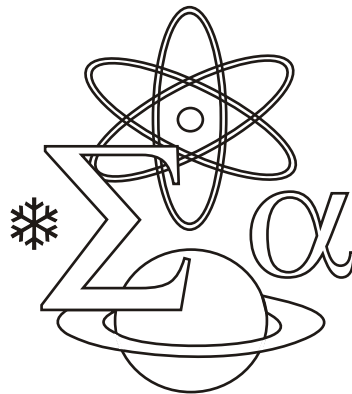


# AJNTS

ALBANIAN  
JOURNAL OF  
NATURAL AND  
TECHNICAL  
SCIENCES



2021 (2)  
XXVI (53)

PUBLISHED BY ACADEMY OF SCIENCES OF ALBANIA



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This Journal is a multidisciplinary publication devoted to all field of Natural and Technical Sciences. The Editor of JNTS invites original contributions which should comprise previously unpublished results, data and interpretations. Types of contributions to be published are: (1) research papers; (2) shorts communications; (3) reviews; (4) discussions; (5) book reviews; (6) announcements.

## ISSN 2074-0867

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## **1ST INTERNATIONAL CONFERENCE ON WATER ENVIRONMENTAL PROTECTION AND SUSTAINABLE DEVELOPMENT (WEPSD) GIVES A MAJOR BOOST TO SCIENTIFIC RESEARCH AND ITS APPLICATION IN THE ECONOMY**

The 1ST International Conference on Water Environmental Protection and Sustainable Development (WEPSD) was organized in Tirana aiming to promote the importance of this science area to the Albanian economy.

Held in Tirana from 17-18 May 2021 it was organized by the Albanian Academy of Sciences, GEF Adriatic, European Biotechnology Thematic Network Association (EBTNA), Balkan Environmental Association (B. EN.A), COST Action 18238 (Ocean4Biotech) and University of Tirana, Albania and welcomed nearly one hundred participants from different European countries and beyond.

The primary objective of WEPSD was the future of environment and its relations with the wellbeing of the society. Consequently, it aimed to invest in future science leaders and innovation; influence properly policy making with the best scientific advice and invigorate science and further education in the field. In addition, it aimed to increase access to the best scientific solutions. Many of the issues tackled require collaboration among the scientists, and among scientists, state institutions and private enterprises. The backbone of the conference was the transboundary collaboration and active participation of the young generation of scientists and multidisciplinary researchers for the benefit of society—what might be called “a good science”. The scientific expertise presented by highly talented scientists, managed to combine a number of qualities: in-depth knowledge, creativity, awareness of the values of science and proper research, motivation, and effectiveness in reaching the goals of the event.

The two-day program of the conference was finalized with a field trip in Divjaka National Park.

The technical program of conference included 64 oral and poster presentations in the following areas:

### ***1. Marine and Freshwater Ecology***

- Aquatic flora, fauna, microbiome & Interactions among them.

- Quality of waters (chemical, physical, biological parameters) & Impact on biome.

- River ecosystems-challenges in 21st century
- Marine and Coastal ecosystems-their services and threats
- Understanding and efforts towards Good Environmental Status (GES)
- Marine Ecology research
- Data tools and management

## **2. *Water Pollution***

- Categories of pollutants and Potential sources
- Methodologies for detection and characterisation of pollutants & problematics related.

- Monitoring systems
- Risk Assessments
- Legislation related to monitoring and management of water pollution

## **3. *Climate Changes, Water Environmental Protection & Sustainable Development***

- Climate change impacts on lagoon ecosystems and Ecosystem-based Adaptation

- Management of Aquatic Protected Areas
- Actual Water Legislation and Gaps, Implementation of Water Framework Directive

- Management of the coastal and marine environment-an ecosystem approach towards sustainable development of the area

- Aquaculture & Marine Biotechnology
- Environmental Education/Training

## **4. *Maritime spatial planning***

- Blue economy for the 21st century
- Cross sector integration through MSP
- Ecosystem approach and MSP
- Data for marine planning and management (data creation, sources of data, data storage, data sharing, modelling)

- Addressing the land-sea interactions in MSP
- Integrating Climate Change aspects into MSP
- Stakeholder Involvement in MSP
- Transboundary MSP cooperation experiences

Prof. Dr. Ariola Bacu  
Blerina Shkreta

## **DRINKING WATER AND HEALTH HAZARDS: AN OVERVIEW**

**Klodiola DHAMO**

Aldent University

**Amilda BALLATA and Lauresha SHABANI**

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### **ABSTRACT**

Biological contamination remains the most significant public health risk associated with drinking water even in industrialized countries. High potential for organic chemical transport to drinking water continues to exist even with source protection because of the multitude of chemical types and quantities. Drinking water is usually not a unique source nor the most significant contributor to total exposure from synthetic organic chemicals but it might be one of the most controllable. The major public concern with drinking water contamination has been possible contribution to cancer risks from organic micropollutants. Even though the actual risks are probably small in most cases it is clearly within the public interest to prevent adulteration of water supplies and to protect their quality for the future so that these concerns or risks can be avoided. Water consumption patterns and the relative importance of the drinking water exposure route show that inorganic water contaminants generally contribute much more to the total daily intake than organic micropollutants. An exception is chloroform and probably the group of typical chlorination by-products. Among the carcinogenic organic pollutants in drinking water only chlorination by-products may potentially increase the health risk. Treatment should therefore be designed to reduce chemical oxidant application as much as possible. As disinfection is the central issue of the present water treatment practice the search for the ideal disinfection procedure will continue and might result in a further reduction in the use of chemical oxidants.

**Keywords:** drinking water, organic micropollutants, chemical oxidant, environment; health risk

## 1. INTRODUCTION

Drinking water organics have been handled in a way that may seem somewhat overdone to those dealing with air or soil contamination but it also provides the most sophisticated examples of how environmental problems can be tackled. The studies on drinking water quality is the most advanced branch of environmental research (Cotruvo *et al.* 2014).

Currently, there is a long list of environmental concerning issues such as acid deposition abatement, introduction of cleaner and less noisy vehicles, disposal of toxic chemical wastes, nuclear energy or renewable energy sources, clean-up of contaminated soil and sediment, which will expand in the future with other issues such as greenhouse effect due to CO<sub>2</sub>, changes in the ozone layer, indoor-air pollution and, nuclear winter (Zoeteman *et al.*, 2005; Trehy *et al.*, 2016). All these problems need to be politically addressed to and investments. Against this background drinking water obtains a low priority, maybe a too low priority. The ultimate environmental calamity is the use of nuclear weapons followed by a further environmental catastrophe. Estimates by Sagan (1983/1984) show temperature drop, varying from 5-50-C in the Northern Hemisphere during periods of 4-12 months, depending on the severity of the nuclear exchange. Such a calamity would of course by far outweigh all other environmental issues mentioned before and for the first time environment starts to become a significant factor of strategic defense planning (Loper, 2003; Kreijl *et al.*, 2004). Our existence on this planet would actually be at risk. We feel threatened externally by toxic vapors, acid rain and eventually a fatal darkening of the sky and internally by coronary heart disease, cancer, viruses and AIDS (Kool *et al.*, 1998; Zoeteman *et al.*, 2002;2006). Within this context we have to look at our problem of today as society feels all these stresses and has to decide to what extent money will be allocated on this particular problem. In comparison with other environmental issues much money has been spent on the study of drinking water organics. This is due to the recent discovery of the occurrence of these compounds in the drinking water, to our wish that drinking water must be absolutely safe and to the traditionally excellent organization of the water supply industry (Chek *et al.*, 1980; Williamson *et al.*,2015). It could be stated that advanced analytical techniques and extremely sensitive epidemiological and toxicological methodologies have been developed and applied to study drinking water quality.

## 2. MATERIALS AND METHODS

A literature analysis has been made. Quality of water consumed requires assessment of the relative importance of the drinking water exposure route. The recently published WHO guidelines for drinking water quality (2011) supporting information which can be used to derive for most of the substances mentioned the relative contribution of drinking water to the total daily intake. Based on this WHO document and some additional publications a survey has been composed and presented. We measured the relative contribution of some drinking water contaminants in the mean daily intake (the estimated mean daily intake for the most frequent substances present in the drinking water) (WHO, 2011), such as some inorganic contaminants (Al, As, Be, Fe, Se, Ag, Ba, Cd, Cr, Mn, Hg, Ni, Na, SO<sub>4</sub>, Cl, Ca, F, Pb, Mg, NO<sub>3</sub>) and some organic components (Chloroform, Trichloroethene, Benzo(a)pyrene, DDT, Vinylchloride, Benzene)

## 3. RESULTS AND DISCUSSIONS

Table 1 summarizes the data, and shows that practically all known organic micropollutants in drinking water contribute less than 1% to the total daily intake of these compounds. The inorganic contaminants seem to be of much greater interest for human health, particularly fluoride, lead and magnesium. The only exception among the many organics is *chloroform* (Table 2). Generally speaking, these compounds are of interest when having water quality manipulated either by chemical treatment or distribution through piping materials that release compounds. Lead is a good example of the latter, and chloroform is an indicator for the total group of halogenated by-products, such as halophenols, halo-acids, haloacetonitriles etc. which are probably mainly ingested via the drinking water route. Table 2 also shows that with the exception of the volatile halogenated organics for which air is the major exposure route, food is always the most important contributor to the daily intake. Exposure to inhalation can also be traced back for some organics to indoor tap water use (Anderson 2015; Haring *et.al.*, 2019). This shows the need to look at these problems in an integrated way. Since adequate water treatment techniques have been developed and applied the past decades industrial organic micropollutants present in raw water sources are generally sufficiently removed to make the drinking water exposure neglectable.

**Table 1.** Survey of the relative contribution of drinking water contaminants to their mean daily intake by man

< 0.1	0.1 - 1.0	1.0 - 10	> 10
	Al, As, Be, Fe, Se, Ag	Ba, Cd, Cr, Mn, Hg, Ni, Na, S04, Cl	Ca, F, Pb, Mg, NO3
Vinylchloride Aldrin/Dieldrin Chlordane, DDT, Hexachlorobenzene Heptachlor(epoxide) Lindane Benzene	Carbon tetrachloride, 1,2 Dichloroethane, Tetrachloroethene, Benzo(a)pyrene	Trichloroethene	Chloroform

*Contribution range (%) of drinking water contaminants to the mean daily intake*

**Table 2.** Main exposure routes for some drinking water contaminants

Substance	% contribution to total intake			
	Drinking water	Food	Air	Smoking
Fluoride	50	50	< 1	-
Lead	32	65	3	-
Magnesium	29	71	< 1	-
Calcium	16	83	< 1	-
Chloroform	15	77	8	-
Nitrate	14	85	< 1	-
Trichloroethene	1	5	94	-
Benzo(a)pyrene	1	87	4	8
DDT	< 1	100	< 1	-
Vinylchloride	< 1	5	95	-
Benzene	< 1	56	44	-

#### 4. CONCLUSIONS

We suggest the new approaches in public water supply be included in environmental policies. Due to the mature status of the water supply industry most of its problems can be handled in the quiet atmosphere of solid cost-benefit optimization studies. A good example was recently presented by Cotruvo (2014) in relation to the cost of chloroform reduction and the benefit

of less cancer treatment costs. Standard setting procedures and inclusion of other exposure routes were applied for drinking water quality in the early stage. Risk assessment methodologies have surprisingly developed for the relative small risks associated with drinking water. Nowadays they obtain already a wider application in the assessment of air pollutants and soil pollutants. Similar trends can be described for the handling of the exposure to radioactive materials, which subject obtains much attention but generally results in smaller risks than those caused by recent environmental problems. In both cases it is the large existing organization that more or less autonomously creates further refinements in the scientific approaches. One of the major benefits of this achievement will be the use of the water supply experience for other environmental problems that have nowadays a high priority (Bock *et. al.*, 2019). Water supply experts can therefore move to other areas of environmental research and policy making. The case of water chlorination has shown the validity of the rule that pollution should be treated as close as possible to its source (Slooff *et.al.*, 2004). Waste water containing enteric bacteria and viruses should therefore be mainly treated before discharge into our water sources (Fiessenger *et. al.*, 1995). Finally, micropollutants released by coatings, plastic pipes and bacterial after-growth in the distribution systems are of great interest.

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## **MAINSTREAMING OF ECOSYSTEM-BASED ADAPTATION INTO SPATIAL PLANNING - ANALYSIS OF INCLUSION OF EBA IN TERRITORIAL PLANS AND PRACTICES IN ALBANIA**

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### **ABSTRACT**

Ecosystem-based Adaption (EbA) was officially defined in the Convention on Biological Diversity (CBD) in 2009 as the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change. The concept of mainstreaming climate change adaptation to foster sustainable urban development and resilience is receiving increasing interest. Adapting to climate change within the coastal environment include options that use infrastructure ('hard' adaption), biodiversity and ecosystem services as part of an overall strategy (ecosystem-based adaptation), or hybrid options techniques of intervention. Up to now researches have shown that conservation and restoration through the mainstreaming EbA as a specific adaptation program not only can lead to risk reduction, but also foster environmental, economic and social benefits. The data here used are obtained literature review and web survey of different national, local institutions websites. In existing territorial plans and instruments, even when considering the role of ecosystem or adaptation, finding entry points for EbA in regulation, policy and planning frameworks remain an ongoing challenge. This study presents theoretical investigation on mainstream EbA level into the territorial planning process. A detailed classification involves land use regulatory planning and strategy of twelve coastal municipalities in Albania, their approach to EbA measures. This study demonstrates that the adaptation mainstreaming in general and the mainstreaming of EbA in particular, are still in their infancy in Albania planning process.

**Keywords:** ecosystem-based adaption, territorial planning, climate change, risk reduction

### **1. INTRODUCTION**

Mainstreaming referring climate change adaptation, means integrating climate concerns and adaptation responses into relevant policies, plans,

programs, and projects at the national, sub-national, and local scales (USAID 2009; 47).

Albania's membership to the United Nations Framework Convention on Climate Change (UNFCCC)-Paris agreement ratified on September 21, 2016, and Kyoto Protocol since April 01, 2005 with the status of Non-Annex 1 Party, provide the basis for actions on climate change adaption. As a developing country Albania has no obligation toward reducing the quantity of greenhouse gas emissions, but is committed to implementing the 'National Appropriate Mitigation Actions'-NAMAs. While carrying little responsibility for global greenhouse gas emissions, Albania is bearing the majority of the environmental, social and economic consequences caused from climate change (UNDP 2020).

The Third National Communication of Albania to the United Nations Framework Convention on Climate Change Project finalized in 2016, and includes the climate change scenarios, assessment of climate related risks and adaptation with focus on biodiversity, water resources, agriculture, forestry, population and health for the entire coastal region. The Fourth National Communication of Albania is to be submitted by the end of 2022, and the First Biennial Report in 2021 (UNDP 2020).

Albania adherence to Barcelona and Ramsar Convention prioritized the principles of Protocols to be included in relevant legislation concerned with protected areas and environment. Thus, Protocol ICZM Article 6- referring ecosystems approach to coastal planning and management shall be applied so to ensure the sustainable development of coastal zone. Albania Adaptive Plan (NAP) process launched in 2015, as a national adaptation strategy and mainstreaming related to climate change include two action plans—the NAP document and the national mitigation plan NMP, which was expected to be adopted in 2018, but is yet to be approved. Meantime, the Law on Climate Change was approved in December 2020.

Referring to the national legislative framework, mainstreaming of EbA concept in Albania is somewhat chaotic as there are over 40 separate pieces of legislation and some 50 agencies which address environmental matters (EbA guidelines 2018). EbA is a new approach for urban climate change adaptation and little is known about the degree to which it is integrated into existing planning processes.

## **2. MATERIALS AND METHODS**

In the present study data collected from available sources were used. Qualitative data were used for the documents review, process analysis, constant consultancy with all the stakeholders involved in. The study was conceived in two main pillars: i) identification and analysis of current

Territorial Plans in relation with ecosystem intervention approach, by providing information of the General Local Plans of twelve coastal municipalities, Strategy and Maps, Detailed Plan for Area of National Importance, approved or in process, sectorial, regional and other plans in force that involve the coastal area and ii) results showing the degree of EbA integration in Spatial Planning Instruments related to Territorial Planning activities. Discussion of findings aims to draw attention to central and local institutions for the poor involvement of EbA solution, fostering the need to establish as soon as possible specific EbA guidelines in the territorial planning process.

### 3. RESULTS

The coastal zone has already shown to be sensitive to the impacts of climate change with consequent degradation of coastal ecosystems (particularly sand dunes, lagoons, wetlands and river deltas) and saltwater intrusion in freshwater systems. According to The Third National Communication of Albania to UNFCCC, the ecosystem coastal zone is one of the most vulnerable area which is divided into 5 sectors i) Drini-Mati; ii) Rodon Cape-Turra Castle; iii) Shkumbin-Seman discharges; iv) South coast, and v) Butrinti areas.

Based on the Law no. 107/2014, dated 31.07.2014 “On Planning and Territorial Development (amended)”, national and general territorial spatial plans are developed. The General National Spatial Plan (GNSP 2016) is defined as the paramount instrument of territorial planning in Albania, which addresses planning issues in an integrated manner, considering the Albanian territory as a whole (NTPA 2016). One of the main objectives of GNSP is to protect, regenerate and promote the sustainable use of ecosystems. Regarding the coastal system GNSP has established the **Blue Line** to protect, monitor and regenerate the natural corridors of water flow. There is a range of guidelines dealing with ecosystem services, climate related risks and disasters regarding precipitation and temperatures. Among inputs, solution applying all-inclusive legislation framework to ensure the integration of adaptation and mitigation in territorial planning and terminology like 'smart and environmentally friendly development' are suggested, but no explicit EbA mention is found. As part of National Spatial Planning Instruments, Integrated Cross Sectoral Plan for the Coast (ICSPC) 2016, give an important guideline on the utilization along the Coastal Belt based on a wide legal framework and international experience, with no mission in showing detailed development condition (NTPA 2016). Identified measures to be taken against climate changes are based on the concept of mitigation and adaptation. The term 'ecosystem-based adaptation' is not used yet, but initiative as reforestation,

planting trees in endangered areas, using ecological materials are encouraged. Alternative terminology such as 'green corridors' and 'infrastructural sensitiveness' is suggested. The adaptation discourse is highly focused on water related hazards. Like GNSP, ICSPC inputs in national and local level suggested infrastructural intervention to protect the coastline system.

Referring to the Detailed Plan for the Area of National Importance (DPANI), most of them are currently found in the drafted format, and are soon to be approved (MTE 2020). Table 1 shows that EbA mainstreaming is here missing. DPANI 'Karavasta Lagoon-Seman River' approved in 2018, support environmental protection and increase local economy. Interventions with adaptation co-benefits came out of environmental planning defense approach like planting trees *pinus-pinia* along the shore of Karavasta lagoon. The 'aquaponics farm' and fruit growing plantation, two strategic investments, have been approved based on sustainable economic solution where metabolic production of fishes is used to feed plants, thus reducing CO<sub>2</sub> emissions after carbon dioxide emitted by fish is exploited by plants in photosynthesis process. Despite this, no reference of EbA concept has been found, even though erosion hazard is threatening this area.

'Building the resilience of Kune-Vaini Lagoon through ecosystem-based adaptation', with EbA technical Guideline and Protocols Report (KUNEVAIN 2018), and Climate Change Adaptation in Drini-Mati Delta and beyond (UNDP 2013), two important projects, show that EbA approach is known. From a Local Planning point of view, no guidance exists about EbA being incorporated into the Territorial Plans (Table 1). In general land use planning instruments represents the involvement of adaptive measures using mostly hard infrastructure intervention, because the costs are easier to be calculated and the impact effects are short-lived.

**Table 1.** Mainstreaming of EbA concept in Territorial Planning Instruments of coastal municipalities December 2020

National Plans			Local Territorial Plans / Coastal Municipalities	Eba approach	Detail Plan (DPANI)	DPANI Phase			Eba	Other Project	Eba approach	
						in process	Approved	Implement				
General National Spatial Plan 2015-2030	ICSP Hiras- Durres	Integrated sectoral plan for the Coast	DIVJAKA	No	Karavasta Lagoon River Seman		revised		No	Management Plan Porto Palermio-L. Iannani (2015)	action relate to sustainable use of ecosystem	
			DURRES	Territorial plan in process	Mandatory Local plans			No				
			FIER	No, but action used for ecosystem protection								
			HIMARE	No								
			KAVAJA	No								
			KONISPOL	No								
			KURBIN	No	Gryke derdhja Ishëm				Climate Change Adaptation in Drini-Mati Delta 2008-2013	Yes		
					Rana e Hedhur - Port of Shengjin			No				
			LEZHA	No	Kune- Vain Lagoon						Building the resilience of Kune Vain Lagoon through EbA 2018	Yes
					Tale							
			RROGOZHINE	No	Spille				Integrated management plan Butrint 2020-2030 Buna management plan 2016-2025	action for sustainable use of ecosystem		
			SARANDE	No								
			SHKODER	No	Buks- Rrjoll			No				
			VLORE	No	Narte Lagoon							
National Adaptive Plan					Not Approved yet							

#### 4. DISCUSSIONS

Different initiatives have taken place in the framework of Territorial Planning of coastal municipalities and beyond. It is noted that the Mainstreaming of EbA in Albania is not included in the General Local Plans or DPANI, but in the heading line 'protect and ecosystem', focusing on disaster risk approach where technical solution dominates. EbA has already been incorporated in informal planning, but the coordination between management plans and local development strategies seems to be distant. There is little cooperation between local land use planning and national spatial plans on providing entry point to EbA. Many stakeholders are unfamiliar with EbA as an alternative and predominately use efforts to adapt to climate phenomena via 'hard' infrastructure measures in local investment due to short-time frames, regardless the high costs. In local level organizational structures and financial budget allocation for adaptation to climate change are poorly developed or inexistent. The Mainstreaming of EbA cannot be effective by separate initiatives, but ongoing policy-making, planning and activities across all sectors (Olhoff and Schaer, 2010). Entry points of EbA should be clearly defined at national and sectorial level to provide an enabling framework in local planning implementation.

Developing EbA interventions applicable to the territory planning process is challenging. Given the difficulties in identifying, monitoring and evaluating financial resource, and technical capacity, further research and collaboration is needed.

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## **EVALUATION OF THE ENVIRONMENTAL STATE AND HUMAN HEALTH RISK DUE TO HEAVY METALS CONTENT IN THE WATERS OF THE KUNE-VAINI COMPLEX LAGOONS, ALBANIA**

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### **ABSTRACT**

The heavy metals content in the waters of Kune-Vaini Lagoon and the impact on the human health is here evaluated. Water samples were collected in different periods and from five selected stations of the Kune-Vaini complex for the spatial and temporal distribution of heavy metals concentration. The Atomic Absorption Spectroscopy technique employing electrothermal atomization, GF-AAS was used for the concentration of heavy metals. The extent of metal pollution in the lagoon water was evaluated by comparing the obtained results with the recommended criteria of heavy metals in surface waters, and by calculating some of the most used indexes of the contamination level, such as the Heavy Metal Evaluation Index (HEI); the Contamination Degree Index (CdI) and Water Pollution Index, WPI. Assessment of health risk due to heavy metals in surface water was estimated with regard to dermal contact and ingestion, as the two main routes of humans exposed to heavy metals according to the USEPA (2004) guidelines. The obtained results showed that the average concentration of heavy metals in selected waters followed the order: Fe>Cu>Cr>Mn, while the concentrations of Pb and Cd were below the limit of detection of the method (LOD). Concentration of heavy metals present in waters of the lagoon was below the recommended value as based USEPA, (2001) standards. The waters belong to the moderately polluted to highly polluted class with regard to Cu and to the moderately polluted class with regard to Cr, based on the NIVA (2000) classification. Health risk assessment analysis suggested that the presence of heavy metals in waters of Kune-Vaini complex show minimum hazard effect on human health.

**Keywords:** heavy metals, water, pollution indexes, health risk assessment, GF/AAS

## 1. INTRODUCTION

Water contamination with heavy metals have been the main focus of many environmental studies performed in the recent decades as they are considered as severe pollutants due to their toxicity, persistence and bioaccumulation in the living organisms [1]. In surface waters, heavy metals are present in a wide range of physico-chemical forms, both in particulate and dissolved phases [2]. Some heavy metals such as copper (Cu), cobalt (Co) and zinc (Zn) are considered to be essential for the aquatic living organisms and humans and others like cadmium (Cd), chromium (Cr), manganese (Mn), and lead (Pb) are considered to be highly toxic [2,3]. Heavy metals enter into human body through several pathways including food chain, dermal contact and inhalation [4]. Estimation of the health risk of certain hazardous substances, including heavy metals usually is based on the degree of the consumption of that substance [5,6]. Commonly, health risk evaluation is based on the comparison of the estimated concentrations with the recommended guidelines for a certain element in the selected environment but this is not sufficient as it can't provide adequate information on the hazard level as well as on the most important contaminant[7,8,9].The most used methods of health risk assessments with regard to human exposure to different contaminants in the environment are based on the US Environmental Protection Agency, USEPA (USEPA, 2004) recommendations[10].The present study primary aimed to evaluate the environmental state of the Kune Vaini lagoons system waters due to temporal and spatial distribution of heavy metals, and identify the polluted sites and periods which can originate such levels of heavy metals posing any health risk to humans. Among the determined metals were Lead (Pb), Chromium (Cr), Cadmium (Cd), Copper (Cu), Iron (Fe) and Manganese (Mn).

## 2. MATERIALS AND METHODS

### Sampling of water samples

Table 1 informs about the five sites selected for water monitoring on the Kune-Vaini lagoon, with a frequency of every two months, from July, 2018-July, 2019.Field trips were organized in joint groups made up of some eminent personalities in the realm of botany, zoology and chemistry from the Faculty of Natural Sciences, University of Tirana, Albania. The ISO 5667-1:2006 standard method was applied for sample collection [7]. The representative water samples (1 L each) were collected from surface water in cleaned plastic bottles, pre-washed with 20% nitric acid ( $\text{HNO}_3$ ) and deionized water. Samples were filtered *in situ*, and a few drops of  $\text{HNO}_3$  were

added before samples transport to the laboratory. Samples were stored in a refrigerator at 4 °C till the day of analysis.

**Table 1.** Sampling stations

Station	Station information
Ceka 1	Ceka, northern part, Lezha.
Ceka 2	Ceka, central part, in front of the new communication tidal channel,
Ceka 3	Ceka, southern part, Lezha.
Zaje 1	Zaje close to the communication channel with the Drini River, Lezha.
Merxhani	Merxhani, at its southern part, in front of tidal channel near Kune, Shengjini.

### **Procedure of heavy metals determination**

All filtered and acidified samples were analyzed for metals (Cu, Fe, Cr, Mn, Pb, Cd) via atomic absorption spectroscopy technique, with electrothermal atomization, AAS/ETA [13]. All samples were analyzed in triplicates together with standards and blanks. Quality control of the obtained results was carried out by analyzing a Certified Reference Material (CRM) for the content of heavy metals in water such as the CRM SPS WW-14. Statistical treatment of the obtained results was carried out by using MINITAB 19 and the Excel Analysis Tool Pack. Basic statistics such as mean and standard deviation were computed along with the descriptive statistics. Boxplot were used to evaluate the spatial and temporal distribution of each metal in selected stations.

### **Pollution assessment indices**

Several standards with regard to the recommended limits of heavy metals in surface waters were employed to determine the pollution status of waters of the Kune-Vaini System lagoon such as the USEPA Water Quality Standards [14] and the Norwegian Institute for Water Research classification [15]. Besides that, the water quality was evaluated by using also different pollution indices, including Heavy Metal Evaluation Index (*HEI*) and the Contamination Degree Index (*CdI*). Accordingly, *HEI* presents the overall surface water quality with respect to heavy metals content and is computed by using the following equation [12]:

$$HEI = \sum_{i=1}^n \frac{Mi}{MACi}$$

where  $M_i$  and  $MAC_i$  are the monitored value and maximum admissible concentration of the  $i^{th}$  metal, respectively. Classifications of surface water quality based on  $HEI$  values are:  $<10$  for low pollution;  $10 - 20$  for moderate pollution and  $>20$  high pollution. Whilst, the Contamination Degree Index  $CdI$  indicates the overall detrimental impact of the HMs on surface water [12], and it is determined according to formula:

$$CdI = \sum_{i=1}^n Cfi \text{ where } Cfi = \frac{Mi}{MACi} - 1$$

where  $Cfi$  is the contamination factor for the  $i^{th}$  metal. The categories used to represent pollution due to heavy metals on the basis of  $CdI$  are:  $<1$  for low,  $1-3$  for moderate and  $>3$  for high pollution of in the surface water body [12].

### Human health risk assessment

Exposure determination was estimated by involving the average daily dose exposure value of a human body to a certain metal. The key exposure routes include direct ingestion and dermal absorption. We have determined exposure by employing ingestion and dermal routes since these are the two important routes of heavy metals exposure from an aquatic ecosystem [16]. The exposure assessment was computed as:

$$ADD_i = \frac{Ci \times IR \times EF \times ED}{BW \times AT} \quad ADD_d = \frac{Ci \times SA \times Kp \times ET \times EF \times ED \times CF}{BW \times AT}$$

The non-carcinogenic risks were determined by applying the hazard quotient ( $HQ$ ) of USEPA [16]. The sum of the non-carcinogenic risk of an individual metal is presented as the Total Hazard Index ( $HQ_{tot}$ ) for the two exposure routes, and computed as:

$$HQ_i = \frac{ADD_i}{RfDi} \quad HQ_d = \frac{ADD_d}{RfDd}$$

$$HQ_{tot} = HQ_i + HQ_d \text{ and } HI = \sum HQ_m$$

$HQ_{tot}$  of a single metal and  $HI$  of all metals present in a water media categorizes health risks into two types;  $HI < 1$  indicates a low detrimental impact of metals on human health, while  $HI \geq 1$  represents greater chances of harmful health effects.

### 3. RESULTS AND DISCUSSIONS

#### Descriptive statistics

Table 2 shows some statistical parameters such as mean, minimum, maximum and relative standard deviation of the obtained results regarding metals concentration in water samples. As it can be seen, Fe and Cu were found to be in higher concentration, compared to other elements while the content of Cd and Pb have resulted to be lower than the limit of detection of the method, being respectively 0.005 and 0.1 µg/L. The metals concentration in selected samples followed the order: Fe>Cu>Cr>Mn while the variations relating to their content between the sampling time and sites, estimated as relative standard deviation ranged between 39% (Fe) to 190% (Mn).

**Table 2.** Descriptive statistics for metals content in selected water samples (µg/L)

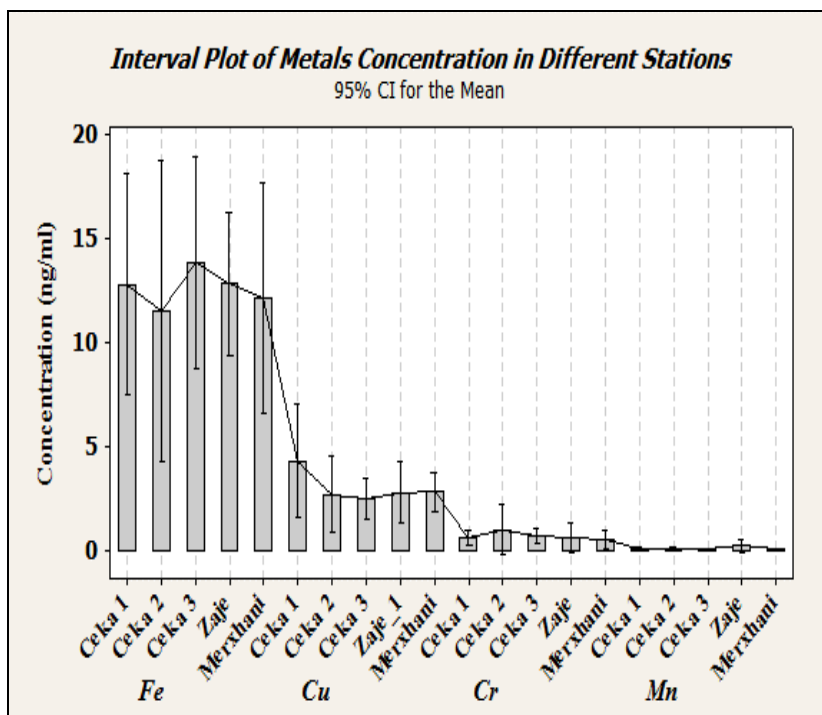
Parameter	Fe N=30	Cu N=30	Cr N=30	Mn N=30
Mean	12.628	3.027	0.676	0.079
Median	12.330	2.585	0.410	0.010
RSD	39.0	54.6	94.1	190
Minimum	2.880	1.330	0.090	0.010
Maximum	22.590	8.250	3.220	0.760
MAC (EPA, 2001)	200	3.1	50	50

#### Spatial and temporal distribution pattern of the elements

The Figure 1 depicts the heavy metals distribution in the waters of Kune-Vaini system, and the forthcoming paragraphs discusses in details this distribution. Box Plots were used to evaluate the temporal and spatial variation of each element concentration in the selected stations in different periods of sampling.

Iron was the metal found in higher concentrations in waters of Kune-Vaini lagoon, ranging from 2.8µg/L (Ceka-2/July 2018) to 22.6µg/L (Ceka-2/January 2019), followed by Cu, which concentration ranged between 1.33 µg/L (Ceka-2/September 2018) to 8.25 µg/L (Ceka-1/January 2019). Higher concentration of Cr (3.22 µg/L) was observed in station Ceka-2 during September, 2018 and the lowest during May, 2019 in three stations, Ceka-1, Zaje and Merxhani. Manganese was the metal found at a lower concentration rate, ranging from 0.01 to 0.76 µg/L in station Zaje, during September 2018. The average values for copper were 2.69 µg/L in Ceka waters, 2.34 µg/L in Zaje, and 2.39 µg/L in Merxhani; based on the Norwegian classification of lake water quality [15], these values belong to quality III (1.5-3 µg/L),

showing significant pollution, while in certain months the quality was IV (heavy pollution). The average for chromium was 0.52  $\mu\text{g/L}$  in Ceka, 0.25  $\mu\text{g/L}$  in Zaje, and 0.25  $\mu\text{g/L}$  in Merxhani, quality II (0.2-2.5  $\mu\text{g/L}$ ), corresponding to moderate pollution. Higher variation of Fe and Cu content between stations was observed during July 2018 and January 2019. Cr concentration varied mostly during September and November, 2018 while Mn during July and September, 2018. The results obtained by the Analysis of Variance, ANOVA (Table 3) confirmed that no significant differences were observed with regard to metals distribution between the selected stations ( $P > 0.05$ ), while significant differences existed between the content of Cu and Cr with regard to different sampling periods. Pollution with copper and chromium is expected in Kune-Vaini lagoons, affected somehow by the waters of the Mati delta; the basin area of this river is traditionally known for the processing of copper and chromium minerals. Concentration of all studied metals have resulted to be lower than the recommended values of heavy metals in surface waters, according to the USEPA, 2001 [14].



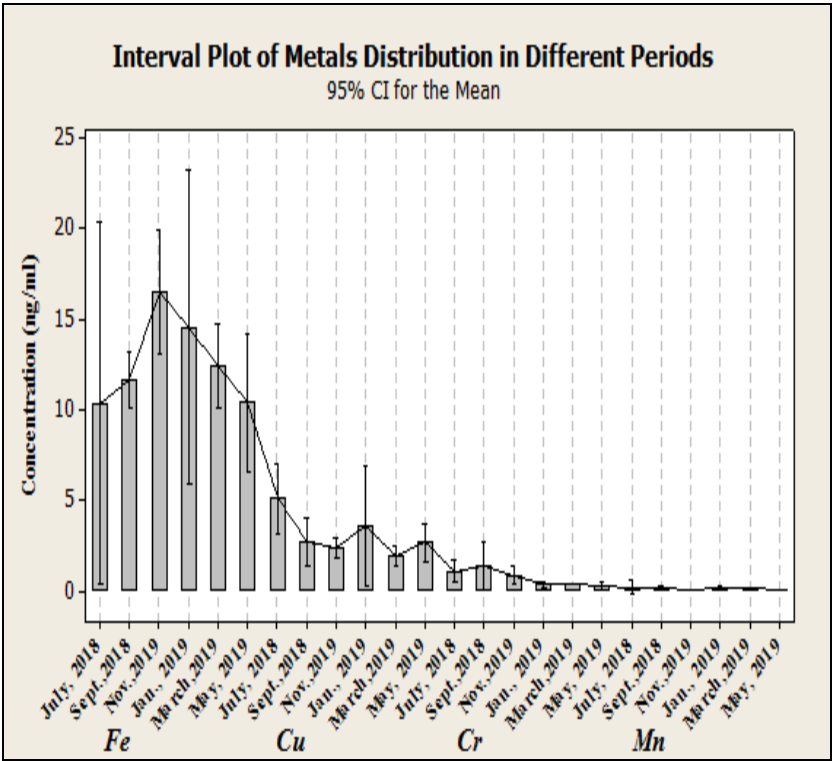


Fig. 1: Box Plots of metals spatial and temporal distribution.

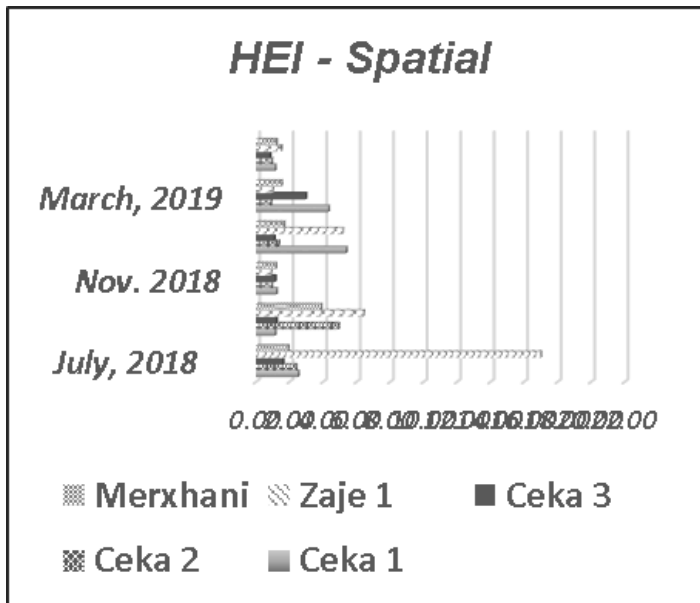
Table 3. Analysis of Variance, ANOVA of metals distribution

	Fe		Cu		Cr		Mn		
Source of Variation	F	P-value	F	P-value	F	P-value	F	P-value	F crit
Stations	0.17	0.95	1.88	0.15	0.75	0.57	1.79	0.17	2.87
Months	1.13	0.38	3.82	0.01	4.06	0.01	0.98	0.45	2.71

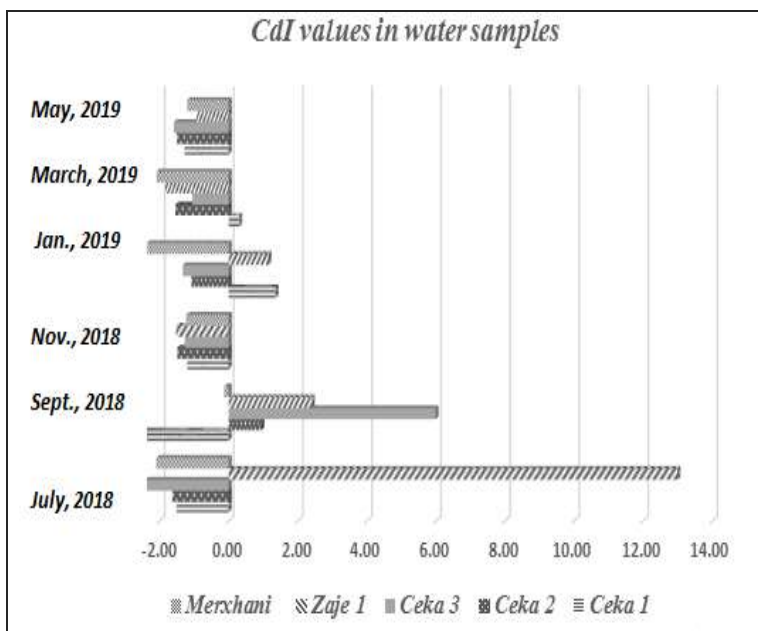
Pollution assessment indices

The overall water quality was observed by calculating the Heavy Metals Evaluation Index, *HEI* and the Contamination Index *CdI* which represents the overall detrimental impact of the HMs on surface water [12].Based on the *HEI* values, surface water quality is classified as “low polluted” (*HEI*<10); “moderately polluted” (*HEI* between 10 – 20) and “highly polluted”(HEI>20)while based on the *CdI* values three classes can be used, accordingly *CdI*<1 for low, 1-3 for moderate and >3 for high pollution of the

surface water body from heavy metals[12].HEI was calculated for each metal in all selected stations in different months. Obtained results show that, except for the highest value of HEI observed in station Zaje, during July, 2018 which suggests a moderate pollution in this station due to metals concentration, the environmental state of the other stations can be classified as low-polluted (Fig.2). The results of CdI values showed that the water quality in most parts of the selected stations could be classified as low-polluted. In station Zaje, during July, 2018, and station Ceka 3, during September 2018 the quality of water was classified as very polluted. During September, 2018 and January, 2019 the quality of water in stations Ceka 1, Ceka 2 and Zaje was classified as moderately polluted (Fig.3).



**Fig. 2:** HEI values of heavy metals in lagoon.



**Fig. 3:** Contamination degree Index, CdI.

### Human health risk assessment

Health risk assessment of each element made by means of Hazard Risk Quotients for ingestion and dermal routes of exposure,  $HQ_{ing}$  and  $HQ_{derm}$ , total Hazard Quotient,  $HQ_{tot}$ , and based on the Hazard Index, HI (Table 4). The results showed that estimated values of  $HQ_{tot}$  and HI was  $<1$ , suggesting an acceptable level of health risk in all selected stations and months due to the analyzed metals. Cu and Fe exhibited higher values of Hazard Quotient due to ingestion compared to the other metals while Cr exhibited higher Hazard Quotient values due to dermal contact. With regard to the total HQ, Cr was the metal which has exhibited higher values of the total Hazard Quotient,  $HQ_{tot}$  ranging from  $1.44E-03$  to  $5.15E-02$  followed by Cu, for which the  $HQ_{tot}$  values ranged between  $1.03E-03$  and  $6.37E-03$ . Total Hazard Quotient values of metals in water of the Kune-Vaini System lagoon followed the order:  $Cr > Cu > Fe > Mn$ .

**Table 4.** Mean, minimum, and maximum values of non-carcinogenic human health risks posed by heavy metals in water of study area via different pathways.

	HQ <sub>i</sub>			HQ <sub>d</sub>			HQ <sub>tot</sub>		
	mean	min	max	mean	min	max	mean	min	max
Fe	5.15E-04	1.18E-04	9.22E-04	1.01E-05	2.74E-06	1.81E-05	5.25E-04	1.21E-04	9.40E-04
Cu	2.33E-03	1.03E-03	6.37E-03	1.95E-05	8.61E-06	5.32E-05	2.33E-03	1.03E-03	6.37E-03
Cr	1.29E-05	1.71E-06	6.13E-05	1.1E-02	1.44E-03	5.15E-02	1.1E-02	1.44E-03	5.15E-02
Mn	1.61E-05	2.04E-06	1.55E-04	9.44E-07	1.2E-07	9.12E-06	1.61E-05	2.04E-06	1.55E-04
HI	2.87E-03	1.15E-03	7.51E-03	1.10E-02	1.45E-03	5.16E-02	1.39E-02	2.59E-03	5.90E-02

#### 4. CONCLUSIONS

In this study, the environmental state of the Kune-Vaini System lagoon waters due to heavy metals was evaluated in five different stations, for a period of 11 months. The metals concentration in selected samples followed the order: Fe>Cu>Cr>Mn, while the variations relating to their content between the sampling time and sites, estimated as relative standard deviation ranged between 39% (Fe) to 190% (Mn).

Based on the results obtained by the Analysis of Variance, ANOVA it was confirmed that no significant differences were observed with regard to metals distribution between the selected stations ( $P>0.05$ ) while significant differences existed between the content of Cu and Cr with regard to different sampling periods. Pollution with copper and chromium is expected in Kune-Vaini lagoons, affected somehow by the waters of the Mati delta; the basin area of this river is traditionally known for the processing of copper and chromium minerals.

Concentration of each metal analyzed has resulted to be lower than the recommended values set for heavy metals levels in surface waters, according to the USEPA.

Health risk assessment of each element was evaluated by means of Hazard Risk Quotients for ingestion and dermal routes of exposure, HQ<sub>ing</sub> and HQ<sub>derm</sub>, total Hazard Quotient, HQ<sub>tot</sub> as well as based on the Hazard Index, HI. Obtained results showed that estimated values of HQ<sub>tot</sub> and HI have resulted to be <1, suggesting an acceptable level of health risk in all selected stations and months due to the analyzed metals. Cu and Fe exhibited higher values of Hazard Quotient due to ingestion compared to the other metals while Cr exhibited higher Hazard Quotient values due to dermal contact. With regard

to the total HQ, Cr was the metal which has exhibited higher values of the total Hazard Quotient,  $HQ_{tot}$  ranging from  $1.44E-03$  to  $5.15E-02$  followed by Cu, for which the  $HQ_{tot}$  values ranged between  $1.03E-03$  and  $6.37E-03$ . Total Hazard Quotient values of metals in water of the Kune-Vaini System lagoon followed the order:  $Cr > Cu > Fe > Mn$ .

## ACKNOWLEDGEMENTS

This study has been carried out in the framework of the project “Construction and sustainability of the Kune-Vain lagoon system through access to the ecosystem (EbA)” supported by UNEP, GEF and the Albanian Government.

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## **ANALYSE OF THE WATER BALANCE AND TECHNOLOGICAL WASTEWATER DURING BEER PRODUCTION, FOCUSING ON THE PRODUCT SAFETY AND QUALITY**

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### **ABSTRACT**

The present study aims to stimulate a complete water balance during processing of beer production. First, the water quantity required for the technological treatment, the equipment cleaning and sanitation, pasteurization and packaging processes, and other purposes as well, were considered. Sensitivity analysis of the brewing process in “Birra Korca” brewery was of great importance at this instance, because it technologically allowed a critical judgment for the feasibility of the entire beer production. The article summarizes a modeling technique and a specific computer’s software, providing adequate data about inaccuracies of water and it’s handling. This technology was a means to address not only the safety and quality of the beer product, but also a comprehensive engineering concept for the whole process of diagram calculations, providing a new structure of data driven algorithm. Applying smart methods such as the process of modeling techniques, numerical tools and computer simulations for the water and the waste water treatment of beer production, proved to be beneficiary with regard to water usage. There are some analytic methods made up of qualitative character, meanwhile during some analysis, these methods provide quantitative indicators regarding the water handling for the main product and the by-products of beer production. The brewing industry in Albania is obliged to apply the requirements of national legislation for water consumption and wastewater treatment. It is known that the ratio between water amount used and discharged from beer industry to the beer volume varies from 2.5-10-liter water per liter beer produced, i.e. one-liter beer requires a considerable amount of water. As it seems, the respective

cost analysis for the water and energy consumption during beer production is imperative, and the beer production unavoidably requires a new innovative water and energy management procedure, subsequently followed by better economic indicators. Therefore: improving the water management in the brewery during production; recycling and reusing the water; designing a treatment spot of the wastewater discharged from beer production, are necessities.

**Keywords:** beer production, water usage and handling, wastewater treatment methodology

## 1. INTRODUCTION

Beer production is associated with these three consequent (successive) biochemical processes: i) enzyme formation during the germination of barley grains, ii) transformation of cellulosic starch into fermentable sugars using these specific enzymes and, iii) fermentation of formed sugar leading to ethyl alcohol formation and CO<sub>2</sub> release.

In terms of quantity, the water used is the most important raw material for beer production. Therefore, the chemical and biological composition of water is of fundamental importance for the beer production. The beer production process is related to water ingredients. The water, either supplied from state entities, or from the wells of the companies, has to be accurately used in these two main directions [1.2]: i) treatment of raw water to fulfill legal criteria, and meet the technological requirements of beer production, ii) selection of the best available technology for industrial wastewater treatment which requires a well-structured and comprehensive methodology for the systematic evaluation of alternative technologies.

The environmental issue is a critical factor for the competitiveness of today's industry. Society and individual consumers need to establish a common framework for companies' commitments in regard of environmental protection, process redesign, by-product recovery or/and reuse, are some of the possible actions directed to an eco-efficient strategy [3].

Based on the above principles, the beer production of "Birra Korça" brewery, carries out a daily monitoring and treatment of water used in the beer production process, along with the monitoring and treatment of wastewaters. This study highlights the best practices used by this plant for the water treatment and analytical monitoring parameters, considering waste according to contemporary best practices. The present study identifies the need for a more efficient approach to water treatment as a raw material, and those that emerge as waste according to the best models that carry out a treatment and monitoring which will provide a control modeled according to a software algorithm. This model guarantees the minimization of the amount of water waste during each beer production step, and the partial reuse of this wastewater, which is of a significant economic benefit under the conditions of

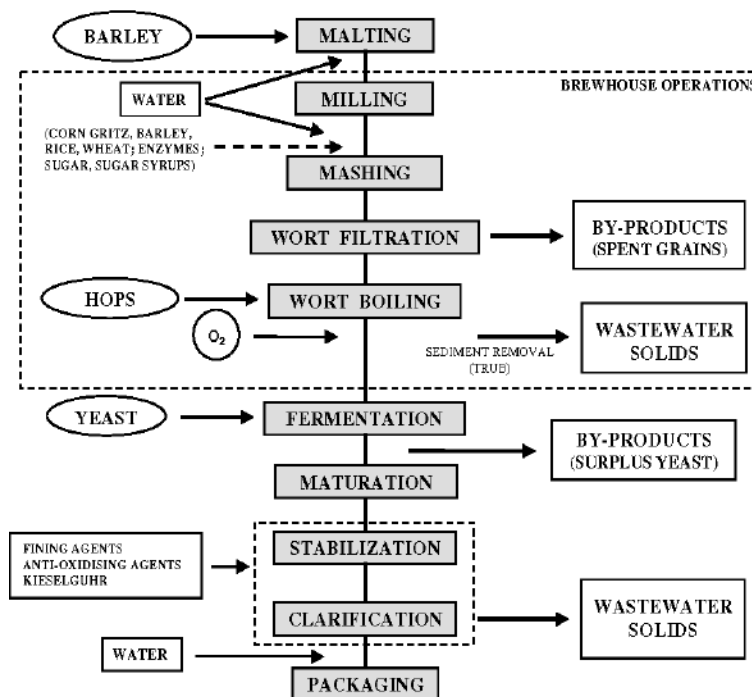
globalization and increased competition atmosphere [4,5].

## 2. "Birra Korca" brewery: analysis and monitoring of water use and waste water management

### 2.1 "BirraKorca" brewery water use

The beer produced in the "Birra Korca" brewery is an alcoholic fermentation product due to the activity of selected yeasts of the genus *Saccharomyces cerevisiae*, on the wort obtained by combining water with milled cereals such as malted barley, corn, etc. Cereals contain complex carbohydrates, which are initially converted into simple sugars by the action of the respective enzymes on them, which are then easily fermented. At the end of fermentation and maturation, beer is obtained as an alcoholic product with a low percentage of alcohol between 4-4.5%.

This process is accompanied by a large use of water consumption, which for the worldwide beer industry goes between 2-10 m<sup>3</sup> of water usage per each m<sup>3</sup> of beer produced. Figure 1 depicts the schematic process of beer production.



**Fig.1:** Technological process in breweries (adapted from Unicer SA and Varnam and Sutherland, 1994).

For the beer production in the “Birra Korca” brewery it is required the use of water with salt content in defined parameters. Consequently, the drinking water supplied by the local entity was processed to diminish the salt content by reducing its hardness in the osmosis plant. The method applied is called the Method of Reverse Osmosis. The water that comes out of the treatment has 0° the German hardness, which once coupled, is brought to the hardness required by the production of PILSEN beer according to the applied technology.

The present study shows the quantities of water used per hl of beer produced during the time period of 2019 and 2020, referring to the efforts to minimize the water quantities used where the best international standards include a water consumption between 2-6 hl of water per hl of beer produced. Water consumption on this brewery generally in the two years taken into consideration varies between 9- 10 m<sup>3</sup> of water per m<sup>3</sup> of beer produced. Of this amount only 1.8-2.3 hl of water is used to produce beer. The rest of 2.3-10 hl water per hl of beer is the residue generated as a major need for technological water treatment, cleaning and sanitation equipment, for pasteurization and packaging processes and other logistical purposes that accompany this process.

The individual stages of water consumption for each step of the process, as reported for the German beer industry, are shown in the Table 1.

**Table 1.** Water consumption in a German type of brewing industry

Process step	Water consumption
Gyle (unfermented wort) to whirlpool	2.0 (1.8– 2.2)
Wort cooling	0.0 (0.0– 2.4)
Filter and pressure tank room	0.6 (0.5– 0.8)
Storage cellar	0.3 (0.1– 0.5)
Bottling (70% of beer produced)	0.5 (0.3– 0.6)
Barrel filling (30% of beer produced)	1.1 (0.9– 2.1)
Wastewater from cleaning of vehicles, sanitary use, etc.	0.1 (0.1– 0.2)
Steam boiler	1.5 (1.0– 3.0)
Air compressor	0.2 (0.1– 0.3)
Filter and pressure tank room	0.3 (0.1– 0.5)
Total	6.6 (4.9–12.6)

\*(m<sup>3</sup>/m<sup>3</sup> of sold beer; numbers in parentheses are ranges)

The individual phases of water consumption for each step of the process, in the “Birra Korca” brewery for 2019 and 2020 are presented in the Table 2 and 3, respectively:

**Table 2.** Water consumption in the “Birra Korca” brewery in 2019

Process step	Water consumption
Gyle (unfermented wort) to whirlpool	2.2 ( 1.8– 2.3)
Wort cooling	1.0 (0.2– 2.4)
Filter and pressure tank room	1.0 (0.8– 1.5)
Storage cellar	0.8 (0.5– 1.5)
Bottling (83% of beer produced)	1.1 (0.8– 1.2)
Barrel filling (17% of beer produced)	1.1 (0.9– 1.8)
Wastewater from cleaning of vehicles, sanitary use, etc	0.3 (0.1– 0.3)
Steam boiler	2.0 (1.0 – 3.0)
Air compressor	0.2 (0.1– 0.3)
Filter and pressure tank room	0.4 (0.1– 0.5)
Total	<b>10.1 (6.3–14.8)</b>

\*(m<sup>3</sup>/m<sup>3</sup> of sold beer; numbers in parentheses are ranges)

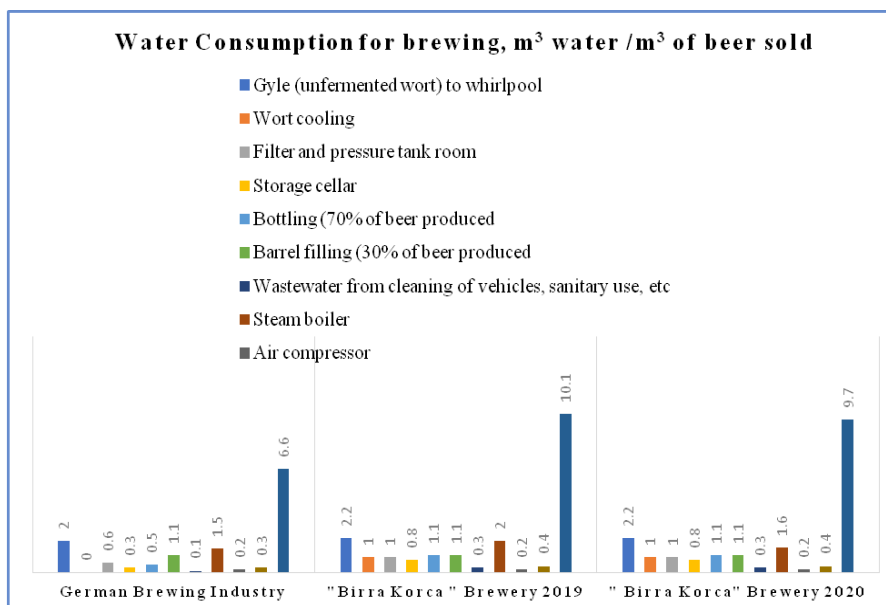
**Table 3.** Water Consumption in the “Birra Korca” brewery in 2020

Process step	Water consumption
Gyle (unfermented wort) to whirlpool	2.2 ( 1.8– 2.3)
Wort cooling	1.0 (0.2– 2.4)
Filter and pressure tank room	1.0 (0.8– 1.5)
Storage cellar	0.8 (0.5– 1.5)
Bottling (83% of beer produced)	1.1 (0.8– 1.2)
Barrel filling (17% of beer produced)	1.1 (0.9– 1.8)
Wastewater from cleaning of vehicles, sanitary use, etc	0.3 (0.1– 0.3)
Steam boiler	1.6 (1.0 – 3.0)
Air compressor	0.2 (0.1– 0.3)
Filter and pressure tank room	0.4 (0.1– 0.5)
Total	<b>9.7 (6.3–14.8)</b>

\*(m<sup>3</sup>/m<sup>3</sup> of sold beer; numbers in parentheses are ranges)

The steam condensate used in its steam production system was recovered in 2020 as recommended by the authors. Consequently, the amount of hl of water used for hl of beer produced in 2020 compared to 2019 was reduced by 4%.

Comparing the amount of water being consumed in a standard German Brewery, with our consumption in the “**Birra Korca**” brewery, during the last two years (2019-2020), it is shown clearly in the graph of figure 2.



**Fig. 2:** Different style of the graphical presentation of the water used in German breweries' standards, comparing to the consumption of the "Birra Korca" brewery throughout 2019 and 2020.

## 2.2. Characterization and management of waste water

Untreated wastewater in breweries usually contains: i) suspended solids in the range of 10–60 milligrams per liter (mg / l), ii) biochemical oxygen demand (BOD<sub>5</sub>) in the range of 1,000–1,500 mg / l, iii) chemical oxygen demand (COD) in the range of 1,800–3,000 mg / l, iv) nitrogen in the range of 30–100 mg / l, v) phosphorus may also be present in concentrations of the range of 10–30 mg / l.

The parameters above are variable depending on the individual steps of the process. For example, bottle washing produces the largest volume of wastewater, but contains only a small fraction of the total organic compounds discharged from the brewery. Wastewater compounds resulting from the fermentation and filtration process have a high content of organic compounds and BOD<sub>5</sub>, but are low in volume. They account for about 3% of the total volume of wastewater, but 97% of the BOD<sub>5</sub>.

The pH of the wastewater remains on average around 7 for the total combined volume, but can vary between 3 to 12, depending on the use of soda-based washing agents and neutralizing acids. The wastewater flow temperatures into the aquifer system take an average of about 30° C. Monitoring the environment influence of contaminated water, includes all the

legal elements that condition the treatment and processing of wastewater prior to discharge into the public system of their collection [6]. Discharges of wastewater from the technological process include wastewaters which are arranged through the sewer manhole and discharged into the main pipeline. Prior to discharge into this receiving aquatic environment these waters are treated and neutralized so they don't contain contaminating components. The sewerage network is constantly monitored and their periodic cleaning is ensured [7]

The monitoring of discharges in wastewater must be within the national legal norms as reported in Table 4.

**Table 4.** Legal wastewater discharge norms

Waste water discharges		
Contaminant		Method
No.2 appendix	Name	Method used
	pH	ISO10523:2008
7439-97-6	BOD <sub>5</sub>	SSHISO5815-1:2003
7439-92-1	COD	SSHISO15705:2013
	Suspended solids	EN872:2005
	Oils and vegetable fats	
	Ammonium nitrate	SSHISO7890-3:2000
	Total phosphorus	SSHENISO6878:2004
	Increased temperature in receiving waters	T:+3°C

**Table 5.** The analytical norms of waste water discharges applied by the "Birra Korca" brewery

Processing section	Parameters	Permitted value (mg/l)
Beer and yeast production	pH	6-9
	Suspended solids	50
	BOD <sub>5</sub>	40
	COD	160
	Oils and vegetable fats	10mg/l
	Ammonium nitrate	10mg/l
	Total phosphorus	5mg/l
	Increased temperature in receiving waters	T:+3°C

During 2020, the measurements of the parameters above were carried out, resulting in conformity with the standards set by the legislation which is reported in Table 6.

**Table 6.** Values of wastewater analyzed in discharges from the "Birra Korca" brewery

Waste Water discharges					
Contaminant		Method		Value	
No.2 appendix	Name	M/L/V	Method used	T (Total) (kg/year)	A (accidental)
	pH	Measured	ISO 10523:2008	7.8	No
	COD	Measured	S SH ISO 15705:2013	105 mg/l	No
	BOD <sub>5</sub>	Measured	S SH ISO 5815-1:2003 Oxitop method	23 mg/l	No
	Oils and vegetable fats	Measured	Barium chloride	3.2 mg/l	No
	Ammonium nitrate	Measured	ISO 15705	5.1 mg/l	No
	Total phosphorus	Measured	ISO 6059	1.0 mg/l	No

The monitoring shows that "Birra Korca" brewery operates within the allowed parameters for legal content of contaminants in the discharged wastewaters.

Given the complexities of keeping the legal parameters of pollution the study here reports fostering technologic system that offers accurate water management throughout the process of beer production and what comes out as wastewater in a more controlled and automated way what is needed.

The best world experiences in this industry prove that accurate forecasting of water quantity needed for each step of the beer production process and the results of wastewater treatment is of great benefit for the companies. This process also unavoidably considers the partial reuse of this water quantity, e.g. the return of part of the steam condensate used for heating towards the hot water storage tanks which are used for steam production, thus leading directly to the saving of usage quantities and economic optimization of the final product obtained. Therefore, the use of modern technology remains a permanent task of the engineering-technological staff of "Birra Korca" brewery.

### 3. CONCLUSIONS

The conclusions to be drawn are: i) beer production remains a complicated process which needs continuous improvements related to technological processes in order to improve product quality in parallel with the reduction of production costs associated with the adaptation of modern technologies, ii) environmental protection remains challenging as the beer production process uses water and agricultural products in great quantities and energy for heating, cooling, boiling and chilling, iii) water demand need optimization of the process. So, these quantities of water used for the units of beer produced should be further reduced in order to approximate the best modern standards, thus giving the opportunity to increase competition in the market, iv) sensitivity analysis of the brewing process in "Birra Korca" brewery in a practical optic software usage and its handling addresses not only the safety and quality of the beer product, but contributes to create a complete engineering concept that maybe necessary for the entire process diagram calculations in a new structure of data driven algorithm, v) technologic development is beneficiary for the industry. There are some analytic methods with qualitative character, but during some analysis, they consist also on quantitative indicators regarding the water handling for performing the main product and the by-products of beer production, vi) water consumption referring to the water used versus the respective hectoliters of beer produced decreased by 4%. Consequently, the cost of the final product obtained was reduced, and at the same time brought to the fore the need to apply advanced engineering methods for further improvements and economic benefits for this brewery and, vii) process optimization and the provision of more productive technologies are being used to realize the economizing of water use and also the implementation of permitted standards for wastewater discharge.

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## **EO5 INTEGRATED MONITORING OF THE ADRIATIC SEA AND COAST AND RELATED ASSESSMENT CRITERIA**

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### **ABSTRACT**

Eutrophication of Adriatic Sea is a process driven by enrichment of water by nutrients, especially nitrogen and/or phosphorus compounds, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation. The distribution of nutrient concentrations is determined by a complex combination of biotic and abiotic factors. Ecological Objectives 5 (EO5) integrated monitoring is related to the common indicator, which summarizes data into a simple, standardized and communicable figure. A common indicator is able to give an indication of the degree of threat or change in the marine and coastal ecosystem and can deliver information to decision makers. There are two common indicators related to eutrophication: Indicator 13, related to concentration of key nutrients in water column and Indicator 14, related to chlorophyll-a concentration in water column. We recommend carrying out the EO5 indicators during 2020-2022, and as a first step we propose the sampling at stations located one kilometre from the coast, in full compliance with IMAP Common Indicators. From the list of coastline stations proposed by the National Environment Agency, 6 stations are selected for sampling purposes at different distances from the Adriatic coast and different depths. The selected stations will allow to have a full picture of eutrophication and evaluate the effect of the main pressures from land (rivers, lagoons and urban areas) as from the open sea. The process of eutrophication will be estimated through physico-chemical and biological parameters.

**Keywords:** EO5, common indicators, eutrophication

## 1. INTRODUCTION

Marine areas provide significant benefits to people in terms of food and other services, but are exploited in different ways by disturbing the balances in these ecosystems. In order to keep coastal ecosystems “healthy”, continuous assessment should be done through monitoring, identifying alterations or changes in physical, chemical and biological parameters as well as environmental indicators related to these parameters. Monitoring of coastline, sea beds, physical, chemical and biological parameters help to get better image of aquatic ecosystems and the status and conditions of these systems. EU legislation defines clearly the monitoring protocols and methods applicable for the protection of marine environments, one of which is the Maritime Directive (Wise Marine 2017; European Union 2017; European Commission, 2019). Conventions also create opportunities for the protection and assessment of the marine environment. Albanian institutions and agencies have worked for a long time to be part of the evaluation and monitoring process of the Adriatic and Ionian coast according to the scientific criteria of these Conventions.

Eutrophication remains a major environmental problem for Europe's seas, which brings changes in the balance of organisms and degradation of sea water quality. Eutrophication is the process of absorbing large amounts of nutrients, such as phosphorus and nitrogen, that causes the uncontrolled growth of algae in aquatic environments. Such a phenomenon has emerged after climate change identified in the last 20 years in the Mediterranean Sea. For many years the Mediterranean Sea, including also the Adriatic Sea, has become part of many Conventions for the marine protection. Ecological objectives have been set based on specific indicators. Ecological Objectives 5 (EO5) is one of them, related to the minimization of eutrophication of marine waters, based on the concentration of nutrients and chlorophyll-a as indicators.

The enrichment of waters by nutrients can be of a natural origin (natural eutrophication), but it is often dramatically increased by human activity (anthropogenic eutrophication). Human induced eutrophication through erosion and leaching from fertilized agricultural areas, urban sewage and industrial discharges could be minimized, especially its lateral effects, such as biodiversity loss, ecosystem degradation, harmful algal blooms and lack of oxygen in the ground waters (Ferreira *et al.*, 2010). This is one of the EO5 ecological objectives that describes the state of marine waters based on specific indicators.

Albania is a Contracting Party to the Barcelona Convention and its Protocols in the framework of UNEP/MAP (Mediterranean Action Plan). This action plan addresses the level of the environmental status of marine waters

and coasts. All countries after the Barcelona Convention (CP) have adopted an Integrated Monitoring and Assessment Programme (IMAP) based on eleven ecological objectives (Decision IG.22/7), and all the Adriatic countries should amend their national monitoring programs.

The project primary aims to restore the ecological balance of the Adriatic Sea using the ecosystem approach and marine spatial planning. At the same time project aims application of Integrated Coastal Zone Management Protocol and implementation of the Integrated Monitoring and Assessment Program. The project is jointly led by UNEP/MAP, PAP/RAC and SPA/RAC (Integrated Monitoring Programme Albania- Draft, 2021).

## 2. MATERIAL AND METHODS

There is an ample relevant information available in marine eutrophication literature; here the emphasis is given to factors which, altered by human activities, trigger and maintain man-made eutrophication, and which man can, at least partially control by continuous monitoring of common indicators.

EO5 integrated monitoring is related to the common indicator, which is an indicator that summarizes data into a simple, standardized and communicable figure. A common indicator is able to give an indication of the degree of threat or change in the marine and coastal ecosystem and can deliver valuable information to decision makers (EEA, 2001, 2015, Wise Marine 2017). There are two common indicators related to eutrophication: Indicator 13, related to concentration of key nutrients in water column, and Indicator 14, related to chlorophyll-a concentration in water column (UNEP/MAP/MED POL 2005, UNEP/MAP, 2015, HALCOM, 2017).

Common Indicator 13: Concentration of key nutrients in water column

Physicochemical parameters:

- *Transparency*
- *Temperature*
- *Salinity*
- *Concentration of dissolved oxygen*
- *Concentration of orthophosphate (PO<sub>4</sub>-P)*
- *Concentration of total phosphorous (TP)*
- *Concentration of nitrate (NO<sub>3</sub>-N)*
- *Concentration of nitrite (NO<sub>2</sub>-N)*
- *Concentration of ammonium (NH<sub>4</sub>-N)*
- *Concentration of total nitrogen (TN)*
- *Concentration of orthosilicate (SiO<sub>4</sub>-Si)*
- *Concentration of total and dissolved organic carbon*

Common Indicator 14: Chlorophyll *a* concentration in water column

Biological parameters:

- *Concentration of chlorophyll a*
- *Numeric concentration of phytoplankton*
- *Phytoplankton community composition*

The Eutrophication Working Group delivered a report as an information document UNEP(DEPI)/MED WG.437/Inf.11 (2019) where common definitions on thresholds, baseline, assessment criteria and review the methods, the criteria and the limit values for assessing eutrophication in Mediterranean and its sub-regions are proposed.

The current practices for monitoring the marine environment, in accordance with IMAP Guidance Factsheets for each of the parameters within Common Indicators for Eutrophication are presented in Monitoring Protocols for Common Indicators related to Pollution (UNEP/MED WG.463/6, 2019), which provide detailed both scientific and technical considerations.

### 3. RESULTS AND DISCUSSIONS

During last twenty years Albanian monitoring institution and organizations have done progress in development and application of updating methods of sampling, assessment and evaluation, as part of the national integrated monitoring program.

In accordance with the outline of the EO5 objectives for assessing national knowledge gaps, still exists a national knowledge gap assessment for EO5 IMAP indicators 13 and 14 in Albania.

During the last years, anthropogenic eutrophication has been identified as a key ecological problem for the Adriatic Sea, resulted in dramatic alterations in the chemical and biological regimes (EVER-EST, 2020). The phytoplankton community, being the first target of nutrient alterations, is perceived to be a decisive factor for the marine water quality and the ecosystem health. It tends to be the most direct visible consequence of natural and man-induced changes.

Several sampling sites were selected. From the list of coastline stations proposed by the National Environment Agency (Raporti i gjëndjes në mjedis 2014; 2016-2018) we selected 5 transects for sampling at different distances from the Adriatic coast and perpendicular to the coast, at a distance of 0.1, 5 and 10 km from the coastline. The samples were collected 0.5 and 10 m deep, but it is important to mention that sampling in 2.0 m above the bottom is very important, because here oxygen concentration shows the eutrophication process.



**Fig.1:** Five transects that represent 15 sampling stations.

These 5 transects, which represent the 15 selected stations for water collection and measurement, will allow to have a full picture of eutrophication and to evaluate the effect of the main pressures from land (rivers, lagoons and urban areas) as well as from the open sea. The 5 transects are: Velipoja, Lalzi Bay, Spille – Kavaja, Divjaka – Semani and Vlora (Zverneci).

Sampling frequency is determined by the variability of the measured parameters and is usually determined by how many samples are needed to reliably assess the differences between two neighbouring mean values. The frequency and spatial resolution of the monitoring programme should reflect spatial variation in eutrophication status and pressures following a risk based approach and the precautionary principle.

The first factor promoting eutrophication is nutrient enrichment. This explains why the main eutrophic areas are to be found primarily not far from the coast, mainly in areas receiving heavy nutrient loads. Additionally, the risk of eutrophication is related to the capacity of the marine environment to confine growing algae in the well-lighted surface layer. The geographical extent of potentially eutrophic waters may vary widely (UNEP/MED WG.463/6, 2019).

Good Environmental Status (GES) has two specific targets: i) a) reference nutrients concentrations according to the local hydrological, chemical and morphological characteristics of the un-impacted marine region; b) decreasing trend of nutrients concentrations in water column of human impacted areas, statistically defined; c) reduction of BOD emissions from land based sources; d) reduction of nutrients emissions from land-based sources, and ii) a) chlorophyll *a* concentration in high-risk areas below thresholds; b) decreasing trend in chl-*a* concentrations in high risk areas affected by human activities (UNEP/MAP/MED POL 2005; UNEP/MAP, 2015; HALCOM, 2017; UNEP/MED WG.463/6, 2019).

Selection of parameters for assessment of eutrophication and achievement of GES are done according IMAP Common Indicator Guidance Facts Sheets (UNEP (DEPI)/MED WG.444/5, 2017) and Integrated Monitoring and Assessment Guidance (UNEP (DEPI)/MED IG.22/Inf.7, 2016), as well as Commission Decision (EU) 2017/848.

#### 4. RECOMMENDATIONS

Laboratories carrying out analyses about nutrients and Chlorophyll *a* have to establish a quality management system according to EN ISO/IEC 17025. An accreditation by a recognized accreditation authority is also recommended. Due to reduced capabilities of Albanian monitoring laboratories, we recommend initiating fulfilment of the Ecological Objectives 5 (EO5) indicators during 2020-2022, only with sampling at stations located one kilometre from the coast, in full compliance with IMAP Common Indicators.

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## **PRELIMINARY RESULTS OF THE MARINE SPATIAL PLANNING PROCESS IN VLORA BAY**

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### **ABSTRACT**

Land Use and Marine Spatial Planning (MSP) are often considered as two separate tools. In the concept of Integrated Coastal Zone Management, instead they are both unavoidably and strictly related. MSP represents analyzing process to allocate spatial-temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives. Competition for maritime space highlighted the need to manage Albanian waters more coherently. As MSP works across borders to ensure human activities at sea take place in efficient, safe and sustainable way, the European Union adopted legislation to create MSP common framework. During MSP preliminary initial assessment report of Vlora area in Albania project (2019-20) funded by Specially Protected Areas Regional Activity Centre (SPA/RAC) and implemented by company “Genc Myftiu”, the first MSP process Guidelines in Albania were prepared within the framework of IMAP, ICZM Protocol and MSP Decision. According to European Commission MSP fulfils four objectives and First Albanian MSP Guidelines make them easy to follow: reducing conflict on access to maritime spaces; reducing cumulative impact of maritime activities on environment; reducing coordination costs for public authorities; improving predictability for private

investments. Guidelines make possible to implement GIS-based MSP, including monitoring and regular evaluation. The follow up and administration have to be carried out by a team including legal, institutional, scientific, social, economic, educational and communication expertise, supervised by a board including representatives of the main concerned Ministries/Administrations. This publication defines the workflow process that brought our team to Final First Guidelines.

**Keywords:** land use; Marine Spatial Planning; competition, marine space, human activities, guidelines

## 1. INTRODUCTION

Land Use Planning and Marine Spatial Planning (MSP) are often considered as two different tools. In the concept of Integrated Coastal Zone Management (ICZM), they are both essential and have to be strictly linked. For the Protocol on ICZM in the Mediterranean Sea, Spatial Planning of the coastal zone is considered an essential instrument for its implementation, as described in the text of this paper. One of the main objectives of ICZM process is to “facilitate, through the rational planning of all activities, the sustainable development of coastal zones by ensuring that both environment and landscapes are taken specially into account, ensuring the harmony equilibrium with economic, social and cultural development” (art. 5) in the same area. Planning is also recalled in many other articles of the Protocol, as in the case articles dealing with the protection of wetlands, estuaries and marine habitats (art. 10) or the protection of coastal landscape (art. 11). Marine Spatial Planning (MSP) is a process that brings together multiple users of marine spaces (including energy, industry, governments, conservation and recreation activities) to make informed and coordinated decisions about how to use marine resources sustainably. MSP generally uses and produces maps and GIS-based systems, in order to create a more comprehensive and “interactive” global vision of a specific marine area, identifying where and how marine area is being used and what natural resources and habitats exist there: it’s almost similar to land-use planning, but applied to marine waters and coastal lands. Through the planning and mapping process of the marine ecosystem, planners and managers can consider the cumulative effect of maritime activities, seek to make these activities more sustainable and proactively minimize conflicts between them seeking to utilize the same marine area. This process is summarized under the European Commission (EC) definition of the four objectives of MSP: i) reducing conflict on access to maritime space, ii) reducing cumulative impact of maritime activities on environment, iii) reducing coordination costs for public authorities and, iv) improving predictability for private investments.

During the MSP preliminary assessment report of Vlora area in Albania project (October 2019 - January 2020) funded by Specially Protected Areas

Regional Activity Centre (SPA/RAC) and implemented by “Genc Myftiu” company, the first Guidelines for MSP process in Albania were prepared within the framework of IMAP, ICZM Protocol and MSP Decision [25].

### Site description

Vlora bay is located in Vlora County, Albania (Figure 1), and the coastline is approximately 36 km long. Vlora County is one of the 12 Albanian counties, and encompasses 7 municipalities (Vlorë, Delvinë, Finiq, Himarë, Konispol, Sarandë and Selenicë), further subdivided into administrative sub-units and villages for a total area of about 2706 km<sup>2</sup>. As of January 2019, Vlora County has a population of 189.311 inhabitants. Administratively, the county is led by a Prefect representing the central authority and a County Council representing the Regional authority. The municipality is the first level of local governance while the County is the second level. The County includes a great number of stakeholders with interest on the coastal area and the sea. The eastern coast of Karaburun peninsula starts from Pasha Limani up to Cape Galoveci by passing capes Kallogeri, Rraguza, Sevasini, Shen Vasili, Gjata, Dim Kushta and Shen Jani [1,2,3].



**Fig. 1:** Vlora area map including administrative units.

Geologically, the eastern side of the bay is a succession of rocks of

different ages, since Jurassic and Neogene (Aquitania, Helvetian, Tortonian and Pliocene) era. The southern part consists of Pliocene rocks and recent sediments. The eastern coast dates since the Upper Cretaceous era, essentially composed of limestone [8].

For the terrestrial environment, the eastern side of Karaburun has areas deforested by fires among a landscape of maquis with a few pines and cypresses shaped by the wind. It is not as wild as the western part: however, the vegetation comes very close to the sea level. Small dry river canyons fall into the sea almost vertically. Orikumi lagoon is nearby a restricted military area; it covers around 130 ha, has a maximal depth of 3 m and is permanently in communication with the sea by a 50 m long canal. In the southern portion of the lagoon, there is a limited input of fresh water [17]. According to recent surveys, the lagoon is not polluted by nitrates and pesticides [24].

Vlora Bay is a quasi-enclosed water area collecting the pollution coming from open sea [6,7,9,10]. The moderate West and North-West winds drive the pollution factors at the end of the bay serving as dumping pocket, while the small bays along the coast serve as temporary or permanent pollution collectors. It will be important to develop a network for monitoring and emergency response in case of oil pollution in the bay [19, 20].

The depth in the bay goes up to 54 meters in SE of Rogozhe (Ragusa) bay [21]. The 50 m isobathic line comes about 100m from the coast near to cape of Kala and starts going seaward reaching around 1000m from the coasts at western quay of Vlore's port. There are about 7 shipwrecks, since WW II and later, which compound an historical sites and biodiversity for created during the years. They are: "Rosandra 3", "Regina Margherita", "Intrepido", "Rovigno", "Lucian", "Stampella", "Andromeda", "Po" and represent a cultural heritage that could be of interest for tourism diving activities.

The marine environment of the Vlora bay reveals a coastline mainly rocky with small gravel beaches except the southern part that is sandy and the center of the bay that is filled by sand and mud. On this substratum, there is locally an important coverage of algae and phanerogams (mainly *Posidonia oceanica*, *Zostera* sp. and *Cymodocea nodosa*) [3,4,5]. Large *Posidonia* sp. meadows [22,23,26], ideal nursery areas and swell shields, as well as *Cymodocea* sp. are seen in shallower depths on the eastern side of Karaburun. Both *Posidonia* and *Cymodocea* sp. are protected in the Mediterranean Sea by law since 1988 [12,13,14]. The first MPA in Albania was proclaimed on 28th April 2010, embracing the coastal and marine area of Sazan Island – Karaburun Peninsula with the National Marine Park status, covering 12,570 ha (Figure 2).



**Fig. 2:** Karaburun Sazan National Park and Marine Protected Area.

## 2. MATERIALS AND METHODS

MSP is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a planning method. MSP is not an end in itself, but a practical way to create and establish a more rational use of marine space and the interactions among its users, to balance demands for development with the need to protect the environment, and to deliver social and economic outcomes in an open and planned way.

The following actions increase the effectiveness of MSP: i) gaining resources and political support. Here, responsible bodies for MSP should ensure adequate financial and skills resourcing and support, ii) data-collection

to support the monitoring and evaluation of the implementation of marine spatial plans; iii) addressing key priorities, i.e., focusing the marine spatial plan on achievable, clearly stated objectives, reflecting wider policy goals; iv) ensuring integration with other planning frameworks: there should be coordination across land and sea, in cross-border areas and with sectorial plans; v) gaining meaningful stakeholder participation: ensuring that MSP is conducted in an inclusive and culturally sensitive manner; vi) maintaining flexibility in MSP practice: the planning measures that are used should reflect the context and needs of the plan area and bodies affected; vii) committing to plan implementation: consideration should be given from the outset to how a plan's proposals are going to be put into practice and, viii) giving greater consideration to costs and benefits of MSP: a more systematic approach to economic valuation should be developed, as well as integrating economic analysis of trade-offs, and building into the MSP cycle.

To better understand the need for marine spatial planning, it is important to identify both apparent current trends, and project what future trends might look like in areas such as: i) increased demand in fresh water for local population, tourism, agriculture, industry, etc., ii) increased demands for energy in Albania, the Adriatic and globally and the trends in both non-renewable (oil and gas development) and renewable energy sources found in the marine environment (offshore wind, wave or current energy), iii) increased shipping and marine transport in the Adriatic, both increase in shipping and the size of vessels, iv) increased demand for tourism development and recreational uses as Albania is recognized as an emerging tourism destination because of its pristine environment and cultural attractions, v) increased demand for fish and seafood with average per capita increase in consumption predicted globally, a similar trend is likely in the Adriatic, vi) increased demand for agriculture which is expanding and becoming increasingly focused on efficiency and output resulting in discharges of phosphorous, nitrogen and other pollutant causing eutrophication of marine ecosystems vii) increased demand for infrastructure development including the building of ports and harbors, bridges and roads, solid waste and waste water systems, for both resident and tourists – all to meet the growing influx and uses of the coastal and marine environment [10,11].

Demographic changes (emigration and immigration) caused land abandon (Orikumi area), land occupation, sprawl, and abusive construction because of internal migration and lack of control (Novesela commune); increase of human pollution and wastes etc.

It is important to present here some conflicting perceptions between central and local level, conflicting activities and perceptions amongst institutions at the same level, and conflicting activities between local user

groups of populations. In particular: i) conflicting interest between central and local level in the resource use expressed in the local population concerns related to their ownership rights and reluctance towards government decision to include project areas under the status of special protected areas, ii) conflicting interests between business / industry and local population: salt plant and fishermen, fishermen organized in associations and individual fishermen, fishermen using the former marshlands and farmers, iii) conflicting interests between business and central or local government branches: malfunction of the communication canals between the seawater and the lagoon, variation of the hydric cycle of the lagoon, reduction of the drainage capacity and the fresh water influx to the lagoon, iv) conflicting interests amongst various individuals or groups of users: fishermen and hunters, wetland and wood ecosystem reduction to increase the arable land, use of pesticide and fertilizers versus organic agriculture, urban waists discharges to lagoon, tourist influx, etc. Conflicting interests between illegal activities: tree cutting, forest fires, fishing with explosives,

In addition to natural changes, human induced changes have to be taken into account, the first being often a reaction to the impacts of the second, being interlinked.

It is possible to identify impacts or risks coming from one sector of activity, but very difficult to reach a consensus on the cumulative impacts of all the sectors together. Considering the marine environment and the coastline, identification of the impact of each activity is nevertheless possible, as shown in the Table 1.

**Table 1.** Activities related to the marine environment and associated risks for the marine and coastal environment

Activity	9	Impacts
Industrial and Artisanal fishing activities	Lack of control	Overfishing Pollution, oil, plastics, lost and discarded nets Bottom trawling impact on ecosystems and species
Date mussels collection	Lack of control Lack of quotas	Habitat destruction
Aquaculture activities	Lack of monitoring Introduction of invasive species Introduction of pathogens and viruses	Impact of organic load on the water column and sea-bottom
Sport fishing	Lack of control	Illegal fishing and selling

Recreational and subsistence fishing	Lack of control Lack of data	Gap in management knowledge
Navigation scheme, maritime traffic	Risk of collisions Lack of control Lack of data	Pollution (accidental from oil and daily from navigation by garbage, plastic and others)
Karaburun-Sazan National Park (marine and coastal) protected area) [27]	Risks form ship accidents and pollution, old and recent sources Uncontrolled land and sea frequentation	Presence of marine debris Locally oil pollution from boats Habitat destruction, animal derangement, illegal fishing
Southern Vlora tourism development zone	Increased water demand Coastal erosion Risk of tsunami if earthquake	Coastal pollution
Military activities	Risks from military operation (collision) and from dumped military material on land and at sea	Oil pollution Noise pollution
Narta saltpans [18]	Coastal erosion Land use change	Water discharge
Harbor and jetties (for fisheries, fret, petroleum, passengers, military and tourism activities)	Accidental pollution (oil and chemicals) related to maritime and land transport, processing and distributing). Alteration of currents and sediment transport by jetties and harbors	Impact from maritime traffic (pollution) Locally, erosion or over sedimentation near infrastructures and impacts on marine ecosystems such as seagrass Marine debris and oil pollution

### 3. RESULTS AND DISCUSSIONS

Currently, the first set of data addressing the status of the Vlora area [15], and the limited information on the vision and orientations for the future of the country and the southern region, merely sketch the future planning and management of the marine environment. Given the present pressures and demands for this coastal region, its development unavoidably increases these pressures, and the needs for fresh water, energy, infrastructures (for transport, industry and tourism) and food supply (from agriculture, fisheries and aquaculture), particularly. On the marine side, the MSP process motivates in

particular five main domains of activities that impact, risk or reduce the equality of the marine environment: i) fisheries, ii) aquaculture, iii) maritime transport and ports, iv) tourism and recreation, and v) conservation areas, cultural and historical sites.

The fisheries [11] need a physical delineation of the different types of fishing: industrial or semi-industrial, artisanal and recreational, taking into account all the existing legislation, the restriction of fishing in specific areas (military areas, harbors, navigation channels, near the mouth of rivers of lagoons outlets, setback for specific activities such as aquaculture sites, cultural and historical remains underwater, obstructions, dumping sites, etc.) and allocating the remaining areas for the agreed activities (fisheries management plan), with new legislation if necessary and adequate penalty and strict enforcement. For aquaculture [11, 13, 16], the existing zones allocated to this activity in the south western part of the Vlora bay needs to be evaluated and an adapted aquaculture management plan has to be set-up with the professional and approved, defining precisely the area, the rules of procedures, the species, the food quality, the level of production and the emergency measures in case of disease, accident or mass mortality, and an independent monitoring program financed by all the aquaculture companies operating in the area. As for fisheries, new legislation could be enacted, with adequate penalties and strict enforcement, considering the closure of operation in case of breach of the agreed rules of procedures. For maritime transport and ports, a specific management plan is needed, as the petroleum harbor, the fisheries harbor, the ferry harbor, the military harbor and the multiple jetties in front of hotel or restaurant for tourism transport are operating all together in a very small area, where accident could occur, entailing the quality of the bay and the attractiveness of the area for tourism. At this stage, it is recommended to request that all the boats related to petroleum products, transport of goods and passengers, and industrial fisheries will use for access to the bay the northern entrance, wider and less risky than the channel between Karaburun and Sazan ferries. The Sazan Karaburuni channel will be only used for nautical tourism and recreational activities and by the control boats of the Navy and other services. For the tourism and recreation activities at sea, it is also necessary to prepare a management plan, with sites selected for swimming (usually coastal area), for diving (specific sites), for small sailing boats (sailing schools in the coastal area) and that all the mortised activities are excluded from the bay and proposed in an offshore area. For the transport of tourists for recreational activities by motorized boats for different activities (tours, transport to the marine protected area, pescatourism, etc.) it is recommended to concentrate the departures in two or three points along the coast in order to be able to control the movement and ensure the security and safety of the passengers. Among these sites a

departure could be in the fishing harbor, one in the ferry harbor and another one along the coast south of Vlora. By reducing the number of operators and setting a restricted number of transports to the Karaburun peninsula or to the Sazan Island, this will allow to reduce the pressure on the national park and to reduce the risk of fire, the amount of garbage and the damage to the terrestrial environment. For the access by private boat to the marine protected area, a system has to be set up, mooring installed and a reservation system in place, by half or full day, remaining on site at night being forbidden, including a fee for the maintenance of the moorings. During the process, some elements have been identified as missing or needing more data or information. It will be necessary to complete a survey and to gather information on these elements or to develop research and monitoring plan for following them or selected indicators for the environmental, social and economic quality of the area. In particular, the following needs and gaps have been identified: i) a research plan for identified knowledge gaps, ii) a monitoring plan for following changes in ecosystems and species (present and expected), the environment, the climate, iii) identification of suitable indicators (in line with MSFD and UNEP MAP – IMAP-ECAP for environmental, social and economic aspects, iv) a report on all the sources of pollution, and the associated risks, precautionary measures and emergency plans, v) evaluation of the potential climate changes impacts at the local level, and vi) identification of all the dumping sites sewage water, dumping areas at sea, rain/storm water outfalls [28,29].

The current trend of increased pressure from tourism development and other economies (such as aquaculture, commercial harbor, marine traffics, marine protected area, etc.) calls for a Marine Spatial Plan (MSP) to protect and revive rich marine biodiversity and cultural heritage of Vlora bay. The proposed MSP for Vlora Bay in Albania considers the anthropogenic activities such as conservation, different types of fisheries, different type of recreational and cultural activities, maritime transport & services (anchorage, etc.) and military, as well as to precise the option for the final zoning of the area based on the report of MSP Guidelines for Albania, a priority. The following table-matrix presents the proposed type of activities, responsible authority with a mandate on the activity and basic regulations to implement (Table 1).

**Table 2.** Proposed type of activities, responsible authority with a mandate on the activity and basic regulations to implement

Type of activity	Responsible authority with a mandate	Basic regulation
Military activities	Military Authority to define and delineate the areas and their accessibility	Surface: navigation to be restricted Water column: no tourism activity Sea bottom: no fishing, no tourism activities
Conservation activities: natural and cultural	Environment and Cultural authorities to define and delineate the areas, their accessibility, the types of activities and the number of visitors on land and at sea	Refer to the management plan of each area: National Park, Marine Protected area, wetlands or cultural sites on land and at sea. For example, exclusion of fisheries, definition of sites open for visits, adoption of a chart for tour operators (land and sea, trekking and diving, etc.), definition of entry fee, ...
Exclusion zones for fisheries (any type)[11]	Fisheries authority in connection with all other authorities.	Exclusion zones: Military areas Marine protected areas Buffer zones (500m) around cultural sites or wrecks Buffer zones (500m) around aquaculture sites 2km around lagoons or river mouths (Narta, Orikum, and river at the north according to legislation) 250m buffer zone for tourism activities along the coast during the touristic season Inside harbours In mooring zones In all navigation channels for petroleum, ferries, and industrial fisheries In polluted or dumping areas 500m buffer zones for sea

Type of activity	Responsible authority with a mandate	Basic regulation
Professional industrial fisheries[11]	Fisheries Authority, excluding the zones allocated to Military, Environment and Maritime transport, and defining precisely the areas and the technics to be used	Develop a management plan for fisheries (model GFCM) for each species of economic importance, define the areas and the depths allowed (80m and below), improve control, define dissuasive penalties, register catch and develop a monitoring plan...
Professional artisanal fisheries [11]	Fisheries Authority, excluding the zones allocated to Military, Environment and Maritime transport, and defining precisely the areas and the technics to be used	Develop a management plan for artisanal fisheries, defining the areas, the technics, water column or sea bottom according to species and ecosystems, identify the areas and depths, improve control, register catches and develop a monitoring plan.
Aquaculture sites	Already identified by fisheries authority To be delineate with a buffer zones of at least 500m around the installations	No tourism, No fisheries No diving Monitoring by environmental authorities
Recreational fisheries	Environment, fisheries and tourism authorities Areas to be define precisely and controlled	Exclusion of recreational fisheries of the zones allocated to other fisheries activities and aquaculture and define the techniques and catch limit per day per boat or person
Maritime transport activities	Maritime transport authorities to define the safer channels for petroleum, trade, ferries and passengers ships, while respecting the areas under the responsibility of Military and Environment authorities and the sensitivity of species and ecosystems	Redefine the entry and departure routes for petroleum products, trade, passengers and professional industrial fisheries, better through the bay northern entrance than in the pass between Karaburun and Sazan



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## **RESULTS OF THE FIRST IMAP MARINE SURVEY IN PATOK-RODONI BAY, ALBANIA**

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### **ABSTRACT**

Rodoni Cape (Albania), located 30 km north of Durres and 30 km south of Montenegro's border splits Lalzit bay into two parts. The outflows of Ishmi and Mati rivers have an impact on the Patok-Rodoni bay in the north, in spite of its relevant biodiversity and the presence of wetlands, complaints sedimentation effect on Posidonia meadows, geophysical disturbance due to various inland anthropogenic activities, contaminants and marine-litter. The first IMAP marine survey was carried out in October 2020 in the framework of the GEF Adriatic Project by an Albanian-Italian research team. A range of activities were required within the framework of IMAP and ICZM Protocol. The Survey was supported by UNEP/MAP, SPA/RAC, MEDPOL and NAPA, with the contribution of PAP/RAC. During the field phase, several IMAP Ecological Objectives were investigated, and environmental data collected to comply with all the relevant common indicators. There were 8 stations distributed along 3 transects and monitored for the assessment of the good environmental status of the area and identification of the main threats: off-shore,

inside Patok bay and near Cape Rodoni in Lalzi bay. Survey provided relevant scientific informations on EO1 Biodiversity, habitat and species, EO2 non-indigenous-species, EO5 eutrophication, EO7 hydrography, EO9 contaminants, EO10 marine-litter and provided preliminary data for fisheries. Important oceanographic equipments (Multi-probe-analyzers, water/sediment samplers, SSS, SBES, ROV) were used. Scientific divers and video-reporters were involved to realize both bionomic underwater LIT transects, both a video-documentary and an innovative 360-Interactive Virtual Tour as a new tool of scientific dissemination. All the data are integrated into the IMAP InfoSystem and the GIS-based maps showing both sensitive and high pressures areas.

**Keywords:** marine survey, Patok-Rodoni, IMAP, SPA/RAC, UNEP/MAP, GEF Adriatic, Ecological Objective, *Common Indicator*, SSS, SBES, ROV, *Underwater scientific divers*

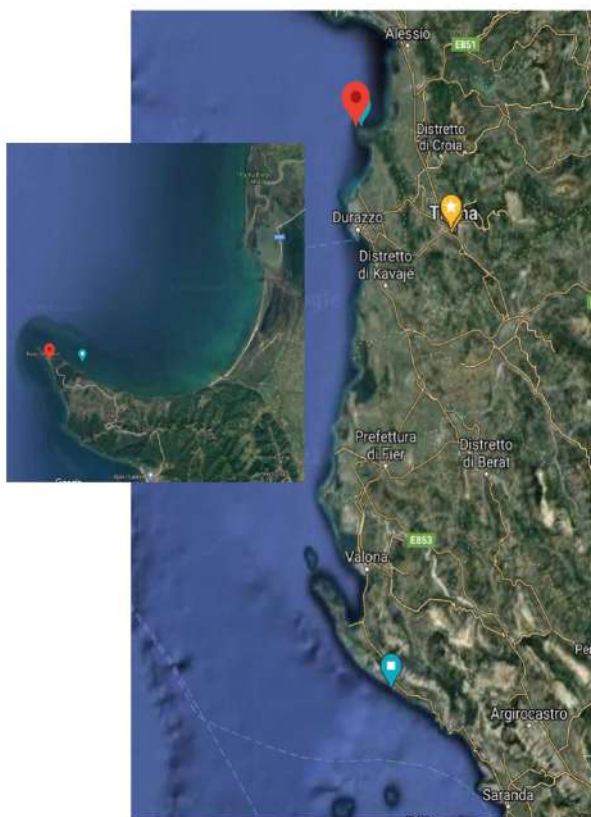
## 1. INTRODUCTION

The GEF Adriatic project aims to support Maritime Spatial Planning (MSP) across the Adriatic region as a tool for sustainable development. It's among the first initiative of its kind, embedding national IMAPs developed within the Barcelona Convention into MSP to achieve good environmental status of the Mediterranean Sea. The project is implemented in Albania and Montenegro by the UNEP/MAP Coordinating Unit with PAP/RAC and SPA/RAC. The Patok-Rodoni Bay, the Albanian surveyed area, is approximately 90 km<sup>2</sup>, and includes the Rodoni Cape and the Rodoni Bay. The area is known for its relevant biodiversity including a 50 km<sup>2</sup> protected area in the coastline. Here, the anthropogenic activity has been evident, in addition to the impact caused by the water exchanges with Patok Lagoon and the inflows from the river of Ishmi and Mati. The whole project was carried out in close cooperation with the SPA/RAC team and the National Agency for Protected Areas (NAPA) of the Albanian Ministry of Tourism and Environment. The present study involves the Certain Indicators (CI) of the IMAP Ecological Objectives (EO) related to biodiversity, hydrology, contaminants and marine litter. The National and International Experts (an Italo-Albanian team) who were hired by SPA/RAC for the survey, employed various oceanographic and marine biology techniques. Final results from data analysis and laboratory work could be found in the Final Report, Annex Files (20), the Executive Summary, the Job Training Session, the complete GIS based Map Archive, the Monitoring Database aligned with IMAP Tables ready to IMAP Info Pilot System, high quality photographic Reportage, long videos from ROV and Scientific Divers investigations, a short promo videoclip, a long version of documentary-film and an experimental Interactive Virtual Tour based on VR360 8K pictures and videos, recorded during Project's field activities. Results and main recommendations area means to

address the pressure on the environment and identification of the most fragile areas of Patok-Rodoni Bay, and sketch the Albanian Integrated Monitoring Programme (IMP) within the area and proposal of measures that allow the preservation of fragile marine areas and the development of sustainable economic activities.

### Study area

The Figure 1 depicts the Rodoni Cape (Albania), located 30 km north of Durres and 30 km south of Montenegro's border splits Lalzit bay into two parts. The Rodoni Bay in the north includes the Patoku Lagoon and the Mati River in the north of the lagoon. The southern part, usually named Lalzi bay, is a long sandy beach of about 18 km. This part of the coast of Albania is characterized by an accumulative sandy coastline. The maximum depth of the bay is around -30 m, diminishing regularly towards the coast. The southern part of the bay is deeper than the eastern part. These depths come closer to each other and with the coast in the region of the Mati mouth. The seabed within the bay is completely silty and sandy: all homogeneous and flat without particular pre-coralligenous or coralligenous habitats. The two rivers and the lagoons have a strong influence on the shape of the coast and the sea bottom, as the rivers' mouth change often their position and can feed alternatively the sea or the lagoon located between them. The movements of the rivers' mouth create an instability of the coast with successive erosion and accretion periods, making the coastal area less safe for boats navigation or mooring. The Cape of Rodoni is a spectacular strip of land entering the Adriatic Sea. It is the outermost peninsula of Albania at north of Durres. The cape is a geological formation of Miocene sandstone-clay banks, strongly eroded and generally barren. The coastal area includes a very poor vegetation dominated by *Crithmum maritimum*, *Elymus pycnanthus*, etc. grows up in some segments. Over this narrow stage, only 3-4 m above sea level, starts another stage dominated by Mediterranean maquis and somewhere by *Quercus pubescens*. The most commune species of this type of vegetation are: strawberry tree (*Arbutus unedo*), tree heath (*Erica arborea*), Spanish broom (*Spartium junceum*), myrtle (*Myrtus communis*), mastic (*Pistacia lentiscus*), phillyrea (*Phyllirea angustifolia*), laurel (*Laurus nobilis*), cistus (*Cistus incanus* and *C. salvifolius*), prickly juniper (*Juniperus oxycedrus*), blackberry (*Rubus fruticosus*) and holm oak (*Quercus ilex*). Close to the sea, on sand or gravel, grow some other species like prickly saltwort (*Salsola kali*), yellow hornpoppy (*Glaucium flavum*), common sea-lavender (*Limonium vulgare*), golden samphire (*Limbarda crithmoides*), cotton weed plant (*Otanthus maritimus*), etc.



**Fig. 1:** Patok-Rodoni bay, Albania.

## 2. MATERIALS AND METHODS

Sampling, storage, analyses and taxonomic and marine litter and pollution classifications are based on SPA/RAC and UNEP/MAP indications, i.e. in line with the IMAP methodology as agreed by the Contracting Parties to the Barcelona Convention. Table 1 reports briefly on the equipment used for the support of field survey mission, and the specific equipment, methodologies and protocols related to each Ecological Objectives are available in the full report ([www.rac-spa.org](http://www.rac-spa.org)).

**Table 1.** Equipment employed and methods applied for each Ecological Objective (EO) and Common Indicators (CI)

EO/CI	EQUIPMENT	METHOD FOR ANALYSIS
EO1 Positioning, Bathymetry Hydrography Geomorphology Mapping	<ul style="list-style-type: none"> <li>- Side Scan Sonar – SSS</li> <li>- Navigation equipment and positioning DGPS system STONEX S990A with ATLAS satellite centimeter correction</li> <li>- Single Beam Echo-Sounder SBES for Depth sounder recorder (ODOM Hydrotrac hydrographic) with inertial sensor Motion Reference Unit (MRU) for angular and heading corrections (model Teledyne MARHS)</li> <li>- Geomorphological survey of the seabed was performed with Triton Sea King Towfish (frequency 325 KHz)</li> <li>- ROV Gladius Mini model from CHASING equipped with a 4k / 12MP UltraHD camera, two 1200 lumen front lights, with positioning system UBSL (Ultra Short Baseline System) model LinkQuest Inc. TrackLink 1500MA</li> </ul>	<p><i>Hypack 2019 software PC acquisition and management by the Hypack 2019 software. Bathymetric data acquired simultaneously using "Netuno 2", software produced by Geocoste Snc,</i></p> <p><b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) : UNEP(DEPI)/MED WG.444/6/Rev.1</i></p>
Mapping benthic habitats	All previous equipment plus diving equipment using NOTROX – line intercept transects LIT, point intercept transect PIT, quadrants, photos, videos Scientific Diving Operators (OSS) with Advanced European Scientific Diver Certification by AIOSS (Italian Association of Scientific Divers),	<p><i>Peres Picard classification of Mediterranean biocenosis Standard IMAP methodology</i></p> <p><b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) : UNEP(DEPI)/MED WG.444/6/Rev.1</i></p>
Sediment sampling	Van Veen Grab of 25 liters	<p><i>Laboratory standard analysis following IMAP recommendations</i></p> <p><b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) : UNEP(DEPI)/MED WG.444/6/Rev.1</i></p>
Marine species such as marine mammals, birds and turtles	Literature review, interviews of fishermen and filed observations	<p><b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) : UNEP(DEPI)/MED</i></p>

		<i>WG.444/6/Rev.1</i>
EO2 Non indigenous species	ROV, diving surveys, photos and videos Sediment samples	<i>Laboratory standards recognition of species following IMAP recommendations</i>  <b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) : UNEP(DEPI)/MED WG.444/6/Rev.1</i>
EO3 Fisheries	Underwater observation and visualization with cameras, scientific divers and ROVs; Literature review Fish market data Interview of local fishermen and professional buyers sellers	<b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) : UNEP(DEPI)/MED WG.444/6/Rev.1</i>
EO5 Eutrophication and other parameters: temperature, salinity, density Conductivity, transparency, turbidity, dissolved oxygen phosphate, total phosphorus, nitrates, nitrites, ammonia, total nitrogen, orthosilicates and chlorophyll a CI 13 CI 14	Measurement of sampling by means of the WTW 340 I Multimeter Secchi disk for transparency WTW Turb 430i DO Probe Water sampler bottle: Kemmerer and Niskin Chlorophyll “a” samples were stored in black nontransparent PTFE bottles Van Veen grab sampler for sediment CTD Multi-parametric probe model YSI 6600 V2 Probe	<i>ISO standards 5667 for water analysis</i> <i>Standard Methods for the Examination of Water and Wastewater, 23<sup>th</sup> edition, 2017 of the American Public Health Association (APHA/AWWA, 2017)</i> <i>WTW Photolab 7600 UV-VIS Spectrophotometer</i> <i>Laboratory standard analysis following IMAP recommendations</i>  <b>Réf:</b> <i>IMAP Guidance fact sheets</i> <i>UNEP/MED WG.467/5</i> <i>Monitoring Guidelines/Protocols for sampling and sample preservation of seawater for the analysis of CI13 and CI14: concentration of key nutrients and chlorophyll a: UNEP/MED WG.482/5</i> <i>Monitoring Guidelines/Protocols for Determination of Concentration of Key nutrients in Seawater – Nitrogen Compounds: UNEP/MED WG.482/8</i>

		<p><i>Monitoring Guidelines/Protocols for Determination of Concentration of Key Nutrients in Seawater – Phosphorous and Silica Compounds: UNEP/MED WG.482/9</i></p> <p><i>Monitoring Guidelines/Protocols for Determination of Chlorophyll a in Seawater: UNEP/MED WG.482/10</i></p>
EO7 Hydrography CI 15	See EO1	<p><b>Réf:</b> <i>IMAP Common Indicator Guidance Facts Sheets (Coast and Hydrography): UNEP(DEPI)/MED WG.444/7</i></p> <p><i>Monitoring Guidelines/Protocols for Determination of Hydrographic Physical Parameters: UNEP/MED WG.482/6</i></p> <p><i>Monitoring Guidelines/Protocols for Determination of Hydrographic Chemical Parameters: UNEP/MED WG.482/7</i></p>
E09 Contaminants CI 17 CI 18	<p><b>BIOTA &amp; SEDIMENTS:</b></p> <ul style="list-style-type: none"> <li>- Trace/Heavy Metals (TM): Total mercury (HgT), Cadmium (Cd) and Lead (Pb)</li> <li>- Organochlorinated compounds (PCBs, Hexachlorobenzene, Lindane and <math>\Sigma</math>DDTs)</li> <li>- Polycyclic aromatic hydrocarbons (US EPA 16 PAHs Compounds)</li> </ul> <p><b>SPECIFIC FOR BIOTA</b></p> <ul style="list-style-type: none"> <li>- Lipid content, flesh fresh/dry weight ratio for normalization purpose</li> </ul> <p><b>SPECIFIC FOR SEDIMENTS:</b></p> <ul style="list-style-type: none"> <li>- Aluminium (Al), Total Organic Carbon (TOC) in the &lt;2mm particle size fraction for normalization purpose for TM and OCs, respectively. The &lt;63µm sediment fraction is recommended to be complementary for metals</li> <li>- Lyophilization ratio (dry/wet sediment ratio)</li> </ul>	<p><i>To fully comply with IMAP requirements, contaminants should be selected in accordance with UNEP (DEPI)/MED WG.444/5, Directive 2000/60/EC, EC Regulation 853/2004 and 1881/2006.</i></p> <p><b>Réf:</b> <i>IMAP Guidance fact sheets UNEP/MED WG.467/5</i></p> <p><i>Monitoring Guidelines/Protocols for Sampling and Sample Preservation of Sediment for IMAP Common</i></p> <p><i>Indicator 17: Heavy and Trace Elements and Organic Contaminant: UNEP/MED WG.482/11</i></p> <p><i>Monitoring Guidelines/Protocols for</i></p>

		<i>Sample Preparation and Analysis of Sediment for IMAP Common Indicator 17: Heavy and Trace Elements and Organic Contaminants: UNEP/MED WG.482/11</i> <i>Monitoring Guidelines/Protocols for Sample Preparation and Analysis of Marine Biota for IMAP Common Indicator 17: Heavy and Trace Elements and Organic Contaminants: UNEP/MED WG.482/14</i> <i>Monitoring Guidelines/Protocols for Sampling and Sample Preservation of Seawater for IMAP Common Indicator 17: Heavy and Trace Elements and Organic Contaminants: UNEP/MED WG.482/15</i> <i>Monitoring Guidelines/Protocols for Sample Preparation and Analysis of Seawater for IMAP Common Indicator 17: Heavy and Trace Elements and Organic Contaminants: UNEP/MED WG.482/16</i>
E10 Marine litter	Line intercept transect, coastal surveys and diving surveys ROV surveys Manta trawl net	<i>IMAP standards</i>  <i>Réf:</i> <i>IMAP Guidance fact sheets</i> <i>UNEP/MED WG.467/5</i>

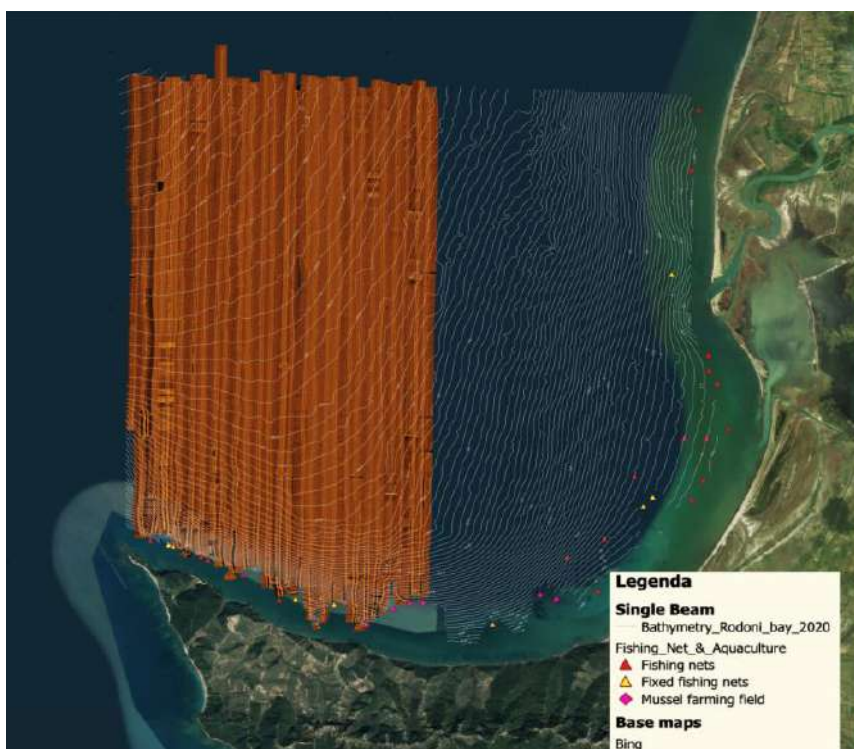
### 3. CONCLUSIONS AND DISCUSSION

The project was carried out in three phases.

*Phase I* concerned the preparation of Inception Report that included collection and analyses of all the previous available studies related to selected areas of Patok-Rodoni Bay, in particular, those relating to marine biodiversity and habitats, pollution, fisheries and hydrography, based on the National Data GAP assessments reports and the Integrated National Monitoring programs elaborated by the GEF Adriatic National and International team of experts provided by SPA/RAC and PAP/RAC.

*Phase II* concerned the marine Survey which included collecting additional data during this First Albanian IMAP Marine Survey through sampling in the selected stations and lab tests, concerning the IMAP Common Indicators identified for specific Ecological Objectives. During field activities the Team worked in order to obtain scientific data was obtained in full compliance with demands of the project from SPA-RAC, PAP-RAC, MEDPOL, UNEP-MAP and NAPA, so data have allowed to: i) assess the GES of the study area (Good Environmental Status); ii) provide reports and GIS based maps related to the data collected; iii) provide high-resolution pictures and video report of the field survey; iv) provide on the Job Trainings to local experts and representative of National Institutions in Albania on the monitoring techniques used; v) support the Integrated National Monitoring Program in Albania; and vi) provide data to implement the database at national and regional level.

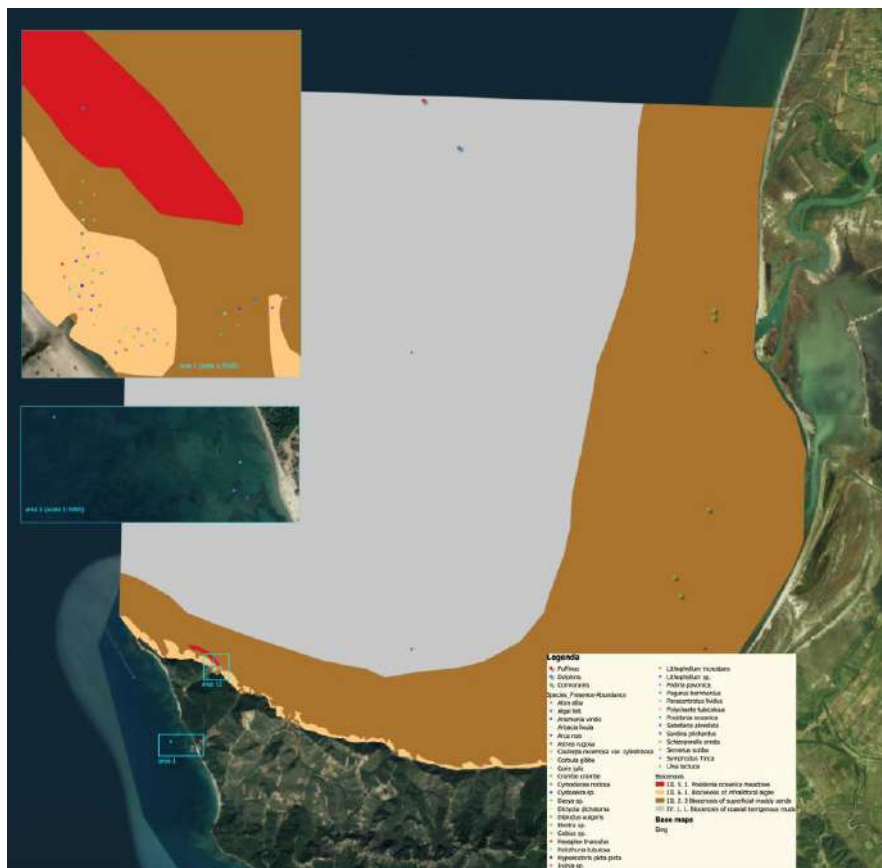
*Phase III* concerned the Validation Meeting and Final Report and Deliverables submission, Annexes Files and specific Recommendations.



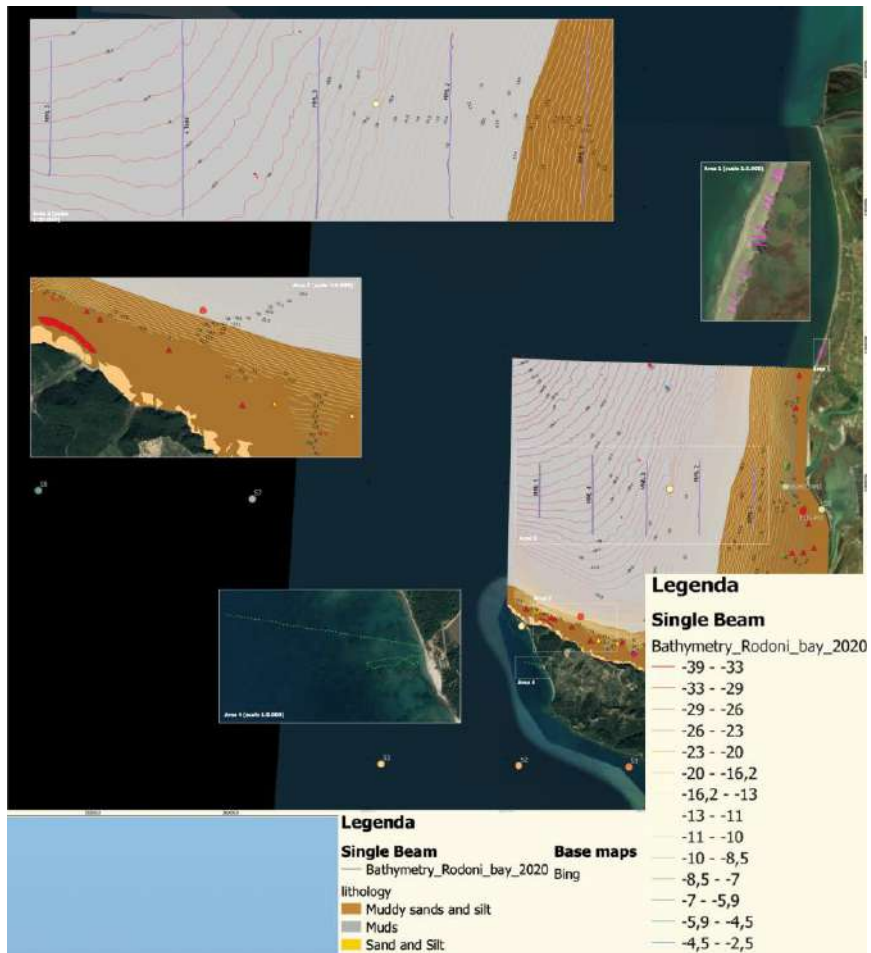
**Fig.2:** Echo mosaic of the SSS investigation.



**Fig. 3:** A first map of the distribution of *Caulerpa*



**Fig.4:** A first map of the distribution of biodiversity and biocenosis in the area.



**Fig. 5:** Map of bathymetry and geological information from the SBES and Scientific Diving surveys.

#### 4. CONCLUSIONS

Conclusions on the marine survey, i.e., of IMAP Ecological Objectives and the relative Common Indicators are in the forthcoming paragraphs described.

*EO1 Biodiversity (Habitat and species) - Common indicators 1, 2, 3*

Regardless the growing interest in these last years on the distribution of marine habitats, the data remains scarce and limited, especially in the north of Albania and restricted to data about the benthic macro-fauna in the *Posidonia oceanica* meadows in the Patok and Lalzit bays. The area is under

the influence of rivers outputs, and characterized mainly by the presence of superficial muddy sands biocenosis in sheltered waters (identification code III.2.3) in the coastal sector and by the biocenosis of coastal terrigenous muds (identification code IV.1.1) for the deeper depths. Near the southern part of the coast, small rocky outcrops emerge from the soft bottom and are characterized by the dominant presence of Ulvaceae and the polychaete *Sabellaria alveolata*. Colonies of this polychaete form bio-constructions with a diameter of up to 50 cm emerging from the bottom. The biocenosis of superficial muddy sands in sheltered waters have always characterized by the not continuous presence of *Cymodoceanodosa* on superficial muddy sands in sheltered waters (identification code III.2.3.4). The seagrass *P. oceanica* is present within the study area only as isolated small patches, both on rocky and sandy bottom, but not as a continuous meadow as observed for the south of Rodoni Cape.

Within the study area, due to the important flow of fresh water and sediment from the coastal rivers, great part of *P. oceanica* are replaced by other seagrasses such as *C. nodosa*, species considered more tolerant, but never growing in dense meadows, and particularly algae as Ulvaceae and Caulerpaceae. Soft bottoms present heterogeneous populations both in terms of community structure and in terms of species diversity. The number of species per sample vary over a very wide range. Hard bottoms host photophilic algal populations mainly represented by *Ulva* sp., while the faunal component is mainly represented by Polychaete *S. alveolata*. The brown alga *Cystoseira* shows an intermittent distribution with consequent low coverage values of hard substrates. Their regular presence of *P. oceanica* as scattered patches is due to changes in salinity and poor transparency of the waters, the abundance of *C. nodosa* and the dominance of *Ulva* sp. are closely linked to the rivers supplies, in particular Drini, and to anthropic activities in the coastal area and upstream of the rivers, which lead to the alteration of sedimentation and the presence of nutrients and pollutants in the water. According to the present study, the conservation state of the *P. oceanica* meadow, in the area of Cape Rodoni is not completely satisfying, and the many key species observed (*P. lividus*, *Chondrilla nucula*, *Caulerpa cylindracea*), suggested the need to realize a detailed digital mapping of the seabed with particular attention to the *P. oceanica* range of distribution area.

The results of the sightings have allowed to identify a stationary population of cormorants (*Phalacrocorax carbo*) near the eastern coastal sector of the survey area. Most of them are using the fixed fishing systems installed on the coast or in the lagoons. The sighting of a single specimen of shore-waters (*Puffinus* sp.) underlines the presence of this species in the area. Several sightings of small groups of the dolphin *Tursiops truncatus* suggest a constant presence of marine mammals in the waters under study. No

specimens of seaturtles and/or sharks were recorded during the survey, although their presence in the area seems to be ascertained from previous observations made by fishermen and Albanian scientists.

#### *EO2 Non Indigenous Species (NIS) - Common Indicator 6*

The invasive species recorded in Rodoni area during the survey are the alga *C. cylindracea* and the blue crabs *Callinectes sapidus* that have been recorded in most of the Albanian coast recently. *C. cylindracea* is widely distributed throughout the area, both on soft bottoms and on rocky outcrops, where it forms extensive carpets. Its presence is also observed in concomitance with photophilic algal populations and/or with the phanerogams *Posidonia oceanica* and *C. nodosa*.

#### *EO3 Fisheries*

Only the variability of fish assemblages will be assessed. In all the investigated sites, the census of fish fauna shows a very low abundance in terms of number of species and number of specimens. The cause probably lies in the intense fishing pressure exerted on the entire area under survey. This is highlighted by the huge amount of fishing gear scattered throughout the area (coast and sea) between Rodoni Cape and Patok Lagoon. The size of the observed specimens varies from medium to small, if we consider the average size, and constitutes further evidence of the high fishing pressure to which this coastal zone is subjected. Implementing measures to reduce fishing pressure in the study area and in the contiguous ones could induce an increase in fish stocks in terms of both the number of species and their size.

#### *EO5 Eutrophication - Common Indicator 13- Common Indicator 14*

The investigations carried out show a progressive increase of presence of silt and mud both in the water column and in the sediments, following a transect that goes from the coast to the open sea. During sampling period, a constant and high turbidity of the surface waters and of whole water column was observed. Total nitrogen, phosphorus and other parameters levels, plus all the chemical-physical parameters, show a gradual increase in hypertrophy in the center of Patok bay and along the coasts, where the river deltas and lagoons are present. The values of chlorophyll-*a* and phytoplankton population show the same pattern of increase. Patok Bay appears as a wide area of sea and coast that has a strong influence of sedimentary supply, of organic and inorganic material, from the rivers and lagoons. With the lack of control of water discharges (rain and sewage water) in the river and at sea, and the lack of permanent monitoring of the marine environment, the situation of trophy and hypertrophy could increase greatly depending on the season, rainfall and temperature.

*EO7 Hydrography - Common indicator 15*

The analysis of bathymetric data together with those relating to transparency, temperature, salinity and tide levels doesn't seem to highlight particular anomalies within the study area. The presence of rivers and abundant fluvial inputs deeply affect the area between Patok Lagoon and Rodoni Cape as regards both the contributions of sediments and the chemical-physical parameters of the water column. The sediments transported by the rivers are then distributed in the Patok Bay forming a flat seabed that slowly deepens from the shore to off-shore. The granulometry analysis of the sediments highlights a preponderance of silt and clay component versus a limited presence of larger size classes. This suggests that the fluvial inputs are mainly made up of fine material easily transported or re-suspended over long distances by waves and currents.

*EO9 Contaminants - Common Indicator 17, 18*

The survey showed a relatively low pollution level in 2020 and, as this was the first detailed survey organized in the Patok Rodoni area, there are no means to compare with previous data. Amongst the information that could have been useful to understand the patterns in the Patok Bay are maps of general currents, micro-currents and tidal currents. This could assist for identifying areas of dispersion and areas of concentration of pollutants coming from the rivers and/or the lagoons. By the way, all values registered appeared within the national limits. PCBs, PCAs and heavy metals values in the biota, as well as all the analysis related to the evaluation of genotoxic effects performed on filter feeders sampled in the area, were found to be very limited or, furthermore, negative-not relevant. All tests on Lysosomal Membrane Stability (LMS), Acetylcholinesterase (AChE) assay and Micronucleus assay in haemocytes resulted completely negative. These data remind that pollution level could be controllable yet if some management, conservation and protection program starts.

*EO10 Marine litter - Common Indicator 22, 23*

The study area is strongly impacted by anthropogenic activities, not only directly carried out on site but also from inland or coastal activities north of the surveyed area, transported by the currents that appear to be dominantly from north to south. The main impacts are linked to the marine litter conveyed/transported by the rivers (Drin, Mat and Ishmi) that flow along the coast, or occasionally in the two coastal lagoons (Tale and Patok) and are blocked in the southern part of the Patok bay by Rodoni Cape. A map of the beach marine litter survey, located in Annexes 006 was drafted based on 5 transects of 100m. Considering each transect perpendicular to the coast, a total of 506 m of beach was sampled.

There were carried out 5 linear paths for sampling the micro-plastics on

the marine surface at 5 stations respectively located at 2 km, 4 km, 6 km, 8 km and 10 km from the coast and the distance covered has a total length of 12652 m. The results of the analysis of the collected micro-plastic samples and of the observations regarding floating macro-plastics are reported in respective tables together with the details of the distance covered by each linear path and the volume of filtered water. The concentration of micro-plastics in the sample, by shape and by color, is expressed as the number of items per transect. While the concentration of micro-plastics at each transect is expressed as the number of items per m<sup>2</sup> of sampled seawater. The results show that within the project area micro-plastic contamination level is much lower compared to Mediterranean level.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The forthcoming paragraphs provide some insights on both planning, future management and interventions that, in the long term, could guarantee an improvement both in the habitats present and in the organisms living in the area. At the same time, they are a means to address the developing or controlling of socio-economic activities (tourism, fisheries, nautical sports) and environmental protection (coastal and marine protected areas) in the area of Patok Rodoni Bay, as currently considered by the national authorities.

**Recommendation for the monitoring of the area** - The scientific research works carried out up to now is insufficient. The existing data could not be validated due to lack of information on positioning and methodology for analysis. This Marine Survey, constituting a baseline for the IMAP process, allowed highlighting some ecological characteristics, which do not sufficiently inform us about the full functioning of the area. It is important for the next monitoring processes to cover the same stations and look for the same elements, by seasons and/or year cycle, while adding additional long periodic or permanent measurements, such as meteorological data (wind, rain, temperature), hydrological data at different stations (sea water temperature, currents, swell and waves, river flow, turbidity, etc.). It is very important to make a calculation of Annual Marine Monitoring Budget to continue evaluating the area in the near future.

**Recommendation about the inclusion of the local survey stations in the national monitoring network.** The ecosystem on both sides of Rodoni Cape are market plays, disruptive growth opportunities with significant revenue potential for ecosystem participants, even though the fluvial supply and the management dynamics of coastal lagoons have a great effect on the north side of the cape. Although the pollution level appears nowadays limited, both the organic and inorganic pollution remain the principal concern which requires appropriate monitoring, management, and control and must be

resolved in a near future. All the selected sampling stations can be included in the national monitoring network for the monitoring of the quality of the marine environment, responding to the participation of the country to the IMAP process except for *Posidonia* due to the scarce presence on the species. Other stations should be added in the future on the basis of the main results.

**Recommendation for the development of a MCPAs.** Albania has identified several sites along its coast for declaring future MPAs, and the Rodoni Cape is one of them. As shown in the survey of the northern part of Cape Rodoni, the Patok bay shows a limited number of point of interest due to the uniformity of the sea bottoms (sandy, muddy) and the limited variety of biocenosis. The extension to the southern part of Rodoni Cape, the Lalzit Bay represents the specificities of the Mediterranean region, including an area of bio-construction with the presence of *P. oceanica* meadows. The marine and coastal protected area centered on Rodoni Cape could associate the marine interests of the north and south of the Cape. In addition, other point of interest are present in the surrounding for developing ecotourism activities, the lagoons or Tale and Patok with their fishing activities and the presence of numerous wild birds and the rivers and their rims.

**Recommendation on MSP and link to ICZM.** Studies on coastal processes along the Albanian coastline show that the coastal defenses that address coastal erosion are not the main concern, but anthropogenic activities are. Environmental indicators within economic budgets, and the ecological constraints at a macroeconomic level are a means to address the negative impacts. Multidisciplinary investigations at a large scale for the environmental impact assessments of development projects, both on land and at sea are of primary importance.

**Recommendation for additional marine hydrographic and sedimentologic studies.** Planning and management of the coastal area require further in-depth studies addressing coastal dynamics and geomorphological evolution. Here, combining the morphological data already acquired (bathymetric and side scan sonar survey) with new data and specific studies is necessary.

**Recommendations for innovative ecological studies.** The preliminary data obtained on the contaminants and possible pollution impacts show that further investigations about the circulation, storage and accumulation of the main pollutants in water and sediment are needed. Heavy metals are one of the existing pollutants in the area, as the survey data report. Their distribution and origin are not very clear, but it is plausible that they are transported by floods of rivers. Once in the sea, they are transported and deposited according to currents. A detailed survey on currents and hydrography, associated with the data obtained from the geomorphological study of this project would help us understand better the distribution of heavy metals, developing proposals for

the improvement and protection of the area and the coasts.

**Recommendation on sites of underwater historical and cultural value.** The survey area encompasses several submerged wrecks of different periods. A dedicated study on the colonization and conservation of these wrecks could be very important, not only for their historical and cultural value, but also for their ecological role within this habitats.

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## **MEDITERRANEAN MONK SEAL IN ALBANIA: HISTORICAL PRESENCE, SIGHTINGS AND HABITAT AVAILABILITY**

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### **ABSTRACT**

Mediterranean monk seal populations were heavily reduced in time all over its entire ancient distribution. In Albania, the species was reported to be present in the past in spite of the lack of references on specific locations, reproductive activities and numbers of individuals. It is nowadays considered to be extinct. Nonetheless, several sightings have been reported, afterward, along the country coasts. With the present project, we intended to investigate and clarify the past and present status of the species in Albania. Information on its historical presence were reviewed along with the collection and evaluation of recent sightings. Furthermore, the ~65 km of the Marine National Park of Karaburuni-Sazani coast were surveyed to check suitable habitat availability for the species (marine caves). Eight caves were mapped, two of which, the ones that presented the best characteristics for breeding, were equipped with infrared cameras. In one of those, we recovered evidence of actual use by the seals. Aside from shed light, for the first time, on the status of the species, our project has the ambition to provide insights for an effective monitoring and conservation

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strategy, to be planned on a long-timescale at a local level, and within a “region-wide approach”.

**Keywords:** Marine mammal, Conservation, Adriatic Basin, Marine National Park, Karaburun-Sazani

## 1. INTRODUCTION

The present study is a first attempt to collect all available information on the Mediterranean monk seal (*Monachus monachus*, Hermann 1779, hereafter MMS), an endangered marine mammal, in Albania, where it is supposed to be extinct. We focused our researches investigating on its past presence along with the species' current frequentation of the country coasts. Furthermore, the study has the main aim to set up the baseline for a broader time and spatial scale investigation, and highlight the conservation priorities for the species recovery at a local and regional level. A strategy for monitoring and for the conservation of this species should include the strengthening of coastal area protection, encompassing the involvement of local stakeholders. Moreover, it should be planned considering the Adriatic and Ionian Seas as a whole region of distribution and/or expansion/re-colonization for the species.

The populations of MMS were once distributed along the eastern north Atlantic coasts, the Mediterranean Sea and the Black Sea<sup>1,2</sup>. During the Roman Empire the species underwent through a dramatic shift, being captured for their furs, meat, oil and even for the Arena's games<sup>2</sup>. Their exploitation within the Mediterranean and Black seas continued during the Middle Age, Renaissance and up to the present time, further decreasing the already reduced populations<sup>3</sup>. Along the Atlantic the exploitation started long after the Roman Empire, during the first trips in search of new trade route through the Atlantic Ocean<sup>3</sup>. The left surviving reproductive nuclei of the species, today, are limited to the coast of Greece and Turkey in the Mediterranean, and to Madeira-Ilhas Desertas (Portugal) and Cabo Blanco (Mauritania/Western Sahara) in the Atlantic<sup>4</sup>. Nevertheless, sightings of seals have been reported, at least over the last two decades, from the other countries of the Mediterranean where the species is believed to have disappeared<sup>5</sup>.

The MMS is internationally protected by the “Convention on International Trade in Endangered Species” (CITES, 1973; ratified in Albania in 2003), the “Convention on Conservation of European Wildlife and Natural Habitats” (1979; ratified in Albania in 1999), the “Convention on the Conservation of Migratory Species of Wild Animals” (CMS, 1979, ratified in Albania in 2001), and the “Convention on Biological Diversity” (1992; Albania is party since 1994). The species is also listed in the “Protocol for Specially Protected Areas and Mediterranean Biological Diversity” (1995; ratified in Albania in 2001) within the “Barcelona Convention on the Mediterranean Sea” and in the

in the European Union “Habitats Directive” (92/43/EEC) binding on all member states. In Albania is protected since the end on the ‘70s by decree on hunting and protected areas<sup>1</sup>.

The MMS was acknowledged to be present in the past along the Albanian coast and is nowadays classified by the International Union for the Conservation of Nature-IUCN as Possibly Extinct<sup>6</sup>. However, no exhaustive biogeographical studies on the species have been performed, nor are available accurate data on presence, population numbers, or reference to reproductive activities along the country coasts. Similarly to other areas of its former distribution in the Mediterranean, as mentioned above, reports of seal sightings have been recorded also from the coasts of Albania<sup>5</sup>.

Information derived from occasional witnesses need to be processed carefully, particularly when dealing with sightings of a rare, endangered and charismatic species. The data derived from the collection of such information can be affected by false negative (absence of information, but with effective presence of the animals) and false positive (sightings erroneously attribute to the subject of the investigation). To avoid false negative data, specifically designed and systematic surveys should be planned. This is particularly true when investigating a “cryptic” species whose presence might goes undetected. False negative can lead to under-estimation or consider the species disappeared, false positive to over-estimation and mistakenly record signs of recolonization<sup>7,8</sup>.

MMS used beaches and marine caves to haul out, rest and give birth. Nowadays, marine caves represent the main terrestrial habitat used by the species<sup>3</sup>. An ideal breeding cave should have one or more entrance/s, preferably underwater (syphon), one or more internal sandy or pebbles beaches or rocky platforms above the sea level and an internal basin not directly exposed to the open sea currents and waves. Resting caves do show less restrictive parameters but with at least one or more beaches or platform above the sea level in their interior part<sup>9</sup>.

The coastline of Albania extends for 476 km, from the eastern south Adriatic Sea, adjoining north with Montenegro, to the northern Ionian Sea, until the Greek border as southern limit. From Shengjin to the bay of Vlora, the Adriatic coastline, representing about 3/5 of the country coast length, is characterized by sandy shores. The Ionian coastline, from Vlora to the Greek border, is predominantly represented by erosive coast with occasional intrusion of pebbly or sandy beaches<sup>10,11,12</sup>. The island of Sazani and the Peninsula of Karaburun, close to the south-west the bay of Vlora, and mark the physical limit between the Adriatic and the Ionian Sea. It is the part of the coast mainly characterized by steep cliffs, deep water, and is the area where are mostly concentrated marine caves. This stretch of coast was established in 2010 as the first marine protected area of the country<sup>10,12,13</sup>.

## 2. MATERIALS AND METHODS

Starting in 2018, we initially reviewed all the useful available information on the MMS carrying out a thorough bibliographical research. The research centered on retrieving historical and recent data on the species presence, sightings, and habitat use along the Albanian coasts.

Additionally, MMS sightings, reported between 2019 and 2020, were verified, checked and analyzed. In 2020 RAPA (Regional Administrative of Protected Area) Vlora, the managing authority of Marine National Park of Karaburuni-Sazani (MNP K-S), set up a network of information for marine species encounters, allowing direct communication of MMS sightings. Such network involves, up to now, 18 fishermen of the bay of Vlora. To avoid overestimation of the monk seal presence, including the chance to add bias, due to false positive, we analyzed only those for which video or photographic material was made available from the witness. The materials were organized in a database and analyzed for individual identification using the characteristics of the fur and the presence of scars.

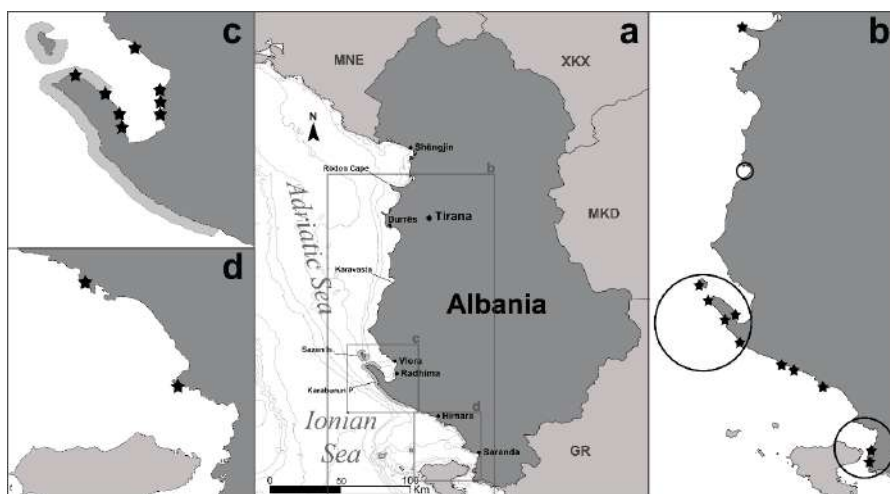
To complete our investigation, the ~65 km of coastline of the MNP K-S were surveyed in search of suitable habitat for the species. The activities focused on marine caves, with entrance above the sea level. Additionally, following the first directly verified sightings, reported in 2019, a short survey was conducted inside the bay of Vlora. Measurements were taken for the caves that presented the morphological characteristics as suitable for the species' use, to create a database of habitat availability. A system of infrared cameras was installed in those that morphologically presented characteristics as potential breeding caves, to be able to record their effective use by the seals and collect additional materials for photo-identification.

## 3. RESULTS AND DISCUSSION

MMS' former presence along the coast of Albania is acknowledged in all the main documents published by official bodies, concerning the conservation and distribution of the species: IUCN, United Nations Environmental Programme/Mediterranean Action Plan-UNEP/MAP, Specially Protected Areas Regional Activity Center-SPA/RAC, and General Fisheries Commission for the Mediterranean-GFCM.

However, through the consultation of the aforementioned official documents and the available publications<sup>14,15,16,17,18,19,20,21,22,23,24</sup>, it was impossible to recover any information on the eventual presence of MMS's stable reproductive nuclei or references on specific habitats used by the species along the coast of the country. The only data, with at least general

information on the locations and dates in which MMS' encounters took place, refer to the decades between the 40s and the 60s, and up until the 80s. All the data represent report of occasional sightings from the areas of Karavasta, Karaburun-Sazani and Saranda<sup>14,25,26</sup>. In one case the information, referred to a female pup caught in a fishing instrument in the area south of Saranda, close to the Greek border, in 1954. This fact was confirmed by the finding of the stuffed specimen preserved in the Museum of Natural Sciences "Sabiha Kasimati", in Tirana, documented also in bibliography<sup>25,27</sup>. Furthermore, vague information has been recovered, for the decade of the 90s, referring to occasional encounters of MMS specimens, concerning the southern Albanian coast, from Karaburun-Sazani to the Greek Border<sup>10,11,12,25,28</sup> (figure 1b).



**Fig. 1.** (a) Map of Albania. In squares are highlighted the areas enlarged in b, c, and d. In (b) are represented the information related to monk seal presence along the country coasts reviewed from the literature. The general areas reported to be frequented by seals between the 40s and the 90s are marked with circles. The more specific information related to the sightings between 2000 and 2017, are marked with stars, and enlisted in table 1. In (c) and (d) are represented the main locations of the sightings collected and verified during the present study, marked with stars, and enlisted in table 2. In (a) and (c) is also represented the Marine National Park of Karaburun-Sazani.

More detailed data could be retrieved for sightings reported between 2000 and 2017. A total of 11 sightings were reviewed from recently published works<sup>5,12,29</sup>, referring to the southern Albanian coast, from Karaburun-Sazani to the Greek border, and one from an area more in the North, in 2006. In one case it was reported the presence of more than 1 animal (in 2003). The data are enlisted, ordered by date, in table 1, indicating the main locations where the sightings were witnessed, and represented graphically in figure 1b.

Similar considerations on the consistency and on the concentration of monk seal sightings in the southern coast and particularly along the Peninsula of Karaburuni, were also outlined in a previous survey (funded by IFAW, the report is not yet available for public consultation, G. Mo *Pers. Comm.*).

**Table 1.** Mediterranean monk seal sightings in Albania, 2000-2017

Date	Location	Date	Locations
Summer 2000	Greek Border	April 2010	Saranda
April 2003	Karaburuni Peninsula	August 2012	Karaburuni Peninsula
September 2003	Sazani Island	12 November 2016	Karaburuni Peninsula
Summer 2004	Karaburuni Peninsula	05 May 2017	Karaburuni Peninsula
Summer 2004	Saranda	25 May 2017	Karaburuni Peninsula
Autumn 2006	Rodoni Cape		

Additionally, several sightings have been reported between 2019 and 2020 and directly collected by one of the authors (N.H.). Of the several sightings collected, 13 provided with photos/videos were analyzed in the present work. The data are enlisted, ordered by date, in table 2, indicating the main location where the sighting was recorded and represented graphically in figure 1c and 1d.

**Table 2.** Mediterranean monk seal sightings in Albania, 2019-2020

Date	Location	Date	Locations
19 March 2019	Vlora Bay	18 March 2020	Karaburuni Peninsula
26 March 2019	Vlora Bay	01 July 2020	North of Saranda
30 March 2019	Vlora Bay	06 August 2020	North of Saranda
31 March 2019	Vlora Bay	11 September 2020	Karaburuni Peninsula
06 April 2019	Vlora Bay	21 September 2020	Karaburuni Peninsula
17 May 2019	Vlora Bay	13 December 2020	Karaburuni Peninsula
30 July 2019	Vlora Bay		

All these documented encounters depict single animals. In most of the cases the images available represented juvenile seals, however, the quality of the images did not allow a proper individual photo-identification. Therefore, it was not possible to quantify and evaluate the number of animals encountered in 2019-2020. It should be noted that most of the previous sightings (2000-2017) could not belong to the same juvenile/srecorded in 2019-2020.

During August 2019 the ~65 km of the MNP K-S coast were surveyed to investigate suitable habitat for the MMS (marine caves). Within the present project only caves with an entrance above sea level were deeply investigated. Additionally, the area where the first sightings were recorded in 2019, between Vlora and Radhima, was checked. Measurements were recorded in those caves that presented morphological characteristics as suitable habitat for the MMS: one or more connection to sea, eventual presence of one or more syphons, and presenting in their interior at least one or more sand or pebbles beaches or rocky platforms above the sea level. Eight caves did present the mentioned characteristics. The caves were mapped to create an archive of potential habitat of the MMS for the park managing authority. Two caves, those with the best morphological characteristics as potential breeding cave, were chosen to be equipped with infrared cameras, in order to record their actual use by the species. A one- or two-months old monk seal scat was recovered in one of the internal beaches of one of them, confirming the effective use of the cave by the species. Infrared cameras were installed in the two caves only in the late winter 2020 due to difficult meteorological condition, and retrieved before summer to avoid being damage or stolen during the holiday season. The short period did not allow to confirm the presence of seals inside the caves, at least until the last camera replacement activity, carried out in the first part of December 2020; however, the cameras will be permanently available to the park to continue the monitoring activities for longer period of time.

#### 4. CONCLUSIONS

It is not clear whether the Albanian coast has ever hosted a stable and reproductive population of MMS or represented only a natural corridor of connection between individuals and subpopulations along the Adriatic and Ionian Seas. Despite the lack of substantial biogeographical knowledge on the species' population consistency and habitat use in the past, the historical data reviewed in the present study cannot exclude either of the possibilities. Similarly, it would be misleading to interpret the recent, more substantial, availability of information relating to sightings, as proved signs of recovery and re-colonization by the species. For instance, all the sightings recorded in 2019-2020 only pictured single specimens. It is worth to mention that in a couple of occasions it was reported the presence of more than one animal, not documented by video or photo, and therefore excluded in the present analysis. Additionally, the description of these encounters was characterized by incongruency that did not allowed proper analysis of the data since it was affected by high bias and uncertainty. The analysis of the video and photographic materials collected, due to the low definition of the material

itself, did not allow to verify or affirm with certainty, if they all represent the same individual, few, or more animals that were visiting the area at different times. The major data availability referring to the last two decades (from 2000 onward) in comparison to the historical data retrieved, might reflect the higher attention towards the species, the increased diffusion of technology that allows the record and easy communication of sightings (mobile phones with camera and social networks), the overall increment of the species recorded in the known reproductive areas that might have driven some specimen to recolonize some areas, or simply records of vagrants outside their natural range. Population numbers cannot be provided by evaluating random records of sighting, without long-term adequate and specific monitoring and conservation programs. Only extensive spatial and temporal monitoring of the habitat, and systematic photo identification of the individuals can provide actual data on the real numbers of seal that frequent an area, as has been recently begun further south for the well-known MMS' breeding population in the central Ionian Sea, Greece<sup>30,31,32</sup>. These methodologies will allow as well to verify the transient or permanent use of the coast, as well as acquire data to elaborate proper conservation measures.

To adequately monitor and preserve the natural biodiversity heritage, at a local level, requires the implementation and reinforcement of the structures responsible for its conservation (the MNP K-S), with the active involvement of local stakeholders (tourist sector and fishermen in particular). At a wider-area level, considering the overall monk seal situation within the Adriatic and Ionian Sea (a known reproductive population under monitoring in the central Ionian Sea, Greece, sightings recorded elsewhere in the region, and the ability of cover long distances by the species), the national commitment towards the species should be planned alongside a network of actors from the surrounding countries. A multi-national strategy common in the region, with a swap of information, could provide more substantial and comparable data (movements and probable exchanges of animals within neighboring countries) rather than simply recording sightings. Furthermore, establishing trans-national agreements for the conservation of the species in the region, as has been accomplished for the MMS' subpopulations in the Northeast Atlantic, could contribute in the long term, with integrated and collaborative approaches, to an effective understanding of its ecology and distribution, and finally aid its recovery.

### **Acknowledgments**

The present work is part of the data analysis collected within the project "Sustainability, threats, presence and habitat use of the Mediterranean monk seal in Albania", funded by the Critical Ecosystem Partnership Fund (CEPF)

and in part co-funded and supported by OceanCare. We wish to express our gratitude to OdiseÇeloaliaj, Ervis Loçe, the fishermen of Radhima, especially to Capitan Baçi and to the passionate volunteers that helped the field work activities in support of RAPA Vlora.

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## EVALUATION OF EPIGENETICS IN TERMS OF ENVIRONMENT AND DISEASE ASSOCIATIONS

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### Abstract

Epigenetics is defined as changes in gene expression that occur through various mechanisms without any change in the DNA sequence. These mechanisms include various modifications such as methylation, acetylation, and sumoylation, and they form a kind of decision-making mechanism on genes by turning on and off the gene expression. The term “environmental epigenetics” has emerged as an epigenetic subtype that deals with the effects of environmental exposures on epigenetic changes, depending on internal factors as well as external factors such as environment and lifestyle. Under this term, the implications of the environment on the development of certain diseases and current approaches to preventing these diseases are aimed to be summarized throughout article. Cancer, obesity, and cardiovascular diseases are the leading health problems worldwide, and new strategies are being developed every day to prevent these diseases before they emerge. Throughout our lifetime, we are familiar with the various pollutants exposed from the intrauterine stage and the habits that make up our lifestyle, such as diet, exercise, smoking and alcohol consumption, have significant effects on the epigenome. This correlation between exposures to epigenetic and environmental factors provides new explanations for how gene expression is regulated, and it is thought that these explanations will lead to significant advances in the field of personalized medicine in the development of effective therapy strategies.

**Keyword:** Epigenetics, environmental factors, cancer, obesity, cardiovascular diseases

### 1. INTRODUCTION

Epigenetics is traditionally defined as changes in gene expression that occur through various mechanisms without any change in the DNA sequence. These mechanisms either enable the addition of various chemical compounds

to the DNA sequence by markers called epigenomic marks, or they are responsible for the activation or deactivation of gene expression through several modifications in histone proteins. On the basis of both changes, chromatin conformational alterations determine the gene expression levels, and thus enable the gene to form a kind of decision-making mechanism[1]. This decision-making mechanism may be dependent on internal factors as well as external factors including environment and lifestyle. “Environmental epigenetics” term has emerged as a subtype of epigenetics, mainly expressing the effects of environmental exposures on epigenetic changes[2].

Although there are many epigenetic gene regulation mechanisms are existent such as DNA methylation, non-coding RNA, histone modifications including acetylation, phosphorylation, sumoylation, and ubiquitination, in this mini review the associations with the diseases and environment’s effect on epigenetics will be discussed. We are already familiar with the fact that various gene polymorphisms are responsible for the basis on predisposition to diseases. Beyond this phenomenon, we can say that the environment has a key role on people’s health as its different effects on epigenetics. In fact, current studies guide us on the need to manage the objectives in terms of epigenetics in the formation of allergic reaction sensitivities and drug resistance caused by anticancer drugs.

Due to the recent increase in the world population, some diseases take the first place among people. Cancer, obesity and obesity-related diabetes and cardiovascular diseases are at the top of this list. The implications of the environment on the development of these diseases and current approaches to prevent these diseases will be discussed throughout this article.

## 2. DISCUSSION

Cardiovascular diseases constitute the largest group of diseases that cause the most death in the worldwide and bring a great economic burden in prevention and treatment of the disease[3]. It is worrying that the emergence of heart diseases at a young age and the complex molecular mechanism underlying the disease constitute the biggest obstacle to solving the root cause of the disease. Undoubtedly, we can convey that the emergence of cardiovascular diseases at a relatively young age is one of the negative impacts of a severely stressful life with the dietary changes brought by today’s modern world. Depending on the complexity of the molecular mechanism underlying in cardiovascular diseases, studies revealed the epigenetic dysregulations are being affected recently. In this field the data acquired from twin studies clearly demonstrate that significant results were obtained about the role of epigenetics in the pathogenesis of the disease. With

the determination of epigenetic changes, particularly in the pediatric age, early diagnosis of the disease becomes possible and it is predicted that the route to be drawn in clinical treatment will be more precise. Based on all these implications, it is thought that the incidence of CVD will decrease in the following years [3].

In addition to emphasizing that the environment is the basis for the early development of diseases, it is fundamental to mention the fact that the environmental conditions that the mother is exposed to during the intrauterine period may be a major risk factor for developing disease in the fetus or diseases in the later stages of life. In previous studies conducted, the detection of fatty streak lesions in the arteries of fetuses taken from mothers who are heavy smokers during pregnancy or mothers with hypercholesterolemia, compared to those who are not exposed, support that CVD may originate in the early stages of life [4]. Looking at the epigenetic basis of the environment's impact on cardiovascular disease development, twin studies are the best guiding map for looking at diseases from a new perspective, and they show up distinct effects of genetic, and environmental factors on biomarkers. In some of these studies, it has been shown that the intrauterine environment has a prominent role in terms of CVD risks in parallel with the development of metabolic syndromes such as type 2 diabetes and obesity [5]. Since DNA methylation has been the most frequently studied mechanism in epigenetics for two decades, it has been shown that toxic agents exposed during the intrauterine period contribute a strong connection between epigenome and CVD by changing the methylation profiles[6,7]. In addition, global hypermethylation observed in atherosclerosis has been shown to have an important effect on pathological processes such as inflammation and coagulation [8]. However, due to the reversible potential of these epigenetic modifications, studies on the use of targeted relevant pharmacological agents are ongoing [9].

Apart from cardiovascular diseases, there is bunch of studies in the literature showing that epigenetic mechanisms such as DNA methylation and histone modifications play a role in the development of obesity. It is a well-known fact that exposure to environmental pollutants causes changes in the gut microbiota and is associated with imbalanced food intake such as weight gain with the additional effect of epigenetic mechanisms. As well as in cardiovascular diseases, obesity has an extremely high heterogeneity and involved in metabolism-related diseases, and its underlying mechanisms remain unclear. As the global prevalence of obesity increases every year, it tends to be of high concern for the development of comorbidities, including children and adolescents. Although factors such as environmental pollutants known as obesogens and gut microbiota influence the susceptibility of diseases, focusing on epigenetic mechanisms in studies can be considered

among the treatment strategies that can be applied even before the emergence of obesity [10]. Since obesity occurs mainly as a result of the lack of balance between energy intake and expenditure, microRNAs have been shown to take important functions in the regulatory network of adipocyte differentiation. Studies in animals have revealed that miR-26b is involved in the process of adipogenesis and its expression is upregulated gradually during differentiation in mature adipocytes [11]. By clarifying the molecular details of this whole process in further studies, it may be possible to develop new targets for therapeutic interventions in obesity, considering environmental factors.

Sedentary lifestyle brings along another leading disease which has a higher number of mortalities such as cancer besides obesity. Epigenetics has a distinct role in understanding metastatic potentials, and there is a tight correlation between environmental agents affecting the epigenome. Nutrition has proven to play an important role among these environmental factors, and the effect of a diet rich in polyunsaturated fatty acids on mutagenic free radical formation is directly related to epigenetic changes [12]. In another study, differences were demonstrated in gene methylation profiles which promote the regulation of proangiogenic mechanisms in human endothelial cells incubated with arachidonic acid [13]. It has also been observed that polyunsaturated fatty acids lead to attenuation of the NF- $\kappa$ B pathway in suppressing tumorigenesis [14].

In conclusion, we aimed to summarize the influence of environment and related epigenetic mechanisms involved in the development of diseases including, CVD, obesity, and cancer. In addition to the genetic background we have, the various pollutants we are exposed to from the in-utero stage and the habits such as diet, exercise, smoking and alcohol consumption that constitute the lifestyle have important effects on the epigenome. Given the correlation between epigenetics and exposure to all these environmental agents, it is expected to help explain how gene expression is regulated depending on these factors. From this point of view, it is thought that it will lead to significant advances in the field of personalized medicine in the development of effective treatments.

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## **EFFECTS OF RELATIONSHIP BETWEEN ENVIRONMENTAL FACTORS AND EPIGENETICS ON HEALTH RISKS**

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### **ABSTRACT**

Environmental pollutants and other harmful factors cause serious changes in genes. However, sometimes changes can occur only in chromatin structure and gene expression, without any changes in DNA sequence. In this case, many epigenetic mechanisms such as DNA methylation and histone modification, acetylation, ubiquitination, and sumoylation are mentioned. Additionally, another important feature of an epigenetic change lies in the fact that it may be inherited. Environmental factors that have serious effects on especially during pregnancy lead to many diseases, including cancer. However, the severity and phenotypic effects of the diseases vary depending on the environment. These factors can be count as air pollution, metal ions, polluted drinking water, UV radiation, tobacco and alcohol consuming and more. In this study, the effects of environmental pollutants on genes and epigenetics have been reviewed.

**Keywords:** Genes, environmental pollutants, Epigenetics; DNA methylation

### **1. INTRODUCTION**

Epigenetics, examine the rearrangement of gene expression by inherited changes in chromatin structure although there is no change in the DNA sequence. Many epigenetic mechanisms such as DNA methylation, histone modifications, and acetylation can modify the genome functioning[1].Epigenetic changes can also be reversible besides inherited changes that last for generations[2]. There is evidence in the literature that environmental influences also play a role in these epigenetic changes. According to recent studies, it has been determined that there are some environmental toxic substances that alter the methylation profile of genes.

Exposure to these substances can cause epigenetic changes and thus lead to health concerns regarding various diseases.

Although there are many epigenetic mechanisms such as acetylation, phosphorylation, ubiquitination, sumoylation and methylation, two particularly important mechanisms inherited can be mentioned in detail DNA methylation and histone modification. DNA methylation is a chemical inherited change in DNA that causes 5-methyl cytosine by adding the methyl group to the C (Cytosine) base in CpG islands. This covalent modification has a prominent role in preserving genome integrity by transcriptional silencing of recurrent DNA sequences. DNA methylation also takes a part in processes such as gene expression regulation, genomic imprinting and X chromosome inactivation. Among the modifications that occur in histones, acetylation and methylation of H3 and H4 are the leading ones[1]. While DNA methylation suppress the transcription, histone acetylation activates transcription[3].

Epigenetic mechanisms are quite significant regarding the talent of transcription factors to regulate DNA binding regions. Studies have shown that DNA methylation occurring in large regions of the genome and in the early stages of life is affected by environmental events. Environmental signals affect the individual's learning, cognition, memory and mood by altering gene expression[4]. Gene-environment interactions affect diseases and can cause the alterations on the phenotypic expression of a genetic trait. Some people may be more susceptible to oxidative damage and therefore to cardiovascular diseases caused by air pollution due to the genetic polymorphism they carry. It is thought that DNA damage and mutations may occur and increase the risk of disease, depending on environmental exposure[1].

## 2. DISCUSSION

There are studies and evidences that genotoxic agents cause DNA damage. For example, it has been determined that high doses of dioxin have carcinogenic effects and cause translocations, and ionizing radiation also increases germinal mutations [1]. There are many other environmental factors that affect epigenetic regulations, particularly DNA methylation. For example, according to a study, it has been found that exposure to asbestos increases methylation in pleural tissues[5]. In a study conducted on rats, it was determined that arsenic is associated with DNA hypomethylation of malignancy that develops in liver epithelial cells. Arsenic exerts its carcinogenic effect by suppressing the expression of DNA methyltransferase genes *DNMT1* and *DNMT3A*. In our daily life, we are exposed to chromium, arsenic and other metal ions mostly for reasons such as professional obligation and drinking water. In a study conducted in the Indian population, it has been reported that high arsenic exposure resulted in the

hypomethylation of the *MT-ND6* gene in the mitochondrial genome [6]. In addition, air pollution is a serious cause of morbidity and mortality, especially causing asthma and cardiovascular diseases. Steel mills, highways and diesel exhaust gases are important sources of air pollution. In studies conducted on mice, it was found that the frequency of mutations was increased in the sperm of mice exposed to polluted air[7].It can be clearly said that the ratio of chemicals contained in air and water in the city and the countryside is not the same.

Another environmental factor that changes the level of DNA methylation is metal ions. Among these metal ions, chromium, cadmium and nickel reduce DNA methylation levels, particularly nickel suppresses gene expression[5]. There is increasing evidence that metal exposure causes DNA mutations, and the impacts of metals may be more than just altering DNA sequence or gene expression [7]. Bisphenol A, which is used in plastic production, which has a great place in our lives, is also effective in tumorigenesis with DNA methylation change. In addition, it was emphasized that tobacco use, alcohol and drug abuse also cause epigenetic changes and hypermethylation of the promoter region was observed in the lung tissue of especially smokers. [5]. Similarly, in another study, it was found that the *HERP* gene promoter region was hypermethylated in individuals who suffers with alcohol dependence [8]. According to the data obtained from animal experiments, nutritional supplements and xenobiotic chemicals can epigenetically alter certain regions of the genome both in the prenatal and postnatal period [9]. Nutrition and diet also affect the epigenetic regulation of gene expression. Abnormal epigenetic markers accumulate and activate tumorigenesis and are thought to be effective in colorectal cancer formation [10]. In addition to environmental factors such as toxins and chemicals that cause diseases with epigenetic changes, there are also environmental factors including nutrition-diet components, lifestyle, exercise, physical activity that change the genome constructively [7].

Meiotic epigenetic inheritance (MEI) has been widely discussed recently, as it can enable the transfer of epigenetic factors such as DNA methylation, histone modifications or RNA to subsequent generations via gametes. The role of DNA methylation in meiotic epigenetic inheritance is still not fully understood, but it is clear that histone modifications, tRNA and microRNAs affect the gene regulation of the offspring. In this context, genome-wide studies are important for the clearer understanding of these regulations [11].Xenobiotics such as environmental pollutants, heavy metals and therapeutic drugs cause mitochondrial dysfunction through epigenetic changes resulting from mtDNA methylation. Gene expression alterations that occur in this way are thought to be associated with mitochondrial dysfunction as well as aging, neurodegenerative disorders, circadian rhythm changes and cancer[6]. In another study, it was shown that it is associated with placental

global DNA methylation levels in people living in polluted cities in the first trimester of pregnancy and therefore in fetuses exposed to polluted air particles. However, it has been emphasized that more studies are needed on the effects of environmental pollutants on early development of the fetus and susceptibility to disease[12]. There are also studies in the literature that support the role of epigenetic abnormalities in cancer development and progression. In addition, studies strengthen the view that DNA methylation, histone modifications, chromatin remodeling, and microRNA may be potential determinants of cancer development [13]. A harmful environmental factor UV radiation, damages essential biomolecules such as DNA, proteins and lipids, thereby activating genotoxic stress. DNA damage caused by UV exposure leads to serious problems such as pyrimidine dimers, DNA double strand breaks and oxidative damage, and ultimately cause various diseases, particularly cancer [14].

In conclusion, there are numerous studies in the literature examining the relationship between exposure to environmental chemicals and epigenetics, but much more studies are needed due to the complex and heterogeneous nature of epigenetics.

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## **HOW TO MAINTAIN PHOSPHORUS LEVEL IN SOIL AND GROUNDWATER BY USING MICROBIAL PHYTASE AS A FEED ADDITIVES**

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### **ABSTRACT**

The changes and the ongoing developments that the Albanian livestock sector has experienced are naturally associated with the expansion and growth of pork production. In the pig sector, today we can discuss contemporary technology, full balanced nutrition, specialized breeding and qualified management. One of the most common causes of water and soil pollution in the areas with high concentration of agricultural and livestock farms are agricultural technologies and raw animal waste that is scattered everywhere. Excessive animal manure and fertilizer inputs do cause various environmental problems, related to the accumulation and elevated leaching, runoff of nutrients (N and P) and heavy metal to ground water and surface water. The P-excretion on the pigs and poultry faeces is potential source for soil and water pollution, due to his high level on the subsoil water and destruction of the ecosystem. The present paper tests the effects of the microbial phytase (*Aspergillus niger*, NATUPHOS) 750 FTU/kg on the increase of P availability and animal performance, as well as in the reducing of environmental pollution. Thirty-six piglets (Large White x Landras) of four litters were transferred to flat-decks and allocated to 2 groups (A and B) with 18 animals (9 males and 9 females), respectively. The control group (A) was feed with a balanced diet, containing mono calcium phosphate. The experimental group (B) was feed with low level of phosphorus, without inorganic phosphorus. This group was supplemented with NATUPHOS phytase 750 FTU/kg feed. During the six weeks of experimental period, Body Weight (BW), Daily Weight Gain (DWG) and Feed Conversion Ratio (FCR, kg feed/kg Body Weight Gain were measured weekly. Data are presented as arithmetic means with standard deviation of the mean (Mean  $\pm$  SD). The supplementation of microbial phytase preparation (*Aspergillusniger*, NATUPHOS) 750 FTU/kg feed was reduced the P-excretion. The P-excretion was

reduced by 20-25%, provided that pig's diets can be supplemented with an economical and efficacious level of phytase that will allow all of the supplemental inorganic P to be removed from the diet (Cromwell and Coffey 1991).

**Keywords:** phosphorous, groundwater, microbial phytase, feed additives

## 1. INTRODUCTION

In Albania the transition by collective to private agriculture has been conducted with sufficient negative phenomena on the land use and management of natural resources (Lushaj and Suljoti 2005). During the last period some significant changes are considered for the Albanian livestock development. But this sector continued to be more problematic as well on the development level as on environment respect. Year after year, the number of livestock farms is growing, but the size of livestock farms is just small.

The changes in environmental performance have been closely linked with the efficient energy use; reform of municipal utilities through such measures as eliminating subsidies and raising tariffs; establishment of basic environmental protection and management systems; improvement of natural resource management and public participation in environmental issues.

Albania continues to application the reforms and developed good institutional and regulatory capacities for managing environmental issues. The roles of the public and private sectors need to be considered according the pollution intensity (solid pollution, the potential collapse of water, water contamination from agricultural or industrial pollutants; energy inefficiency; threats to natural resources; etc.). A regulatory framework and institutional capacity for environmental management needs to be installed or to be applied. Here, the access of rural populations is very limited or inexistent (Bregasi and Veizaj 2007).

Nowadays, pollution is a serious threat to all parts of our environment, including the soil, ground water and surface water (Fodor and Szabo 2005).

Excessive animal manure and fertilizer inputs do cause various environmental problems, including the accumulation and elevated leaching and runoff of nutrients (N and P) and heavy metal to ground water and surface water (de Vries *et al.*, 2005). Groundwater contamination by nitrate-nitrogen and eutrophication of surface waters by phosphorus originating from land application of fertilizers and animal manure are well documented in some most populated areas like, Durres, suburb of Tirana, Lushnja etc.

Nonpoint source nutrient pollution of ground water and surface water by agriculture is a major, longstanding environmental issue in the United States (Sims 2005). As comprehensive nutrient, management planning has considerably widespread in the U.S., it has become increasingly apparent that the primary source of nonpoint nutrient pollution in many regions is nutrient

imbalance. This is particularly true in areas where animal production has been geographically concentrated. Nutrient surpluses, usually due to imports of feed and fertilizer far in excess of exports in crops and animal products, lead to the buildup on nutrients in soils and increase the likelihood of poorly timed applications of manures. It is now widely accepted that a fundamental tenet of agro-environmental policy must be restoring nutrient balance on farms, especially those referred to as ‘concentrated animal feeding operations’ (CAFO-s). To achieve nutrient balance on farms or in watersheds requires a number of political, social, economic and logistic challenges.

### **Animal nutrition and Environmental problems**

As a result of growing concern about the environment, intensification of animal production in many European countries is considered as potential source of air pollution and threat to soil and drinking water quality (Eeckhout and de Paepe 1994).

Nutritive ration of non-ruminant animals (pigs and poultry) contains 90% cereals seed (corn, wheat, barley, rye, and oat). The majority of “P” in cereal grains is organically bound as phytic acid or phytate. This form of P is nutritionally unavailable to non-ruminant animals due to the lack of phytase in their digestive tract. The P-excretion on the pigs and poultry faeces is potential source for soil and water pollution, due to his high level on the subsoil water and destruction of the ecosystem. In such situation the solution is utilization of phytase on the nutritive ration of pigs and poultry.

The current problems related to the phytase utilization are:

- The farmers have sometimes distributed the animal manure everywhere, as it is allowable by the law. In such situation the government has no control on the quantity of phosphorus and nitrogen in the arable soil and ground water. In Albania, the problems related to soil and water pollution are of great concern.

- On the other hand, some of the big companies, which produce feedstuff for animals, began four years ago to use the phytase in pigs and poultry nutritive rations. Most of the feedstuff is imported by neighbor countries like Italy, Greece, Republic of North Macedonia and Montenegro, and sometimes there is little known about the phytase.

- These companies produce meal and also pellet feedstuff for all animal categories. In consequence the possible destruction of phytase by pellet or heat treatment must also be considered.

- Because of the high price, most of the small farmers have no possibility to buy the feedstuffs from these companies, therefore to use the phytase on their farms. They are using Albanian cereals and legumes as feed for animals.

▪ Some of the pigs and poultry farms in Albania are in the suburb of the cities, but some others are near the living center, like as in Tirana, Durres, Vlore, Shkoder etc. The fecal excretion only by the poultry farms in Albania are nearly 41450 T per year.

Based on the data, Albanian livestock has increased from 31% to 50% of agricultural production since 1991. Dairy cows are raised throughout the country, while sheep and goats are common in the hills and mountainous areas while herds prevail in the south. While owning livestock is important for maintaining subsistence levels, profitability increases considerably with increase in herd size. On the other hand, it's important to evidence that Albania is a mountainous country and only 16% of its territory is located at elevations of less than 100 m a.s.l. The agricultural land is distributed as follows: 43,3% in the plan or flat areas, 34% in the hilly zones and the remainder in the mountainous region.

The Table 1 reports the average quantity of organic fertilizer belongs to the species in Albania

Table 2 reports the composition of organic fertilizer in Kg/ton.

Table 3 reports about the N and P amended in the cultivated soils with manure.

**Table 1.** The average quantity of organic fertilizer belongs to the species in Albania (Piu and Locher 2001).

Species	Live weight (kg)	The quantity (ton)/year
Cow	300	7
	400	8
	500	10
Sow with piglets in maternity	200	2
Pigs	100	1.2
Piglets	30	0.9
Chicken	2	0.07
Sheep	40	0.6
Goat	30	0.4
Horse	500	6

**Table 2.** The composition of organic fertilizer in Kg/ton (Piu and Locher 2001)

	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Mg
<b>Organic manure</b>				
Cow manure	2	3	6	1.2
Horse manure	2.4	3	6.3	1
Sheep manure	3.2	3.3	8	0.8
Poultry manure	10	28	16	4
Pig manure	3.3	3.2	2.3	0.6
Liquid manure	6	5	5	3

**Table 3.** N and P amended in the cultivated soils with manure (Sulce and Veizaj 2006)

	Number of livestock	Annual manure production (in 000/tons)	N (tons)	P (tons)
Cattle	32 000	170 (35% moisture)	1300	380
Chickens	977 000	70 (60% moisture)	1200	300
Pigs	4 000	4 (45% moisture)	150	25
Sheeps/goats	40 000	20	600	100
Total			3250	805

### Phytase supplementation as a way to reduce phosphorus excretion in non ruminant animals.

Interest in phytase for monogastric animals take place in regions, where soil and groundwater pollution due to animal wastes is a serious problem and phosphorus is a major concern. Indeed, plant phytate is the major form of plant phosphorus (Kirby and Nelson 1988) and phytate phosphorus itself has low availability.

The majority of the P in cereal grains and oilseed meals is organically bound as phytic acid or phytate. This form of P is nutritionally unavailable to non-ruminant animals due to the lack of phytase in their digestive tract. As result swine and poultry diets must be supplemented with highly available, inorganic sources of P to meet their P requirements. The poor bioavailability of P in the natural feedstuffs along with high dietary levels of supplemental P result in higher levels of fecal P compared with ruminant animals.

Studies in the early 1990s at Kentucky and Michigan showed that feeding pigs a low-P, corn-soy diet supplemented with phytase from a mutant strain of *Aspergillus niger* improved the bioavailability of P. At about the same time, research in the Netherlands also demonstrated the efficacy of phytase produced by recombinant *Aspergillus niger* in studies with pigs and chicks. In November, 1995 a commercial source of recombinant-produced phytase (Natuphos) was approved for use in the USA. Since then, other sources and

forms of phytase have been developed and evaluated. From 1992 to 2001, 82 papers involving phytase were published in Poultry Science (N=55) and the Journal of Animal Science (N=27) with 48 of these published in the last 4 years. The studies clearly show that phytase increases the digestibility and bioavailability of P from phytate, reduces the amount of inorganic P needed to maximize growth and bone mineralization, and markedly reduces fecal excretion of P. Phytase seems to increase the bioavailability of Ca, Z, and other divalent cat ions that otherwise bind to phytate. Some studies suggest that phytase may improve ideal digestibility of amino acids slightly, but other studies have not shown this response. This new technology offers substantial benefits to swine and poultry production by reducing the potential for environmental problems associated with excess P excretion (Cromwell and Coffey 1991).

Information about the effect of microbial phytase use as a partial replacer of the bicalcium phosphate in the layers and weaned piglets, aiming a better utilization of the phytic phosphorus and decrease of the environment pollution could be found in (Piu *et al.*, 2008). Utilization of microbial phytase (Natuphos) on the nutritive ration of weaned piglets (28 days old), was accompanied with improved performance parameters. In the experimental group, treated with Natuphos (750 FTU/kg), the excreted phosphorus amount in the dropping is decreased by 6,8%, while the excreted nitrogen amount is decreased by 5,2%. So, there is a positive output towards the minimizing of the environmental pollution with no degradable Phosphorus and Nitrogen.

Cromwell and Coffey (1991) concluded that a 50% reduction of excreted phosphorus would mean that 100.000 fewer tons of phosphorus would be excreted into the environment annually in the United States. Obviously, this could have a major impact and would be especially significant in countries, where livestock production is restricted because of environment pollution.

## 2. MATERIAL AND METHODS

Thirty-six piglets (Large White x Landras) of four litters were transferred to flat-decks and allocated to 2 groups (A and B) with 18 animals (9 males and 9 females), respectively. Two piglets from different litters (1 male and 1 female), with the same body weight were housed in every box (experimental unit). The litter origin was taken into account, avoiding that piglets from the same litter were allocated in the same treatment. There were nine replications per control group and nine also per treated group. The control group (A) was feed with a balanced diet, containing mono calcium phosphate. The experimental group (B) was feed with low level of phosphorus, without inorganic phosphorus. All the phosphorus in this group originates from

soybean meal. This group was supplemented with NATUPHOS phytase 750 FTU/kg feed.

Ambient room temperature was maintained at 24°C for three first weeks and lowered by 1°C for each week thereafter. The ventilation also was provided to ensure good air quality. The basal diet mainly contained maize and soybean meal and the nutrient contents met or exceeded nutrient requirements recommended by NRC. The diets were offered ad-libitum and animals had free access to water.

**Table 4.** The calculated nutrient concentration of diet.

Nutrient concentration (g/kg feed)		
	Control group (A)	Experimental group (B)
ME (MJ/kg)	12.75	12.80
Crude protein	190.1	191.1
Crude fibre	38.4	38.1
Calcium	6.90	6.45
Phosphorus	6.0	4.2
Lysine	2.1	1.9
Methionine+Cystine	6.4	6.5

The six weeks of experimental period, Body Weight (BW), Daily Weight Gain (DWG) and Feed Conversion Ratio (FCR, kg feed/kg Body Weight Gain) were measured weekly. Data are presented as arithmetic means with standard deviation of the mean (Mean  $\pm$  SD). One-way analysis of variance and Student's *t*-test ( $P < 0.05$ ) were performed to test the differences between two groups.

### 3. RESULTS AND DISCUSSION

Feeding phytase NATUPHOS has slightly improved the production parameters respectively: Final Body Weight (FBW) by 5.6% and Daily Weight Gain (DWG) by 7.3%, compared with the control group.

**Table 5.** Efficacy of supplemented phytase in low phosphorus diet for piglets

Parameters		Control group	Experimental group
Production	<sup>1</sup> n	X $\pm$ SE	X $\pm$ SE
Initial BW, kg	16	12.2 $\pm$ 0.90	12.6 $\pm$ 0.48
Final BW <sup>2</sup> , kg	16	23.2 $\pm$ 1.06	24.5 $\pm$ 0.96
DWG <sup>3</sup> , g	16	369 $\pm$ 10.0	396 $\pm$ 7.33
FCR <sup>4</sup>	16	2.44 $\pm$ 0.11	2.43 $\pm$ 0.10

<sup>1</sup> Number of animals, (18 piglets/ every group, at the beginning of the experiment)

<sup>2</sup> BW at the end of the trial.

<sup>3</sup>DWG for whole experimental period. <sup>4</sup>FCR for whole experimental period.

Feed Conversion Ratio (FCR) was reduced (-4.1%) compared with the control group, but the differences were insignificant.

The supplementation of microbial phytase preparation (*Aspergillusniger*, NATUPHOS) 750 FTU/kg feed reduced the P-excretion by 20-25%, provided that pig's diets can be supplemented with an economical and efficacious level of phytase that will allow all of the supplemental inorganic P to be removed from the diet (Cromwell and Coffey 1991).

With the industrial production of phytase, application of this enzyme to pig's diet to increase P availability and improve animal performance, as well as reducing environmental pollution has gained widespread attention. The beneficial effects of supplementary phytases on P digestibility and animal performance have been well documented (Rao *et al.*, 1999; Ravindran *et al.*, 1999). The efficacy of any enzyme preparation depends not only on the type, inclusion rate and level of activity present, but also on the ability of the enzyme to maintain its activity in the different conditions encountered through the gastrointestinal tract and the conditions used for the pre-treatment of a feedstuff or diet.

#### 4. CONCLUSIONS

Agricultural techniques and animal rest is a serious problem for soil and water pollution, especially in the areas with a big concentration of livestock farms. The situation is more problematic, when we add the fact that there is not government law to not allow the distribution of animal manure in everywhere. In such situation, it is difficult to have control on the quantity of phosphorus and nitrogen in the arable soil and ground water.

An original solution is the utilization of microbial phytase on the nutritive rations of non-ruminant animals. This could have a major impact in countries, where livestock production is restricted because of environment pollution. Nowadays, phytase supplementation is considered as a good way to reduce phosphorus excretion in non-ruminant animals.

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## **THE ASSESSMENT OF HEAVY METALS CONTENT IN SURFACE SEDIMENTS IN THE ALBANIAN PART OF OHRID LAKE**

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### **ABSTRACT**

The content of five heavy metals in surface sediments for three areas in the Albanian part of Ohrid Lake has been investigated from June 2015 to June 2016. As for the coastline from Lini village to Tushemisht village these mean values ( $M \pm SD$ , mg/kg) of heavy metals content were reported: Arsenic (As)  $8.93 \pm 2.976$ ; Chromium (Cr)  $270.13 \pm 203.229$ ; Nickel (Ni)  $277.95 \pm 158.191$ ; Lead (Pb)  $20.71 \pm 2.552$  and Zinc (Zn)  $192.47 \pm 60.903$ . Results reported approximate mean values for the nickel and chromium content ( $t = 0.031$ ;  $P > 0.01$ ). Analyzed according to the three shore areas of the lake, the area at the entrance of the city of Pogradec was distinguished for the higher content of metals in surface sediments. The sediments of the Lin coastal area contained less heavy metals compared to the other two sampling areas.

**Keywords:** Ohrid Lake, heavy metals, surface sediments, anthropogenic sources

### **1. INTRODUCTION**

The sediments in the lake play a major role in the contamination of the lake due to the physical, chemical and hydro-geochemical and biological characteristics of the aquatic system. The geochemical composition of the sediments clearly stipulates the current condition of the lake environment

(Karthikeyan *et. al.*, 2018). There is a global concern about the pollution caused by metals due to the environmental persistence of these elements, biogeochemical recycling and the ecological hazards they pose. Sediments are the largest deposit for heavy metals in aquatic environments and sediment quality is recognized as an important indicator of water pollution (Wu *et. al.*, 2014).

The main sources for trace elements, like metals, in natural waters are related to natural processes and anthropogenic impacts. Their common feature is that even in relatively small concentrations their effects are toxic and precisely for this reason they are included in the category of very dangerous environmental pollutants (Kastori and Maksimovic, 2006). The fact that heavy metals are present in the environment does not mean that they are in any case suitable for assimilation by living things and for inclusion in their body. Determining the total content of heavy metals in sediments is insufficient to assess their impacts on aquatic ecosystems. As some of the metals are involved in the crystal structures of minerals, or are bound to other sediment substrates, they might not pose a risk to living things. Having an information on all the mobile or biologically available metals, i.e., metals that can be obtained and metabolized from the lake organisms is of great importance. The content of a metal does not necessarily reflect the severity of pollution as it depends a lot on the chemical form of the polluting metal. Here we can mention the chromium atoms with different valences (Kastratovic *et. al.*, 2016).

## 2. MATERIALS AND METHODS

Figure 1 depicts the sampling sites in the Albanian part of the Ohrid Lake (Lin village, coastal zone in the beginning of city of Pogradec, Tushemisht village) where the present study was carried out from June 2015 to June 2016.



**Fig. 1.** Three sampling sites in the Albanian part of Ohrid Lake (a. coastal zone in Lin village; b. coastal zone in the beginning of city of Pogradec; c. coastal zone in Tushemisht village).

There were 5 samples seasonally collected from each area. In total, 45 samples were analyzed for the three seasons. Arsenic (As), chromium (Cr), nickel (Ni), lead (Pb) and zinc (Zn) content, in mg per 1 kg of sediment was investigated. The portable sediment grab sampler model BDN-F was used for samples collection. In general, each sample was not less than 1 kg.

The samples are put away in fixed Ziploc sacks with lake water and tests are passed to the research facility and put away at  $-20^{\circ}\text{C}$ . Prior to the substantial metal examination method, the sample is dried at  $60^{\circ}\text{C}$  for 48 h. A small amount of dried samples is sieved through a mesh a  $63\text{-}\mu\text{m}$  nylon mesh for homogenization and stored in a fixed plastic sacks.

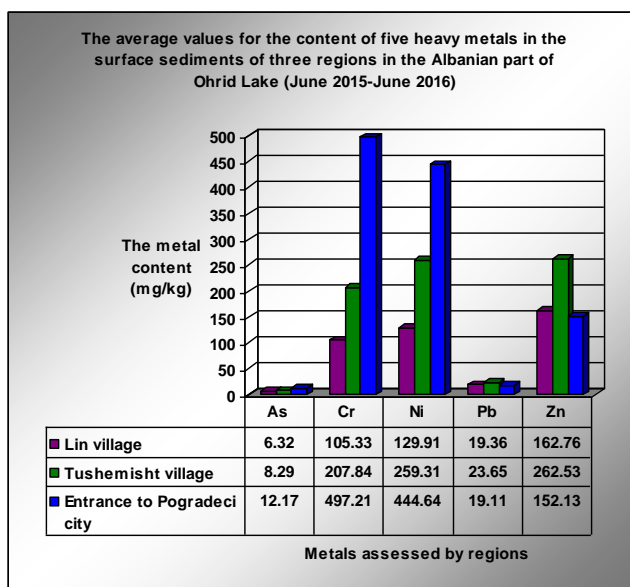
The analysis of metals such as As, Cr, Ni, Pb, and Zn were performed by inductively coupled plasma mass spectrometry (Ammann,2007).

### Statistical analysis

Quantitative data were analyzed separately based on the sampling sites. The one-way analysis of variance (ANOVA) and Duncan's multiple range tests (Montgomery, 2013) were involved for the calculation of t-test values and determination of the significance of differences ( $P<0.05$ ) among zones and seasons.

### 3. RESULTS AND DISCUSSIONS

The Figure 2 depicts the mean values (M, mg / kg) of the five heavy metals content in the surface sediments, for the three sampling sites.



**Fig. 2:** The situation of heavy metal content in the surface sediments for the Albanian part of Ohrid Lake (the shoreline from Lini village to Tushemisht village).

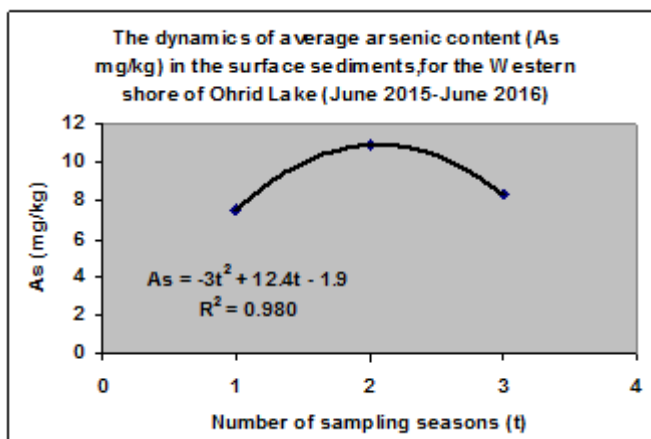
Based on the figure we have calculated the mean values and standard deviation values ( $M \pm SD$ ) for each metal content, for the entire coastal area, from Lini village to Tushemisht village. The values (in mg / kg) are as following: Arsenic (As)  $8.93 \pm 2.976$ ; Chromium (Cr)  $270.13 \pm 203.229$ ; Nickel (Ni)  $277.95 \pm 158.191$ ; Lead (Pb)  $20.71 \pm 2.552$  and Zinc (Zn)  $192.47 \pm 60.903$ .

Analyzed according to the three shore areas of the lake, the area at the entrance of the city of Pogradec was distinguished for the higher content of metals in surface sediments. Chromium (497.21 mg/kg) and nickel (444.54 mg/kg) had the highest mean concentration rate. The sediments of the Lin coastal area had less heavy metals content compared to the other two sampling areas. In this area the chromium content was 4.7 times lower compared to the lake area at the entrance of Pogradec, and almost twice lower compared to the coastal area of Tushemisht. Meanwhile, the respective nickel contents for Lin were 3.4 and 2.0 times smaller compared to the two areas shown above.

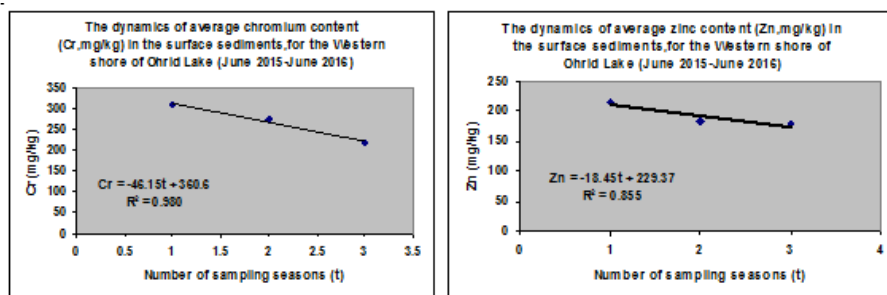
After calculating the average values, it resulted that the surface sediments on the Albanian part of Ohrid Lake had approximate nickel and chromium content ( $t = 0.031$ ;  $P > 0.01$ ). These two metals, as mentioned, were found at the highest concentration rate. The arsenic content manifested an upward trend with a north-southwest extension, 6.32 mg / l and 12.17 mg / l, respectively. The arsenic, in the Albanian part of the lake, was found at a lower mean concentration rate compared to the rest of chemical elements.

After analyzing the seasonal changes of the mean concentration rate for the five metals in the surface sediments of the Albanian part of Ohrid Lake (regressions in Figures 3- 5) we found that:

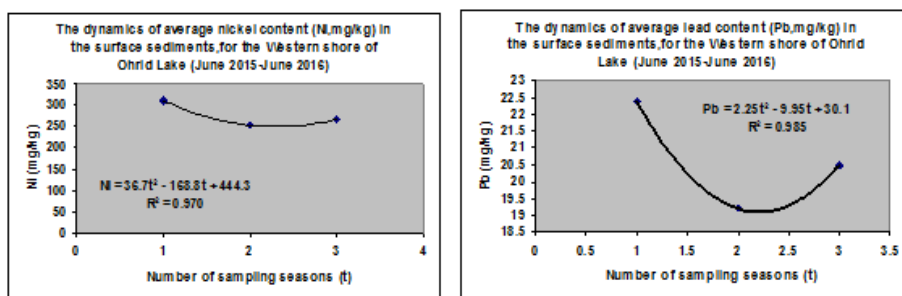
The polynomial correlation with positive value of the "b" intercept ( $b = 12.4$ ;  $r = 0.989$ ) was typical of the dynamics of time-depending changes of arsenic concentrations. The polynomial correlation with negative value of the "b" intercept was of the dynamics of time-dependent changes of nickel ( $b = -168.8$ ;  $r = 0.984$ ) and lead ( $b = -9.95$ ;  $0.992$ ) concentrations, while linear correlation was typical of the dynamics of time-dependent changes of the concentrations of chromium ( $b = 360.6$ ;  $r = 0.989$ ) and zinc ( $b = 229.37$ ;  $r = 0.924$ ) in the surface sediments of the lake.



**Fig. 3:** The correlation between arsenic content (As, mg/kg) in the surface sediments of Albanian part of Ohrid Lake and sampling seasons ( $r = 0.989$ ).



**Fig. 4:** The correlation between chromium content (Cr, mg/kg) in the surface sediments of Albanian part of Ohrid Lake and sampling seasons ( $r = 0.989$ ) and the correlation between zinc content (Zn, mg/kg) in the surface sediments of the Albanian part of Ohrid Lake and sampling seasons ( $r = 0.924$ ).



**Fig. 5:** The correlation between nickel content (Ni, mg/kg) in the surface sediments of Albanian part of Ohrid Lake and sampling seasons ( $r = 0.984$ ) and the correlation between lead content (Pb, mg/kg) in the surface sediments of Albanian part of Ohrid Lake and sampling seasons ( $r = 0.992$ ).

It could be concluded that in the one-year period, from June 2015 to June 2016, the **arsenic (As)** concentration rate has increased in the first phase of analysis (June 2015), while in the second phase (December 2015) it reached the maximum value. The third phase of analysis (June 2016) marked a decreased arsenic concentration rate. **Nickel (Ni)** has manifested a relatively significant downward trend in the first phase of analysis, has shown a minimum average value in the second phase of analysis and a slight upward trend in the third phase of analysis. **Lead (Pb):** Pb concentration rate has significantly reduced from the first to the third analyzes' phase. Despite this dynamic, the average concentration for June 2016 was lower than that of June 2015. **Chromium (Cr):** Cr concentration rate was characterized from June 2015 to June 2016 by a systematic reducing trend (the value of the angular coefficient in the regression equation ( $a = -46.15$ ) was negative.) The maximum average value of the concentration in surface sediments for this

metal was measured in the first phase of the analysis while the minimum average value was found in the third phase of the analysis. **Zinc (Zn)** showed dynamics of content in the same sediments as chromium. The value of the angular coefficient "a" in the regression equation for this metal was  $a = -18.45$ .

The results showed the highest content of arsenic (As) in the surface sediments of the shoreline of Ohrid Lake at the entrance of the city of Pogradec compared to the shoreline of Tushemisht and the shoreline of Lin. Enrichment of sediments with arsenic in the southwestern area of the lake is related to the proximity of this area to the region known as "Guri i Kuq". In this region are found the iron-nickel and chromium mines and a mineral enrichment plant. Iron compounds during precipitation take up arsenic ion, favoring its deposition in the surface sediments of the lake. Kanamori (1965) and Crecelius (1975) said that the co-precipitation of arsenic with ferric hydroxide can be an important process in removing arsenic from oxygenated water and passing it to sediments. The water of Ohrid Lake is generally distinguished for its high oxygen levels, which favors the deposition of arsenic in sediments in those areas where iron flows are high. Here we can mention the shoreline of the lake from the former iron-nickel enrichment plant to the entrance of the city of Pogradec.

Regarding the annual dynamics of arsenic content of the surface sediments, winter marked an increase of arsenic content rate compared to summer. The source of such increase might be the increased inflows of this element as a result of more abundant rainfall and water flows with increased flow in the cold seasons of the year. Crecelius (1975) said that atmospheric input and flow transport account for almost half of the arsenic that is present in lakes. About 20% of the dissolved arsenic in the lake water is transferred to the sediment every year, as it is transformed into insoluble form, bound to iron and manganese.

The chromium content in the surface sediments of the lake, for the coastal area from Lini to Tushemisht varied from 94.0 mg / kg (lake area of Lin) to 534.15 mg / kg (lake area at the entrance of the City of Pogradec). Compared to the contents of this metal (35.6-127.0 mg / kg) (Kastratovic *et al.*, 2016) in the sediments of Shkodra Lake, the contents found by us for Lake Ohrid are several times higher. The main reason must be the differences in the geological features of the two areas. It is very likely that the largest amount of chromium present in the surface sediments of the lake, especially in the coastal area Pojske-Guri i Kuq, is of lithogenic origin. Mwamburi (2016) said that it is possible the dominance of lithogenic chromium sources in the surface sediments of lakes, but also the presence of possible anthropogenic sources that are transported by drainage systems and from urban areas located near their shores.

The investigation here carried out reported that the content of zinc in the surface sediments of the lake varied from 128.9 mg/kg (coastal area in the entry of Pogradec) to 285.3 mg/kg (coastal area of Tushemisht). All the analyzes concerning this metal, its levels were always above 459 mg/kg, about which MacDonald *et. al.*, (2000) said that impacts the aquatic life. The differences we have experienced for the spatial distributions of concentrations in sediments, between chromium and zinc, if not random, may express the existence of specific influences of the same sources of these two metals or the presence of their different sources. Bojakowska *et. al.*, (2014) said that there is a strong correlation between the zinc content in lake sediments and the carbon and organic sulfur content. We mention that this phenomenon of intensive organic decantation, with high content of sulfur compounds, has been known, not many years ago, for the nearby shore in the south-western area of the lake which is quite populated and has many tourist centers.

The results reported that the nickel (Ni) content in surface sediments of Ohrid Lake, was in the range 93.17-468.33 mg / kg, which is relatively high, but remain within the values reported in (Szarek-Gwiazda *et al*, 2011) about two mountain lakes in Poland with values 15.6-83.1 µg/g, giving information about the geological content of the terrain that borders the West shore of the lake, especially the lake area at the entrance of Pogradec. The mineral exploitation for a long time and the existence of the plant for enrichment of this mineral in "Guri i Kuq", very close to our sampling points in the lake area at the entrance of Pogradec have determinate the most intensive deposition of nickel in the surface sediments of this area. Nriagu and Pacyna (1988), Farkas *et. al.*, (2007) and Szarek-Gwiazda *et. al.*, (2011) claim that even some human interventions affect in nickel content in water and basin sediments. Among such interventions we mention the discharge of raw municipal waters, dumping metallurgical and mechanical industries waste in water basins, urban waste landfill placement near watercourses, watercourses discharge starting from agricultural lands especially after rainfall, etc.

#### 4. CONCLUSIONS

The following conclusions could be drawn: i)arsenic (As) was found at a significant increasing rate between June and December for the sediments in the Lin area ( $t = 8.23$ ;  $P < 0.01$ ) and for the sediments of the lake area at the entrance of Pogradec ( $t = 3.77$ ;  $P < 0.01$ ), and at approximate rates for the sediments of the Tushemisht area ( $t = 0.65$ ;  $P > 0.01$ ;  $n = 5$ ), ii) chromium content rate had insignificant differences for the period between June and December for the sediments of the coastal area of Lin ( $t = 2.048$ ;  $P > 0.05$ ;  $n = 5$ ) and difference of the significant level in the surface sediments of the

coastal areas of Tushemisht ( $t = 11.52$ ;  $P < 0.001$ ) also in the entrance to the of Pogradec city ( $t = 4.79$ ;  $P < 0.01$ )

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## PHYTOPLANKTON DATA OF THE KUNE-VAINI LAGOONS, LEZHA

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### ABSTRACT

The present paper briefly discusses about the phytoplankton of the Kune-Vaini complex (Lezha). The samples were collected bimonthly from July 2018 to July 2019, in Ceka, Zaje, and Merxhani lagoons; quantitative samples were preserved in Lugol, while net samples in formalin. The optic microscope Motic BA310, objective 100x, and a digital camera were used to determine the species. The Utermöhl method employing the inverse microscope Optica, objective 40x, and sedimentation chambers 5 ml and 25 ml was applied for the quantitative data (cell/ml). About 100 species of algae, mostly pennate (50) and centric diatoms (24), and dinoflagellates (16) were found. Fewer species were observed in other groups. Ca. 10 species are known as potentially toxic, belonging to *Skeletonema*, *Amphora*, *Pseudo-nitzschia*, *Dinophysis*, *Prorocentrum*, *Oscillatoria*. Quantity of phytoplankton was relatively low; an unusual high peak was observed in Ceka in September (49,883 cells/ml) and November 2018, and another much smaller in May 2019; in Merxhani showed an unusual high peak in January 2019, and another much smaller in May 2019; the winter peak (7,525 cells/ml in January 2019) was mainly dominated by *Skeletonema costatum*, known to be toxic. Continuous monitoring of the lagoons is recommended, especially for toxic algae. Water circulation in the lagoon can enhance the biodiversity and avoid dystrophic events due to the nutrient circulation and reduced anaerobic conditions. Therefore, continuous efforts to ensure the tide exchange, as well as efforts against water pollution are strongly suggested.

**Keywords:** Coastal ecology, Lezha lagoons, phytoplankton, toxic algae

### 1. INTRODUCTION

Phytoplankton organisms are the primary producers, together with submersed macrophytes and attached periphyton, and constitute the first nutrient level in lagoons, enriching them at the same time with abundant

amounts of oxygen. But in certain circumstances some species can grow out of control and with toxic or harmful effects on people, fish, shellfish, marine mammals and birds (harmful algal blooms) (Hallegraeff *et al.*, 2004); HABs can harm even man when consuming fish and other polluted aquatic organisms.

There is little known about the phytoplankton of the Kune-Vaini lagoons. Miho and Mitrushi (1999) carried out sporadic sampling in Ceka (probably Zaje) in June 1993, in Merxhani in May 1994, and in Ceka, Merxhani and Knalla in July 1996. The present study is the first step towards the regular assessment of the phytoplankton in the lagoon system of Kune-Vaini, and information is merely here summarized. The complete data (list of species and plates with microscopic photos) could be found in Kola (2019). The present study is part of the Master Program focused on the ecological approach of the wetland complex, financially supported by the Kune-Vaini Project (<http://kunevain.com>). Beside the phytoplankton, there were also assessed the aquatic vegetation (macrophytes) (Gjata, 2019), the zooplankton (Lika, 2019), and physic-chemical parameters, heavy metals (Muçaj, 2019), nutrients (nitrogen and phosphorus) and chlorophylls (Ramaj, 2019); diatoms in periphyton were also assessed (Qevani, 2020)

## 2. MATERIALS AND METHODS

The samples were bimonthly collected from 5 representative stations; 3 in Ceka, 1 in Zaje, and 1 in Merxhani lagoon, in July, September, November 2018 and January, March, May, July 2019, respectively. The quantitative samples were obtained using the Ruttner bottle, or directly from the boat, and preserved in Lugol in 250 ml glass bottles (CEN/TC 230/2006). In addition, Nansen net samples (25  $\mu$ m mesh size) were taken for the qualitative approach, and were stored in formalin (ca. 4%) in plastic bottles (50 ml).

The diatom frustules were cleaned by boiling the plankton material in H<sub>2</sub>O<sub>2</sub>cc (EN13946:2003). Microscopic slides were embedded with Naphrax (1.71). The species were determined using mainly the fresh material, or permanent slides, the optic microscope Motic BA310, with objective 100x, and a digital camera, and the available literature (Trégouboff and Rose, 1957; Sournia, 1978; Krammer and Lange-Bertalot, 1986-2000; Witkowski *et al.*, 2000; Hallegraeff *et al.*, 2004; Guiry and Guiry, 2019; WoRMS, 2019, Faust and Gullede 2020). Quantitative data (cell/milliliter) were taken applying the Utermöhl method (1958) (EN 15204: 2006) involving the inverse microscope Optica, with objective 40x, and sedimentation chambers 5 ml and 25 ml. More than 400 cells were counted in total, giving a confidence 95% ( $\pm 10\%$ ).

### 3. RESULTS AND DISCUSSIONS

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 (Miho and Mitrushi, 1999), more than 160 species in the phytoplankton of Kune-Vaini lagoons are known in total. With the diatoms species found in the periphyton, during the same period from Qevani (2020), the total number of microscopic algae known in Kune-Vaini habitats is about 310 species, where 280 species are diatoms; the rest are phytoplankton species of different algal groups, Dinophyceae (19 species), Chlorophyceae (4), Cyanobacteria (4), Chrysophyceae (1), Euglenophyceae (1), Pyramimonadophyceae (1), Cryptophyceae (1).

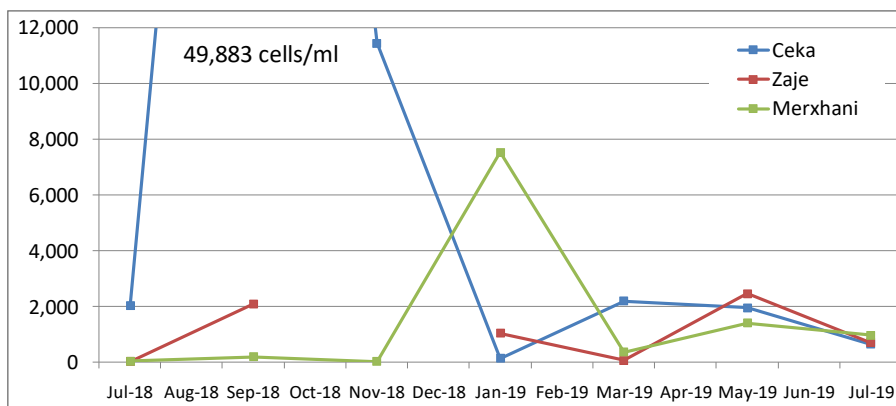
*Chaetoceros* spp. *diverse*, *Melosira moniliformis*, *Skeletonema costatum* from centric diatoms; *Amphora* spp. *diverse*, *Navicula* spp. *diverse*, *Nitzschia reversa*, *N. sigmoidea*, *Pleurosigma angulatum*, *P. elongatum*, *Rhopalodia musculus* and *Thalassionema nitzschioides* from pennate diatoms; *Dinophysis* spp. *diverse* (ie *Dinophysis sacculus*), *Peridinium* spp. *diverse* and *Prorocentrum micans* from dinoflagellates were found in all the lagoons. Species of the genera *Euglena* (*Euglena viridis*), *Synura* (*Synura* cf. *uvella*), and cryptophytes (*Rhodomonas* spp.) were found in Ceka (September and July 2019).

More than 10 species are known to be potentially toxic (Hallegraeff *et al.*, 2004), such as the centric diatoms *Ceratulina pelagica* (in Merxhani), *Conticribra weissflogii* (in Ceka) 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*) and *Pseudo-nitzschia* species are capable of producing the neurotoxin domoic acid (DA), which is responsible for the neurological disorder in humans known as amnesic shellfish poisoning (ASP). Miho (1994) and Bushati (2013) said that *Pseudo-nitzschia seriata* and *P. delicatissima* are found abundant also in Butrinti. From dinoflagellates were found *Dinophysis* spp., *Gonyaulax spinifera*, *Prorocentrum cordatum* (in Ceka and Zaje), *Scrippsiella acuminata* (in Ceka). Frequently found in all the Lezha lagoons, *Dinophysis sacculus* is a toxic species associated with DSP outbreaks in Europe (Faust and Gullede, 2020). *Oscillatoria* species (ie *Oscillatoria* cf. *princeps*) (cyanobacteria) were found almost throughout the period and in all the stations, but mostly in Merxhani and their toxins can harm both humans and animals (Swanson-Mungerson *et al.*, 2017).

In Mediterranean lagoons, the phytoplankton dynamics is seasonal with a high peak in spring, and another smaller in autumn (Subba Rao 1981; Miho 1994; Bushati 2013). This is sometimes clearly expressed or not, depending on climatic conditions and the general condition of the ecosystem. A large peak was observed in Ceka in September and November 2018 (up to 11,857 cells/ml), and in November 2018 (up to 16,455 cells/ml), mainly with *Nitzschia* and centric species (*Chaetoceros* spp. *diverse*; another much smaller peak was in March 2019 (up to 3,102 cells/ml), mainly dominated by cryptophytes (*Pyramimonas* spp. in Ceka, and *Rhodomonas* spp. in Merxhani).

The primary productivity of Ceka lagoon was further enhanced by dense meadows of the perennial herb *Ruppia cirrhosa* (in July 2018) mixed with macrophytic algae (*Chladophora*, *Chaetomorpha* and *Ulva* species) (Gjata, 2019). Macrophyte production in shallow waters can be ten times higher than phytoplankton production (Mann, 1972). *R. cirrhosa* is common in large permanent water bodies, and in these environments, it is the only macrophyte to survive and show healthy growth in salinities above 20‰ (Verhoeven 1979; Calado and Duarte, 2000). A similar case was observed in Ceka during summer.

The phytoplankton was generally low in Zaje (up to 2,457 cells/ml in May 2019), with almost seasonal dynamic, with a peak in May 2019 and one in September 2018 (Fig. 1). Dinoflagellates were relatively abundant in May, including *Prorocentrum cordatum*, known as highly toxic (Hallegraeff *et al.*, 2004). The seagrass *Zostera noltii* was found only in Zaje in July 2018, but with negligible cover, scarcely mixed with *Chladophora* and *Ulva* species (Gjata, 2019).



**Fig. 1:** Quantitative data of phytoplankton (cells per milliliter) in Kune-Vaini lagoons, during July 2018-July 2019; average value of the three stations in Ceka.

A large peak could be noted in Merxhani in January 2019 (up to 7,525 cells/ml), and another much smaller in May 2019 (Fig. 1). The winter peak was mainly dominated by *Skeletonema costatum*, known to be toxic. This ecosystem appears immediately as highly dystrophic, loaded with decomposing organic matter, and bad smell. No traces of the phanerogams were observed, only blooming of *Ulva* species, another indicator of poor water quality (Gjata, 2019). Relatively fewer phytoplankton species were found (37 species), compared to Ceka (63) and Zaje (54); it differs from what was reported by Miho and Mitrushi (1999). Moreover, other toxic algae such as *Ceratulina pelagica*, *Pseudo-nitzschia* species, or *Oscillatoria* species (cyanobacteria) were observed. Worth to mention that in Ceka we assessed the phytoplankton in three stations, and respectively only 1 station in Zaje and Merxhani.

Phytoplankton in Ceka and Merxhani showed an unusual dynamic, probably due to scarce water exchange, water oxygenation and nutrient circulation. Permanent water body in Ceka is also shown from the dense presence of the phanerogam *Ruppia cirrosa*. Relatively high content of nutrients (nitrogen and phosphorus) was assessed by Ramaj (2019), too. Average value of total phosphorus (TP) was 88.91 for Ceka, 66.31 for Zaje, and 56.57 µg/L for Merxhani. Also, the average content of total nitrogen ( $\text{NO}_2 + \text{NO}_3$ ) was higher than the 'very highlimit (>8 µmol/L)' set by EEA (2017): 10.72 for Ceka, 21.59 for Zaje, and 9.90 µmol/L for Merxhani. This combined also with the dense presence of green algae (*Ulva* species), tolerant to pollution (known as nitrophyl species), and low IPS values calculated by Qevani (2020), all represent an evidence of the surrounding impact in all three lagoon ecosystems (through the two Pumping Stations in Shengjini and Tale, the related tide channels and the Drini delta). Continuous monitoring of the lagoon complex is recommended, especially for toxic algae.

## ACKNOWLEDGMENTS

The present study was supported by the Kune-Vain project (<http://kunevain.com/>), funded by UNEP, GEF and the Albanian Government. Field trips, the chemicals, glassware, literature and master fee were granted. We are also grateful for the cooperation and support given by the Administration of the Protected Area, Lezha, and for the cooperation between our group of experts and students.

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## **THE ROLE OF THE FISHERIES SECTOR IN THE PROCESS OF SEA PROTECTION AND MARITIME PLANNING**

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### **ABSTRACT**

The Marine Strategy Framework Directive (MSFD) is the environmental pillar of European maritime policy designed to create a framework for sustainable use of the continent's marine waters. The MSFD aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020. In order to achieve GES by 2020, each Member State is required to develop a strategy for its marine waters (or Marine Strategy). In addition, and in line with MSFD, Contracting Parties to the Barcelona Convention adopted the Integrated Monitoring and Assessment Programme (IMAP), committing to achieve GES of the Mediterranean Sea. In order to assess the state and pressure of marine diversity at the open part of Montenegrin coast, data from the field of marine fisheries for the period 2014-2016 were processed. The analyses were performed in accordance with the IMAP common indicators (CIs), and the results of the conducted analyses can significantly contribute to the provision of guidelines for maritime spatial planning in Montenegro. Detailed analysis was performed for spatial distribution (CI3) and population

size (CI4) for the most economically important species of fish and crustaceans, - anchovies (*Engraulis encrasicolus*), sardines (*Sardina pilchardus*) and other pelagic species (OPS), red mullet (*Mullus barbatus*), European hake (*Merluccius merluccius*) and deep-water pink shrimp (*Parapenaeus longirostris*). All data were collected during international projects MEDIAS (Mediterranean International Acoustic Survey), MEDITS (Mediterranean Trawl Survey) and FAO AdriaMed (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea), while assessment of state and pressure of fishery resources in Montenegro was carried out as part of the project "Implementation of ecosystem approach in the Adriatic Sea through marine spatial planning" (GEF Adriatic).

**Keywords:** maritime spatial planning, marine fisheries, ecosystem approach, MSFD, IMAP

## 1. INTRODUCTION

Marine spatial planning (MSP) is a place-based, multi-sectoral decision-making approach that is being widely promoted for reducing the conflicts and impacts commonly encountered in conventional sector-by-sector planning (Lester *et al.*, 2018). This is especially important in countries that have developed tourism or for which tourism is a priority activity, as is the case with Montenegro. The coastal area is under increasing pressure from different sources - pollution, intensive and/or illegal construction, and other anthropogenic activities leading to conflicts between different sectors competing for the same area. Given that the coastal area is limited and finite in physical and spatial terms, long-term planning is extremely important both for the development of the sector and for the conservation of resources (Mandić *et al.*, 2020).

This paper presents the MSP as part of the case study in Montenegro which was undertaken in the frame of the project "Implementation of ecosystem approach in the Adriatic Sea through marine spatial planning" (GEF Adriatic). The data presented in this paper were processed in accordance with the requirements of Marine Strategy Framework Directive (MSFD) and Integrated Monitoring and Assessment Programme of the Barcelona Convention in the framework of the Ecosystem Approach (EcAp). EcAp is a strategy for comprehensive and integrated management of activities that affect marine and coastal ecosystems with the ultimate goal of achieving good ecological status of the Mediterranean Sea and coast.

## 2. MATERIALS AND METHODS

The data here used have been provided by the international projects such as MEDIAS (Mediterranean International Acoustic Survey), MEDITS (Mediterranean Trawl Survey) and FAO AdriaMed (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea) for the period 2014-2016. Analyses of data were done in accordance with IMAP ecological objectives, operational objectives and indicators for the Mediterranean area (IG 20/4). In particular, data for ecological objective 3 (EO3) were processed, which stipulates that “*populations of selected fish, crustaceans and molluscs used for commercial purposes are within safe biological limits, and the distribution of population by age and size shows that the fund is healthy.*” Detailed analysis was performed for spatial distribution (Common Indicator 3 - CI3) and population size (CI4) for the most economically important species of fish and crustaceans, - anchovies (*Engraulis encrasicolus*), sardines (*Sardina pilchardus*) and other pelagic species (OPS), red mullet (*Mullus barbatus*), European hake (*Merluccius merluccius*) and deep-water pink shrimp (*Parapenaeus longirostris*). Data were processed using GIS application in order to define spatial distribution of species and spawning zones of anchovies. By interpolating the data in GIS, spatial zones ranging from low biomass intensity to very high biomass intensity were obtained.

The data are summarized and presented as a spatial distribution of pelagic and demersal fish species, in order to define the areas that are most valuable in terms of resource richness, which can significantly contribute to the MSP process in Montenegro.

## 3. RESULTS AND DISCUSSIONS

Spawning of anchovies indicates two main spawning areas of this species - the bay of Kotor and bay of Tivat - in which the spawning intensity was extremely high throughout the study period. Significant spawning was also found in the area of Risan bay. The period when spawning will be most intense, as well as the locality where the number of eggs will be the highest, are generally related to zones with high productivity, especially when the conditions for feeding the adult population are favourable (Somarakis *et al.*, 2004; Martin *et al.*, 2008).

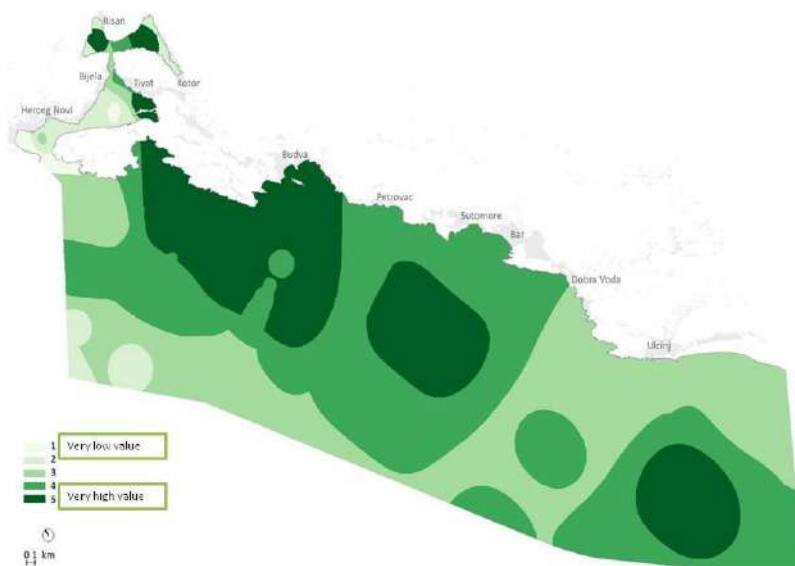
A detailed analysis of the spatial distribution of the early developmental stages of anchovies indicates the existence of two spawning zones in the open waters of the Montenegrin coast. The first, smaller zone extends from Bigova bay to Budva bay, while the second, larger and most important zone stretches from Crni rt to the border with Albania. In both zones, the distribution of the early stages of anchovies is observed from relatively small depths (almost

from the shoreline) to the iso bath of about 100 meters, i.e., the area of the continental shelf (Figure 1).

Analysis of the adult anchovy population indicated the highest density in the area in front of Platamuni and in the area in front of Ulcinj. The highest density of sardines was recorded in the area in front of the Platamuni (near the coast), while a high concentration was also found in the area in front of Budva and in front of Ulcinj (Figure 1).

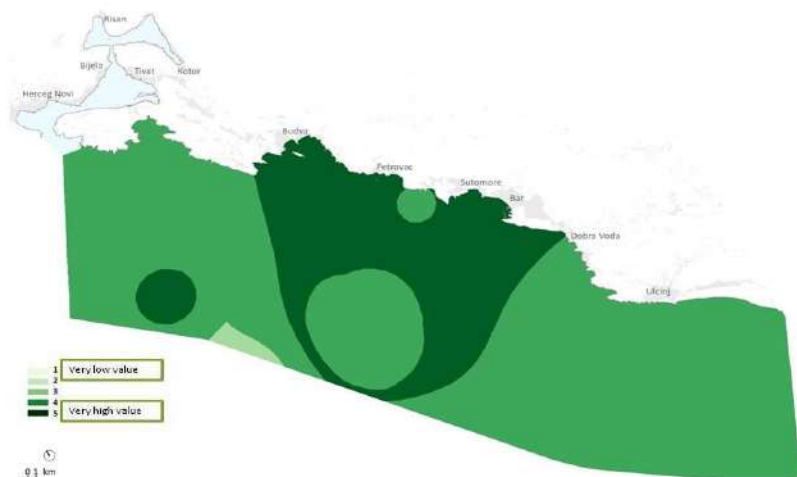
Analyses of the total biomass of the adult population of anchovies and sardines, as well as all pressures (fishing mortality, fishing, CPUE, etc.), indicate that the biomass of sardines and anchovies in the entire Adriatic is overexploited and overfished (Angelini *et al.*, 2017). However, the measures adopted at the GFCM level on the protection of pelagic resources in the Adriatic do not apply to Montenegro due to the extremely small share in the total fishery in the Adriatic Sea (GFCM/42/2018/8).

In addition to the targeted species (sardines and anchovies) in the catches of pelagic hauls, the following species were also found: *Trachurus trachurus*, *Trachurus mediterraneus*, *Spicara smaris*, *Spicara flexuosa* and *Spicara maena*, *Boop boops*. All species were caught sporadically in individual specimens, and making spatial distribution maps for them is impossible. As none of these species is a target species in fishing and a by-catch, their populations are not under great pressure from fishing and for them there is no biomass assessment at the Adriatic level. Data on pelagic species (adult anchovies and sardines and early life stages of anchovies) were collected during MEDIAS and FAO AdriaMed projects.



**Fig.1:** Overall assessment of the value of the area in relation to the spatial distribution of pelagic resources.

When it comes to demersal resources, a high density of *M. barbatus* biomass is present in the area between Platamuni and Volujica at a depth range of 40-110 meters (Figure 2). There are two centers of high biomass of hake on the Montenegrin coast - above the entrance to the Boka Kotorska Bay at depths range between 160-300 meters. The area of the Montenegrin coast with highest hake biomass is the southern Adriatic continental slope, which in Montenegro includes only a small part of the unique slope. In this area and going north towards the Jabučka valley, the largest hake biomass in the Adriatic was recorded through previous hake research surveys through the MEDITS program (Piccinetti *et al.* 2012), so our findings fully agree with these data and they point to the importance hake as a shared resource in the Adriatic Sea. There are two centers of high *P. longirostris* biomass in the area of the Montenegrin coast, above the entrance to the Boka Kotorska Bay at depths range between 100-250 meters. Data on demersal resources were collected during the MEDITS surveys.



**Fig. 2:** Overall assessment of the value of the area in relation to the spatial distribution of demersal resources.

The Adriatic Sea is an area with marked pressure on fishery resources, especially pelagic. Data report that anchovies and sardines are overfished across the Adriatic Sea. Nevertheless, Montenegro participates in total fishing below 1% and measures to limit catches of small pelagic fishes do not apply to Montenegro (GFCM/42/2018/8;GFCM/43/2019/5).

National measures in Montenegro are in place to ensure sustainable exploitation of resources, and relate to the protection of fish stock during the reproduction period by a total ban on fishing, bans for large purse seiners within the area of Boka Kotorska Bay and within 3 NM or 50 m isobath on the open sea area.

The most important demersal species in Montenegro is the red mullet. The value of mullet biomass is significantly higher than the estimated biomass for the central and southern Adriatic Sea (Stock Assessment Form Demersal species *Mullus barbatus* in GSA 17 & 18 Reference year: 2016). Although the intensity of catches at the level of Montenegro does not represent significant pressures for the biomass on Adriatic level, it is important to note that there are national measures which ensure sustainable exploitation of resources, bans for trawlers within the area of Boka Kotorska Bay and within 3 NM or 50 m isobath on the open sea area.

The measures currently in force, in line with European directives and guidelines, international conventions and regulations, should be respected in order to protect the fish stock, and especially in order to protect economically important fish species during the reproduction period (Pešić *et al.*, 2011, Ikica

*et al.*, 2013). As part of the MSP process in Montenegro presented results and findings will be taken into considerations, together with other environmental data, to identify the most sensitive marine areas where careful planning of sea uses should be applied in order to reach good environmental status and ensure conservation of the area's natural resources and social wellbeing. This is mostly important for the area of Boka Kotorska ay, which is partly under UNESCO protection and where fishery sector has a centuries-old tradition.

### ACKNOWLEDGEMENT:

The present investigation is the outcome of the projects MEDIAS (Mediterranean International Acoustic Survey) and FAO AdriaMed (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea). Assessment of state and pressure of fishery resources in Montenegro is part of the project "Implementation of ecosystem approach in the Adriatic Sea through marine spatial planning" (*GEF Adriatic*).

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## AN ECOLOGICAL APPROACH FOR THE ASSESSMENT OF THE WETLAND COMPLEX OF KUNE-VAINI (LEZHA): MAIN OUTCOMES

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### ABSTRACT

Despite the strong changes over the years, the Kune-Vaini wetland (Lezha, Albania) still preserves special scientific and economic values, as well as a very attractive landscape between land and sea. During our bimonthly monitoring approach (July 2018-July 2019), relatively high nutrient load (nitrogen and phosphorus) were observed in lagoons, and relatively poor biological quality. Unusual winter peak of phytoplankton, chlorophylls and zooplankton was observed in Merxhani. Phytoplankton was dominated by toxic algae which are unhealthy both for the ecosystem and humans. Microplastics were found in water and crabs, etc. **Hydrological regime** and tide water exchange could be considered poor and scarce in lagoons, especially in Ceka and Merxhani. The existing ecological conditions call for a continuous maintenance of the water exchange that would in return help enhancing the biodiversity and primary production, preventing also the dystrophic conditions. The Management Plan revision is recommended, addressing an ecosystem-based adaptation (EbA) approach to climate changes, and other concerns, like water exchange, sea erosion and related hydrotechnical works, Drini River rehabilitation, flood control and management. Other important aspects would be the unsustainable urbanization and tourism infrastructures, water pollution and solid waste, eutrophication and harmful algae, reforestation and plant nurseries, fishing, aquaculture and hunting, etc.

**Keywords:** Coastal ecology, Lezha wetlands, lagoons, hydrological regime, Ecosystem-based Adaptation (EbA)

## 1. INTRODUCTION

Kune-Vaini wetland complex is situated in the northern part of the Albania's Adriatic Coast, west of Lezha plain (Fig. 1). It is formed under the influence of Drini and Mati rivers. The complex consists of these four main water bodies: Merxhani and Knalla (in Kune, northern part of Drini), and Ceka and Zaje (in Vaini, in the south). The related Management Plan (CEIA, 2010) was approved by DCoM432/2010; the Kanalla pond was excluded, and the coastal area of Tale and the related lagoon was included within Kune-Vaini-Tale Nature Reserve (IV Category); the total area covers about 44 km<sup>2</sup> (<http://akzm.gov.al/>) of which 12.5 km<sup>2</sup> are covered with water. Miho *et al.*, (2013) said that the remains are swamps, reed bed, forests and shrubs, and sandy dunes.

The Department of Biology and the Department of Chemistry of the Faculty of Natural Sciences of the University of Tirana, Albania, have jointly applied a Master Program focused on the ecological approach of the wetland complex, financially supported by the Kune-Vaini Project (Law 33/2016). Important chemical and biological components were assessed as topics of a number of master theses under our supervision and expertise. The most important outcomes are here briefly discussed.

## 2. MATERIALS AND METHODS

The sampling and other field investigations were bimonthly carried out, respectively in July, September, November 2018 and January, March, May, July 2019. At least 5 representative stations were visited: three in Ceka, and one in Zaje and Merxhani (Fig. 1). The parameters measured and discussed in separate master theses were: physical-chemical parameters, heavy metals (Cu, Pb, Cr, Fe, Mn) (Muçaj, 2019), nutrients (N and P) and chlorophylls (Ramaj, 2019), phytoplankton and toxic algae (Kola, 2019), submersed macrophytes (Gjata, 2019) and zooplankton (Lika, 2019). It was further extended to other topics such as diatoms in periphyton (Qevani, 2020), flora and vegetation (Bici, 2019; Sanxhaku, 2020), wintering and breeding waterbirds (Selgjeka, 2020), microplastics (Cani, 2020), etc. Detailed data on material and methods, and results obtained can be found in each thesis. Some data will be presented in more details in WEPSD-2020; meanwhile a separate volume with all the data is under the preparation.

### 3. RESULTS

The three lagoons represent some notable differences based on their **physic-chemical** conditions (Muçaj, 2019). 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). A narrow sandy belt separates the Merxhani lagoon with the sea; two or more times per year, the seawater overflows and mixes with the lagoon waters. Values of oxygen saturation (DO%) were generally below 100%, mainly in Ceka and Zaje. Certain pollution with copper and chromium was observed (Bratli, 2000).

As expected, **nutrient (N & P) content was significant** (Ramaj, 2019) due to 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 Shengjini Island. Urban and agriculture wastes are discharged 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<sub>4</sub> 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).



**Fig. 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 inlets; sampling stations; only periphyton samples (from Google Earth 2020).

Moreover, the average content of total nitrogen ( $\text{NO}_2 + \text{NO}_3$ ) was higher than the 'very high limit' ( $>8 \mu\text{mol/L}$ ) set by EEA (2017):  $10.72 \mu\text{mol/L}$  for Ceka,  $21.59 \mu\text{mol/L}$  for Zaje, and  $9.90 \mu\text{mol/L}$  for Merxhani. Combined with the dense presence of green algae (*Ulva* species), tolerant to pollution (known as nitrophyl species) (Gjata, 2019), and low IPS values calculated by Qevani (2019), all is an evidence that the surrounding zone has a significant impact on all three lagoon systems.

Different types of **vegetation** are well expressed in Kune-Vaini area, from submersed vegetation, reed, halophytes or psamophytes, up to aquatic shrubs and typical Mediterranean forest and sandy dunes. The forest area, shrubs and aquatic vegetation extend in  $13.4 \text{ km}^2$ ; the most important and most sensitive is the Mediterranean alluvial mixed forest, dominated mainly by alder (*Alnus glutinosa*) and narrow-leaved ash (*Fraxinus angustifolia*), often mixed with white poplar (*Populus alba*), *Ulmus minor* and *Quercus robur* (Bego *et al.*, 2013). The dominant aspect of the dune vegetation is the cultivated of pines (*Pinus pinaster*, *P. pinea*, *P. halepensis*), that spreads along the coast in Kune and in Vaini areas.

More than 270 species of **higher plants** were reported (Miho *et al.*, 2013), most of them flowering plants. About 18 species such as *Pancratium maritimum*, *Matthiolatricuspida*, *Juniperus macrocarpa*, *Ammophila*

*arenaria*, *Stachys maritima*, which are mainly found on sandy dunes and gradually less in coniferous forests (Bici, 2019), belong to the endangered species. Sanxhaku (2020) said that 10 priority habitat types of Natura 2000 list have been identified; 3 in coastal dunes, and 7 habitats within the wetland zone of Kune-Vaini.

The bottom of the lagoons is often inhabited by the **submersed plant species (macrophytes)**; extended meadows of the grass *Ruppia cirrhosa* in Ceka; and scarce spots of *Zostera noltii* in Zaje (Gjata, 2019). The grasses were mixed mainly with green algae (*Chaetomorpha*, *Cladophora*, *Ulva*, etc.), and red algae (*Gracilaria*, *Polysiphonia*, etc.). In the littoral parts with less salinity, various *Potamogeton* and *Myriophyllum* species grow up too (i.e. in Drini delta; Qevani, 2020). Large areas are covered by reedbeds, dominated by hydro-hygrophite species (*Phragmites australis*, *Typha angustifolia*, *Scirpus* spp., etc.), which extend largely in the littoral parts (especially in Ceka, Knalla), along the riverbanks, drainage channels, etc.

About 100 species of **microscopic algae** were found in phytoplankton (Kola, 2019) and about 200 species of **diatoms** in periphyton (Qevani, 2020). In total, there are known 310 species of microscopic algae; ca. 280 species are diatoms, including those found previously in phytoplankton by (Miho and Mitrushi 1999). Around 10 species belonging to genera *Skeletonema*, *Amphora*, *Pseudo-nitzschia*, *Dinophysis*, *Prorocentrum*, *Oscillatoria* are known as potentially toxic. **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, known to be toxic (Hallegraeff *et al.*, 2004). The same peak was observed with photosynthetic pigments (30.61 µg/L Chl *a*, 2.49 µg/L Chl *b* and 16.89 µg/L Chl *c*) (Ramaj, 2019), and zooplankton (105.8 ind./L in January 2019) (Lika, 2019). The one-peak growth provides a clear evidence to the poor state of ecosystem, scarce water exchange and nutrient circulation.

Ca. 32 taxa of **zooplankton** were found for the first time in Kune-Vaini (Lika, 2019); copepods were the most abundant. The quantity was generally higher in Zaje (average value 154.3 ind./L), slightly lower in Ceka (113.7 ind./L), and much lower in Merxhani (83.6 ind./L). The rotifer *Brachionus plicatilis*, was abundant in Ceka, known as indicator of eutrophic state.

More than 340 **animal species** have been reported in years (Miho *et al.*, 2013), 23 mammals, 196 birds, 59 insects, 58 fishes, 10 reptiles. However, the studies are limited in number and sporadic. In addition, they do not cover all taxa. About 190 species are in the Albanian Red List (Order 1280/2013), especially 33 species of birds and 4 species of mammals that belong to the IUCN Red List (2007) as globally threatened species. The most common fish species are mullets, eel, sea bass, sea breams, sand smelts, torpedo, leer fish, shidrum, bogue, sole and Atlantic horse. Both Vaini and Kune are mentioned

for their high diversity of waterfowl species. Reed beds, especially in Vaini, are important habitats for wintering birds; from 196 species of birds recorded in years, 59 species were permanent nesting birds, 65 migratory wintering, 51 summer migratory, and 21 vagrant birds (Miho *et al.*, 2013).

The heron colony in Kune was one of the largest in Albania and the Western Adriatic as well. It started to collapse in the 70s, and almost disappeared after the radical hydrological changes of the system in 1991. We observed for the first time **the revitalization of the colony**, represented by 5 species (550-570 nesting pairs in 2019 and 420-600 pairs in 2020). The little egret (*Egretta garzetta*) was the largest (68%), then the squacco heron (*Ardeolaralloides*), the pygmy cormorant (*Microcarbo pygmaeus*), the cattle egret (*Bubulcus ibis*) and the black-crowned night heron (*Nycticorax nycticorax*) (Selgjeka, 2020). Wintering waterfowl was at a higher rate in Vaini (mostly in Ceka) than in Kune in January 2020. Despite the positive aspects observed, again **the trend remains negative compared to the previous years**. Based either on the literature or in our observations, anthropogenic activity is concerning.

#### 4. DISCUSSIONS

The Kune-Vaini wetlands shelter **sensitive and fragile ecosystems**, like sandy dunes and river deltas, Mediterranean coniferous, alluvial and mixed riparian forests (Bego *et al.*, 2013; Miho *et al.*, 2013). But it has undergone severe hydrological changes over decades until present.

The system is **closely dependent upon the influence of Drini and Mati rivers**. Since 1963, the Drini in Shkodra (known as Drinasa) has been fully diverted to the Buna River, avoiding flooding of Zadrime plain and Lezha town. Drini of Lezha represents nowadays mostly a drainage channel of the Zadrime and Kakarriqi plains. Knalla pond was originally in close hydrological connectivity with Merxhani lagoon, but blocked after 1990s, due to heavy urbanization of the zone that still continues, and left also outside PA (DCM 432/2010); for the same reason was also blocked the Kularitide channel in the northern part of Merxhani lagoon. The channels connecting Zaje with Ceka were also blocked for fishing purposes. A dike was built some years ago on the south side of Drini mouth. A new inlet channel was constructed in Ceka in August 2018 by the Project support (GBA, 2017), connecting the lagoon directly with the sea (Fig. 1); it was soon blocked by sediments. Several artesian wells (ca. 30 to 35 L/s) were important part of the hydrographic network, drilled during 1973-75 (Pano, 1998; Kallfa, 2014); they provided freshwater in several parts of the whole wetland area, necessary for wildlife (e.g. waterfowl and waterbirds). But, water pressure in the last 20 years has dropped down, due to the impoverishment of the aquifer, overuse of

groundwater for irrigation, damage or blockage of the wells, etc. (Eftimi, 1998).

Totoni *et al.*, (2010) as experts on drafting the Kune-Vaini-Tale **Management Plan** (CEIA, 2010) make recommendations on sustainable tourism. They stated that the tourism opportunities and environmental features are strongly related. **Mass tourism is not encouraged. Uncontrolled and unsustainable urbanization and tourism infrastructures have continuously increased** in the surrounding areas of Lezha, Shengjini and along the Shengjini beach. Some residential or service buildings are also located within the Vaini reserve, and others continue to be built within the boundaries of the Kune reserve. Paved road was extended close to Kune reserve after 2000s; recently (yr. 2020), paved roads cross through Vaini Reserve, too. Schonewald-Cox and Buechner (1992) and NRC(2005) reported that motor vehicles are not environmentally friendly, and have adverse effect on its high native biodiversity.

Beside the support given in years (CEIA, 2010; UNDP, 2013; Ligji 33/2016; GBA, 2017), combined effect 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), wetland biodiversity and ecology, and ecosystem services**, further exacerbated even by global warming. Extreme events such as heavy rain, floods and droughts are already causing habitat loss and fragmentation.

The Convention on Biological Diversity (CBD, 2009) recommends the **ecosystem-based adaptation (EbA)** for the conservation, sustainable management and restoration of ecosystems, including coastal wetlands. Hence, the main goal of the Kune-Vaini project was focused on building the ecosystem resilience of wetland complex, addressing the climate change risks (i.e. coastal erosion, hydrological regime, etc.) (GBA, 2017).

To our opinion, the four water bodies (Ceka and Zaje in Vaini, Merxhani and Knalla in Kune), pumping stations (in Shengjini and Tale), the related tidal inlet channels, and the Drini River must be considered as one integral hydrological system and be assessed and managed through a common ecosystem-based approach. Improved **hydrological regime and water exchange of the wetlands** is one of the most important determinants of primary productivity, the basis of the great biodiversity that the system holds; wetlands in stagnant state have low productivity; species richness, at least in the vegetation community, increases when water exchange increase; it is as a stimulus to diversity, caused by its ability to renew minerals and reduce anaerobic conditions (Mitch and Gosselink, 2007).

Therefore, **continuous efforts to keep the tidal exchange** in Kune-Vaini are unavoidable. Ceka and Merxhani lagoons may be considered with scarce water exchange. Hydrological regime could be enhanced, if the existing tidal

inlets are constantly deepened and maintained. Reopening the communication channels between Ceka and Zaje is necessary for a better water exchange between both lagoons, and with Drini delta, in addition to the reopening of the Kulari tidal inlet in Merxhani, and the restoration of Knalla communication with the northern marsh of Merxhani. The biodiversity and primary production, up to higher levels (fish and waterbirds) would enhance as well, preventing the dystrophic conditions observed in the lagoons.

We strongly suggest the **rehabilitation of Drini River (Lezha)**, through partial and controlled diversion of the waters from Drinasa to the former Drini river (Lezha). It would help to prevent the significant coastal erosion, and also keep healthy the whole wetland complex. We are not sure if the dike built in the southern part of Drini outlet was an adequate practice (confirmed also by Gjini, 2015). The same could be said for the new tidal inlet in Ceka in 2018 (GBA, 2017). A group of experts, hydrologists and ecologists, can work together to face with issues of hydrological regime and erosion along the coast, and find out the proper hydrotechnical interventions that would better face with climate changes, as well.

Relatively high nutrient load (nitrogen and phosphorus) and trophic level was observed in lagoons (Ramaj, 2019; Qevani, 2020). Regular collecting and **wastewater treatment**, along with the strict control of the wastewater discharge into the surrounding drainage channels or Drini are an emergency. Worth to mention the water pollution in drainage channels (Ramaj, 2019; Qevani, 2019) and solid waste immense sparse in channels, beach and river delta. Microplastics (< 5 mm) were found in all water column and crabs (Cani, 2020). Further studies are needed to unravel the possible toxic effects and the profound impact that water-borne pollution could have on lagoon biota and ecosystem health. The current and future plans for urbanization and tourism infrastructures, as well as solid waste management need a strict control.

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). Planting with beachgrass *Ammophila arenaria* (UNDP, 2013) would be not a proper EbA measure to reduce coastal erosion in Vaini. Nevertheless, we strongly support reforestation in the whole area, to prevent erosion, flooding and improve the wildlife in general. **Forest nurseries** must be supported in Lezha, as a long-term practice to provide native plant seedlings, large-scale and continuous reforestation activities; volunteering reforestation activities can also be encouraged (Mullaj *et al.*, 2017).

We hope that our data and considerations will assist PA Administration, local decision-making and local environmental expertise in the conservation and ecological restoration of the wetland complex. **The revision of**

**Management Plan 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 present study is part of the Kune-Vaini project (<http://kunevain.com/>), funded by UNEP, GEF and the Albanian Government. Field trips, chemicals, glassware, literature, master fee and tutorial for master students are funded. We are also grateful to the Administration of the Protected Area, Lezha for the cooperation and support given to the cooperation among the group of experts and students. Congratulations and thanks to Albanian Academy of Sciences, and the organizers of WEPSD-2020 Conference.

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## DIATOMS (BACILLARIOPHYCEAE) AND THE RELATED BIOLOGICAL QUALITY OF WATERS IN KUNE-VAINI, LEZHA

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### ABSTRACT

Additional information about the diatoms (Bacillariophyceae) from different habitats of Kune-Vaini (Lezha, Albania) is here reported. Periphyton samples were collected from the Ceka and Zaje (Vaini), Merxhani (Kune) lagoons and Drini delta from July 2018 to July 2019. The material was boiled in H<sub>2</sub>O<sub>2</sub>cc and microscopic slides were embedded with Naphrax to clean up the diatom frustules. The microscope Motic BA310, objective 100x, and a digital camera were used to determine the species. More than 400 frustules were counted, and the IPS was calculated. About 200 species of diatoms were found. 13 out of the 200 species of diatoms were centric, and the reminder was pennate, showing relatively high diversity. There are 79 species found in Ceka, 61 in Zaje, 75 in Merxhani and 112 in the Drini delta. *Halamphora coffeiformis*, a toxic species, was found in all the habitats, relatively abundant in Ceka drainage channel (up to 65% of periphyton community in March 2019) and Ceka lagoon (up to 28% in July 2018). IPS values were relatively low. 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 is rather low, considering the abundant marine species. It somehow shows the anthropogenic impact in water quality to the zone, as confirmed also by the related working groups within the Kune-Vaini Project during the same period. Water quality remains of the greatest concern.

**Keywords:** Lezha lagoons, diatom diversity, coastal ecology, T SI, water quality

### 1. INTRODUCTION

Diatoms are the main group of plant protists that populate mostly the aquatic habitats, living in benthos or periphyton (attached to submerged surfaces) and in phytoplankton. They are the primary producers and constitute

the first trophic level in the food chain, and at the same time, they enrich the aquatic habitats with abundant amounts of oxygen (Van den Hoek *et al.*, 1995). Diatoms are adapted to habitats of good natural state, unpolluted and without high nutrient load. In undisturbed habitats they grow up with high diversity. They are very sensitive not only to the environmental conditions, but also to the content of nutrients (N and P), heavy metals, organic pollution, etc. Therefore, the diatoms are largely used as indicators of surface water quality (WFD, 2000; etc.). Several indexes have been developed for the assessment and classification of fresh water quality. Index of Pollution Sensitivity (IPS) is one of the most frequently used, beside some limitations in certain cases (Trábert *et al.*, 2017). It was originally developed at the Cemagref institute by (Coste 1982), using the formula of Zelinka and Marvan (1961). It was elaborated after by Eloranta & Kwandrans (1996). The ecological values ( $S_i$  and  $V_i$ ) were taken from the OMNIDIA database (Lecointe *et al.*, 1993). The water quality is given into 5 classes. IPS combines the impact of inorganic and organic nutrient loads.

There is little information about the periphyton diatoms on the Kune-Vaini wetlands. The present paper is the first approach on the samples collected from different habitats. A complete information (list of species and plates with microscopic photos) can be found in master theses of Qevani (2020). The work was combined together with the phytoplankton assessment by Kola (2019) in the framework of the Kune-Vaini project (<http://kunevaini.com>).

## 2. MATERIALS AND METHODS

About 16 periphyton samples were collected from the Ceka, Zaje, Merxhani lagoons and Drini delta from July 2018 to July 2019. The material was with submersed macrophytes: the grass *Ruppia* and green algae (*Chladophora*, *Chaetomorpha* and *Ulva* species) in Ceka lagoon and/or drainage channel (6 samples: July 2018, January, March, May, and July 2019); the seagrass *Zostera* and/or *Chladophora* and *Ulva* species in Zaje (3 samples: November 2018, March and May 2019); *Ulva* species in Merxhani (3 samples: November 2018, March and May 2019) (Gjata, 2019); *Myriophyllum* sp. (freshwater aquatic plant) and *Ulva* spp. in Drini delta (4 samples: January, March, May, and July 2019) (EN 13946:2003).

The diatom frustules were cleaned by boiling the material in  $H_2O_2$ cc (EN13946:2003). The microscopic slides were embedded with Naphrax (1.71). The species were determined using the optic microscope Motic BA310, objective 100x, a digital camera, and abundant information provided in (Sournia, 1978; Krammer and Lange-Bertalot, 1986-2000; Witkowski *et al.*, 2000; Hallegraeff *et al.*, 2004; WoRMS and AlgaeBase 2019). More than

400 frustules were counted (confidence 95%,  $\pm 10\%$ ), and the IPS was calculated (EN14407: 2004).

### 3. RESULTS AND DISCUSSIONS

More than 200 species of diatoms (Bacillariophyceae) were found in total. 13 species were centric and 189 were pennate; 79 species were found in Ceka, 61 in Zaje, 75 in Merxhani, and 112 in Drini delta. With what was found in phytoplankton by Miho & Mitrushi (1999) and Kola (2019). The total number of microscopic algae found in the Kune-Vaini Lagoon is about 310 species; ca. 280 species are diatoms.

The Table 1 reports about the species per sample found in the Drini delta (62 species in January 2019), Merxhani (43 species in March 2019) and Ceka (40 species in March 2019). The Margalef index,  $d$  (1958), combines the data of the total number of species ( $S$ ) and the total number ( $N$ ) of frustulae counted in each sample community;  $d$  ranges from 3.27 in Zaje to 9.89 in Drini, corresponding also with the species number.

*Nitzschia* and *Naviculas* species (up to 24 species each one) were widespread and abundant in periphyton community. *Cocconeis lineata* was also present in all habitats, but it was found relatively abundant in Zaje (up to 74% in May 2019) and in Ceka (up to 63% in July 2019). *C. scutellum* was present only in the lagoons, relatively abundant in Zaje (up to 82% in November 2018) and in Ceka (up to 67% in May 2019). *C. placentula* var. *euglypta* was present in all the habitats, relatively abundant in Ceka (up to 28% in January 2019). *Halamphora coffeiformis* was present in all habitats, relatively abundant in Ceka (up to 65% in March 2019); worth to mention that *H. coffeiformis* is a toxic species. *Conticribra weissflogii* (scarcely present in Ceka) is also known to be potentially toxic (Hallegraeff *et al.*, 2004).

Other pennate diatoms present in periphyton community of all habitats were: *Navicula gregaria*, relatively abundant in Drini (up to 33% in March 2019); *N. perminuta* abundant in Drini (up to 30% in March 2019). *Navicula recens* was present only in Zaje and Drini (up to 45% in May 2019). *Nitzschia lacuum* was present in all habitats, and relatively abundant in Drini (up to 23% in January 2019). *Tabularia fasciculata* was present in all samples, but relatively abundant in Zaje (up to 72% in March 2019). Relatively present, but less abundant were *Achnanthes adnata*, *A. armillaris*, *Cocconeis placentula* var. *euglypta*, *Navicula gregaria*, *N. phylleptosoma*, *Nitzschia inconspicua*, *Tabularia tabulata* and *Tryblionella apiculata* were present in all the habitats. *Halamphora holsatica*, *Licmophoragracilis*, *Mastogloia pumila*, *Nitzschia sigma*, *Opephora mutabilis*, *Rhopalodia musculus*, *Tryblionella granulata* were present only in the lagoons.

Muçaj (2019) said that the three lagoons represent notable differences, based on physico-chemical parameters. The waters were mesohaline (8-18‰) in Zaje, as expectable for its water exchange with the Drini delta. The Ceka waters were polyhaline (18-30‰); whereas the waters in Merxhani were euhaline (25-40‰). Meanwhile, most of diatoms found were fresh waters species (82 species). There were 17 marine/freshwater species; 69 marine species and 33 brackish species. Since the IPS and the OMNIDIA database (Lecointe *et al.*, 1993) are valid mostly for freshwater habitats, some of the species counted by us have no ecological values ( $S_i$  and  $V_i$ ) (mostly marine species) and cannot be considered in IPS calculation. In our case, the total percentage of species with ecological values that have contributed in the IPS calculation varied from 79 to 97% in Ceka and Zaje; 74 to 93% in Merxhani, 83 to 99% in Drini; the average was 90.67% in Ceka, 97.33% in Zaje, 83% in Merxhani, and 92.75% in Drini (Tab. 1). Therefore, the IPS values can give somehow the quality of each habitat under interest, even with a certain approximation. The IPS reliability could be considered rather low in the Merxhani Lagoon, where the abundance of marine species (without ecological values) in periphyton community was higher.

Based on the aforementioned statement, the IPS values were relatively low. The lowest value, 5.98 ('poor' quality), was found in the drainage channel outside the Ceka Lagoon. The highest IPS values were found in Zaje (12.77 in May 2019) and Drini (12.39 in January 2019). The average was 8.85 in Ceka, 8.36 in Zaje, both 'poor' quality; and 9.55 in Merxhani, 10.34 in Drini delta, both 'moderate' quality class (Tab. 1). It is somehow a proof of anthropogenic impact on the water quality of the area, as confirmed also by the related working groups within the Kune-Vaini Project (Gjata, 2019; Kola, 2019; Ramaj, 2019) during the same period.

**Table 1.** Periphyton data from wetland habitats in Kune-Vaini, Lezha. N, species number; d, Margalef index (1958); IPS, Index of Pollution (Coste në Cemagref, 1982); %, percentile with IPS ecological values. Colors after water quality classes of WFD 2000/60/EC.

Ecosystem	Ceka						Zaje		
Habitat	Lagoon				Lagoon shore	Drainage channel	Lagoon		
Time	July 2018	January 2019	May 2019	July 2019	March 2019	March 2019	November 2018	March 2019	May 2019
N	27	20	25	25	40	29	25	38	21
d	3.65	3.08	3.91	3.88	6.34	4.53	3.38	5.74	3.27

IPS	9.17	10.10	7.02	10.87	9.94	5.98	6.21	6.12	12.77
IPS Classes	Moderate	Moderate	Poor	Moderate	Moderate	Poor	Poor	Poor	Moderate
%	91	96	95	92	79	91	96	97	99

Ecosystem	Merxhani				Drini		
Habitat	Lagoon				River delta		
Time	November 2018	January 2019	March 2019	May 2019	January 2019	March 2019	May 2019
N	33	24	43	38	62	63	34
d	5.19	3.77	6.90	6.02	9.66	9.89	5.36
IPS	10.87	6.50	7.71	10.05	12.39	8.86	9.61
IPS Classes	Moderate	Poor	Poor	Moderate	Moderate	Poor	Moderate
%	82	74	74	93	83	90	99

Continuous monitoring of the lagoon complex, including biological monitoring is required to improve water quality. In addition, the existing potential risk to wildlife could be reduced, and human health improved. Protection of the three lagoons from urban and agricultural pollution is necessary. It could be achieved through collecting and treatment of wastewaters, and not discharging directly to the drainage system or the Drini River.

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## **LONG-TERM IMPACTS OF HYDROPOWER DAMS ON COASTAL ENVIRONMENT- LESSONS LEARNED FROM DRINI RIVER**

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### **ABSTRACT**

GIS and satellite imagery analysis were used for the investigation of the long-term coastal dynamics in Drini-Lezha and Drini-Buna rivers, influenced by hydropower (HP) activity upstream of Drini River. Coastal habitats and riverine ecosystems of Drini-Buna and Drini-Lezha were mapped and classified based on their dynamics (1960 to 2014) when the HPs were constructed. The drastic changes of river flow and sediment regime have had an impact on the coastline dynamic, downstream river morphology, coastal habitat structure and quality. The progradation of both river deltas has stopped and the fronts have receded about 660m in Drini-Buna, and 604m in Drini-Lezha, with the island of “Franc Joseph” disappearing in the process. River length of main Buna and Drini-Lezha rivers have decreased as well. With a sedimentation budget several times lower than prior to HP construction, both deltas have become more susceptible to coastal erosion. The reduced river flow has led to the entrapment of fine sediments along the riverbanks which resulted in an increasingly narrower riverbed on both Buna delta river branches and Drini-Lezha River. Coastal habitats (dunes, estuaries, halophytic and brackish marshes, coastal lagoons) shrunk in their surface area, dunes being the most affected, losing 982 ha or 63% of their total surface between 1960 and 2014 in the Buna delta, and 123ha in the Drini-Lezha delta. Coastal erosion and narrowing of riverbeds have led to an increased incidence of floods with further socio-economic implications. Ecosystem resilience to climate change has decreased and flood prevention and management costs have increased. Reductions in size and quality of coastal lagoons and other wetland habitats have resulted in loss of species biodiversity, particularly in breeding colonial water birds. These changes have affected the ecotourism and recreational values of both deltas. All these adverse impacts and their associated costs not been taken into account during decision making, and the lack of cost-benefit analysis could affect HP development in other rivers of Albania as well, including Vjosa.

**Keywords:** GIS, Drini river deltas, HPP, coastal erosion, digital mapping, habitat dynamics

## 1. INTRODUCTION

The first HP dam in the Drini River watershed was built in 1971 at Vau i Dejes. Later on, three other dams were built upstream. Consequently, the majority of sediments produced within the Drini River watershed since 1971 have been trapped inside the HP dams, creating a negative budget of sediments discharged into the coastal area, causing an ongoing intensive coastal erosion in both river deltas (Bego *et al*, 2012; Le Tissier, 2013).

The effects of hydropower dams built along the rivers on the plain coastal dynamics have been documented by many authors worldwide (Collier *et al*, 1996; Milliman, 1997; Rosenberg *et al.*, 1997 and 2000; Kowalewski *et al*, 2000; Sahagian, 2000). Hydropower dams and reservoirs trap sediments that in natural river's water regime are discharged and distributed along the coast, playing a vital role in coastal ecosystem stability and dynamics.

However, obtaining information and data to quantify long term impacts of such upstream interventions on the coastal ecosystem and biodiversity is a challenge for small countries. Remote-sensing has considerable potential as a source of information on the state and pressures on biological diversity and ecosystem services, at multiple spatial and temporal scales (Pettoreli *et al.*, 2014a, b).

Remote sensing here used provides long-term information and data about impact of the construction of hydropower (HP) dams upstream to the state of wetlands and coastal habitats downstream in over 50 years, using Drini River as a case study.

## 2. MATERIALS AND METHODS

### *Study area*

The figure 1 depicts the study area including the downstream section of Drini River and the Buna and Drini delta. Both deltas are created and influenced by the Drini River, the biggest river in Albania, whose watershed is shared among Albania, Montenegro, Kosovo and Macedonia.

The Drini River and its tributaries drain large terrains in the eastern, central and northern parts of Albania and neighboring countries (Montenegro, Kosovo and North Macedonia). The drainage basin comprises a total area of about 14,173 km<sup>2</sup> (Kabo *et al.*, 1990). The catchment basin of the Drini is five times smaller than that of the river Po, but its total annual sediment load has been calculated to be 15x10<sup>6</sup>t/yr (Milliman and Meade, 1983; Milliman and Syvitski, 1992), 20 % greater than that of the Po. Pano *et al.*, (1992) said that

about 50 % of the total freshwater input from all Albanian rivers to the Mediterranean is provided by the rivers Drini and Buna. Milliman and Syvitski (1992) said that Drini River had a very high sediment yield ( $1200 \text{ t/km}^2/\text{yr}$ ) before the diversion measures.



**Fig.2.** Location of the Buna delta and Drini delta (the latter was the delta of Drini River, until 1831, time when Drini river changed its course towards north, joining with Buna River via Drinassa, but not fully abandoning its former river course towards Lezha (Source: Google Earth image of 2011).

The hydraulic regime of the Drini is characterized by occasional floods, caused by a combination of the predominantly torrential river dynamics with snow melt events and the influence of the karstic hydrography. The annual discharge of the Drini is  $12,266 \text{ m}^3/\text{s}$  (Pano and Avdyli 2009). However, due to artificial dredging and re-direction in 1958, only one third of the Drini's total discharge flows through Lezha today. The second distributary, now the main course, is called "Great Drini" (Drini i Madh) or the Drinassa and is connected with the Buna River (Bojana River).

Maps and scientific reports show that the Drini River changed its course and the location of the river mouth many times during history (Uncu 2011).

The flood damage potential of the Drini was partly reduced after drainage measures were introduced in the 1950s. Additionally, three dams were built along the river to harness electricity in the 1970s. These dams created big artificial lakes, with the most prominent being Lake Fierza (73 km<sup>2</sup>). Nowadays, these lakes work as sediment traps – one of the main reasons why the sediment budget of the Drini and Buna delta is now negative.

Important wetlands and coastal habitats of Mediterranean and European Conservation interest are created in the estuarine and littoral zone of Drini's deltas, such as Velipoja and Viluni (Buna delta), and Kune-Vaine (Drini delta). All of them have been identified as Specially Protected Areas (SPA), Important Bird Areas (IBAs) and Emerald Sites, and are an important part of the network of the coastal Protected Areas in Albania.

### *Methods*

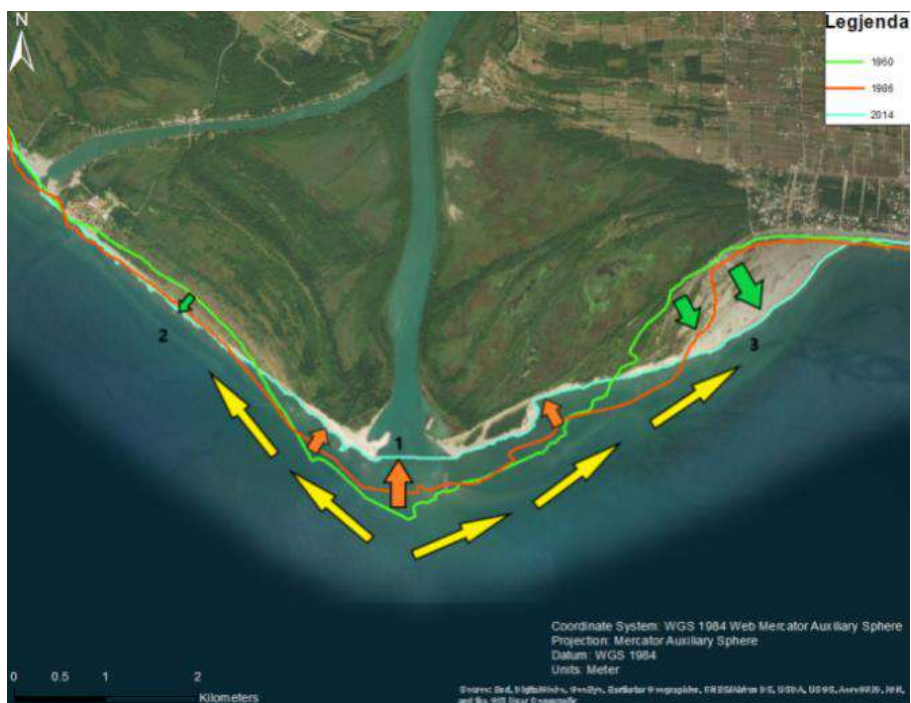
To stabilize the baseline map of the study area and their coastal habitats the oldest topographic maps of scale 1:25.000 of Albania produced by Russian cartographers were used. Those topographic maps are based on the images registered in the '60s, before the construction of the first hydropower dam of Vau i Dejes in 1971 in the lower section of the Drini River. To measure the impact of the HP dams on both deltas of Drini River and their related coastal habitats we have processed the remote sensing imageries for the study areas from 2013 (provided by ESRI).

Digital maps for periods between 1960 – 2013 have been created using ArcMap 10.5, either through digitalization of old pre-existing maps, or through digital mapping based on satellite imagery available on ESRI's database. The study area and habitats found within were mapped and classified according to the Natura 2000 network. For agricultural lands and human settlements, we used identification codes in accordance with the EUNIS system for habitat classification. Furthermore, to assess the riverbank dynamics we measured the riverbed width over the years using remote sensing. Similarly, habitat dynamics over the study period were monitored using a combination of field surveys and remotely sensed information such as habitat surface area, composition, natural shifts and transformation. Field surveys have also been conducted for ground truthing and habitat classification purposes, in both Drini-Buna and Drini-Lezha deltas.

## **3. Results and Discussions**

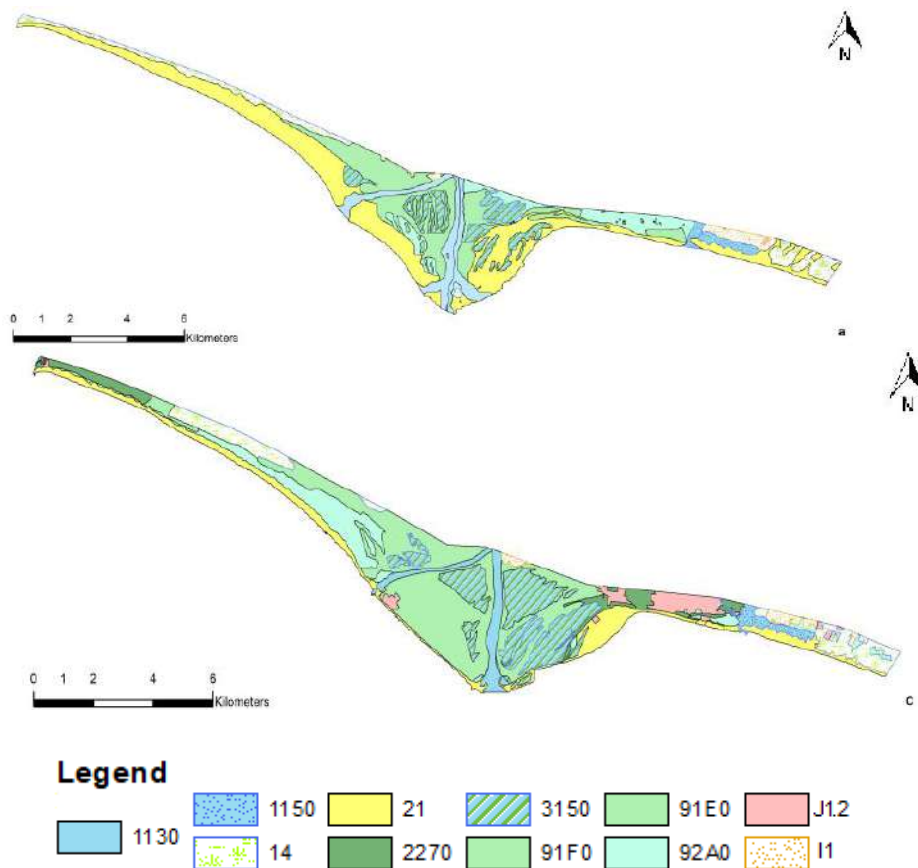
Data analysis shows that the Buna delta has a net gain of 191.8 ha in surface area since 1960. Compared to its progradation in 1900-1960 during which the delta surface area nearly doubled (from 2100ha in 1900 to 4237ha in 1960), there is a clear indication that the construction of hydropower dams

along Drini River in 1971 has disrupted this process. Reduced sedimentation and entrapment of sediment have exacerbated the intensity of coastal erosion in the Buna delta (Bego et al, 2012; Le Tissier, 2013; Faloutsos et. al. 2015), as well as Drini-Lezha delta (Boçi, 1994; Ciavola *et al.*, 1995; Gjijnuri, 1995; Simeoni *et al.*, 1997; Mathers *et al.*, 1999; Fouache *et al.*, 2001, 2010; Pano *et al.*, 2003; Meçaj 2005). Consequentially, substantial coastline alterations are evident comparing imagery from the 1960-2014 timeperiod (Figure 2 and 3). In the last three decades, coastal erosion has led to the loss of “Franc Joseph” island, formerly situated at the very front of the Buna Delta (Dhora, 2017). *Part of the eroded material from the front of the delta gets redistributed along the shoreline, gradually leading to the flattening of the entire delta.*



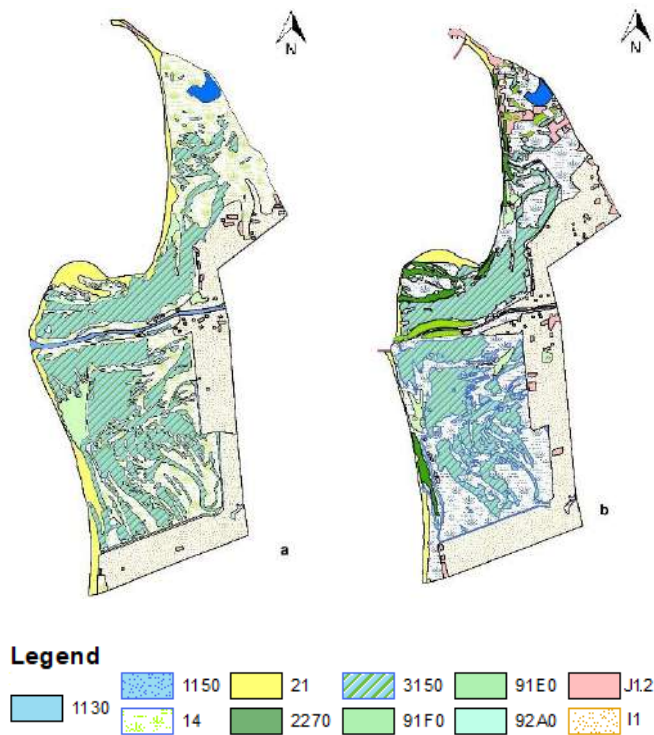


forests with a noted increase in surface area in Buna, mostly due to them replacing other types of habitats. However, the Drin-Lezha alluvial forests have a decrease in surface area.



**Fig.4:** The habitat map of Buna Delta of 1960 (a) and 2014 (c).

Codes refer to habitats as follows: **1130**- Estuaries, **1150**- Coastal lagoons **14**- Mediterranean Salt Marshes, **21**- Sand Dunes, **2270**- Wooded dunes with *Pinus pinea*, **3150**- Natural eutrophic lakes, **91F0**- Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmus minor*), **91E0**- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicionalbae), **92A0**- *Salix alba* and *Populus alba* galleries, **J1.2**- Residential buildings of villages and urban peripheries, **I1**- Arable land and market gardens



**Fig.5:** Drini-Lezha Delta habitat map of 1960(a) and 2013(b).

Codes refer to habitats as follows: **1130**- Estuaries, **1150**- Coastal lagoons **14**- Mediterranean Salt Marshes, **21**- Sand Dunes, **2270**- Wooded dunes with *Pinus pinea*, **3150**- Natural eutrophic lakes, **91F0**- Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmion minoris*), **91E0**- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicetion albae*), **92A0**- *Salix alba* and *Populus alba* galleries, **J1.2**- Residential buildings of villages and urban peripheries, **I1**- Arable land and market gardens.

In 1960 human settlements took up an average of 7.07ha (0.1% of the total area in the study zones), growing over 200 ha in 2014 and continuing on an exponential upward trend. This is an added pressure to natural coastal habitats which are already being negatively impacted by coastal erosion.

In both deltas, the riverbank noted a decrease in average width since 1971, after the construction of “Vau i Dejes” HP dam, as shown in Table 1. This increased the risk and incidence of floods, adding severe economic setbacks to the list of negative impacts of hydropower plants have caused.

**Table 1.** Riverbank width for both deltas in the river section leading to the delta mouth

Delta / Average riverbank width	1960	2014
Buna (West Branch)	190.56m	154.63m
Buna (East Branch)	505.82m	348.19m
Drin- Lezha	75.15m	40.36m

Both Drini-Lezha and Drini-Buna deltas are currently found in a state of degradation. Their once characteristic shovel-shaped deltas have been gradually getting flatter under the effect of intensive coastal erosion, with a negative sediment budget and an entirely halted progradation. Comparing the rate of progradation of both deltas before and after the construction of HPPs along upstream Drini river in 1971, it is evident there is an undeniable correlation between these events. The Buna delta front has receded by ca. 750m, an annual average of 13m since 1960. Likewise, in Drin-Lezha delta front has receded by ca. 660m, an annual average of 12m since 1960. Sand dunes, coastal lagoons, alluvial forests are among the most affected habitats in both deltas, being subject to coastal erosion, natural succession, eutrophication, as well as urbanization and tourism development. Many coastal habitats have been replaced and lost, or altered to accommodate the ever-increasing human presence in the areas.

*Not only there have been substantial losses in habitats and alterations of the coastal ecosystem, but also the resilience to climate change and carrying capacity of the ecosystem as a whole has been reduced as proved by the drastic decline of colonial water bird populations over the years in Kune-Vaini lagoon complex (from a colony counting 2000-2500 breeding pairs in the 1950s, to a colony counting only 420-600 breeding pairs in 2020) (Selgjakaj 2020; Selgjakaj and Bego 2021).*

#### 4. SUGGESTIONS AND RECOMMENDATIONS

The information here provided is a means to address the conservation of other parts of the Albania's coast that are expected to be impacted by other HP dams in a near future in other rivers' watersheds. Conservation of the coastal wetlands and their biodiversity is of an exceptional ecological, social and economic importance. Albania is committed to protecting and enhancing the conservation of the coastal wetlands and their related biodiversity due to the various international conventions that have been signed or ratified. *Acknowledging the adverse impacts of extensive and unsustainable*

*hydropower project development and the lessons learnt from the Drini River case are critical.*

*Delta degradation following hydropower plant construction upstream is inevitable. Although remediation is possible and necessary for Drini River, it is not cost effective at this stage, because constant efforts are required to improve the sedimentation load downstream. Consequently, holistic approach adopting sustainable development standards, exploring alternative renewable energy sources to avoid the same mistakes with other rivers in Albania, specifically with Vjosa River would be vital.*

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## COPEPODS FROM KUNE-VAINI LAGOONS, A TAXONOMIC AND ECOLOGICAL VIEW

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### ABSTRACT

In this paper, we present data on copepod taxonomy and ecology of the Kune-Vaini lagoon system, as one of the main zooplankton taxa. Sampling was carried from July 2018 to July 2019, on bimonthly bases. The samples were collected in five stations, using a planktonic net (mesh size – 50  $\mu\text{m}$  and mouth diameter – 25 cm) and Ruttner bottle (2 L). In each station, there were applied two sampling methodologies: a) filtering 6 liters of water using the Ruttner bottle and planktonic net for the quantitative analyses; and b) horizontal and vertical tows of the net for qualitative analyses. The biological material was preserved in formaldehyde 4%, and examinations were carried out using the Stereo microscope OLYMPUS CZX9 and Inverted Microscope OPTICA. Copepods (Arthropoda) were most represented in taxa in zooplankton (13 species). The most represented order was Harpacticoida, with *Euterpina acutifrons*, *Microsetella norvegica*, *Harpacticus gracilis*, *Canuella perplexa* and *Metis* sp. The Order Calanoida was represented by *Paracartialati setosa*, *Paracalanus parvus*, *Acartia clausi* and *Acartia* sp. The Order Cyclopoida was represented by *Oithona nana*, *Oithona similis*, as well as *Ergasilus* sp. and *Cyclops* sp. Density values of copepods range from 8.8 ind./L to 1252.2 ind./L throughout the sampling months. Of the total abundance, nauplii larvae occupy more than 90% of the total number of counted individuals. The annual trend of population dynamics shows the highest peak in March for Ceka and Zaje lagoons with 283.4 ind./L and 940.8 ind./L, respectively; meanwhile in Merxhani the highest density (124.8 ind./L) was observed in July 2018.

**Keywords:** copepods, Kune-Vaini lagoons, taxonomy, abundance, population dynamics

## 1. INTRODUCTION

Lagoons are areas of high biological diversity and productivity (Mitsch and Gosselink, 2000). They are important for many biochemical processes, provide key ecosystem services, and are vital nursery areas (Basset and Abbiati 2004; Barnes *et al.*, 2013.).

Changes within the circulation patterns of water and land fluctuations (e.g. rivers, sewage flow) make these systems extremely variable (Walsh, 1988). Dynamics of the populations may be the result of this variability. For example, the planktonic forms, which thrive in coastal systems, and can hide the underlying patterns of seasonality abundance and biomass of organisms (Calbet *et al.*, 2001).

In Albania, lagoons constitute very important habitats in terms of biological diversity and other services they provide. The Kune-Vaini lagoon complex is located in the northern part of Albania and belongs to the network of protected areas of the country. It is one of the most vulnerable system in terms of climate change, impacts, and the most affected. Closure of the communication channels with the sea is one of the biggest problems facing the lagoons. It results in less communication with the sea and consequently reduced the impact of the sea on the lagoons. As a result, salinity decreases and other physical-chemical parameters change, which greatly influences the biological communities of the lagoons.

The production of copepods in any natural water body is equivalent to secondary producers, as most of them are main consumers of phytoplankton. Copepods affect phytoplankton gatherings by selectively grazing by food size (Chen *et al.*, 2017, Nejstgaard *et al.*, 2001; Calbet and Saiz 2005; Sherr and Sherr 2007; Calbet,2008).

Copepods are usually more numerous than other zooplankton groups, both in number and variety. They, on the other hand, contribute significantly to the food chain of many carnivores. Some fish depend mainly on the abundance of copepods, especially calanoids (Cushing, 1953; Cushing and Burd, 1957; Wimpenny, 1966; El-Rashidi, 1987).

Studies of zooplankton in Albania have been sporadic and have mainly aimed at determining species composition. This is the first study of copepods, and zooplankton, in Kune-Vaini lagoons, supported by the project “*Building the resilience of Kune-Vaini lagoons through Ecosystem-based Adaptation (Eba)*”. Besides the zooplankton, carried out by us, there were also assessed in parallel the phytoplankton, the macrophytes and the physico-chemical parameters, nutrients and photosynthetic pigments.

Knowledge of zooplankton, especially copepods helps to understand and explain the state of the food webs, and further on the state of fish stocks. Due

to their small size and short life cycle, the zooplankton community is highly sensitive to environmental stresses, reflected in changes in their biomass and community. Such changes modify the links in food webs, and affect the survival of species of higher trophic levels (Richardson 2008; Taylor *et al.*, 2002; etc.).

## 2. MATERIALS AND METHODS

The study covered the whole area of Kune-Vaini lagoon complex, located in both sides of Drini Delta in Lezha, in the north-western part of the Albanian coast. It consists of the lagoons of Merxhani and Kenalla in Kune (Northern part of Delta), and Ceka and Zaje in Vaini (Southern part of Delta). The lagoon complex was formed by accumulated sediments from the Drini and Mati rivers.

Merxhani Lagoon is the most important water body, with a surface of 2.5 km<sup>2</sup>, a mean and maximum depth of 0.75 m and 1.3 m, respectively. Communication channel of the lagoon with the sea is 500 m long, 0-70 m wide and 1-2 m deep. Ceka and Zaje Lagoons are the most important water bodies of the Vaini wetland (surface of 8.5 km<sup>2</sup>). The mean depth is about 0.7 m with a maximum of 1.3 m. A land belt separates the two lagoons. Ceka communicates with the sea through a communication channel 1.5 km long (Miho *et al.*, 2013).

Zooplankton monitoring was carried out bimonthly at five stations (Fig. 1) from July 2018 to July 2019. Three stations were in Ceka, and only one station in Zaje and Merxhani, respectively, representing relatively well each water body. Sampling was performed simultaneously, at all 5 stations at regular time intervals between the sampling periods.

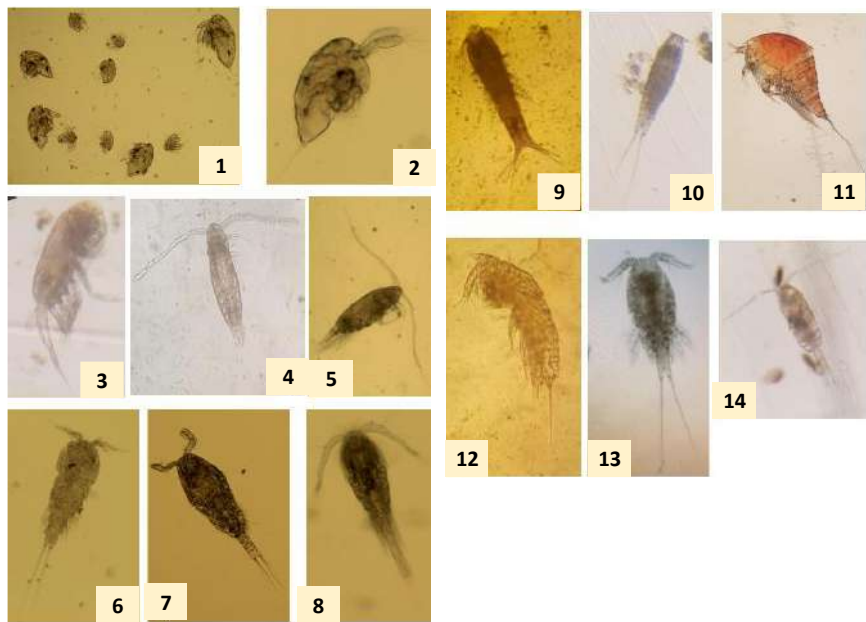
Sampling was carried out using a standard plankton net (mesh size 55 µm) and Ruttner bottle (2 L). For the qualitative and quantitative assessment, two sampling modes were combined: i) Vertical and horizontal tows of the net from the boat; ii) Sampling with Ruttner bottle for quantitative assessment. In each station, a total of 6 liters of water was filtered using the planktonic net. The samples were soon fixed in 4% formaldehyde solution. Copepods were identified down to their species and genus level using an Inverted Microscope OPTICA; the counting was done using the Stereomicroscope OLYMPUS, using the literature of Trégouboff and Rose (1957), Carli and Crisafi (1983), etc.



**Fig. 1.** The sampling stations in Kune-Vaini lagoons, Lezha, Albania.

### 3. RESULTS AND DISCUSSIONS

The complete zooplankton data (list of species, abundance and plates with microscopic photos) can be found in Lika (2019). Only data on copepods, taxonomy and ecology, will be discussed in this paper, as one of the main zooplankton taxa in Kune-Vaini lagoons. They were represented by 3 orders: calanoids, cyclopoids and harpacticoids. Calanoids are exclusively planktonic; four taxa were observed: *Paracartialia setosa*, *Paracalanus parvus*, *Acartia clausi* and *Acartia* sp. Harpacticoids, which are tychoplanktonic (Kennish, 2001), was the most represented order in the samples, represented by: *Euterpina acutifrons*, *Microsetella norvegica*, *Harpacticus gracilis*, *Canuella perplexa* and *Metis* sp. The third order of Cyclopoida was represented by *Oithona nana*, *O. similis*, as well as *Ergasilus* sp. and *Cyclops* sp. Ceka lagoon showed the highest diversity, with 11 species; 10 species were found in Merxhani Lagoon with and 7 species Zaje Lagoon (Tab. 1). Some microscopic photos are reported in figure 2, and their presence in each lagoon are given in Table 1.



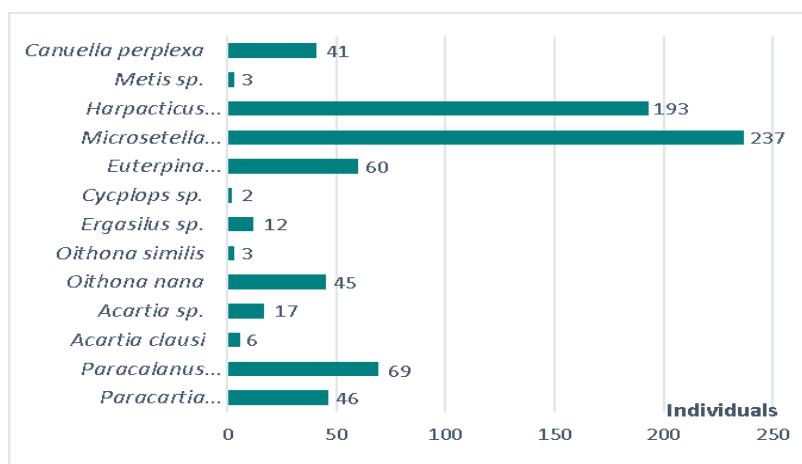
**Fig. 2.** Copepods from Kune-Vaini Lagoons. 1-2, larva nauplius; 3, *Paracalanus parvus*; 4, *Paracartiatati setosa*; 5, *Acartia* sp.; 6, *Harpacticus gracilis*; 7, *Ergasilus* sp.; 8, *Oithonanana*; 9, *Canuela perplexa*; 10, *Microsetellanorvegica*; 11, *Metis* sp.; 12, *Euterpina acutifrons*; 13, *Cyclops* sp.; 14, *Calanoid* sp.

**Tab. 1.** Presence of copepod speciesin Kune-Vainlagoons (“+”present; “-”absent).

<i>Species scientific name</i>	Lagoon	2018			2019			
		Jul.	Sep.	Nov.	Jan.	Mar.	May	Jul.
<i>Paracartiatati setosa</i> (Krichagin, 1873)	Ceka	-	-	-	-	-	-	-
	Merxhani	+	-	-	-	+	-	-
	Zaje	-	-	-	-	-	-	-
<i>Paracalanus parvus</i> (Claus, 1863)	Ceka	+	-	-	-	+	+	-
	Merxhani	+	+	-	-	+	-	-
	Zaje	-	-	-	-	+	-	-
<i>Acarti aclausi</i> (Giesbrecht, 1889)	Ceka	+	+	-	-	-	-	-
	Merxhani	+	-	-	-	+	-	-
	Zaje	-	-	-	-	+	-	-
<i>Acartia</i> sp.	Ceka	-	-	-	-	+	-	+
	Merxhani	-	-	-	-	+	-	+
	Zaje	-	-	-	-	+	-	-
<i>Oithona nana</i> (Giesbrecht, 1893),	Ceka	+	+	+	+	-	-	-
	Merxhani	+	-	-	+	+	-	+
	Zaje	-	-	-	-	-	-	-

<i>Species scientific name</i>	Lagoon	2018			2019			
		Jul.	Sep.	Nov.	Jan.	Mar.	May	Jul.
<i>Oithona similis</i> (Claus, 1866)	Ceka	-	+	-	-	-	-	-
	Merxhani	-	-	-	+	-	-	-
	Zaje	-	-	-	-	-	-	-
<i>Ergasilus sp.</i>	Ceka	-	-	+	-	-	-	-
	Merxhani	+	-	-	-	-	-	-
	Zaje	-	-	-	-	-	-	-
<i>Cyclops sp.</i>	Ceka	+	-	-	-	-	-	+
	Merxhani	-	-	-	-	-	-	-
	Zaje	-	-	-	-	-	-	-
<i>Euterpina acutifrons</i> (Dana, 1847)	Ceka	+	+	+	+	+	-	+
	Merxhani	+	+	-	+	+	+	-
	Zaje	-	-	-	-	-	-	-
<i>Microsetella norvegica</i> (Boeck, 1865)	Ceka	+	-	-	-	-	-	+
	Merxhani	-	-	-	-	+	-	-
	Zaje	+	-	-	-	-	-	-
<i>Harpacticus gracilis</i> (Claus, 1863)	Ceka	-	-	-	-	-	-	+
	Merxhani	-	-	-	-	+	+	+
	Zaje	-	-	-	-	+	-	-
<i>Metis sp.</i>	Ceka	-	-	-	-	-	-	-
	Merxhani	-	-	-	-	-	-	-
	Zaje	-	-	-	-	-	+	-
<i>Canuella perplexa</i> (Scott T. & Scott A., 1893)	Ceka	+	+	-	-	+	-	+
	Merxhani	+	-	-	-	+	-	-
	Zaje	+	-	+	+	-	+	+
<i>Nauplii</i>	Ceka	+	+	+	+	+	+	+
	Merxhani	+	+	+	+	+	+	+
	Zaje	+	+	+	+	+	+	+

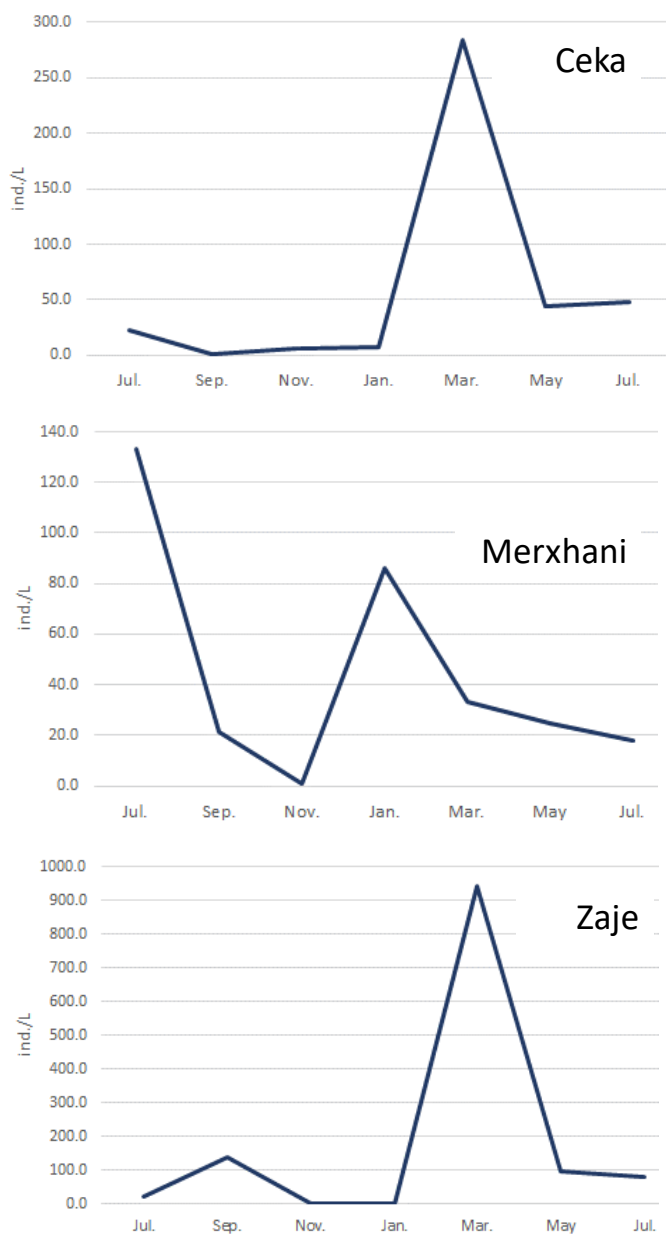
Ca. 17,391 individuals were counted during all sampling period in all the stations; 16,657 individuals belonged to nauplii larvae (96%). They were present in samples throughout the sampling period at all stations (Tab. 1). The harpacticoids *M. norvegica* and *H. gracilis* showed the highest abundance, respectively 237 and 193 individuals, followed by *P. parvus* with 69 individuals (Fig.3).



**Fig. 3.** Average abundance of copepod taxa in Kune-Vain lagoons.

The annual trend of copepods in the three lagoons is reported in Fig. 4, nauplii larvae, are the main drivers of the overall performance. In the Ceka Lagoon, the highest density was in spring, March 2019 (283.4 ind./L); the peak of larval density was up to 278.6 ind./L. In the Merxhani Lagoon, the highest peaks were in July 2018 (124.5 ind./L) and January 2019 (85.2 ind./L); the same pattern was observed for the density of nauplii larvae, respectively 122.5 ind./L in July 2018 and 83.8 ind./L in January 2019. In the Zaje Lagoon, were observed two peaks, respectively in spring (March 2019) and a smaller one in autumn (September 2018), respectively 940.8 ind./L and 138 ind./L. Nauplii larvae seemed to be determinant, reaching the highest density in March 2019 and September 2018, respectively 916.7 ind./L and 138 ind./L.

The copepods dynamics during all sampling months, in the three lagoons, were compared with the values of some chemical parameters presented by Muçaj (2019), shown in the Tab. 2. This study was performed at the same time, same stations and same frequency as the study of zooplankton (copepods).



**Fig. 4.** The annual trend of copepods in the three Lezha lagoons.

**Tab. 2.** Temperature, salinity and copepod density data at the three Lezha lagoons (data from Muçaj, 2019).

Month	Lagoons	Temperature (° C)	Salinity (‰)	Copepods density (ind./L)
July 2018	Ceka	28.5		22.9
	Merxhani	28.1		133.3
	Zaje	28		22.2
September 2018	Ceka	27.1	23.9	1.7
	Merxhani	26.2	40.2	21.3
	Zaje	24.2	14.2	138.0
November 2018	Ceka	13.3	34.2	6.4
	Merxhani	11.4	41	1.2
	Zaje	13	18.4	1.2
January 2019	Ceka	1.0	19.5	6.9
	Merxhani	4.0	25.2	86.2
	Zaje	3.0	13.3	1.8
March 2019	Ceka	16.0	17.9	238.4
	Merxhani	15.8	36.8	33.0
	Zaje	15.8	16.1	940.8
May 2019	Ceka	23.1	17.5	43.6
	Merxhani	24.6	30.4	24.5
	Zaje	24.2	8	83.0
July 2019	Ceka	26.4	26.2	47.4
	Merxhani	25.7	37.4	17.7
	Zaje	25.8	13	83.0

Based on water temperature, the copepods density decreased with temperature; 1, 4 and 3°C in January 2019, respectively for Ceka, Merxhani and Zaje lagoons. But, copepods density increases when salinity gets lower values. In Ceka, at a salinity level of 17.8‰ the copepods density reaches the highest peak – 283.4 ind./L (see Fig. 4); in Merxhani, the lowest salinity is met in January (25.2‰), where we have one of the highest values of copepod density (85.2 ind./L). The same was seen in the Zaja Lagoon, where at the

lowest salinity (10‰) in March, we have the highest level of density of copepods (940.8 ind./L).

#### 4. CONCLUSIONS

Copepods in the Kune-Vaini Lagoon Complex were presented by 13 species; 9 were determined at the species level and 4 up to the genus level. Ceka showed the highest diversity, with 11 species; Merxhani with 10 species and Zaje with only 7 species. *M. norvegica* was the most abundant species with 237 individuals counted, followed by *H. gracilis* with 193 individuals and *P. parvus* with 69 individuals.

Copepods in Ceka lagoon showed the highest density in the spring, March 2019 (283.4 ind./L). In the Merxhani lagoon, the highest peaks were reached in July 2018 (124.5 ind./L) and January 2019 (85.2 ind./L). In the Zaje lagoon, copepods reached two peaks, respectively in spring (March 2019) and a smaller one in autumn (September 2018), respectively 940.8 ind./L and 138 ind./L. Nauplii larvae occupied 96% of the total number of copepods counted. They were the main drivers of the overall performance of copepods in the three lagoons.

#### ACKNOWLEDGMENTS

The study was part of the Master Program focused on the ecological approach of the wetland complex, financially supported by the Kune-Vaini Project (<http://kunevain.com>).

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## OBSERVATION OF SHKODRA LAKE WATER QUALITY USING SATELLITE IMAGERY

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### ABSTRACT

Remote sensing imagery was applied to investigate the water quality of the Shkodra Lake. Distribution of phytoplankton, macrophytes, and sediments were calculated using Landsat and MODIS band combinations, and compared with data from *in situ* measurements. The impact of the wind and geomorphology of the area to the circulation of waters in the Lake was investigated as well.

**Keywords:** Shkodra Lake, remote sensing, Landsat, MODIS, water quality

### 1. INTRODUCTION

Shkodra Lake is the largest lake in the Balkans with a surface area of 350-500 km<sup>2</sup> and a maximum depth of 8.3m. The main water supplier is Moraca River, with 63% of the total, and a large number of karstic springs (crypto-depressions), some of which are up to 60 m deep. Morača River also brings approximately 50,000 tons of suspended matter to the lake. The lake discharges through the Buna River to the Adriatic Sea with an average amount of 300 m<sup>3</sup>/s.

Shkodra Lake is characterized by highly developed submerge and emergent vegetation and a rich flora and fauna with high endemism. As it is rich in biodiversity, the lake was proclaimed National Park (Montenegrin part), while the Albanian part was proclaimed a "Managed Natural Reserve" or IUCN Category IV (Dhora 2017).

Water quality is a continuous concern, as it is related to human's activities, like fishery, tourism, industry, etc.

The biodiversity and water quality of Skadar/Shkodra Lake are threatened by various forms of economic activities such as tourism and fishery in the lake as well as agriculture and industry in the lake water basin. Shkodra Lake is one of the hot-spots regarding the ecological status and biodiversity. Its aquatic ecosystem, water contamination have been continuously monitored and studied in addition of air pollution (Mezler, 1999; Hollert *et al.*, 2004; GIZ, 2005; Rakaj *et al.*, 2000; 2009; Rakaj, *et al.*, 2006; Dhora and Rakaj, 2010; Frasheri *et al.*, 2010; Mandija *et al.*, 2010; Neziri *et al.*, 2011; Malollari *et al.*, 2012; Neziri, 2012; Rakaj, 2012; Rakocevic 2013; Alushi and Abdija, 2014; Bektashi and Cupi, 2014; Frasheri *et al.*, 2014; Mandija, 2013; 2015; Bushati and Neziri, 2016; Dhora *et al.*, 2016; Dhora, 2017; Năpăruș-Aljančić *et al.*, 2018).

During different seasonal periods, as a result of heavy rains and winds blowing from the north and south at speeds up to 6 m/s, lake waters are often disturbed by high concentrations of suspended matter, up to 50 g/m<sup>3</sup> and chlorophyll a concentration (about 10 mg/m<sup>3</sup>) in the middle of the lake and more than 15 mg/m<sup>3</sup> along the southeast coast. These recurring events occasionally form cyclonic circulation (counterclockwise) in the middle of the lake (Kostianoy *et al.*, 2018).

During the last decade, direct/indirect remote sensing techniques have also been utilized in order to have a clear picture in a large scale of this basin and surrounding areas.

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object, in contrast to in situ or on-site observation. Nowadays, it is used in numerous fields, including geography, land surveying and most Earth science disciplines (for example, hydrology, ecology, meteorology, oceanography, glaciology, geology); it also has military, intelligence, commercial, economic, planning, and humanitarian applications, among others. Remote sensing observations provide data and images at different spatial scales (Frasheri *et al.*, 2010a,b; Frasheri *et al.*, 2014; Kostianoy *et al.*, 2018; Mandija *et al.*, 2019). It is not time-consuming like *in-situ* measurements and it covers also the areas uncovered by field-based observations.

## 2. MATERIALS AND METHODS

Satellite imagery is used to evaluate the quality of ground water surfaces, including water turbidity, biomass (chlorophyll-a concentration), sediments, and lake surface roughness. Landsat 8 images was employed for the analysis of Shkodra Lake waters.

The water parameters such are phytoplankton, macrophytes, sediments, etc. are investigated using different satellite image band combinations; B4: B3: B2, B4: B3/B1, B2-B1 (enhanced), B2:B2, NDVI and NDWI (Mc Feeters, 2013; Gholizadeh 2016; Serrano *et al.*, 2018; Avdan *et al.*, 2019; Elhag *et al.*, 2019); where bands used are: B1 – water aerosols, B2 – Blue, B3 – Green, B4 – Red, B5 – NIR, B6 – SW1, B7 - SW2.

Image results were compared with data from field work done in 2014. Landsat images are obtained from USGS repository (<https://earthexplorer.usgs.gov/>) for dates 26-08-2013, 27-04-2014 and 28/08/2014.

Additional remote sensing data were collected using NASA's Earth Observing System Data and Information System EOSDIS. GIOVANNI portal provides data mad maps of the wind components (MERRA-2 Model M2T1NXFLX v5.12.4), absorption coefficient of non-algal material and phytoplankton (MODIS-Aqua\_L3m\_IOP\_8d\_4km v2018).

Field work was done for Chlorophyll a (Phytoplankton-Chl a) in 26/08/2013 and 27/04/2014 in depths of 3m-4m using a black glass bottles 1l (Rakocevic 2013); and for aquatic vegetation (Macrophytes) in 20/08/2014, by transect method in depths of 3m-4m using a bout and Double-sided Luther-rake with soft rope depth marked (Wetzel & Likens 2000) in the three following stations:

1. Sterbeq, 4.5 km from shore, depth 6.7m, coordinates N 42 11' 44" E 19 23' 03"
2. Zogaj, 2.3 km from shore, depth 5.5m, coordinates N 42, 04' 22.6" E 19 24' 13.9"
3. Shiroke, 2.2 km from shore, depth 4.6m, coordinates N 42 03' 41" E 19, 27' 13.9"

The temperature, depth and transparency of water were measured in advance by Disc Sechi.

All parameters were analyzed applying standard methods (Sartory and Grobbelaar 1984; Melzer, 1999), while the trophic state index (TSISD, TSI-CHLa) was calculated based on (Carlson 1977).

### 3. RESULTS AND DISCUSSIONS

#### 3.1 Field-based observations

Table 1 reports about the transparency, chlorophyll *a* and macrophytes content for all the three stations.

**Table 1:** Analyzed data for three stations: Sterbeq, Zogaj and Shiroke

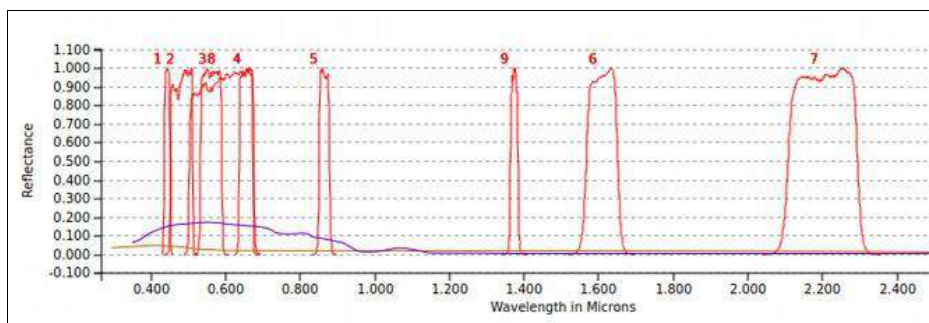
Nr	Stations	Transparency	Chlorophyll <i>a</i>	(TSI-SD)	(TSI-CHLa)	MI (macrophytes) 30/08/2014
		26/08/2013 and 27/04/2014				
1.	Sterbeq	2.8	3.17 2.70	42.51 36.31	41.64 37.53	3.66
2.	Zogaj	3.1	3.19 2.90	43.75 38.84	40.86 40.16	3.87
3.	Shiroke	2.6	2.97 2.60	41.67 36.87	42.61 38.63	3.84
RSD (%)		8.9	8.2	7.7	4.7	3.0

The results did not report any significant difference among the three stations. The relative standard deviation (RSD) was used for the dispersibility of values of water parameters.

$$RSD = \frac{1}{\bar{x}} \sum \frac{1}{N-1} (x_i - \bar{x})^2 \quad (1)$$

The result reported that RSD is lower than 10% for transparency, chlorophyll, TSI-SD, TSI-CHLa and MI, respectively, i.e. the stations do not differ from one another with regard to water properties.

Reflectance of turbid waters is higher in visible bands B1 – B5, compared with the reflectance of clear waters (Figure 1):

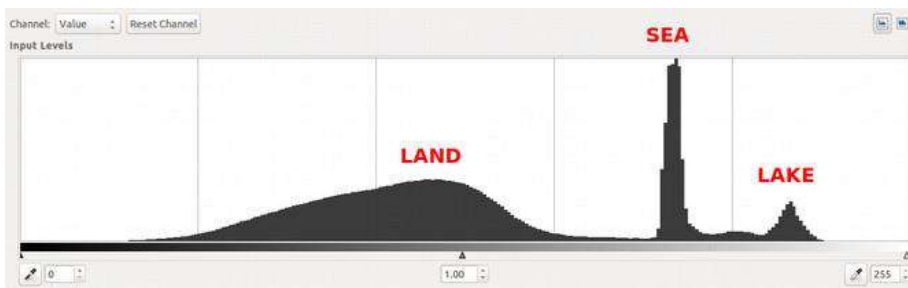


**Fig.1:** Reflectance of water: magenta ~ turbid, brown ~ clear waters (source USGS).

### 3.2 Satellite-based observations

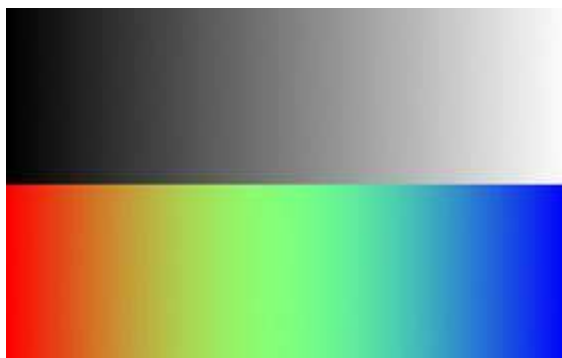
#### 3.2.1 Landsat products

Histograms of gray scale images are two and three-modal, which separates land pixels from water pixels, in part of cases even sea pixels from lake pixels. Enhancing of false color images for separation of water proprieties are based in modes of histograms as in Figure 2:



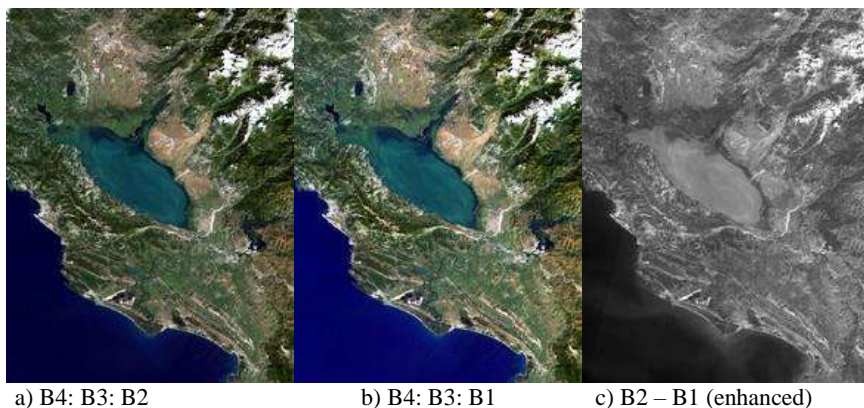
**Fig.2:** Separation land pixels from water ones based on typical histograms

Color coding for gray scale images is made using the palette in the Figure 3:



**Fig.3:** False color palette compared with the grayscale.

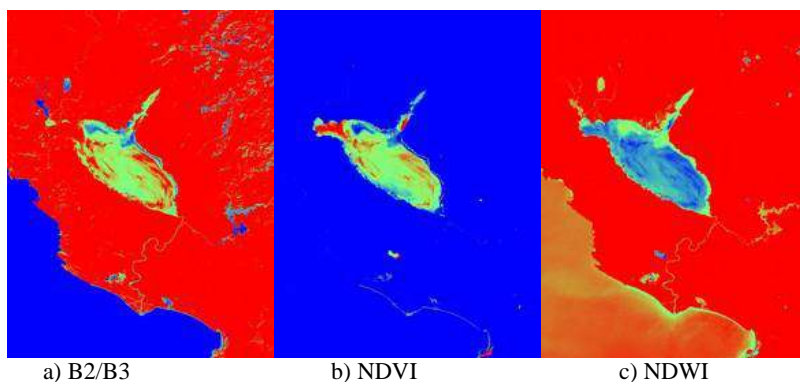
Satellite images of 28/08/2014 were the best from the cloud coverage point of view, relative to measures of Macrophytes in 30/08/2014. The view of Lake in natural colors with band combination B4: B3: B2, false color combination B4: B3: B1 as RGB, and enhanced difference B2–B1 are given in Fig. 4:



**Fig.4:** natural colors and impact of band B1.

The natural color reflectance of the Lake is dominated by green nuances indicating also the presence of circular flow of waters. Differences between images B4: B3: B2 and B4: B3: B1 are almost invisible except clearer blue color in the Adriatic Sea waters (Fig.4a and b), indicating its clearness compared to Lake waters. Enhanced difference between B2 and B1 in Fig.4c indicates high values for the Lake surface, corresponding with the turbidity of waters; sediments are also visible in the Adriatic Sea around Buna River delta, Great Beach (Ulcinj, Montenegro) and Velipoja.

Combination of Blue/Green bands, difference vegetation index  $NDVI = (NIR-Red)/(NIR+Red)$ , and difference water index  $NDWI = (green-SW2)/(green+SW2)$  are presented in FIG.5:

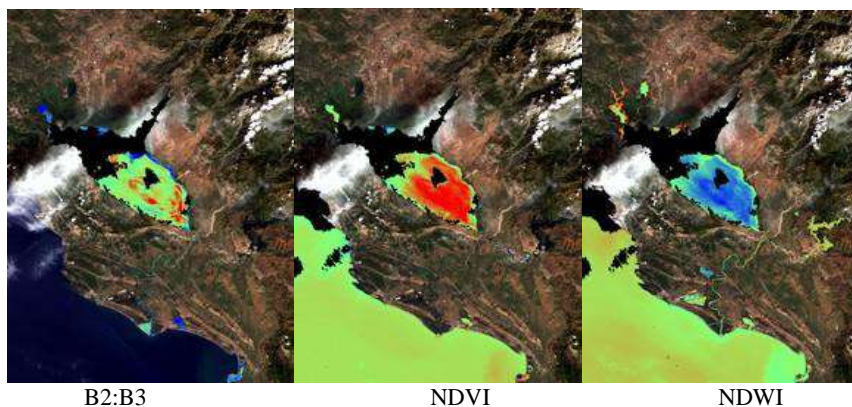


**Fig. 5:** false color band combinations for water quality and chlorophyll.

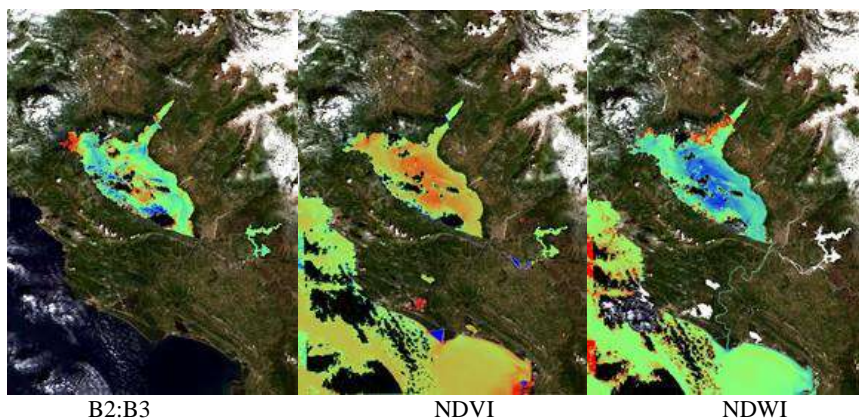
Comparing different reflectance in Green and Blue, the dominance of Green band indicates turbid waters. The status of colors in Fig.5a indicates

high values of the ratio Blue/Green only in northeastern shores of the Lake. The same happens for the normalized difference vegetation index NDVI in Fig.5b. While normalized difference water index NDWI reflects the difference between Green and InfraRed bands, with high values for turbid waters, which is visible in Fig.5c where high values of this index cover most of the Lake surface. Both these figures suggest that the major part of the lake is characterized by high turbid waters. Only the Albanian bridges and Montenegro western littoral reflects a different picture, characterized by clearer waters.

Field values from 30/08/2014 for macrophytes (MI) are lower for Sterbeq (northeast shore of the Lake) compared to the values found in Zogaj and Shiroke (south-east past of the lake). Turbidity of waters with low levels of NDVI indicate presence of sediments and other pollutants not related with chlorophyll.



**Fig.6:** The status of Lake in end of 25 August 2013.



**Fig.7:** The status of Lake in 8 May 2014.

There are some differences between the satellite observations during 25/08/2013 and 08/05/2014 (Fig. 6-7). The ratio bands B2:B3 indicates a more turbid state of the lake during the second date, due to the presence of chlorophyll among others. In addition, NDVI maps indicate more vegetation during 08/05/2014 compared to 25/08/2013.

The images of Figure 6 and 7 show: i) circulation of Lake waters in anti-clock sense, ii) increase of turbidity in central regions of lake, caused water circulation, and iii) low values of NDVI in central areas of the lake.

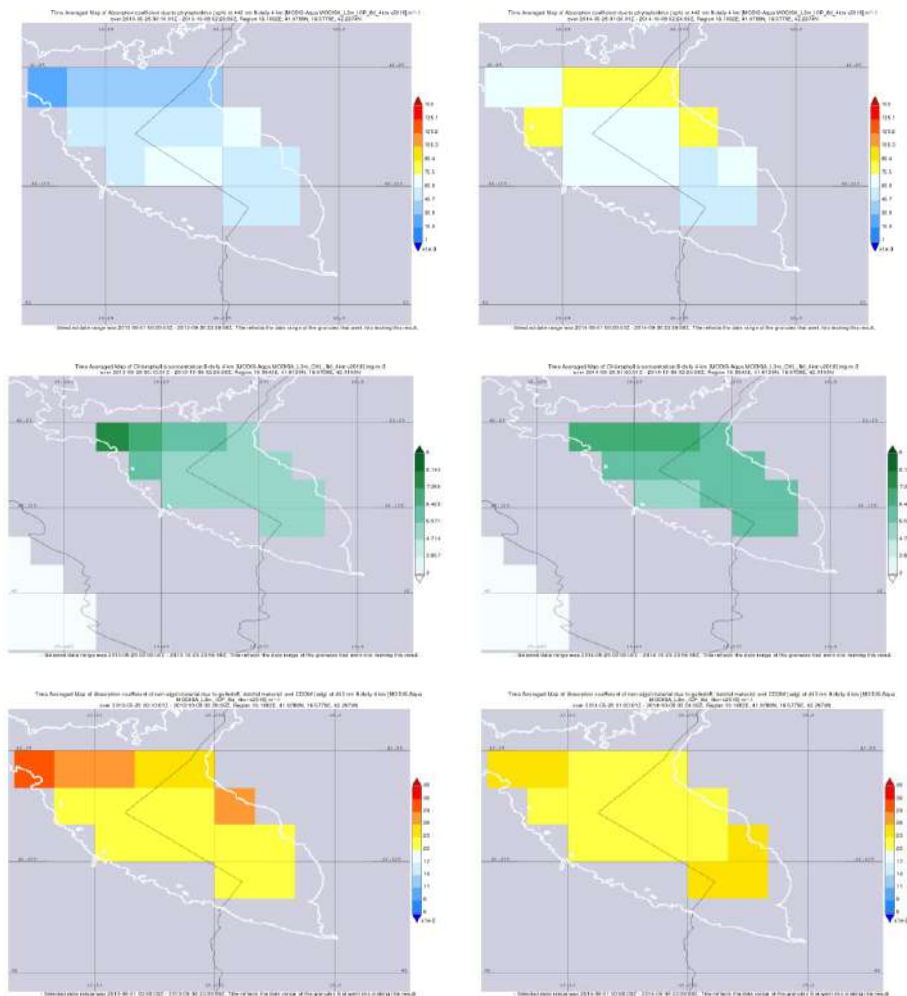
### **3.2.2 MODIS products**

The MODIS-Aqua products given by GIOVANNI platform were used for a detailed information about spatial distribution of the phytoplankton and non-algal materials (due to gelbstoff, detrital material, and CDOM), as well as the chlorophyll concentrations.

Figure 8 depicts the spatial distribution of the averaged phytoplankton, non-algal materials and chlorophyll, as well as the chlorophyll concentrations over the Shkodra Lake during the periods from 25-May to 8-Oct for the two consecutive years, 2013-2014.

Spatial distribution of the absorption coefficients over Shkodra Lake, suggest that phytoplankton has been non-uniformly distributed during these two consecutive years. Meanwhile, during 2013 the maxima was reached over the Sterbeq shore and the central part of the lake, in 2014 even higher values are obtained especially in Sterbeq shore and a fraction of the norther part of the lake.

On the other hand, in 2013, the non-algal material appeared to be more concentrated in the northern part of the lake and in Sterbeq shore, while in 2014 lower concentrations were observed with higher values in separated parts of the lake. Chlorophyll concentrations in these two periods were higher over the northern part of the lake.

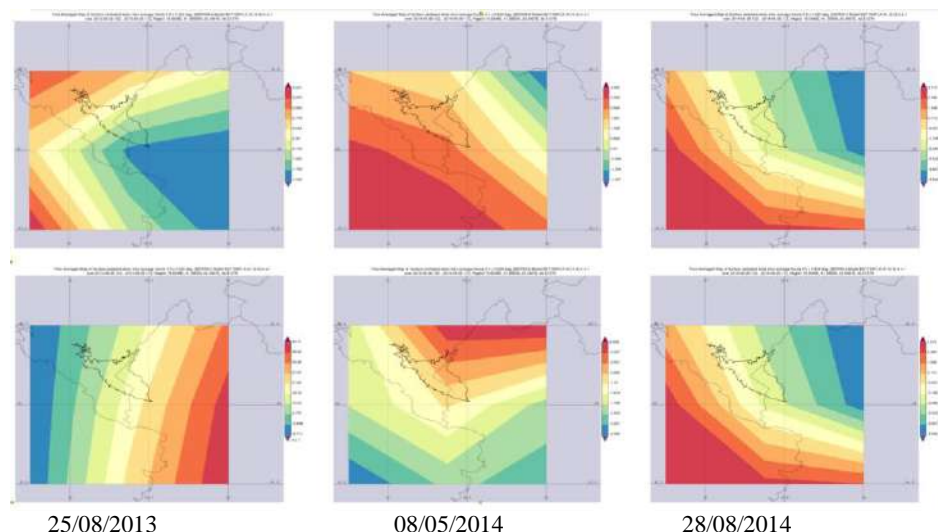


**Fig.8:** GIOVANNI-Time Averaged Map of Absorption coefficient due to phytoplankton (upper panel) and non-algal material due to gelbstoff, detrital material, and CDOM (middle panel) as well as chlorophyll concentrations (lower panel), at 443 nm 8-dayly 4 km [MODIS-Aqua MODISA\_L3m\_IOP\_8d\_4km v2018]. 25/05 - 0808, 2013-2014.

### 3.3 Wind speed analyses

Little is known about currents in Skadar/Shkodra Lake, but due to its shallowness (mean depth  $\approx 5$  m), the wind direction should play a key role in the formation of the circulation patterns in the lake (Kostianoy et al. 2018). We analyzed the surface wind speed to determine which factor contributes in the water circulation in the lake the most. Consequently, the u and v wind components during the satellite observations were averaged. Figure 9 depicts

the maps of northward and eastward winds during 25/08/2013, 08/05/2014 and 28/08/2014.



**Fig.9:** GIOVANNI-Time Averaged Map of Surface northward and eastward wind components. Wind maps over the Shkodra Lake during three days 25/08/2013, 08/05/2014 and 28/08/2014. The upper and lower panels represent northward and eastward winds, respectively, (source NASA's Earth Observing System Data and Information System EOSDIS).

Despite the low wind speed values, the maps in the Fig. 9 suggest an important feature of the wind directions over the lake during this period. The wind directions are inconsistently distributed over the entire lake area. Northward and eastward components are variable over the area, changing even their signs. This fact gives some insights over the water circulation over the lake, observable in the satellite images.

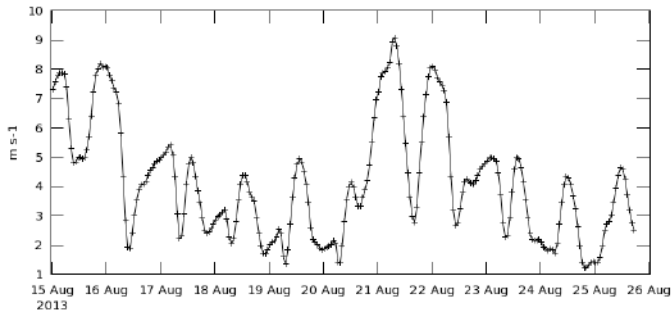
Average values of the wind speed components results are presented in Table 2.

**Table 2.** Wind speed north and east components as well as the total vector over Shkodra Lake for three days; 25/08/2013, 08/05/2014 and 28/08/2014.

Date	Component N	Component E	Total speed	Direction
25/08/2013	2.15	1.60	2.68	NNE
08/05/2014	1.30	-0.80	1.53	NNW
28/08/2014	2.00	-1.15	2.31	NNW

However, daily wind values may not present the whole wind effect on turbidity. Sediments lifted by the wind activity, can remain suspended up to several days. Consequently, time series of the area-averaged of surface wind speed are analyzed. For each of the three days, we have chosen an interval of 10 days prior the satellite imagery was taken. Figure 10 shows the time-series of the total surface wind speed for 10-days period ending at the three satellite-observation dates.

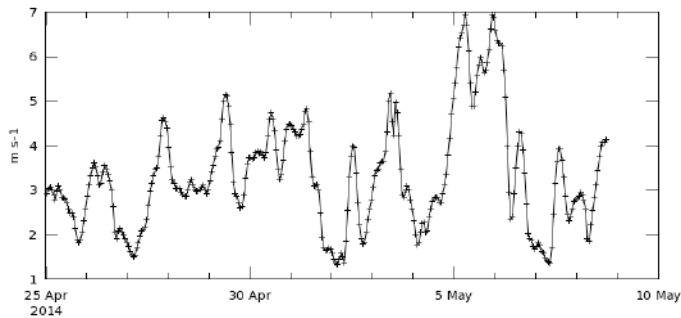
Time Series, Area-Averaged of Surface wind speed, time average hourly  $0.5 \times 0.625$  deg [MERRA-2 Model M2T1NXFLX v5.12.4]  $m\ s^{-1}$  over 2013-08-15 00Z - 2013-08-25 17Z, Region 18.6548E, 41.3855N, 20.3467E, 42.8137N



- The user-selected region was defined by 18.6548E, 41.3855N, 20.3467E, 42.8137N. The data grid also limits the analyzable region to the following bounding points: 18.75E, 41.5N, 20E, 42.5N. This analyzable region indicates the spatial limits of the subsetted granules that went into making this visualization result.

15/08/2013 - 25/08/2013

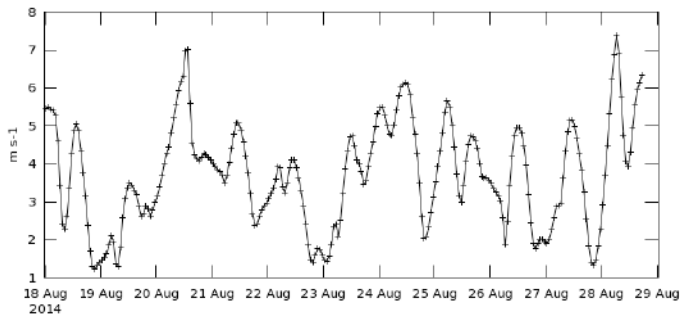
Time Series, Area-Averaged of Surface wind speed, time average hourly  $0.5 \times 0.625$  deg [MERRA-2 Model M2T1NXFLX v5.12.4]  $m\ s^{-1}$  over 2014-04-25 00Z - 2014-05-08 17Z, Region 18.6548E, 41.3855N, 20.3467E, 42.8137N



- The user-selected region was defined by 18.6548E, 41.3855N, 20.3467E, 42.8137N. The data grid also limits the analyzable region to the following bounding points: 18.75E, 41.5N, 20E, 42.5N. This analyzable region indicates the spatial limits of the subsetted granules that went into making this visualization result.

25/4/2014 - 08/05/2014

Time Series, Area-Averaged of Surface wind speed, time average hourly  $0.5 \times 0.625$  deg [MERRA-2 Model M2T1NXFLX v5.12.4]  $\text{m s}^{-1}$  over 2014-08-18 00Z - 2014-08-28 17Z, Region 18.6548E, 41.3855N, 20.3467E, 42.8137N



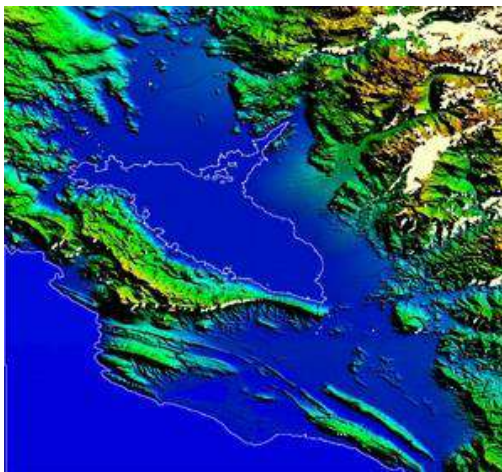
- The user-selected region was defined by 18.6548E, 41.3855N, 20.3467E, 42.8137N. The data grid also limits the analyzable region to the following bounding points: 18.75E, 41.5N, 20E, 42.5N. This analyzable region indicates the spatial limits of the subsetting granules that went into making this visualization result.

18/08/2014 - 28/08/2014

**Fig.10:** Time Series, Area-Averaged of Surface wind speed, time average hourly  $0.5 \times 0.625$  deg. [MERRA-2 Model M2T1NXFLX v5.12.4]  $\text{m s}^{-1}$ , Region 18.6548E, 41.3855N, 20.3467E, 42.8137N (source NASA's Earth Observing System Data and Information System EOSDIS).

Time series in the Figure 9 suggest that wind speed did not exceed the value of  $9 \text{ m/s}$ , during the entire 10-days period prior the satellite images were taken. During the first period, the wind speed reached up to  $8\text{-}9 \text{ m/s}$  during 3-4 days before the satellite image was taken. After that, its values were lower than  $5 \text{ m/s}$ . Similar situation is observed also during the second period, where wind speed reached the peak on  $7 \text{ m/s}$  2-3 days before the satellite image and then decreased lower than  $5 \text{ m/s}$ . Even lower wind speed was observed during the third period. Maximal values reached up to  $5\text{-}6 \text{ m/s}$  during this period.

Shkodra Lake has northwest-to-southeast extension, and is bordered by mountains in southwest shores. This terrain configuration favors winds from north and east with greater speed during southwestern shores, contributing to water circular observed in satellite images (Fig. 11).



**Fig.11:** SRTM digital terrain model of Shkodra Lake area (source USGS).

All these wind speed values may be considered low to be the principal factor water circulation and suspended matter in the lake during the investigation periods (Anthony and Downing, 2003; Cho, 2007; So *et al.*, 2013). Thus, wind activity together with Buna and Moraca (even Drini in special cases) rivers streams contribute in this circulation patterns of the lake's waters.

About the role of Drini River, we have compared Landsat images in Near Infra-Red band for years 1975 – 2009, combined in a false color image (Red indicates areas of lost land surfaces covered with water, cyan-blue areas of lost free water surfaces due to sediments and vegetation (reeds). Northern shores of the lake are clearly characterized by development of vegetation areas covering free water surface, and sedimentation is visible in southeastern corner of the lake where the Buna River source is situated (Fig. 12). At the same time abrasion of sandy shores at Buna River delta are visible, and deposition of sands at Velipoja beach (Frasheri *et al.*, 2010a, Frasheri *et al.*, 2014).



**Fig.12.** Shoreline changes during 1975-2009, aerial view of Buna source and Buna delta.

#### 4. CONCLUSIONS

Remote sensing based on satellite imagery offers a clear view of the status of Lake waters, including distribution of suspended matter of different kind and phytoplankton, chlorophyll distribution and concentration, water circulation patterns, wind activity, etc.

Comparing spectral particularities from Landsat images with few field data, the conclusion is that Shkodra Lake waters have high content of different pollution mass, mostly sediments and vegetation residuals, and less algae and other living vegetation mass, which is indicated by low levels of infrared radiation. Less polluted result Adriatic seashore, except the Buna delta, where polluted mass was observed too.

An interesting feature of the water's dynamics in Shkodra Lake is their rotational circulation, which might be due to wind activity, rivers flow, karst springs and additional minor environmental factors.

Comparison of infrared images for a long time period of 30 years indicates changes in shoreline of Shkodra Lake and Buna River delta. In the northern shores of the Lake there is a continuous development of emergent vegetation (reeds, bulrushes, cattails etc.) and reduced free water surface due to sediments from rivers and erosion of agriculture lands and shores around it. At the same time development of sediments and loss of free water surface is observed at beginning of Buna River, near Shkodra City, which shows temporary water leakage with sediments (flows), at the time of floods, from Drini River to the lake (i.e. inversion of water flow).

MODIS-Aqua data also suggest higher non-algal material as well as chlorophyll concentrations over the north shore of the lake. Meanwhile, MODIS data show more distributed the phytoplankton data, with lower values over the north of the lake. Their correlations range from low positive in the inner part of the lake to negative around most of its shores.

Although some interesting results have been obtained from this work, it is imperative that more detailed field observations data are needed in the future

to identify all water quality components/ingredients. In-situ measurements must be carried out in more sites distributed over the lake shore but also inside the area of the lake. These data combined by the remote sensing observations give the possibility to extrapolated results with minor error over the entire area.

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## HISTOLOGICAL ANATOMY AND EPIDERMAL CHARACTERISTICS OF LEAVES IN SPECIES WITHIN THE FAMILY NYMPHAEACEAE

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### Abstract

This is the first study about the micromorphology of aquatic plants of the family Nymphaeaceae in Albania. These species have the status of rare and endangered and have medicinal and decorative values. Given the current status and importance, the present paper provides important information about the taxonomy and phylogeny of Albanian flora. The two species here studied have been collected from the “National Park of Lura”, Albania. The histo-morphological techniques, i.e. the colloidal technique and leaf epidermis detachment technique were employed. Leaf morphology and anatomical characteristics can serve as bioindicators of plant response to altered environmental conditions and changing habitat use. The present study reports about the micromorphology of leaf and indicators of epidermis of leaf in *Nymphaea alba* L. and *Nuphar lutea* (L.) Sibth. & Sm. Parameters of stomatal density, stomatal index, stomatal size, trichomes density, trichomes index and druses density were measured. As a result, leaf epidermis indicators such as stomata, trichomes and druses (crystals) show variations within the same species but grown in two lakes with different microclimates thus displaying intraspecific diversity in these species. The presence of staurocytic stomata, stomatal clusters and druses density in both species is for the first time reported.

**Key words:** Aquatic flora, bioindicator, pollution, leaf, micromorphology

### 1. INTRODUCTION

The family Nymphaeaceae includes perennial aquatic plants with floating leaves. There are two species of this family: *Nymphaea alba* and *Nuphar lutea* in Albania (Xhulaj *et.al.*, 2013). Leaf morphology and anatomical features can serve as bioindicators of plant response to altered environmental conditions and changing habitat use, particularly air (Pal *et. al.*, 2002;

Chaturvedi *et al.*, 2013) and soil (Abrams 1998; Tomasevic *et al.*, 2004; Sharma and Dietz, 2006). The morpho-anatomy of plant leaves can vary from contamination (Royer *et al.*, 2008; Miller-Rushing *et al.*, 2009; Pourkhabbaz *et al.*, 2010). Differences in chemical composition and water depth, light intensity, and nutrient sediment conditions can lead to the genesis of specific morphotypes in plants that are not genetically determined and change rapidly with changing environmental conditions. Formal recognition of environmentally induced morphotypes has often resulted in an unwarranted evolutionary reversal and morphological sub-classifications of taxa (Kaplan 2002). In terms of *N. alba* species, its native population is declining rapidly in many European countries (Tomšovic 1988; Ejankowski and Małysz 2011). Despite the low number of European indigenous species, their high morphological polymorphism and plasticity have caused a persistent controversy regarding the divisions between taxa (Kabátová *et al.*, 2014). As for *N. lutea* species, extreme morphological variability, uniform chromosome numbers and presumed hybridization have been obstacles to clearly understanding the relationships between taxa and to making a consistent taxonomic treatment (Padgett 2007). The epidermal parameters of the leaves, specifically the stoma and trichomes, their recognition and specification, serve the deeper characterization of a species and are an important indicator in determining the taxa in many plant families (Stuessy 2009). A change in stomatal density can be used as an indicator of environmental change (Case 2004). The presence or absence of trichomes and their density are influenced by various ecological factors, including tolerance to biotic and abiotic stresses (Bleeker *et al.*, 2012; Tian *et al.*, 2012). The specific mechanism that controls druses formation is unclear, but it has been suggested that a number of factors such as proteins, polysaccharides, and lipids or macromolecular membrane structures affect the shape and growth of crystals (druses). Druse may also have a purpose in regulating calcium (Horner and Wagner 1980; Arnott and Webb 1983; Webb, 1999). The different parameters of druse crystals are also related to the morphology of the leaves, as the density of these druse crystals is positively related to tissue density (Franceschi & Nakata, 2005). For these reasons, the micromorphological structure of the leaf and the stomata, trichomes and druses have been studied as an indicator of the relationship of *N. alba* and *N. lutea* species with the water ecosystem where they grow.

## 2. MATERIALS AND METHODS

Lura Lakes are a group of lakes of glacial origin, located in the eastern mountains of Lura and the Lura National Park in Albania. The aquatic plants studied here were collected in fresh condition, precisely from the “Liqeni i

Luleve” and the “Liqeni i Madh”. The coordinates of these lakes determined by GPS are: “Liqeni i Luleve” N 41044'25 "E 20011'52.9" with an altitude of 1572 m above sea level and “Liqeni i Madh” N 41 ° 47'24.3 "E 20 ° 11'51.2" with an altitude of 1716 m above sea level.

Optic microscope, Olympus microscope connected to C200 camera, camera, lugol, blumethylene, transparent nail polish, fresh leaves, scotch tape, razor are in the present study used.

*The colloidal technique.* Five species for each genus were collected per habitat, and the morphological features of the leaf were analyzed. The leaf epidermis was cleaned up with water and then letting it dry with water. Once dried up, in the middle of the sheet, on the upper and lower epidermis, it was placed transparent nail polish. Once the nail polish is dried, it is placed on top of the painted part of the scotch glue, then the glue that takes the traces of the stomata and trichomes from the sheet is removed, and placed on the lame. ([Http://www.zoo.utoronto.ca/able/volumes/copyright.htm](http://www.zoo.utoronto.ca/able/volumes/copyright.htm)). All the leaves underwent this process. The microscope first with a small zoom, and then with a 40x zoom was used.

*The detachment technique.* It consists of detachment of the leaf epidermis with a scalpel or razor and placing the removed part on the blade, where a lugol or blumethylene dye has been previously applied. In our case for the study of stomatal types in the leaves of species *N. lutea* the dyeing technique has been modified for a clearer appearance and for this reason the stomata have been dyed first with lugol and then with blumethylene. Clean areas are photographed with a camera and a computer-connected camera (Johnston and Watson 1976; Hilu and Randall 1984). The preparations are placed under a microscope for observation.

The transverse cutting technique was employed for the anatomical study of the leaves.

*The transverse technique.* The leaves were transversely incised to study of tissues and the construction of canned organs (leaf). These incisions are made with a sharp razor and with the help of the spinal cord when they become perpendicular to the axis of the organ to be cut. The material (leaf) is placed between the two pieces of the marrow of the appendage, which helps to make thin cuts.

*The dyeing technique.* The cuts are transferred to a clock glass with distilled water, and then passed to a clock glass with safranin where they are left for 2-3 minutes to be colored. The same procedure is followed for dyeing with toluidine. After dyeing, the cuttings are sent back to a watch glass with clean water to be rinsed. After this action, the cuts are ready to be observed.

*The preparation and observation.* In the center of the blade we release a drop of glycerin, place the thinnest incisions and cover them with lamellae (Topuzi 2005). The Olympus microscope with a 40x lens was involved for the

observation of the preparations. The Olympus camera was used to photograph the preparation. The photos were edited through the Microgliciel and Photoshop software.

### 3. RESULTS

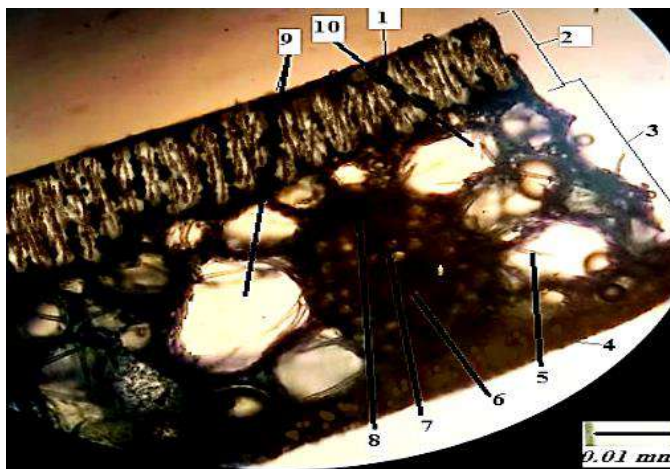
The figure 1 depict the “Liqeni i Luleve” and “Liqeni i Madh”. The area around the “Liqeni i Luleve” is characterized by deforestation. Light intensity is high, erosion occurs and pollution could be noted. Erosion and *sediment* transport into the lake is the source of water depth reduction and eutrophication “Liqeni i Madh” does not suffer from erosion. Here the water is clearer and the water depth is greater and light intensity lower because of forestation.



**Fig. 1: a.** “Liqeni i Madh”;

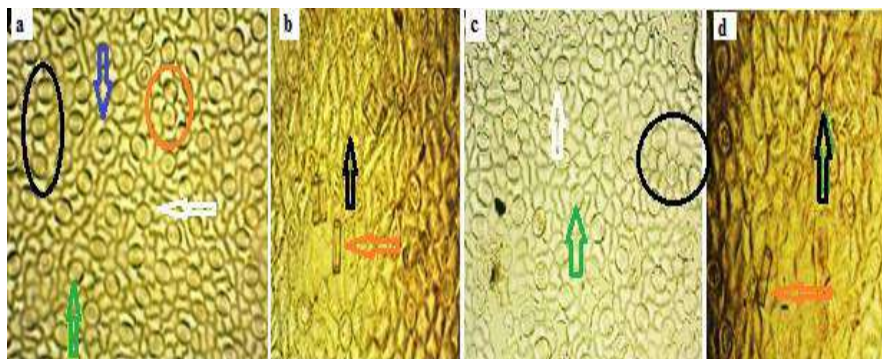
**b.** “Liqeni i Luleve”.

Regarding the micromorphological structure of the leaf of the species *N. alba*, the upper epidermis covered by the thin cuticle could clearly distinguished. The transverse anatomy of the leaf appears to have a polygonal spongy tissue structure composed of typical aerenchyma, and the upper mesophyll was occupied by homogeneous palisade parenchyma. Beneath the upper epidermis, there is the palisade mesophyll which occupies about 1/3 of the leaf, and below it is the spongy mesophyll which occupies most of the leaf, about 2/3 of it.



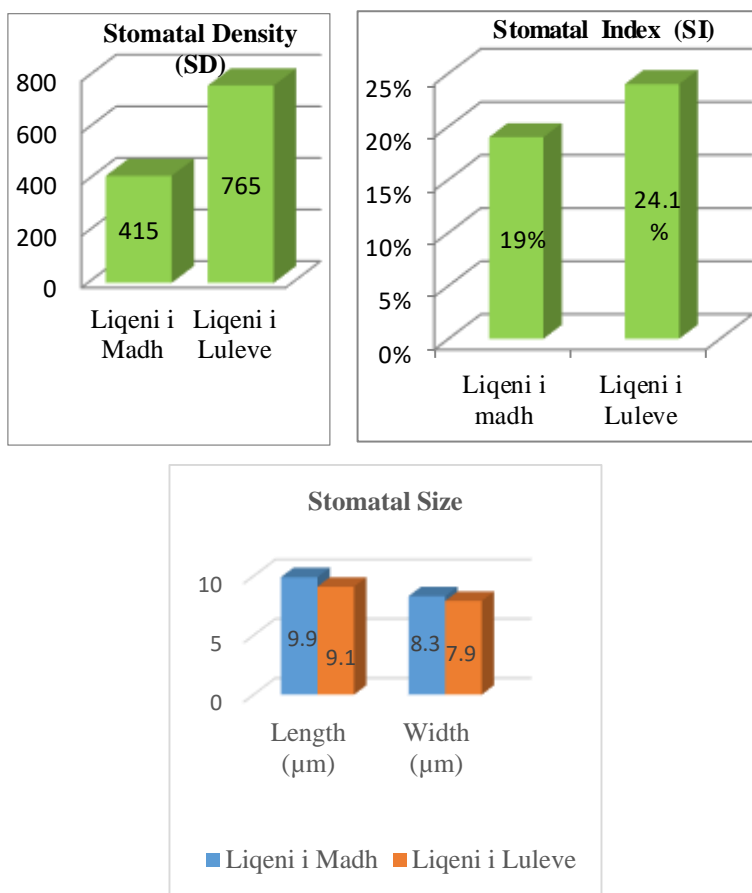
**Fig.2:** Cross section of leaves in species *Nymphaea alba*; 1. upper epidermis; 2. palisad mesophyll; 3. spongy mesophyll; 4. lower epidermis. 5. elonged sclereide; 6. phloem; 7. Xylem, 8. phloem (6-8 - forms bicolateral vascular bundles); 9. Air space; 10. Asterosclereides (star-shaped trichosclereides).

Aerenchymes with different and relatively large dimensions could be distinguished in spongy mesophyll. In these air spaces, sclereides could also be distinguished. They are extensions of spongy mesophilic cells and their tops extend to the air spaces. The sclereides found on these leaves are of the elongated sclereides type and star-shaped sclereides with branching otherwise known as asterosclereides. Vascular bundles of the bicolateral type extend along the width of the spongy mesophyll. The last layer of the leaf is the lower epidermis, which is usually submerged in water (Fig. 2). The leaves of *N. alba* are of the epistomatic type, as they have stomata only in the upper epidermis. Anomocytic (white arrow), actinocytic (green arrow) and staurocytic (blue arrow) are types of stomata. Trichomes (black arrow) and druse (red arrow) are found in the lower epidermis of the leaf. The presence of large stomatal clusters in this species has also been encountered. Stomatal clusters are contiguous (red circle) and non-contiguous (black circle), where non-contiguous clusters dominate (Fig. 3). Based on statistical processing, both populations of *Nymphaea alba* show variability of stomatal parameters. The leaves of *N. alba* are of the epistomatic type as they have stomata only in the upper epidermis.



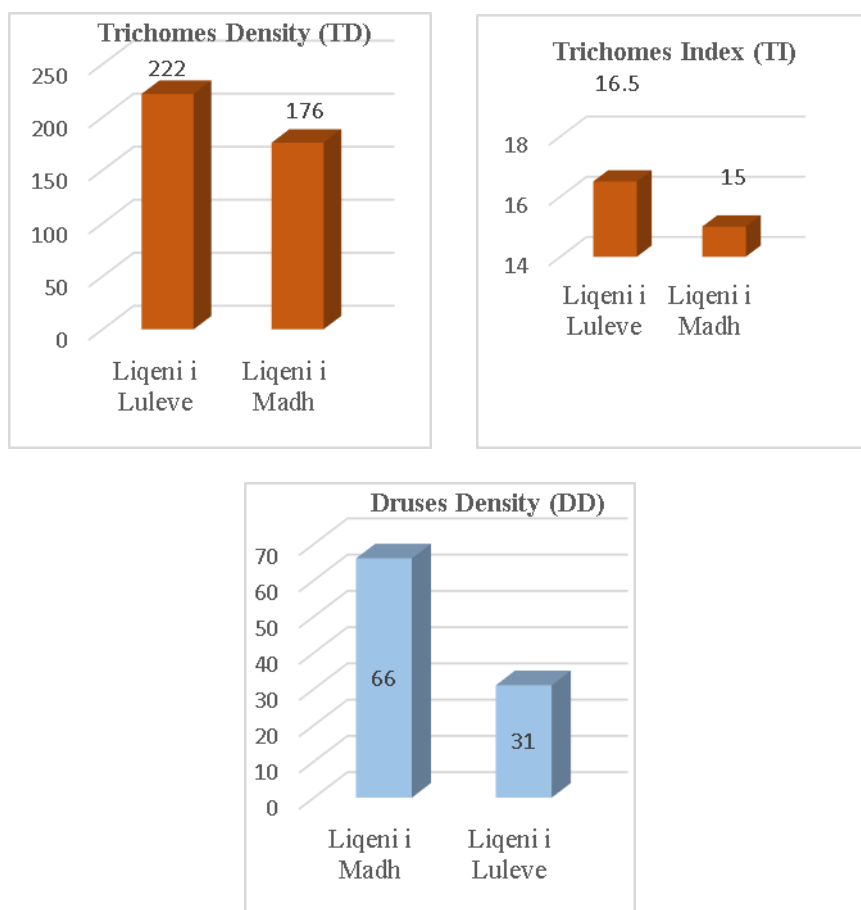
**Fig. 3.** Stomata, trichomes and druses in both population of *N. alba*. **a.** stomata of the upper epidermis in the “Liqeni i Luleve”, **b.** trichomes and druses on the lower epidermis in “Liqeni i Luleve”, **c.** stomata in the upper epidermis in the “Liqeni i Madh”, **d.** trichomes and druses on the lower epidermis in the “Liqeni i Madh”.

The mean value of Stomatal Density (SD) for the “Liqeni i Madh” population is 415 stomata/mm<sup>2</sup>. The mean SD value for the “Liqeni i Luleve” population is 765 stomata/mm<sup>2</sup>. In addition to the variation between the two populations in terms of SD, the variation regarding the Stomatal Index (SI) parameter is also reported. The mean SI value for the “Liqeni i Madh” population is 19%. The mean SI value for the “Liqeni i Luleve” population is 24.1%. Regarding the stomatal size, the variation between the two populations appears both in the length of the stomata and in their width. The species of “Liqeni i Madh” appear with stomata of greater length and width than the species of Liqeni i Luleve. The mean value of stomata length for the population of the “Liqeni i Luleve” is smaller (9.1 µm) than the mean value of the length of stomata for the population of the “Liqeni i Madh” (9.9 µm). The mean value of stomata width for the population of Liqeni i Luleve is smaller (7.9 µm) than the mean value of stomata width for the population of the “Liqeni i Madh” (8.3 µm) (Graph 1).



**Graph 1.** Mean value of stomatal density, stomatal index and stomatal size in both population of *N. alba*.

*The peltate glandular trichomes* could be found. Statistical data about the populations of *Nymphaea alba* show variability of trichome parameters which could be noted in the figure 3, where the distribution of trichomes in the lower epidermis occurs.

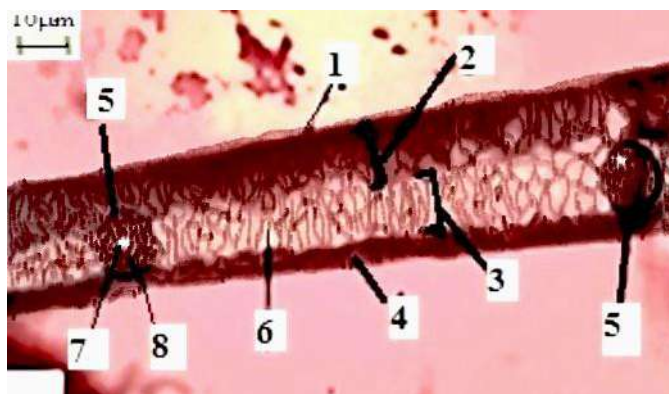


**Graph 2.** Mean values of trichomes and druses. **a.** density of trichomes; **b.** index of trichomes; **c.** density of druse in both population of *Nymphaea alba* L.

The Trichomes Density (TD) represents the number of trichomes per 1 mm<sup>2</sup>. The mean TD value for the “Liqeni i Madh” population is lower (176 trichomes/mm<sup>2</sup>) than the mean TD value for the “Liqeni i Luleve” (222 trichomes/mm<sup>2</sup>). The Trichomes Index (TI), which represents the percentage occupied by trichomes per 1 mm<sup>2</sup> of leaf area, was also measured. Regarding the species of the “Liqeni i Luleve”, TI is higher. The mean TI value for the “Liqeni i Madh” population is lower (15%) than the mean TI value for the “Liqeni i Luleve” population is higher (16.5%). In terms of druses, Druses Density (DD) represents the number of druses per 1 mm<sup>2</sup>. The mean DD value for the “Liqeni i Luleve” population is lower (31 druses/mm<sup>2</sup>) than the

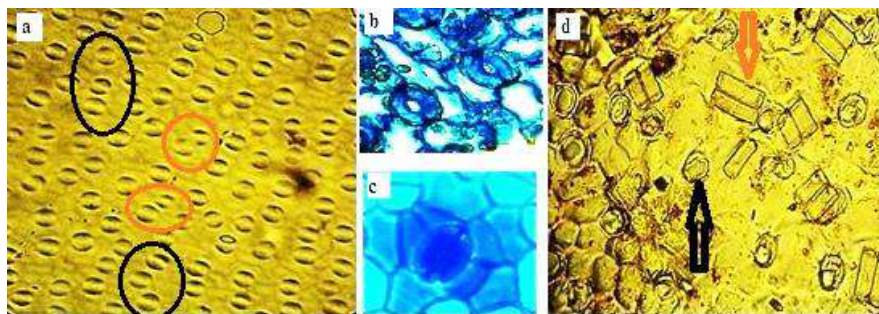
mean DD value for the “Liqeni i Madh” population is higher (66 druses/mm<sup>2</sup>) (Graph 2).

The Figure 4 depicts the micromorphological structure of the leaf in species of *Nuphar lutea*. The upper epidermis is covered by the cuticle, the palisade mesophyll and the spongy mesophyll and the lower epidermis could be clearly distinguished. In spongy mesophyll, elongated air spaces (aerenchyma) could be distinguished. Vascular bundles extending along the width of the spongy mesophyll could be found. They are of the collateral type where the xylem stands opposite the phloem. The last layer of the leaf is the lower epidermis, which has 2 - 3 cell layers. The lower epidermis is usually submerged in water. The leaves of *N. lutea* are large and heterophyllous, of the epistomatic type, i.e. the stomata are only in the upper epidermis.



**Fig. 4:** Cross section of the leaf of the species *N. lutea*. 1. Upper epidermis; 2. Palisade mesophyll; 3. Spongy mesophyll; 4. Lower epidermis; 5. Vascular bundle (surrounded); 6. Aerenchyma; 7. Xylem; 8. Phloem; (zoom 10x).

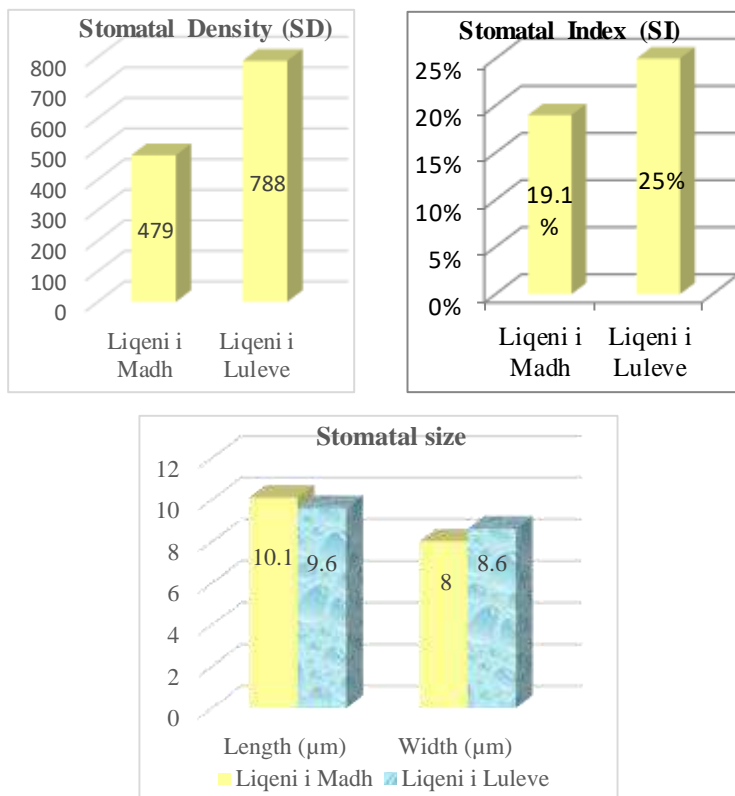
The stomata encountered in these plants are of the anomocytic (Fig. 5 b) and staurocytic type (Fig. 5c). The presence of staurocytic spores in the leaf of *N. lutea* has not been previously mentioned by the scholars studying the family Nymphaeaceae. The Figure 5d depicts the trichomes (black arrow) and druses (red arrow) in the lower epidermis of the leaf. The presence of large stomatal clusters in this species has also been encountered. Stomatal clusters are contiguous (red circle) and non-contiguous (black circle), but non-contiguous clusters prevail (Fig. 5a). Based on the data obtained from the statistical processing, both populations of *Nuphar lutea* present variability of stomatal parameters.



**Fig. 5:** View of the upper epidermis and lower epidermis of leaves in species *N. lutea*. **a.** stomata in the upper epidermis; **b.** anomocytic stomata; **c.** staurocytic stomata; **d.** trichomes and druse in the lower epidermis.

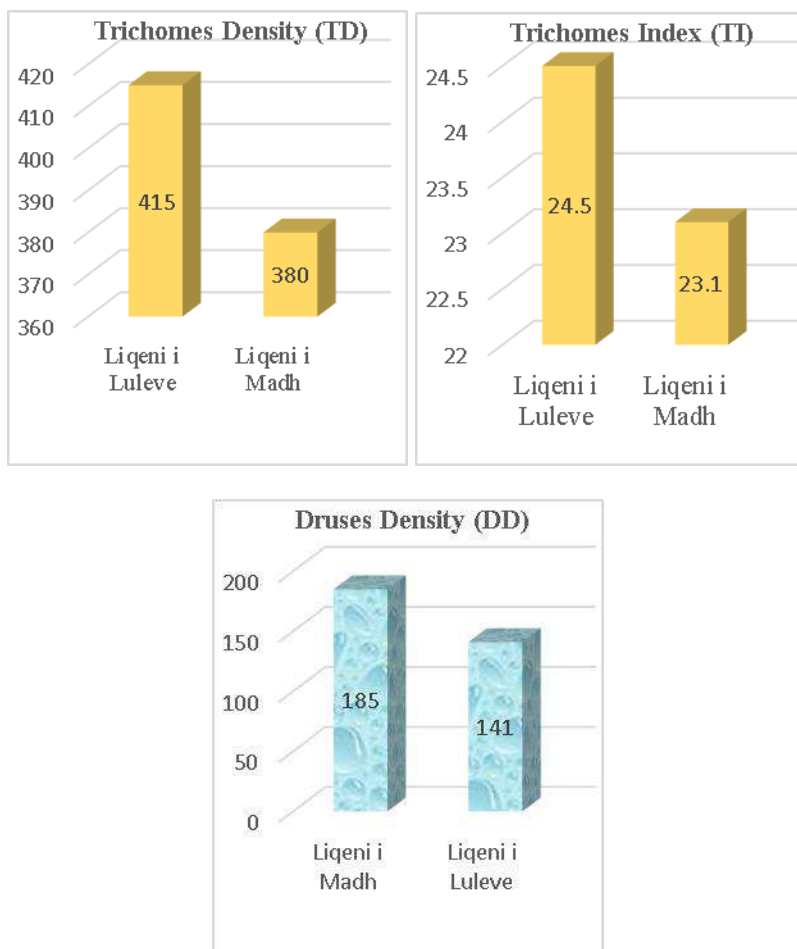
In addition to the variation between the two populations in terms of DS, the variation regarding the Stomatal Index (SI) was also reported. The mean SI value for the “Liqeni i Madh” population is lower (19.1%) than the mean SI value for the Liqeni i Luleve population (25%). In terms of stomata size, the variation between the two populations is manifested in both the length and width of stomata (Graph 3).

The mean value of stomata length for the population of the “Liqeni i Luleve” is 9.6  $\mu\text{m}$ . The mean value of stomata length for the population of the “Liqeni i Madh” is 10.1  $\mu\text{m}$ . The mean value of stomata width for the population of “Liqeni i Luleve” is higher (8.6  $\mu\text{m}$ ) and the mean value of stomata width for the population of the “Liqeni i Madh” is smaller (8.04  $\mu\text{m}$ ). Regarding trichomes, from the analysis of data as a result of statistical processing the two populations of *Nuphar lutea* present variability of trichomes parameters. The mean TD value for the “Liqeni i Madh” population is lower (380 trichomes / $\text{mm}^2$ ) and the mean TD value for the Flower Lake population is higher (415 trichomes/ $\text{mm}^2$ ) (Graph 3).



**Graph 3.** Mean values of dental density, dental index and stomata size in both populations of *N. lutea*.

The mean TI value for the “Liqeni i Madh” population is lower (15%) than the mean TI value for the Liqeni i Luleve population (16.5%). In terms of druses, they represent variability in the number of druses in each population. A parameter measured in relation to drues is the density of druses (DD) which represents the number of druses per 1 mm<sup>2</sup>. This parameter is presented for the first time. The mean DD value for the “Liqeni i Luleve” population is lower (141 druses/mm<sup>2</sup>) than the mean DD value for the “Liqeni i Madh” population (185 druses/mm<sup>2</sup>) (Graph 4).



**Graph 4.** Mean values of trichomes density, trichomes index and druses density in both populations of *N. lutea*.

#### 4. DISCUSSIONS

The upper epidermis of the *Nymphaea alba* leaf is covered by a thin cuticle. Also the polygonal structure of the spongy tissue composed of typical aerenchyma, and the upper part of the mesophyll occupied by homogeneous hepatic parenchyma are also described by Gonzalez (2002) for the order Nymphaeales. The sclereides found on these leaves are of the elongated type and star-shaped sclereides with branching otherwise known as asterosclereides. Asterosclereides in aerenchymes have also been reported by

Conard (1905) and Sculthorpe (1967). The vascular bundles are of the bicolateral type, which have also been reported by Kaul (1976). In the family Nymphaeaceae, anomocytic stomata (Solereder 1908; Metcalfe and Chalk 1950; Carpenter 2006) and actinocytic stomata (Carpenter 2006) have been reported. While the presence of staurocytic stomata is reported for the first time in the family Nymphaeaceae and in the genus *Nymphaea*. The presence of contiguous and non-contiguous stomatal clusters has also been encountered. Both populations of *Nymphaea alba* present variability of epidermal indicators in leaves. These changes consist of marked variations in terms of stomatal density, stomatal index, stomatal size, trichomes density, trichomes index, and druses density. This shows marked intraspecific diversity between the population of *N. alba* in the “Liqeni i Luleve” and the population of *N. alba* in the “Liqeni i Madh”. Regarding the density of trichomes Carpenter (2006) reported that the density of trichomes in the genus *Nymphaea* is on average about 188 trichomes/mm<sup>2</sup> while in our study the density of trichomes in the population of *N. alba* in the “Liqeni i Luleve” is on average 222 trichomes / mm<sup>2</sup> and in the “Liqeni i Madh” is 176 trichomes/mm<sup>2</sup>.

The micromorphological structure of the leaf of *Nuphar lutea*, in the spongy mesophyll has air spaces (aerenchymes) with elongated shapes. Coan *et. al.*, (2002) said that the presence of many separate aerenchymes as chambers presents an important adaptation because it facilitates the storage of a minimum amount of oxygen needed in aquatic environments and enables the transport of oxygen from the leaves to the roots. Collateral vascular bundles are distinguished in spongy mesophyll. For Sculthorpe (1967), a sufficient number of lacunar protoxylames observed in conductive herds may represent the only structure that transports water to many aquatic species.

The presence of staurocytic stomata is reported for the first time in even in the genus *Nuphar*. The presence of contiguous and non-contiguous stomatal clusters has also been encountered. Both populations of *Nuphar lutea* present variability of epidermal leaf indicators. These changes consist of marked variations in terms of stomatal density, stomatal index, stomatal size, trichomes density, trichomes index, and druses density. This shows marked intraspecific diversity between the population of *N. alba* in the “Liqeni i Luleve” and the population of *N. alba* in the “Liqeni i Madh”.

Based on Monteiro (2001) and Freire *et al.*, (2007), these histological structures have adapted to changing environmental conditions, which made them reflect the changes in their morphology and structure. Case (2004) said that a change in stomatal density can be used as an indicator of environmental change. Some researchers have shown that stomatal density varies in response to water availability (Edward and Meidner 1978), light intensity (Retallk, 2001; Lu *et al.*, 1993), temperature (Ciha and Brun, 1975), geographical

location (Retallk, 2001) and CO<sub>2</sub> concentration (Bristow and Looi 1968; Woodward 1987; Woodward and Bazzaz 1988).

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## ON THE COLONIAL BREEDING WATERBIRDS IN THE LAGOONARY COMPLEX OF KUNE-VAINI

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### ABSTRACT

Immediately after World War II, considerable areas of wetlands in Albania were drained with subsequent affect on colonial breeding water birds (herons and cormorants) of Kune-Vaini lagoonary complex, either by severely affecting them or causing their extinction. Until the mid-twentieth century, only one colony of this kind had retained its characteristics: the “Ishull Lezha” colony, one of the largest in the country and Western Adriatic. In the 70s, the colony declined rapidly while during the transition period after the radical regime changes in 1991, this colony was entirely lost. In 2019 the first revitalization of this colony was observed, with counts of 550-570 breeding pairs, of which 68% *Egretta garzetta*, 23 % *Ardeola ralloides*, 5% *Microcarbo pygmaeus*, 3% *Bubulcus ibis* and less than 1% *Nycticorax nycticorax*. Direct and systematic counting of nests, as well as areal observations taken through drone were used to obtain the aforementioned data. Furthermore in 2020, a relatively similar number of breeding pairs was observed, dominated again by *Egretta garzetta* (55%), however there was a noticeable increase in percentage of other species, especially *Bubulcus ibis*. Monitoring results over a two year period show that the colony occupies an area of 0.2- 0.25 ha, far smaller than the colony in the 50s counting 2000-2500 breeding pairs occupying a 10 ha area. Historical and existing threats that led to the decline of this colony as well as the recovery measures are discussed in this study.

**Key words:** Colonial water birds, herons and cormorants, Kune-Vain lagoonary complex, status, trend, threats, Lezha

### 1. INTRODUCTION

A number of wetland sites along the Adriatic Coast are recognized as Important Birds and Biodiversity Areas (BirdLife International 2021), and identified as Special Protected Areas under Barcelona Convention (Karavasta,

Narta, Patok, Vilun-Velipoje, Orikum, and Lalzi Bay) (Bego *et.al.*, 2013.), including also the Kune-Vaini wetland, which is our study area. Kune- Vain has been widely known for the avifaunistic values. Up to now this area has had significant numbers of nesting cormorants and herons. The habitat consisted of forests with *Tamarix* (*Tamarix parviflora* mainly), surrounded by freshwater ponds and swamps. The birds used to feed in the swamps of Shëngjin, Kune, Bilanc, Ceka lagoon, and in wet meadows that stretch along Drini to Lezha. Eight species have been breeding together in a dense colony of about 10 ha located in an area separating the Kuna lagoon from the Adriatic Sea (Beudels *et al.*, 1996). Detailed studies in this area were made from 1951 to 1964 (Lamani 1966a, 1966b; Zeko and Lamani 1966), and the last time when species composing the colony have been reported nesting, were in 1998 and 2000. Since then, no more detailed studies have been made. In the colony of the years 1951-1954, 7 species of waterbirds were breeding together with a total of 2000-2500 nesting pairs. While, in 1991 and 1993, separate colonies were observed on solitary poplars and in a dense 20- year-old pine plantation (Crockford and Sutherland 1991).

## 2. MATERIALS AND METHODS

Data about the colonial breeding waterbirds of Kune-Vain lagoony complex were obtained in 2019 and 2020. The visits were made on May (2 expeditions), June (3 expeditions), and July, which corresponded to the beginning of the breeding process of the species, mid-phase (the end of the incubation phase and the hatching of the eggs) as well as the end of the breeding process. Based on a manual or protocol, direct and systemic nest counts have been conducted. This method provides a more reliable estimate than the counting of the total number of adults. The total number of adults includes both breeding and non-breeding birds, thus the estimation would not be that accurate. Although the preferred method for monitoring the colonies that are located in trees and large shrubs is to conduct strip transects through the colony (NACWCP 2003), the presence within the colony for a long period of time could produce excessive disturbance or abandonment of nests. Another technique for obtaining data was remote sensing with use of drone (Mavic Pro). Through drone, photos were taken from above, where the number of species present in the colony was estimated, but with difficulties to identify all the species by this method as the nests were also found inside the pine trees or its branches, not only at the top. Photos have been analyzed and georeferenced through Qgis. Aerial photographs, although giving very accurate data of the nesting surface, enable only the monitoring of the upper part of the nests, while the other nests are not visible. In order to make accurate estimates of the number of nests, it was necessary to keep records on

the average number of nests in each tree in some parts of the colony. This methodological element was followed in the present case, albeit with a specificity. Since in this case the nests are located on pine trees, then the crown of each pine is visible from satellite photography. In this way all the pines within the nesting surface were counted. To obtain the number of nests and consequently nesting pairs, the number of pines was multiplied by the average number of nests per pine.

The equipment needed for the counting comprised of optical aids like binoculars (8x40, 10x40 most widely used for birdwatchers), telescope, identification guide, drone for aerial photography, pencil and notebook for notes during the monitoring, GPS (Wetlands International 2010).

### 3. RESULTS AND DISCUSSIONS

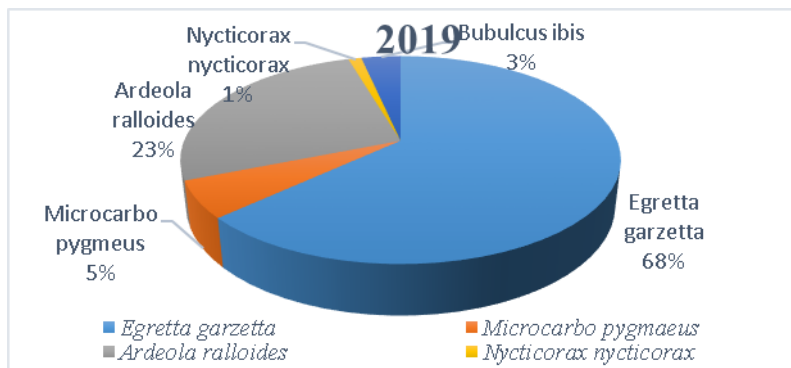
The colony is located in Kune lagoon and consists of 5 bird species breeding together: Little egret (*Egretta garzetta*), Squacco heron (*Ardeola ralloides*), Pygmy cormorant (*Microcarbo pygmaeus*), Cattle egret (*Bubulcus ibis*) and Black-crowned night heron (*Nycticorax nycticorax*). Each species covers an average percentage in the mixed colony. In 2019, approximately 550-570 breeding pairs were counted, of which circa 68% consisted of *Egretta garzetta*, 23 % *Ardeola ralloides*, 5% *Microcarbo pygmaeus*, 3% *Bubulcus ibis* and circa 1% *Nycticorax nycticorax*. Furthermore in 2020, a relatively similar number of breeding pairs was estimated (420-600 pairs), dominated again by *Egretta garzetta* (55%), however there was a noticeable increase in percentage of other species, especially *Bubulcus ibis* (15%). *M. pygmaeus* is represented with 7%, *A. ralloides* with 20% and *N.nycticorax* with 3%. In a study carried out from 1951 to 1953, it was reported that cormorants had the largest portion compared to other species of the colony (Lamani and Zeko, 1966). Monitoring results over a two year period show that the colony occupies an area of 0.2- 0.25 ha, far smaller than the colony in the 50s counting 2000-2500 breeding pairs, 7 species and occupying a 10 ha area (Table 1). *E. garzetta* and *M. pygmaeus* nests have been observed in the upper part of the *Pinus halepensis*, while other species were located mostly in the middle part of the tree.

There is no doubt that the breeding potential of this area has remarkably decreased over the last 60-70 years, and the sources are the large-scale changes that happened inside the ecosystem over more than half a century period of time, and the increased disturbance level in the area and its surroundings, particularly to the colony of the breeding birds. The quality of the *Tamarix* has decreased since 1966 due to salinization of the marshes from the digging of a channel linking the site with Merxhani lagoon. The destruction for 2-3 consecutive years of nests and the marine vegetation itself

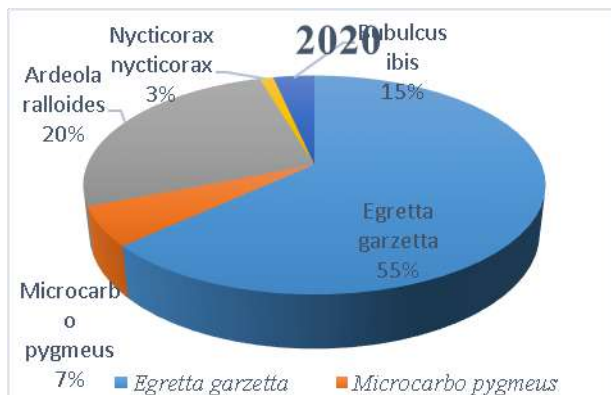
caused the changes in the colony. The reduction of these swamp areas that served as a place to provide their food has had a negative impact. In 1991 and 1993, no nests were found in the *Tamarix* vegetation. In 1991, isolated colonies were observed in solitary poplars and in a dense 20-year-old pine plantation (Crockford and Sutherland, pers. Comm.) In 1993, nests were found in only a fragment (5 ha) of forest land wet, alluvial and isolated woods of *Populus alba*. The studies carried out for a long time in the area report that the colony began to move towards pine plantations due to the drying of vegetation with *Tamarix*, which is suitable for nest construction. This may explain why the colony located in 2019 in the pine forest (*Pinus halepensis*) planted in Kune (Merxhan). Today, this habitat is totally degraded and filled with dead trees. Such an ecological upset is extremely detrimental to these populations and is most probably the main reason for the disappearance of any breeding concentration (Beudels *et al.*, 1996). Furthermore, as the size of the colony in the last two years is almost the same, we can assume that the colony has already reached the carrying capacity of the ecosystem, which is drastically reduced over the last 70 years.

**Table 1.** Colony composition and number of breeding pairs in Kune – Vain (Lamani and Zeko 1966; Bego and Selgjakaj 2019; 2020)

SPECIES	1951-1953	2019	2020
<i>P. CARBO</i>	400-500	0	0
<i>P. PYGMEUS</i>	600-750	25-28	*
<i>A. CINEREA</i>	200-250	0	0
<i>E. GARZETTA</i>	400-500	380-386	*
<i>A. RALLOIDES</i>	200-250	125-130	*
<i>P. LEUCORODIA</i>	100-125	0	0
<i>P. FALCINELLUS</i>	100-125	0	0
<i>N. NYCTICORAX</i>	0	3-6	*
<i>B. IBIS</i>		17-20	*
NUMBER OF PAIRS	2000-2500	550-570	420-600



*The percentage that occupy the species in the mixed colony for 2019*



*The percentage that occupy the species in the mixed colony for 2020.*

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## **POLLUTION AND QUALITY ASSESSMENT OF BUNA AND DRINI RIVERS AND VELIPOJA BEACH, SHKODËR, ALBANIA**

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### **ABSTRACT**

The quality of surface water is a constant problematic issue in Albania, including its northern region as well. Many of the worst and of the best-known environmental problems result from the anthropogenic activities, regardless the priority given in the last years to the quality of these waters. As the waters quality is closely related to their biodiversity, a regular assessment of this bio diversity is of great importance. Shkodra, otherwise known as the city of waters, requires attention in terms of the waters quality because of climate change, their misuse, non-treatment of wastewater when dumped, overpopulation, etc. The present paper aims to determine the locations of pollution sources that contribute to the poor quality of water of the two main rivers in northwestern Albania: Drini and Buna, as well as the Velipoja Coast, bordering Montenegro. Here some chemical-physical and microbiological parameters of 7 locations have been analyzed: 2 locations for the Buna River, 2 locations for the Drin River and 3 locations in Velipoja in Adriatic Sea, during the years 2018-2020. Microbial indicators such as *E. coli* and chemical-physical ones such as: pH, temperature, turbidity, odor,  $\text{NO}_2$ ,  $\text{NO}_3$ ,  $\text{NH}_4$ ,  $\text{PO}_4$  have been evaluated, and the results showed that increased attention and coordination of the work of a number of local and central institutions for the preservation of the biodiversity, as a means to address the development of socio-economic life, tourism and Public Health of this area is crucial.

**Keywords:** bacterial indicators, parameters chemical-physical, water quality

## 1. INTRODUCTION

Mallin *et al.*, (2020) said that the quality of surface water has always been a major problem in the world; therefore, the assessment of water quality in rivers remains of great importance.

The rivers are habitats for many organisms so the quality of rivers water is a fundamental factor in economic growth and tourism in the region.

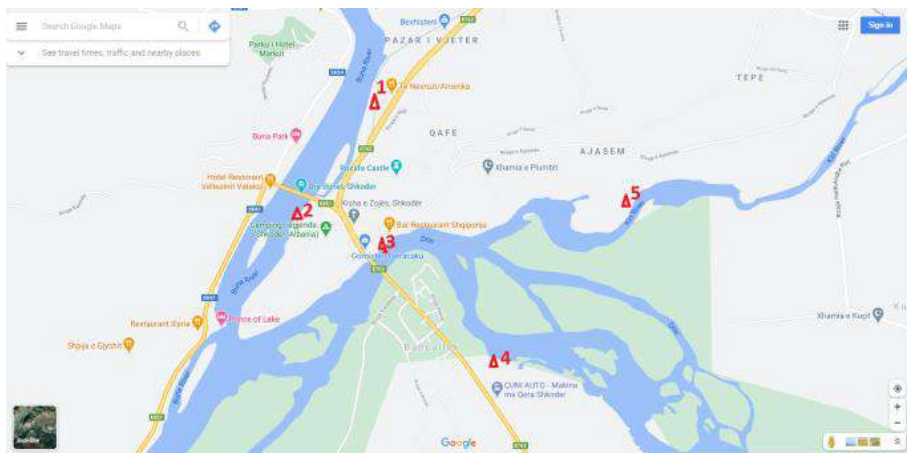
Therefore, the pollution from pathogens is a very serious issue for all the surface waters and surrounding communities. Bad water quality is associated with the growth of these pathogenic microorganisms. Consequently, assessment and monitoring are essential for surface waters 'U.S. Environmental Protection Agency (2010a). Ene *et al.*, (2020) and Yunus *et al.*, (2020) said that *E. Coli* is the typical bacteria used as an indicator for fecal water pollution in rivers and coastal waters.

Ashbolt (2015) said that constant identification of these microorganisms is crucial, because based on (Häder *et al.*, 2020) it is a means to address ecological protection of aquatic ecosystems and the protection of this water resources that have an impact on public health, economy and tourism.

Shkodra, known also as aquatic city, needs this kind of attention. Drin River, Buna River and Velipoja coast need continuous monitoring for a sustainable blue growth. Climate change, waters mismanagement, fecal discharges and overpopulation are the sources of pollution (Cherif *et al.*, 2019; Mallin, *et al.*, 2020). In addition, Rivers use for recreational activities such as sailing, bathing and angling and other amenities is also increasingly important for the economic growth and social life. The growing number of users and uses of rivers and coasts— perhaps especially around in the areas with high population densities and high industrial development— has increased the exploitive pressures on waters, posing a risk to human health. The figure 1 and 2 depict the sampling stations.



**Fig. 1: a) Ada, b) Center, c) Viluni.**



**Fig. 2:** 1. Pedonalja, Buna River, 2. Thertore, Buna River 3. Mbi Kuz, Drini River 4. Nen Kuz, Drini River.

## 2. MATHERIALS AND METHODS

Sampling was done from 2018 to 2019 in two different sampling stations in each river (Drini and Buna) and in three sampling stations in the Velipoja coast. The samples were collected each year, from May to October for the physico-chemical parameters and the microbiological parameters of water.

There are 42 samples for the physic-chemical parameters and 42 samples X 7 analyzed for the microbiological parameters.

The Most Probable Number (MPN) method was applied to identify the *Fecal coliforms* (EU Directive 2006/7 / EC). This technique can assess the most probable number of microbial colonies in liquid media (lactose). MPN shows the probable number of *Coliforms* or *Streptococcus* in 100 ml water. This statistical assessment is based on a specific reading based on specific tables which were build using probability formulas. We have used EC broth media. EC Broth was prepared and poured into tubes 20x150 mm that contains Durham tubes with 10 ml each. Then, they were sterilized using autoclave in 121°C for 15 minutes. Their final pH should be 6.9 +/-0.1.1

The final reading was based in the numbers of positive and negative tubes. Positive tubes were easily identified by the change of color and the production of gas.

In this study we have also conducted the physic-chemical parameters of the water.

Each water sample was analyzed for temperature, pH, turbidity, nitrites and ammonium levels in the laboratory of the Public Health of Shkodra. The

temperature and the pH were measured in situ employing the AQUALITYC equipment. The EC Directive for Surface Water mentions a pH range of 5.5 - 8.5. Temperature assessment was made using thermometer directly in the water. Turbidity was measured via TURB 7. Before each measurement, the cuvettes were rinsed with distilled water and wiped so as not to affect the turbidity value.

This procedure was followed ammonium: pour into tubes 10 ml of water from the sample to be analyzed. First pour NH<sub>4</sub>-1 → 1.2 ml. Then add NH<sub>4</sub>-2 → 2 tablespoons of chemicals and mix. Leave to rest for 5 min. Then add NH<sub>4</sub>-3 → 8 drops. Leave for 5 minutes in silence. Finally, it is placed in the spectrophotometer where the results are obtained. The allowed value of NH<sub>4</sub> is 0.4 mg/l. This procedure was followed for NO<sub>3</sub>: pour 10 ml of water from the sample to be analyzed into the tubes and add 2 tablespoons of NO<sub>3</sub> chemical. Leave for 10 minutes at rest. It is then placed on a spectrophotometer where the results are obtained. The permissible values of nitrites based on the EC Directives for the Surface Water are 0.18 mg/l. For all parameters we studied the Pearson Correlation Coefficient.

### 3. RESULTS AND DISCUSSIONS

The present paper reports about pollution and quality assessment of Buna and Drin Rivers, and Velipoja beach, Shkodër, Albania and tries to demonstrate some improvement in the prevailing conditions in the aforementioned spheres of environment by comparing the data collected in 2020 with the data collected from 2018 to 2019 (Yunus *et al.* 2020).

#### *Microbiological data*

The quality of surface water with regard to *Fecal coliforms* could be classified as 'excellent', 'good', and 'satisfactory' (EU Directive 2006/7 / EC) and ISO 7899-1.

Based on the EU Directive 2006/7 / EC for the presence of *Fecal coliform* (Fig.3 and table 1), the mean values classify Velipoja coast as 'Excellent'. The samples were collected from three stations Ada, Qendra and Viluni and the results classify the region as 'excellent quality'.

The various samples collected from the Buna River show the highest microbial values for 2018 (940 cfu/100 ml). The Adriatic Sea resulted to be the less polluted (79.8 cfu/100ml).

**Table 1.** New directive 2006/7/EC for surface waters

Parameter	Excellent quality	Good quality	Sufficient quality
<i>Enterokoke intestinal</i> (cfu/100ml)	200(*)	400(*)	330(**)
<i>Escherichia coli</i> (cfu/100ml)	500(*)	1000(*)	900(**)

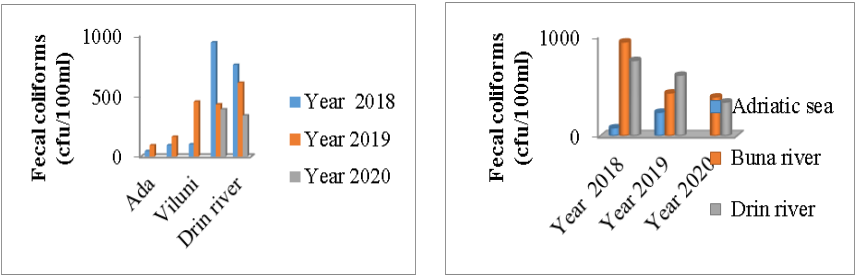
cfu: colony forming units

The mean value of *Fecal coliforms* in 2017 for the Adriatic Sea was 79.8 cfu/100 ml. In 2018 it was 234 cfu/100ml, classifying it as ‘excellent’.

The mean value of *Fecal coliforms* in 2018 for the Buna River was 940 cfu/100ml, classifying it as ‘Good’. In 2019 it was 429 cfu/100ml, classifying it as ‘excellent’ since then, as even in 2020 the mean value was 389 cfu/100ml.

Both in 2018 and 2019 Drini River was classified as ‘good’, because the mean values for *Fecal coliforms* were 755 cfu/100ml and 607 cfu/100ml, respectively. In 2020 it was 338 cfu/100ml, classifying it as ‘excellent’.

These results show industries and tourism *have significant* cumulative *impacts* on the quality of these watersheds. In addition, 2020 marked some improvement in the prevailing conditions in the aforementioned spheres of environment due to lockdown from Covid-19. The figure 3 depicts for the 2020 a drastic a drastic reduction of pollution as a result of the lockdown.

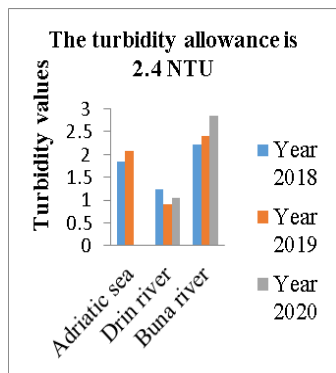


**Fig. 3:** The level of microbial contamination .

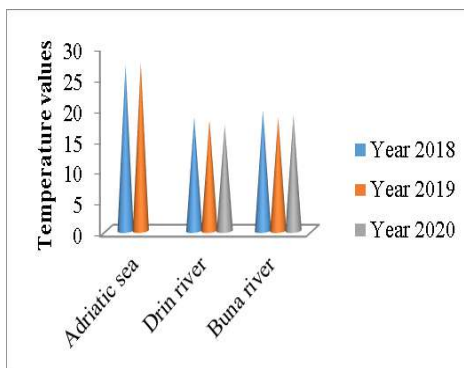
### ***Physico-Chemical data***

The graphs in the figure 4 plot that the turbidity are values within allowance, except Buna River (2.8 NTU). The *permissible* limit for turbidity is 2.4 NTU.

The figure 5 depicts the same temperature values across the three years of study.



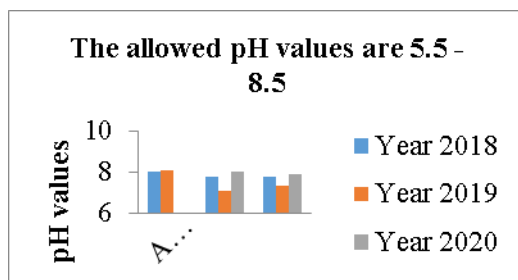
**Fig. 4:** Distribution of turbidity values



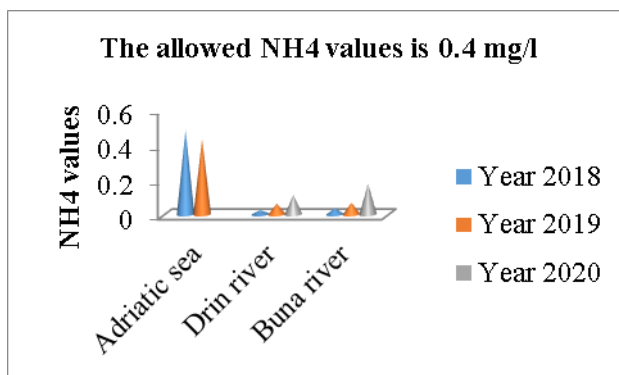
**Fig. 5:** Distribution of temperature values

The figure 6 depicts that pH values are within the allowance.

The figure 7 depicts that in 2018 NH<sub>4</sub> for the Adriatic Sea is 0.48 mg/l, and in 2019 it is 0.43 mg/l, exceeding the *allowable* limit. Samples have been collected from Buna and Drini River for three and the results showed *allowable turbidity* limit, which is is 0.4 mg/l



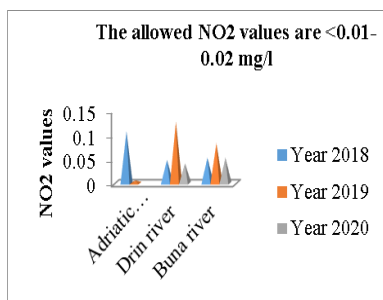
**Fig. 6:** Distribution of pH values.



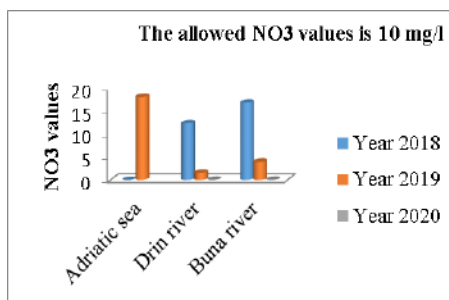
**Fig. 7:** Distribution of NH<sub>4</sub> values

The figure 8 depicts the NO<sub>2</sub> exceeding the *allowable* limit. The allowed limit for NO<sub>2</sub> is <0.01-0.02 mg/l.

In 2018 NO<sub>3</sub> exceeded the *allowable* limit in the case of both Buna River (16.7 mg/l) and Drin River (12.3 mg/l), like the Adriatic Sea as depicted in the figure 9. The allowable limit for NO<sub>3</sub> is 10 mg/l. The same was reported about the Adriatic Sea for 2019. There were reported satisfactory values from 2019 to 2020 for both rivers.



**Fig. 8:** Distribution of NO<sub>2</sub> values



**Fig. 9:** Distribution of NO<sub>3</sub> values

The figure 10 depicts that in the case of the Adriatic Sea, PO<sub>4</sub> was 0.32 mg/l in 2018. In 2019 it was 0.45 mg/l, exceeding the allowed limit. Drin River reported exceeded values for 2018 and 2019; 0.5 mg/l and 2019 is 0.4 mg/l, respectively. In 2020 it was 0.2 mg/l, i.e. within allowed limit. Regarding Buna River, PO<sub>4</sub> levels appear to be within allowance for 2018 and 2019 (0.7 mg/l and 0.2 mg/l, respectively). In 2020 it was 0.6 mg/l, exceeding the allowed limit, which is 0.31 mg/l.

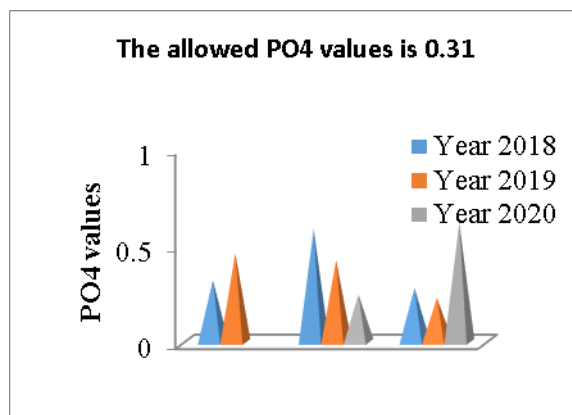


Fig. 10: Distribution of PO<sub>4</sub>, Adriatic Sea, Buna River, Drini River

Table 2 report the anthropogenic activities, their impact and recommendations.

**Table 2.** The impact of human activities and the problems identified

Problems	Causes	Consequences	Recommendation
<b>Waste is deposited in uncontrolled open fields</b>	Waste collection doesn't work very well all the time. During the tourist season with the increase of the population the waste multiplies	Pollution of the beach area and rivers which are also tourist attractions (Buna navigable river)	Landfill use where transport and financial cost is low due to favoring the Velipoja-Bushat distance
<b>Untreated wastewater discharged into the sea</b>	Not the whole territory of Velipoja and along the rivers Buna and Drin is connected to the sewers, where the wastewater treatment is done	Occurrence of infectious diseases	Municipality intervention for the connection of sewers throughout the territory
<b>The change of the coastline</b>	The natural factor and the human factor	Extinction of many plants, loss of many hectares of land	Awareness on the part of people increasing green through local initiatives and beyond
<b>Fishing</b>	Fishing in the breeding season and non-enforcement of the law	Extinction of rare fish, reduction of fish at breeding time	Prohibition of fishing during the breeding season. Establishment of fisheries associations for their monitoring

#### 4. CONCLUSIONS

The present paper reports about pollution and quality assessment of Buna and Drin Rivers, and Velipoja beach, Shkodër, Albania for 2018 and 2019. In addition, it tries to clarify whether the lockdown had an impact with regard to

microbiological parameters. Results reported that 2020 marked some improvement in the prevailing conditions in the aforementioned spheres of environment due to the lockdown.

The physical parameters appear to be within allowance. The pH values do not pose any problem for Public Health.

Regarding the *Fecal coliform*, the Velipoja coast could be classified as ‘excellent’, as based on the EU Directive 2006/7 / EC. The samples were collected from three sampling stations: Ada, Qendra and Viluni.

Buna River and Drin River were classified as ‘good’ in 2018.

From 2019 to 2020 Buna River was classified as ‘excellent’.

Drini River was classified as ‘good’ in 2019 and 2020.

It could be concluded that sustainable blue growth requires cooperation among stakeholders and continuous monitoring of polluting factors of Drini and Buna rivers and Velipoja coast.

## 5. RECOMMENDATIONS

As good surface water quality is essential for human health, animals and their biota, continuous monitoring and protection against various contaminants, especially those related to the spread of disease, is required.

Setting up wastewater treatment plants in the city of Shkodra and the surrounding areas is crucial. In addition, raising awareness between the communities and local institutions about the importance and protection of the Buna and Drini rivers is important.

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*Manuscripts* should be written in good English. They should be typed throughout with double line spacing and wide margins on numbered, single, column pages.

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