

Impacts of excessive nutrients load in aquatic ecosystem

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The mechanisms of water eutrophication are not fully understood, but excessive nutrient loading into surface water system is considered to be one of the major factors. This paper reviews nutrient inputs to surface water; the role of nutrients in the eutrophication of surface water; the response of biota to nutrient enrichment; monitoring of changes due to eutrophication and the management. The major influencing factors on water eutrophication include nutrient enrichment, hydrodynamics, environmental factors such as temperature, salinity, carbon dioxide, element balance, microbial and biodiversity. With regards of international and national legislative for the ecological status assessment ecological potential, chemical status, biological quality elements, supporting physical-chemical and hydro-morphological quality elements have been investigated. The aim of this paper is to analyse eutrophication and salinization problem, factors affecting this process, its consequences and possibilities of prevention. The partial aim is to evaluate eutrophication state of surface water in Žitný ostrov channel network following the assessment physical-chemical and microbiological indicators in monitored period.

KEY WORDS: surface water, eutrophication, nitrogen, phosphorus

Introduction

Eutrophication of a water body occurs when nutrients, specifically nitrogen and phosphorus, accumulate in the water column and bottom sediments. If eutrophication is accelerated through human activity it can become detrimental to ecosystem. High nutrient levels promote blooms of photosynthetic life, which will eventually die and become food for aerobic bacteria. The proliferation of bacteria that follows can lead to decreased dissolved oxygen levels and a consequential drop in biodiversity. This nutrient enrichment can lead to highly undesirable changes in ecosystem structure and function (Rathore et al., 2016). The nutrients of main concern are nitrogen (N) and phosphorus (P), and an oversupply of either nutrient can cause changes in the structure and function of aquatic ecosystems, although is probably the more important in surface water impacted by agriculture (Withers and Lord, 2002; Smith et al., 1999).

Water eutrophication has become a worldwide environmental problem in recent years. Understanding the mechanisms of water eutrophication will help for prevention and remediation of water eutrophication. In this paper, recent advances in current status and major mechanisms of water eutrophication, assessment and evaluation criteria, and the influencing factors were reviewed. Eutrophication as excessive plant growth resulting from nutrient enrichment (mainly nitrogen and phosphorus compounds) by human activity is the primary

problem relating most surface waters today.

Ingrowth of water stream by vegetation is very often surface water problem, above all in lowland area. Presumption of its grow is mainly vegetation period. Water vegetation reduces flow profile of water streams, deforms velocity profile and by that affect too transport processes in the surface flow. Additionally, surroundings of water flow in the downland areas of oftentimes markedly agricultural managed with used manorial, what results in a nutrient concentrations of increasing of grow. Salinization is an increasing environmental problem in ecosystems. The assessment of total dissolved solids (TDS), pH, electrical conductivity (EC), exchangeable sodium percentage (ESP), alkalinity and the concentrations of main ions makes possible to identify salinization degree. The salt affected groundwater occur in the south-east part of Žitný ostrov, where the dry and mild summer climate, evaporation soil water regime and mineralized groundwater create conditions for salinization of surface water. Five localities with highly-mineralized groundwater were monitored to evaluate salinity in the period 1989–2019. Evaporative residues (salt content) reached value 0.1–0.2%. In 2019 dry evaporative residues (salt content) was higher than 0.2%, EC was higher than 250 mS m⁻¹. The mentioned data allow us to state that salinization of soils and surface water is developing.

Eutrophication is the term applied to the observable effects of increased nutrients on an aquatic system.

If eutrophication is accelerated through human activity it can become detrimental to ecosystems. The limiting factors – namely concentrations of nitrogen (N) and phosphorus (P), temperature, pH, light, dissolved oxygen and CO₂ level - are known to affect eutrophic water bodies. The need to reduce anthropogenic nutrient inputs to aquatic ecosystems in order to protect drinking-water supplies and to reduce eutrophication. Developing the appropriate nutrient management strategy is very important. Nitrogen (N), needed for protein synthesis and phosphorus (P), needed for DNA, RNA, and energy transfer, are both required to support aquatic plant growth and are the key limiting nutrients in most aquatic ecosystems. (Conley et al., 2009). The external supplies of N and P to aquatic ecosystems are derived from a wide variety of sources, including groundwater, fluvial, and atmospheric inputs. The sum of these three sources can be termed the external load. As can be seen the external supplies of nutrients to a water body can originate both as point sources, which are localized and more easily monitored and controlled, and as nonpoint sources, which are diffuse and much more difficult to monitor and regulate. The relative contributions of these two types of sources can differ substantially from watershed to watershed, depending upon local human population densities and land use. N and P exports from point and nonpoint sources can have profound effects upon the quality of receiving waters (Conley, 1999; Smith et al., 1999).

Agriculture and urban activities are major sources of phosphorus and nitrogen to aquatic ecosystems. Atmospheric deposition further contributes as a source of N. These nonpoint inputs of nutrients are difficult to measure and regulate because they derive from activities dispersed over wide areas of land and are variable in time due to effects of weather. In aquatic ecosystems these nutrients cause diverse problems such as toxic algal blooms, loss of oxygen, loss of biodiversity. Nutrient enrichment seriously degrades aquatic ecosystems and impairs the use of water for drinking, industry, agriculture, recreation, and other purposes. (Fiala, 2016). Nitrogen (N), needed for protein synthesis, and phosphorus (P), needed for DNA, RNA, and energy transfer, are both required to support aquatic plant growth and are the key limiting nutrients in most aquatic and terrestrial ecosystems. Massive increases in fixed N additions to the biosphere, largely through the production of fertilizers and increases in fossil fuel emissions. P levels have also significantly increased because of fertilizer use, as well as from municipal and industrial wastewater. Most researchers have concluded that no single factor is responsible, but rather interactions between two or more factors control the rates. (Carpenter et al., 1998). Nitrogen has clearly been established as the nutrient limiting spring phytoplankton production; it is the sinking spring bloom that sends organic matter to bottom waters, which partly sustains hypoxia. The excess P in the water column leads to summer blooms of cyanobacteria, some of which are N₂ fixers that increase N concentrations in surface waters when they are abundant. P limitation, N limitation, and colimitation, and what nutrient is most limiting can change both

seasonally and spatially. At the transition between fresh and saline water, P can often be the limiting nutrient during the spring, with N limitation commonly occurring during summer months. Algal production during summer is supported by rapidly recycled P within the water column or released from sediments. (Schneider and Melzer, 2003).

Lampman et al., (1999) developed a simple model that used point source N loading (sewage inputs) combined with fertilizer and NO₃ (inorganic oxides of N) They found that their model explained NO₃-N export well, with about 20% of fertilizer plus NO_y deposition inputs exported in rivers as NO₃-N. These types of studies and improved understanding of nonpoint pollution are needed because human inputs of N and P are greatly increasing worldwide. Losses of nitrogen (N) and phosphorus (P) in land run-off and drainage from agricultural land can impair river water quality and may pose a potential health hazard. Losses of P are up to an order of magnitude smaller than those of N, but may be more significant with respect to freshwater eutrophication. At the field scale, research suggests that rates of nutrient loss are sensitive to both nutrient and land management, in particular, where nutrient inputs continuously exceed production requirements and where farming methods increase land vulnerability to run-off and erosion. A clear distinction can be made between N and P in the timescales over which inputs of these nutrients are buffered by terrestrial ecosystems against loss, which has implications for control strategies. (Harper, 1992; Nash et al., 2021).

At the river basin scale, any targets for reducing nutrient loss are best guided by site-specific information on their likely ecological impact, but this information rarely exists for rivers affected by eutrophication, and only general guidelines are available. True management of the environment requires integrated approaches which include both N and P taking account of differences in their source areas and delivery mechanisms, the vulnerability of land use and adoption of safe management options in relation to landscape characteristics and the sensitivity of the watercourse along its reach. For P, the identification of vulnerable zones represents a step forward to the management of the river basin in smaller definable units, which can provide a focus for safe management practices. This requires a better understanding of the linkages between nutrient sources, transport and impacts is considered an urgent research priority (Withers et al., 2002).

Based on our review, we are certain that (1) eutrophication is a widespread problem in rivers, lakes, estuaries, and coastal oceans, caused by over enrichment with P and N; (2) nonpoint pollution, a major source of P and N to surface waters, results primarily from agriculture and urban activity, including industry; (3) inputs of P and N to agriculture in the form of fertilizers exceed outputs (4) nutrient flows to aquatic ecosystems are directly related to animal stocking densities, and under high livestock densities, manure production exceeds the needs of crops to which the manure is applied; (5) excess fertilization and manure production cause a P surplus to accumulate in soil, some of which is transported to aquatic ecosystems; and (6) excess

fertilization and manure production on agricultural lands create surplus N, which is mobile in many soils and often leaches to downstream aquatic ecosystems, and which can also volatilize to the atmosphere, redepositing elsewhere and eventually reaching aquatic ecosystems (James et al., 2004; Meisinger and Delgado, 2002). If current practices continue, nonpoint pollution of surface waters is virtually certain to increase in the future. Such an outcome is not inevitable, however, because a number of technologies, land use practices, and conservation measures are capable of decreasing the flow of nonpoint P and N into surface waters.

From our review of the available scientific information, we are confident that: (1) nonpoint pollution of surface waters with P and N could be reduced by reducing surplus nutrient flows in agricultural systems and processes, reducing agricultural and urban runoff by diverse methods, and reducing N emissions from fossil fuel burning; and (2) eutrophication can be reversed by decreasing input rates of P and N to aquatic ecosystems, but rates of recovery are highly variable among water bodies. Often, the eutrophic state is persistent, and recovery is slow.

Excess nutrients cause eutrophication of freshwaters all over the world. Decision-support tools are needed to assess nutrient discharges from catchments. This paper used 28-year nutrient-discharge, hydroclimate and land-use history of small rural catchments to calibrate a simple nitrogen (N) and phosphorus (P) runoff model. (Pärn et al., 2012; Pärn et al., 2018). Nutrient pollution is a growing problem for water bodies. This nutrient enrichment, or eutrophication, can lead to highly undesirable changes in ecosystem structure and function. Water chemistry is of great importance to freshwater systems. It has an effect on species composition and can influence which species might have competitive advantages over others to become dominant. Therefore, the growth of phytoplankton populations is limited by their access to phosphorus and nitrogen for metabolic processes. On the other hand, if these nutrients are present in excess, populations can flourish (Khan and Ansari, 2005; Schneider and Melzer, 2003).

Mechanisms and assessment of water eutrophication investigated (Rathore et al., 2016; Yang et al., 2008). Water eutrophication has become a worldwide environmental problem in recent years, and understanding the mechanisms of water eutrophication will help for prevention and remediation of water eutrophication. Recent advances in current status and major mechanisms of water eutrophication, assessment and evaluation criteria, and the influencing factors were reviewed. The need to reduce anthropogenic nutrient inputs to aquatic ecosystems in order to protect drinking-water supplies and to reduce eutrophication (Pärn et al., 2012). Developing the appropriate nutrient management strategy is very important. Nitrogen (N), needed for protein synthesis and phosphorus (P), needed for DNA, RNA, and energy transfer, are both required to support aquatic plant growth and are the key limiting nutrients in most aquatic ecosystems. (Conley et al., 2009).

Massive increases in fixed N additions to the biosphere, largely through the production of biosphere, largely

through the production of fertilizers and increases in fossil fuel emissions P levels have also significantly increased because of fertilizer use, as well as from municipal and industrial wastewater. The question of whether one or both nutrients should be controlled to reverse the detrimental effects of eutrophication. Most researchers have concluded that no single factor is responsible, but rather interactions between two or more factors control the rates (Devlin et al., 2011; Harper, 1992; Hessen, 1999; Gentry et al., 1998; Lampman, 1999). P is rapidly recycled between sediments and water. Ecosystems that have been heavily loaded with nutrients can display P limitation, N limitation, and colimitation, and what nutrient is most limiting can change both seasonally and spatially. At the transition between fresh and saline water, P can often be the limiting nutrient P is also often limiting during the spring, with N limitation commonly occurring during summer months (Conley, 1999).

Algal production during summer is supported by rapidly recycled P within the water column or released from sediments. Also, although much of the P in freshwater systems is not biologically available because it is adsorbed by clay and other particles, a considerable fraction of the P desorbs as readily available, dissolved phosphate under saline conditions. Thus, as the summer progresses, available P increases as N declines and is not effectively compensated by N_2 fixation. The hypoxic conditions also result in injection of large amounts of P back into surface waters during deep winter mixing. Impact of vegetation on flow in a lowland stream during the growing season investigated (Velísková et al., 2017; Dulovičová et al., 2016; Schügerl et al., 2018). The purpose of these studies was to determine how aquatic vegetation influences flow resistance, water depth and discharge in the Komárňanský channel at the Žitný ostrov area. Eutrophication as excessive plant growth resulting from nutrient enrichment (mainly nitrogen and phosphorus compounds) by human activity is the primary problem concerning most surface waters today.

Non-point pollution of surface waters from N and P inputs is well established with agricultural and urban activities constituting the major sources. This has led to wide-spread eutrophication of surface waters, causing degradation of aquatic ecosystems and problems such as toxic algal blooms, loss of oxygen, fish kills, and loss of biodiversity (David and Gentry, 2000). Non-point sources of N and P are difficult to measure and regulate because of the large land areas involved and extreme temporal variability due to weather. Recently, many efforts have been made to construct N and P balances for watersheds of various sizes in attempts to relate inputs to non-point contributions to surface waters (Carpenter et al., 1998; Maistone and Parr, 2002; Wang et al., 2001).

Much of this increase was estimated to be from fertilizer applications. In order to understand these sources and sinks, we have conducted studies linking N and P export to surface waters with agricultural activities both at the field (Gentry and David, 2000) and small watershed scale. Agricultural non-point sources are important contributors of N and P to surface waters. We determined

N and P net anthropogenic inputs for Žitný ostrov region, examining changes during the last 30 years and linkages to surface water export of N and P. Inputs (fertilizer, atmospheric deposition, and N_2 fixation) were compared to exports (grain export, after accounting for animal and human consumption, plus animal product export) from 1987 through 2019 using state-reported data on fertilizer sales, crop production, and human and animal populations. Large inputs of N were found about 1987, coinciding with increased N fertilizer applications. For P, a different pattern was found for state net anthropogenic inputs with a large input from 1987 to 1990.

Animal and human consumption therefore are currently a small part of N budget, due to the decreasing populations of animals and low human population compared with the amount of agricultural production in the state. These changes in inputs and outputs of N have led to large, but variable, net inputs of N and P each year. The net anthropogenic inputs were greatest during the 1980s. State P net anthropogenic inputs are not similar to N, suggesting that each fertilizer must be examined independently. Phosphorus fertilizer use did follow that of N, however, with large increases through the 1970s and 1980s. Nitrogen has clearly been established as the nutrient limiting spring phytoplankton production; it is the sinking spring bloom that sends organic matter to bottom waters, which partly sustains hypoxia. The excess P in the water column leads to summer blooms of cyanobacteria, some of which are N_2 fixers that increase N concentrations in surface waters when they are abundant. This new N helps to sustain the springtime production and eutrophication. Models suggest that, here,

too, reductions in the inputs of both P and N are required for significant improvements in dissolved oxygen concentrations, transparency, and other water-quality conditions. It is prudent, and in most cases essential, to implement a dual-nutrient-reduction strategy when developing measures to control eutrophication (Vahtera, 2007; Wang et al., 2001).

The Žitný ostrov is one of the most productive agricultural areas of Slovakia, situated on the Danube Lowland. Under its surface is the richest water reservoir of Slovakia. For this reason, it is very important to deal with quantity and quality of water resources in this region. The channel network at the Žitný ostrov area was built up for drainage and also to provide irrigation water. There are three main channels of this network: Chotárny channel, Gabčíkovo-Topoľníky channel and Komárňanský channel (Fig.1).

The Žitný ostrov is one of the most productive agricultural areas of Slovakia, situated on the Danube Lowland, where is the richest drinking water reservoir of Slovakia. For this reason, it is very important to deal with quantity and quality of water resources in this region (Kobza and Gáborík, 2008; Western, 2001; Khan and Ansari, 2005). The channel network at the Žitný ostrov area was built up for drainage and also to provide irrigation water. There are three main channels of this network: Chotárny channel – is the P1M water body type (partial river-basin Váh, code SKW0029), Gabčíkovo-Topoľníky channel – is the P1M water body type (partial river-basin Váh, code SKW0023), Komárňanský channel – is the P1M water body type (partial river-basin Váh, code SKV0226).

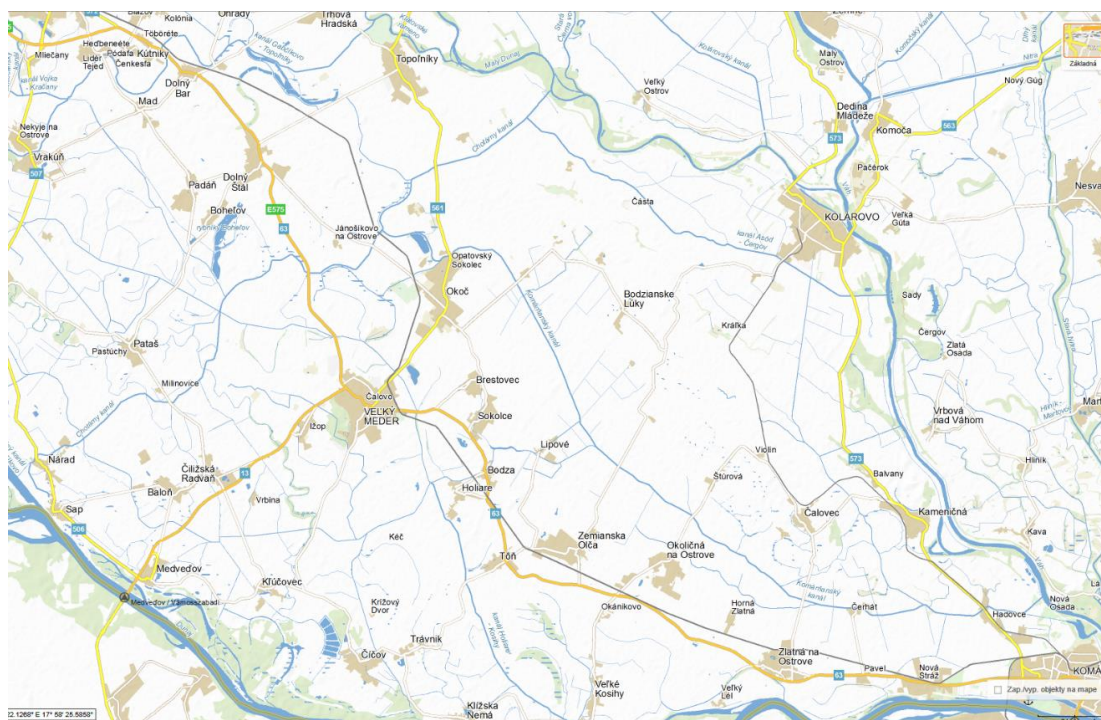


Fig. 1. Žitný ostrov region – channel network (Chotárny channel, profile Ňarad – 1, channel Gabčíkovo-Topoľníky, profile Vrútky – 2, Komárňanský channel, profile Okoličná na Ostrove – 3).

Material and methods

Factors influencing water eutrophication

Water eutrophication is mainly caused by excessive loading of nutrients into water bodies like N and P. Excessive nutrients come from both point pollution such as waste water from industry and municipal sewage, and non-point pollution like irrigation water, surface run water containing fertilizer from farmland, etc. Increased nutrient load to water body is now recognized as a major threat of water quality degradation (Yang et al., 2008).

Excessive total nitrogen (TN) and total phosphorus (TP) in water was considered as the only factors inducing water eutrophication. At present nutrient enrichment is only the necessary but not the sufficient condition for algal bloom. Eutrophication is not likely to occur if both TN and TP in water are low, but eutrophication may not occur in water high in TN and TP if other conditions such as temperature and current speed are not favorable. The influencing factors of water eutrophication include: (1) excessive TN and TP, (2) slow current velocity, (3) adequate temperature and favorable other environmental factors, and (4) microbial activity and biodiversity.

- (1) Nutrient enrichment
- (2) Hydrodynamics
- (3) Environmental factors
- (4) Microbial and biodiversity

(1) The relationship of nutrient enrichment to water eutrophication and algal bloom: (a) When P concentration in water is low, it may be the limiting factor for inducing water eutrophication and algal bloom; (b) When P concentration in water increases rapidly, other may become a new limiting factor, such as pH, water depth, temperature, light, wave, wind or other biological factors. N and P input and enrichment in water are the most primary factors to induce water eutrophication.

(2) Hydrodynamics is not related to disturbing water itself but is influenced indirectly by changing light and nutrient status. In shallow water, increased frequency of disturbance could increased the P release from the sediment, especially at high temperature.

(3) Temperature and salinity are the two important factors to induce alga bloom. Alga bloom always occurs at temperature between 23°C and 28°C, salinity between 25‰ and 30‰. The variation of temperature and salinity also affect algal bloom, and an important condition for algal bloom is that temperature increases and salinity decreases faster than ever in short time. Statistical analysis shows that the influence of temperature on algal growth rate is the largest, followed by salinity and their interaction. Change of salinity is also influenced by the concentration of nutrition. Research shows that salinity is negatively related with N-NO_3^- and P-PO_4^{3-} , but positively related with N-NH_4^+ and however, it is not very related with N-NO_2^- .

(4) Light plays an important role in the growth, diversity and density of aquatic flora. Algal growth has been reported to increase with light intensity, and luminescence of 4000 lux was found most favorable.

There are other factors like pH and dissolved oxygen affecting water eutrophication. The direct relationship between phytoplankton and dissolved oxygen content has been observed by a number of researchers. The change in pH is directly related to the availability and absorption of nutrients from solution. Ionization of electrolytes or the valence numbers of different ion species are influenced by changes in pH. High pH values promote the growth of phytoplankton and result in bloom.

Assessment of surface water quality

Historically are important year 1991, when was passed Directive 91/271/EHS regard cleaning urban waste-water and Directive 91/676 EHS regard nitrate agricultural source pollution and year 2000, when was passed Water Framework Directive (WFD) 2000/60/ES. The ecological status, ecological potential and chemical status assessment the biological quality elements (phytoplankton, phytobenthos and water macrophytes, benthic invertebrates), supporting physical-chemical and hydro-morphological quality elements as well as the specific substances have been investigated. Ecological status/potential assessment has been type specific, it has reflected reference conditions, the species diversity, quantity (abundance or biomass) and sensitive species have been included as well. The classification schemes have been already harmonized in the process of European intercalibration.

Makovinská et al. (2015) and Hucko et al. (2013) proposed assessment of the trophic state of water bodies according to following methodics:

- a) Assessment of the trophic state of surface water with regards of the Supplement No.1 Directive of Government SR No. 269/2010 – monitored indicators are: total nitrogen, total phosphorus, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen concentrations and phytoplankton biomass (chlorophyll-a) (Table 1).
- b) The trophic assessment of surface water trophic state is necessary to use average summer concentrations of nitrates, phosphates and total phosphorus and maximum summer concentration for chlorophyll-a (summer period means months april–september) (Table 2).
- c) Assessment of the trophic state of backwaters with regards of OECD methodic (annual average of total phosphorus and nitrogen concentrations, chlorophyll-a concentrations).

Monitoring of surface water in Žitný ostrov channel network has been provided in terms of requirements Supplement No.1 Directive of Government SR No. 269/2010, Part A (general indicators) and Part E (hydrogeological and microbiological indicators) in the period of 1987–2019. For assessment of sensitive sites and identification of eutrophication endangered places the Supplement No. 12 and No. 13 are used. Monitoring and assessment of following indicators were performed – total nitrogen (N_{TOT}), nitrate nitrogen (N-NO_3^-), nitrite nitrogen (N-NO_2^-), ammonia nitrogen

Table 1. Evaluation of trophic state of surface water according to Supplement No.1 Directive of Government SR No. 269/2010

Indicator	Symbol	Unit	Limit value
Ammonia nitrogen	N-NH ₄ ⁺	mg l ⁻¹	1
Nitrite nitrogen	N-NO ₂ ⁻	mg l ⁻¹	0.02
Nitrate nitrogen	N-NO ₃ ⁻	mg l ⁻¹	5
Nitrogen total	N _{TOT}	mg l ⁻¹	9
Phosphorus total	P _{TOT}	mg l ⁻¹	0.4
Phytoplankton biomass (chlorophyll-a)	CHL _a	µg l ⁻¹	50

Table 2. Evaluation of trophic state– Directive 91/676/CEE – Surface water – rivers

Indicator	Unit	State				
		I Ultraoligotrophic	II Oligotrophic	III Mezotrophic	IV Eutrophic	V Hypereutrophic
Nitrates (average summer concentration)	mg l ⁻¹	< 2	< 10	< 25	< 50	> 50
Phosphates (average summer concentration)	mg l ⁻¹	< 0.1	< 0.5	< 1	< 2	> 2
Phosphorus tot. (average summer concentration)	mg l ⁻¹	< 0.05	< 0.2	< 0.5	< 1	> 1
Chlorophyll-a (max.summer conc.)	µg l ⁻¹	< 2.5	< 8	< 25	< 75	> 75

(N-NH₄⁺), total phosphorus (P_{TOT}), phosphate phosphorus (P-PO₄³⁻) according the Supplement No.1 Directive of Government SR No. 269/2010, Part A and biomass of phytoplankton (CHL_a) according Part E.

The external supplies of N and P to aquatic ecosystems are derived from a wide variety of sources, including groundwater, fluvial, and atmospheric inputs. The sum of these three sources can be termed the external load. The external supplies of nutrients to a water body can originate both as point sources, which are localized and more easily monitored and controlled, and as nonpoint sources, which are diffuse and much more difficult to monitor and regulate. The assessment of water eutrophication has been advanced from simple individual parameters like total phosphorus, total nitrogen, etc., to comprehensive indexes like total nutrient status index. The major influencing factors on water eutrophication include nutrient enrichment, hydrodynamics, environmental factors such as temperature, salinity, carbon dioxide, element balance, microbial and biodiversity. The occurrence of water eutrophication is a complex function of all the possible influencing factors (Yang et al., 2008).

Generally, the physical and chemical evaluation parameters were used to assess water eutrophication, mainly nutrient concentration (N and P), algal chlorophyll, water transparency and dissolved oxygen. Although there are many different assessment parameters, the concentrations of total nitrogen and phosphorus are the two basic ones. (Cheng and Li, 2006)

used total nutrient status index (TNI) to assess eutrophication status of surface water. The calculation of total nutrient status index is as follows:

$$TNI = \sum W_j TNI_j, W_j = r_{ij}^2 / \sum r_{ij}^2 \quad (1)$$

where

TNI is the sum of indexes of all nutrient parameters,

TNI_j is the TNI of *j* parameter,

W_j is the proportion of *j* parameter in the TNI,

r_{ij} is the relation of chlorophyll a (Chla) to other parameters.

The available parameters concerned include total nitrogen (TN), total phosphorus (TP), Chla, dissolved oxygen (DO), chemical oxygen demand by K₂MnO₄ oxidation method (COD_{Mn}), biological oxygen demand (BOD₅), etc., and TN, TP and Chla are selected for calculating the TNI (Cheng and Li, 2006; Yang et al., 2008). Table 1, 2 shows the limiting values of TN, TP and TNI in various eutrophicated water.

Results and discussion

The results of nitrogen and phosphorus amounts reported in this study are the best indicators of the level of eutrophication. The major influencing factors on water eutrophication include nutrient enrichment, hydrodynamics, environmental factors such as

temperature, salinity, carbon dioxide, element balance, microbial and biodiversity.

This paper investigated surface water to determine their trophic status, measured by water chemistry and biological indicators and briefly review the process, the impacts, and the potential management of eutrophication in freshwater, ecosystems. The limiting factors – namely concentrations of nitrogen (N) and phosphorus (P), temperature, pH, light, dissolved oxygen and CO₂ level – are known to affect eutrophic water bodies. The results of nitrogen and phosphorus amounts reported in this paper are the best indicators of the level of eutrophication (Pavlidou et al., 2015; Nedwell et al., 2001; Newman et al., 2005; Smith et al., 1999; Rathore et al., 2016).

The present paper evaluated the ecological consequences of increased nutrient loading to freshwaters in the context of providing information on the effects of implementing international and national legislative for the ecological status assessment. The limiting factors – namely concentrations of nitrogen (N) and phosphorus (P), temperature, pH, light, dissolved oxygen and CO₂ level – are known to affect eutrophic water bodies. The results of nitrogen and phosphorus amounts reported in this study are the best indicators of the level of eutrophication (Cheng and Li, 2016; James et al., 2004; Jickells, 2005). The net anthropogenic inputs were greatest during the 1980s. State P net anthropogenic inputs are not similar to N, suggesting that each fertilizer must be examined independently. Phosphorus fertilizer use did follow that of N, however, with large increases through the 1970s and 1980s. The nutrient level in surface water has decreased after 1990th in response to decreased discharge of domestic wastes and non-point pollution from agricultural practices and urban development. However we observe slight increasing in Komárňanský channel during last 5 years. We observed exceeded the limit values not only in some months, but average annual

values for nitrates and phosphates, too. For the evaluation the water quality we used the data obtained on Institute of Hydrology SAS during the 1987–2019. Monitored localities was chosen so that they be the most representative area-covering (Fig. 2, 3).

The study was focused on identification of the long-term trends in the surface water quality on Žitný ostrov channel network. Fig. 2, 3 shown changes in measured values of nitrates and phosphates in particular channels in years 1987–2019. It was shown the channel water quality has been changed significantly during the period 1987–1990, after 1990 was slightly decreased. However we observe slight increasing in some profiles of Komárňanský channel with major agricultural activities during last few years. Regarding the eutrophication, the WFD intends to improve the ecological status, including eutrophication status, of all European surface waters of which many are considered to be eutrophic (Jickells, 2005). The present work focus on the assessment of the eutrophication state of surface water in Žitný ostrov region. The values from monitoring in 1987–2019 were evaluated according to Supplement No.1 Directive of Government SR No. 269/2010, part A (general indicators) and part E (hydrogeological and microbiological indicators). In terms of N, nitrate-N concentrations is the limit value 5 mg l⁻¹ N-NO₃⁻. Nitrite-N concentrations is the limit value 0.02 mg l⁻¹ N-NO₂⁻. For phosphorus is the limit value 0.4 mg l⁻¹ P_{TOT}. In general, the rate of increase the external supplies of N and P has slowed down in Žitný ostrov area during the monitoring period, but slight increasing in some profiles of Komárňanský channel with major agricultural activities during last few years. The limiting factors – namely concentrations, temperature, pH, light, dissolved oxygen and CO₂ level – are known to affect eutrophic water bodies. The results of nitrogen and phosphorus amounts reported in this study are the best indicators of the level of eutrophication (Table. 3).

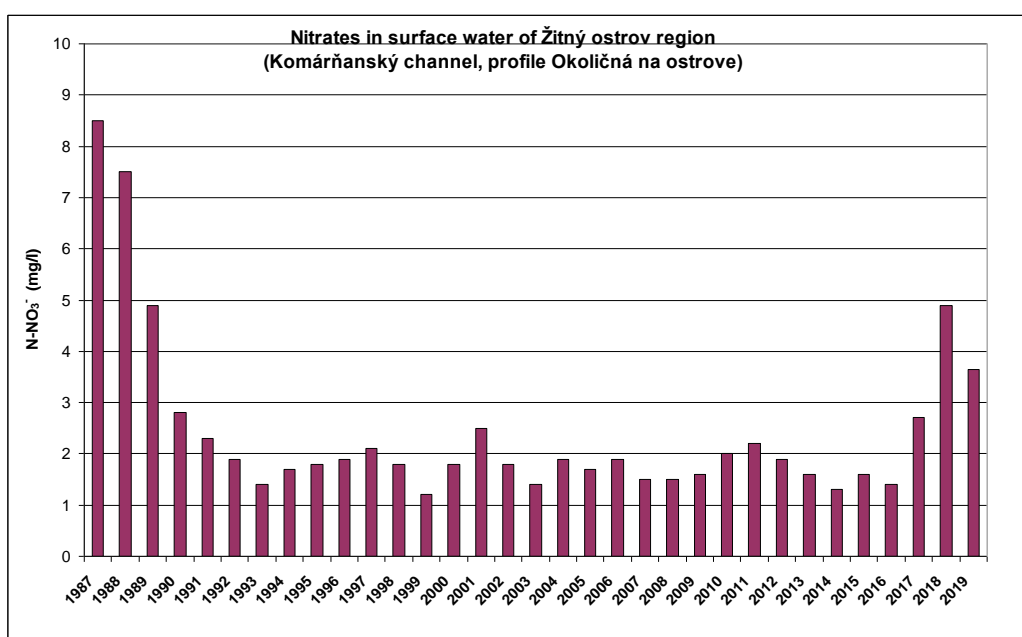


Fig. 2. Nitrates in surface water – Komárňanský channel.

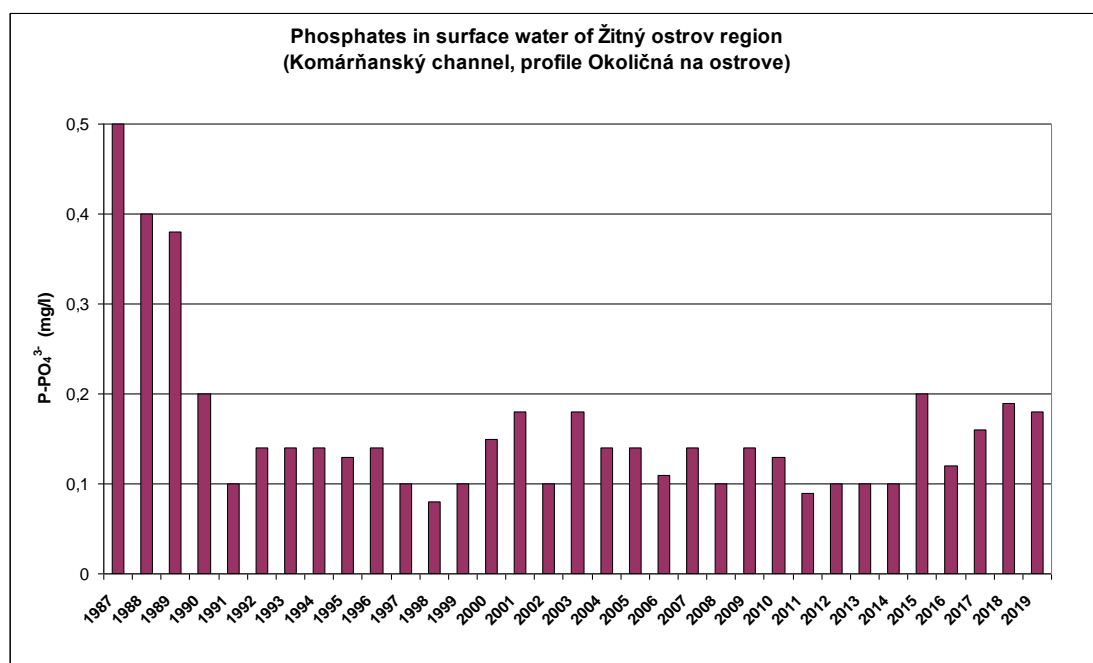


Fig. 3. Phosphates in surface water – Komárňanský channel.

Table 3. Evaluation of trophic state of surface water according to Supplement No. 1 Directive of Government SR No. 269/2010

Place of sampling point: Komárňanský channel Profile: Okoličná na Ostrove				Typ VÚ: P1M Code VÚ: SKV0226			Partial watershed Váh Monitoring: 2019		
Part A – general water quality indicator									
Term of indikator	Symbol	Unit	Number statements	Min.	Max.	Average	P90/10	Value according to NV 269/2010	Meet/Does not meet
Dissolved oxygen	O ₂	mg l ⁻¹	12	8.4	14.0	10.8	8.5	> 6.0	M
Temperature	t	°C	12	3	21.6	11.4	20.3	< 27	M
Chemical consump. oxygen	CHSKCr	mg l ⁻¹	12	5.0	18.0	7.7	10.8	< 25	M
Reaction	pH	-	12	6.39	8.19	7.93	8.16	8.5	M
Conductivity	EC	μS cm ⁻¹	12	349	543	420	50.1	≤ 700	M
Specific conductivity	SPC	μS cm ⁻¹	12	370	933	548	62.2	700	M
Total dissolved solids	TDS	mg l ⁻¹	12	284	630	405	0.19	800	M
Ammonia nitrogen	N-NH4	mg l ⁻¹	12	0.05	0.9	0.34	0.16	1	M
Nitrate nitrogen	N-NO3	mg l ⁻¹	12	2.7	5.2	3.68	3.61	5	N
Total nitrogen	Ntot	mg.l ⁻¹	12	2.2	9.4	7.23	3.17	9	N
Phosphate phosphorus	P-PO4	mg l ⁻¹	12	0.17	0.42	0.30	0.32	0.35	N
Total phosphorus	Ptot	mg l ⁻¹	12	0.18	0.43	0.35	0.38	0.4	N
Turbidity	T	NTU	12	14	64	42	38	100	M

The nutrient level in surface water has decreased after 1990th in response to decreased discharge of domestic wastes and non-point pollution from agricultural practices and urban development. However we observe slight increasing in Komárňanský channel (Fig. 2, 3) during last few years.

The study is focused on identification of the long-term trends in the surface water quality in channel network at Žitný ostrov region. The paper shows changes in measured values of nitrates and phosphates in particular channels in years 1987–2019. It was shown the channel water quality has been changed significantly during the period 1987–1990, after 1990 obtain around the same level. But we observe increasing in some profiles of Komárňanský channel with major agricultural activities during last few years. Approach to limit value – nitrate nitrogen 5 mg l⁻¹, nitrogen total 9 mg l⁻¹, phosphate phosphorus 0.35 mg l⁻¹, phosphorus total 0.4 mg l⁻¹.

Conclusion

The present paper deals with the studies conducted on the impact of nitrogen and phosphorus amount on eutrophication in surface water on the Žitný ostrov channel network. The review covers the definition and concept of eutrophication and the adverse effects on quality and ecosystem functioning. The eutrophication of several water bodies leads to significant changes in the structure and function of the aquatic ecosystem. Some profiles in this region have recently been found to be eutrophic.

The limiting factors – namely concentrations of nitrogen (N) and phosphorus (P), temperature, pH, light, dissolved oxygen and CO₂ level – are known to affect eutrophic water bodies. The results of nitrogen and phosphorus amounts reported in this study are the best indicators of the level of eutrophication. In terms of N, nitrate-N concentrations has the limit value 5 mg l⁻¹, N-NO₃, N-N₂ concentrations has the limit value 0.02 mg l⁻¹ N-NO₂. For phosphorus has the limit value 0.4 mg l⁻¹, Ptot. (Table 3). The paper shows changes in measured values of nitrates and phosphates in particular channels during 1987–2019. It was shown (Fig. 2,3) the channel water quality has been changed significantly during the period 1987–1990, after 1990 it reaches about the same level, but we observe increasing in some profiles of Komárňanský channel with major agricultural activities.

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