CONSIDERATIONS ON PRIMARY PRODUCERS OF LEZHA WETLANDS, ALBANIA

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Abstract

An ecological approach of the wetland complex of Kune-Vaini, Lezha, Albania, was carried on during July 2018 and July 2019. At least 5 representative stations as the most important water bodies were visited bimonthly: 3 in Ceka, and 1 in Zaje and Merxhani, respectively; periphyton samples were also taken in the Drini delta and in some drainage channals bordering with the area. Important physic-chemical and biological components were assessed. Only an overview of primary producers will be discussed here, focused mainly on aquatic macrophytes, phytoplankton and periphyton. A brief overview on terrestrial or submersed vegetation is also reported. Macrophytes were collected with proper combs directly from the boat. Optic microscope Motic BA310, objective 100x and a digital camera, was used for the determination of algal species. A Motic stereomicroscope up to 40x magnification was also used for the determination of algae and other macrophytes. Quantitative data of phytoplankton (cell/milliliter) were taken using the Utermöhl method (1958), using the inverse microscope Optica, objective 40x, and sedimentation chambers 5 ml and 25 ml.

About 20 species of macrophytes were found, 18 algae, and 2 angiosperms; green algae (*Chaetomorpha, Cladophora, Ulva*, etc.) dominated in general. Aquatic grass *Ruppia cirrhosa* formed large meadows in Ceka (in July 2018) or spots (in September 2018 and May 2019); *Zostera noltii* was found only in Zaje in July 2018, but with negligible cover. Submerged grasses were never seen in Merxhani. About 100 species of microscopic algae were found in phytoplankton and about 200 species of diatoms in periphyton of submersed macrophytes. Ca. 10 species belonging to *Skeletonema, Amphora, Pseudo-nitzschia, Dinophysis, Prorocentrum, Oscillatoria* were known as potentially toxic. Checklist of microscopic algae and macrophytes found in Kune-Vaini is reported at the end. An unusual winter peak of phytoplankton was observed in Merxhani (7,525 cells/ml in January 2019) dominated mainly by *Skeletonema costatum*, and *Oscillatoria* species. Dinophlagellates were mostly dominant in Zaje, some of them toxic. Phytoplankton growth was alternated with *Ruppia* meadows growth in Ceka: high phytoplankton in autumn vs. dense submersed meadows in spring-summer. Large areas are covered by reedbed, dominated by hydro-hygrophyte species (*Phragmites australis, Typha angustifolia, Scirpus* spp., etc.). The improved hydrological regime and water exchange is one of the most important determinants of primary productivity, the basis of the biodiversity that the system holds.

***Keywords*:** Lezha wetlands, macrophytes, microscopic algae, toxic algae, hydrological regime.

Të dhëna mbi prodhuesit parësorë të ligatinave të Lezhës, Shqipëri

Përmbledhje

Gjatë periudhës korrik 2018 dhe korrik 2019 u krye një studim mbi qasjen ekologjike të kompleksit ligatinor të Kune-Vainit, Lezhë. Çdo dy muaj u kryen matje dhe u morën mostra në të paktën 5 stacione përfaqësuese në 3 trupat ujorë më të rëndësishëm: në 3 stacione në Cekë dhe nga 1 stacion përkatësisht në Zaje dhe Merxhan; për perifitonin u morën mostra edhe në deltën e lumit Drin dhe në ndonjë kanal kullues në periferi të zonës. U vlerësuan tregues të rëndësishëm fiziko-kimikë dhe biologjikë. Këtu diskutohet përmbledhtas vetëm mbi prodhuesit parësorë, përqendruar kryesisht në makrofitet ujore, fitoplanktonin dhe perifitonin; gjithashtu shumë shkurt flitet edhe mbi florën dhe bimësinë e steresë së zonës. Makrofitet u mblodhën me krehëra të posaçëm direkt nga varka. Për përcaktimin e algave u përdor Mikroskopi optik Motic BA310, me objektiv 100x dhe me aparat digjital. Për përcaktimin e algave dhe makrofiteve të tjera u përdor edhe një stereomikroskop Motic me zmadhim deri 40x. Të dhënat sasiore të fitoplanktonit (qeliza/mililitër) u morën me anë të metodës Utermöhl (1958), duke përdorur mikroskopin invers Optica, objektiv 40x dhe gota sedimentimi 5 ml dhe 25 ml.

Gjithsej u gjetën rreth 20 lloje makrofitesh, 18 alga dhe 2 angjiosperme; përgjithësisht mbizotëronin algat e gjelbra (*Chaetomorpha, Cladophora, Ulva* etj.). Barishtja e zhytur monokote *Ruppia cirrhosa* formonte në Cekë livadhe të dendura nënujore (në korrik 2018) ose njolla (në shtator 2018 dhe maj 2019); barishtja tjetër *Zostera noltii* u gjet me mbulesë të papërfillshme vetëm në Zaje në korrik 2018. Në Merxhan nuk u panë asnjëherë barishte të zhytura. Në fitoplankton u gjetën rreth 100 lloje algash mikroskopike, dhe në perifitonin e makrofiteve të zhytura u gjetën rreth 200 lloje diatomesh. Rreth 10 lloje prej tyre njihen si helmuese, të cilat u përkasin gjinive *Skeletonema, Amphora, Pseudo-nitzschia, Dinophysis, Prorocentrum, Oscillatoria*. Në fund jepet e plotë lista e llojeve të algave mikroskopike dhe makrofiteve të zhytura të Kune-Vainit. Në Merxhan në fitoplankton u vu re një kulm i pazakontë dimëror (7,525 qeliza/ml në janar 2019), i mbizotëruar kryesisht nga diatomeja rrethore *Skeletonema costatum* dhe lloje cianobakteresh të gjinisë *Oscillatoria*, të njohura për veti helmuese; në Zaje mbizotëronin më së shumti dinoflagjelatët, disa prej tyre gjithashtu helmues. Zhvillimi i fitoplanktonit në Cekë këmbehej me rritjen e livadheve të *Ruppia*: fitoplankton i lartë në vjeshtë kundrejt livadheve të dendura nënujore në pranverë-verë. Sipërfaqe të mëdha në zonë mbulohen nga kallamishtet, të mbizotëruara nga llojet hidro-higrofite (*Phragmites australis, Typha angustifolia, Scirpus* spp., etj.). Përmirësimi i regjimit hidrologjik dhe ujëkëmbimit me detin është një nga faktorët më të rëndësishëm për prodhimtarinë parësore, dhe biodiversitetin e këtij ekosistemi.

Fjalë kyçet: Ligatinat e Lezhës, makrofitet, algat mikroskopike, algat helmuese, regjimi hidrologjik.

Introduction

The wetland system of Kune-Vaini is situated in the northern part of Albania's Adriatic Coast, west of Lezha plain (Fig. 1) (Kabo, 1990-1991). It is formed under the influence of Drini and Mati rivers. The complex consists of four main water bodies (12.5 km^2 in total): Merxhani (2.5 km^2) and Knalla (2.2 km^2) (in Kune, northern part of Drini), in Shëngjini area, and Ceka (4.9 km^2) and Zaje (2.4 km^2) (in Vaini, in the south), Lezha area; the rest are swamps, reedbeds, forests and shrubs, and sandy dunes.

The average and maximum depth of Ceka, Zaje and Merxhani are about 0.7 m and 1.3 m, respectively; the depth in Knalla is higher: average 4.2 m and maximal 13.5 m (Miho *et al.*, 2013). Ceka and Zaje are separated from each other by a strip of land; previously they communicated through two artificial channels, currently closed by the fishermens. Zaje is connected to the Drini delta by an artificial canal near the estuary. Ceka exchanges water with the sea through the Matkeqe channel (Fig. 1 & 7), about 3 km long (GBA, 2017), 2 m deep and 20-30 m wide. The tide exchange is through a canal in the center of the Merxhani lagoon, 500 m long, 40-70 m wide and 1-2 m deep.

The Kune-Vaini area is protected as Managed Nature Reserve, now within Kune-Vaini-Patoku-Fushe Kuqe-Ishmi (80.9 km^2, in total; IV Category; http://akzm.gov.al/; DCM 60/2022). The total surface of the Kune-Vaini area (without Tale zone and Kenalla lagoon) under our ecological approach is about 20 km^2 (after Law 9868/2008 in Totoni *et al.*, 2010).

Submersed macrophytes, their periphyton and phytoplankton are important primary producers of the wetland ecosystem, oxygen production, habitat stabilization and shelter for aquatic animals. They reflect well the hydrological regime and water exchange, and other environmental conditions; but they are very sensitive also to the content of nutrients (N and P), heavy metals, organic pollution, etc. Therefore, they are largely used as indicators of surface water quality, together with phytoplankton/periphyton (diatoms), macroinvertebrates and fishes (WFD 60:2000; etc.).

The Departments of Biology and Chemistry, FNS, UT, have jointly applied a Master Program focused on the ecological approach of the wetland complex, within the Kune-Vaini Project (Law 33/2016; McCue, 2018; 2020). Ceka, Zaje and Merxhani (Fig. 1) were in the focus of Kune-Vaini project as the most important wetland part of PA. Important physic-chemical and biological components were assessed as topics of several master theses (i.e. Gjata, 2019; Kola, 2019; Muçaj, 2019; Ramaj, 2019; etc.). The most important outcomes were summarized by Miho *et al*. (2021), and more detailed from other separated working groups, Kola & Miho (2021) (phytoplankton), and Qevani & Miho (2021) (periphyton - diatoms), Vallja *et al.* (2021) (general physic-chemistry), Duka *et al.* (2021) (nutrients, pigments and water trophy). A complete edition of the whole data from each separated group is under the preparation.

An overview of primary producers will be discussed here, focused mainly to aquatic macrophytes, phytoplankton and diatoms in periphyton; a brief overview on terrestrial or submersed vegetation is also discussed. The same content as reported here was first represented in IPSAT 2021 (https://www.ipsat.gen.tr/) (Gjata, *et al*., 2021).

Material and methods

The sampling and other field investigations were bimonthly carried out, respectively on 2018 (July, September and November) and 2019 (January, March, May and July). At least 5 representative stations were visited: three in Ceka (due to its bigger surface), and one in Zaje and Merxhani respectively; periphyton samples were also taken in the Drini delta and in some drainage channals bordering with the area (Fig. 1).

Figure 1. Satellite view of the Kune-Vaini wetland complex. The arrows show the coastal beach under erosion; Wastewater Treatment Plant; pumping stations; tide inlets; blocked tide inlets; o sampling stations; o only periphyton samples (from Google Earth 2020).

Submersed macrophytes were collected directly from the boat, using proper combs according to monitoring protocols by ISPRA (2010); the total macrophyte cover was assessed directly from the boat by touching with a comb 20 times the bottom of the lagoon (15-30 m in diameter), to detect the presence/absence of macroalgae. The specific coverage of submerged angiosperms was determined according to the Visual Recording Technique also from the boat. Results were reported as a percentage of coverage. Material was stored in formaldehyde (up to 4%) in plastic jars (500 ml) or as dried material. Besides the floristic analysis, the macrophyte cover and biomass was assessed, and water quality using the Macrophyte Quality Index (MaQI) (ISPRA, 2010; Sfriso, 2010; Sfriso *et al.*, 2014).

Collected material from macrophytes was preserved in ethanol and used to assess the diatoms in periphyton (EN13946: 2003). The quantitative phytoplankton samples were taken using the Ruttner bottle, or directly from the boat; they were preserved in Lugol in 250 ml glass bottles (CEN/TC 230: 2006); also, Nansen net samples (25 µm mesh size) were taken for the qualitative approach, stored in formaldehyde (up to 4%) in plastic bottles (50 ml).

The species determination was done using mainly the fresh material (phytoplankton; macrophytes), or permanent slides (diatoms in periphyton or phytoplankton), using the optic microscope Motic BA310, with objective 100x, and a digital camera. The cleaning of diatom frustules was carried on by boiling the plankton material in H_2O_2cc (EN14407: 2004); microscopic slides were embedded with Naphrax (1.71). Stereomicroscope Motic was used additionally for the determination of macrophytes.

Available literature was used for species determination - **macrophytes**: Starmach (1972), Dhargalkar & Kavlekar (2004), Al-Yamani *et al*. (2014), Bertuccio (2013), Afanasyev *et al.* (2016), etc.; **microscopic algae**: Hallegraeff *et al.* (2004), Krammer & Lange-Bertalot (1986-2001), Sournia (1978), Trégouboff & Rose (1957), Witkowski *et al.* (2000), Bourrelly (1970-1981), and personal photo collection of A. Miho and Bushati (2013). Taxonomic names were always consulted with WoRMS (2021) and AlgaeBase (Guiry & Guiry, 2021).

Utermöhl method (1958) was used for quantitative phytoplankton data (cell/milliliter) (EN15204: 2006), using the inverse microscope Optica, with objective 40x, and sedimentation chambers 5 ml and 25 ml. More than 400 cells or diatom frustules were counted in total (phytoplankton or periphyton, respectively; confidence 95%, error ±10%). Based on the diatom community, IPS was calculated (CEMAGREF, 1982), using the formula of Zelinka & Marvan (1961), elaborated after by Eloranta & Kwandrans (1996). The ecological values (S_i and V_i) were taken from the OMNIDIA database (Lecointe *et al.*, 1993), valid mostly for freshwater habitats; since some species counted by us have no ecological values (Si and Vi) (mostly marine species) were not considered in IPS calculation (*see* further comments in Qevani & Miho, 2021). Therefore, the IPS values can give with a certain approximation the quality of each habitat under interest; the reliability could be considered rather low in the Merxhani, where the abundance of marine species (without ecological values) in periphyton community was higher (ca. 17%).

Results

The data reported here are given for the first time, focused mainly to aquatic macrophytes, phytoplankton and diatoms in periphyton; checklist of species is also reported in table 1. Kallfa (2014) in her doctorate work has reported data about physic-chemistry and photosynthetic pigments, taken monthly during July-October 2010 and March-October 2011. The assesment of physic-chemical parameters, nutrients, and photosynthetic pigments were part of our Kune-Vaini Project, too (Muçaj, 2019; Ramaj, 2019). After the mentioned works relatively high productivity was observed, although with irregularities in seasons and years (Kallfa, 2014; Duka *et al.*, 2021; Miho *et al.*, 2021; Vallja *et al.*, 2021).

The three lagoons represent some notable differences based on their physic-chemical conditions. The waters in Zaje were less salty (8-18‰) (mesohaline), due to water exchange with the Drini river; Ceka's waters represented average salinity (polyhaline, 18-30‰), whereas the waters of Merxhani were generally of higher salinity (25-40‰; euhaline) (Fig. 2). A narrow sandy belt separates the Merxhani with the sea; two or more times per year, the seawater overflows and mixes with the lagoon waters. The oxygen saturation (DO%) was generally below 100%, mainly in Ceka and Zaje (Miho *et al.*, 2021; Muçaj, 2019; Vallja *et al.*, 2021).

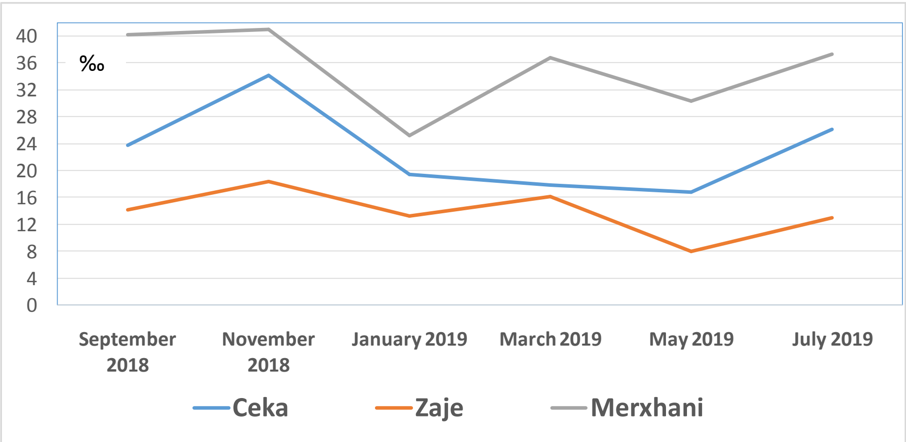

Figure 2. Salinity (‰) in waters of the Kune-Vaini complex, Lezha (September 2018-July 2019); for Ceka the average value at three stations is given (Miho *et al.*, 2021).

Relatively high nutrient load (nitrogen and phosphorus) and the trophic level were observed in waters (Ramaj, 2019; Duka *et al.*, 2021; Miho *et al.*, 2021). As expected, nutrients (N & P) were not negligible; it is probably for the close interconnectivity the lagoons have with the surrounding watershed and the sea: Ceka with the pumping station in Tale; Zaje with the Drini delta; Merxhani with the pumping station in Shëngjini Island (Fig. 1). Urban and agricultural waste is collected into drainage channels and then in the respective lagoons.

The average of the total phosphorus (TP) for September 2018-July 2019 was 88.91 µg/L for Ceka, 66.31 µg/L for Zaje, and 56.57 µg/L for Merxhani, exceeding several times the limit values reported for Mediterranean countries by Poikane *et al*. (2019). In addition, the PO_4 average was 2.87 µmol/L in Ceka, 2.14 µmol/L in Zaje and 1.83 µmol/L in Merxhani; all belong to the category 'bad', according to the EEA criteria for nutrients in transitional, coastal and marine waters (Crouzet *et al.*, 1999). Moreover, the average content of total nitrogen (NO_2 + NO_3) was higher than the 'very high limit' (>8 µmol/L) set by EEA (2017): 10.72 µmol/L for Ceka, 21.59 µmol/L for Zaje, and 9.90 µmol/L for Merxhani. As shown in following, combined with the dense presence of green algae (*Ulva* species), tolerant to pollution (known as nitrophyl species), and low IPS values, all is an evidence that the surrounding zone has a significant impact on all three lagoon systems (*See* also Miho *et al*., 2021).

Submersed macrophytes: About 20 species were found (Tab. 1), 18 algae, and 2 angiosperms; green algae (C*haetomorpha, Cladophora, Ulva*, etc.) dominated in general, followed by red algae (*Gracilaria, Polysiphonia*, etc.). Aquatic grass *Ruppia cirrhosa* formed large meadows in Ceka (in July 2018) or spots (in September 2018 and May 2019) (Fig. 3); *Zostera noltii* was found only in Zaje in July 2018, but with negligible cover. It is worth mentioning that *Z. noltii* belongs to the Red List of Albania (VU A2d; Order 1280/2013).

Figure 3. Left, floating green algae, *Cladophora* spp., on meadows with *Ruppia cirrhosa* in Ceka (July 2018). **Right**, floating red algae, *Polysiphonia* spp., and *Ruppia* meadows spots in Ceka (May 2019).

The largest number of species was found in July 2018; less species were recorded in November 2018 and January 2019, due to winter conditions. Areas closer to sea communication and less affected by human activity were more inhabited by fanerogams and sensitive macroalgae (most evidenced in Ceka, in July 2018). While opportunistic macroalgae (*Ulva* and *Cladophora*) were dense in areas with scarce communication with the sea and closer to human influence, mostly in north-eastern part of Ceka and everywhere in Merxhani (Fig. 3). Based on MaQI, the quality of waters in Ceka were good or high, and poor in Zaje and Merxhani.

The most common species belong to the green algae, mainly to *Cladophora* (5 species) and *Ulva* (4 species). *Cladophora* sp. 4 (Gjata, 2019) and *Ulva prolifera* were often present in Ceka (Tab. 1); *U. intestinalis* was mostly present in Ceka and Zaje; whereas *U. compressa* and *Cladophora* sp. 1 were more present in Zaje and Merxhani. The red algae *Gracilariopsis longissima* and *Polysiphonia morrowii* were often present in Merxhani, while *Gracilaria gracilis* was often found in Zaje.

Aquatic macrophytes normally represent an important part of primary productivity in shallow waters, particularly in land-locked systems, such as some coastal lagoons (Wetzel, 1975), with dense stands covering wide areas, as it was observed in Ceka lagoon. Mann (1972) suggests that macrophyte production in shallow waters can be ten times higher then phytoplankton production. On the other hand, *R. cirrhosa*, found dense in Ceka, is a common grass in large permanent water bodies, with a healthy growth in salinities above >20‰ (Verhoeven, 1979).

Phytoplankton: About 100 phytoplankton species were found in total, mostly pennate (50 species) and centric diatoms (24 species), followed by dinoflagellates (16 species); other groups were represented with fewer species, also difficult to determine. Considering the previous approach of Miho & Mitrushi (1999), more than 160 species in the phytoplankton were known in total. With the diatoms found in the periphyton from Qevani (2020) (also Miho & Qevani, 2021), during the same period, the total number of microscopic algae known in Kune-Vaini habitats is about 310 species (Tab. 1). From these, 280 species are diatoms and the rest are phytoplankton species of different algal groups, e.g. Dinophyceae (19 species), and the other groups less represented, Chlorophyceae, Chrysophyceae, Euglenophyceae, Cryptophyceae, Pyramimonadophyceae and Cyanobacteria.

Phytoplankton showed an unusual dynamic in Ceka and Merxhani, related probably with scarce water exchange, their oxygenation and nutrient circulation. In Ceka, a very high peak was observed in the autumn (September-November 2018, 49,883 and 11,446 cells/ml respectively) and another much smaller peak in May 2019 (1,953 cells/ml) mainly dominated by diatoms (Kola, 2019; Kola & Miho, 2021). The phytoplankton content was generally low in Zaje, showing nearly a seasonal dynamics, with a peak in May 2019 (2,457 cells/ml) mainly dominated by dinophlagellates (up to 1,856 cells/ml) and in September 2018 (2,095 cells/ml) also dominated by dinophlagellates and diatoms. A large peak was seen in Merxhani in January 2019 (7,525 cells/ml), and another much smaller in May 2019 (1,393 cells/ml), both mainly dominated by diatoms; the winter peak was mainly dominated by *Skeletonema costatum*, known to be toxic (Hallegraeff *et al.*, 2004).

PLATE I

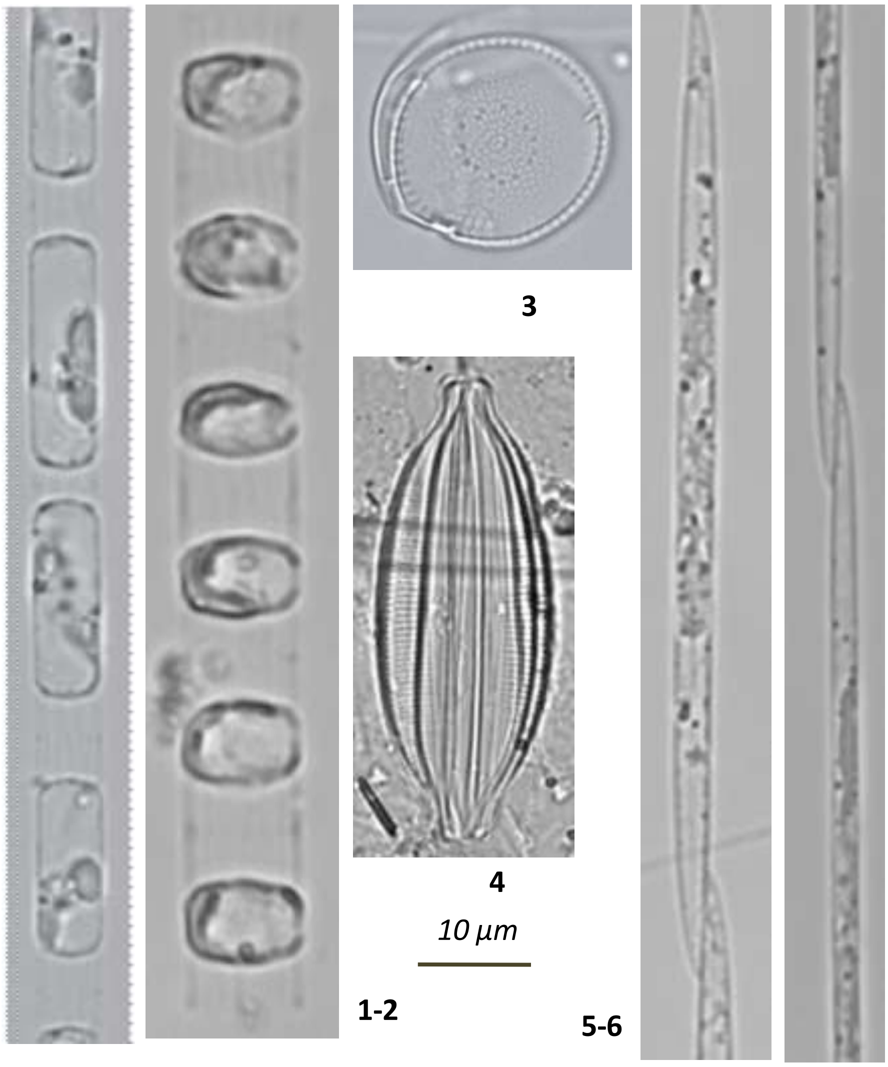

PLATE I: Toxic diatoms from Lezha lagoons. **1-2,** *Skeletonema costatum*; **3,** *Conticribra weissflogii*; **4,** *Halamphora coffeiformis*; **5-6,** *Pseudo-nitzschia* spp.

PLATE II

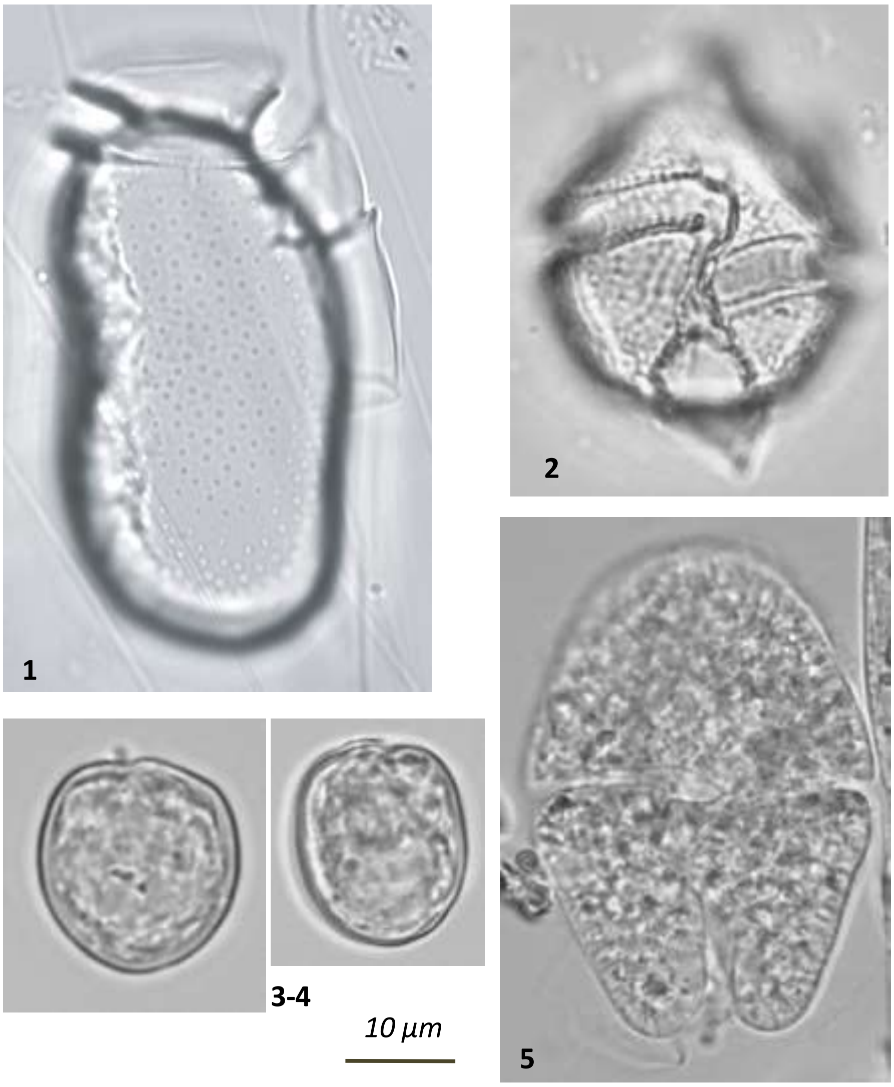

PLATE II: Dinophyceae from Lezha lagoons. **1,** *Dinophysis sacculus*; **2,** *Gonyaulax spinifera*; **3-4,** *Prorocentrum cordatum*; **5,** *Akashiwo sanguinea*.

The abnormal situation in Merxhani was also evidenced by the high presence of opportunistic nitrophyle macroalgae (*Ulva compressa*, *Chaetomorpha ligustica*, *Cladophora* sp.) (Fig. 6) (Salas *et al.*, 2006). Also the dominant presence of dinophlagellates in Zaje cannot be considered normal; some of present species like *Dinophysis sacculus*, *Gonyaulax spinifera* and *Prorocentrum cordatum*, are known as toxic (Plate II). Dinoflagellates are mostly mixotrophic, and grow in special conditions where other groups of algae could not; they are well known as the source of red tides leading to fish and other marine animal kills, as well as various types of human illness caused by their toxins (Hallegraeff *et al.*, 2004). In Albanian and Mediterranean lagoons a spring peak of phytoplankton can be normally observed (Subba Rao, 1981; Miho, 1994; Xhulaj & Miho, 2008; Bushati, 2013), depending on climatic conditions and general condition of the ecosystem. It was not observed in Ceka, or in Merxhani lagoons. The low spring peak in Ceka can be somehow complementary to the dense growth of the grass *R. cirrhosa* (Fig. 3) as suggested by Mann (1972).

PLATE III

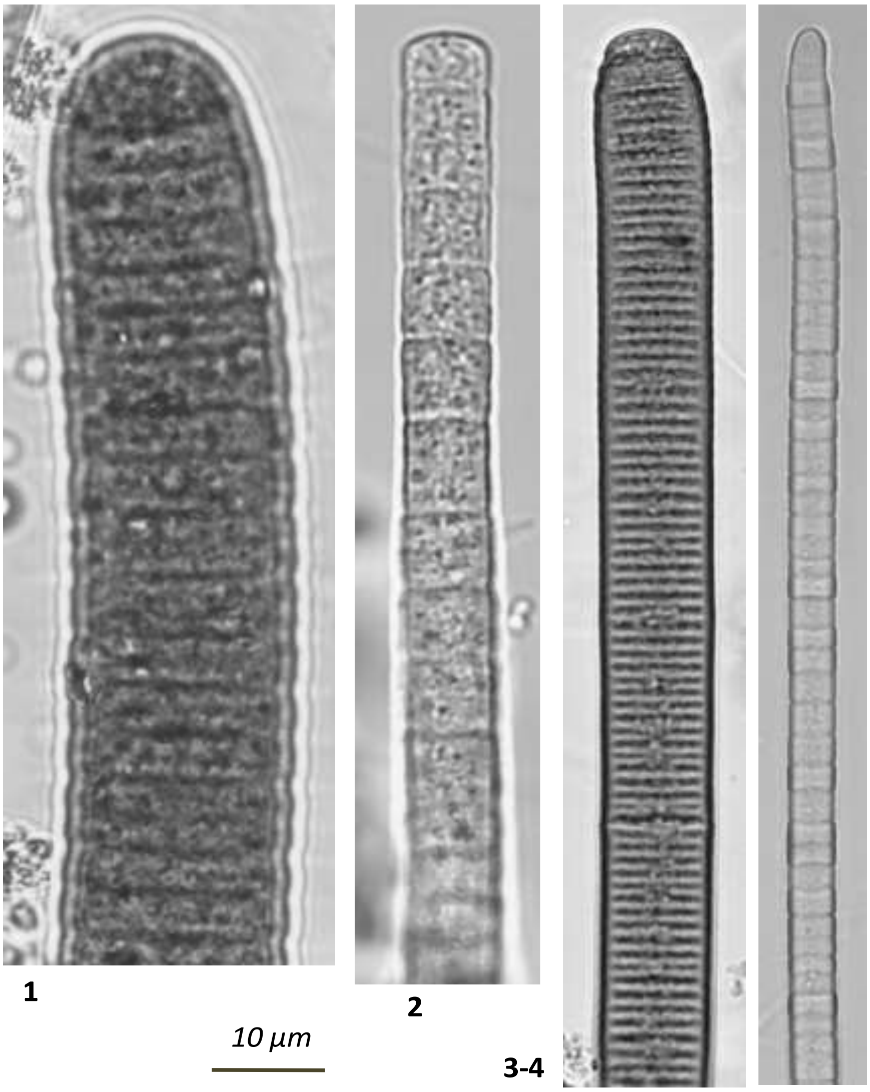

PLATE III: *Oscillatoria* spp. from Lezha lagoons. **1,** *Oscillatoria* cf. *princeps*.

Toxic species: More than 10 species were known to be potentially toxic (Hallegraeff *et al*., 2004). *Ca*. 11 species with 15 microscopic photos are reported in PLATES I to III. The centric diatoms were *Ceratulina pelagica* (in Merxhani), *Conticribra weissflogii* (in Ceka; in phytoplankton and periphyton) and *Skeletonema costatum* (in all lagoons, but abundant in Merxhani in January 2019). Pennate diatoms *Pseudo-nitzschia seriata*, *P. delicatissima* (both in Zaje and Merxhani), or *Amphora* species (i.e. *Halamphora coffeiformis;* in phytoplankton and periphyton) and *Pseudo-nitzschia* species are capable of producing the neurotoxin domoic acid (DA), responsible for the neurological disorder in humans, known as amnesic shellfish poisoning (ASP). *Pseudo-nitzschia seriata* and *P. delicatissima* were found abundant also in Butrinti lagoon (Miho, 1994; Bushati, 2013).

Toxic dinoflagellates were *Dinophysis* spp., *Gonyaulax spinifera, Prorocentrum cordatum* (in Ceka and Zaje), *Scrippsiella acuminate* (in Ceka). Frequently found in all the Lezha lagoons, *Dinophysis sacculus* is a toxic species associated with DSP outbreaks in Europe. Faust & Gulledge (2002) note that *Akashiwo sanguinea* is a red tide species associated with fish and invertebrate kills. *Oscillatoria* species (i.e. *Oscillatoria* cf. *princeps*) (cyanobacteria) were found almost throughout the period and in all the stations, but mostly in Merxhani; their toxins can harm both humans and animals (Swanson-Mungerson *et al.*, 2017). Most of them were also found also in Butrinti lagoon Miho, 1994; Bushati, 2013) or other Adriatic lagoons of Albania (Xhulaj & Miho, 2008).

Diatoms in periphyton: About 200 species of diatoms were found in periphyton samples (Tab. 1), showing relatively high diversity; 13 were centrics, and the rest pennate. 79 species were found in Ceka, 61 in Zaje, 75 in Merxhani and 112 in the Drini delta. IPS values were relatively low (CEMAGREF, 1982). Their average was 8.85 in Ceka, 8.36 in Zaje, both classified into the ‘poor’ quality class; and 9.55 in Merxhani, 10.34 in Drini, both classified into the ‘moderate’ quality class. But the reliability of quality in Merxhani can be considered rather low, considering the abundant marine species not considered in IPS calculation. *Halamphora coffeiformis*, a toxic species, was found in all the habitats, relatively abundant in the drainage channel around Ceka (up to 65% of periphyton community in March 2019) and Ceka lagoon (up to 28% in July 2018) (Qevani & Miho, 2021).

Overview on terrestrial or submersed vegetation: The knowledge of flora and vegetation of Kune-Vaini started early (Mullaj, 1989; etc.), resumed in 2009-2012 (Mullaj & Muça, 2009-2012), and updated during 2018-2019, by Bici (2019) and Sanxhaku (2020). Ca. 330 species of higher plants are known. 21 species belong to the Red List of Albania, found mainly on sandy dunes, and on riparian and coastal Mediterranean coniferous forests, such as *Ammophila arenaria, Butomus umbellatus, Cladium mariscus, Colchicum autumnale, Desmazeria marina, Hypericum perforatum, Juniperus communis, J. macrocarpa, Lotus cytisoides, Matthiola tricuspidata, Origanum vulgare, Pancratium maritimum, Pinus pinea, Populus alba, Quercus ilex, Q. robur, Sambucus nigra, Stachys maritime, Tamarix hampeana, Ulmus minor,* etc. (Fig. 4). Furthermore, up to 10 priority habitat types of the Natura 2000 list have been identified: 3 in coastal dunes, and 7 within the wetland zone.


Figure 4. European beachgrass, *Ammophila arenaria* (**left**), and sea daffodil, *Pancratium maritimum* (***right***) that grow on Kune-Vaini sandy dunes (Bici, 2019).


Figure 5. Different habitats in Kune-Vaini wetland area: ***left***, view Ceka lagoon in Tale area, bordered by reed habitats and Mediterranean alluvial mixed forest; ***right***, view of Kune wetlands and its pine forest on December 2020.

Besides the lagoonary habitats, different types of vegetation are well expressed, from submersed vegetation, reed, halophytes or psamophytes, up to aquatic shrubs and typical Mediterranean forest and sandy dunes (Fig. 1). The forest area, shrubs and aquatic vegetation extend in 13.4 km^2. The most important and also the most sensitive is **the Mediterranean alluvial mixed forest** (*ca*. 200 ha) (Fig. 5), dominated mainly by alder (*Alnus glutinosa*) and narrow-leaved ash (*Fraxinus angustifolia*); the forest is often mixed with white poplar (*Populus alba*), *Ulmus minor* and *Quercus robur* (Bego *et al.*, 2013; Miho *et al.*, 2013); in some spots (about 4 ha in total), the white poplar forms pure associations. The alluvial forest offers a good possibility for shrubs to grow up densely: like *Rubus ulmifolius*, *Crataegus monogyna, Rosa sempervirens, Tamarix dalmatica;* the lianas, such as *Hedera helix, Smilax aspera, Periploca graeca, Clematis viticella*; and the herbaceous, such as *Lythrum salicaria, Asparagus acutifolius, Galium aparine, Agrostis stolonifera*, etc. The forests were heavily damaged in past years from woodcutting, urbanization, and strong and increasing erosion (Fig. 8).

Figure 6. Reedbed, dominated by hydro-hygrophyte species (*Phragmites australis, Typha angustifolia, Scirpus* spp., etc.) in Zaje onJuly 2018.

Figure 7. View of Matkeqe tide channel on December 2020: ***left side***, part of dune pine forest; ***right side***, part of the Mediterranean alluvial mixed forest.

Close to forests, important areas are also covered by **shrubs**, dominated by *Tamarix* spp. (*T. dalmatica* and *T. hampeana*), up to 4-5 m tall. Other species grow up with them, like *Vitex agnus-castus, Rubus ulmifolius, Juncus acutus, Arthrocnemum glaucum*, etc. Along the riverbanks of Drini, a narrow shrubby belt of willows grows up, mainly *Arundo donax*, mixed with *Salix alba* and *S. elaeagnos*; with them other species complete the vegetation physiognomy, like *Ditrichia viscosa, Lythrum salicaria*, etc. The dominant aspect of the dune vegetation are the cultivated pines (*Pinus pinaster, P. pinea, P. halepensis*), that grow out along the coast in Kune and in Vaini areas (Fig. 7).

Large area of the complex is covered by **reed**, dominated by hidro-higrophyte species of *Phragmites australis, Typha angustifolia, Scirpus* spp., etc. (Figs. 5-7). Common reed (*P. australis*) is largely extended in littoral parts of the lagoons (especially in Ceka), along the riverbanks of Drini, drainage channels, etc. Reedbeds with *Typha* are more limited along Drini river banks, channels and torrents. Small parts covered with water only during the wet period are spread out in the whole system, but in less extent as reed; they are dominated by *Scirpus maritimus* (growing up mainly in depressions of dunes) and *S. lacustris* (Miho *et al.*, 2013). In the littoral parts with less salinity, various *Potamogeton* and *Myriophyllum* species grow up, too (*i.e.* in Drini delta; Qevani, 2020). In the calm and fresh waters, floating duckweeds can grow up, composed mainly of *Lemna minor;* also *Spirodela polyrhiza* was found occasionally in freshwater channels.

During hot summer, in some zones the salinity increases evidently; the soil is covered even with a delicate layer of white salt; their vegetation belongs to **halophytes**, mainly succulent species dominated largely by *Arthrocnemum* species (*A. fruticosum, A. perenne, A. glaucum*); a scarce number of species accompany them, like *Salicornia europaea, Limonium vulgare, Inula crithmoides, Halimione portulacoides, Artemisia coerulescens*, etc. Habitats flooded during the most part of the year are also proper place where *Juncus* species grow up, mainly *J. acutus* (with large ecological amplitude) and *J. maritimus*. Associations with *Arthrocnemum* and *Juncus* are often alternated with each other or even with other species, like *Scirpus holoschoenus, Saccharum ravenae, Plantago crassifolia, Schoenus nigricans*, etc. It makes evidently the vegetation physiognomy quite fragmented and interesting (Miho *et al.*, 2013).

Discussion

The Kune-Vaini wetlands shelter sensitive and fragile ecosystems and high plant diversity, like sandy dunes and river delta, lagoons, Mediterranean coniferous, alluvial and mixed riparian forests. They are distinguished by their wealth of breeding and refuge habitats, especially for fish and wintering or migratory aquatic birds (Selgjekaj & Bego, 2021), some of them globally endangered. But it has undergone severe hydrological changes over decades until present. Drini River was fully diverted to the Buna in 1960s (Bego *et al.*, 2021; Miho *et al.*, 2021). Knalla pond was originally in close hydrological connectivity with Merxhani lagoon; it was blocked after 1990s due to heavy urbanization of the Shëngjini zone (Fig. 10, *left*). The Kulari tide channel in the northern part of Merxhani lagoon was also blocked. The channels connecting Zaje with Ceka were also blocked for fishing purposes. Several artesian wells (*ca*. 30 to 35 L/s) drilled during yrs. 1973-75 (Pano, 1998) were an important part of the hydrographic network; but, in last 25 years water pressure has dropped down, due to the impoverishment of the aquifer, overuse of groundwater for irrigation, damage or blockage of the wells, etc. (Eftimi, 1998).

Figure 8. Strong erosion along the sea coast of Kune promontory, Shëngjini on December 2020.

Figure 9. Blooming of *Ulva compressa* in Merxhani (***left***) on March 2019, and of *Chladophora* spp. in Ceka (***right***) on May 2019.

Combined effects of all these stressors has led to severe consequences on the lagoon hydrological regime, coastal erosion (inward rate *ca*. 2-4 m/year) (Fig. 1 & 8), wetland biodiversity and ecology, and ecosystem services, further enhanced even by global warming. Extreme events such as heavy rain, floods and droughts are already causing habitat loss and fragmentation. The situation in Merxhani lagoon was shocking, very dystrophic, with high content of decomposing organic matter, high presence of nitrophyle communities dominated by *Ulva compressa* (Fig. 9), and everywhere a bad smell. Fishermen complain that fish stock has dropped significantly, from 800 kv per year just a few years ago, to less than 100 kv today! In April 2016, fishermen reported in the media about fish deaths (*Anonymous*, 2016); they say that such a situation had occurred for more than a year. We believe that this situation may also affect the quality of bathing water on the nearby Shëngjini beach. A scarce tidal regime is observed in Ceka, as shown by the large blooming of *R. cirrhosa* (Calado & Duarte, 2000).

Totoni *et al.* (2010) as experts of the Kune-Vaini-Tale Management Plan (CEIA, 2010) made recommendations on **sustainable tourism**, where the mass tourism was not encouraged. Contrary, not controlled and not sustainable urbanization and mass tourism infrastructures have accelerated continuously in Shëngjini zone (Fig. 10, *left*), close to Kune area. Water pollution, relatively high trophy, was observed either in lagoons or in drainage channels (McCue, 2018; Ramaj, 2019; Qevani & Miho, 2021); unfortunately, even solid waste were ugly sparsed in channels, beach and river delta; microplastics (< 5 mm) were found in all water column and crabs (Cani, 2020; Fig. 10, *right*). Paved road and motor vehicles that move through wetland areas (in Kune, and recently in Vaini) are not environmentally friendly; many experts, i.e. Schonewald-Cox & Buechner (1992), NRC (2005), etc., consider it with adverse consequences for its high native biodiversity, especially waterbirds (Selgjekaj & Bego, 2021).

Figure 10. Wetland habitats in Northern part of Merxhani Lagoon (Shëngjini) and related adverse human impact: ***left***, heavy urbanistion of wetland habitats; ***right***, plastic rubbish sparsed along the lagoon on December, 2020.

Improved and well kept the **hydrological regime and water exchange** is one of the most important determinants of primary productivity, the basis of the biodiversity that the system holds. The biodiversity and primary production would enhance as well, up to higher levels (fish and waterbirds), preventing the dystrophic conditions observed in the lagoons (see Mitch & Gosselink, 2007). Therefore, continuous efforts for keeping the tidal exchange in Kune-Vaini are strongly suggested; hydrological regime would be enhanced, if the existing tidal inlets will constantly deepen and be maintained. Reopening the communication channels between Ceka and Zaje, for a better water exchange between both lagoons, and with Drini delta; reopening the Kulari tidal inlet in Merxhani, and the restoration of Knalla communication with the northern marsh of Merxhani is also suggested. Moreover, the rehabilitation of Drini River (Lezha) would improve better and preserve the lagoonary life; it can be through partial and controlled water divert from Drini in Shkodra (known as Drinasa) to the former Drini River (Lezha).

About 7 hectares of degraded areas including dune rehabilitation have been reforested with *Tamarix* sp., *Pinus* sp., *Quercus robur* and a green fence with *Nerium oleander* (!) (In northern embankments of Merxhani) (GBA, 2017). We strongly support **reforestation**, to prevent erosion, flooding and improve the wildlife in general. **Forest nurseries** must be supported in Lezha, as a long-term practice; it can provide native plant seedlings, and help with large-scale and continuous reforestation activities (Mullaj *et al.*, 2017); volunteering reforestation activities can also be encouraged. Regular collecting and **wastewater treatment** are an emergency, along with the strict control of the wastewater discharge into the surrounding drainage channels or Drini River. **The revision of Kune-Vaini-Tale Management Plan** (CEIA, 2010) is highly recommended, addressing its major concerns, urbanization and tourism, pollution, eutrophication and harmful algae, lagoon tidal inlets, erosion and related hydrotechnical works, Drini rehabilitation, reforestation and plant nurseries, fishing, aquaculture and hunting, etc.

Acknowledgments

The study was part of the Kune-Vaini project (http://kunevain.com/; 2018-2019), funded by UNEP, GEF and the Albanian Government. We greatly appreciate this spirit of cooperation, which not only helped many of our master students of Environmental Biology to have ample material for their theses work, but also because this material helped to know better this important wetland area. We are also grateful for the cooperation and support given by the Administration of the Protected Areas, Lezha.

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Table 1: Submersed macrophytes (algae & grasses) found by Gjata (2019) in Kune-Vaini lagoons. The table follows with checklist of microscopic algae found by Kola (2019) and by Miho & Mitrushi (1999) (marked with *) in plankton samples, and by Qevani (2020) in periphyton samples (marked with **). C, Ceka; Z, Zaje; M, Merxhani; K, Knalla; D, Drini Delta.

Submersed macrophytes (Algae & Grasses)

Chlorophyceae

Chaetomorpha ligustica Kützing, M
C. linum (O.F. Müller) Kütz. - C
Cladophora albida (Nees) Kützing - C, Z
C. vagabunda (Linn.) C. Hoek - C?
Cladophora sp.1 - Z, M
Cladophora sp. 2, 3 & 4 - C
Ulva compressa Linnaeus -M
U. intestinalis Linnaeus - C, Z
U. prolifera O. F. Müller - C, M
U. rigida C.Agardh - C?

Phaeophyceae

Cystoseira barbata f. *aurantia* (Kützing) Giaccone - M

Rhodophyceae

Gracilaria gracilis (Stackho - Z
Gracilariopsis longissima (S. G. Gmelin) Steentoft *et al*. - M
Polysiphonia morrowii Harvey - C, Z, M
P. subtilissima Montagne, M
Polysiphonia sp. - C?

Angiospermae

Ruppia cirrhosa (Petagna) Grande - C
Zostera noltii Hornemann - Z

Microscopic algae

Bacillariophyceae - Centrales

Actinocyclus normanii (W.Gregory ex Greville) Hustedt - C
A. subtilis (W.Greg.)Ralfs - Z, D**
Actinoptychus sp. - M*
Amphitetras antediluviana Her. - Z**, M**
Asteromphalus heptactis (Bréb.) Ralfs - M*
Bacteriastrum delicatulum Cl. - Z, M, K*
B. furcatum Shadbolt - Z, M
Cerataulina pelagica (Cl.) Hendey - M
Cerataulina sp. - C
Chaetoceros affinis Lauder - Z
C. atlanticus Cleve - Z, M
C. atlanticus var. *neapolitanus* (Schröder) Hustedt - M*
*C. convol*utus Castracane - Z (cf.)
C. curvisetus Cleve - Z (cf.)
C. decipiens Cleve - C, M
C. lauderi Ralfs ex Lauder - M (cf.)
C. muelleri Lemmermann - K*
Chaetoceros spp. - C, Z, M, M*
Conticribra weissflogii (Grunow) Stachura-Suchoples & D.M.Williams - C, C**
Coscinodiscus sp. - C, C*, Z, M*
Cyclotella caspia Grunow, C, M, C**
C. distinguenda Hustedt - Z
C. meneghiniana Kütz. - Z, C**, D**
Cyclotella spp. - C, Z
Dactyliosolen blavyanus (H.Per.) Hasle - M*
D. fragilissimus (Bergon) Hasle - C, M*
Guinardia sp. - C, M
Hemiaulus hauckii Grunow ex V. Heurck - M*
Lindavia bodanica (Eulen. ex Grun.) T.Nak. - Guillory - Julius - Theriot & Alvers. - Z (cf.)
Melosira moniliformis C.Agardh - C, C**, Z, Z**, M, M*, M**
M. nummuloides C.Ag. - C, C**, M*, K*
M. varians Agardh - D**
Odontella aurita (Lyngb.) C.Agardh - Z
O. obtusa Kützing - Z**, M** (cf.)
O. turgida (Her.) Kützing - M*, K*
Pantocsekiella comensis (Grunow) K.T.Kiss & E.Ács - C, Z, D**

P. ocellata (Pantocsek) K.T.Kiss & Ács - Z, Z**, D**
P. rossii (H.Håkansson) K.T.Kiss & E.Ács - Z**
Proboscia alata (Bright.) Sund. - C, M, M*, Z
Psammodiscus nitidus (W.Gregory) Round & D.G.Mann - M*
Rhizosolenia imbricata Bright. - Z (cf.)
Rhizosolenia spp. - Z, M
Skeletonema costatum (Grev.) Cleve - C, Z, M
Stephanodiscus medius Håkan. – C, D**
Tertiarius cf. *elgeri* (Hustedt) V.Houk - R.Klee & H.Tanaka - Z
Thalassiocyclus lucens (Hustedt) Håkansson & Mahood - M**

Bacillariophyceae - Pennales

Achnanthes adnata Bory - C, C**, Z**, M, M**, D**
A. armillaris (O.F.Müller) Guiry - C**, Z**, M, M*, M**, D**
A. brevipes var. *intermedia* (Kützing) Cleve - M*
A. lemmermannii Hustedt - D**
Achnanthidium pyrenaicum (Hustedt) H.Kobayasi - D**
Amphipleura rutilans fo. *baltica* Å.Berg - M**
Amphora commutata Grunow - Z**
A. exilitata M.H.Giffen - M**
A. helvetica Ehrenberg - M*, K*
A. holsaticoides T.Nagumo & H.Kobayasi - M** (cf.)
A. lineolata Ehrenberg - M*, K*
A. ovalis (Kützing) Kützing, M*, D**
A. pediculus (Kützing) Grunow - D**
A. robusta W.Gregory - M*
A. strigosa Hustedt - D** (cf.)
A. tenerrima Aleem & Hust. - D** (cf.)
Amphora spp. - C, C*, Z, M, M*
Ardissonea crystallina (C.Agardh) Grunow - C, C**, M**
A. fulgens (Greville) Grun. - C, M, K*
Asterionellopsis glacialis (Castra.)Round - C
Bacillaria paxillifera (O.F.Müller) T.Marsson - C, C*, C**, M, M**, D**
Berkeleya fennica Juhl.-Dan. - C**, M**, D**
Berkeleya rutilans (Trentepohl ex Roth) Grunow - D**
Brachysira estoniarum Witkowski, Lange-Bert. & Metz. - C**, M**, D**
Bracteamorpha trainorii Fuciková, P.O.Lewis & L.A.Lewis (=*Gomphonema olivaceum* var. *salinarum* Pant.) - D**
Caloneis elongata (Grunow) Boyer - Z** (cf.)
Campylodiscus cf. *clypeus* (Ehrenberg) Ehrenberg ex Kützing - Z
Campylodiscus echeneis Ehrenberg ex Kützing - C, C*
Campylodiscus neofastuosus Ruck & Nak. - M*
Catacombas gaillonii (Bory) D.M.Williams & Round - M**, D**
Cocconeiopsis pullus (Hustedt) Witkowski, Lange-Bertalot & Metzeltin - C** (cf.)
Cocconeis molesta Kützing - M** (cf.)
C. krammeri Lange-Bert. & Metz. - M**
C. lineata Ehrenberg - C, C**, Z**, M**, D**
C. neodiminuta Krammer - D**
C. pediculus Ehrenberg - D**
C. placentula Ehrenberg - Z, M**
C. placentula var. *euglypta* (Ehrenberg) Grunow - C*, C**, Z**, M*, M**, D**
C. scutellum Ehrenberg - C**, Z, Z**, M*, M**
C. speciosa W.Gregory - C** (cf.)
Cocconeis sp. - C, Z
Ctenophora pulchella (Ralfs ex Kütz.) D.M.Williams & Round - C*, C**, M**, D**
Cylindrotheca closterium (Ehrenberg) Reimann & J.C.Lewin - C, M*, M**
Cymbella helvetica Kützing - D**
C. tumida (Brébisson) Van Heurck - M**, D**
Diatoma moniliformis Kütz. - D**, Z**
D. tenuis C.Agardh - D**
D. vulgaris Bory gr. - C**, D**
Diploneis caffra (M.H.Giff.) Witkowski, Lange-Bertalot & Metzeltin - Z**
D. notabilis (Grev.) Cl. - C**, Z** (cf.)
D. papula (A. Schmidt) Cleve - Z** (cf.)
D. didymus (Ehr.) Ehrenberg - M*, Z**

D. mirabilis Cleve - C**, M**, D**
D. ovalis (Hilse) Cleve - K*, D**
D. smithii (Brébisson) Cleve - Z**
D. subovalis Cleve - M*
Encyonema ventricosum (C.Ag.) Grun. - D**
Encyonopsis descripta (Hustedt) Krammer - Z**, M**, D**
E. microcephala (Grunow) Krammer - Z**
Entomoneis costata (Hustedt) Reimer - C**
E. paludosa (W.Smith) Reimer - C, C*, Z, D**
Epithemia gibba (Ehrenberg) Kützing - C**, M**, D**
E. goeppertiana Hilse - C
E. pacifica (Krammer) Lobban & J.S.Park - C (cf.)
E. turgida var. *granulata* (Ehrenberg) Brun - M*, K*
E. turgida var. *helvetica* (Ehrenberg) Brun - M*, K*
Fragilaria capucina Desmaz. agg. - C**
Gomphonella olivacea (Hornemann) Rabenhorst, Z**, D**
Gomphonema exiguum var. *minutissimum* Grunow - D**
G. insigne W.Gregory - D**
G. micropus Kützing - D**
G. parvulum Kützing agg. - D**
G. pseudotenellum Lange-Bertalot - Z**, D**
G. pumilum (Grunow) Reichardt & Lange-Bertalot - M**
G. truncatum Ehrenberg - D**
Grammatophora angulosa Ehr. - M*
G. oceanica Ehr. - C**, M, M*, M**
Gyrosigma acuminatum (Kütz.) Raben. - C*, K*
G. attenuatum (Kütz.) Raben. - D**
G. balticum (Ehrenberg) Rabenhorst - C*, Z, M, M*, M**
G. fasciola (Ehrenberg) J.W.Griffith & Henfrey - Z, C**
G. fasciola var. *arcuatum* (Donkin) Cleve - C* (cf.)
G. peisone (Grunow) Hustedt - C**, M** (cf.)
G. scalproides (Raben.) Cleve - Z**
G. strigilis (W.Smith) J.W.Griffin & Henfrey - C* (cf.)
Gyrosigma spp. - C, Z
G. wansbeckii (Donkin) Cleve - C**
Halamphora acutiuscula (Kütz.) Levkov - C**
H. coffeiformis (C.Agardh) Mereschkowsky - C*, C**, Z**, M**, D**
H. holsatica (Hust.) Levkov - M*
Haslea stundlii (Hust.) Blanco, Borrego-Ramos & Olen. (=*Navicula duerrenbergiana* Hust., nom. inval.) - C**, M**
Hyalosira parietina Witkowski - Lange-Bertalot & Metzeltin - M**
Hyalosynedra laevigata (Grunow) D.M.Williams & Round - M**
Iconella helvetica (Brun) Ruck & Nak. - M (cf.)
I. spiralis (Kützing) E.C.Ruck & T.Nakov) - C*
Kolbesia gessneri (Hustedt) Aboal - C**
Lemnicola exigua (Grunow) Kulikovskiy - Witkowski & Plinski - M**
Licmophora abbreviata C.Agardh - M**
L. debilis (Kützing) Grunow - D**
L. gracilis (Ehrenberg) Grunow - C**, M**, Z**
L. remulus (Grun.) Grun. - M*, M**
Licmophora spp. - Z, M
Luticola cohnii (Hilse) D.G.Mann - D**
L. mutica (Kützing) D.G.Mann - M**, Z**, D**
L. mutica var. *ventricosa* (Kützing) P.B.Hamilton - D**
L. muticopsis (V. Heurck) Mann - D**
L. nivalis (Ehr.) D.G.Mann - D**
L. paramutica (W.Bock) Mann - D**
Lyrella clavata (W.Greg.)D.G.Mann - M* (cf.)
L. hennedyi (W.Smith) Stickle & D.G.Mann - Z (cf.)
L. sulcifera (Hust.) Witkowski - M*, K*
Martyana schulzii (C. Brock.) Snoeijs - C**
Mastogloia angulata F.W.Lewis - M*
M. belaensis Voigt - C**
M. pumila (Grun.) Cl. - C**, M**, Z**
M. pusilla Grunow - C
M. robusta Hustedt - C**

M. smithii Thwaites ex W.Smith - Z**
Metascolioneis tumida (Brébisson ex Kützing) Blanco & Wetzel - Z**
Nanofrustulum krumbeinii (A.Witkowski - Witak & K.Stachura) E.Morales - D**
Navicula agatae Witkowski - Lange-Bertalot & Metzeltin - D**
N. antonii Lange-Bertalot - M**
N. arenaria Donkin - C**, D**
N. arenaria var. *rostellata* Lange-Bertalot - C**
N. capitatoradiata H.Germain ex Gasse - D**
N. caterva Hohn & Heller. - Z**, D**
N. cryptocephala Kützing - C**
N. cryptotenella Lange-Bertalot - M**, Z**, D**
N. cryptotenelloides Lange-Bertalot - M**, Z**, D**
N. directa (W.Sm.) Bréb. - C**, D**
N. erifuga Lange-Bertalot - D**
N. gregaria Donkin - C**, Z**, M**, D**
N. mollis (W.Smith) Cleve - D**
N. pavillardii Hustedt - C*, C**
N. perminuta Grunow - Z, C**, Z**, M**, D**
N. phyllepta Kützing - C* C**, D**
N. phylleptosoma Lange-Bertalot - C**, Z**, D**
N. radiosa Kützing - Z**, D**
N. ramosissima (C.Agardh) Cleve - C**, M**, D**
N. recens (Lange-Bertalot) Lange-Bertalot - Z**, D**
N. reichardtiana Lange-Bertalot - D**
N. salinarum Grunow - C**, M**, Z**, D**
N. salinarum f. *minima* Kolbe, C**, D**
N. salinicola Hustedt - Z**
N. schroeteri F.Meister 1932, D**
N. tripunctata (O.F.Müller) Bory, Z, M**, D**
N. vandamii var. *mertensiae* Lange-Bertalot - Z**, M**, D**
N. veneta Kützing - M**, D**
Navicula sp., C, Z, M
Nematoplata virginica Kuntze (=*Fragilaria laevis* Ehrenberg, nom. illeg.) - C, M**, D**
*Nitzschia acic*ularis (Kütz.)W.Sm. - C* (cf.)
N. amundonii Aleem - M**
N. angularis W.Smith - M
N. brevissima Grunow - D**
N. filiformis (W.Smith) Van Heurck - D** (cf.)
N. improvisa Simonsen - C** (cf.)
N. prolongata Hustedt - M** (cf.)
N. coarctata Grunow - C*
N. dissipata (Kütz.) Grunow, Z**, D**
N. distans W.Gregory - D**
N. fusiformis Grunow - C**, M**
N. incognita Legler & Krasske - M**
N. incospicua Grunow - C**, Z**, M**, D**
N. kurzii Rabenhorst - M**, D**
N. lacuum La.-Bert. - C**, M**, D**
N. linearis (Agardh) W. Smith var. *linearis* - M**, D**
N. longissima (Brébisson) Ralfs - Z, M, M*, M**
N. palea (Kützing) W. Smith var. *palea* - C**, D**
N. pellucida Grunow - M**
N. perminuta Grunow - Z**, D**
N. perspicua Sovereign - D**
N. pusilla Grunow - D**
N. reversa W.Smith - C, C*, K*, Z, M, M*, M**
N. scalpelliformis Grunow - C, C**, Z**, D**
N. sigma (Kützing) W.Smith - C**, M**, Z**
N. sigma var. *sigmatella* Grun. - C*, M*
N. sigmoidea (Nitz.) W.Sm. - C, Z, M
Nitzschia valdecostata Lange-Bertalot & Simonsen - D**
Odontidium mesodon (Kütz.)Kütz. - M**
Opephora mutabilis Sabbe & Wyverman - C**, Z**, M**
Petrodictyon gemma (Ehr.)Mann, C, Z
Petroneis humerosa (Brébisson ex W.Smith) Stickle & D.G.Mann - M*
Pinnularia borealis var. *rectangularis* G.W.F.Carlson - D**
Placoneis elginensis (W.Greg.) - C** (cf.)
Pleurosigma angulatum (J.T.Quekett) W.Smith, C, C*, C**, Z, M, M*, M**

P. elongatum W.Smith - C, C*, C**, Z, M*, K*,
P. longum Clev - M (cf.)
P. formosum W.Smith - M*, M**
P. salinarum (Grun.) Grunow, C**, M**
Pleurosigma spp. - C*, M*
Pleurosira laevis (Ehr.) Compère - M**
Pseudo-nitzschia delicatissima (Cl.) Heid. - Z
P. seriata (Cleve) H.Peragallo - Z, M, C*
Pteroncola inane (Giffen) Round - M**
Rhabdonema adriaticum Kütz. - Z, C*, M*, K*
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot - D**
R. linearis Østrup - D**
Rhopalodia brebissonii Kram. - C**, Z**, M**
R. constricta (Brébisson) Krammer - C, C**, Z**
R. musculus (Kützing) O.Müller - C, C*, C**, Z, Z**, M, M**
Sellaphora pupula (Kütz.) Mereschk. - Z**
Seminavis basilica Danielidis - C**
S. strigosa (Hustedt) Danieledis & Economou-Amilli - D**
Stauroneis phoenicenteron (Nitzsch) Ehrenberg - Z**
S. plicata C.Brockmann - Z** (cf.)
Staurosira leptostauron (Ehrenberg) Kulikovskiy & Genkal - M**
Staurosirella pinnata (Ehrenberg) D.M.Williams & Round - C**, D**
Striatella unipunctata (Lyngbye) C.Agardh - C, M, M*, M**
Surirella angusta Kützing - D**
S. brebissonii var. *kuetzingii* Krammer & Lange-Bertalot - C**, D**
S. fluminensis Grunow - C
S. librile (Ehrenberg) Ehrenberg - D**
*S. rec*edens A.W.F.Schmidt - M* (cf.)
S. robusta Ehrenberg - D** (cf.)
S. striatula Turpin - C, C*, M**, D**
Surirella sp. - C, Z
Tabularia fasciculata (C.Agardh) D.M.Williams & Round - C**, M**, Z**, D**
T. helvetica (C.Agardh) D.M.Williams & Round - C, C*, Z
T. parva (Kützing) D.M.Williams & Round - Z**
T. tabulata (C.Agardh) Snoeijs - M*, C**, Z**, M**, D**
Thalassionema nitzschioides (Grunow) Mereschkowsky - Z, M, C*
Toxarium undulatum Bailey - M, K*, M**, D**
Trachyneis sp. - Z
Tryblionella apiculata W.Gregory - C*, C**, M**, Z**, D**
T. circumsuta (Bailey) Ralfs - C*
T. coarctata (Grun.) D.G.Mann - C*, M**
T. compressa (Bailey) Poulin - C, C*, C**, Z, M*, D**
T. granulata (Grunow) D.G.Mann - C**, M**, Z**
T. lanceola Grunow - D**
T. levidensis W.Smith - D**
T. pararostrata (Lange-Bertalot) Clavero & Hernández-Mariné - C**
Ulnaria acus (Kützing) Aboal - M**, D**
U. ulna (Nitz.) Compère) - C*, M*, D**

Chlorophyceae

Chlorococcale - C
Gonium pectorale O.F.Müller (cf.) - M
Scenedesmus quadricauda (Turpin) Brébisson - Z (cf.)
Sphaerocystis sp. - C

Chrysophyceae

Synura sp. (*Synura uvella* Ehrenberg) - C

Dinophyceae

Akashiwo sanguinea (K.Hirasaka) Gert Hansen & Moestrup - M (cf.)
Ceratium hirundinella (O.F.Müll.) Duj. - C, M
Dinophysis acuminata Claparède & Lachmann - C (cf.)
D. ovum F.Schütt - C
D. sacculus Stein - C, Z, M
Dinophysis sp. - C, Z, M
Gonyaulax monacantha Pavillard - C*
G. spinifera (Claparède & Lachmann) Diesing - C, Z

Gonyaulax sp.1 & 2 - C
Gymnodinium sp. - K*
Peridinium sp. - C, C*, Z, M
Prorocentrum cordatum (Ostenfeld) J.D.Dodge - C, C*, Z
P. micans Ehrenberg - C, C*, Z, M
P. scutellum B.Schröder - Z (cf.)
Prorocentrum sp. - C, M
Protoperidinium divergens (Ehr.) Balech - C
P. steinii (Jørg.) Balech - C
Protoperidinium sp. - C, M
Scrippsiella acuminata (Ehr.) Kretschmann - Elbrächter - Zinssmeister - S.Soehner - Kirsch - Kusber & Gottschling - C

Euglenophyceae

Euglena sp. [*Euglena viridis* (O.F.Müller) Ehrenberg] – C

Pyramimonadophyceae

Pyramimonas spp. - C

Cryptophyceae

Rhodomonas spp. - M

Cyanobacteria

Anabaenopsis circularis (G.S.West) Woloszynska & V.V.Miller - K*
Oscillatoria princeps Vauch. ex Gom. - C, Z (cf.)
Oscillatoria spp. C, Z, M, K*
Phormidium sp. - C
Spirulina sp. - C,