Deterioration of the Environment by Water and Soil Pollution

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https://doi.org/10.29227/IM-2026-02-02-018

Submission date: *2026-11-06* | Review date: *2026-29-06*

Abstract

This study has focused Danube Lowland, a region that is vulnerable to long duration droughts that have substantial impacts on groundwater resources, and which is facing increasing pressures on water management. Surface water resources become increasingly limited, because of climate change as a consequence in decreasing precipitations, rising temperature and higher evaporation. The pollution of the environment is spreading throughout the world due to the global industrial and agricultural progress. Due to the increase in pollution, rapid urbanization, industrialization and agriculture the essential elements of life such as air, water and land are constantly getting contaminated. Especially the presence of total nitrogen and total phosphorus, as well as the presence of heavy metals, leads to a deterioration in the status of surface waters. Nutrient ions (N, P) lead to undesirable overgrowth of the canal network of the Danube Lowland and heavy metals threaten humans, animals and plants. The evaluation of the physico-chemical parameters were used to assess water deterioration, mainly temperature, pH, nutrient concentration (N and P), algal chlorophyll-a, conductivity, total dissolved soils, water transparency and dissolved oxygen. We used total parameters status index (TPSI) to assess the status of surface water. During the years 2010 – 2025 the surface water quality was deteriorated on the Danube Lowland (Slovakia). The calculation of total parameters status index on Danube Lowland achieved value 3,5.

Keywords: *surface water, pollution, total parameters status index*

1. Introduction

Surface water resources, dependent on very irregular rains become increasingly limited because of climate change resulting in decreasing precipitations, rising temperature and consequently higher evaporation. According to [1], long-term periods of little rain in catchment areas bring about hydrological drought that manifests itself in rivers as low flows. Climate warming leads to important changes in river flow. The climate featuring one dry and one rainy season from April to October and November to March, respectively. Climate variation at all-time scales influences the hydrological process, which directs water availability necessary for the ecological systems in the basins [2,3].

The seasonal irregularity were relevant indicator of hydrological drought and surface water scarcity. The sensitivity of the hydrological regimes to the change of aridity in the Danube Lowland basin shout be the basis for sustainlable water management strategies in this region. Since 2010 on the Danube Lowland annual raifall and flow have changed and leading to the climatic and hydrological droughts persistence. Indeed increase in climatic aridity (20%) results from the precipitation and flow regime sensitivity to the effects of the dry climate. As the monthly aridity index showed, it is evident that the Danube Lowland is affected and faces problems of plant growth and water suply. Hydrological regime sensitivity to the increasing aridity in the Danube Lowland should be an indicator to develop adequate and sustainable environment protection and water management strategies in this region [4].

[5,6] supported that the sensitivity on the hydrological regimes to the change of aridity in the Danube basin should be a basis for sustainable water management strategies development on the Danube Lowland. The region is heavily dependent on groundwater resources, and is thus vulnerable to long drought episodes. The drought has major impacts on agriculture and the environment. Of the lowland areas of south-west to prolonged rainfall deficits. The region is already the driest part of Slovakia and is projected to become appreciably warmer and drier in future, and will face increased drought severity according to scenario-based climate change analyses.

The focus of this study is the Danube Lowland surface water deterioration. This area on south-west part of Slovakia is defined by its geographical, climatological, hydrogeological characteristics. Semi-arid areas faced both a rainfall decrease, and an increase of industry and associated agricultural activities, which led to a rapid degradation of land cover [7,8]. Climate change in recent years has also greatly affected extreme drought, floods and surface water quality too. These changes significantly affects the surface waters of the Danube Lowland and the subsurface waters as well. The warming observed over the past several decades is associated with changes in a number of components of the hydrological cycle and hydrological systems such as: intensity and extremes, changing precipitation, widespread melting of snow and ice; increasing atmospheric water vapour, increasing evaporation, changes in soil moisture and runoff. There is significant natural variability [4].

Adverse effects of climate change on freshwater systems aggravate the impacts of population growth, land-use change and urbanization. Globally, water demand will grow in the coming decades, primarily due to population growth will become regionally large changes in irrigation water demand as a result of climate change are expected. as stated by authors who deal with this issue [9, 10. 11].

The Danube Lowland is one of the most productive agricultural areas of Slovakia. 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. In terms of geomorphology, this territory is characterised as a young riverside plain with a very low denivelisation of the surface with an overall inclination from north-west to south-east, break up in transversal as well as in longitudinal directions in to different geomorphologic areas. In the sense of transversal division, we recognice the upper, the middle and the lower parts of the Danube Lowland. Within transversal division, we distinguish the Pleistocene core, late Holocene aggradation walls and early Holocene depressions [12].

The canal network on this area was built up for provide irrigation water and also to drainage. There are three main canals of this

network: Chotárny canal, Gabčíkovo-Topoľníky canal and Komárňanský canal. Aquatic vegetation significantly influences fluvial dynamics and sediment budgets [13, 14, 15, 16]. The regime of the groundwaters on the Danube Lowland, which are fed by waters of the Danube river closely correlated with the river regime. Character of water conditions and flow rate in the canals is primarilly regulated in dependence on seasons of the year, weather conditions and needs of agriculture.

The process of creation of chemism in groundwaters is affected by primary and secondary factors. From among the primary factors the folloving ones are of determining significance chemical status of the Danubian water, composition of precipitation waters as well as mineralogical and petrographic composition of Quaternary sediments [12].

The study area is presented in Fig. 1.

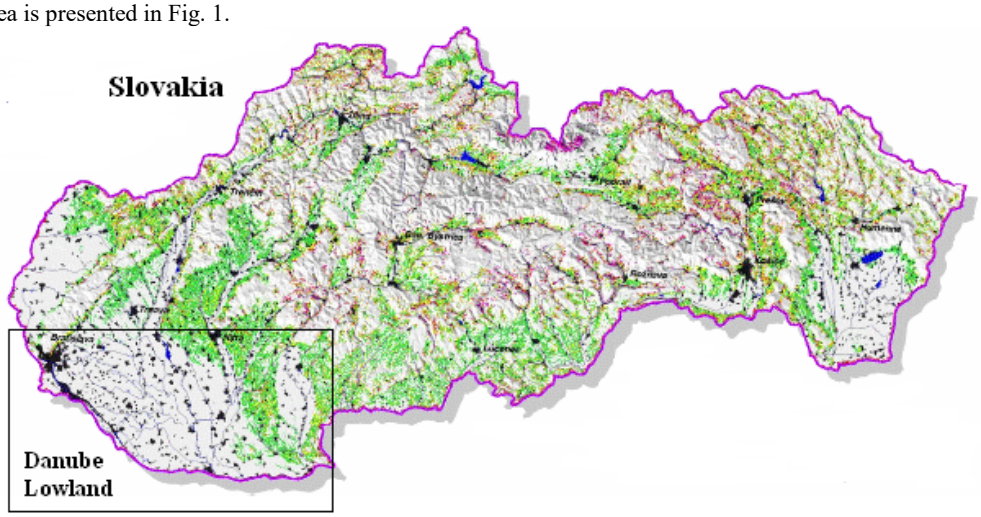

Fig. 1. The study area - Danube Lowland

Mechanisms and assessment of waters deterioration investigated [17]. They become a world-wide environmental problem in recent years. Understanding these mechanisms are necessary for prevention and remediation of water eutrophication. Recent advances in current status and major mechanisms of water deterioration and the influencing factors were reviewed. Water quality was assessment by the comparison of the characteristic values for individual indicators in all sampling sites calculated and the recommended value for these indicators [18]. An excessive amount of chemical substances (mainly total nitrogen and total phosphorus) leads to deterioration of water quality.

The major factors responsible for water contamination, especially in agricultural soils areas, where excesive nutrient (nitrogen, phosphorus) and heavy metals gets into the water through various agronomic practices, such as the application of chemical nitrate and phosphate fertilizers, manures, pesticides, fungicides, and wastewater [19, 20, 21]. Heavy metals constitute a group of difficult to remove water and soil pollution. They are highly persistent in the environment due to their non-biodegradability, thermal stability, and ability to accumulate to dangerous levels even at low concentrations. These metals can constitute a significant health risk to humans and animals because there is no effective mechanism to eliminate them from the body.

The quality of human life depends of the quality of the food, which is determined by the quality of the soil. High levels of pollutants can have natural or anthropic sources, but in most cases it is associated with human activity, which determined the accumulation of contaminants at high concentrations that can be a risk to the environment as well as to humans. Initially, the soil heavy metal contents are inherited from rocks through geo-chemical and pedo-chemical alteration of the materials that form the soil

High levels of heavy metals can have natural or anthropic sources, but in most cases it is associated with human activity, which determined the accumulation of contaminants at high concentrations that can be a risk to the environment as well as to humans. The application of the nutrients, sewage sludge, manure, mineral fertilizers, fungicides, pesticides are known as sources of agricultural pollution with heavy metals. Due to long time application of mineral fertilizers, pesticides, fungicides, large area of land are contaminated [22]. In this paper, the status of the selected heavy metals in some agricultural soils and the influence of agricultural practices such as mineral fertilization on the heavy metal contents were evaluated.

Due to agro-climatic conditions, anthropogenic activities, presence and distribution of pollutants are inevitable. Soils contain heavy metals in the form of inorganic compounds or they may remain bonded with organic matter, clays or as oxides. Heavy metals in soil may exist in one or more following forms: (a) as dissolved (in soil solution), (b) as exchangeable (in inorganic components), (c) as structural components of the lattices of soil minerals, (d) as insoluble precipitates with other soil components The distribution of heavy metals in solid phases depends on their amounts, their type and origin [23]. The binding mechanisms of heavy metals vary with soil depth, depending on the physico-chemical properties of the soil such as pH, redox potential and water content, all these play an important role for the rate of chemical transformation of an element in a solid phase. The accumulation of heavy metals in soils of agricultural field and lands is of increasing concern due to food safety, potential health risks as well as its deleterious effects on floral and faunal soil ecosystems. Based on results it may be concluded that heavy metals accumulation and their distribution in soils of alluvial and aeolic plain of Danube Lowland are inevitable due to climatic conditions and anthropogenic activities. The mean ranges of extractable heavy metals concentration in studied samples were found below the permissible limit. therefore, present results of the study are very useful to estimate the metal contamination and risk associated in agricultural soil to assure better soil health, crop quality and production.

A total of 27 topsoils (0–10 cm) samples were collected from 3 zones (high C1 central C2 and low part C3 of Danube Lowland monthly (total 324 annually) and analysed for content, spatial distribution, sources, and pollution indices using statistical methods. These results indicate the need for the implementation of urban soils pollution monitoring according to specific urban zones to provide an applicable basis for the development of plans and strategies concerning urban soil use management for the purpose of the sustainable urbanization and agriculture. Non-anthropogenic and anthropogenic activity have an impact on the components of the river hydrological regime, potentially leading to negative effects on the surface water. Therefore, monitoring changes in the quantity and quality of water

in streams is necessary. The deterioration is accelerated through human activity it can become detrimental to ecosystem. To prevent the over consumption of heavy metals frequent screening of soil and water resources were conducted. [24].

The pollution of the environment with toxic heavy metals is spreading throughout the world due to the global industrial and agricultural progress. The heavy metals released from the industries causes several ailments in both plants, animals and human beings. The release of toxic heavy metals into the environment occurs through the industries. The most common heavy metals are lead (Pb), nickel (Ni), Chromium (Cr), Cadmium (Cd), Arsenic (As), Mercury (Hg), Zinc (Zn) and Copper (Cu).

Due to the increase in pollution, rapid urbanization, industrialization and agriculture the essential elements of life such as air, water and land are constantly getting contaminated. Of these heavy metal pollutions of soil and waste water is a significant problem. Several guidelines were being framed by many countries for the presence and exposure of heavy-metals as well as bioremediation. Although heavy metals are naturally present in the environment and anthropogenic activities increase the concentration of these elements to amounts that are harmful to both plants and animals. Some of these activities include mining and smelting of metals, burning of fossil fuels, use of batteries and other metal products [25, 26].

Especially the presence of total nitrogen and total phosphorus, as well as the presence of heavy metals, leads to a deterioration in the status of surface waters. Nutrient ions (N, P) lead to undesirable overgrowth of the canal network of the Danube Lowland and heavy metals threaten humans, animals and plants. This study has focused Danube Lowland, a region that is vulnerable to long duration multi-annual droughts that have substantial impacts on groundwater resources, and which is facing increasing pressures on water management. Surface water resources, dependent on very irregular rains become increasingly limited, because of climate change resulting in decreasing precipitations, rising temperature and consequently higher evaporation [27, 28, 29]. The pollution of the environment is spreading throughout the world due to the global industrial and agricultural progress.

Generally, the physical and chemical evaluation parameters were used to assess water deterioration, mainly temperature, pH, nutrient concentration (N and P), algal chlorophyll-a, conductivity, total dissolved soils, water transparency and dissolved oxygen. We used total parameters status index (TPSI) to assess the status of surface water. Monitoring of surface water quality on Danube Lowland canal network has been provided in terms of requirements Supplement No.1 Directive of Government SR No. 269/2015, Part A (general indicators), Part B (non-syntetics substances, heavy metals) and Part E (hydrogeological and microbiological indicators) in the period of 2010-2025 [30, 31]. From obtained results it follows that the mean pH value varied from 6 to 8 over the whole interest period. In clean natural waters (both surface and grandwaterd). The pH value is determined by physico-chemical and biological parameters and the carbonate balancee (between free CO_2 and bound CO_2). low conductivity values were measured in winter and spring. In the summer months, its values increased up to its maximum value in july.

Physico-chemical and biological processes taking place in the water affect pH of the water. Was found a generally increasing tendency of pH and EC values in water course of Komárňanský canal (profile Veľké Kosihy), Gabčíkovo-Topoľníky canal (profile Vrakúň) and Chotárny canal (profile Ňarád). A regularity in the seasonal dynamics of pH and electrical conductivity values was observed. Buth the sampling location had a greater influence on the pH and EC, than the seasonal dynamics (Fig.2).

The deterioration is accelerated through human activity it can become detrimental to ecosystem. Surface water is neutral (pH 7) in natural condition. If there are more H^+ than OH^- ions, the water is acidic (the pH value decreases). The high pH values promote the growth of phytoplankton. The impact of vegetation on flow in a lowland area during the growing season has been investigated. Climate change in recent years has also significantly affected extreme drought, floods and surface water quality too [3].

The canal network on the Danube Lowland area was built up for drainage and also to provide irrigation water. Aquatic vegetation significantly influences fluvial dynamics and sediment budgets. This study investigates the impact of in-channel vegetation on flow resistance and sediment storage in a lowland stream, using field data from 2010 to 2025 [8, 14, 16]. The antrophogenic activity have an impact on the components of the hydrological regime of rivers, potentially leading to negative effects on the quantity and quality of water. In terms of climatic situation. The Danube Lowland belongs to a very warm and very dry agro-climatic area. Moisture conditions of the territory are deficient. The climatic indicators of irrigation, and precipitation stating have the difference of potential vapour.

2. Material and methods

Water degradation is mainly caused by excessive loading of nutrients as total nitrogen (Ntot) and total phosphorus (Ptot) into water bodies. They 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 cause of water quality degradation.

Excessive total nitrogen (Ntot) and total phosphorus (Ptot) components of interest in water are considered as the only factors inducing water deterioration, but nutrient enrichment is only the necessary but not the sufficient condition for algal boom. Eutrophication is not likely to occur if both Ntot and Ptot in water are low, but deterioration may not occur in water high in Ntot and Ptot if other conditions such as temperature, current speed etc. are not favorable. The influencing factors of water degradation include: (a) excessive Ntot and Ttot, (b) slow current velocity, (c) adequate temperature and favorable other environmental factors, and (d) microbial activity and biodiversity.

(a) The relationship of nutrient enrichment to water deterioration and algal bloom: (1) When nitrogen and phosphorus concentrations in water is low, it may be the factor for induce deterioration of water on algal bloom; (2) When N, P concentrations in water increases rapidly, other may become a new limiting factors (such as pH, water depth, light, temperature,, wind or biological factors).

(b) Hydrodynamics is influenced indirectly by nutrient status and changing light. In shallow water, increased frequency of disturbance could increase the phosphorus release from the sediment, especially at high temperature.

(c) The algal bloom is reduced by two important factors: temperature and salinity. It always occurs at temperature between 23 °C and 30 °C, salinity between 15% and 45%. The variation of temperature and salinity significantly affect algal bloom, and an important condition is when the temperature increases and salinity decreases in short time. Statistical analysis shows that the influence of temperature on algal growth rate is the largest, followed by salinity, concentration of nutrition and their interactions. Light plays an important role in the growth, diversity and density of aquatic flora. Algal growth increase with light intensity of 4000 lux. There are other factors like pH and dissolved oxygen affecting water eutrophication.

(d) There is the direct relationship between phytoplankton, dissolved oxygen conten and pH.t The change in pH is related to the availability and absorption of nutrients from solution. High pH values promote the growth of phytoplankton and result in bloom

Were investigated 27 samples monthly (total 324 samples annually). That means 324 samples from three main canals on Danube Lowland location C1, C2., C3 were investigated every year. Monitoring of surface water on Danube Lowland has been provided in

terms of requirements Supplement No.1 Directive of Government SR No. 269/2015, Part A (general indicators), part B (non-synthetics, heavy metals) and Part E (hydrogeological and microbiological indicators) biomas of phytoplankton (Chl_a) in the period of 2010-2025 (Table 1, 2, 3, 4).

The current study aimed to determine the state of deterioration of surface water by nutrients and by the heavy metals in agricultural soils areas, assess the pollution level and potential ecological risk. 324 surface water samples from different places were collected, they were analysed to dissolved oxygen (DO), reaction (pH), conductivity(C), total dissolved solids (TDS), turbidity (T) by Multiparametric probe YSI. The following characteristics of samples were examined and estimated: total nitrogen (Ntot), total phosphorus (Ptot), heavy metals like Cd (cadmium), Pb (lead), Cu (copper), Cr (chromium), As (arsenic), Ni (nickel), Hg (mercury) and Zn (zinc) using Spectrofotometer Hach-Lange 2800. Samples were obtained from the 9 primary sampling stations at Danube Lowland during 2010-2025.

Nutrient enrichment Ntot, Ptot which cause excessive growth of vegetation and heavy metal contamination which in agricultural soils has been a significant health concern worldwide due to their persistent and non-biodegradable nature. The present study was conducted to assess their value in soil samples collected from Danube Lowland (Slovakia) after drying the samples on laboratory temperature we determined their associated health and ecological risks in the leachate. The calculated contamination factor showed their low to moderate contamination in the study area for three types of samples, indicating the moderate potential of ecological risks of environment.

Generally, the physical and chemical evaluation parameters were used to assess water deterioration, mainly temperature, pH, nutrient concentration (N and P), algal chlorophyll-a, conductivity, total dissolved soils, water transparency and dissolved oxygen and heavy metals. We used total parameters status index (TPSI) to assess the status of surface water. The calculation of total parameters status index is as follows: (Eq.1)

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

where

TPSI -is the sum of indexes of all parameters

TPSIj is the TPSI of *j* parameter

Wj is the proportion of *j* parameter in the TPSI

rij represents the correlation between chlorophyll (Chl-a) and other parameters (e.g., pH, nitrates, phosphorus). Chl-a are an indicators of eutrophication. TPSI reaches values 1 – 10.

The TPSI values were calculated according to the relationship (Eq. 1) which showed from low to moderate level of risk associated with environment contamination. The results of the present study will be used as basic data for management of the environmental protection, which can to minimize pollutants contamination.

On the Danube Lowland the measurements had been carried out in observation locations C1, C2, C3. In the present study, to investigate the pollution characteristics of 27 samples from 3 typical profiles were collected monthly (total 324 samples annually). Uptake of heavy metals from soil is one of the processes that regulates quality of soil and water. Agriculture soils reveal great diversity in a potential bioavailability of heavy metals in Danube Lowland.

The presence of organic matter increases the cation exchange capacity (CEC) of soils, and negative correlations between CEC and the solubility of trace metals are observed because the added organic matter immobilizes the metals. At higher soil pH, soluble organic matter can supress the trace metal adsorption on silicates and oxides and promote dissolution of trace metals from adsorption sites on clay minerals. The persistency of these metal-organic complexes is attributed to the tendency of metals to form stable complexes with dissolved organic matter.

The soil samples were obtained from Danube Lowland area (27 samples from upper part of Danube Lowland, 27 from middle and 27 from lower part of Danube Lowland). The locations cover a variety of water pollution with extensive agricultural activity. To quantify heavy metal sorption onto soil horizons was determined by laboratory batch experiments. The soils were sampled, and air dried until the experiments were performed. The physico-chemical characteristics were measured (the texture, organic matter, content of organic carbon, calcium carbonate, cation exchange capacity, pH) in soil leachate (Table 5,6).

3. Results and discussion

Many researchers revealed a relatively high pollution of water in industrial and agriculture areas. The present research was conducted to assess the nutrients (N, P) deterioration of water and the ecological and health risk of heavy metals, such as Cd, Pb, Cu, Cr, As, Ni, Hg, Zn. The excessive amount of chemical substances (mainly total nitrogen and total phosphorus) leads to deterioration of water quality from agricultural areas. In recent years, water contamination calls for significant concerns due to the rapid industrialization and agriculture. Based on results it may be concluded that heavy metals accumulation and their distribution in soils of alluvial and aeolian plain on Danube Lowland are inevitable due to climatic conditions and anthropogenic activities. Extractable heavy metals concentration in studied samples were found below the permissible limit.

The Danube Lowland is one of the most productive agricultural areas of Slovakia. 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 canal network at this area was built up for drainage and also to provide irrigation water. There are three main canals of this network: Chotárny canal, Gabčíkovo-Topoľníky canal and Komárňanský canal. Chotárny canal – is the P1M water body type (partial river-basin Váh, code SKW0029), Gabčíkovo-Topoľníky canal – is the P1M water body type (partial river-basin Váh, code SKW0023), Komárňanský canal – is the P1M water body type (partial river-basin Váh, code SKV0226). For the evaluation the water quality the data obtained on Institute of Hydrology SAS during the 2010-2025 were used. Monitored localities was chosen as the most representative area-covering.

The main purpose of this paper is to provide a review on recent state of surface water deterioration on Danube Lowland canals understanding its mechanisms and progresses in identifying the influence factors inducing water deterioration. The nutrient level (N, P) in surface water has slightly decreased in response to point pollution (discharge of domestic wastes) and non-point pollution (from agricultural practices and urban development) (Table 1-4). However we observe slight increasing in Komárňanský canal during last few years. Excessive nutrient inputs exceeded the limit values (not only in some months, but average annual values for nitrates and phosphates, too) and other conditions, such as high temperature, decreased dissolved oxygen content, higher pH and increased light intensity in summer period induced enhanced water eutrophication.

The available parameters concerned include temperature, pH, conductivity, dissolved oxygen (DO), total sissolved solids (TDS),

total nitrogen (Ntot), total phosphorus (Ptot), Chl-a, oxidation methods (COD_{Mn}), chemical oxygen demand by K_2MnO_4 biological oxygen demand (BOD_5) are selected for calculating the TPSI.
The TPSI values were calculated according to the relationship (Eq. 1) which showed from low to moderate level of risk associated with environment contamination. The results of the present study can serve as basic data for management of the environmental protection, which can to minimize pollutants contamination. The total parameters status index on Danube Lowland achieved value 3,5.

Tab. 1. Evaluation state of surface water according to Supplement No.1 Directive of Government SR No. 269/2015.

Place of sampling point: Komárňanský canal Profile : Veľké Kosihy			Typ VÚ: P1M Code VÚ: SKV0226				Partial watershed Váh Monitoring: 2025	
Part A – general water quality indicator								
Term of indicator	Symbol	Unit	Number statements	Min.	Max.	Average	P90/10	Value according to NV 269/2015	Meet/Does not meet
Dissolved oxygen	O_2	$mg.l^{-1}$	12	8.6	16.0	12.3	8.5	> 6.0	M
Temperature	t	ºC	12	4	26.6	15.3	20.3	< 27	M
Reaction	pH	-	12	6.59	8.50	7.54	8.16	8.5	M
Conductivity	EC	$\mu S.cm^{-1}$	12	349	830	589,5	350.1	≤ 700	M
Total dissolv. solids	TDS	$mg.l^{-1}$	12	320	810	565	319	800	M
Total nitrogen	Ntot	$mg.l^{-1}$	12	4.2	22.4	13.3	8.17	9	N
Total phosphorus	Ptot	$mg.l^{-1}$	12	0.6	0.83	0.71	0.78	0.4	N
Turbidity	T	NTU	12	40	90	65	38	100	M

Tab. 2. Evaluation state of surface water according to Supplement No.1 Directive of Government SR No. 269/2015.

Place of sampling point: Gabčíkovo-Topoľníky canal Profile : Vrakúň			Typ VÚ: P1M Code VÚ: SKV0226				Partial watershed Váh Monitoring: 2025	
Part A – general water quality indicator								
Term of indicator	Symbol	Unit	Number statements	Min.	Max.	Average	P90/10	Value according to NV 269/2015	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	ºC	12	3	21.6	11.4	20.3	< 27	M
Reaction	pH	-	12	6.39	8.19	7.93	8.16	8.5	M
Conductivity	EC	$\mu S.cm^{-1}$	12	349	543	420	350.1	≤ 700	M
Total dissolv. solids	TDS	$mg.l^{-1}$	12	284	630	405	290	800	M
Total nitrogen	Ntot	$mg.l^{-1}$	12	2.2	9.4	7.23	3.17	9	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

Tab. 3. Evaluation state of surface water according to Supplement No.1 Directive of Government SR No. 269/2015.

Place of sampling point: Chotárny canal Profile : Ňarád			Typ VÚ: P1M Code VÚ: SKV0226				Partial watershed Váh Monitoring: 2025	
Part A – general water quality indicator								
Term of indicator	Symbol	Unit	Number statements	Min.	Max.	Average	P90/10	Value according to NV 269/2015	Meet/Does not meet
Dissolved oxygen	O_2	$mg.l^{-1}$	12	6.4	24.0	15.2	8.5	> 6.0	M
Temperature	t	ºC	12	8	26.6	11.4	20.3	< 27	M
Reaction	pH	-	12	6.1	8.29	7.19	8.16	8.5	M
Conductivity	EC	$\mu S.cm^{-1}$	12	320	640	480	340	≤ 700	M
Total dissolv. solids	TDS	$mg.l^{-1}$	12	284	620	452	319	800	M
Total nitrogen	Ntot	$mg.l^{-1}$	12	6.2	19.4	12.8	6.17	9	N
Total phosphorus	Ptot	$mg.l^{-1}$	12	0.28	0.83	0.55	0.38	0.4	N
Turbidity	T	NTU	12	18	80	49	38	100	M

Tab. 4. Limit values of heavy metals in r surface water in agricultural region. Evaluation state of surface water according to Supplement No.1 Directive of Government SR No. 269/2015.

indicator		unit	highest permissible concentration	
Cd	cadmium	µg.l^{-1}	1.class	0.08
			2.class	0.10
			3.class	0.15
Pb	lead	µg.l^{-1}	-	7.2
Cu	copper	µg.l^{-1}	1.class	1.1
		µg.l^{-1}	2.class	4.8
		µg.l^{-1}	3.class	8.8
Cr	chromium	µg.l^{-1}	-	9
As	arsenic	µg.l^{-1}	-	7.5
Ni	nickel	µg.l^{-1}	-	20
Hg	mercury	µg.l^{-1}	-	0.05
Zn	zinc	µg.l^{-1}	1.class	7.8
		µg.l^{-1}	2.class	35.1
		µg.l^{-1}	3.class	52

Heavy metal contamination in agricultural soils has been a significant health concern worldwide due to their persistent and non-biodegradable nature. The present study was conducted to assess their concentrations in soil samples collected from Danube Lowland (Slovakia), and to determine their associated health and ecological risks. The calculated contamination factor showed their low to moderate contamination in the study area for three types of soils samples, indicating the moderate potential of ecological risks of soils. Total parameters status index values were calculated according to the relationship (Eq. 1), which showed from low to moderate level of risk associated with heavy metals contamination. The results of the present study can serve as basic data for management of the environmental protection, which can to minimize heavy metals contamination in the agricultural soils.

In the soils on Danube Lowland the measurements have been taken in observation locations. In the present study, to investigate the soil heavy metal pollution characteristics 27 samples from 3 typical soil profiles were collected. Uptake of heavy metals like Cd (cadmium), Pb (lead), Cu (copper), Cr (chromium), As (arsenic), Ni (nickel), Hg (mercury) and Zn (zinc) from soil is one of the main processes that regulates quality of soil and water. Agriculture soils reveal great diversity in a potential bioavailability of heavy metals on Danube Lowland (Table 5, 6)

Tab. 5. Limit values of heavy metals in soils in agricultural region
Evaluation state of surface water according to Supplement No.1 Directive of Government SR No. 269/2015.

Soil type Limit values	Cd mg.kg^{-1}	Pb mg.kg^{-1}	Cu mg.kg^{-1-}	Cr mg.kg^{-1-}	As mg.kg^{-1-}	Ni mg.kg^{-1-}	Hg mg.kg^{-1-}	Zn mg.kg^{-1}
clay-loamy, loamy, clay	1.00	115	70	200	30	60	0.75	200
sandy loamy - loamy	0.70	70	60	150	25	50	0.50	150
sandy – loamy sandy	0.40	25	30	100	10	40	0.15	100

Tab. 6. Estimated values of total parameters status index (TPSI)

locality	HM Mean conc.	Cd mg.kg^{-1}	Pb mg.kg^{-1}	Cu mg.kg^{-1}	Cr mg.kg^{-1}	As mg.kg^{-1}	Ni mg.kg^{-1}	Hg mg.kg^{-1}	Zn mg.kg^{-1}	TPSI
Danube Lowland C1	Mean (n=27)	0.63	8.48	3.45	0.0085	0.0067	0.0195	0.0121	19.076	0.48
Danube Lowland C2	Mean (n=27)	0.89	8,98	3.3	0.0043	0,0046	0.0135	0.0256	26.055	0.52
Danube Lowland C3	Mean (n=27)	1.26	7.13	4.6	0.043	0.0059	0.0315	0.0471	25.315	1.09

Chemical and biological processes taking place in the water can significantly affect pH of the water. Was found a generally increasing tendency of pH and EC values in the longitudinal profile of the water course of Komárňanský canal in Veľké Kosihy profile. We observed regularity in the seasonal dynamics of pH and electrical conductivity values. Buth the sampling location had a greater influence on the pH and conductivity, than the seasonal dynamics.

During the years 2010 –2025 the values of pH were evaluated Danube Lowland canals network. From obtained results it follows that the mean pH value varied from 6 to 8 over the whole monitored period. In clean natural waters (both surface and groundwater),

the pH value is determined by physical-chemical parameters and the balance between free CO_2 and bound CO_2 (the carbonate balance). Low conductivity values were measured in winter and spring. In the summer months, its values increased up to its maximum value in july (Fig.2).

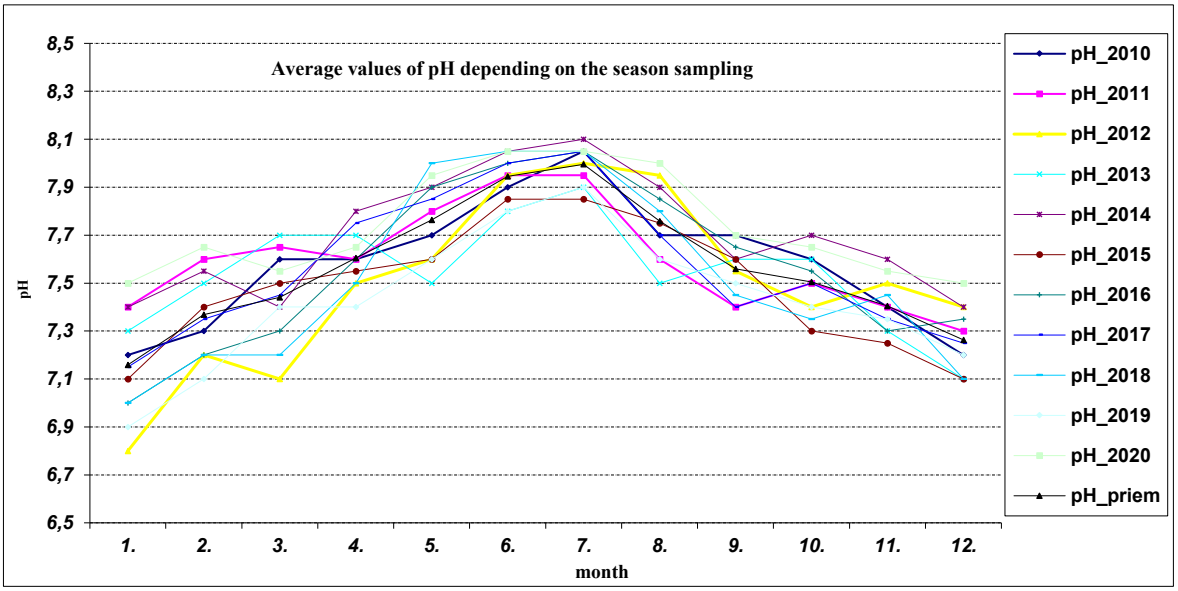

Fig. 2. Average values of pH depending on the seasson sampling (2010-2025).

This area forms a separate part of the observation places. Itt plays an important role in the entire process of monitoring changes in water quality in Slovakia, as it represents a source of drinking water. The nature of land use (agricultural areas) is reflected in increased contents of phosphorus, nitrogen, phosphorus as well as sulfates, chlorides, organic and heavy metals pollution from fertilizers. There are three main canals of this network: Chotárny canal – is the P1M water body type (partial river-basin Váh, code SKW0029), Gabčíkovo-Topoľníky canal – is the P1M water body type (partial river-basin Váh, code SKW0023), Komárňanský canal – is the P1M water body type (partial river-basin Váh, code SKV0226). The Danube Lowland is one of the most productive agricultural areas of Slovakia. under which is located the richest water reservoar of drinking water of Slovakia. For this reason, it is very important to deal with quality and quantity of water resources in this region. For the evaluation the water quality we went out from the data obtained on Institute of Hydrology SAS, v.v.i. On the evaluation of the obtained results we used statistical methods.

Monitoring of pesticides in Slovakia surface water is carried out annually, in accordance with the relevant Water monitoring program of the Ministry of the Environment of the Slovak Republic. Pesticides are substances intended to suppress the growth or eliminate of unwanted organisms - animals, plants, fungi or various microbes. Contamination of the environment by pesticides can pose serious harmful effects on other organisms and also on human health. In order to establish appropriate measures for the environmental protection. It is necessary to monitor and evaluate the occurrence of pesticide residues in individual components of the environment. This study presents the results of the monitoring of ten important pesticides used in agricultural production (over 10 000 kg/year) during the period 2010-2025 in Slovakia. There are only two substances, pendimethalin and chlorpyrifos, which exceeded the environmental quality standard.

Some researchers have concluded that interactions between two or more factors control the rate degree of pollution and overgrowing of canals on Danube Lowland (Slovakia). Flow velocity in vegetation growth channel is reduced. River aquatic systems that have been heavily loaded with nutrients (nitrogen and phosphorus) can display change both seasonally and spatial. Climate change is difficult to influence factor greatly affected surface water quality. Influence of different vegetation types on flow characteristics and sediment deposition would be important for informing river restoration and management practices.

4. Conclusion

Today, due to the increase of the population, the growth of industry and agriculture determines the variety of chemical compounds. The quality of drinking water has decreased. Estimate of river water quality characteristics and processes is a main issue in the management of aquatic environments and water resource. Ten monitoring stations on the Danube Lowland are as provider of data used for modelling.

The study aims to explore low flow generating processes on a catchment scale by compering runoff signatures on a regional scale. Based on hydrological drought types we use hot-spots of close by gauges to explore climate-catchment interaction based on catchment similarity. The outcome shall build the foundation for a hydrological drought typology across European regimes.

Gradual warming on the Danubian Lowland is experiencing state, of which the impact on surface water runoff are large. In this context, it is necessary to undenstand the hydrological regime change to provide the best decision tools for water management. Surface water resources, dependent on very irregural rains become increasingly limited, because of climate change resulting in decreasing precipitations, rising temperature and consequently higher evaporation.

The present article aims with the studies on the impact of selected parameters on deterioration in surface water on the Danube Dowland (Slovakia). The review covers the definition and concept of surface water deterioration and the unfavorable effects on quality of the ecosystem. The deterioration 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. Most of the surface water are surrounded with densely populated urban aeras areas and agricultural fields. The size of smaller water bodies in human settlement areas is on the decrease with rise in population. The runoff brings down fertilizers and other chemicals from agricultural fields. The Ntot and Ptot contained in these effluents is known to promote excessive growth of plants.

The detergents are the major source of phosphorus inputs into water bodies through sewage and drainage systems have been discussed. The detergents comprises builders containing polyphosphate salts. An environment-friendly and effective synthetic builder is yet to be developed to replace existing phosphorus containing builders of detergents. Nitrogen and phosphorus affect the phytoplankton production in eutrophic waters in temperate regions. This review describes the role, sources, and monitoring of nitrogen and phosphorus, as well as its influence on surface water deterioration. The limiting factors (namely temperature, pH, light, dissolved oxygen and CO_2 level) are known to affect deteriorated water bodies. The results of nitrogen and phosphorus amounts reported in this study are the best indicators of the level of eutrophication.

Continuous point sources of nitrogen and phosphorus, dominated by sewage treatment works, have a highly important influence on its level in the growing season. It is important to solve point sources comprehensively so that reductions in nutrients concentrations during the critical time of year. Diffuse sources, particularly from agriculture, are a major contributor to nutrient levels in riverine sediments, where it can be utilised by benthic algae and rooted plants. These nutrients can also be released into the water by a variety of processes. As point sources are brought under control, the relative contribution from diffuse sources becomes increasingly important.

Monitoring of pesticides in Slovak surface water is carried out annually, in accordance with the relevant Water monitoring program under the responsibility of the Ministry of the Environment of the Slovak Republic. Pesticides are substances intended to eliminate or suppress the growth of unwanted organisms - animals, plants, fungi or various microbes. Contamination of the environment by pesticides can pose serious harmful effects on non-target organisms and also on human health. In order to set appropriate measures for the environmental protection, it is necessary to monitor and evaluate the occurrence of pesticide residues in individual components of the environment. The paper presents the results of the monitoring of ten important pesticides used in agricultural production (over 10 000 kg/year) in Slovakia during the period 2010-2025. So far, the monitoring has not proven a significant long-term contamination of surface water in the Slovak Republic by pesticides. There were only two substances, pendimethalin and chlorpyrifos, which exceeded the environmental quality standard.

The study was focused on identification of the long-term trends in the surface water quality in canals network at Danube Lowland region. The paper shows changes in measured deterioration parameters in years 2010-2025. It was shown that canal water quality has been changed no-significantly during the period 2010-2025. However we observe slight increasing in some profiles of Komárňanský canal with major agricultural activities during last decade.

Acknowledgments

This contribution was supported by project VEGA 2/0028/23 Seasonal variations of hydrodynamic and morphological parameters in lowland vegetated rivers.

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