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EVALUATION OF THE CURRENT STATE OF WATER QUALITY IN THE GORGOVA-UZLINA DEPRESSION (DANUBE DELTA, ROMANIA), USING PHYSICO-CHEMICAL PARAMETERS STUDY CASE: UZLINA, POJARNIA, CHIRIL, ISACOVA AND DURNOLIATCA LAKES

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Abstract

The Gorgova-Uzlina Depression situated on the fluvial delta plain, bordered by the Sulina branch in the north and by Sf. Gheorghe branch in the south-east, is an important hydrographic unit, hosting numerous of native plant and animal species, as well as several recreational navigation, fishing, and water tourism spots. The water quality of this area may be heavily affected by natural or local human-related factors as agricultural activities, fishery exploitation, navigation along the water courses etc. The present study aimed to identify factors or processes that set out the water quality of investigated lakes. Thereby, surface water samples from fifty-four sampling points were collected in July 2017 and analyzed for different common physico-chemical parameters (pH, DO, N-NO_2^-, N-NO_3^-, P-PO_4^{3-}, EC, TDS, SO_4^{2-}, turbidity, TSS, chl"a", SiO_2, ORP etc.). Furthermore, on the basis of a limited number of punctual sampling stations, was measured the distribution of heavy metals in the surface water samples. The obtained results were related to standard water quality criteria to assess the current state of the surface water quality of explored lakes. Generally, the common water quality parameters results showed comparable mean values, without significant exceedances of regulatory criteria. Particularly, in some incidental cases were exceeded the value orientations imposed by environmental quality standards. It was noticed that few samples were significantly less saturated with oxygen, sporadically the nitrite levels meet the class I criteria, and the orthophosphates, infrequently, meet the class I and V criteria of the national standard. Other samples contained higher amounts of total suspended solids and higher turbidity levels. The heavy metal concentration generally agreed with the criteria of national water quality standard. The exceptions were represented by Ba and Ni that meet the class I standard, including Mn that meet the class I and II criteria. Taking into consideration the widely-known spatial-temporal variability of surface water quality, this evaluation suggested that the water quality is in a relatively good condition. The disturbances in seasonal concentrations of some physico-chemical parameters did not show detectable levels of potential concern and are probably due to local natural circumstances (climate variability, flow rate and hydrologic characteristics, surficial geology and substrate etc.). The water quality in the investigated perimeter is consistent with the freshwater environment under deltaic natural circumstances, probably, due to intense self-purification capacity.

Keywords: anthropogenic activities, evaluation, physico-chemical parameters, surface water, water quality

1 INTRODUCTION

The freshwater is an inestimable resource essential to life, supporting human well-being in many ways, as well as inland waters and freshwater biodiversity. Globally, the surface freshwaters, *i.e.*, streams, rivers, lakes, riparian areas, and other wetlands are among the most affected aquatic ecosystems to environmental stressors (Poff et al., 2002; Capon et al., 2013). For instance, the environmental effects of the Industrial Revolution of the mid-19th century, discerned in the quality of water, have led to the awareness of the negative effects on aquatic ecosystems. Several aquatic ecosystems have been subject to the loss and degradation, many of them being completely destroyed as a result of stressors caused by human-related activities including anthropogenic climate change, land-use change, hydro technical works which led to changes in the morphology of rivers and lakes, hydrologic flow change, chemical inputs, improper exploitation of fish, loss of native species, expansion of non-native invasive species etc. The diversity of species in freshwater habitats is unbalanced, since the freshwater cover approximately 0.01% of the world's water, and approximately 0.8% of the Earth's surface and this small part of global water is home to at least 100000 species out of an estimated 1.8 million - almost 6% of all described species (Dudgeon et al., 2006).

The surface water quality is being increasingly vulnerable to various natural processes and anthropogenic activities and has become a global issue of concern. The EU Water Framework Directive (WFD, 2000/60/EC) is an important issue of environmental legislation designed to improve the water resources and relates to rivers, lakes, groundwater, estuaries and coastal waters. Lately, various national initiatives and programs have preoccupied with assessing the impact of natural and anthropogenic activities on water quality. The problem of water impairing, affecting different Danube Delta sectors, has been continuously investigated by national specialized institutions from the multiple perspectives (e.g. water resources management, the state of the environment etc.) (Munteanu et al., 2012), as well as by several authors (David et al., 1999; Rădan et al., 2000; Ibram et al., 2002; Năstase and Oțel, 2011; Friedrich et al., 2003; Postolache, 2006; Seceleanu-Odor et al., 2016). The main aim of these investigations is represented by the water quality improvement and achieving a sustainable development (Order 161/2006).

The Danube Delta Biosphere Reserve (DDBR) is part of the largest European macro-geo-ecosystem consisting of the Danube River – Danube Delta – Black Sea, and represents the natural interface between the river basin and the sea, acting as a buffer area by regulating the water and sediment transfer (Panin, 1996). The DDBR region is a vast area (5800 km^2) which in turn embodies the Danube alluvial plain (Isaccea-Tulcea sector, 102 km^2), the Danube Delta itself (3510 km^2), the Razim-Sinoie Lagoon Complex (1145 km^2), the marine coastal waters (20 izobath, 1030 km^2) and the Danube River between Cotul Pisicii and Isaccea (13 km^2) (Gâştescu, 2009). The Danube Delta ecosystems may be critically affected by human-related activities that take place on the Danube River's route, both upstream and downstream, as settlements, agriculture, deforestation and the burning of fossil fuels, industry, the execution of dams and hydroelectric power stations etc. (Panin et al., 1999). The impacts of both upstream and downstream anthropogenic activities may be problematic for the freshwater biodiversity, for some plants and animals that may find themselves into an inappropriate habitat. It is worth mentioning the triple status assigned to the DDBR, being recognized as a UNESCO Biosphere Reserve, a World Cultural and Natural Heritage site, as well as a Ramsar Wetland (Ramsar Convention, 1987). As a natural buffer zone with land and wetland habitats, the DDBR is home to a great complex wildlife, flora and fauna species (Gâștescu and Știucă, 2008), numerous species of water birds and fish, many of them being specified a threatened species for protection. Numerous bird species usually mixed some permanent, other temporary, wintering and colonize this vast deltaic lagoon-area (Rose, 1992; Rose et al., 1993).

In these circumstances, it is important to study the physico-chemical characteristics of water in the Danube Delta – an environmental treasure, which is a progressively vulnerable aquatic system as a result of complex and diverse pressures.

This article is in line with the latest trends that are considering the water quality assessment of aquatic ecosystems using environmental criteria, aiming to better understand the temporal and spatial evolution characteristics of relevant parameters correlated with regulatory criteria.

2 MATERIALS AND METHODS

2.1 Study area

The Gorgova-Uzlina Depression consists of a large number of small and large lakes (*i.e.*, Fastic L, Cuzmânțu Mare L., Rotund L., Rădăcinos L., Gorgovăț L., Gorgova, Potcoava, Babinții Mari, Potcoava Mare, Obretinciuc, Uzlina, Isacova, Pojarnia, Chiril, Durnoliatca etc.) that run entirely within the western sector of the fluvial delta plain, but also receives some watercourses that rise upstream, or outside its boundaries (Sulina distributary in the northern part, Litcov Canal, Perivolovca Stream, Sf. Gheorghe distributary, Mahmudia cutoff meander, Canal Isac 1, 2, 3, Uzlina Canal etc.).

These ecosystems can be subjected to the impacts of human-related activities. In this region, there are small human settlements in which small agricultural activities or animal husbandry takes place, as well as other local activities, as reed exploitation (reed grows in a wide range of environmental conditions but mainly in humid areas). There are also impacts associated with the existence of several canals and watercourses bordering or traversing the Gorgova-Uzlina unit, that are used as an access to neighborhoods and to the unit itself (fishing, navigation).

Five lakes, namely Uzlina, Pojarnia, Chiril, Isacova and Durnoliatca lakes were considered to assess the potential impacts of natural factors and/or upstream anthropogenic activities on water quality within and around its catchment environment (Fig. 1).

2.2 Sampling and analytical procedures

The water samples were collected from fifty-four water stations in the Gorgova-Uzlina lacustrine unit in July 2017. The sampling sites were regularly dispersed on a grid settled by a randomly chosen starting point (Fig.1). In this study, different physico-chemical measurements and tests were performed to characterize the state of water quality based on the comparative analysis of the physico-chemical parameters with national and another related environmental permissible limit.

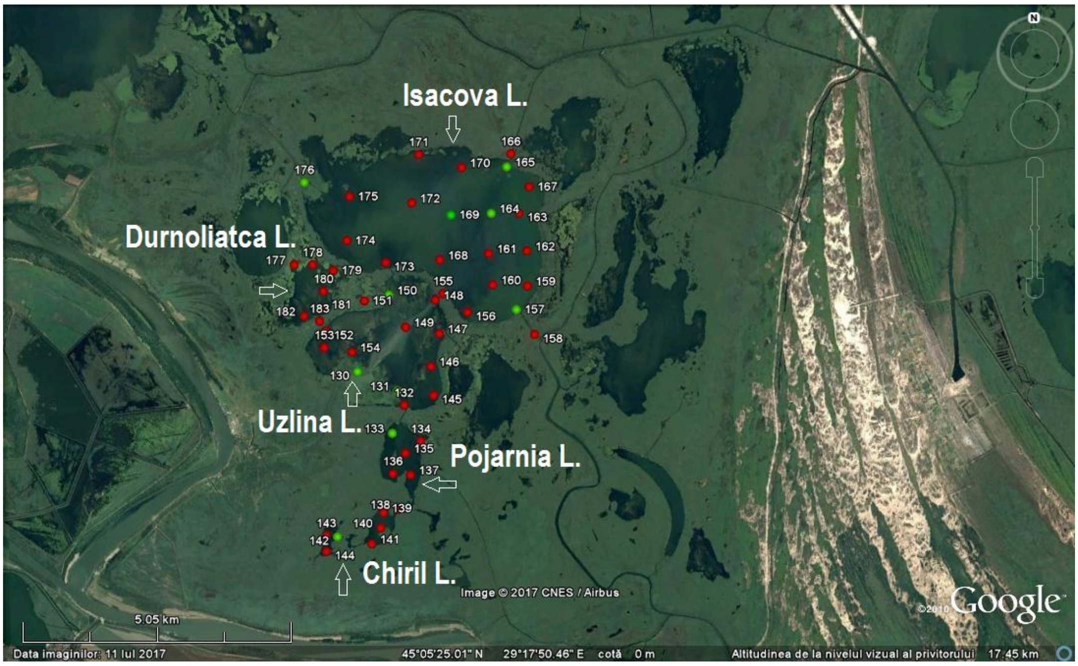

Figure 1. Location map of surface water sampling stations in Uzlina, Pojarnia, Chiril, Isacova, and Durnoliatca (Gorgova-Uzlina Unit)

The classical and instrumental analytical methods for determining the *in situ* and *ex situ* water quality parameters were carried on, using regular chemical reagents and water quality testing equipment. The different procedures through which data used for this study were gathered and analyzed are presented below. Field measurements (*in situ*) of temperature, dissolved oxygen, conductivity, and pH were taken along with water transparency/visibility (VDS) using a Secchi disc (25 cm) at each sampling site, aboard the fluvial research boat belonging to the GeoEcoMar Institute. Samples of surface water were gathered for analyses (*ex situ*) of the following variables: nitrites, nitrates, orthophosphates, sulphates, total suspended solids, chlorophyll ”a”, silica, oxido-reduction potential etc.Water quality testing equipment was used for measuring the water physical-chemical parameters, as WTW Multiline P4 Multiparameter (dissolved oxygen, temperature, electrical conductivity, total dissolved salts, pH), HACH 2100Q (turbidity), HACH 5000 - UV-Vis – Spectrophotometer (nitrates, nitrites, phosphates, sulfates).A total of nine surface water samples was collected and transported to the Water Pollution Control Laboratory belonging to INCD ECOIND Bucharest for heavy metal analyzes. Heavy metal screening in surface water was investigated to determine the concentration of heavy metals (As, Ba, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Se, and Zn) in surface water. The treatment of the water samples for analyzes was carried out according to the standard SR EN ISO11885:2009.

3 RESULTS AND DISCUSSIONS

Water can be regarded as an integrator of existing environmental issues and strategies relating to water resources management, in all areas of human activities: agriculture, economy, transport, energy, industry, environmental protection, etc. Water is an important factor of development, being essential for the coexistence of aquatic organisms, but also for sustenance, hygiene, comfort and the health of people. Water quality is strongly affected by the industrial development, agricultural practices, thermal energy sources and domestic activities. The impact of climate change requires the adoption of a flexible and coherent water management system. The EU Water Framework Directive (WFD, 2000/60/EC) for sustainable management involves qualitative and quantitative water management as a precondition for healthy aquatic ecosystems, aiming to achieve "good status" of water quality.

The assessment of overall surface water quality was accomplished in conformity with the National Environmental Standards for Water Quality in Romania, namely, Order of the Ministry of Environmental and Water No. 161/2006 (for the Approval of the Norm Concerning the Reference Objectives for the Surface Water Quality Classification, Official Journal of Romania, Part 1, No 511 bis). In addition, a set of several environmental standards was considered to evaluate the environmental indicators as TDS (total dissolved solids content), (https://en.wikipedia.org/wiki/Total_dissolved_solids), turbidity (STAS 6323 – 88), TSS (total suspended solids), (ANZECC 2000 Guidelines), ORP (Sigg, 2000) and silica (http://www.freedrinkingwater.com/water_quality/quality2/j-24-typical-concentrations-for-silicates-ground-n-surface-waters.htm.)

The climate of the Danube Delta may be distinguished as a continental-temperate climate with some pontic (marine influence) (Gâştescu and Driga 1985) and a dry season between June and August. The sampling period was characterized by high temperatures, lack of precipitation, abundant underwater vegetation and a lower mean value of the river water level (67.5 cm) registered in July 2017 (Fig. 2).

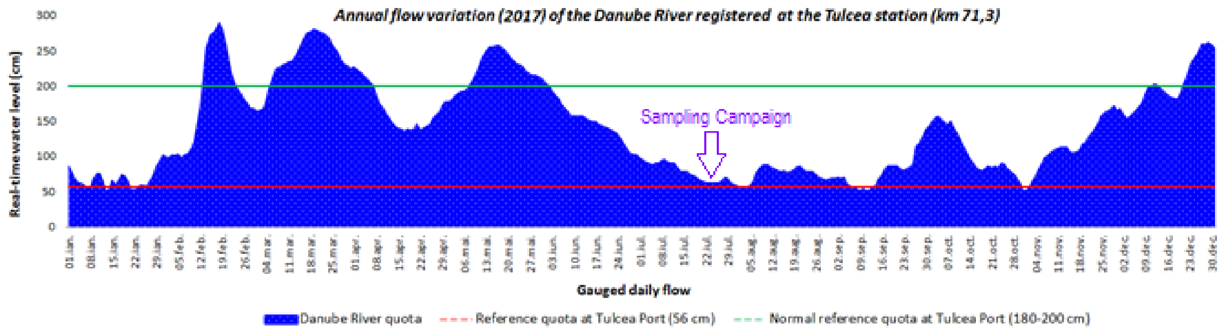

Figure 2. Trends in the Danube River levels variations at the Port of Tulcea station (Tulcea gauge station) (Km 71.3) in 2017

A summary of the selected physico-chemical parameters obtained from the investigated lakes are shown in table 1, and the results are expressed as the minimal, maximal and mean value of each parameter per investigated sampling site. Overall, the investigated parameters revealed comparable average values without significant overruns, excepting some punctual situations. The physico-chemical parameters of the investigated lakes (*i.e.*, Uzlina, Pojarnia, Chiril, Isacova, and Durnoliatca) and their comparative analyses with various environmental standard permissible limits are discussed below.

The water temperature assessment was consistent with the expected seasonal fluctuations for the dry period. The average temperature measurements were relatively constant across the investigated lakes, and varied in a relatively narrow range, as follows: Uzlina (23.36°C), Pojarnia (23.38°C), Chiril (24.33°C), Isacova (28.03°C) and Durnoliatca (28.26°C).

In general, pH values of each of the 5 lakes were found to be approximately neutral to slightly alkaline, with pH units ranging, as follows*:* Uzlina (7.88), Pojarnia (8.41), Chiril (8.03), Isacova (8.62) and Durnoliatca (8.08). Surface pH measurements in this range are typically of values normally measured in lake systems in the Danube Delta area (Munteanu et al., 2012; Rădan et al., 2000) during summer conditions.

The measured surface concentrations of dissolved oxygen in the majority of the evaluated lakes were relatively similar, with dissolved oxygen concentrations in excess of 5 mg/l. A minimum dissolved oxygen concentration of 5 mg/l is recommended to adequately support aquatic life (www.niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/impacts/dissolved-oxygen). In this study, the dissolved oxygen concentration was consistently higher with a median such as Uzlina (6.45 mg/l), Pojarnia (13.16 mg/l), Chiril (10.55 mg/l), Isacova (12.33 mg/l) and Durnoliatca (9.43 mg/l). Incidentally lower surface dissolved oxygen concentration was observed in 2 sampling points from Uzlina L. and 1 sampling station from Isacova L. The majority of the tested water samples showed values below the threshold level values for the first class of water quality (very good ecological status).

Table 1. Summary of constituents measured in surface water samples from five lakes in Gorgova-Uzlina lacustrine unit during July 2017

Lake	Value	*Depth (m)*	*T (°C)*	*pH (units)*	*O_2 (mg/l)*	*N-NO_2^- (mg/l)*	*N-NO_3^- (mg/l)*	*P-PO_4^{3-} (mg/l)*	*Chla (µg/l)*
UZLINA (n = 13)	min	0,7	22,4	6,85	2,69	0,006	0,01	0,016	9,71
	max	3,8	24,8	9,05	9,97	0,024	0,05	1,163	358,08
	mean	1,28	23,36	7,88	6,45	0,013	0,02	0,236	114,20
	Value	***EC* (µS/cm)**	***TDS* (mg/l)**	***SO_4^{2-}* (mg/l)**	***Turb* (NTU)**	***TSS* (mg/l)**	***VDS* (m)**	***SiO_2* (mg/l)**	***ORP* (mV)**
	min	277	139	9	3,64	8	0,2	1,20	2
	max	389	195	41	91,3	74	1,1	7,10	95
	mean	338,54	169,62	21	31,91	31,15	0,60	3,07	40,85
POJARNIA (n = 5)	Value	***Depth* (m)**	***T* (°C)**	***pH* (units)**	***O_2* (mg/l)**	***N-NO_2^-* (mg/l)**	***N-NO_3^-* (mg/l)**	***P-PO_4^{3-}* (mg/l)**	***Chla* (µg/l)**
	min	0,8	23,1	8,26	10,54	0,008	0,02	0,026	189,99
	max	1,2	23,6	8,57	15,9	0,02	0,03	0,05	345,36
	mean	0,94	23,38	8,41	13,16	0,0123	0,02667	0,03	276,85
	Value	***EC* (µS/cm)**	***TDS* (mg/l)**	***SO_4^{2-}* (mg/l)**	***Turb* (NTU)**	***TSS* (mg/l)**	***VDS* (m)**	***SiO_2* (mg/l)**	***ORP* (mV)**
	min	296	148	15	80,3	67	0,1	6,5075	31
	max	348	174	48	113	84	0,2	9,0475	56
	mean	316,8	158,6	29,33	91,26	74,8	0,17	7,85333	49,2
CHIRIL (n = 7)	Value	***Depth* (m)**	***T* (°C)**	***pH* (units)**	***O_2* (mg/l)**	***N-NO_2^-* (mg/l)**	***N-NO_3^-* (mg/l)**	***P-PO_4^{3-}* (mg/l)**	***Chla* (µg/l)**
	min	0,8	24	7,46	5,92	0,008	0,01	0,09	40,05
	max	1,3	24,6	8,47	14,4	0,018	0,02	0,196	260,15
	mean	1,06	24,33	8,03	10,55	0,01	0,02	0,13	153,00
	Value	***EC* (µS/cm)**	***TDS* (mg/l)**	***SO_4^{2-}* (mg/l)**	***Turb* (NTU)**	***TSS* (mg/l)**	***VDS* (m)**	***SiO_2* (mg/l)**	***ORP* (mV)**
	min	377	189	6	7,41	15	0,2	8,915	9
	max	485	243	11	71,6	53	0,55	11,16	50
	mean	427,14	213,86	7,80	42,07	36,71	0,32	10,17	32,43
ISACOVA (n = 22)	Value	***Depth* (m)**	***T* (°C)**	***pH* (units)**	***O_2* (mg/l)**	***N-NO_2^-* (mg/l)**	***N-NO_3^-* (mg/l)**	***P-PO_4^{3-}* (mg/l)**	***Chla* (µg/l)**
	min	0,8	26,9	6,9	2,9	0,005	0,01	0,023	6,88
	max	3,6	29,8	9,21	15,12	0,024	0,03	0,163	67,45
	mean	1,50	28,03	8,62	12,33	0,01	0,02	0,08	30,68
	Value	***EC* (µS/cm)**	***TDS* (mg/l)**	***SO_4^{2-}* (mg/l)**	***Turb* (NTU)**	***TSS* (mg/l)**	***VDS* (m)**	***SiO_2* (mg/l)**	***ORP* (mV)**
	min	281	141	19	4,05	6	0,2	0,8375	9
	max	359	180	47	58,7	53	0,75	2,3175	105
	mean	309,82	155,36	28,75	25,31	26,73	0,42	1,57	50,23
DURNOLIATCA (n = 7)	Value	***Depth* (m)**	***T* (°C)**	***pH* (units)**	***O_2* (mg/l)**	***N-NO_2^-* (mg/l)**	***N-NO_3^-* (mg/l)**	***P-PO_4^{3-}* (mg/l)**	***Chla* (µg/l)**
	min	0,8	26,5	7,39	5,3	0,008	0,01	0,016	103,30
	max	2,9	28,7	8,52	13,22	0,016	0,02	0,03	113,79
	mean	1,13	28,26	8,08	9,43	0,011	0,017	0,024	108,54
	Value	***EC* (µS/cm)**	***TDS* (mg/l)**	***SO_4^{2-}* (mg/l)**	***Turb* (NTU)**	***TSS* (mg/l)**	***VDS* (m)**	***SiO_2* (mg/l)**	***ORP* (mV)**
	min	338	169	11	12,5	15	0,2	1,365	35
	max	381	191	39	76,4	65	0,6	4,22	50
	mean	361,71	181,00	20,66	40,17	39	0,34	2,575	43,29

Some spatial patterns in water quality constituents (*i.e.*, temperature, dissolved oxygen, and pH) across the lakes were evident, although these were not very noticeable, and seasonal patterns at sites were probably more apparent (Fig. 3).

In general, all of the measured water samples were found to have low levels of nutrients. Both nitrite and nitrate has been frequently below the imposed limit and indicated relatively narrower fluctuations with an overall median of nitrite nitrogen (N-NO_2^-) such as: Uzlina (0.013 mg/l), Pojarnia (0.0123 mg/l), Chiril (0.01 mg/l), Isacova (0.01 mg/l) and Durnoliatca (0.01 mg/l). It was noted that the threshold level values for the first class of water quality (very good ecological status) were more or less exceeded. The nitrate nitrogen (N-NO_3^-

) concentrations were relatively constant across the investigated lakes, as follows: Uzlina (0.02 mg/l), Pojarnia (0.02667 mg/l), Chiril (0.02mg/l), Isacova (0.02 mg/l) and Durnoliatca (0.017mg/l).

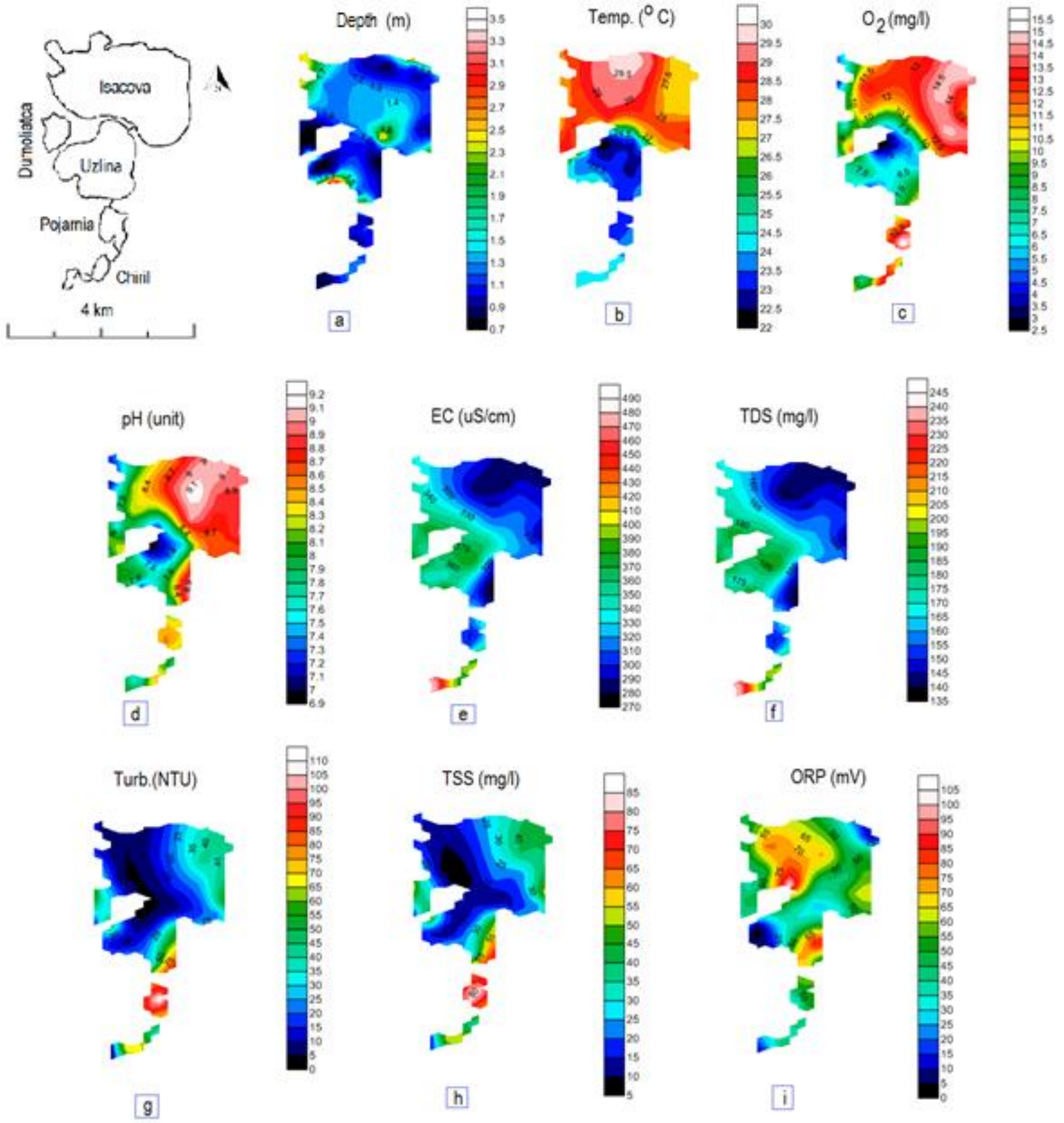

Figure 3. Map of the study area (Uzlina, Pojarnia, Chiril, Isacova and Durnoliatca lakes). The physico-chemical parameters and their spatial variation of distribution in water (from ”a” to ”i”)

The analyses indicated values of results below the threshold level values for the first class of water quality (very good ecological status). Instead, the orthophosphates (P-PO_4^{3-}) ranged widely: Uzlina (0.236 mg/l), Pojarnia (0.03 mg/l), Chiril (0.13 mg/l), Isacova (0.08 mg/l) and Durnoliatca (0.024 mg/l), and all sites showed similar seasonal patterns, excepting some incidental cases with exceedances of the value orientations imposed by environmental quality standards. In this sense, the threshold level values for the first, second (Chiril and Isacova lakes) and, respectively, the fifth class of water quality (Uzlina L.) were reached incidentally by some samples. A possible explanation for these higher levels of orthophosphates may be related to the phosphorus remobilization from the sediment (Chapman 1996).

The chlorophyll ”a” concentrations (Chla) were also consistently high across the lacustrine system, with an overall median such as: Uzlina (114.20 µg/l), Pojarnia (276.85 µg /l), Chiril (153 µg/l), Isacova (30.68 µg/l) and Durnoliatca (108.54 µg/l). So, the results pointed out that the threshold level values for the third class of water quality (moderate ecological status) were reached by some water samples. Possibly, the higher chlorophyll ”a” content may be related to yield under drought condition.

In general, specific conductivity (EC) and TDS measurements in these lakes were found to be typical of the values normally measured in Danube Delta lakes in other previous investigations (Munteanu et al., 2012; Rădan et al., 2000). EC levels measured in water samples have been frequently below the imposed limit, with an overall median, as Uzlina (338.54 µS/cm), Pojarnia (316.8 µS/cm), Chiril (427.14 µS/cm), Isacova (309.82 µS/cm) and Durnoliatca (361.71 µS/cm). As regards the TDS all lakes showed similar spatial and seasonal patterns, taking into account that TDS closely simulate patterns exhibited by electro conductivity, with values frequently below the imposed limit, as Uzlina (169.62 mg/l), Pojarnia (158.6 mg/l), Chiril (213.86 mg/l), Isacova (155.36 mg/l) and Durnoliatca (181 mg/l). The lowest values of the EC showed that the threshold level values for the first class of water quality (very good ecological status) were not reached. Some spatial patterns of the EC and TDS levels across the lakes were evident, although these were not very noticeable, and seasonal patterns at sites were probably more apparent (Fig. 3).

Sulphate concentrations were relatively constant across the investigated lakes, with an overall median, as follows: Uzlina (21 mg/l), Pojarnia (29.33 mg/l), Chiril (7.8 mg/l), Isacova (28.75 mg/l), Durnoliatca (20.66 mg/l) and did not show significant variation. Therefore, the lowest values of the sulphates indicated that the threshold level values for the first class of water quality (very good ecological status) were not reached.

The mean depth of these lakes was relatively low, as Uzlina (1.28 m), Pojarnia (0.94 m), Chiril (1.06 m), Isacova (1.5 m) and Durnoliatca (1.13 m), and very limited spatial variation across the lacustrine system. The water was relatively turbid throughout measurements. Secchi disk transparency/visibility (VDS) was consistently low, with a median, as follows: Uzlina (0.6 m), Pojarnia (0.17 m), Chiril (0.32 m), Isacova (0.42 m) and Durnoliatca (0.34 m). Total suspended solids (TSS) and turbidity were consistently high indicating elevated values. For example, the TSS showed an overall median, as Uzlina (31.15 mg/l), Pojarnia (74.8 mg/l), Chiril (36.71 mg/l), Isacova (26.73 mg/l) and Durnoliatca (39 mg/l). As well, the turbidity values were above related limits, consistently high, with a median, as follows: Uzlina (31.91 NTU), Pojarnia (91.26 NTU), Chiril (42.07 NTU), Isacova (25.31 NTU) and Durnoliatca (40.17 NTU). The relatively high values of the turbidity and the total suspended solids were observed compared to the reference standards. Higher turbidity or higher TSS levels may be due to both organic sources (such as algae and other organic matter), as well as inorganic sources (such as colloids and sediment material) resulting from the dominant in-lake physico-chemical processes, erosion of the banks or particles transported by the Danube River intake. Some spatial patterns of the turbidity and TSS across the lakes were evident, although these were not very noticeable, and seasonal patterns at sites were probably more apparent (Fig. 3).

The measurements of oxidation-reduction potential (ORP) were relatively uniform in the assessed lakes and did not show significant variation. Therefore, the overall median of the ORP levels varied as follows: Uzlina (40.85 mV), Pojarnia (49.2 mV), Chiril (32.43 mV), Isacova (50.23 mV) and Durnoliatca (43.29 mV).

Silica concentrations ranged widely as Uzlina (3.07 mg/l), Pojarnia (7.855 mg/l), Chiril (10.17 mg/l), Isacova (1.57 mg/l) and Durnoliatca (2.575 mg/l), with no clear seasonal trends across the lakes.

Measured concentrations of the heavy metals in surface water samples collected in certain sampling points from investigated lakes on July 2017 are summarized in Table 2.

Heavy metal screening in surface water was investigated in Uzlina C. (1 sampling point), Uzlina L. (2 sampling points), Pojarnia L. (1 sampling point) and Isacova L. (4 sampling points).

Table 2. Concentration and distribution of the heavy metals in surface water samples

Sampling sites	Sample	*As*	*Ba*	*Cd*	*Cr*	*Co*	*Cu*	*Fe*	*Mn*	*Ni*	*Pb*	*Se*	*Zn*
		µg/l	*mg/l*	*µg/l*	*µg/l*	*µg/l*	*µg/l*	*mg/l*	*mg/l*	*µg/l*	*µg/l*	*µg/l*	*µg/l*
C. Uzlina	DD17-130	< 0,6	0,0289	< 0,4	< 1,3	< 0,75	3,4	0,0545	0,005	1,3	< 0,15	< 0,34	10,1
L. Uzlina	DD17-131	< 0,6	0,0217	< 0,4	< 1,3	< 0,75	1,1	0,0351	0,0041	< 1,2	0,5	< 0,34	6,3
L. Pojarnia	DD17-133	< 0,6	0,0343	< 0,4	< 1,3	< 0,75	6,1	0,052	0,191	4,8	0,5	< 0,34	20,9
L. Chiril	DD17-142	< 0,6	0,0562	< 0,4	< 1,3	< 0,75	1,3	0,04	0,0127	1,2	< 0,15	< 0,34	7,1
L.Uzlina	DD17-150	< 0,6	0,0307	< 0,4	1,7	< 0,75	2,3	0,0555	0,0125	3,9	0,2	< 0,34	6,9
L. Isacova	DD16-157	< 0,6	0,0199	< 0,4	3,5	< 0,75	2,8	0,0242	0,0054	12,4	0,3	< 0,34	6,8
L. Isacova	DD17-165	< 0,6	0,0174	< 0,4	< 1,3	< 0,75	1,5	0,0196	0,0105	2,6	< 0,15	< 0,34	8,7
L. Isacova	DD17-169	< 0,6	0,0175	< 0,4	< 1,3	< 0,75	1,1	0,0188	0,0092	< 1,2	0,3	< 0,34	9,8
L. Isacova	DD17-176	< 0,6	0,0283	< 0,4	< 1,3	< 0,75	2,8	0,0374	0,0107	1,3	0,5	< 0,34	19,4

In general, each of the 9 tested water samples was found to exhibit lower levels of the investigated heavy metals, with a majority of the values less than the threshold level values imposed by the environmental standard. All analyzed heavy metals were found to be less than the applicable heavy metal criteria for the third class of water quality (moderate status) outlined in the national standard. Some incidental situations were encountered for elements as Ba, that reached the threshold level values for the first class of water quality (very good ecological status) in Chiril L., Mn, that reached the threshold level values for the first and second class of water quality in Pojarnia L., and Ni, that reached the threshold level values for the first class of water quality in Isacova L. in one water sample. Based upon the results obtained it can be appreciated that the potential contamination from heavy metals does not appear to be a significant concern in investigated lakes within the Gorgova-Uzlina unit. Anyways, more extensive investigations are desirable given the limited number of investigated water samples.

4 CONCLUSIONS

The results of the short-term survey carried out in July 2017, following the drought and a lower Danube River water level indicated that the water quality in the assessed lakes (*i.e.*, Uzlina, Pojarnia, Chiril, Isacova, and Durnoliatca) have been of good ecological conditions.

In general, water quality characteristics of lakes in the investigated area and related to the physico-chemical measurements appear to be typical of Danube Delta lake systems.

Short-term investigation performed during July 2017, showed that each of the evaluated lakes is reasonable to sufficiently support aquatic life, with low values of the main physico-chemical parameters of interest, as well as measured heavy metals levels. At the time of the investigation, the environmental circumstances were characterized by a relative abundance of emergent and submergent vegetation, relative water level conditions and certain sectors of lakes showing incidental exceedances of environmental indicators. These ecological feedbacks are governed by a variety of factors, such as the climate conditions, *i.e.*, the intensity and persistence of drought, the Danube River water level, diurnal and seasonal fluctuations etc., along with the anthropogenic impact on the Danube Delta environment. Anyways, the water quality trends in the majority of the investigated lake appear to be relatively stable in comparison to previous environmental studies. Based upon the measured surface values, the majority of the investigated lake met the criteria for the first and second class of water quality, *i.e.*, very good and good ecological status.

The water quality in the investigated perimeter is consistent with the freshwater environment under deltaic natural circumstances, probably, due to intense self-purification capacity.

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REFERENCES

ANZECC Guidelines (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, On line at: http://www.mfe.govt.nz/fresh-water/tools-and-guidelines/an zecc-2000guidelines.

Capon, S.J., L.E. Chambers, L.E., R. Mac Nally, R., R.J. Naiman, R.J., P. Davies, P., N. Marshall, N., J. Pittcock, J., ……. M. Reid, M. et al. (2013). Riparian ecosystems in the 21st century: Hotspots for global change adaptation. *Ecosystems,* **16**: 359–381.

Chapman, D. (1996). Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring-Second Edition, Published on behalf of UNESCO, WHO, UNEP. E /FNSPON. London. Great Britain, University Press, Cambridge, 100, 626.

David, C., Hulea, O., Dumitru, R., Tudor, M., Török, L., Tomeș, A., (1999), Spatial and temporal distribution of major abiotic and biotic components of aquatic ecosystems in R.B.D.D. IN: *IDD Annals*, 289-296. [in Romanian]

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z., Knowler, D.J., Leveque, C., Naiman, R.J., Prieur-Richard, A.H., Soto, D., Stiassny, M.L., Sullivan, C.A. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews* **81**:163–182.

European Union Council, (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities*, **43** (L327), 1-73.

Friedrich, J., Dinkel, C., Grieder, E., Radan, S., Secrieru, D., Steingruber, S., Wehrli, B. (2003). Nutrient uptake and benthic regeneration in Danube Delta lakes. *Biogeochemistry*, **64**, 373–398.

Gâştescu P. and Driga B. (1985). Danube Delta. Touristic Map, sc. 1:150 000. Ed. Sport Turism, București. [in Romanian]

Gâştescu, P. (2009). The Danube Delta biosphere reserve. Geography, biodiversity, protection, management, *Rev Roum Géogr*., **53**, 2, 139–52.

Gâştescu, P. and Ştiucă, R. (2008). *The Danube Delta - A Biosphere Reserve*. CD Press Publishing House, Bucharest, 400. [in Romanian, with Contents and Introduction in English]

Ibram, O., David, C., Cojocaru, L. (2002). Nutrients and heavy metals dynamic in the Danube Delta Lakes. IN: *Sc. Annals 2000-2001*, Tulcea, 82-86.

Munteanu, I., Tuzlaru, C., Cioroiu, L., Vasilescu, G., Raicu, M., Bascau, F., Raileanu, G, Nitu, M., Varzaru, E., (2012), *Report on the Danube Delta Biosphere Reserve - State of the Environment in 2012*, elaborated by the Ministry of Environment and Climate Change [in Romanian], http://www.ddbra.ro/media/Starea%20mediului%202012(3).pdf website http://www.ddbra.ro/media/Starea%20mediului%202012(3).pdf, 109

Năstase, A., Oțel, V. (2011). Studies of fish community from predeltaic area (Somova-Parcheș lake-complex) in 2009, *Scientific Annals of the Danube Delta Institute, Tulcea, Romania*, **17**, 53-64.

Online at: http://http://www.freedrinkingwater.com/water_quality/quality2/j-24-typical-concentrations-for-silicates-ground-n-surface-waters.htmhttp://www.freedrinkingwater.com/water_quality/quality2/j-24-typical-concentrations-for-silicates-ground-n-surface-waters.htm.

Online at: http://https://en.wikipedia.org/wiki/Total_dissolved_solidshttps://en.wikipedia.org/wiki/Total_dissolved_solids

Online at: http://www.niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/impacts/dissolved-oxygenwww.niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/impacts/dissolved-oxygen

Order no. 161/2006 - Standard on surface water quality classification for determination of the ecological status of Water bodies, Annex C - Elements and physico-chemical quality standards in water, published in Romanian Official Monitor, part I, no. 511 bis, from 13th of June, 2006.

Panin, N. (1996). Danube Delta: Genesis evolution and sedimentology. *GeoEcoMarina*, **1**, 11-34.

Panin, N., Jipa, D.C., Gomoiu, M.T., Secrieru, D. (1999). Importance of sedimentary processes in environmental changes: Lower River Danube-Danube Delta-Western Black Sea system, IN: *Environmental Degradation of the Black Sea: Changes and Remedies*, edited by S.T. Besiktepe et al., 23-42, NATO Sci. Ser., Springer, New York.

physical Research, (abstract) 2, p. 201, Nice (France).

Poff, N. L., M.A. Brinson, M.A. and J.W. Day, J.W. (2002). Aquatic ecosystems and global climate change: potential impacts on inland freshwater and coastal wetland ecosystems in the United States. *Report of PEW Center on Global Climate Change*, Arlington, Virginia, VA: **44**.

Postolache, C. (2006). The chemistry of the Danube Delta. IN: *Danube Delta. Genesis and Biodiversity* (eds. Tudorancea C, Tudorancea M.M.), Backhuys Publisher, The Netherlands, 65-93.

Rădan, S., Ganciu, A., Strechie, C. (2000). Overview of the Long-term Ecological Research performed by GeoEcoMar in the Danube Delta, Romania, IN: *Lajtha K. and Vanderbilt K., eds. 2000 - Cooperation in Long Term Ecological Research in Central and Eastern Europe*, Oregon State University, Corvallis, OR, 101-112.

Rădan, S.C., Rădan, M., Rădan, S., Ganciu, A. Szobotka, S.T., Oaie, Gh. (2000). Magnetic signature of sedimentary environments in fuvial-marine interaction zones. A case study: Danube – Black Sea. *Geo-*

Ramsar Convention, (1971). Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971, UN Treaty Series No. 14583, As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987, Ramsar Convention on Wetlands, Gland, Switzerland.

Romanian Standard – STAS 6323 – 88 – Determination of turbidity.

Rose, P.M. (1992). Western Palearctic Waterfowl Census, *IWRB*, Slimbridge, UK.

Rose, P.M. and Taylor, V. (1993). Western Palearctic and South West Asia Waterfowl Census. *IWRB*, Slimbridge, UK.

Seceleanu-Odor, D., Burada, A., Teodorof, L., Despina, C., Țigănuș, M, Tudor, I.M., Ibram, O., Spiridon, C., Tudor, M. (2016). Seasonal dynamics of the inorganic nutrients from aquatic complex Somova-Parcheș in 2016, *Scientific Annals of the Danube Delta Institute, Tulcea, Romania*, **22**, 125-132.

Sigg, L. (2000). Redox Potential Measurements in Natural Waters: Significant Concepts and Problems. IN: *H.D. Schulz, W. R. Fischer, J. Bottcher and W.H.M. Duijinisveld (Eds) Redox: Fundamentals, Processes and Applications*, Springer, Berlin, Germany