AL-KUFA JOURNAL FOR BIOLOGY
ISSN (Print): 2073-8854 **ISSN (online):** 2311-6544

Original Research Paper

Impact of Water Quality on Density of Birds in Bahr Najaf Depression, Iraq

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Article history
Received: 12/7/2024
Revised: 15/8/2024
Accepted: 10/9/2024

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DOI: 10.36320/ajb/v16.i3.16628

Abstract: The study aimed to assess the impact of water quality standards on bird density in the Bahr al-Najaf depression over a period of seven months, from October 2023 to April 2024. We selected three sites for the study. We measured various physical and chemical aspects of the water, including its temperature, air temperature, electrical conductivity, total dissolved solids, salinity, pH, dissolved oxygen, biological oxygen demand, total hardness, calcium, magnesium hardness, and chloride. We determined the density of birds and the number of species in the study area. The air temperature ranged between (20.6 - 31) °C, the water temperature ranged (20 - 28) °C, the electrical conductivity ranged between (19.8 - 168.25) ms/cm, and the total dissolved solids ranged from (11,200 - 83,750) mg. /l, salinity between (13.85 - 117.777) ppt, pH between (7.9 - 8.2), dissolved oxygen between (0.73 - 5.6) mg/l, and biological oxygen demand between (0). 73 - 3 5 .5) mg/L, total hardness between (2200 - 21066.66) mg/L, and calcium hardness between (961.9 - 4382.08) mg/L, magnesium between (216.4 - 4625.7) mg/L, chloride between (1799 - 17061) mg/L The study identified 29 families and 82 species. Bird species diversity was greatest in the family Scolopacidae. The family Scolopacidae had the highest diversity with 14 species, followed by Laridae with 10 species, Charadriidae, Columbidae, and Ardeidae with five species each, Motacillidae and Anatidae with four species, and Corvidae and Passeridae with three species each. The three locations had different species diversity and abundance. With the exception of one month, the density of birds at the third site exhibited a higher species abundance and diversity compared to the other sites. Bird density showed a significant positive correlation with TDS, salinity, and electrical conductivity, while Mg ions showed a significant negative correlation. We observed a significant positive correlation between the number of species and pH, and a significant negative correlation between the number of species and chloride.

Keywords**:** Bahr, Bird, Najaf, survey, water quality

1.Introduction

Avian communities are a prominent, diversified, and abundant feature of freshwater ecosystems and the wetlands that surround them all over the world. [1]. Due to their widespread distribution and sensitivity to environmental changes, birds are excellent indicators of the health of the ecosystem. Since they are frequently common inhabitants of the ecosystem, people have regarded them as indicator species of both the environment and populated areas [2].

Numerous permanent and migratory bird species depend on wetlands for their food because they are extremely nutritious and productive [3]. The availability of food, detestability and capture, nesting site location, nesting material availability, predator presence, and competition

DOI: 10.36320/ajb/v16.i3.16628

are the key factors influencing bird populations and their ability to forage and breed. [4].

Key physical and chemical aspects of the hydrosphere change, affecting wetlands as linked systems. These in turn impact ecosystem characteristics such as species richness, distribution, and density, as well as communities that depend on wetlands [5]. Waterfowl prefer wetlands based on a variety of factors, such as physical features, aquatic vegetation, invertebrate fauna, and water chemistry [6].

The physical and chemical properties of water bodies influence the species composition, productivity, abundance, and physiological circumstances of aquatic life [7]. Understanding an ecosystem's community structure necessitates understanding the interactions between biotic and abiotic variables. Changes in the hydrosphere's primary physical and chemical factors impact wetlands, which are integrated systems at the watershed scale. According to [5], they have an impact on the communities that depend on wetlands, as well as ecological characteristics such as species richness, distribution, and density.

Governance and management of the water environment are contingent upon the assessment of water quality. Because of its adaptability and ease of use, the water quality index (WQI) approach—which incorporates data from several water quality parameters—is a well-liked instrument for evaluating the quality of water [8]. Groundwater [9, 10] and surface water [11, 12, 13] have extensively used WQI.

However, a number of factors determine the traditional WQI, frequently necessitating a significant investment of time and money in field water quality monitoring. As a result, by determining a minimal WQI (WQImin) using a small number of crucial characteristics, some researchers have concentrated on the precise and effective assessment of water quality [14]. The physical and chemical characteristics of the water have a significant impact on the biotic elements of the ecosystem, which include aquatic birds [15]. We can understand the resilience of the wetland environment and the defined conservation goals of aquatic birds in urban contexts by understanding the effects of water quality on aquatic bird diversity [16]. This study aimed to attempt to assess the impact of water quality parameters on the ecological state and bird density of the Bahr Najaf Depression.

2.Methodology

Study area

Bahr Al-Najaf, one of the country's major wetlands, is located in the lower regions of Iraq, in the Middle Euphrates region, to the west of the Euphrates River and 2 km west of Al-Najaf city. The area that forms the edge of the alluvial plateau is to the south of the marshes and nearby orchards [17]. The western desert's boundaries, which stretch south and west into Saudi Arabia's deserts, make up the region to the north and west of Bahr al-Najaf. Extending along the northwest-southeast direction, covering an area of approximately 360–750 square kilometers Coordinates: Longitude 43° 40–44° 25 E, Latitude 31° 40–32° 10 N, and Altitude About 11 m a. S.L. [18, 19] (Figure 1). Both the topography of the region and the surrounding environment clearly show Bahr Al-Najaf's placement between two separate types of habitat zones (wetlands and deserts). In addition to the nearby groundwater, water springs and an oasis in the northwest provide the water for the body of water and the lower marshes. Additionally, surface waters from the western side enter the Bahr through watercourses that periodically transport water from the highland desert to the west following significant rainfall [20]. The first site is a wide body of water with an area of approximately 5 km² and no vegetation. It is located at coordinates: longitude 44° 17'25 E, latitude 31° 58'19 N. The second site consists of several bodies of water with an area estimated at approximately 8 km2, containing *Phragmites australis*, Schoenoplectus, and Tamarix plants, and is located at coordinates: longitude 44° 12'51 E, latitude 31° 58'34 N. As for the third site, it consists of a large water depression with dry land estimated at an area of about 14 km^2 and is located at coordinates 44° 11'11 E and 31° 57'5 N. It consists of Tamarix and Schanginia plants.

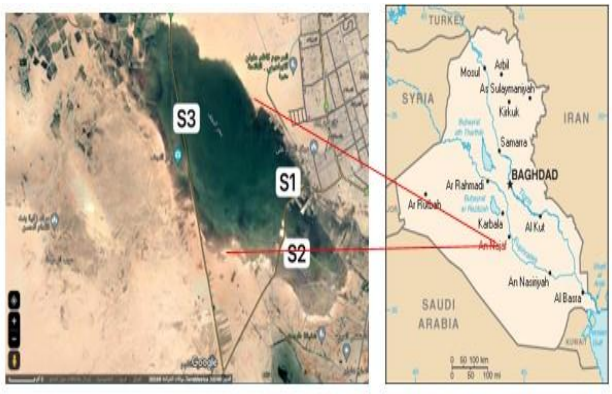

Fig. 1. Study sites in Bahr Al-Najaf depression.

Water Samples

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We selected three sites in Bahr Al-Najaf and collected water samples from each site at a depth of approximately 30 cm from the surface. We used 1 liter of pre-cleaned, marked polyethylene containers to collect the samples and study their physical and chemical properties. We stored these samples at 4 ^{o}C using ice boxes. We used Winkler glass bottles to measure dissolved oxygen (DO) and BOD5 [21].

Experiment Analysis

Water Quality: Physical parameters
Water temperature, hydrogen ions (pH), electrical conductivity (EC, µS/cm), and total dissolved solids (TDS, mg/l) were measured using a digital portable multimeter in a HANNA device after calibration.

Chemical parameters.
We measured total hardness using the titration method [22]. We prepared DO and BOD using the Winkler method as described in [23]. We determined the chlorides using the method as described by [24].

Bird survey
The following various habitat types are present in the research area: The lake, or open body of water, is located in the Bahr Al-Najaf. The marsh and reed bed areas; We selected three sites for the study: the first site is approximately 2 km from the city, the second site is approximately 5 km away, and the third site is 14 km away. We used 8x42mm binoculars and an 8x spotting scope during the observations, and took pictures with a Nikon Coolpix P1000 camera with a 24-3000mm lens. We used a 4x4 field vehicle to visit the three observation stations in the study area. We created and used a single field form to record the bird species and their numbers during the count. We used numerous ornithological classification field guides throughout the investigation to accurately identify bird species based on their morphology. We utilized the following field guides, arranged by year of publication: [25, 26, 27]. We computed the density estimates for each species of bird in each survey [28] using distance sampling, which relied on precise distance analysis and simple density estimates from line-transect data. The following formula was used to determine the estimated species density (D) for each survey:

$$D = n\sqrt{\left[\frac{2n}{\pi\sum(xi2)}\right]}/2L$$

where

n= total number of birds detected L=length of Transect xi= perpendicular distance of the birds detected from the transect line.

Perpendicular distance (xi) was calculated using the formula: $Xi = Ksin\,\theta$

Where

k=distance from observer to the bird in meter (m) θ = measured observation angle (Fig.3.2).

We calculated the observation distance (k) in all stations using the MILESEEY Company's Rangefinder gadget (PF 210) and expressed it in meters through analysis. Using a compass manufactured by the SHENZHEN JYC business, the observation angle (ɵ) was measured in each transect and expressed in degrees.

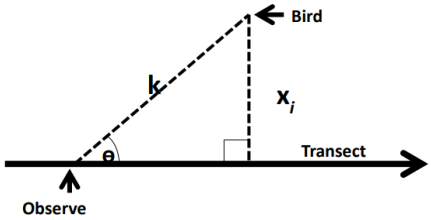

Fig. 2. Figuring out the ith bird's perpendicular distance (xi) from the Transect line [31].

3. Results and Discussion

Physical parameter
The air temperature showed the highest value in October and April (31 ºC) at sites 2 and 3, and a low value was recorded in November at site 2 (Fig. 2B). Water temperature was highest (28 ºC) in October, April at site 3, and lowest in March at site 1 (Fig. 2A). The general characteristics of Iraq's climate relate to the noticeable difference in air and water temperatures between the winter and summer months. The study's data on air and water temperatures revealed a wide range of monthly variations. The study stations showed a positive and significant association between air and water temperatures, suggesting a slight correlation between changes in water temperature and changes in air temperature. Sample time discrepancies could be the cause of the modest variations in air and water temperatures across different locations [29]. Bahr Al-Najaf's temperature fluctuations might stem from their

DOI: 10.36320/ajb/v16.i3.16628

significant dependence on the prevailing desert environment.

Site 3 had the highest EC value in October, at 134.6 ms/cm, while Site 2 had the lowest value in March, at 19.8 ms/cm (Fig. 2 C). Site 3 recorded the highest TDS value at 67000 mg/l in October, while Site 2 recorded the lowest value at 11200 mg/l in March (Fig. 2D). October, Site 3, recorded the highest salinity value at 117.777 ppt, while March, Site 2, recorded the lowest value at 13.85 ppt (Fig. 2.E).

According to [30, 31], the monthly variations in electrical conductivity values are caused by a decrease in water levels and an increase in the rate of evaporation in the hot months, which causes the dissolved ions to be more concentrated and increases the electrical conductivity values in the water. The low electrical conductivity values in the water may also be the result of precipitation dilution of salts [32]. The electrical conductivity value, which signifies the water content of salts, nutrients, and organic components, exhibits a clear correlation with the total soluble solids [33].

According to [34], temperature can have a big impact on water's conductivity and TDS (total dissolved solids). Generally speaking, water's conductivity rises with its temperature. This is due to the fact that water molecules move more swiftly and may carry more charged ions at higher temperatures, increasing conductivity overall. Temperature and TDS have a slightly more complicated relationship. The term TDS describes the total amount of dissolved solids, which includes salts, minerals, and other materials, in water. Some chemicals' solubility can change with increasing water temperature, which may affect the TDS measurement. For instance, some salts lose some of their solubility at higher temperatures, which may cause the TDS to drop.

The water quality measurements (EC and TDS) indicate salinity. Comparing the two measurements, the EC value measurement is much simpler. Acquiring the TDS concentration, however, is crucial since it provides a more comprehensive explanation of the water quality than only the EC number. As a result, when conducting studies on water quality, calculating the TDS value based on the EC value is highly helpful [35]. The highest pH value was 8.2 in March and April at site 2, and the lowest value was 7.9 in October and November at site 1 (Fig. 2 F). The pH values were within the alkalinity trend during the study period, and this is a distinctive characteristic of Iraqi water and is consistent with previous studies [36; 37, 38]. We attribute this to the water's regulating capacity, which stems from its high content of carbonates and bicarbonates. During this study in the Bahr Najaf depression, the pH values ranged from 7.9 to 8.2, with the spring months recording the highest values. High temperatures and increased evaporation lead to an increase in dissolved salt concentrations in the water, particularly calcium salts [39], resulting in relatively high pH values in the alkalinity direction [40]. Statistical analysis reveals a significant positive correlation between pH and salinity in water stations.

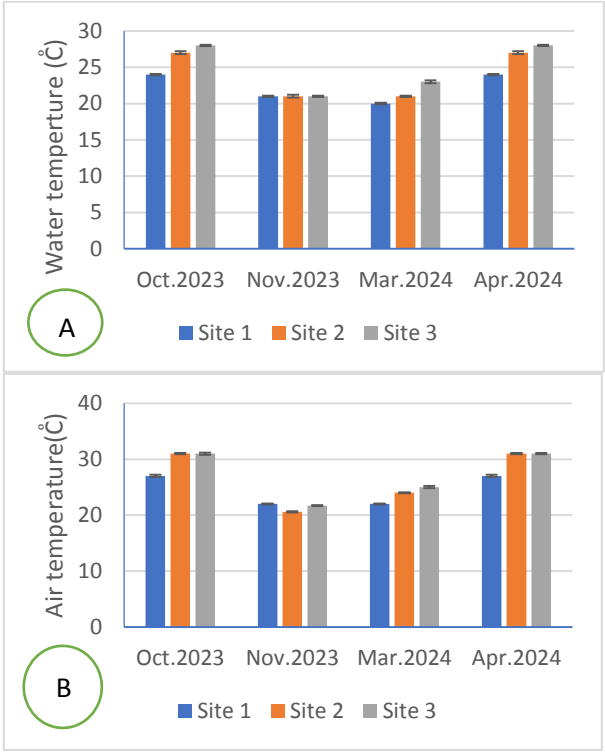

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Figure 2: Mean of physical parameter (A- water temperature B- Air Temperature C- EC D- TDS E- Salinity and F- pH in study site during study period

3.2 Chemical parameter

The DO results showed the highest value was (5.6) mg/l in March, site 2, and the lowest value was (0.73) mg/l in November, site 3 (Fig. 3A). All living things that inhabit aquatic environments depend on dissolved oxygen for essential metabolic functions [41]. Its significance in a body of water is evident since it shows the conditions there and makes the body suitable for the existence of creatures that depend on the availability of energy for development and survival. By means of respiration [42]. One of the most crucial markers for assessing the body's water quality is the amount of dissolved oxygen in the water [43]. According to [44], the atmosphere, phytoplankton, and aquatic plants that release oxygen during photosynthesis are the main sources of dissolved oxygen in bodies of water.

The BOD results also showed the highest value was 5.53 mg/l in March, site 2, and the lowest value was 0.73 mg/l in November, site 3 (Fig. 3B). The natural sources of biological oxygen demand (BOD) in surface waters are organic materials from decaying plants and animal feces. Plants supply the building blocks for proteins, which animals fertilize. Microbial processes of ammonification, deamination, and proteolysis create ammonia and hydrocarbon skeletons, the two primary chemical forms that contribute to biological oxygen demand (BOD). A variety of microorganisms, including bacteria and protozoa, metabolically oxidize these reduced nitrogenous and carbonaceous compounds in water. According to Water Quality [45], BOD is another important determinant of surface water quality.

The highest value of TH was shown (21066.66) mg/l in November, Site 3, and the lowest value was (2200) mg/l in October, Site 2 (Fig. 3D). Due to items like rocks and other materials dissolving in the water, the overall hardness content of the water recorded a higher value during the winter, a finding that was also reported by [46]. Hardness can be caused by salts that naturally accumulate in rocks, soils, and industrial waste. A greater degree of hardness results from increases in calcium and magnesium content, which correlates with the amount of multivalent cations dissolved in the water. Among the main contributors to overall hardness are magnesium and calcium. Ions and chemicals discharged into the water are the source of total hardness [47]. Considering that the soil in Iraq is calcareous [48], it is also possible to attribute the increase in hardness to rains washing the soil and transferring these ions into the river.

The highest value of Ca was observed (4382.08) mg/l in March, site 3, and the lowest value was observed (961.9) mg/l in April, site 2 (Fig. 3E).

The highest value of Mg was recorded (4625.7) mg/l in November, Site 3, and the lowest value was recorded

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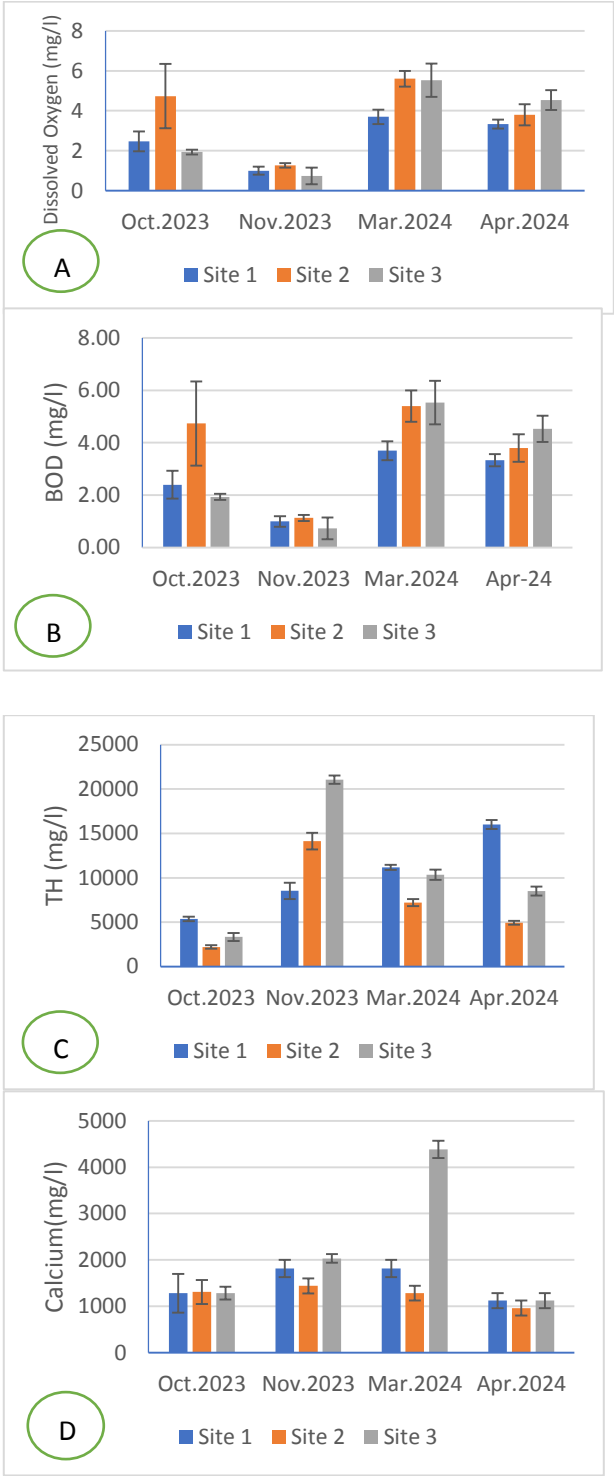
(216.4) mg/l in October, Site 2 (Fig. 3 F). Living things require magnesium, a micronutrient, in trace amounts for survival [49]. Magnesium ions aid in the creation of transport enzymes during the phosphorylation process of cellular metabolic activities. Compared to what is available in fresh water, algae photosynthesis and its requirements for metabolic activities are negligible [41].

At sites 2 and 3, soil erosion or a high discharge of waste and excreta may have caused the magnesium ion to record higher values in November than the calcium ion [50]. According to [51], there was a notable drop in the magnesium concentration in October, particularly at the second location. Since algae cells need magnesium for the synthesis of the chlorophyll molecule [41], this decrease could be due to algae consuming it, or it could be due to the presence of sulfates, which aid in depositing magnesium on the magnesium sulfate bodies of the algae cells [52]. Chloride results also showed the highest value (17061) mg/l in October, Site 1, and the lowest value (1799) mg/l in March, Site 2 (Fig. 3.F). Because they dissolve easily and adsorb poorly on metal surfaces, chloride salts are more common in water than other salts. Surface waters include significant amounts of chloride ions from several sources, including natural and industrial waste, cleaning supplies, irrigation and drainage water, and organic waste. Nature contains chlorides in a variety of forms, including calcium (Cacl), potassium (Kcl), and sodium (NaCl). The notable drop in water levels in October led to increased evaporation rates and the washing or removal of chloride-laden salts from nearby agricultural lands, particularly sodium chloride salt, which is abundant in the river area and increases the concentration of chloride ions in the water [53]. [54] also documented the discovery of elevated chloride ion concentrations in Iraqi water.



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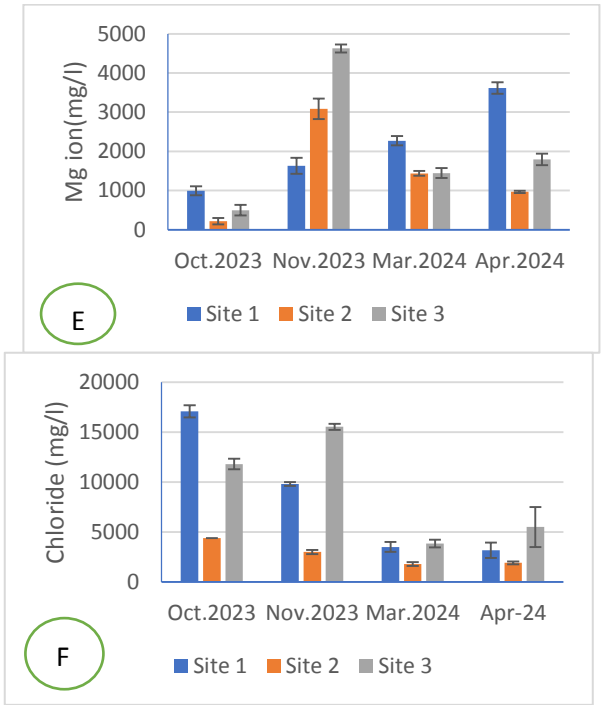

Fig.3. Mean of chemical parameters(A- DO, B- BOD, C- Total hardness , D- Calcium hardness E- Magnesium and F- Cl) in study site during study period

Classification of recorded Birds in Bahr AL-Najaf Depression

The current field surveys at Bahr Al-Najaf Depression (October 2023–April 2024) reported a total of 82 species, Throughout the six months of the study, individuals from 12 orders and 29 families were found in the investigated regions (Table 1). This represents about 18% of all the birds in Iraq (398 species) [55]. The IUCN lists this classification and conservation status globally in Table 1. The family of Scolopacidae recorded a higher percentage (17%), followed by the family of Laridae at 11% (fig. 8). This study agrees with [56], who recorded 73 species of resident and migratory birds during the period from January to December 2012, and [57], who recorded 168 species of birds during the four seasons of 2015 in the same area. It appears that the Bahr Al-Najaf area ranks well in terms of biological variety, particularly in terms of avifauna, due to the diversity of its topography and habitats. The IUCN Red List (http://www.iucnredlist.org) indicates that a number of vulnerable birds appear to be present in the research region. During the current investigation, we found four threatened bird species in the area; three were endangered, and one was vulnerable (Table 2). This increases the research area's and the neighboring areas' eligibility for protection; it also confirms and reinforces the suggestions made by [57].

Density of bird

The data analysis indicates that the total area of Najaf Depression (360,000 ha) seems to be ecologically significant for bird species. The Al-Najaf Depression was home to a bird community with 82 species. Site 3 recorded the highest number (3642 individuals/ha) in October 2023, while site 2 recorded a lower density (4 individuals/ha) in December, and site 2 recorded a higher density of 1757 individuals/ha in March (fig. 4 and 5). Notably, the majority of observed bird species and populations reside in or near wetlands. The availability of water and mudflats, which offer a variety of micro-habitats for these species and draw migrant waders and waterbirds (which are congregator species) in relatively large numbers, may be the reason why the bird species numbers and population in site 3 were highest in October [58]. It appears that the majority of the bird species that come to this marsh to rest and feed are gull, tern, duck, and other wader species. travel from Europe to Africa [59]. There could be a variety of reasons for the variations in the number of species and bird populations in this region across the seasons. The migratory birds' arrival, the area's diverse floral conditions, and the variety and accessibility of food sources that change with the seasons are all important variables [60; 61]. Most of these bird species that come to this marsh for feeding and resting appear to be migrants between Eurasia and Africa, including gulls, terns, ducks, and other wader species [59]. The number of newly discovered bird species is a sign of the area's virginity and the need for greater scientific and technological investigation to fully understand the flora and fauna of this relatively unexplored region. According to the current study, winter months have comparatively low bird species occurrence, while spring months and fall have the highest numbers of bird species (Figure 5). There is a positive relationship between bird density and EC, TDS, and salinity tables (2), as well as a negative relationship between bird density and magnesium tables (3).

Bird species

Figure 6 and 7 shows that site 2 in March 2024 reported the highest bird species count (49 species) in the research area, while site 1 in December had a lower species density (3 species). The area recorded only 20 bird species throughout December, with the majority belonging to the resident populations. Several factors contribute to this situation, including the wintertime precipitation and temperature drop in this region, as well

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as the results of recent fieldwork [56]. There is a positive relationship between the number of birds and pH Table (2), as well as a negative relationship with chloride Table (3).

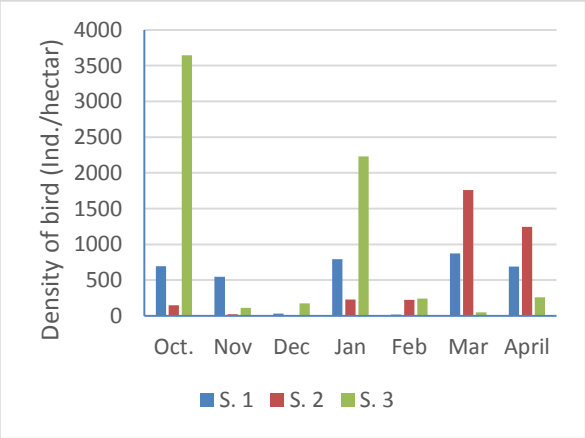

Fig.4: Density of birds in study area during study period.

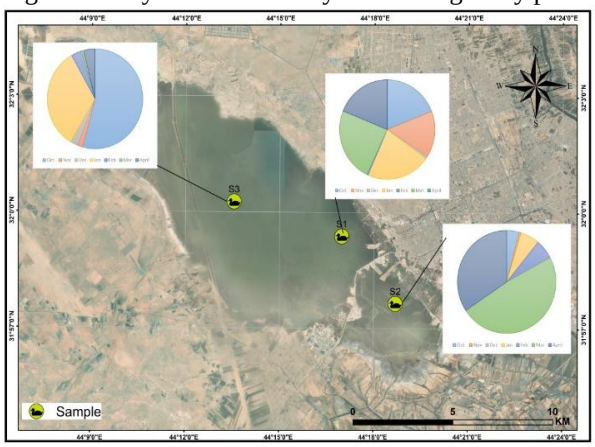

Fig.5: Density of birds in study site during study period by GIS

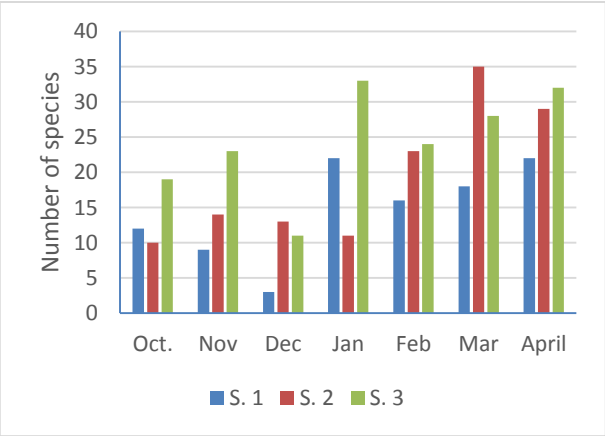

Fig.6 : Number of birds species in study site during study period.

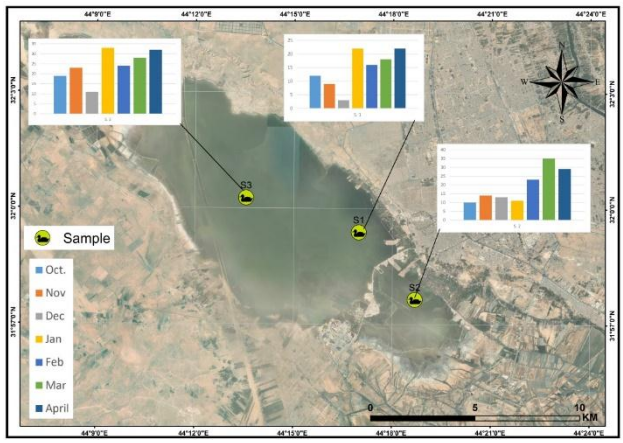

Fig.7 :Number of birds species in study site during study period by GIS.

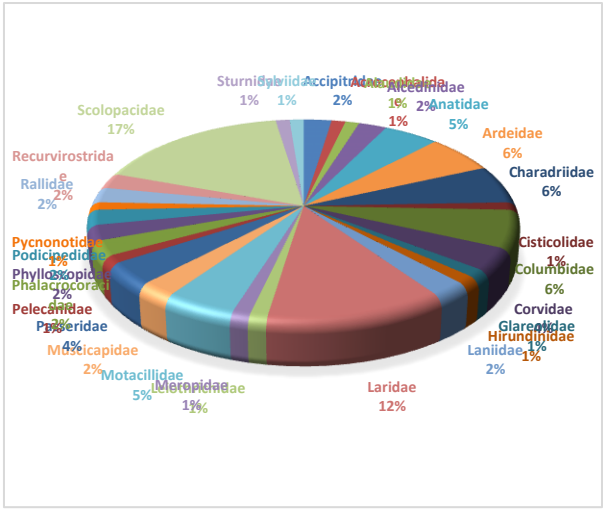

Fig.8: Percentage of birds' families in study site during study period.

Conclusion

The results show that there are 82 bird species in the region, five of which are native to Iraq. Numerous species reports from the environments under study, including birds that are of worldwide concern. The existence of endemic and globally fragile species within the research habitats demonstrates their importance for bird conservation. The Bahr al-Najaf depression is considered an important wetland area for biodiversity in Iraq. The Bahr al-Najaf depression is considered a resting and wintering area for migratory birds. The

increase in rainfall during the month of November led to a decrease in the percentage of salinity, TDS, and other physical and chemical factors in the Najaf Sea's water. The increase in aquatic plant growth in the third month led to an increase in bird diversity this month, especially at the second site. Bird density exhibited a significant positive correlation with TDS, salinity, and electrical conductivity, while Mg ions showed a significant negative correlation. The number species and pH exhibited a significant positive correlation, while the number species and chloride showed a significant negative correlation.

Acknowledgement

We thank the ecology department at the University of Kufa for supporting this work, and we thank Prof. Dr. Salwan Ali Abed for continuing and helping with the identification of birds.

Ethics

This study was conducted under approval by the medical ethics committee at the University of Kufa (2017). Verbal and written consent was provided by parents and agreement for publication was obtained from both participants and researchers.

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