{3-}$ concentrations in water was also plumbless. $P\text{-}PO_4^{3-}$ positively correlated with $P_{Tot.}$ (r = 0.47).

Mean concentration of total phosphorus during the monitored years was 0.73 mg dm^{-3} (Fig 12). Brantley et al. (2008) found out that from September 1998 to October 2000 the mean concentration of total phosphorus in freshwater wetland in Louisiane was 1.1 mg dm^{-3}. From the diagram of mean concentrations of $P_{Tot.}$ as dependent on sampling time (see Fig 13) it can be seen that the minimum mean concentrations over the whole monitored period were obtained generally in the winter months with minimum being in February (0.51 mg dm^{-3}) in which the lowest mean concentration was measured (0.45 mg dm^{-3}) in this month in 2008. Maximum mean concentration over the whole monitored period was in June (1.01 mg dm^{-3}) when the highest mean value (1.12 mg dm^{-3}) was measured in 2007. The source of total phosphorus is probably an intensive decomposing

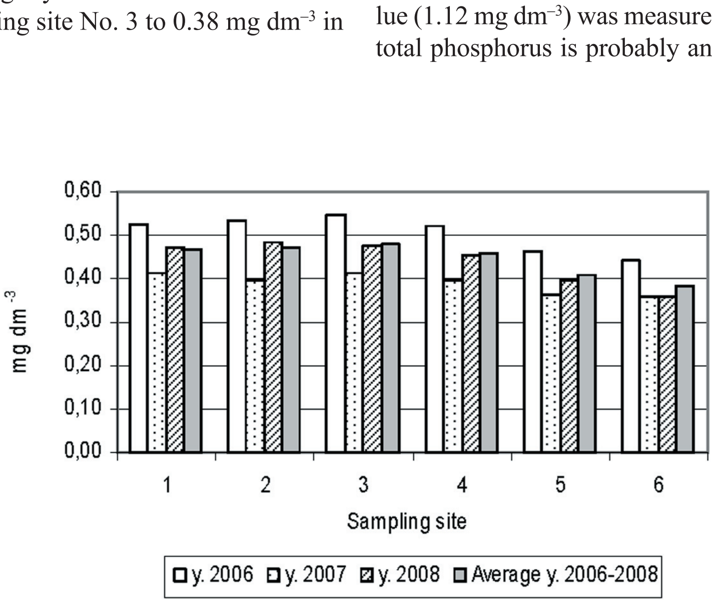

Fig 11. The mean $P\text{-}PO_4^{3-}$ concentrations as dependent on sampling site

biomass in sediments. The influence of sampling month on changes of $P_{Tot.}$ concentrations was confirmed also statistically.

Mean concentrations of $P_{Tot.}$ in sampling sites during the monitored years are shown in Fig 14. Similarly to phosphate phosphorus, gradual decrease of its concentrations from the first to the last sampling site can also be seen. A statistically important influence of sampling place on the change of its values was also confirmed, too. Maximum mean concentration of $P_{Tot.}$ over the whole monitored period was in Sampling site No. 1 (0.80 mg dm^{-3}). In 2007 the highest mean concentration (0.92 mg dm^{-3}) was found out in this sampling site. Minimum mean $P_{Tot.}$ concentration over the whole period was in Sampling site No. 6 (0.63 mg dm^{-3}). Brantley et al. (2008) also recorded clear decrease of total phosphorus content in profile of sampling sites in wetland system in Louisiane.

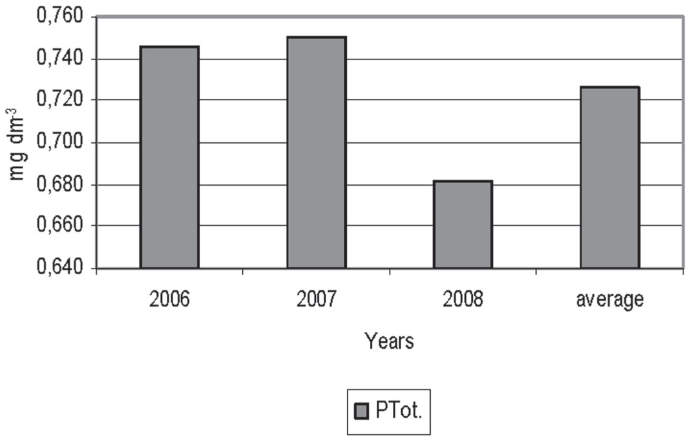

Fig 12. The mean concentrations $P_{Tot.}$ (mg dm^{-3}) in the years 2006–2008

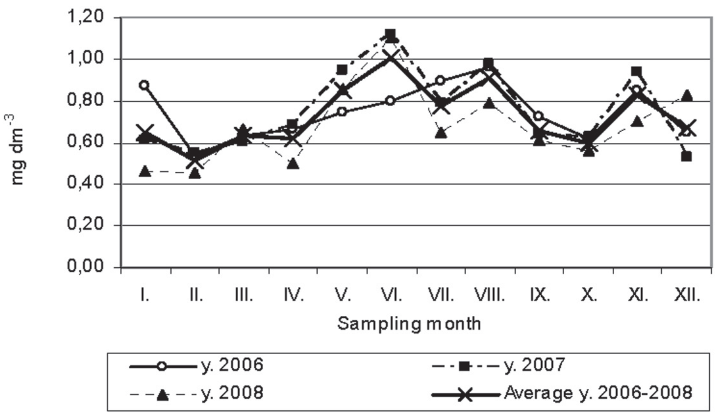

Fig 13. The mean $P_{Tot.}$ concentrations in dependence on sampling time

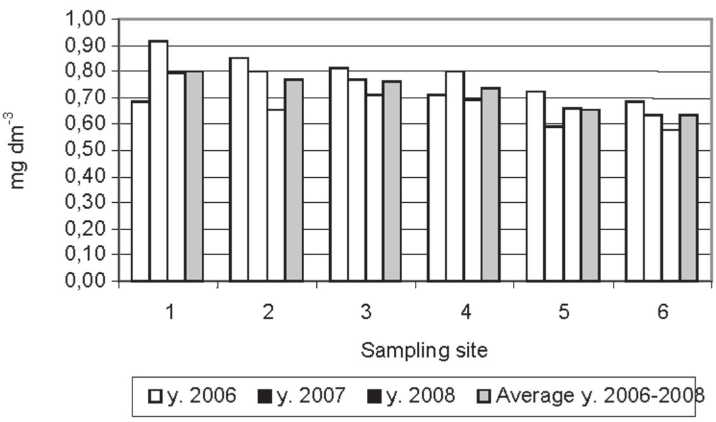

Fig 14. The mean $P_{Tot.}$ concentrations in dependence on sampling site

Acknowledgement

This research was supported within the grant project VEGA 1/0275/08 “A Study of Abiotic and Biotic Parts of the Nature Reserve Alúvium Žitavy and Its Importance for the Biodiversity Conservation of Agricultural Landscape”.

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Koncentrácie fosforečnanového a celkového fosforu vo vode v rôznych biotopoch Prírodnej rezevácie Alúvium Žitavy

Súhrn

V priebehu rokov 2006–2008 sa vo vode Prírodnej rezervácie Alúvium Žitavy, ktorá sa nachádza v juhozápadnej časti Slovenskej republiky, hodnotili koncentrácie $P\text{-}PO_4^{3-}$ a $P_{Celk.}$ v závislosti od času a miesta odberu. Na základe získaných výsledkov môžeme konštatovať, že priemerná koncentrácia fosforečnanového fosforu vo vode PR za celé sledované obdobie bola 0,44 mg dm^{-3}. Z celkového fosforu predstavoval až 60,27 %, zvyšok tvorili ostatné formy fosforu. V závislosti od času odberu sme najvyššie koncentrácie $P\text{-}PO_4^{3-}$ za celé sledované obdobie zistili v letnom období s maximom v mesiaci august a najnižšie v mesiacoch február a marec. V závislosti od odberového miesta priemerné hodnoty $P\text{-}PO_4^{3-}$ mierne klesali od prvého odberového miesta po posledné. Analýzou rozptylu sme zistili štatisticky významný vplyv všetkých troch kvalitatívnych faktorov (rok odberu, mesiac odberu, miesto odberu) na zmenu koncentrácií tejto formy fosforu. Celkový fosfor za celé sledované obdobie dosiahol priemernú hodnotu 0,73 mg dm^{-3}. Najnižšie priemerné hodnoty za celé sledované obdobie sa vyskytovali spravidla v zimnom období s minimom v mesiaci február, v ktorom sa v roku 2008 namerala aj absolútne najnižšia priemerná koncentrácia. Maximálna priemerná koncentrácia za celé sledované obdobie bola v mesiaci

jún. Podobne ako pri $P\text{-}PO_4^{3-}$, aj pri $P_{Celk.}$ jeho priemerné hodnoty vo vode spravidla mierne klesali od prvého po posledné odberové miesto. Vplyv odberového miesta sa potvrdil aj štatisticky. Uvedené zistenie poukazuje na čistiacu schopnosť mokraďových biotopov nachádzajúcich sa v PR.

Received November 10, 2009
Accepted November 13, 2009