Estimation a Conversion Factor Between Electrical Conductivity and Total Dissolved Solids in Žitný ostrov Surface Water

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Abstract

The aim of this contribution was to analyse the worsening.water quality problem, factors affecting this process, its consequences and possibilities of prevention. Evaluating a water worsening state of surface water in Žitný ostrov region (Danube Lowland, Slovakia) following the assessment of the physical-chemical and microbiological indicators, with regards of international and national legislative for the water quality status. The study was focused on the surface water pollution of Žitný ostrov channel network. Monitoring and assessment of following indicators were performed – temperature (t), dissolved oxygen (O2), chemical oxygen consumption (CHSKCr), pH, electrical conductivity (EC), specific conductivity (SPC), total dissolved solids (TDS), total nitrogen (NTOT), nitrate nitrogen (N-NO3-), nitrite nitrogen (N-NO2-), ammonia nitrogen (N-NH4+), total phosphorus (PTOT), phosphate phosphorus (P-PO43-). In most surface waters these include the cations Na+, K+, Ca2+, Mg2+, and the anions Cl–, HCO3–, SO42–. Estimations of total dissolved solids (TDS) content are commonly based on electrical conductivity (EC) measurements, using a conversion factors (f) retrieved from regulations or guidelines. This paper determinate a conversion factor parameters as a case study to identify if reported conversion factors of Žitný ostrov surface waters are valid.

Keywords: electrical conductivity, total dissolved solids, surface water quality, Slovakia

Introduction

The electrical conductivity of an aqueous solution is its ability to pass an electric current. The characteristic property of solutions, it is used in a range of fields and industrial applications. Electrical conductivity depends mainly on the concentration of dissolved electrolytes and gases. With respect to the dissociated ions in particular, EC is a function of their mobility [1-4].

Electrical conductivity strongly depends on the solution's temperature . because the movement of ions is directly proportional to the temperature. Due to the large dependency of EC on temperature, values are only comparable if either measured at or converted to the same reference temperature [5]. Different authors assume that the terms electrical conductivity indicate that the solution-specific property of conductivity was normalized to 25°C. This is commonly accepted as a convention. [6-8].

Estimations of total dissolved solids (TDS) content are commonly based on electrical conductivity (EC) measurements, using a conversion factor f retrieved from in situ monitoring. At lower concentrations, the relation between concentration and EC for single electrolyte solutions is linear and flattens off for higher ones because the ionic mobility decreases with increasing concentration due to interferences and interactions between the ions. The slope of the linear part, as well as the degree of flattening off at higher concentrations, differs for different dissolved electrolytes. As natural waters are not simple solutions and contain various ionic and undissociated species with widely varying amounts and proportions, the relationship between EC and TDS becomes complicated. However, it is generally well enough defined to be of good practical value and a linear relationship is usually a reasonably good estimate [9].

Establishing to a conversion factor for EC and TDS parameters using dataset of measurements in Žitný ostrov region (Danube Lowland, Slovakia) were performed. This area forms a separate part of the observation network, because it 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 nitrogen, phosphorus ions, as well as sulfates, chlorides and organic pollution. [12]. There are three main channels of this network: Chotárny channel, Gabčíkovo-Topoľníky channel and Komárňanský channel. 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 reservoar of drinking water of Slovakia. For this reason, it is very important to deal with quantity and quality of water resources in this region [13, 14, 15]. For the evaluation the water quality we went out from the data obtained on Institute of Hydrology SAS, v.v.i. [10, 16, 17, 18].

Electrical conductivity (EC) is a surrogate measure of total dissolved solids (TDS). Electrical conductivity methods are more advantageous as the measurement is faster than gravimetric measurement of TDS and will be highly useful. It is also effective as compared to the laboratory measurements. The relationship between TDS and EC is a function of the type and nature of the dissolved cations and anions in the water (Figure 1). This relationship EC and TDS is not directly linear, since the conductive mobility of ionic species is variable [19].

[6] provides a detailed analysis and discussion on the relationship of conductivity to TDS. He plotted TDS versus EC data that ranged from about 50 to 5000 $mg.l^{-1}$ and observed that the data set fit a straight line of regression with a slope of 0.59. He stated that for the range of natural water evaluated the range for the ratio of TDS: EC was 0.54 to 0.96 and that for water high in sulfate could exceed the upper end of the range [20, 21]. Several authors indicated that the slope of the line of regression is not constant

over a wide range of dissolved solids concentration. The relationship of TDS to EC is less well defined for waters with TDS exceeding about 50,000 $mg.l^{-1}$. In general, the range for the ratio of TDS: EC was (0.50 – 0.75) natural type of water [2, 22].

Total dissolved solids (TDS): this is the total number of ions in solution, whether they are dissociated or not. It is defined by [24] as the sum of the major ions in the water expressed in $mg.l^{-1}$. In most surface waters these include the cations Na^+, K^+, Ca^{2+}, and Mg^{2+}, and the anions Cl^- , HCO_3^-, and SO_4^{2-}. The analysis of TDS concentration from EC value can be used to give an overview of water quality. For more precision, TDS concentrations need to be analyzed using the gravimetric method in the laboratory. Total dissolved solids (TDS, in $mg.l^{-1}$) was estimated from measurements of electrical conductivity at 25°C (EC, in $\mu S.cm^{-1}$) by applying a conversion factor (f).

One of the most important tools for evaluating water quality and character in a catchment is a detailed knowledge of the ranges and trends in salinity pollution of natural water. Although measurements are simple, effective assessment requires intensive measurement of the parameter in a reliable and consistent manner with respect to location, time and hydrological condition requires intensive measurement of the parameter in a reliable and consistent manner with respect to location, time and hydrological condition [23].

Electrical conductivity has been widely used in freshwater research but usual methods employed for converting measurements to conductance at a given temperature have not given uniformly accurate results. The temperature coefficient used to adjust conductivity of natural waters to a given temperature varies depending on the kinds and concentrations of electrolytes, the temperature at the time of measurement, and the temperature to which measurements are being adjusted. The temperature coefficient was found to differ for various stream waters, and showed seasonal changes. High precision can be obtained only by determining temperature coefficients for each water studied. Mean temperature coefficients are given for various temperature ranges that may be used where less precision is required [5, 25]. The transfer of energy and matter within complex spatial structures is a central topic in landscape ecology, which provides useful information for functional water management and land use planning. In this context, comprehensive studies exist on the nutrient cycles in rural catchments [26, 23].

The Relationship Between TDS and EC

Electrical conductivity

Since total dissolved solids (TDS) is not easily measured, except under controlled conditions in reputable laboratories, a common alternative method is to utilise the simple permeate electrical conductivity (EC) reading and multiply by a standard correction factor to obtain the required TDS result. It was demonstrates the considerable problems, both theoretical and practical, associated with these apparently simple measurements and shows that just one simple linear conversion factor cannot be suitable throughout the range of water samples, but that several different factors ranging from 0.50 to 0.75 need to be used [27].

The problem of predicting the conductivity of dilute electrolytes is of general chemical interest and much theoretical and experimental work has been carried out [28, 29]. The conductivity of natural waters depends on chemical composition. Precision farming requires information on spatial variability of pollutants in a field and conventional methods of sampling and analysis is time consuming and costly.

Temperature correction

Electrical conductivity strongly depends on the sample's temperature because the movement of ions is directly proportional to the temperature. Due to the large dependency of EC on temperature, values are only comparable if either measured at or converted to the same reference temperature. This procedure is referred to as temperature correction or temperature compensation and is done by applying a linear or non-linear correction algorithm, which is even required for measurements close to 25°C. [22, 30] Many conductivity meters have a built-in temperature compensation, using mainly linear algorithms to convert the sample conductivity to the chosen reference temperature. For natural waters with conductivities of approximately 50–1 000 $\mu S.cm^{-1}$, a non-linear compensation can be used.

Total dissolved solids

There are three groups of ions that contribute to the water's EC: significant (H+, Na+, Ca2+, Mg2+, NH4+, K+, Cl-, SO42-, HCO3-, CO32-, F-, Al3+, Fe2+, NO3-, HSO4-), moderate (Li+, Fe3+, Cu2+, Mn2+, Zn2+, OH-, NaCO3-) and very little contribution (Ba2+, Br-, Cs+, Sr2+, KSO4-). OH- needs to be considered for pH higher than 9 and H+ for pH below 5.

Total dissolved solids (TDS) or filterable matter was measured of the total concentration of dissolved matter in a water sample [7]. It includes all inorganic and organic dissociated anions and cations as well as undissociated dissolved species [23]. The standard method for the determination of TDS is gravimetric, where an accurately measured volume of filtered sample is evaporated and dried at a certain temperature. The volume of sample to be evaporated depends on the expected TDS, which can be estimated from a quick EC measurement. Though the determination of TDS seems to be relatively straightforward, the results of TDS determination are influenced by various parameters, such as pore size, porosity and filter thickness, particle size, amount of sample and drying time as well as method used.

Some parameters may cause a longer drying time. These are a particularly high mineral content, a high bicarbonate concentration or large concentrations of calcium, magnesium, chloride and sulphate. At lower temperatures, not all of those processes occur until completion, usually leading to more water retained in the solids. Different temperatures are recommended for drying by different standards. Because the evaporation method is time consuming and expensive, methods for determining TDS mathematically from ion concentrations be possible,. If a reasonably complete chemical analysis was performed, a possible method for determining TDS is to add up all of the ion concentrations.

Material and Methods

The Žitný ostrov is one of the most productive agricultural areas of Slovakia, situated on the Danube Lowland. Under its surface is the richest reservoar of drinking water of Slovakia. For this reason, it is very important to deal with quantity and quality of water resources in this region [31, 13, 14, 15]. Conductivity for most natural waters is measured in µS.cm-1.

Water samples were taken along the main Žitný ostrov channels. The dry and warm summer climate, evaporation soil water regime and mineralized groundwater create here convenient conditions for development and spreading of the saline and alkaline soils [27, 3, 9]. Climate in this region is characterized by dry summers. These conditions, in addition to the use of high to medium salt-content irrigation water and bad drainage, lead to an increased risk of salinization and sodification in agricultural area [11]. The territory shows slight height differences, it is partly divided by dead branches of the Danube. There are alluvial deposits with different grain sizes, often with a relatively high $CaCO_3$ content (up to 35% in some places). In the lower part of the alluvial deposits, there are gravels of medium to fine grain, which emerge already at depths of around 2.5 m and occasionally up to the surface. [10]. The higest underground reservoir of fresh water in Central Europe is situated under the Žitný ostrov area .[11]. The exact value for the conversion factor depends on the water's ionic composition, especially its pH and bicarbonate concentration. [10] documented that factors were not consistent between sites belonging to different river systems, but varied little for individual sities. Site specific validation were used.

Electrical conductivity (EC) and total dissolved solids (TDS) are water quality parameters, which are used to describe salinity level. These two parameters are correlated and usually expressed by a simple equation: TDS = f .EC (in 25 0C). By finding the correlation value. TDS concentration can be measured from EC value measured from EC value. EC can be measured easily and inexpensively in situ by a portable water quality checker (YSI Multiparametric probe). The analysis of TDS is more difficult and expensive as it needs more equipment and time. Previous research results have found that the correlation between TDS and EC are not always linear. For more precision, TDS concentrations need to be analyzed using the gravimetric method in the laboratory [32].

The relationship between total dissolved solids (TDS) and electrical conductivity (EC) is established in 648 samples collected from Žitný ostrov channels. These data are extremely variable in content, reliability and periodicity of sampling. The data were sorted into useable modules, and their statistical distribution was examined. The median ratios of TDS/EC obtained for different salinity ranges were between 0.5 and 0,9 with normal variability ranging from below 0.3 to greater than 1.1, particularly at lower salinities. The data set used has sufficien sample numbers and areal distribution per increment to give reasonable reliability within the electrical conductivity range of 50–5 000 µS.cm--1.

Sampling

Samples were taken once per month in the same day as samples for chosen indicators of water quality assessment from the same sampling sites. By the evaluation of the obtained results we used several statistical methods. Water quality was evaluated by the comparison of the characteristic values for individual indicators in all sampling sites calculated and the recommended value for these indicators [33, 20, 22, 24].

A total of 648 samples from three main channels in Žitný ostrov (location Z1, Z2., Z3) were investigated. We measured water purity once a month in each 9 localities during the years 2020 – 2022. The samples provide a wide range of EC, TDS and conversion factors with showing a distribution, with EC < 5 000 µS.cm-1 and EC around 15 000 µS.cm-1. However, the conversion factors calculated from single measurements are close to a normal distribution [34]. The influence of temperature of measurements on the temperature coefficient can, however, have a strong effect on the accuracy of the adjustment of results to a standard temperature, particularly where measurements are obtained over a wide temperature range and conductivities vary little.

To determine the extent of variation the coefficient in different waters (Table 1),.Samples were analyzed from freshwater (stream) with conductivities ranging from 50 to 5000 µS.cm-1; in addition samples were obtained from three Žitný ostrov channels: Chotárny channel (locality Z1), Gabčíkovo-Topoľníky channel (lokality Z2), Komárňanský channel, (locality Z3). Monitored localities was chosen so that they be the most representative area-covering.

The water most often is of inadequate quality for use in any field or for direct discharge into rivers. Several studies [20, 27] referring to EC/TDS conversion factor have already been conducted in Žitný ostrov channel network compiled physical, physico-chemical and microbiological parameters. EC/TDS correlation was establishing using field and laboratory measurements. EC/TDS ratios is from below 0.5 to above 0.9 with use statistical data. In the dataset, they included the 'total dissolved solids imbalance', which is based on the measured and calculated TDS from the chemical analysis. Their TDS/EC ratios range between 0.50 and 0.9 with an average of 0.68, which is close to the ratio of 0.65 recommended.

EC-TDS conversion factors

As a result of its own dissociation, the EC of pure water is 0.054 µS.cm-1 at 25°C. In natural waters, conductivity will typically range from tens of µS.cm-1 to tens of mS.cm-1 [6]. Because almost all the conductivity is accounted for by the dissolved ions, there is a direct proportionality between EC and TDS:

$$TDS = f \, . \, EC \qquad (1)$$

This conversion factor f (Equation 1) allows the estimation of TDS from a precisely measured EC [7] and is commonly used in all situations where TDS needs to be established quickly (e.g. agriculture, industry, water supply, resource management [1].

At lower concentrations, the correlation factors between TDS and EC for single electrolyte solutions is linear and flattens off for higher ones because the ionic mobility decreases with increasing concentration. As natural waters are not simple solutions and contain various ionic and undissociated species with widely varying amounts and proportions, The relationship between EC and TDS becomes complicated. However, it is generally well enough defined to be of good practical value [6]. Linear relationship is usually a reasonably good estimate. Commonly, predefined conversion factors without proper site-specific validation are used.The factors differ for different types of waters (Table 1), depending on the dominant major ions varying between water bodies, sampling locations and seasons [10].

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Tab. 1. Correlation EC and TDS in various type of water

EC in 25 °C	Ratio TDS/EC (*f*)
Natural water for irrigation	0.50 – 0.75
Natural water EC 50 − 5 000 μS.cm^{-1}	0.50 – 0.75
Distillate water EC 1 − 10 μS.cm^{-1}	0.05
Freshwater EC 200 − 800 μS.cm^{-1}	0.50
Seawater EC 45 000 − 60 000 μS.cm^{-1}	0.9

Consequently, TDS calculated from a generalised factor is an estimate and accurate TDS calculations need site- and runoff-specific conversion factors [5]. The exact value for the conversion factor depends on the water's ionic composition, especially its pH and bicarbonate concentration [10,25] documented that factors were not consistent between sities belonging to different river systems, but varied littlefor individual sites. Although f should have the unit (mg·cm)/(l·μS) derived from TDS and EC. All of the following factors are for conversion from EC in μS.cm-1to TDS in mg.l-1. Recommends a factor of 0.75 to estimate the volume of water to be evaporated for TDS determination. [2,25] discussed converting EC to total dissolved electrolytes.

For the use of water in various fields, including domestic, industrial and agricultural, with strong emphasis put on the average lying at 0.65. Factor increases for higher TDS [23] ascertained factors of 0.59–0.72, with a normal variability between < 0.35 and > 1.00 in a conductivity range of 50–1 000 μS.cm-1.Other scientists use regressions between EC and TDS that do not intersect at the origin, avoiding a simple factor for conversion. Instruments for measuring and logging EC often have built-in options to perform the conversion to TDS with settings ranging from 0.5 to 0.75, to calculate TDS in some cases; in other sections it was not indicated which method was used to estimate TDS, although several options are referred to in the theoretical section. The site-specific validation were used.

Monitoring of water worsening rates and effects needs to be adapted to the type of surface system under investigation. Groundwater nutrient concentrations and their variability by region and over time are less well documented and this needs further work. Pollution of surface waters best managed by reducing inputs to the river surface water system, rather than any in situ remedial action. Point source pollutants are easily managed, but diffuse pollution from agriculture, industry, urbanisation and others is less easily controlled. Diffuse pollution may be caused by leaching of nutrients from soil over a long period.

The external supplies of aquatic ecosystems contamination 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 relative contributions of these two types of sources can differ substantially from watershed to watershed, depending upon local human population densities and land use. Pollution exports from point and nonpoint sources can have profound effects upon the quality of receiving waters. The most common effects of increased pollutant supplies on aquatic ecosystems are perceived as increases in the abundance of algae and aquatic plants. The degradation of water resources by eutrophication pollution can result in worsening of water quality [5]. Pollution in freshwaters is primarily driven by increases the compounds.

Impact of vegetation on flow in a lowland stream during the growing season investigated [31, 13, 15]. Vegetation growing in the water along watercourses has been the subject of several studies since it was recognized that it could have a significant impact on the water flow. It may increase resistance to flow and cause higher water levels. Also, it has an effect on the velocity profiles. Previous investigations on the flow of water through emergent vegetation have shown different results. The purpose of these studies was to determine how aquatic vegetation influences flow resistance, water depth and discharge in the Chotárny channel at the Žitný Ostrov area. The Chotarny channel is one of three main channels of this network. Measurements performed during 2020 – 2022 years at this channel were used for an evaluation of vegetation impact on flow conditions.

The roughness coefficient was used as one way of quantifying this impact. The results show variation of this parameter during the growing season. Vegetation causes resistance to flow; it reduces flow velocities, discharge and increases water depth. How the sprouting of stream bed vegetation influences channel`s flow conditions and its capacity was demonstrate. Many practices result in point and non-point source of surface water pollution, include fertilizers and manure applications, dissolved nitrogen and phosphorus in precipitation, irrigation flows, and dry atmospheric deposition were reduced.

Mechanisms and assessment of water pollution investigated [20]. Deterioration of water quality has become a worldwide problem in recent years. Understanding the mechanisms of water pollution will help to prevent and remedy of water quality. The assessment of water pollution has been advanced from simple individual parameters like total phosphorus, total nitrogen, etc., to comprehensive indexes like total pollutants status index. The major influencing factors on water pollution include nutrient enrichment, hydrodynamics, environmental factors such as temperature, salinity, carbon dioxide, element balance, and microbial and biodiversity, etc. The conversion factors calculated from single measurements are close to a normal distribution. The influence of temperature of measurements on the temperature coefficient can, however, have a strong effect on the accuracy of the adjustment of results to a standard temperature, particularly where measurements are obtained over a wide temperature range and conductivities vary little.

The mechanisms of water pollution are not fully understood, but excessive pollutants loading into surface water system is considered to be one of the major factors. Increased nutrient load to water body is now recognized as a major threat of water quality degradation. Monitoring of surface water in Žitný ostrov channel network (Danube Lowland, Slovakia) has been provided in terms of requirements Supplement No.1 Directive of Government SR No. 269/2010 [15], Part A and WHO guidlines [16] Measuring and assessment of following indicators were performed. These values were exceeding - total nitrogen (NTOT), nitrate nitrogen (N-NO3-), nitrite nitrogen (N-NO2-), ammonia nitrogen (N- NH4+), total phosphorus (PTOT), phosphate phosphorus (P-PO43-, (TABLE 2).

Tab. 2. Shows the limiting values of indicators in various polluted water.

Place of sampling point: Komárňanský channel Profile : Okoličná na Ostrove				Typ VÚ: P1M Code VÚ: SKV0226				Partial watershed Váh Monitoring: 2020	
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	$mg.l^{-1}$	216	8.4	14.0	10.8	8.5	> 6.0	M
Temperature	t	°C	216	3	21.6	11.4	20.3	< 27	M
Chemical consump. oxygen	$CHSK_{Cr}$	$mg.l^{-1}$	216	5.0	18.0	7.7	10.8	< 25	M
Reaction	pH	-	216	6.39	8.19	7.93	8.16	8.5	M
Conductivity	EC	$\mu S.cm^{-1}$	216	349	543	420	50.1	≤ 700	M
Specific conductivity	SPC	$\mu S.cm^{-1}$	216	370	933	548	62.2	700	M
Total dissolved solids	TDS	$mg.l^{-1}$	216	284	630	405	0.19	800	M
Ammonia nitrogen	N-NH4	$mg.l^{-1}$	216	0.05	0.9	0.34	0.16	1	M
Nitrate nitrogen	N-NO3	$mg.l^{-1}$	216	2.7	5.2	3.68	3.61	5	N
Total nitrogen	Ntot	$mg.l^{-1}$	216	2.2	9.4	7.23	3.17	9	N
Phosphate phosphorus	P-PO4	$mg.l^{-1}$	216	0.17	0.42	0.30	0.32	0.35	N
Total phosphorus	Ptot	$mg.l^{-1}$	216	0.18	0.43	0.35	0.38	0.4	N
Turbidity	T	NTU	2	14	64	42	38	100	M

The limit value has been exceeded for ions nitrate nitrogen $N\text{-}NO_3$, ammonia nitrogen $N\text{-}NH_4$, total nitrogen Ntot, phosphate phosphorus $P\text{-}PO_4$, total phosphorus Ptot. The conversion factors were determined using field and laboratory measurements. The site-specific validation was used. Some profiles in this region have recently been found to be highly polluted. [36].

Results and Discussion

Summary of a conversion factors between electrical conductivity and total dissolved solids were performed by analysis a total of 648 samples from three main channels in Žitný ostrov (location Z1, Z2., Z3) were investigated. We measured water purity once a month in each 9 localities during the years 2020 - 2022.

EC can be measured easily and inexpensively in situ by a portable water quality checker (YSI Multiparametric probe). The analysis of TDS is more difficult and expensive as it needs more equipment and time. The TDS concentration from EC value can be used to give an overview of water quality. For more precision, TDS concentrations need to be analyzed using the gravimetric method in the laboratory. Total dissolved solids (TDS, in $mg.l^{-1}$) was estimated from measurements of electrical conductivity at 25°C (EC, in $\mu S.cm^{-1}$) by applying a conversion factor (*f*) (TABLE 3).

Tab. 3. Statistics for the results of samples from the Žitný ostrov area (n=648) from these three localities Z1, Z2, Z3

	k_{25} $\mu S.cm^{-1}$	TDS $mg.l^{-1}$	f = TDS. k_{25}		
			Z1	Z2	Z3
Minimum	67	70	0.4	0.45	0.6
Maximum	1 200	7 000	1.1	1.2	1.5
Median	633.5	3535	0.75	0.82	0.45
Average	633.5	3535	0.76	0.83	1.05
SD	566.5	3463	0.35	0.50	0,85
SD %	85	80	70	60	95

The Žitný ostrov area forms a separate part of the observation network, because it 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 nitrogen, phosphorus ions, as well as sulfates, chlorides and organic pollution. The results of the to establish a conversion factor for those parameters using dataset of measurements in Žitný ostrov region. This investigation is to establish the relationship between TDS and conductivity in a large set of water chemistry data from highly variable environments.

Estimation of total dissolved solids (TDS) content are commonly based on electrical conductivity (EC) measurements, using a conversion factor f retrieved from Žitný ostrov measurement. Total dissolved solids (TDS, in mg l-1) can be estimated from measurements of electrical conductivity at 25°C (EC, in µS.cm-1) by applying a conversion factor f. This factor is reported to range from 0.5 to 0.9. For 648 water samples, factors between 0.4 and 0.9, with a median of 0.8, were determined. The samples cover an EC-range of 50– 5 000 µS.cm-1 and TDS of 70–7 000 mg.l-1. Linear regression for the entire dataset yields a conversion factor of 0.85, but for samples with EC < 5 000 µS.cm-1 a conversion factor of 0.9 is recommended. However, both of these factors allow only estimates of TDS and for accurate TDS values it is necessary to determine the conversion factor specifically for each site. Besides spatial variations, temporal variations of conversion factors were also observed [1, 12].

Electrical conductivity (EC) and total dissolved solids (TDS) are frequently used as water quality parameters. These two parameters are indicators of pollution level, which make them very useful. The value of EC and TDS are correlated. Its ability depends mainly on dissolved ion concentrations, ionic strength, and temperature of measurements. The dissolved ions concentration is usually measured as TDS. EC can be measured easily and inexpensively in situ by a portable water quality checker (Multiparametric probe YSI flow-group Professional Plus). On the other hand, the analysis of TDS is more difficult and expensive as it needs more equipment and time.

The factor is commonly reported to range from 0.5 to 0.9. For 648 water samples, conversion factors between 0.5 and 0.9, with a median of 0.8, were determined. The samples cover an EC-range of 50 – 5000 µS.cm-1 and TDS of 70 –7 000 mg.l-1. Linear regression for the entire dataset yields a conversion factor of 0.75 but for samples with EC < 5 000 µS.cm-1 a conversion factor of 0.9 is recommended. However, both of these factors allow only estimates of TDS and for accurate TDS values it is necessary to determine the conversion factor specifically for each site. Besides spatial variations, temporal variations of conversion factors were also observed [1,12].

Žitný ostrov channel network

The higest underground reservoir of fresh water in Central Europe is situated under the Žitný ostrov area .[11]. There are three main channels of this network: Chotárny channel (Z1) – is the P1M water body type (partial river-basin Váh, code SKW0029), Gabčíkovo-Topoľníky channel (Z2) – is the P1M water body type (partial river-basin Váh, code SKW0023), Komárňanský channel (Z3) – is the P1M water body type (partial river-basin Váh, code SKV0226). For the evaluation the water quality we went out from the data obtained on Institute of Hydrology SAS, v.v.i. EC can be measured easily and inexpensively in situ by a portable water quality checker (Multiparametric probe YSI flow-group Professional Plus). Some profiles in this region have recently been found to be highly polluted

Generally, the physical and chemical evaluation parameters were used to assess worsening water quality pollution, mainly nutrient ions concentration (N and P), algal chlorophyll, water transparency and dissolved oxygen. Although there are many different assessment parameters which were used. The available parameters concerned include total nitrogen, total phosphorus, Chla, dissolved oxygen (DO), chemical oxygen demand by K2MnO4 oxidation method (CODMn), biological oxygen demand (BOD5), total nitrogen, total phosphorus and Chla are selected. The calculation of water quality status (Table 2). shows the limiting values of physical, physico-chemical and biological parameters in various polluted water. Evaluation of surface water pollution according to Supplement No.1 Directive of Government SR No. 269/2010 [18].

The main purpose of this paper is to provide a brief review on recent state of water quality in Žitný ostrov channel network and understanding the mechanisms of worsening of water quality. Surface water quality 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 kanál during last few years. Have been gone over the limit values not only in some months, but average annual values for indicators of water quality.

Surface water pollution 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. The external supplies of individual ions 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 pollutions nutrients to a water body can originate both as point sources, which are localized and more easily monitored, and as nonpoint sources, which are diffuse and much more difficult to monitor and regulate. The most common effects of increased N and P nutrient supplies on aquatic ecosystems are perceived as increases in the abundance of algae and aquatic plants. However, the environmental consequences of excessive nutrient enrichment are more serious and farreaching, than nuisance load increases in plant growth alone - the degradation of water resources by eutrophication and worsening of water quality.

Monitoring of surface water bodies has been provided in terms of requirements of the Water Framework Directive in the period of 2020-2022. 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 as well as the specific substances have been investigated. The aim of this contribution is to analyse pollution problem, factors affecting this process, its consequences and possibilities of prevention. The partial aim was to evaluate the state of water in Danube River basin following the assessment physical-chemical and microbiological indicators in monitored period.

The present review deals with the studies conducted on the impact of pollutants amount on ecological status eutrophication in surface water on the Žitný ostrov channel network. The review covers the definition and concept of indicators for the adverse effects on quality and ecosystem functioning. The contaminations of several water bodies leads to significant changes in the structure and function of the aquatic ecosystem. The surface water bodies are surrounded with densely populated human settlement areas and agricultural fields. Since total dissolved solids (TDS) is not easily measured, except under controlled conditions in reputable laboratories, a common alternative method is to utilise the simple permeate electrical conductivity (EC) reading and multiply by a standard correction factor (typically 0.7) to obtain the required TDS result. But that several different f factors ranging from 0.50 to 0.75 need to be used for increasingly polluted waters.

The relationship between total dissolved solids (TDS) and conductivity is established in around 348 samples, collected from Žitný ostrov channel network. These data are extremely variable in content, reliability and periodicity of sampling. The data were sorted in to useable modules, and their statistical distribution was examined. The median of conversion factors ratios of TDS/Conductivity obtained for different salinity ranges were between 0.50 and 0.75, with normal variability ranging from below 0.35 to greater than1.00, particularly at lower salinities. The data set used has sufficient sample numbers and areal distribution per increment to give reasonable reliability within the conductivity range of 50–1000 µS.cm--1. A table has been developed that enables selection of conversion factors from conductivity to salinity (as TDI) which could be used to predict TDS from future conductivity measurements from the same surface water population [23].

Electrical conductivity is a water quality property often measured when water samples are collected for chemical analyses. Modern instrumentation allows rapid and reliable conductivity measurements to be made in the field. Several methods have been reported for calculating the conductivity of a natural water sample from its chemical composition [2, 28, 29]. However, existing conductivity methods for natural waters have been limited by the lack of conductivity data in the literature or not properly accounting for the ion pairing. Consequently, the existing methods can not be used to reliably calculate conductivity for a wide range of natural waters. Here a new method for calculating conductivity for a wide range of natural waters is presented. The method incorporates new electrical conductivity measurements for electrolytes found in natural waters having ionic strengths of up to 1m and temperatures of 5–90oC [3]. The method also uses speciated water analyses calculated with geochemical models, rather than total solute concentrations.

Correlation between EC and TDS in natural waters.

Conductivity (EC) and total dissolved solids (TDS) are water quality parameters, which are used to describe pollution level. These two parameters are correlated and usually expressed by a simple equation: TDS = f EC (in 25 0C). TDS analysis is very important, because it can illustrate water quality, intrusion better than EC analysis. These conditions make research in revealing TDS/EC ratios. By finding the ratio value, TDS concentration can be measured easily from EC value. Previous research results have found that the correlation between TDS and EC are not always linear. The analysis of TDS concentration from EC value can be used to give an overview of water quality. Electrical conductivity (EC) and total dissolved solids (TDS) are frequently used as water quality parameters. EC ability depends on dissolved ion concentrations, ionic strength, and temperature of measurements.

EC can be measured easily and inexpensively in situ by a portable water quality checker. The analysis of TDS is more difficult and expensive as it needs more equipment and time. TDS analysis is very important and principal because it can illustrate water quality, particularly in understanding intrusion better than EC analysis. Researchers have done various investigations to find out the precise mathematical correlation between these two parameters, so TDS concentration can be simply calculated from the EC value. The correlation of these parameters can be estimated.

The value of f will increase along with the increase of ions in water. However, the relationship between conductivity and TDS is not directly linear; it depends on the activity of specific dissolved ions. Previous studies to determine mathematical relationship between EC and TDS have been done decades ago.The ratio of TDS/EC (f value) for natural water was formulated [20]. Later investigation [17] showed similar result with the former. Additionally, in 1989 a more detailed relationship between these two parameters was published. As shown in Table 1, the author classified the correlation between EC and TDS by its correlation coeficients.

The analysis of TDS is more difficult and expensive as it needs more equipment and time [10]. It is very important and principal because it can illustrate water quality, particularly in understanding intrusion better than EC analysis. TDS and EC ratio cannot be defined easily. Thus, the research on this subject continues until now with various modifications of research methods. This paper presents a review of the relationship between TDS and EC for various types of water (TABLE 1).

The sources of material in TDS and EC can come from nature, i.e. geological condition and seawater, and from human activities, i.e. domestic and industrial waste and also agriculture. There are many standards that govern TDS and EC in water. For health reason, desirable limit for TDS is between 50 mg.l-1 and 1.000 mg.l-1 and for EC is no more than 1.500 µS.cm-1 [20]. There are many standards that govern TDS and EC in water. For health reason, desirable limit for TDS is between 50 mg.l-1 and 1.000 mg.l-1 and for EC is no more than µS.cm-1. TDS has also been classified into four types: type I is freshwater with TDS < 1.000 mg.l-1 type II is brackish water with TDS between 10 000 and 10.000 mg.l-1; type III is saline water with TDS from 10.000 till 100.000 mg.l-1 and type IV is brine water with TDS > 100.000 mg.l-1. Water classification based on EC, according to [10]

Freshwater in this paper is defined as water that is uncontaminated, especially by human activities. The water samples of freshwater were taken from three locations. The main difference between the locations is the EC value; in the first location the EC value is less than 6.000 µS.cm-1, while in the second location the EC value is higher up to 10.000 µS.cm-1. The samples from the most polluted location Z3 were analyzed. Table 1, 2 shows the limiting values in various pollution water. The result of this research was determine of constant coefficients for predicting of total dissolved solids (TDS) based on electrical conductivity (EC) with statistics of correlation coefficient. For this purpose, three experimental areas (Z1, Z2, Z3) on Žitný ostrov area were selected for measuring. Finally, in FIGURE 1. we illustrate the effect of differing chemical composition by computing the reference conductivity for a measured conductivity of for each case.

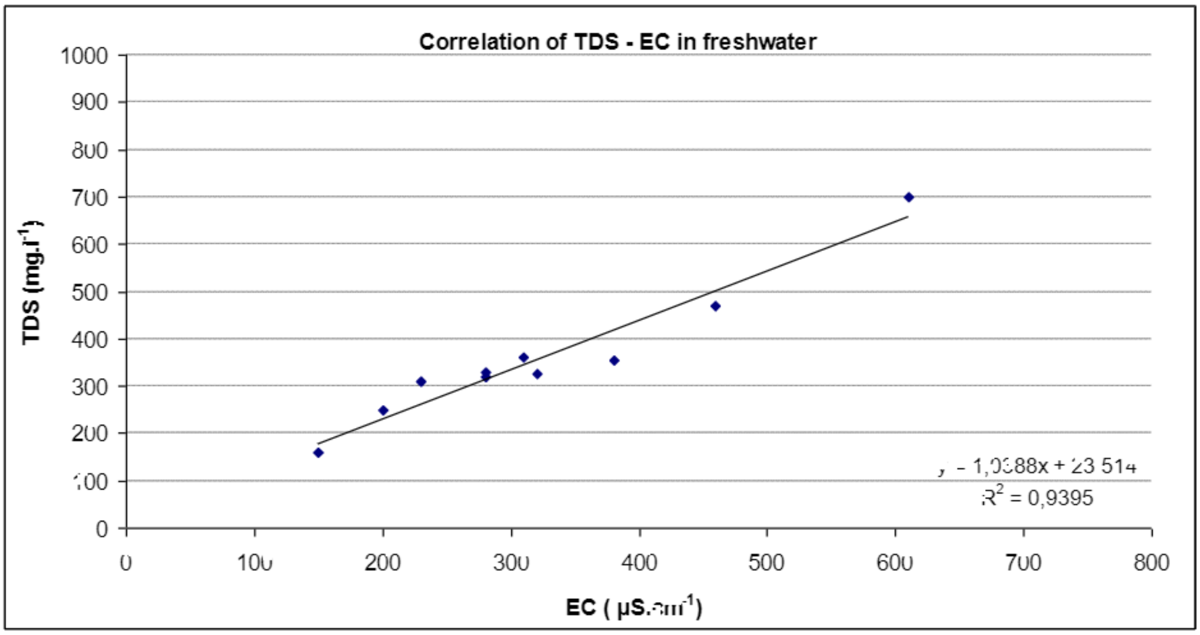

Fig. 1. TDS - EC correlation in freshwater.

The study was focused on pollution the surface water quality on Žitný ostrov channel network. Monitoring and assessment of following indicators were performed – temperature (t), dissolved oxygen (O_2), chemical oxygen consumption ($CHSK_{Cr}$), pH, electrical conductivity (EC), specific conductivity (SPC), total dissolved solids (TDS), total nitrogen (N_{TOT}), nitrate nitrogen (N-NO_3^-), nitrite nitrogen (N-NO_2^-), ammonia nitrogen (N-NH_4^+), total phosphorus (P_{TOT}), phosphate phosphorus (P-PO_4^{3-}). In most surface waters these include the cations Na^+, K^+, Ca_2^+, and Mg_2^+, and the anions Cl^- and HCO_3^-, with SO_4^{2-}. Estimations of total dissolved solids (TDS) content are commonly based on electrical conductivity (EC) measurements, using a conversion factor (*f*) retrieved from regulations or guidelines. The aim of this study is to establish a conversion factor parameters as a case study to identify if reported conversion factors are valid for surface waters in Žitný ostrov region (Danube Lowland, Slovakia).

Conclusions

Electrical conductivity (EC) and total dissolved solids (TDS) are frequently used as water quality parameters. These two parameters are indicators of pollution level, which make them very useful. The value of EC and TDS are correlated [xRusidy Correlation between]. Its ability depends mainly on dissolved ion concentrations, ionic strength, and temperature of measurements.

The analysis of TDS concentration from EC value can be used to give an overview of water quality. For more precision, TDS concentrations need to be analyzed using the gravimetric method in the laboratory. The conversion factors calculated from single measurements are close to a normal distribution. EC can be measured easily and inexpensively in situ by a portable water quality checker. The analysis of TDS is more difficult and expensive as it needs more equipment and time [TDS analysis is very important and principal because it can illustrate water quality, particularly in understanding intrusion (prenikanie) better than EC analysis.

Since total dissolved solids (TDS) is not easily measured, except under controlled conditions in reputable laboratories, a common alternative method is to utilise the simple permeate electrical conductivity (EC) reading and multiply by a standard correction factor to obtain the required TDS result. That several different correlation factors (f) ranging from 0.50 to 0.75 need to be used.

This paper provides establishing a conversion factor for EC and TDS parameters using dataset of measurements in Žitný ostrov region (Danube Lowland, Slovakia). Monitored localities was chosen so that they be the most representative area-covering. Measurements shows that just one simple linear conversion factor cannot be suitable throughout the range of waters.

The conversion factors were determined using field and laboratory measurements. The site-specific validation are used. The limit value has been exceeded (Table 2) for ions nitrate nitrogen N-NO3, ammonia nitrogen N-NH4, total nitrogen N tot, phosphate phosphorus P-PO4, total phosphorus Ptot. Some profiles in this region have recently been found to be highly polluted. The degradation of water resources by pollution can result in worsening of water quality.

The present review deals with the studies conducted on the impact of pollutants amount on eutrophication in surface water on the Žitný ostrov channel network. Were evaluated 648 samples (μS.cm-1), covers the definition and concept of pollution and the adverse effects on quality ecosystem functioning. The pollution 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 highly eutrophic. Most of the surface water bodies are surrounded with densely populated human settlement areas and agricultural fields. Frequent sampling is needed to capture intra-event and seasonal fluctuations of pollutants concentrations for accurate load estimations to surface waters; however, processing water samples for multiple nutrients can be expensive and time consuming .

The goal of this study is to investigate electrical conductivity as an inexpensive surrogate for traditional water quality sampling and analysis. This study is being conducted in a heavily tile-drained-agricultural watershed typical of the Žitný ostrov region. This watershed has a unique setup where drained water from flows into a single location, where both surface runoff and drained water from the drainage district can be monitored.

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