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Aquatic plants as bioindicators for pollution with impact on human health

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Abstract

Pollution of water sources with heavy metals, pesticides or industrial waste poses a serious risk to human health, contributing to problems such as chronic diseases, endocrine disorders, infertility and cancers. In this study, we analyze the role of the native aquatic plants Nuphar lutea and Nymphaea alba as bioindicators of pollution in the Lura Lakes, through measuring stomatal density (mouths) and morphological characteristics of leaves.

The findings suggest possible links between changes in these parameters and the presence of potentially hazardous pollutants to human health. Given that these lakes serve as indirect sources for drinking water, fishing, and nature tourism, monitoring through "nature technologies" offers an efficient, affordable, and sustainable method for preventing human exposure to toxic pollutants. This approach lays the foundation for the development of early models of environmental biosecurity, which serve to protect public health, especially in rural communities with limited access to modern technologies.

Keywords: *Human health, water pollution, heavy metals, plant bioindicators, Nuphar lutea, Nymphaea alba, chronic exposure*

1. Introduction

Context and significance

Contamination of water sources with heavy metals and other organic and inorganic pollutants is a growing public health concern. According to a study published in Environmental Health and Preventive Medicine, exposure to arsenic and heavy metals in drinking water has been linked to adverse effects on the nervous system, immune system, and increased risk of cancer (Hosseini et al., 2019).

Use of plant bioindicators

Plant bioindicators are organisms that reflect changes in the environment through their physiological responses. Aquatic plants such as Nymphaea alba and Nuphar lutea are particularly sensitive to water pollution, indicating environmental stress through changes in micromorphology, such as the number and size of stomata (Kadlec & Wallace, 2009).

Purpose of the study

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This study aims to explore the density of stomata on the leaves of these plants collected from the Lura lakes and see if they reflect environmental pollution that could have potential consequences on human health.

2. Methodology

Study area

The Lura Lakes are part of the Lura National Park and represent a fragile ecosystem of national importance for biodiversity. Recent human interventions, including construction and tourism, have increased pressure on the water quality of these lakes.

Sample collection

Samples were collected from various locations around the three largest lakes of Lura in July-August 2024. The leaves were preserved in 70% ethanol and prepared for microscopic analysis in the laboratory.

Equipment and tools

The work on this topic was carried out in the Histo-cytology laboratory at the Department of Biotechnology, Faculty of Science, University of Tirana. The equipment and tools used are:

- Shovel, vase for taking plant material, ruler, caliper for measuring vegetative and reproductive organs;
- Slides, coverslips, scalpels, Petri dishes, tweezers, alcohol lamp, filter paper, transparent nail polish and transparent paper glue;
- Electronic scales, thermostat, refrigerator;
- Paralux trinocular microscope with Sony Paralux camera connected to a computer on which the Microgiciel program is installed, Bright Field Optical Microscope, Olympus Microscope, Phase Contrast Microscope, Motic Stereomicroscope, Micrometer objective, Micrometer eyepiece;
- Photography of plants in the field and microscopic fields was carried out with a Samsung S4 phone and an Olympus digital camera;
- PCs and computer programs for data processing;.

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Fig. 1.Photo of the laboratory facilities and tools: a. Paralux trinocular microscope with Sony Paralux camera connected to a computer; b. Phase contrast microscope; c. Motik stereomicroscope; d. stainer and auxiliary equipment e. analytical balance and f. magnetic stirrer

Microscopic analysis

An optical microscope with 400x magnification was used to determine stomatal density. Counting was performed on standardized areas of the coverslips following the methodology described by Wilcox & Cavaliere (1994).

Counting and measuring histological indicators in leaves

The counting and measurement of stomata was performed with a 40x objective for the microscopic field (Fig. 2) and the counting and observation of the type of stomata, trichomes and drusen was done with a 40x objective. The diameter of the microscopic field with 40x magnification on the Olympus microscope from the measurement with a 0.01 mm (10 µm) micrometer objective, is 0.45mm (r = 0.225 mm). Knowing the formula for calculating the area of a circle, it results that the area of the microscopic field with a 40x objective of the Olympus microscope is:

$$\mathbf{S = \pi\ r2 = 3.14\ x\ 0.2252 = 0.16\ mm2}$$

Stomata were counted per microscopic field (S = 0.16 mm2) and then stomatal density/mm2 was calculated.

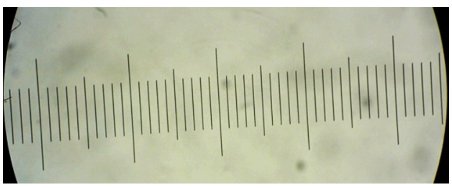

Figure 2. *Microscope with micrometer and 40x objective*

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For each population, 5 plants were taken for each species studied and 5 leaves were taken for each species, where 5 microscopic fields were prepared for each leaf. So, in total, 25 microscopic fields were studied for each epidermal surface of the leaf, for each population of the species studied. Observations for statistical calculations were carried out in a Paralux microscope. Photographs were taken with a Samsung J4 phone and a digital camera, directly in the eyepiece. Measurements of stomata dimensions were carried out with a micrometer eyepiece. The computer programs used for measurements were Paint and Microsoft Office Picture Manager programs. As a basis for determining the type of stomata, the stomatal classification scheme was used (Freire et al., 2007; Zekaj et al., 2007; Giulano.2000; Barroso, 1976; Metcalfe & Chalk, 1950, 1979; Sinclair & Sharma, 1971).

Results

Stoma density

The results showed significant differences in stomatal density between samples taken at different points. This suggests that environmental factors such as oxygen content, pH, and the presence of metal pollutants can directly affect plant morphology.

Fig. 3. View of plants and their leaves from the lake where the samples for the study were taken

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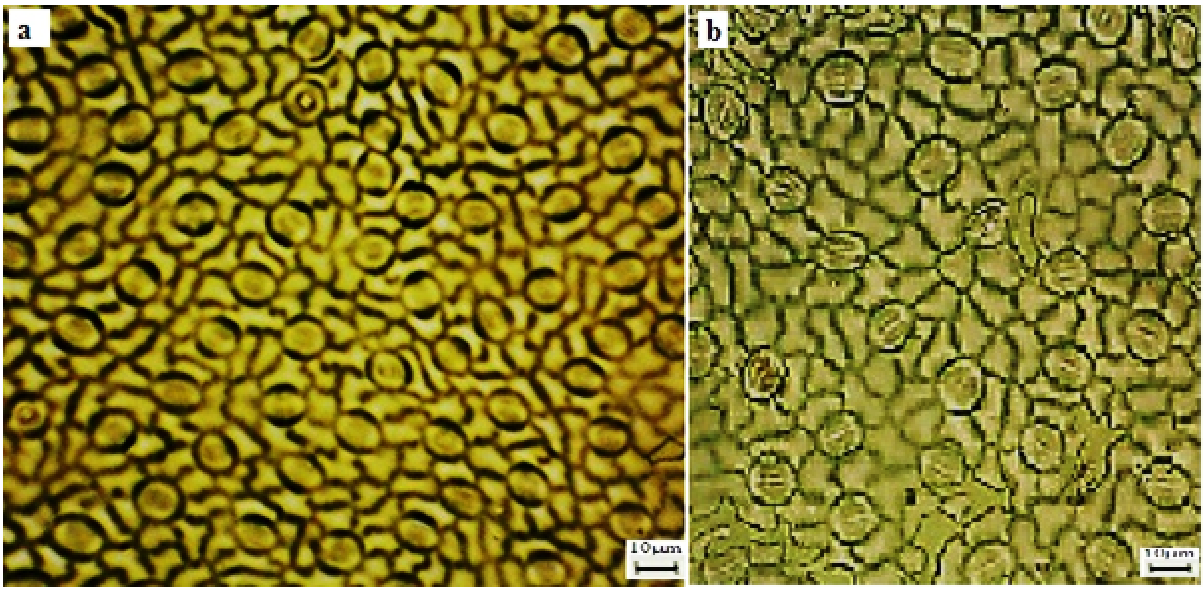
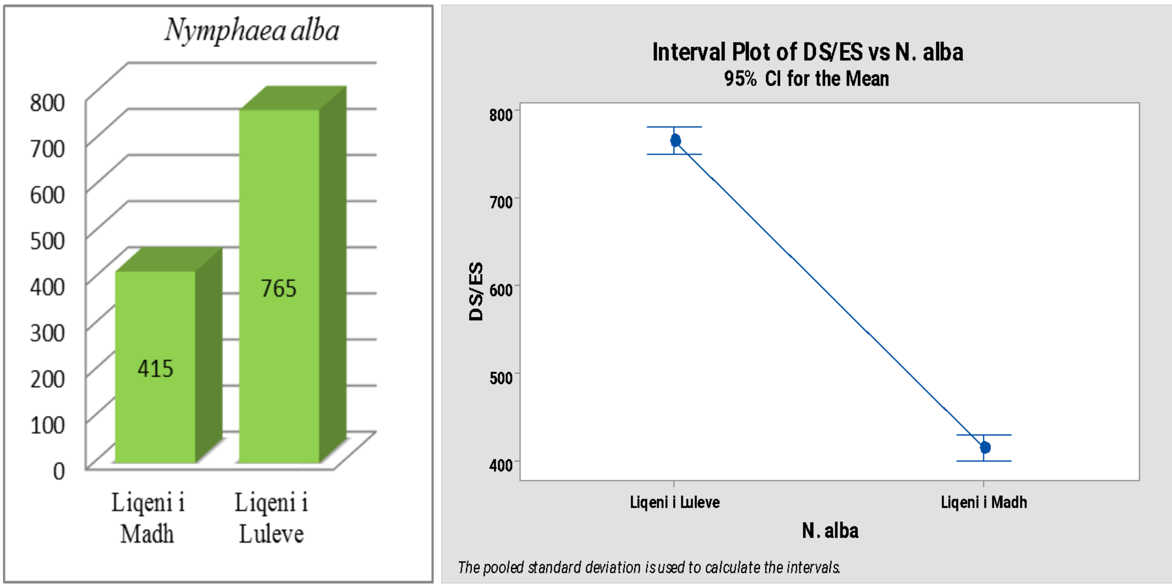


Fig. 4. *Microscopic view of stomata, showing different concentrations of stomata on the leaves of two plants taken from different points of the lake.*



ab

Chart 1. Stomatal density (DS) in the upper epidermis of leaves for two populations of N alba; a. Mean values of stomatal density; b. Difference of means for DS and confidence interval

- **Stomatal density/mm2**

The high number of stomata per microscopic field in the Flower Lake population also results in higher stomatal density than in the Great Lake individuals (Graph 3.8).

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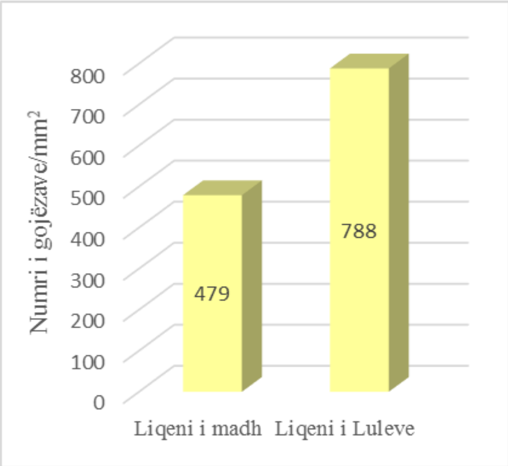

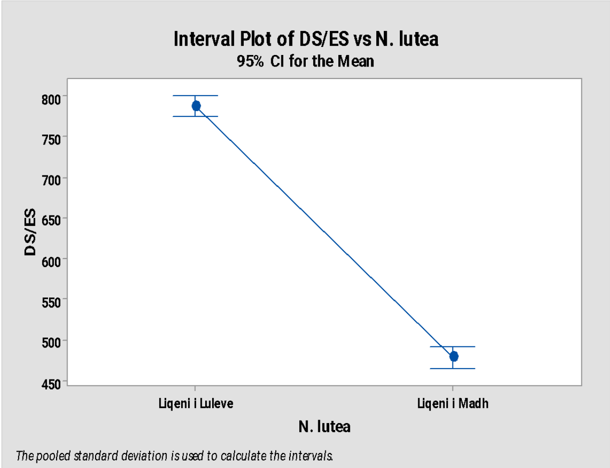

a. b.

Chart 2. Stomatal density in the upper epidermis of leaves for two populations of N. lutea; a. Mean values of stomatal density; b. Difference of means and confidence interval for stomatal density

Impacts on human health

Metals such as cadmium, lead and mercury are known to have toxic effects on the nervous system, renal system and neurological development in children (Jaishankar et al., 2014). Pollution of lake water that can be used for recreation or irrigation poses a potential risk to the local population.

Discussion and Conclusions

Plants as environmental biosensors

The results support the thesis that Nuphar lutea and Nymphaea alba are effective indicators of water quality changes. Similar studies have shown the sensitivity of these plant species to environmental stress, especially in sensitive ecosystems such as marshes and alpine lakes (Vymazal, 2011).

Impact on public health policies

Monitoring water quality through bioindicators is a green, low-cost method that helps prevent human exposure to potentially dangerous pollutants. In this way, nature-based technologies also contribute to the protection of public health.

Limitations and suggestions

The lack of direct measurements of pH, heavy metals, or dissolved oxygen is a limitation. However, morphological changes in plants constitute a valuable indicator for the presence of environmental stressors.

The study highlights the importance of using aquatic plants as bioindicators for pollution of the aquatic environment, having direct implications for human health. The innovation lies in using natural mechanisms to assess health risks, helping in sustainable decision-making.

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