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Assessment of Water Quality and Nutrient Dynamics in the Mediterranean Lagoon of El Mellah

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ABSTRACT

Coastal lagoons are among the most productive yet vulnerable ecosystems worldwide, facing increasing pressure from human activities and climatic variability. This study evaluated the current physico-chemical status and organic pollution of Lake El Mellah, a Mediterranean lagoon in northeastern Algeria, to provide an updated baseline for environmental management. Water quality was assessed across 15 stations through monthly monitoring of temperature, pH, dissolved oxygen, and key nutrients (NO_3, NH_4, PO_4). Stream discharge and precipitation data were analyzed to interpret hydrological patterns. Results revealed strong seasonal contrasts, with winter rainfall and inflows sustaining higher water renewal, while summer stagnation promoted nutrient accumulation. Nitrate concentrations reached up to 62mg L^{-1}, reflecting agricultural influence, and orthophosphate levels peaked in summer, suggesting sediment release under low oxygen conditions. The organic pollution index indicated moderate to high organic loading, exceeding recommended limits for fishery waters at several sites. This study offers the first comprehensive, seasonally resolved assessment of Lake El Mellah's nutrient and organic pollution dynamics, highlighting anthropogenic and hydrological drivers of eutrophication. Compared to previous work focused mainly on hydrobiology or biodiversity, this research integrates physico-chemical, hydrological, and pollution indicators, providing an essential reference for long-term monitoring and conservation of Mediterranean coastal lagoons.

INTRODUCTION

Coastal lagoons rank among the most productive ecosystems globally. These transitional zones between land and sea are shaped by strong ecological gradients, resulting from the shift from continental to marine influences, which create unique ecological conditions (**Pérez-Ruzafa *et al.*, 2011; Cataudella *et al.*, 2015**). In recent years, Mediterranean coastal lagoons have faced increasing environmental pressure due to land reclamation, aquaculture, capture fisheries, and pollution (**Cataudella *et al.*, 2015**). These activities have deeply altered their structural and functional integrity, leading to a marked decline in avian diversity and abundance of species that play key role in lagoon trophic dynamics (**Aymerich & Celdrán, 2011; Cataudella *et al.*, 2015**).

Over the past decades, global wetland areas have declined sharply, prompting numerous conservation programs and the establishment of national and international regulations (**Barnaud, 1997**). Recent climatic events further highlight the urgency of preserving and restoring the remaining wetlands, given their critical ecological importance.

Historically, the **Millennium Ecosystem Assessment (2005)** reported that over half of certain wetland types were lost during the 20th century in regions such as Australia, New Zealand, Europe, and North America, while noting that applying these estimates elsewhere would be speculative. **Junk *et al.* (2013)** similarly observed that global wetland loss varies widely from 30 to 90% depending on the region. **Davidson** (**2014**), after reviewing 189 assessments, estimated a global wetland loss of 64–71% during the 20th century, with the most severe declines occurring in Asia. He also noted that inland wetlands have degraded faster and more extensively than coastal ones, with inland areas shrinking by 69–75% and coastal by 62–63% over the same period **(Davidson, 2014)**.

Water quality has been severely affected by uncontrolled industrial discharges, agricultural fertilizers, and excessive water use (**Amira & Bougdah, 2018**). Maintaining good water quality is essential for public health, as contamination can degrade soil, harm human health, and trigger broader crises.

Several ecological studies have examined the El Mellah Lagoon, including **Draredja *et al.* (2019)**, who analyzed various ecological aspects. On the other hand, **Saoudi *et al.* (2017)** focused in their research on cyanobacterial dynamics.

Lake El Mellah, located in northeastern Algeria's El Kala region, faces growing pressure from agricultural runoff, and seasonal hydrological fluctuations. These local stressors threaten water quality and ecological balance, underscoring the need for comprehensive assessment.

This work provides the first integrated assessment of nutrient dynamics and organic pollution in Lake El Mellah, linking local anthropogenic pressures with seasonal hydrological variability. It establishes a scientific baseline for developing management strategies to mitigate eutrophication and preserve the ecological integrity of this Mediterranean coastal lagoon.

MATERIALS AND METHODS

1. The study area

The Mellah Lagoon is located in the far northeast of Algeria (8° 20' E and 36° 54'N), bordering Tunisia, and is bounded to the north by the Mediterranean Sea. The study site characteristics are based on its configuration and the inflowing wadis (seasonal rivers), the watershed is subdivided into three sub-watersheds: the Oued Reguibet, Mellah, and El Aroug sub-watersheds.

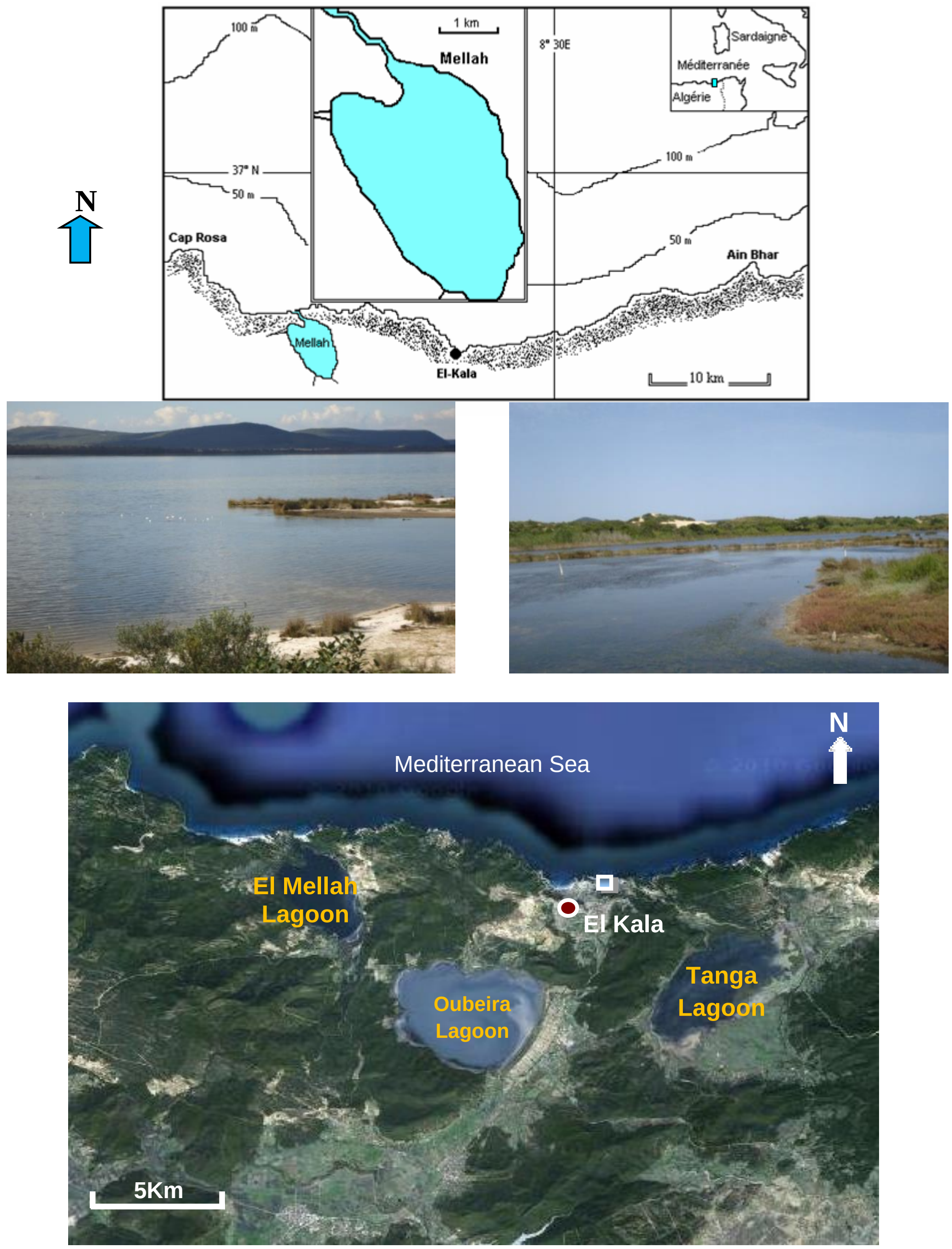

Fig. 1. Location and satellite views of the main lagoons in the El-Kala region, including El Mellah Lagoon

The water surface of Lake Mellah covers an area of 864 hectares, representing 10% of the total surface area. The lake can be considered a base level toward which both surface water and groundwater converge. It forms a unique receptacle due to its direct connection with the sea through a channel in the north (**Draredja *et al.*, 2019**). Based on Table (1), the quality of El Melah Lagoon was assessed through samples collected from 15 stations in 2018.

Table 1. Location of the sampling stations

Sampling Station	**Sampling Station Name**	Latitude (DMS)	Longitude (DMS)
1	Lac Bleu	36° 51′ 51.5″ N	8° 17′ 18″ E
2	2nd Bridge Oued Rguibet	36° 54′ 10.8″ N	8° 18′ 25″ E
3	1st Bridge Upstream Oued El Aroug	36° 50′ 08.6″ N	8° 20′ 16.9″ E
4	2nd Bridge Oued El Aroug	36° 52′ 29.0″ N	8° 20′ 16.1″ E
5	1st Bridge Oued Rguibet	36° 54′ 24.2″ N	8° 17′ 54.5″ E
6	Oued El Aroug – Inside the Wildlife Park	36° 50′ 47.6″ N	8° 19′ 45.3″ E
7	Well southwest of the lake	36° 53′ 21.3″ N	8° 18′ 41.0″ E
8	Center of the lake, near the mouth	36° 54′ 42.1″ N	8° 18′ 40.5″ E
9	Upstream Oued Boumalek	36° 49′ 45.77″ N	8° 26′ 26.98″ E
10	Outlet of Oued Mellah	36° 47′ 17.18″ N	8° 32′ 23.28″ E
11	Oued Bouhadjla	36° 53′ 29.1″ N	8° 18′ 29.4″ E
12	Source of Lac Bleu	36° 54′ 37.4″ N	8° 20′ 04.4″ E
13	Well a few meters from Oued Rguibet	36° 53′ 07.0″ N	8° 18′ 55.0″ E
14	Center of the lake, near Mirdor	36° 48′ 41.98″ N	8° 34′ 36.08″ E
15	Center of the lake, depth exceeding 3 m	36° 53′ 59.0″ N	8° 18′ 54.8″ E

2. Measurement of stream discharge

The method involves determining the cross-sectional area of the watercourse (depth) using two water gauges to indicate average depth. A weighted line is lowered to measure depth. Velocity is measured by establishing two reference points separated by a known distance along the river course, such as two piers of a bridge or two taut ropes across the water. The distance (L) between these points is measured. Small floating objects (e.g., cork pieces) are released upstream, and the time required for them to travel between the two reference points is measured with a chronometer.

$$\text{Discharge} = \text{Velocity} \times \text{Depth} \times \text{Width}$$

3. Water analysis

Water quality measurements were taken monthly at a depth of 50cm below the surface. On-site, a multiparameter instrument (Consort, 535) was used to directly measure temperature, pH, and dissolved oxygen**.** Additionally, laboratory analysis determined concentrations of nitrite **(**NO_2), nitrate **(**NO_3), phosphate **(**PO_4**)**, and ammonium **(**NH_4**)** using colorimetric methods (**Aminot & Chaussepied, 1983**).

RESULTS

1. Physical parameters

Table (2) presents seasonal precipitation data, highlighting monthly and average values across summer, spring, winter, and autumn. The data are expressed in millimeters (mm) of precipitation. During summer, precipitation levels are notably low, with August receiving only 4mm and July 9.3mm, contributing to a seasonal average of 4.8mm, indicating arid conditions. In contrast, spring shows a marked increase in rainfall, with values ranging from 1.1mm in June to 38.7mm in May, averaging 70.3mm for the season. Winter records the highest average precipitation (124 mm), suggesting it is the wettest season, although specific monthly values are not detailed in this subset. Autumn exhibits moderate rainfall with an average of 79mm, positioning it between winter and spring in terms of precipitation intensity. These patterns reflect a Mediterranean climate, characterized by hot, dry summers and cool, wet winters, which has important implications for water resource management, agriculture, and ecosystem dynamics in the region.

Table 2. Average seasonal precipitation at the El-Kala station

Season	**Summer**	**Spring**	**Winter**	**Autumn**
Month	August	July	June	May
P (mm)	4	9.3	1.1	38.7
Avg (mm)	4.8	70.3	124	79

- **P (mm):** Monthly precipitation in millimeters
- **Avg (mm):** Average seasonal precipitation in millimeters

2. Rainfall in the area and estimation of inflow rates of the Lake Mellah watershed

Precipitation is a crucial factor influencing the hydrological regime through its annual, monthly, and daily distribution patterns. It constitutes a significant component of the water balance. These various aspects of precipitation, modulated by the combined effects of other physical parameters (altitude, aspect, and distance from the sea) (**Seltzer, 1946**) and climatic factors (temperature and evaporation) explain the quantitative variations in the components of the hydrological regime of the study region. According to **Seltzer** (**1946**), two primary meteorological phenomena influence rainfall in this region: cyclonic disturbances and Mediterranean depressions between Corsica and Sardinia. December is the month with the highest rainfall (153.1mm), while the lowest precipitation levels occur during the summer period, specifically in June (1.1mm). The spatial distribution of precipitation within the study area is a key element for interpreting the spatial patterns of runoff. The monthly distribution of precipitation throughout the year is closely related to the thermal regime. It directly influences the flow regime of watercourses (**Amira & Bougdah, 2018**) and the fluctuations in groundwater levels.

3. Chemical parameters

The Oued Mellah, which feeds the lake, exhibits a significantly higher discharge compared to the other wadis, with 79.06L s^{-1} during the winter season. This can be attributed to differences in slope index and infiltration index (the Souk Rguibet and Boumalek aquifers, and vegetation cover). The observed discharge rates at this point are directly related to precipitation and the flow regime of the wadis, as low discharge rates correspond to the dry season with low precipitation. High discharge rates coincide with the wet season with high precipitation. The flow regime of the wadis is highly irregular during both periods. The Oued Bouhadjla is practically dry during the summer months.

Analysis of key parameters reveals distinct patterns in the water quality of Lake El Mellah and its surrounding areas. Nitrite **(**NO_2**)** concentrations consistently remain below the norm, typically ranging from 0.02 to 0.18mg L^{-1}, with slightly higher values observed in Oued Rguibet and Oued El Aroug, likely due to agricultural runoff. Conversely, nitrate **(**NO_3**)** levels are notably elevated, particularly at Oued Rguibet, reaching up to 62 mg L^{-1} in both summer and winter. This is attributed to discharge from nearby residential areas. Higher nitrate concentrations are also observed in the lagoon during colder periods, especially in areas influenced by continental inputs. This winter accumulation is linked to reduced plant uptake during inactive periods and improved water oxygenation. The presence of nitrate also characterizes freshwater-influenced zones, with its abundance correlating with increased water flow from wadis during certain times of the year, leading to higher nitrate and ammonium concentrations as river water generally has higher nutrient levels than seawater. During summer, lagoons become particularly susceptible to nitrogen inputs, notably from urban effluents. Orthophosphate **(**PO_4**)** concentrations are at their highest in summer, especially in the wadis, and notably at well station 7, reaching 9.2mg L^{-1}. This increase at deeper points is influenced by sediments and low oxygen conditions. Conversely, winter months exhibit the lowest orthophosphate levels, while values in Lac Bleu and Lac El Mellah remain consistently low across both periods.

Ammonium **(**NH_4**)** levels generally remain low, varying between 0.15 and 1.52 mg L^{-1}, falling within good to passable water quality classes. While overall low, spikes are observed in all sampled sites during both climatic periods.

Water quality exhibited clear spatial heterogeneity across Lake El Mellah. Upstream inflows such as Oued Rguibet (stations 2 and 5) and Oued El Aroug (stations 3, 4, and 6) showed the highest nitrate concentrations (up to 62 mg L^{-1}), reflecting strong agricultural influence. In contrast, central lake stations (8, 14, and 15) were characterized by higher orthophosphate levels and lower oxygen, likely due to internal nutrient release from sediments during summer stratification. The outlet (station 10) displayed intermediate nutrient levels but elevated BOD_5, suggesting accumulation of organic matter before discharge. Groundwater wells (stations 7 and 13) had relatively stable, moderate concentrations, indicating limited direct contamination but potential subsurface exchange with the lagoon.

Biochemical oxygen demand (BOD5) indicates significant organic pollution in Lake El Mellah. The high BOD5 values categorize the water quality as Class 1, signifying excessive pollution and exceeding the standards for fish farming waters.

4. Organic pollution

Within Lake El Mellah, IPO values consistently indicate moderate pollution (3.00) across all three monitoring stations during both low and high water periods. This suggests an ongoing process of self-purification within the lake, contributing to a stable, albeit moderate, organic pollution level. In contrast, Lac Bleu exhibits greater variability in its IPO. During low water periods, it shows strong pollution (2.25), which then moderates during the winter. This heightened pollution during drier periods is likely due to the concentration and increased fermentation of pollutants within the reduced water volume. For the rivers, all sampled points demonstrate strong pollution (IPO = 2.00 and 2.25) specifically during rainy periods. This can be attributed to the natural presence of pollutants in rainwater combined with runoff from soils rich in organic manure, leading to a concentrated influx of organic pollution into these water bodies.

Table 3. Classification of organic pollution based on physicochemical parameters

Class	BOD5 (mg O_2 L^{-1})	NH_4 (mg N L-1)	NO_2 (mg N L^{-1})	PO_4 (µg P L^{-1})	IPO	Organic Pollution
1	> 15	> 6	> 150	> 900	1.9–1.0	Very High
2	10.1–15	2.5–6	51–150	251–900	2.9–2.0	High
3	5.1–10	0.91–2.4	11–50	76–250	3.9–3.0	Moderate
4	2–5	0.1–0.9	6–10	16–75	4.5–4.0	Low
5	< 2	< 0.1	5	15	5.0–4.6	None

The classification in Table (3) provides a systematic framework for evaluating the level of organic pollution in aquatic ecosystems based on key water quality indicators. These include BOD_5 (Biochemical Oxygen Demand over 5 days), ammonium (NH_4), nitrite (NO_2), phosphate (PO_4), and the IPO (Organic pollution index). BOD_5 reflects the amount of oxygen consumed by microorganisms to decompose organic matter, with higher values indicating greater pollution. Ammonium (NH_4) and nitrite (NO_2) are forms of nitrogen that, in elevated concentrations, signal contamination from sewage or agricultural runoff. Excess phosphate (PO_4) contributes to eutrophication, which disrupts aquatic life through algal blooms and oxygen depletion. The IPO integrates these variables into a single index that categorizes water bodies into five classes: Class 1 (very high pollution), Class 2 (high), Class 3 (moderate), Class 4 (low), and Class 5 (none). Class 1 represents severely degraded water quality, unsuitable for most uses and harmful to aquatic ecosystems, while Class 5 indicates clean, minimally impacted water with excellent ecological conditions (Table 3). This classification is widely used in environmental monitoring to assess the status of freshwater systems, guide remediation efforts, and support sustainable water resource management.

DISCUSSION

The present assessment of Lake El Mellah's water quality reveals a system undergoing advanced nutrient enrichment and organic pollution, characteristic of Mediterranean coastal lagoons exposed to increasing anthropogenic pressure (**Pérez-Ruzafa *et al.*, 2011; Cataudella *et al.*, 2015**). The marked variability in physico-chemical parameters across seasons and sampling stations underscores the combined influence of hydrological dynamics, seasonal precipitation, and human activities on the lagoon's ecological equilibrium (**Amira & Bougdah, 2018**).

1. Nutrient enrichment and seasonal variability

The recorded nitrate concentrations of 62mg L^{-1} at Oued Rguibet substantially exceed the ecological threshold for eutrophic waters (10– 15mg L^{-1}) (**Pérez-Ruzafa *et al.*, 2011**), representing an enrichment approximately sixfold higher than recommended limits. Similarly, orthophosphate (PO_4^{3}) levels peaked at 9.2mg L^{-1} during summer at station 7, nearly 15 times above the eutrophication risk threshold of 0.6mg L^{-1} (**Solidoro *et al.*, 2010**). These extreme values reflect the combined impacts of agricultural runoff, urban wastewater discharge, and internal sediment release under anoxic conditions (**Cataudella *et al.*, 2015; Saoudi *et al.*, 2017**).

In contrast, nitrite concentrations (0.02–0.18 mg L^{-1}) remained within normal limits, suggesting efficient nitrification despite organic loading. Ammonium (NH_4^+) values ranged between 0.15 mg L^{-1} and 1.52 mg L^{-1}, consistent with Class III to II water quality and comparable to findings from other North African lagoons (**Aymerich & Celdrán, 2011**). The seasonal pattern of low nutrient levels in winter and peaks during the dry summer months mirrors the Mediterranean climate (**Seltzer, 1946**) and aligns with similar hydrological behavior described by **Newton *et al.* (2014)** and **Draredja *et al.* (2019)**.

2. Organic pollution and biochemical oxygen demand

The biochemical oxygen demand (BOD_5) values exceeding 15mg O_2 L^{-1} at multiple sites reveal substantial organic pollution, surpassing the 10mg O_2 L^{-1} limit for fishery waters (**Aminot & Chaussepied, 1983**). Corresponding IPO values (2.0–3.5) classify the lagoon within the high to moderate pollution range (Table 3), reflecting strong organic loads derived from untreated domestic effluents and decomposing vegetation. These findings are consistent with reports from similar Mediterranean lagoons such as Venice and Mar Menor, where restricted water renewal fosters eutrophic conditions (**Solidoro *et al.*, 2010; Newton *et al.*, 2014**).

Interestingly, moderate IPO values (3.0) observed during the wet season suggest that self-purification processes including sediment oxygenation and microbial degradation remain active within Lake El Mellah (**Aymerich & Celdrán, 2011**). However, the persistence of strong pollution indices during both wet and dry periods indicates that these natural mechanisms are increasingly overwhelmed by cumulative nutrient and organic inputs (**Draredja *et al.*, 2019**).

3. Comparative trends and ecological implications

When compared with previous studies, current results indicate a progressive rise in nutrient concentration. Nitrate values (62 mg L^{-1}) have increased by approximately 25–30 % relative to those reported by **Draredja *et al.* (2019**). This escalation reflects intensified eutrophication over the past decade, a phenomenon also observed across

Mediterranean lagoons with limited flushing capacity (**Kjerfve, 1994; Cataudella *et al.*, 2015**).

Such enrichment not only threatens aquatic biodiversity but also alters trophic dynamics and sediment–water interactions (**Aymerich & Celdrán, 2011**). Similar trajectories of degradation have been documented globally: **Davidson** (**2014**) reported global wetland loss rates of 64–71 %, with inland wetlands declining by 69–75 %, underscoring the urgency of intervention. Moreover, **Junk *et al.*** (**2013**) estimated worldwide wetland loss between 30 and 90%, highlighting the vulnerability of transitional ecosystems like Lake El Mellah.

4. Management and conservation perspectives

The quantitative evidence from this study firmly positions Lake El Mellah among the most ecologically stressed Mediterranean lagoons, with nitrate > 60 mg L^{-1}, phosphate ≈ 9 mg L^{-1}, and BOD_5 > 15 mg O_2 L^{-1}. These conditions indicate an advanced eutrophic state that jeopardizes both biodiversity and water quality within the El Kala Biosphere Reserve (**Saoudi *et al.*, 2017**).

Effective mitigation requires a multi-faceted management framework incorporating wastewater treatment, nutrient input reduction, and buffer vegetation restoration (**Newton *et al.*, 2014; Cataudella *et al.*, 2015**). Implementation of continuous monitoring, including physico-chemical and biological indicators, will be essential to detect early signs of ecological imbalance and guide adaptive management (**Draredja *et al.*, 2019).**

CONCLUSION

The present study provides an integrated assessment of the physico-chemical characteristics and organic pollution status of Lake El Mellah, a Mediterranean coastal lagoon of high ecological significance. The findings reveal a clear pattern of nutrient enrichment and organic loading, primarily linked to agricultural runoff, urban effluents, and seasonal hydrological fluctuations. Quantitatively, the measured parameters nitrate (62 mg L^{-1}), orthophosphate (9.2 mg L^{-1}), BOD_5 (> 15 mg O_2 L^{-1}), and IPO values (2.0–3.5) indicate moderate to high organic pollution and confirm an advanced stage of eutrophication.

These results are consistent with previous observations in similar Mediterranean lagoons and corroborate earlier research in the El Mellah system. The study demonstrates that seasonal rainfall patterns and limited hydrological exchange play decisive roles in regulating nutrient dynamics, while anthropogenic pressures continue to exacerbate degradation processes.

From a management perspective, these findings emphasize the urgent need for integrated watershed management, including wastewater treatment, agricultural nutrient control, riparian buffer establishment, and continuous ecological monitoring. Such interventions are essential to mitigate further eutrophication, preserve water quality, and maintain the lagoon's ecological functions within the El Kala Biosphere Reserve.

In conclusion, Lake El Mellah stands as both an ecologically valuable and increasingly vulnerable ecosystem. Without proactive conservation and long-term regulatory action, persistent nutrient enrichment and organic pollution may irreversibly compromise its biodiversity and ecosystem services. Therefore, this study contributes valuable baseline data and scientific evidence to support sustainable management and policy decisions aimed at safeguarding Mediterranean lagoon ecosystems under growing environmental and climatic pressures.

REFERENCES

Aminot, A.C. and Chaussepied, M.M. (1983). Manuel des analyses chimiques en milieu marin. CNEXO, Brest, 379 p.

Amira, A.B. and Bougdah, M. (2018). Influence of Mafragh and Seybouse inputs (sediment and salts) on the productivity of Annaba Bay. *Aquac. Aquarium Conserv. Legis.*, 11(3): 653–665.

Aymerich, R.F. and Celdrán, P.F. (2011). Waterbirds as bioindicators in coastal lagoons: background, potential value and recent research in Mediterranean areas. In: Lagoons: Biology, Management and Environmental Impact, pp. 153–184.

Barnaud, G. (1997). Conservation des zones humides: concepts et méthodes appliqués à leur caractérisation. Ph.D. Thesis, University of Rennes 1, France.

Bensaâd-Bendjedid, L. and Touati, H. (2023). Biomonitoring of trace metal contamination in El Mellah Lagoon (Algeria) using cockle Cerastoderma glaucum (Bivalvia: Cardiidae). *Hippocampus*, 1(2): 42–49.

Cataudella, S.; Crosetti, D. and Massa, F. (2015). Mediterranean coastal lagoons: Sustainable management and interactions among aquaculture, capture fisheries and the environment. *Gen. Fish. Comm. Mediterr., Stud. Rev.*, 95: 1–256.

Davidson, N.C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. *Mar. Freshw. Res.*, 65(10): 934–941.

Draredja, M.A.; Frihi, H.; Boualleg, C.; Gofart, A.; Abadie, E. and Laabir, M. (2019). Seasonal variations of phytoplankton community in relation to environmental factors in a protected meso-oligotrophic southern Mediterranean marine ecosystem (Mellah Lagoon, Algeria) with an emphasis on HAB species. *Environ. Monit. Assess.*, 191(10): 603.

Junk, W.J.; An, S.; Finlayson, C.M.; Gopal, B.; Květ, J.; Mitchell, S.A. and Robarts, R.D. (2013). Current state of knowledge regarding the world's wetlands and their future under global climate change: a synthesis. *Aquat. Sci.*, 75(1): 151–167.

Kjerfve, B. (1994). Coastal lagoons. *Elsevier Oceanogr. Ser.*, 60: 1–8.

Newton, A.; Icely, J.; Cristina, S.; Brito, A.; Cardoso, A.C.; Colijn, F. and Zaldívar, J.M. (2014). An overview of ecological status, vulnerability and future perspectives of European large shallow, semi-enclosed coastal systems, lagoons and transitional waters. *Estuar. Coast. Shelf Sci.*, 140: 95–122.

Pérez-Ruzafa, A.; Marcos, C. and Pérez-Ruzafa, I.M. (2011). Mediterranean coastal lagoons in an ecosystem and aquatic resources management context. *Phys. Chem. Earth*, 36(5–6): 160–166.

Pérez-Ruzafa, A.; Marcos, C.; Pérez-Ruzafa, I.M. and Pérez-Marcos, M. (2011). Coastal lagoons: "Transitional ecosystems" between transitional and coastal waters. *J. Coast. Conserv.*, 15(3): 369–392.

Radwan, A.R. and Latfy, I.M. (2002). On the pollution of Burullus lake water and sediments by heavy metals, Egypt. *Aquat. Biol. Fish.*, 6(4): 147–164.

Rani, S. and Arzjani, Z. (2025). Dynamics of land and water resources of South Asia. In: Land and Water Nexus in South Asia: Exploring the Interplay of Resources. Springer Nature, Cham, pp. 49–84.

Saoudi, A.; Brient, L.; Boucetta, S.; Ouzrout, R.; Bormans, M. and Bensouilah, M. (2017). Management of toxic cyanobacteria for drinking water production of Ain Zada Dam. *Environ. Monit. Assess.*, 189: 361.

Seltzer, R.E. (1958). Arizona Agriculture 1958. College of Agriculture, University of Arizona, Tucson, AZ.

Solidoro, C.; Bandelj, V.; Bernardi, F.A.; Camatti, E.; Ciavatta, S.; Cossarini, G. and Torricelli, P. (2010). Response of the Venice Lagoon ecosystem to natural and anthropogenic pressures over the last 50 years. In: *Coastal Lagoons: Critical Habitats of Environmental Change*, pp. 483–511.