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12. Zooplankton and water quality of Carasuhat and Zaghen wetlands, Danube Delta Biosphere Reserve

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Abstract: This study evaluated the water quality and zooplankton community of two wetlands, Carasuhat and Zaghen after five years of ecological restoration. Five sampling sites for Carasuhat and four sampling sites for Zaghen, were selected and throughout one sampling year, following the guidelines of the Water Framework Directive, several physico-chemical and biological parameters were evaluated seasonally, as well as the zooplankton community. Values of nutrients concentrations indicated relatively narrower fluctuations and were frequently below the imposed limits. The values of chlorophyll "a" concentration displayed a similar trend along the year with the lowest values recorded in spring, and highest values in summer and autumn seasons. According to the concentration of chlorophyll "a", water quality, was within the limits of "very good" and "good" quality class for Carasuhat and "good" and "moderate" quality class for Zaghen. Zooplankton communities reach their highest abundance and diversity during the summer season. Carasuhat is more rich in species (46 species) than Zaghen (29 species). Numerical density throughout the year was higher in Zaghen (24.60 Ind/L) and lower in Carasuhat (7.91 Ind/L). Most of the species identified in this study are, also common in other types of aquatic ecosystems of the Danube Delta, and indicate high trophic conditions.
Keywords: zooplankton, nutrients, water quality, ecological restoration

INTRODUCTION

Over time, a large part of the Danube Delta, including the Carasuhat and Zaghen wetlands have been impacted by human activity. Policies of resource use through, damming large areas for agriculture, fish farming or forestry, have led to important changes in the natural ecosystems of the Danube Delta. Existing policies have identified these ponds as priority habitats and have been including them in restoration projects, aimed at protection and conservation.

Ecological restoration focuses on repairing the damage human activities have caused to natural ecosystems and seeks to return them to an earlier state or to another state that is closely related to one unaltered by human activities (Veblen et al., 2019).

The first study area is part of the Carasuhat agricultural polder and is bordered on the north by the Litcov channel, and on the south, west, and east by the St. George arm of the Danube river.

Drainage of the Carasuhat wetland ceased in the 1980's, and between 1 March 2012 - 30 August 2015, was initiated by the Administration of Danube Delta Biosphere Reservation (DDBRA), World Wildlife Fund (WWF) Romania, Local Council Mahmudia the project "Ecological rehabilitation of the lands belonging to the public domain of Mahmudia local administration in Carasuhat agricultural area from Danube Delta".

Carasuhat wetland was created by reconnecting 924 ha from this area to the St Gheorghe arm, Danube river.

The creation of wetland aims to: restoration of 18 types of habitats, which before being drained offered food, shelter, and a breeding ground for plants, fish, birds and mammal species, increase fish populations and biodiversity, support sustainable ecotourism activities, reduce the risk of flooding by creating a large water retention zone, improve access to the Danube Delta. (Mihai et al, 2020).

The second study area, Zaghen lies in the eastern part of the municipality of Tulcea, respectively in the floodplain adjacent to the terrace where the city is located, delimited in the north by the Tulcea branch of the Danube river, and DJ222C Tulcea-Malcoci road on the south and is proposed for ecological reconstruction over an area of approx. 200 ha.

From 05.04.2012-to 07.04.2015, it was implemented the project "Ecological Reconstruction in the Zaghen Polder of the Danube Delta Cross-Border Biosphere Reserve Romania / Ukraine SMIS-CNSR 36276".

Restoration activities aim to bring water from the Danube into Zaghen, to establish an adequate hydrological regime typical for flooded areas, restoration of natural habitats, conservation of biological diversity, and providing ecosystem services in line with interests of the local community (Dimitriu et al., 2010, Dumitrescu and Carsmariu, 2014).

One of the communities that take advantage of these new created conditions is zooplankton.

Zooplankton community is an important element of the aquatic food chain, because they occupy an intermediary position in the food chain, transferring energy from primary producers such as phytoplankton to higher consumers invertebrates and fish who in turn feed on them. (Jeppensen et al., 2011, Lampert and Sommer, 1997)

Because of their short generation time, zooplankton are highly sensitive to changes in aquatic ecosystems and readily react to physical and chemical habitat conditions.

Assessment of its community structure provide a good model to observe the impacts on these aquatic ecosystems. Effects of environmental disturbances may be detected by changes in species composition, abundance and size distribution. (Muñoz-Colmenares et al, 2021).

Moreover, zooplankton, are cost-effective indicators of the trophic status of aquatic ecosystems, because of these characteristics they can be an adequate indicator of water quality.

MATERIALS AND METHODS

2.1. Study Sites

For each studied area five respectively four sampling stations were established as follows: C1, C2, C3, C4, and C5 for Carasuhat and Z1, Z2, Z3, Z4 for Zaghen.

Station C1 is located in the north - west section of the wetland, station C2 is located in the north – east part of the wetland, station C3 is in the south - west section of the wetland, station C4 is selected in the south – est part of the wetland and station C5 is located in the middle of the wetland. (Figure 1).

Figure 1. Location of Carasuhat wetland and sampling stations

Station Z1 is located at the smallest distance from the urban area, station Z2 is located in the center of the lake, station Z3 is near the decanter basin, and station Z4 is located near the pumping station. (Figure 2).

Figure 2. Location of Zaghen wetland and sampling stations

2.2. Sampling

The sampling was conducted in the 2021 year, within a comprehensive research program of the National Institute of Danube Delta for Research and Development, concerning the assessment of the ecological state of the Danube Delta Biosphere Reserve aquatic ecosystems.

In 2021, three field campaigns were conducted as follows: in spring (March), in summer (July), and in autumn (October), these sampling periods coincide with the annual development cycles of planktonic organisms as well with higher and lower water levels.

Monitoring of physicochemical and biological parameters, temperature (◦C), pH, conductivity (μS/cm), dissolved oxygen (mg O_2/L) and chlorophyll a (μg/L), was performed in situ with the YSI EXO2 multiparameter.

2.3. Nutrient Samples

For nutrient analysis, the samples were taken into the water column in plastic bottles, preserved, and properly stored until processing.

Ammonium nitrogen, nitrite nitrogen, nitrate-nitrogen, total nitrogen, orthophosphate, and nutrients in total forms (nitrogen and phosphorus), were determined spectrophotometrically using UV-VIS Lambda 10 Perkin Elmer and ISO standards, in the Chemistry Laboratory of Danube Delta National Institute for Research and Development, Tulcea, accredited RENAR since 2005, according to the ISO/IEC 17025:2005 reference.

2.4. Water Quality Parameters

The assessment of water quality based on nutrients and chlorophyll-a (µg/L), was accomplished according to the national legislation, Order of the Ministry of Environment and Water Management no 161/2006, part of the European Water Framework Directive. (Table 1).

Quality classes and trophic classification of the lakes using chlorophyll-a (µg/L) concentrations, were assessed respecting the following limits: oligotrophic 1–2.5; mesotrophic 2.5–8; eutrophic 8–25; hypereutrophic >25; and water quality classes very good (I) < 25; good (II) 25–50; moderate (III) 50–100; poor (IV) 100–250; bad (V) > 250.

Table 1 . Quality standards for surface water according to Order 161/2006 – nutrients

Indicator	Unit	Class quality / ecological status					Maximum allowed concentration (mg/L)
		I (very good)	II (good)	III (moderate)	IV (poor)	V (bad)	
Ammonium N-NH_4	mg N/L	0.4	0.80	1.2	3.2	>3.2	0.80
Nitrites N-NO_2	mg N/L	0.01	0.03	0.06	0.3	>0.3	0.03
Nitrates N-NO_3	mg N/L	1	3	5.6	11.2	>11.2	3
Total nitrogen TN	mg N/L	1.5	7	12	16	>16	7
Orthophosphate P- PO_4^{-3}	mg P/L	0,1	0.20	0.4	0.9	>0.9	0.20
Total phosphorus TP	mg P/L	0.15	0.40	0.75	1.2	>1.2	0.40

2.5. Zooplankton Community

Zooplankton samples were collected on the water column by filtering 30 L water through a plankton net (55 µ mesh size), following established standards. (Tudor et al., 2015).

The samples were collected in 100 mL plastic bottles and preserved with 96 % alcohol. In the laboratory, samples were concentrated and 2 subsamples were analyzed for taxonomic identification and abundance assessment, in a 1 ml Sedgewick – Rafter chamber under a Zeiss Axio Lab A1 microscope. The species composition was carried out using identification keys for rotifers (Damian-Georgescu, 1963), cladocerans (Negrea, 1983), and copepods (Rudescu, 1960).

Numerical density of the main taxonomic groups (Rotifera, Cladocera, Copepoda) were estimated for each sampling station and time according to the methods established by APHA (Clesceri et al, 1989) and expressed as individuals per liter, using the following formula:

$$\text{Density (ind/L)} = (n*v_1)/(v_2*v)$$

where n represent the number of organisms counted in the sub-sample; v_1 - concentrated volume of sample; v_2- analyzed volume of sub-sample; v - volume of water filtered in the lake

2.6. Biodiversity Indices

The biodiversity indices as species richness (number of taxa), Shannon's diversity index (H) and Evenness (e^H/S), completed the image of the structure of zooplanktonic communities. Shannon's index (H), taking into account the number of taxa and number of individuals, as follows:

$$H' = \log n - \frac{1}{n}\sum_{i=1} n_i \log n_i$$

where n is the total number of individuals and ni is the number of individuals of taxon.

Evenness measures the uniformity of the individuals among the community's taxa .Both indexes were calculated in PAST statistical software (Hammer et al., 2001), using the number of taxa in the sample unit.

RESULTS AND DISCUSSION

Physicochemical Parameters
Physicochemical characterization of studied wetlands was summarized in Tables 2-4.

Dissolved oxygen
Oxygen is essential for all forms of aquatic life, including zooplankton. The oxygen content of natural waters varies depending on temperature, salinity, turbulence, the photosynthetic activity of algae and aquatic plants, and atmospheric pressure. The solubility of oxygen in water is directly proportional to atmospheric pressure and inverse proportional to temperature and salinity (Wetzel 2001). Changes in dissolved oxygen can occur seasonally or over 24 hour periods, in relation to temperature and biological activity (photosynthesis and respiration).

Biological respiration, especially as a result of decomposition processes, reduces dissolved oxygen concentrations. High organic matter and nutrients concentrations can lead to decreases in dissolved oxygen concentrations as a result of the increased microbial activity (respiration) occurring during the degradation of the organic matter. (Chapman, 1996).

Average dissolved oxygen values at Carasuhat ranged from 5.59 to 14.33 mg/L and were inversely related to water temperature. The lowest value was recorded at station C2 in the summer season, while the highest value occurs during the spring season at sampling station C5, situated in the middle of the lake. In Zaghen, dissolved oxygen concentration varied from a minimum value of 4.19 mg/L, recorded in the summer at the Z1 sampling station to a maximum value of 11.49 mg/L recorded in spring at sampling station Z2 also located in the middle of the lake.

Water temperature

Water temperature is a key factor in the development of aquatic organisms, directly affecting their life cycle, metabolism, reproduction and distribution.

Water temperature influences the physical, chemical and biological processes of water bodies and hence the concentration of many variables. As water temperature increases, the rate of chemical reactions usually increases with evaporation and volatilization of substances from the water. An increased temperature also reduces solubility of gases in water, such as O_2 and CO_2. (Chapman, 1996). The metabolic rate of aquatic organisms is also temperature-related, increased respiration rates in warm waters, resulting in increased oxygen consumption and decomposition of organic matter (Chapman 1996).

During the monitoring period, the mean water temperature along Carasuhat varied from to During the monitoring period, the average water temperature along Carasuhat ranged between 6.22 ^{0}C and 31.30 ^{0}C. As reported, the lowest water temperature was measured in March at sampling station C4, and the highest in July at the same sampling station.In Zaghen values of water temperature ranged between 8.61 ^{0}C in March at sampling station Z3 and 29.61 ^{0}C in July at sampling station Z4. It can be said that, overall, water temperature and dissolved oxygen followed opposite tendencies in all sampling sites, meaning: in spring, low water temperatures favoured the solubility of oxygen in the water, and in summer, the increase in temperature led to a decrease in dissolved oxygen concentration.

pH

The mean values of pH, ranged between 7.56 and 8.67, at all five stations along Carasuhat, minimum and maximum values were registered in spring, the lowest value was noted at station C5, while the highest value was observed in sampling station C2. In Zaghen values of pH, ranged between 7.2 and 8.7, the lowest was registered at station Z4 in spring and the highest value was observed in summer at the same sampling station. Both in the case of Carasuhat and also for Zaghen, mean pH values, classify the waters as alkaline, pH followed a global trend with lower values along the first month of the sampling period (colder month), associated with detritus oxidation, produced through photosynthetic activity, followed by an increase in the coming months (hotter months), correlated, mainly, to the increase in CO_2 uptake because of the rise in the photosynthetic of phytoplankton and macrophytes activity, which leads to higher pH values (Alprol et al, 2021).

Electrical conductivity

Conductivity is related to the concentrations of total dissolved solids and major ions.

The conductivity of most fresh waters varies from 10 to 1000 µS/cm, but can exceed 1000 µS/cm, particularly in polluted waters, or those receiving large amounts of runoff. The average electrical conductivity values of Carasuhat remained constant throughout the sampling period, ranging between 338 - 428 µS/cm, with the highest values in spring and autumn and the lowest values in summer. Zaghen stands out by having higher conductivity values compared to Carasuhat, ranging between 2025.4 - 2389.4 µS/cm, lowest values were observed in spring, then in summer and autumn has recorded an increase, this may be attributed to the low water levels and evaporation processes during the summer time.

Table 2. Physicochemical parameters in Carasuhat and Zaghen wetlands during spring

Spring		Dissolved oxygen (mg O_2/L)	Temperature (◦C)	pH	Conductivity (µS/cm)
Carasuhat	Station C1	13.13	6.35	7.69	398.9
	Station C2	12.15	6.29	8.67	412.5
	Station C3	12.9	6.26	7.56	428
	Station C4	12.5	6.23	7.73	423
	Station C5	14	6.3	7.6	400.8
Zaghen	Station Z1	11.23	8.691	7.72	2040
	Station Z2	11.49	8.713	7.76	2040
	Station Z3	8.8	8.62	7.36	2062
	Station Z4	11.4	8.97	7.2	2025

Table 3. Physicochemical parameters in Carasuhat and Zaghen wetlands during summer

Summer		Dissolved oxygen (mg O_2/L)	Temperature (◦C)	pH	Conductivity (µS/cm)
Carasuhat	Station C1	7.59	29.9	8.47	352
	Station C2	5.59	29.5	8.04	343
	Station C3	7.44	28.6	8.06	358
	Station C4	8.72	31.31	8.52	342.3
	Station C5	6.7	30	8.3	338.7
Zaghen	Station Z1	4.19	28	8.3	2188.1
	Station Z2	6.45	28.6	8.4	2185
	Station Z3	6.96	28.1	8.65	2291
	Station Z4	5.96	29.6	8.7	2152

Table 4. Physicochemical parameters in Carasuhat and Zaghen wetlands during autumn

Autumn		Dissolved oxygen (mg O_2/L)	Temperature (◦C)	pH	Conductivity (µS/cm)
Carasuhat	**Station C1**	9.11	15.107	7.95	402.5
	Station C2	8.63	13.88	7.87	401.9
	Station C3	9.38	16.65	8.01	407.4
	Station C4	8.21	15.89	7.84	410
	Station C5	9.5	13	8	386
Zaghen	**Station Z1**	9.06	11.99	8.35	2389
	Station Z2	9.24	11.729	8.31	2301.9
	Station Z3	10.18	12.794	8.33	2303.4
	Station Z4	9.76	11.65	8.34	2022

Nutrients

Nitrogen is essential to living organisms, undergoing biological and non-biological changes in the environment as part of the nitrogen cycle.
In the environment, inorganic nitrogen occurs in a range of oxidation states as nitrate (N-NO_3) and nitrite (N-NO_2), the ammonium ion (N-NH4) and molecular nitrogen (TN).

Nitrates indicate "very good" and "good" ecological conditions. The results for the ammonium quality indicator show the existence of a "very good" ecological state, the nitrites indicate in general "good" and "moderate" conditions.

The values of total nitrogen, generally indicated "good" and "moderate" ecological state, in all stations and sampling times.

The average values for nitrite-nitrogen (N-NO_2), concentrations were higher at Zaghen, compared to Carasuhat, ranging from 0.012 mg/L in summer to 0.036 mg/L in autumn, exceeding the maximum allowed concentration regulated by Order 161/2006, respectively 0.03 mg/L. For Carasuhat the range varies between 0.005 mg/L in summer to 0.02 mg/L in autumn.

Regarding nitrate-nitrogen (N-NO_3) concentrations, they varied from 0.33 mg/L in summer to 1.17 mg/L in spring, in Carasuhat, and 0.16 mg/L to 1.95 mg/L in Zaghen.

The ammonium (N-NH4) concentration ranged from 0.11 mg/L to 0.19 mg/L in Carasuhat and 0.09 mg/L to 0.26 mg/L in Zaghen.

Total nitrogen (TN) showed a different pattern of seasonal variation between the two water bodies, the average concentration of total nitrogen (TN) was 3.70 mg/L in spring but in summer the total nitrogen (TN) concentration in Carasuhat significantly increased to 9.23 mg/L, exceeding the maximum allowed concentration regulated by Order 161/2006 meaning 7 mg/L followed by a decrease again in autumn (6.43 mg/L).

In the case of Zaghen lake, the average concentration of TN ranged from 6.53 mg/L in spring, then showed a downtrend in summer (2.90 mg/L) and increased again in autumn (4.34 mg/L).

Phosphorus is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species.

Phosphates (P- PO_4^{-3}) and total phosphorus (TP) concentration never exceeded the limit for good ecological status. In the case of Carasuhat total phosphorus concentration, recorded the lowest value in March (0.05 mg/L), the highest values were in July (0.117 mg/L) and after that, it decreased slightly in October (0.113 mg /L). The lowest total phosphorus concentration in Zaghen was observed in the autumn (0.08mg /L) and the highest value was noted in summer (0.14mg /L).

The values of phosphates (P- PO_4^{-3}) concentration in Zaghen were greater than in Carasuhat. Values of phosphates was lowest in the spring (0.018 mg/L) and increased constantly in summer (0.049

mg/L) and autumn (0.083 mg/L). In Carasuhat, values of phosphates, were lowest in March (0.010 mg/L), highest in July (0.033 mg/L), and decreased again in October (0.011 mg/L).

Chlorophyll-a

The concentration of chlorophyll-a (µg/L) is an indicator of phytoplanktonic biomass and reflects water quality in the aquatic environment (Huang et al., 2010).
When assessing the chlorophyll-a concentration, it was noted that Carasuhat recorded the highest value in summer 31.89 µg/ L, while Zaghen stands out by having high concentrations of chl - a in the autumn, reaching a maximum value of 85.46 µg/ L.

In the national legislation Order of the Ministry of Environment and Water Management no 161/2006 and the Water Framework Directive (WFD), it is specified that the concentrations of chlorophyll-a above the threshold of 8 µg/L indicate eutrophy and above the threshold of 25 µg/L hypereutrophic, conditions which warn the occurrence of algal blooms.

Complying with the limits mentioned before, we noticed that in Carasuhat, were dominant the conditions of mesotrophic and eutrophic status, while in Zaghen were dominant hypereutrophic status. According to the concentration of chlorophyll "a", water quality, was within the limits of "very good" and "good quality class for Carasuhat and " good " and "moderate " quality class for Zaghen. (Table 5).

Table. 5. Trophic status and water quality classes based on in situ chlorophyll-a (µg/ L) concentration

		Spring		**Summer**		**Autumn**	
		Trophic Status	Ecological Potential	Trophic Status	Ecological Potential	Trophic Status	Ecological Potential
Carasuhat	Station C1	Mesotrophic	Very good conditions	Hypertrophic	Good conditions	Eutrophic	Very good conditions
	Station C2	Mesotrophic	Very good conditions	Eutrophic	Very good conditions	Eutrophic	Very good conditions
	Station C3	Mesotrophic	Very good conditions	Mesotrophic	Very good conditions	Mesotrophic	Very good conditions
	Station C4	Mesotrophic	Very good conditions	Eutrophic	Very good conditions	Mesotrophic	Very good conditions
	Station C5	Eutrophic	Very good conditions	Eutrophic	Very good conditions	Eutrophic	Very good conditions
Zaghen	Station Z1	Hypertrophic	Good conditions	Hypertrophic	Moderate conditions	Hypertrophic	Moderate conditions
	Station Z2	Hypertrophic	Good conditions	Hypertrophic	Good conditions	Hypertrophic	Moderate conditions
	Station Z3	Hypertrophic	Good conditions	Hypertrophic	Moderate conditions	Hypertrophic	Moderate conditions
	Station Z4	Hypertrophic	Good conditions	Eutrophic	Very good conditions	Hypertrophic	Moderate conditions

Zooplankton Communities
Diversity

Zooplankton community is composed of small organism (Crustacea and Rotifera) passively floating within the water column inhabiting a wide variety of habitats.

Over the study period, the zooplankton biodiversity of the Carasuhat wetland was represented by 46 taxa, including 36 species of Rotifera, 6 species of Cladocera and 4 species of copepods. Twenty-nine species of zooplankton have been recorded in Zaghen: rotifers (20), cladoceras (3) copepods (6).

In Carasuhat, station C3 was characterized by the highest species richness (31 species) and Shannon index diversity (3.38), followed by C2 station and C5 station (27 species), C4 station (25 species), with close values of Shannon diversity. The lowest diversity was observed in the C1 station (21 species) and Shannon index diversity (2.94).In Zaghen, a higher number of species were recorded at the Z4 station (20 species) and Shannon index diversity (2.92), followed by the Z3 station (18 species), Z2 station (17 species). The lowest diversity was observed in the Z1 station (13 species) and Shannon index diversity (2.44).

Temporal and spatial variations in the diversity and evenness of the zooplankton community in the studied wetlands were compared between the stations and also between different sampling times between March and October 2021 (Tables 6 - 7). Rotifer *Keratella cochlearis, Keratella quadrata, Pompholyx sulcata, Notholca acuminata, Filinia longiseta, Polyarthra vulgaris*, and species belonging to the genus *Brachionus*, are the most frequently observed species at all Carasuhat sampling stations, they mostly feed on detritus, bacteria, and also blue-green algae (Ejsmont-Karabin 2012, Gannon and Stemberger, 1978.)

Crustaceans include species belonging to the order Cladocera, *Diaphanosoma brachyurum*, *Chydorus sphaericus*, and *Bosmina longirostris*, as well as *Megacyclops viridis* and *Macrocyclops albidus*, of the order Cyclopoida. Nauplii and copepodites larvae, cladoceran *Moina brachiata*, cyclopids crustaceans *Megacyclops viridis, Macrocyclops albidus*, and rotifers species *Keratella serrulata, Keratella cochlearis, Keratella valga, Polyarthra vulgaris Brachionus angularis, Brachionus diversicornis*, were recorded from all sampling stations in Zaghen.

Most of these species have great ecological adaptability and the capacity to be resistant to organic pollution, common in all types of aquatic ecosystems of the Danube Delta, indicating high trophic conditions, which confirms again the eutrophic character of these water bodies.

Table 6. Spatial variation of zooplankton species richness and Shannon and Evenness diversity-index recorded in studied ecosystems

Carasuhat	**C1**	**C2**	**C3**	**C4**	**C5**
Taxon number	**21**	**27**	**31**	**25**	**27**
Shannon-Wiener index (H')	**2.949**	**3.223**	**3.382**	**3.176**	**3.193**
Evenness	**0.9087**	**0.9293**	**0.9493**	**0.9581**	**0.9026**
Zaghen	**Z1**	**Z2**	**Z3**	**Z4**	
Taxon number	**13**	**17**	**18**	**20**	
Shannon-Wiener index (H')	**2.447**	**2.728**	**2.815**	**2.921**	
Evenness	**0.8889**	**0.9004**	**0.9276**	**0.9277**	

Table 7. Temporal variation of zooplankton species richness and Shannon and Evenness diversity-index recorded in studied ecosystems

Carasuhat	**Spring**	**Summer**	**Autumn**
Taxon number	**34**	**23**	**12**
Shannon-Wiener index (H')	**3.384**	**2.953**	**2.39**
Evenness	**0.8673**	**0.8333**	**0.9093**
Zaghen	**Spring**	**Summer**	**Autumn**
Taxon number	**18**	**14**	**8**
Shannon-Wiener index (H')	**2.733**	**2.472**	**1.973**
Evenness	**0.8546**	**0.8465**	**0.899**

Abundance

The annual mean densities of zooplankton, shows that crustaceans are usually the most abundant group, especially those in the order Cladocera (water fleas), and the class Copepoda, particularly the order Cyclopoida, having similar values of abundances respectively 13.21 ind/L and 12.82 ind/L

In contrast to the highest number of species, rotifers recorded the lowest abundance of 6.24 ind/L. In Zaghen, Cladocera has the higher value of density respectively 142.94 ind/L, followed by Copepoda (19.16 ind/L) and Rotifera (10.19 ind/L).

Seasonal variations in zooplankton are influenced by physical and biological factors, such as the availability of food resources and prey pressure (Battes 2018).

Therefore values were lowest in March (7.84 ind/ L), increased to 9.07 ind/L in July, and decreased to 6. 79 ind/L in October. In Zaghen, recorded values were 9.61 ind/L in March, 40.79 ind/L in July, and 26.63 ind/L in October. Cladocera abundance was low in spring and autumn and high in summer for both studied wetlands.

The maximum summer population of Cladocera can be attributed to temperature and availability of food. Suspended detritus, physicochemical parameters such as water temperature, dissolved oxygen and nutrients play an important role in controlling Cladocera's diversity and density.

In Carasuhat, a maximum number of Copepods population with young stages of nauplii and copepodites, was recorded in spring and autumn months while minimum in summer. In Zaghen the dominant group in spring was Copepoda and rotifers in the autumn.

The mean densities of the principal zooplankton taxonomic group dynamics at all sampling stations and times are shown in Figures 3-4.

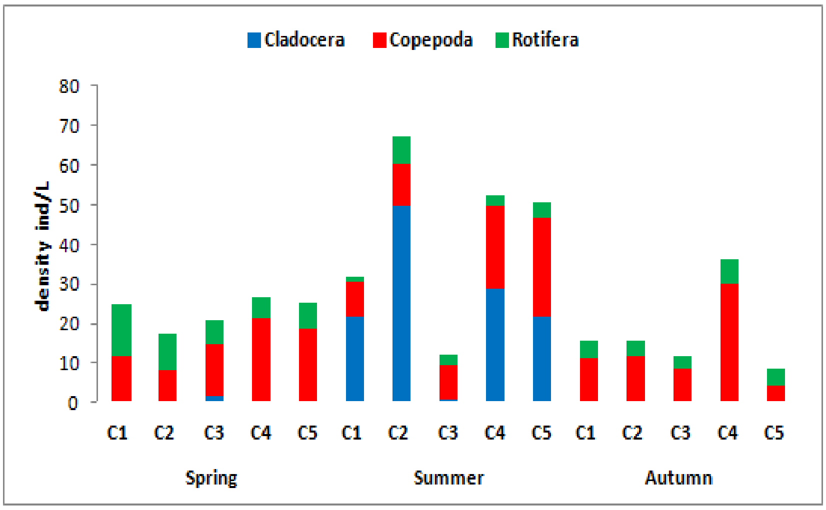

Figure 3. The dynamics of zooplankton density groups (Cladocera, Copepoda, Rotifera) in Carasuhat wetland during spring, summer, autumn 2021

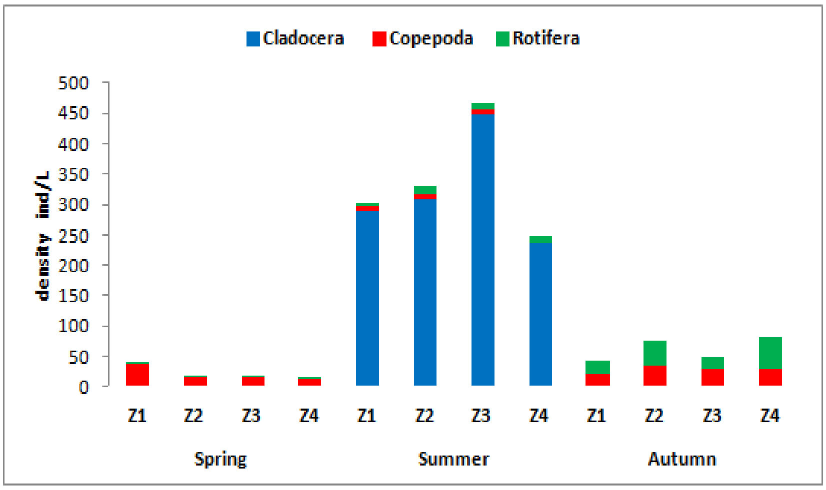

Figure 4. The dynamics of zooplankton density groups (Cladocera, Copepoda, Rotifera) in Zaghen wetland during spring, summer, autumn 2021

CONCLUSIONS

An assessment of the zooplankton community succession of the Carasuhat and Zaghen, was conducted seasonally, throughout one sampling year, coupled with a water quality evaluation following the Water Framework Directive standards and using other important physico – chemical and biological parameters. Water temperature (°C), dissolved oxygen (mg/L), pH, electrical conductivity (μS-cm), chlorophyll – a, zooplankton abundance and diversity indices were analyzed and compared in this study and the results of these investigations enable to draw certain conclusions at the moment.

As regards the nutrients concentrations, these were frequently below the imposed limits. Quality indicator ammonium, shows the existence of a "very good" ecological status. Nitrates indicate "very good" and "good" ecological conditions. Values of total nitrogen and nitrites have indicated in general "good" and "moderate" ecological status.

Regarding phosphates and total phosphorus, concentration never exceeded the limit for good ecological status. Chlorophyll – a concentrations and zooplankton community showed the wetlands tendency for eutrophy conditions. According to the concentration of chlorophyll "a", water quality in Carasuhat, were classified in class I "very good" and class II " good" quality. Compared to Carasuhat, the results obtained for chlorophyll "a", for Zaghen ranked water in class II ("good quality") and class III ("moderate quality").

Zooplankton fauna of Carasuhat was more diversified (46 species), than in Zaghen (29 species). Rotifers appeared to be the most dominating community throughout the study period, most of the zooplankton species were species present in other types of water bodies of Danube Delta, and indicate high trophic conditions. Zooplankton communities reach their highest abundance and diversity during the summer season, this may be attributed to favorable temperature and availability of food.Throughout the year numerical density was higher in Zaghen (24.60 Ind/L) and lower in Carasuhat (7.91 Ind/L).

Monitoring these two wetlands contributes to the knowledge of the water quality and zooplankton communities of the Danube Delta Biosphere Reserve ecological restoration areas, further research will be continued to monitor impacts on these aquatic ecosystems.

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