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Biodiversity Assessment and Ecological Significance of Ain Al-Ghazala Lagoon, Eastern Libya

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Abstract

Ain Al-Ghazala Lagoon is a vital marine ecosystem along the Libyan coast, supporting a rich biodiversity that plays a crucial role in maintaining ecological balance and sustaining local economic activities. This study aimed to assess the biodiversity of the lagoon, focusing on fish, mollusks, crustaceans, marine algae, and flora in the region through field surveys conducted during the winter and summer seasons of 2023–2024. The results recorded several fish species, notably Atherina boyeri, Chelon auratus, Diplodus sargus, Siganus rivulatus, and Siganus luridus, alongside the presence of invasive species such as Pterois miles and Lagocephalus sceleratus, raising environmental concerns about their potential impact on native species. The mollusk diversity was notably high, with Gastropoda being the most dominant group, followed by Bivalvia, including species such as Mytilus edulis and Donax trunculus, which play a key role in ecosystem functions like biofiltration and nutrient cycling.

Crustacean diversity included species such as Callinectes sapidus, Portunus pelagicus, and Penaeus semisulcatus, Additionally, the study documented a diverse assemblage of marine algae, including Chlorophyta, Rhodophyta, and Ochrophyta, which contribute to nutrient stabilization and provide essential habitats for fish and invertebrates. The study results indicate significant plant diversity in the region, with species adapted to both arid and coastal environments. The identified species belong to Gymnosperms and Angiosperms, including monocotyledons such as Hordeum murinum and dicotyledons like Eryngium maritimum, highlighting the ecological richness of the area. The study also underscores the urgent need for effective conservation strategies to protect the lagoon's biodiversity and mitigate the risks posed by invasive species, which could disrupt the ecological balance of this unique marine environment.

Key words: Ain Al-Ghazala Lagoon, Biodiversity, Invasive Species, Marine Algae, Conservation Strategies**.**

* Introduction

The Libyan coast and its lagoons serve as vital ecosystems that sustain the biodiversity and productivity of Mediterranean marine life. Marine Protected Areas (MPAs) are fundamental tools for marine environmental conservation and sustainable development (Salem et al., 2024). In developing nations, local communities heavily rely on these lagoons for essential activities such as irrigation, transportation, fishing, cooking, and washing. Ain Al-Ghazala, located along Libya's eastern coast, is a significant lagoon characterized by a predominantly rocky shoreline and minimal tidal fluctuations. Despite the absence of discernible tidal movements, the lagoon encompasses extensive shallow areas, including mudflats and Zostera beds, which support diverse ecological communities (Haddoud & Rawag, 1995; Okoro et al., 2014; Team, 2010).

This lagoon is a crucial hydrological and ecological resource, renowned for its rich aquatic biodiversity and distinctive environmental attributes. Studies assessing its water quality for aquaculture suitability indicate that Ain Al-Ghazala exhibits higher electrical conductivity and elevated concentrations of chemical components compared to adjacent water bodies. The lagoon hosts a wide array of marine species, including the copper shark (Carcharhinus brachyurus), whose

diet primarily consists of benthic and pelagic bony fish, with feeding patterns fluctuating based on seasonal variations and individual size (Buzaid & El-Mor, 2015). Other notable species, such as the thin-lip grey mullet (Liza ramada)and the common two-banded sea bream (Diplodus vulgaris), display distinct feeding behaviors, further underscoring the ecological richness of the lagoon (El-Maremie et al., 2015; Abdalhafid & El-Mor, 2014).

Beyond its role as a critical marine habitat, Ain Al-Ghazala has been the subject of extensive scientific research, particularly in reproductive biology and genetic diversity studies (Abdalhafid & El-Mor, 2014; Razek et al., 2014). Its ecological significance is further highlighted by the presence of Lagocephalus sceleratus, a toxic pufferfish species, marking its first recorded occurrence in Libyan waters (Milazzo et al., 2012).

Chemical analyses of the lagoon's waters reveal elevated concentrations of chloride, nitrites, nitrates, sulfates, phosphates, silicates, carbonates, calcium, magnesium, sodium, and potassium, exceeding those found in neighboring water bodies. This unique chemical composition significantly influences the types of organisms that can thrive within the lagoon (Fitori et al., 2022). Ain Al-Ghazala's distinct water chemistry, which fosters a rich biodiversity, highlights its potential for sustainable aquaculture development. Preserving Ain Al-Ghazala Lagoon is essential for maintaining ecological balance and protecting the region's biodiversity. Therefore, this study aims to document the diversity of marine life within the protected area, contributing to a deeper understanding of the lagoon's environmental dynamics.

*** Material and methods**

*** Geographical and Topographical Description of Ain Al-Ghazala Lagoon**

Ain Al-Ghazala Lagoon is located along the Mediterranean coast in northeastern Libya, situated between latitudes 32.05°–32.15° N and longitudes 23.14°–23.26° E. The lagoon is bordered by sandy beaches interspersed with rocky shorelines, forming a unique coastal landscape. Spanning an area of approximately 180 hectares, the lagoon extends 6 kilometers in length and 1.5 kilometers in width, with water depths ranging from 3.5 to 5 meters.

At the lagoon's entrance lies Almarakeb (Ulbah) Island, which acts as a natural barrier, mitigating the impact of northern winds and

wave action, thus protecting the bay's ecological integrity. The surrounding region is marked by diverse topographical features, including narrow coastal plains, low hills to the south with elevations reaching up to 192 meters above sea level, expansive sand dunes, and prominent bays, among which Ain Al-Ghazala Bay is the most significant (Fig. 1).

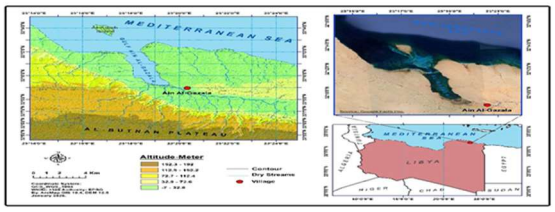

Figure 1: Geographic location of Ain Al-Ghazala Lagoon on the northeastern coast of the Mediterranean Sea in Libya.

* Climatic Characteristics of the Ain Al-Ghazala Region

The climate of Ain Al-Ghazala exhibits typical Mediterranean characteristics, characterized by hot, dry summers and mild, wet winters. The region experiences significant seasonal variation in rainfall, with an annual average precipitation exceeding 180.9 mm (Fig. 2). The mean annual temperature is 22.2°C, while the average annual relative humidity is 63.9%. Evaporation rates in the region are notable, averaging approximately 6.6 mm/day, which corresponds to a monthly average of 198 mm (Fig. 3). These climatic conditions significantly influence the hydrological and ecological dynamics of the lagoon, shaping its environmental characteristics and biodiversity.

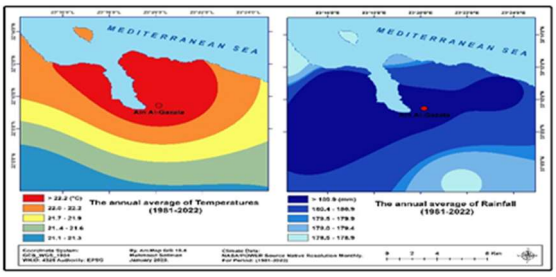

Figure 2: Average temperature from 1981 to 2022 in the study area.

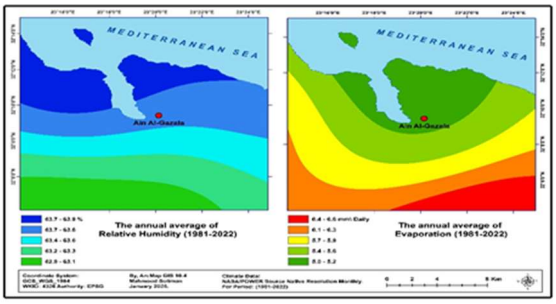

Figure 3: Average relative humidity from 1981 to 2022 in the study area.

* Sampling

Fieldwork was conducted during both the winter and summer seasons of 2023-2024. Local divers and fishermen from the study area were actively involved, alongside specialists from the Marine Biology Research Center in Benghazi. A 50×50 cm wooden square frame was prepared and placed at randomly selected, pre-determined points within the study area. All target organisms, including marine macrophytes (algae), mollusks, and crustaceans, were collected using tweezers where necessary. Fish species were documented and collected with the assistance of the research team. For the plant species

surrounding the lake, photographic documentation was employed. Various physical and chemical parameters of the lake were measured and recorded. The collected samples were subsequently transported to the Department of Marine Resources at the University of Tobruk for required analysis.

1- Results and discussion

2- Ecological

3- Fauna

4- Fishes, Mollusca and crustacean

In this study, fish samples were collected from the Ain Al-Ghazala Lagoon to assess biodiversity and document the species present in the area. As detailed in Table 1, several species from the phylum Chordata and class Actinopterygii were identified, representing a diverse assemblage of ray-finned fishes. Among the collected species, economically and ecologically significant fish, such as Atherina boyeri, Chelon auratus, and Diplodus sargus, were recorded. These species are commonly found in coastal waters and occupy a range of habitats. Additionally, species such as Siganus rivulatus and Siganus luridus were observed, further contributing to the ichthyofaunal diversity of the lagoon. Notably, invasive species including Pterois miles and Lagocephalus sceleratus that identified, raising ecological concerns due to their potential impact on native communities. As presented in Table 1, the collected species belong to various families, including Sparidae (Diplodus vulgaris, Sparus aurata) and Mugilidae (Mugil cephalus), highlighting the biological richness of the area. These species play key ecological roles in maintaining ecosystem balance by preying on a variety of organisms, thus supporting a complex and dynamic food web within the lagoon (El-Maremie et al., 2015; Agbali et al., 2014).

The findings of this study suggest that the Ain Al-Ghazala Lagoon hosts a diverse array of fish species, which could serve as a foundation for future research on the impacts of environmental changes and human activities on local biodiversity.

Table 1. List of fishes collected in the study area.

Phylum	Class	Species
Chordata	Actinopterygii	*Atherina boyeri*
Chordata	Actinopterygii	*Chelon auratus*
Chordata	Actinopterygii	*Chelon labrosus*
Chordata	Actinopterygii	*Chelon ramada*
Chordata	Actinopterygii	*Dicentrarchus labrax*
Chordata	Actinopterygii	*Diplodus annularis*
Chordata	Actinopterygii	*Diplodus sargus*
Chordata	Actinopterygii	*Diplodus vulgaris*
Chordata	Actinopterygii	*Epinephelus marginatus*
Chordata	Actinopterygii	*Mugil cephalus*
Chordata	Actinopterygii	*Parablennius sanguinolentus*
Chordata	Actinopterygii	*Sardinella aurita*
Chordata	Actinopterygii	*Scomber japonicus*
Chordata	Actinopterygii	*Siganus luridus*
Chordata	Actinopterygii	*Siganus rivulatus*
Chordata	Actinopterygii	*Solea solea*
Chordata	Actinopterygii	*Sparus aurata*
Chordata	Actinopterygii	*Sphyraena chrysotaenia*
Chordata	Actinopterygii	*Pterois miles*
Chordata	Actinopterygii	*Lagocephalus sceleratus*

The molluscan fauna in the region includes a variety of species, with gastropods being the most dominant class, followed by bivalves and a single species of polyplacophora. This diversity is consistent along the western coast of Libya, indicating a rich and varied molluscan community (Abushaala et al., 2014).

The results in table2, presents a diverse range of species belonging to the phylum Mollusca, distributed across various classes such as Scaphopoda, Bivalvia, and Gastropoda, reflecting the significant biodiversity of this phylum in marine environments.The species listed in the table1 include common bivalves such as Mytilus edulis and Donax trunculus, which are ecologically and economically important. These bivalves play a crucial role in marine ecosystems by filtering water, contributing to nutrient cycling, and providing habitat for other marine organisms.Additionally, the table includes a variety of gastropods, such as Conus ventricosus and Clanculus corallinus, which are part of the rich biodiversity found in shallow marine waters. Many of these species are integral to the ecological processes, including organic matter decomposition and the maintenance of marine food webs.The results also features Scaphopoda species like Antalis vulgaris and Dentalium, which, although less well-known, are vital components of marine ecosystems.

Table 2. Molluscan species collected in the Study area

Phylum	Class	Species
Mollusca	Scaphopoda	*Antalis vulgaris*
Mollusca	Scaphopoda	*Dentalium*
Mollusca	Bivalvia	*Abra alba*
Mollusca	Bivalvia	*Acanthocardia paucicostata*
Mollusca	Bivalvia	*Cardites antiquates*
Mollusca	Bivalvia	*Donax trunculus*
Mollusca	Bivalvia	*Donax vittatus*
Mollusca	Bivalvia	*Donnia exoleta*
Mollusca	Bivalvia	*Donnia lepinus*
Mollusca	Bivalvia	*Lithophaga lithophaga*
Mollusca	Bivalvia	*Mactra corallina*
Mollusca	Bivalvia	*Mactra glauca*
Mollusca	Bivalvia	*Modiolus barbatus*
Mollusca	Bivalvia	*Mytilus edulis*
Mollusca	Bivalvia	*Mytilus galloprovincialis*
Mollusca	Bivalvia	*Polititapes aurnus*
Mollusca	Bivalvia	*Polititapes rhomboides*
Mollusca	Bivalvia	*Ruditapes decussatus*
Mollusca	Bivalvia	*Venerupis corrugata*
Mollusca	Gastropoda	*Alvania cimex*
Mollusca	Gastropoda	*Alvania lacuna*
Mollusca	Gastropoda	*Bittium reticulatum*
Mollusca	Gastropoda	*Bolinus brandaris*
Mollusca	Gastropoda	*Bulla ampulla*
Mollusca	Gastropoda	*Cerithium vulgatum*
Mollusca	Gastropoda	*Clanculus corallinus*
Mollusca	Gastropoda	*Clanculus cruciatus*
Mollusca	Gastropoda	*Clanculus miniatus*
Mollusca	Gastropoda	*Columbella rustica*
Mollusca	Gastropoda	*Conus ventricosus*
Mollusca	Gastropoda	*Diodora italica*
Mollusca	Gastropoda	*Epicomitra cornicula*
Mollusca	Gastropoda	*Gibberula miliaria*
Mollusca	Gastropoda	*Gibbula ardens*
Mollusca	Gastropoda	*Gibbula fanulum*
Mollusca	Gastropoda	*Gibbula(Magulus)*
Mollusca	Gastropoda	*Haminoea*

The results in table 3, presents a comprehensive list of marine organisms belonging to the phylum Arthropoda, class Malacostraca. The species included are predominantly marine crustaceans, which highlight the diversity of this group within marine ecosystems. Below are key observations concerning the species listed.The organisms in encompass a wide variety of crustacean species, including Callinectes sapidus (blue

crab), Dardanus arrosor (hermit crab), and Portunus pelagicus (swimming crab). The list features species of considerable ecological and economic significance, such as Penaeus semisulcatus (shrimp), Metapenaeus monoceros (prawn), and Pagurus bernhardus (European hermit crab). These organisms are known for their importance in both ecological dynamics and human economies.

The findings highlight the substantial biological diversity within the class Malacostraca, including species like Thalamita poissonii and Eriphia verrucosa, both of which are integral to the ecological functions of marine environments. All species in the table belong to Malacostraca, a class well regarded for its ecological contributions. These organisms play pivotal roles in nutrient cycling, predator-prey interactions, and the overall stability of marine food webs.

Ain Al-Ghazala lagoon in Libya serves as an important habitat for a variety of marine species, including crustaceans, which are vital to the diet of local marine fauna. The presence of crustaceans as a primary food source for species such as Sepia orbignyana and Diplodus vulgaris emphasizes their critical role in the food chain within the lagoon. This dietary dependence underscores the ecological significance of crustaceans in maintaining the balance and health of the lagoon's marine ecosystem.

Crustaceans are essential components of the food web in Ain Al-Ghazala lagoon, acting as a primary food source for significant species like Diplodus vulgaris and Sepia orbignyana. Their abundance and presence are indicators of their ecological importance in supporting the lagoon's biodiversity and sustaining its marine life (EL-Maremie et al., 2015; Agbali et al., 2014).Table. 3. crustacean collected in the study area

Table 3. Crustacean species collected in the Study area

Phylum	Class	Species
Arthropoda	Malacostraca	*Callinectes sapidus*
Arthropoda	Malacostraca	*Dardanus arrosor*
Arthropoda	Malacostraca	*Eriphia verrucosa*
Arthropoda	Malacostraca	*Gammarus locusta*
Arthropoda	Malacostraca	*Lysianassa ceratina*
Arthropoda	Malacostraca	*Metapenaeus monoceros*
Arthropoda	Malacostraca	*Pagurus bernhardus*
Arthropoda	Malacostraca	*Penaeus semisulcatus*
Arthropoda	Malacostraca	*Pilumnus hirtellus*
Arthropoda	Malacostraca	*Portunus pelagicus*
Arthropoda	Malacostraca	*Quadrimaera inaequipes*
Arthropoda	Malacostraca	*Squilla mantis*
Arthropoda	Malacostraca	*Thalamita poissonii*
Arthropoda	Malacostraca	*Tritaeta gibbosa*

* Flora in study area

* Macrophytes

The results presented in Table 4 highlight the diversity of marine species from three major groups of algae and marine plants. Various species were identified across

different phyla and families, including Chlorophyta (green algae), Rhodophyta (red algae), Ochrophyta (brown algae), and Tracheophyta (seagrasses). This diversity indicates a rich marine environment that supports a wide array of marine organisms.

Ecologically, these species play a critical role in maintaining the stability of marine ecosystems. They contribute to water purification and provide essential breeding grounds for a variety of marine organisms. In addition, these species are economically valuable, particularly in the context of eco-tourism and fisheries, both of which enhance environmental sustainability. As such, effective management and protection of marine areas, safeguarding them from pollution and climate change, is imperative for the long-term health of these species and the broader marine ecosystem.

The presence of algae in Ain Al-Ghazala Lagoon supports not only the dietary needs of local fish species but also contributes to the overall ecological health of the lagoon. The nutrient-rich waters that foster algae growth also sustain a diverse range of other aquatic organisms, thereby maintaining a balanced and thriving ecosystem (Fitori et al., 2022; El-Maremie et al., 2015; Rafalah & El-Mor, 2014). Marine algae are integral to the ecosystem of Ain Al-Ghazala Lagoon, as they form a key component of the diet for local fish species and help maintain the ecological balance of the lagoon. The lagoon's nutrient-rich waters facilitate algae growth, which sustains a variety of marine life forms.

Table4. Macrophytes collected in the study area

Phylum	Class	Species
Chlorophyta	Ulvophyceae	*Halimeda monile*
Chlorophyta	Ulvophyceae	*Dasycladus vermicularis*
Chlorophyta	Ulvophyceae	*Penicillus capitatus*
Chlorophyta	Ulvophyceae	*Anadyomene stellata*
Chlorophyta	Ulvophyceae	*Caulerpa prolifera*
Chlorophyta	Ulvophyceae	*Chaetomorpha crassa*
Chlorophyta	Ulvophyceae	*Chaetomorpha indica*
Chlorophyta	Ulvophyceae	*Chaetomorpha linum*
Chlorophyta	Ulvophyceae	*Cladophoropsis puillus*
Chlorophyta	Ulvophyceae	*Ulva lactuca*
Chlorophyta	Ulvophyceae	*Valonia aegagropile*
Chlorophyta	Ulvophyceae	*Valonia macrophysa*
Rhodophyta	Florideophyceae	*Laurencia obtusa*
Rhodophyta	Florideophyceae	*Jania rubens*
Rhodophyta	Florideophyceae	*Amphiroa rigida*
Ochrophyta	Phaeophyceae	*Dictyota linearis*
Ochrophyta	Phaeophyceae	*Padina pavonia*
Tracheophyta	Monocots	*Posidonia oceanica*

The study involved conducting a comprehensive survey of the area, during which flowering plant species and shrubs were collected and classified. In the collection process, all scientific conditions and methods for plant sample collection were adhered to. Afterward, the samples were identified using Libyan flora reference booklets, including: EL-Gadi & Jafri (1976-1989), EL-Gadi & Jafri (1989-1992), and Al-Shaeri (2002).

This study was undertaken due to the lack of information on the plant species distributed in this region, which falls within the Butnan area. Therefore, this research aimed to address the information gap. The project focused on identifying and cataloging the growing flowering plants, documenting their numbers, and determining the life forms of these plant species. The ultimate goal was to assist in creating a comprehensive database of plant species spread across the region.

The flora study revealed that the area contains 58 species of flowering plants and 53 genera belonging to 21 plant families. These species are part of those listed in the study by Saaed et al. (2021). The results, presented in Table 5, highlight significant plant diversity within the studied area. The presence of species capable of adapting to both arid and coastal environments reflects the ecological diversity of the region. It is crucial to monitor these species to assess the potential impact of climatic and environmental changes on them in the future.

The study identifies a range of plant species from two major groups: Gymnosperms, and Angiosperms, further categorized into monocotyledons and dicotyledons. Monocotyledons, including species from the Poaceae family such as Hordeum murinum and Lolium perenne, and dicotyledons, represented by various families like Apiaceae Eryngium maritimum and Asteraceae Anthemis secundiramea, were observed. The dicotyledon group also includes species from families like Boraginaceae Echium angustifolium and Brassicaceae Matthiola tricuspidata, along with other families such as Caryophyllaceae, Chenopodiaceae, and Solanaceae. These species contribute to the biodiversity of the region, highlighting the significance of both monocot and dicot plants in the ecosystem.

Table 5.List of Plant Species in study area

Scientific name
A-Gymnosperms
There is no
B- Angiosperms **-Monocotyledons**
POACEAE
Hordeum murinum (L).
Hyparrhenia hirta (L) Stapf
Lophochloa cristata (L).
Lolium perenne L.
Piptherum coerulescens (Desf).
Schismus barbatus (L.) Thell
Stipa capensis Thunb.
-Dicotyledons
APIACEAE
yngium maritimum L.
Pituranthos tortuousus (Desf).
ANCARDIACEAE
Rhus triartita Ucria
ASTERACEAE
Anacyclus monanthos (L.) Thell
Anthemis secundiramea Biv.
Artemisia herba-alba Asso *Syn. Seriphidium herba-album* (Asso) Sojak
Carthamus divaricatus Beguinot & Vacc
Centaurea alexandrina Delile, Descr.
Chrysanthemum coronarium L.
Filago desertorum Pomel, Nouv
Launaea nudicaulis (L.) Hooker, fil
Notobasis syriaca (L.) Cass.
Pallenis spinosa (L.) Cass.
Picris asplenoides L.
Reichardia tingitana (L.) Roth.
Senecio vulgaris L.
BORAGINACEAE
Echium angustifolium Mill.
BRASSICACEAE
Didesmus bipinnatus (Desf) DC.
Matthiola tricuspidata (L.) R. Br.
Moricandia arvensis (L.) DC.
Senecio Spinosa (L).
CONVOLVULACEAE
onvolvulus althaeoides L.
EUPHORBIACEAE
Euphorbia retusa Forsk.
FABACEAE
Hippocrepis cyclocarpa Murb
Lotus corniculatus L.
Medicago stiva L.
Melilotus sulcatus Desf
Trifolium arvense L.
GERANIACEAE
Erodium laciniatum (Cav.) Willd.
LAMIACEAE
Salvia lanigera Poir.
Salvia verbenaca L.
MALVACEAE
Malva aegyptia Linn.
Malva sylvestris L.
PLUMBAGINACEAE
Limoniastrum monopetalum (L.) Boiss
Limonium pruinosum var. *hirtiflorum* (Cavara) Tack.
POLYGONACEAE
Polygonum equisetiforme Sibth & Sm
RHAMNACEAE
iziphus lotus L.
SOLANACEAE
Lycium europaeum L.
TAMARICACEAE
Reaumuria hirtella Jaub .
THYMELIACEAE
Thymelaea hirsuta (L.) Endl.
ZYGOPHYLLACEAE
Fagonia sinaica Boiss.

* Water Quality

* Water Sampling and Analysis Methods

Water samples were collected at the designated locations (10 points per site) using Van Dorn bottles made of polyvinyl chloride for chemical analysis. To assess various physicochemical parameters, a multi-portable HACH device (USA) was employed at all study sites, including the measurement of pH. Additional water samples were stored in a one-liter polypropylene bottle in an icebox and later analyzed in the laboratory. The following parameters were measured: conductivity (mS/cm), total dissolved solids (TDS) (mg/L), total hardness (TH) (mg/L), total alkalinity (TA) (mg/L), sulfate (SO_4) (mg/L), phosphate (PO_4) (mg/L), chloride (Cl) (mg/L), nitrite (NO_2) (mg/L), nitrate (NO_3) (mg/L), silicate (SiO_2) (mg/L), calcium (Ca) (mg/L), bicarbonate (HCO_3) (mg/L), and carbonate (CO_3) (mg/L). Potassium (K) (mg/L), sodium (Na) (mg/L), and magnesium (Mg) (mg/L) were measured using conventional manual techniques (Beutler et al., 2014).

The results obtained in this study align with findings from previous studies evaluating the physical and chemical properties of water bodies in eastern Libya (Table

6). The electrical conductivity of the waters in Ain Al-Ghazala Bay was notably high, with the hydrogen ion concentration reaching its highest value at 8.3. Furthermore, the average chloride (Cl) values exceeded internationally recognized limits. In addition, concentrations of nitrites (NO_2), nitrates (NO_3), sulfates (SO_4), phosphates (PO_4), silicates (SiO_2), carbonates (CO_3), calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) were higher in Ain Al-Ghazala Bay compared to other water bodies in eastern Libya. These findings underscore the need for increased attention to the conservation of such vital natural resources (Fitori et al., 2022).many studies also examined the aquatic habitats along the Libyan coast, particularly in Ain Al-Ghazala Lagoon, which includes marine ecosystems and seagrass meadows. These ecosystems play significant ecological roles, including supporting biodiversity, providing productive areas for marine species reproduction, and serving as a natural water source.

Given the results, further research is needed to investigate human activities contributing to water quality degradation, with a particular focus on water management and environmental protection efforts around lakes. It is essential to avoid the disposal of waste and urban products in these areas, as they are highly sensitive to ecological imbalances. Urgent action is required to protect these habitats. Additionally, as a fish breeding facility and an aquaculture complex are being developed in Ain Al-Ghazala Lake, it is crucial to initiate large-scale capacity building for the national aquaculture sector in the near future (Fitori et al., 2022).

Table 6. Mean ±SD Water criteria sampled from the study area.

Water parameter	Mean ±SD
Conductivity(mS/cm)	62.500±1.141
TDS (mg/l)	41.511±0.760
pH	8.21±0.07
Hardness(mg/l)	7.302±0.132
Alkalinity (mg/l)	3.253±0.210
Chlorides (mg/l)	6.822±0.190
NO2(mg/l)	0.223±0.004
NO3(mg/l)	2.285±0.314
SO4(mg/l)	2.341±0.340
PO4(mg/l)	0.410±0.008
SiO2(mg/l)	0.008±000
CO3(mg/l)	0.064±0.001
HCO3(mg/l)	3.085±0.067
Ca(mg/l)	6.116±0.114
Mg (mg/l)	1.042±0.370
Na(mg/l)	5.681±0.109
K(mg/l)	0.3007±0.024

Ain Al-Ghazala Lagoon in Libya holds significant ecological importance due to its unique environmental characteristics and role in supporting biodiversity. It is part of the Libyan coast, which is known for its relatively unpolluted waters and rich marine biodiversity,

providing essential habitats for various marine species, A vital habitat for fish and other marine creatures, the lagoon is home to a wide variety of marine life. It contributes to the overall productivity of the Mediterranean marine ecosystem by serving as a nursery for numerous species at different stages of life. Ain Al-Ghazala is recognised as a Marine Protected Area (MPA), recognising its relevance in conservation efforts. MPAs are essential for maintaining marine biodiversity and making sure that marine resources are used sustainably.Although the lagoon is generally unpolluted, there is a need for continued preservation measures to maintain its ecological integrity. Human activities, such as agriculture and possible industrial growth, could pose challenges to its water quality and biodiversity.

*** Conclusion**

Ain Al-Ghazala Lagoon, located along the northeastern Libyan coast, is an ecologically rich and diverse marine habitat that plays a crucial role in the surrounding environment and local livelihoods. The lagoon's distinct water chemistry, featuring elevated concentrations of various chemical components, supports a wide range of marine species, including economically and ecologically important fish, mollusks, crustaceans, and algae. Despite the challenges posed by invasive species, the lagoon's biodiversity highlights its significance as a marine resource.

This study contributes valuable data on the biodiversity and ecological dynamics of Ain Al-Ghazala, underscoring its potential for sustainable aquaculture development and the importance of its preservation. Given its ecological value, the lagoon's protection is critical not only for maintaining biodiversity but also for sustaining the livelihoods of local communities dependent on its resources for activities such as fishing and irrigation.As climate change and human activities continue to pose threats to coastal ecosystems, further research and effective management strategies are necessary to safeguard the lagoon's unique environmental attributes. Sustainable conservation efforts, coupled with awareness of the lagoon's ecological role, are essential for ensuring its long-term health and the continued availability of its resources for future generations.

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