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# Study Distribution of Azolla Filiculoides Lam Firstly Recorded in Al-Hawizeh Marsh of Maysan Province, Southern Iraq

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## Abstract

From December 2017 to November 2018, the community of Azolla filiculoides and its relationships with environmental variables were investigated at four sites in Al-Hawizeh Marsh, southern Iraq. The percentage of vegetation cover and biomass for A. filiculoides has also been calculated in the current study. Water temperature, mean and standard deviation for dissolved oxygen, Electrical conductivity, Nitrate and phosphate values were varied among the study sites. The vegetation cover percentage of A. filiculoides was detected monthly and seasonally. Highest value identified in August; lowest value showed in January. The maximum seasonal value of A. filiculoides revealed during the summer, minimum value done during the winter. Additionally seasonally biomass of A.filiculoides was estimated where lowest value done in Winter and highest value gets in the Summer. The mean and standard deviation of biomass showed the highest value during summer, the lowest value recorded during winter. There was a positive correlation ($P>0.05$) between high temperatures and plant density in the water, especially during summer, while it is less correlation in winter.

**Keywords**: Azolla , Vegetation cover , Biomass, Al-Hawizeh marsh , Iraq

# دراسة توزيع نبات Azolla filiculoides المسجل لاول مرة في هورالحويزة بمحافظة ميسان جنوب العراق

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## الخلاصة

في الفترة من كانون الأول/ديسمبر 2017 إلى تشرين الثاني/نوفمبر 2018، تم دراسة مجتمع Azolla filiculoides وعلاقته مع المتغيرات البيئية في أربعة مواقع في هور الحويزة، جنوب العراق. كذلك تم حساب النسبة المئوية للغطاء النباتي والكتلة الحيوية لـ A. filiculoides في الدراسة الحالية. تباينت قيم درجة حرارة الماء ومتوسط الانحراف المعياري للأوكسجين المذاب والتوصيل الكهربائي وقيم النترات والفوسفات بين مواقع الدراسة. تم الكشف عن نسبة الغطاء النباتي لنبات A. filiculoides شهرياً وموسمياً. حيث أعلى قيمة تم تحديدها في أب وأدنى قيمة في كانون الثاني. تم الكشف عن أعلى قيمة موسميا لـ A. filiculoides خلال فصل الصيف، وأدنى قيمة خلال فصل الشتاء. بالإضافة إلى ذلك، تم تقدير الكتلة الحيوية الموسمية لـ A. filiculoides حيث تم الحصول على أدنى قيمة في الشتاء وأعلى قيمة في الصيف. سجلت اعلى قيمة لمتوسط والانحراف المعياري للكتلة الحيوية خلال فصل الصيف، وأدنى قيمة سجلت خلال فصل الشتاء. كانت هناك علاقة ارتباط موجبة عند مستوى معنوية $(P>0.05)$ بين درجات الحرارة العالية وكثافة النبات في الماء خلال فصل الصيف، في حين كانت أقل قيمة للارتباط في فصل الشتاء.

**الكلمات المفتاحية:** أزولا ، الغطاء النباتي ، الكتلة الحيوية ، هور الحويزة ، العراق

## 1. Introduction

In flooded areas, floating vegetation is a common sight and plays a key role in controlling the global water balance, in particular through evapotranspiration (Kimani , et al., 2020). As a free-floating aquatic macrophyte belonging to pteridophytes, Azolla filiculoides Lamarck (Azollaceae) (water fern) has a detrimental impact on the aquatic environment due to its ability to rapidly colonize to form a dense mat over water surfaces (Taranath , et al., 2018). Therefore, when shaded by Azolla filiculoides mats (Rodríguez , et al., 2019), submerged plants turn to another morphotype and its biological characteristics lead mainly to the fertilization of nitrogen (N). Furthermore, regardless of the depth of the floodwater, Azolla's efficiency as an N substitute in agricultural ecosystems can be accomplished even when P is present (Kimani , et al., 2020).

Free-floating species that frequently inhabit wetlands have gotten a lot of attention recently because of their potential to generate a lot of biomasses, have high bioremediation rates and are inexpensive and simple to manage and harvest (Sudiarto , et al., 2019). Azolla is one of the world’s most economically important macrophytes (Kollah , et al., 2016; Kosesakal, 2018), because of its high growth rates (Muradov , et al., 2014). Using the nitrogen fixing capacity of its natural Symbiont, Azolla can grow efficiently even in the absence of nitrogen in media (Miranda , et al., 2020). The rate of plant growth and production of biomass depends on the temperature adjacent to the plant and each species has a minimum, maximum and optimum specific temperature range.

Azolla species displayed rapid vegetative proliferation under ideal conditions, with a biomass doubling period of 2 to 5 days (Sadeghi , et al., 2013).When cultivated on artificial media, wastewaters, and maturation ponds, Azolla is one of the world's fastest-growing plants, with productivity ranging from 2.9 to 5.8 g dw/m$^2$-day (10.5–21.1 t dw /ha -yr ) ( Kollah , et al., 2016). Under optimal conditions, Azolla can bloom with growth rates of up to 300 g/m$^2$, day of dry biomass (93.4–100 t dw/ha-yr) in natural habitats as rivers, lagoons, and irrigation channels (Miranda, et al., 2016).

Growth in wastewater is linked to total nitrogen (TN) and total phosphorus (TP) removal rates of up to 2.6 t N/ha and 0.434 t P/ha, respectively (Muradov , et al., 2014). Azolla is a new bioenergy feedstock with a promising future due to its unique chemical makeup (Brouwer , et al., 2016).

Together with their evolutional symbiont, Azolla representatives contain three major types of energy molecules, lignocellulose, sugars/starches, and neutral lipids, which are found separately in known terrestrial feedstocks and microalgae (Miranda , et al., 2016 ; Mouradov , et al.,.2014).

Azolla filiculoides have very high growth rates, in which the invaded area can multiply in 7 to 10 days when the temperature is between 15 and 20 ° C. It develops into very large and dense mats (up to 30 cm thick), causing eutrophication of riverine waters and reducing biodiversity in aquatic environments. In water with a pH of 3.5-10, Azolla can live, although the optimum value is 4.5-7(Sadeghi , et al., 2012).

Although Azolla belongs to its own family, the Azollaceae, it is frequently lumped in with Salvinia in the Salviniaceae family. Salviniaceae and Marsileaceae form a monophyletic group of water ferns, which are all heterosporous, ie. produce two kinds of spores, large female megaspores, and small male microspores .

This genus currently has only 6 or 7 species. Because high magnification is needed to show the distinctive features clearly, Azolla species are difficult to identify. In addition, the plants are often sterile and thus lack most of the features essential for identification (EOL, 2017).

The genus Azolla Lam. with the species Azolla filiculoides Lam. were identified and recorded for the first time for the aquatic Pteridophyta of Iraq by (Al-Saadi , et al., 2016). The species appeared for the first time in Al-Hawizeh marsh about sixty km in Maysan Southern of Iraq. Azolla filiculoides were found to be closely related to Lemna minor.

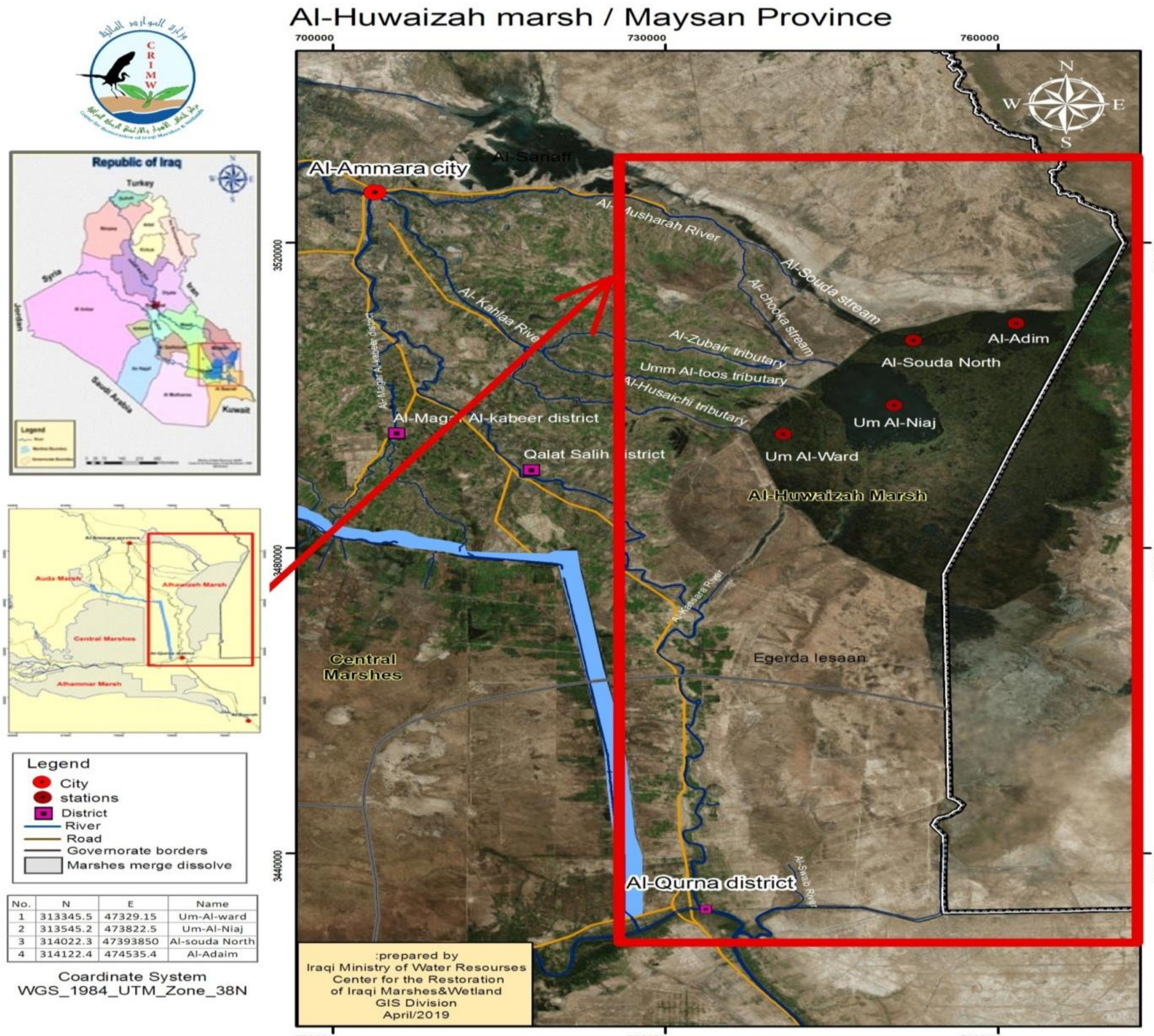
The goal of this study was to see if there was a link between Azolla invasion and water quality. (i.e. Water temperature, pH, Electrical conductivity (EC), Dissolved Oxygen, Nitrate ($NO_3$), and Phosphate ($PO_4$)) in the Al-Hawizeh marsh, as well as detected the Vegetation cover percentage (%) and the biomass of Azolla filiculoides in four studies sites within the marsh.

## 2. Materials and Methods

### 2.1. Description of study area

This is considered to be the first study for Azolla filiculoides registered on the World Heritage List in the Al-Hawizeh Marsh. Located east of the Tigris River, the Al-Hawizeh Marsh straddles the Iran-Iraq border and is approximately 70 km from Al-Ammara City. It extends between (31°00'-31o45 'N, 47°25'-47o 50' E). It is approximately 80 km long, from the Iraqi-Iranian border to the east of the Tigris River in its western portion, and 30 km wide (Abbas, 2006). The total size of the marsh during the flood season is around 2400 km$^2$, which extends to 3500 km$^2$ and shrinks to 650 km$^2$ during the dry season. The marsh reservoir is approximately 7000 billion cubic meters, collected from the excess water of the nearest Tigris and 2-4 meters above sea level (Al-Rubaiy, 1991). Two major distributors of the Tigris River, known as the Al-Musharah and Al-Kahla Rivers, feed the Al-Hawizeh Wetlands. In addition, rainfall water and water from the rivers that come from Iran, such as the rivers Al-Karkha, Tayib and Duwayaraj, which discharge into Al-Sanna'f marsh that empties into Al-Hawizeh marsh.

Azolla filiculoides and water quality data were collected and analyzed using standard methods in four areas of the marsh, namely Umm Al-Ward ( N 31°33′ 45.50″: E 47° 32′ 9.15": ), Um Al-Nia’aj ( N 31°35′ 45.15″: E 47° 38′ 22.50"), Al-Souda north ( N 31°40′ 22.26″: E 47° 39′ 50.38") and Al-Adaim (N 31° 41′ 22.36″: E 47° 45′ 35.40") in Al-Hawizeh marsh from December 2017 till November 2018 (Figure (1)). Water temperature, Electrical conductivity, and pH were measured in situ using a digital portable WTW Multi-meter model (Multi 350i meter). Whereas the Electrode method was used to measured Dissolved oxygen (DO), the Ultraviolet spectrophotometric screening method was used to measure Nitrate ($NO_3^-$) using a spectrophotometer. Additionally, the ascorbic acid method was used to determined phosphate ($PO_4^{-3}$), which was a colorimetric method by using a spectrophotometer. Water samples were analyzed by the center environmental laboratory, Ministry of Health and Environment Iraqi according to standard procedures (APHA ,2012).



| No. | N | E | Name |
|---|---|---|---|
| 1 | 313345.5 | 47329.15 | Um-Al-ward |
| 2 | 313545.2 | 473822.5 | Um-Al-Niaj |
| 3 | 314022.3 | 47393850 | Al-souda North |
| 4 | 314122.4 | 474535.4 | Al-Adaim |

Coardinate System
WGS_1984_UTM_Zone_38N

Figure (1): Al-Hawizeh marsh location in Maysan province southern Iraq (Source: CRIM 2019).

## 2.2. Water analysis

Samples of water were obtained from each stand at a depth of 0-20 cm. The digital portable WTW Multi-meter (model Multi 350i meter) was used to calculate the water temperature (C), electrical conductivity (µ.S/cm) and pH directly in the field .Incubated bottles of 300 ml of capacity were completely filled with water marsh and tightly closed with glass plugs, then measured by DO-meter in the laboratory. To revealed the phosphate ($PO_4^{-3}$) used 50 ml of filtrate water (GF/C) into a clean, dry test tube, 0.05 ml of phenolphthalein indicator was added. When a red color develops, $H_2SO_4$ solution was dropwise to just discharge the color. Then 8.0 ml of combined reagent and mixed thoroughly, after 10-30 min, measure the absorbance of each sample at 880 nm. Phosphate concentration was calculated in ppm according to the following equation:

P (mg / l) = P mg ( in approximately 58 ml final volume) × 1000 / Sample in ml .

Whereas to test Nitrate ($NO_3^-$), 50 ml clear sample (filtrate with GF/C) 1 ml of HCl (1 N) were added and mixed thoroughly, a standard curve of $NO_3^-$ was prepared using $KNO_3$ in the range of 0-7 mg/L and served as samples, the absorbance of $NO_3^-$ was measured at 220 nm , a second measurement made at 275 nm to correct the value (to avoid the interference caused by the dissolved organic matter in water). The following equation was used to calculate nitrate:

Nitrate (mg/L) = (A – B) × dilution× 4.43 Where: A = Concentration of nitrate at 220 nm, B= Concentration of organic matter at 275 nm.

## 2.3. Production of biomass

From December 2017 to November 2018, three quadrats (1 m x 1 m) were harvested monthly at each site. Azolla plants were manually picked and then washed by the water marsh and placed in plastic bags until they entered the laboratory in the herbarium of the college science in University of Basrah. Determination of Azolla filiculoides according to (Al-Mayah and Al-Hemeim 1991; Al-Mayah , et al., 2014). The plant was left air-dried and deter-mined with fresh weight. The plant was then oven-dried to a constant weight (dry weight) at 80 °C.The percentage of dry weight was determined on the basis of fresh weight.

## 2.4. Vegetation cover percentage (%) of plant

Belt Transect method was identified to assess and analyze of Azolla filiculoides plant community in the present study (Rader , et al., 2001). Percentages of vegetation cover calculated according to the Braun- Blanquet scale described in (Kent and Coker1992). Using randomly sampling plots within each plot a square of 1m × 1m at every meter mark situated at random, ten transects were established in each quadrate.

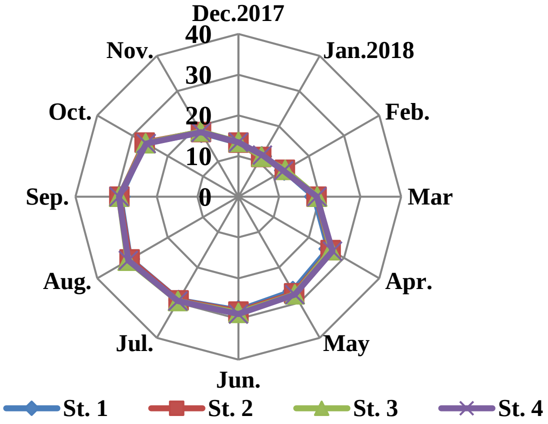
## 2.5. Statistical analysis

The data of this study treated by using two statistical programs, statistical package for social sciences (SPSS) version 22 for F-test, mean ± SD (standard deviation) for water parameters among stations and months by using analysis of variance (ANOVA) and correlation between water parameters and Azolla filiculoides. All tests were conducted at a probability of 5% level of statistical significance ($P>0.05$).

# 3. Results

## 3.1. Ecological factors

The water temperature began to fluctuate regularly in January and peaked in August 2018. Water temperature varied during the study period by minimum value of 11.3°C was recorded in January, and a maximum value of 31.4°C was tested in August (Figure (2)). Non-significant differences (P>0.05) were detected in water temperature values among study stations.



Figure(2):.Monthly variations in water temperature (°C ) at study stations of marsh

## 3.2. Hydrogen ion concentration (pH )

The monthly variations in pH values were shown in (Figure (3)). The minimum value of 7.2 was recorded in June and July at station 2, while the maximum value of 8.4 was recorded in December at the same station. Non-significant differences (P>0.05) between stations have been found.

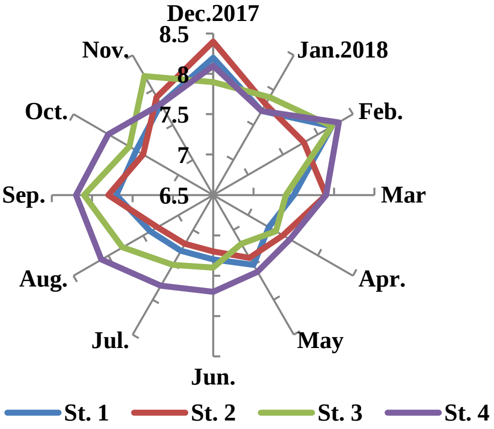


Figure (3): Monthly variations in pH values at study stations of Al-Hawizeh marsh

### 3.3. Electrical conductivity (μ.S/cm)

The EC is a calculation of the capacity of water to hold electric current, based on total dissolved salts, used as a water quality indicator. In November, the minimum EC value was 2257 μ.S/cm at station 2, and the maximum value was 6859 μ.S/cm at station 4 in April (Figure (4)). The results showed strong significant differences ($P \leq 0.05$) in EC among study stations.

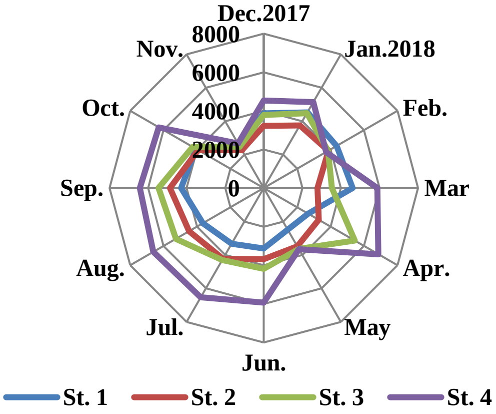


Figure (4): .Monthly variations in Electrical conductivity at study stations of Al-Hawizeh marsh

### 3.4. Dissolved oxygen (mg/L)

Dissolved oxygen (DO) is an integral parameter to be taken into account when the goal is to determine the quality of water. Monthly variations are reported in DO values. The maximum DO value of 10.5 mg/L was registered at Station 1 in April, while the minimum DO value of 1.88 mg/Lwas detected at Station 4 in September (Figure (5)). The findings showed that there were substantial differences ($P > 0.05$) in DO values between the study stations.

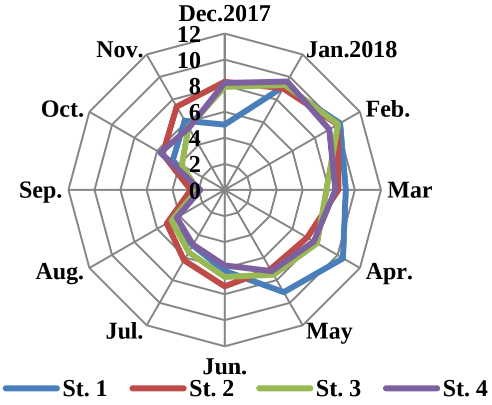


Figure (5): Monthly variations in DO values (mg/L) at study stations of Al-Hawizeh marsh

### 3.5. Nitrate ($NO_3^-$)

During the study periods, the nitrate concentrations differed considerably. A maximum nitrate value of 12.2 mg/L registered at station 4 in June and a minimum nitrate value of 1.9 mg/L at station 2 in March (Figure -6). Significant differences ($P>0.05$) in $NO_3^-$ between stations have been reported.

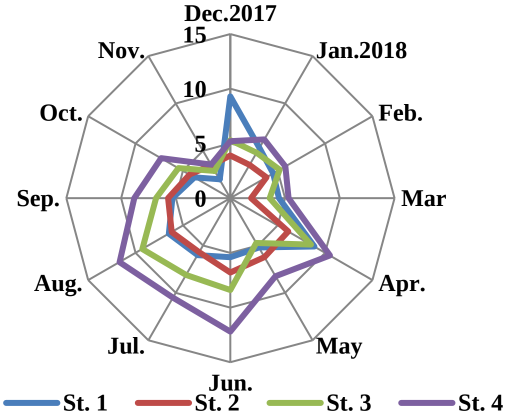


Figure (6): Monthly variations in $NO_3^-$ values (mg/L) at study stations of Al-Hawizeh marsh

### 3.6. Phosphate ($PO_4^{-3}$) mg/L

In all of the stations studied, the current results showed variations in $PO_4^{-3}$ values. The maximum $PO_4^{-3}$ value was 1.34 mg/L at station 2 in December, while the minimum value was 0.12 mg/L at stations 1 and 2 in November (Figure -7). Between the study stations, significant differences ($P>0.05$) in $PO_4^{-3}$ were detected.

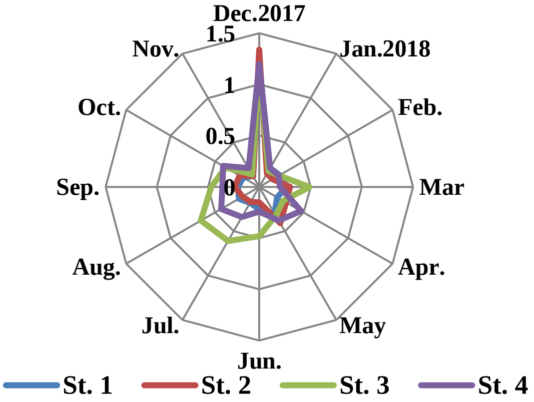


Figure (7): .Monthly variations in $PO_4^{-3}$values(mg/L)at study stations of Al-Hawizeh marsh

On the other hand, the average depth of water in the Al-Hawizeh marsh ranged from 33 cm in September to 98 cm in February, where the maximum depth of 118 cm was found at station 2 in April, while the minimum depth of 27 cm was registered at station 4 in September. Significant differences ($P\leq0.05$) were found between study stations in water depth.

### 3.7. Distribution of plant

Azolla filiculoides plant community was distinctly varied in the marsh which corresponds to hydrological and geomorphic differences. The free-floating plant A, filiculoides presented at all stations of the marsh. So, it was recorded for the first time at all studies stations throughout the study period with different densities in the marsh (Photos 1 and 2). Additionally, it is not recorded before this study in Marsh since 1980. Furthermore, A. filiculoides species was growing heavily at station 2 compared with others 1,3 and 4 stations, which may be due the present abundant quantities of water, availability conditions for plant growth, high concentrations of dissolved oxygen in water, also rich available nutrients in this site.

### 3.8. Vegetation cover percentage (%)

Vegetation cover has played a clear role in maintaining the natural environment and improving human lives and other living species, but the negative shift that occurs to vegetation cover as a result of human activity or other causes, such as habitat balance destruction, biodiversity loss, and poor water, frequently reach to a drastic limit (Cross and McInerny 2006). Where the highest value 79 % found in August at station 3, while the lowest value 25 % reported in January at station 4. The monthly variations in vegetation cover percentages (%), mean and standard deviation (mean% ± standard deviation) in all studied stations of marsh are shown in (Table (1)). Thereby, the highest vegetation cover percentages were recorded during the summer months, while the lowest percentages were revealed during winter. These variations may due to many reasons, as the variation in quantities of water flowing to the marsh, depth of water in studies stations, and the environmental variables, which are the most important role of these changes in periods of plant growth.

Photo (1): Spread and distribution of Azolla filiculoides to form a mat in some studies area

Photo (2): Morphological shape of Azolla filiculoides in water of Al-Hawizeh marsh

On the other hand, the highest annual rates of vegetation cover for Azolla filiculoides, have recorded 56.5±14.57 at station 2,the lowest annual rates of vegetation cover gave 42.17±13.74 in station 4. Whereas the mean % and standard deviation (mean%±SD) of vegetation cover for A. filiculoides achieved 50.48±6.44 for this species during the study period (Table (1)).

Table (1): Monthly and annually vegetation cover percentages (%), mean and standard deviation (mean%±SD) of Azolla filiculoides community of four stations within Al-Hawizeh marsh

| Station | Dec.18 | Jan.18 | Feb.18 | Mar.18 | Apr.18 | May.18 | Jun.18 | Jul.18 | Aug.18 | Sep.18 | Oct.18 | Nov.18 | Average ± SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station1** | 28 | 32 | 36 | 37 | 39 | 41 | 57 | 68 | 73 | 67 | 58 | 49 | 48.75± 15.41 |
| **Station2** | 36 | 38 | 43 | 45 | 48 | 51 | 71 | 73 | 75 | 72 | 65 | 61 | 56.5±14.57 |
| **Station3** | 36 | 37 | 38 | 40 | 46 | 52 | 66 | 71 | 79 | 68 | 64 | 57 | 54.5±15.05 |
| **Station4** | 26 | 25 | 27 | 33 | 35 | 39 | 48 | 60 | 66 | 56 | 48 | 43 | 42.17±13.74 |
| **Total** | 31.5 | 33 | 36 | 38.75 | 42 | 45.75 | 60.5 | 68 | 73.25 | 65.75 | 58.75 | 52.5 | 50.48±6.4 |

Vegetation cover of plant:

The seasonal variations in cover vegetation values (%) for Azolla filiculoides throughout four seasons within Al-Hawizeh marsh detected the highest values 73% in Um Al-Nia'aj (station 2) during summer, the lowest value achieved 26% in Al-Adaim (station 4) during winter, these values were obtained from monthly tested which conducted in the study area. Additionally, the highest average cover vegetation of Azolla filiculoides done 67.25% in summer, but lowest average of cover was 33.5% in winter, thus the results revealed the highest values were during summer, lowest values noted in the winter season (Table (2)).

Table (2): Seasonal variations in vegetation cover (%) of Azolla filiculoides in four stations of Al-Hawizeh marsh

| Station | Winter | Spring | Summer | Autumn |
|---|---|---|---|---|
| Station 1 | 32 | 39 | 66 | 58 |
| Station 2 | 39 | 48 | 73 | 66 |
| Station 3 | 37 | 46 | 72 | 63 |
| Station 4 | 26 | 35.67 | 58 | 49 |
| Average | 33.5 | 42 | 67.25 | 59 |

### 3.9. Biomass of plant

Biomass comprises live and dead parts of live plants that are still attached, while peak biomass is the single largest value of the plant material present during the growing season (Westlake 1969). In other words, biomass is an organic, non-fossilized material that resides in a given ecosystem consisting of both living and non-living beings (Velázquez-Martí 2017) which reached its peak of growth in the summer season. There is a disparity between the biomass values found in the winter and summer seasons. Azolla filiculoides ranged from 47 gm/m$^2$ at station 4 during the winter to 138 gm/m$^2$ at station 2 during the summer. Biomass values of 126.5 ± 13.12 gm/m$^2$ were typically the highest mean and standard deviation (mean± standard deviation) during the summer, the lowest value 60 ± 10.65 gm/m$^2$ occurred during the winter (Table .3).

Table (3): Biomass values (gm/m$^2$)for Azolla filiculoides during Winter and Summer seasons

| Season | Station 1 | Station 2 | Station 3 | Station 4 | Average ±SD |
|---|---|---|---|---|---|
| Winter | 58 | 71 | 67 | 47 | 60 ± 10.65 |
| Summer | 124 | 138 | 135 | 109 | 126.5 ± 13.12 |

## 4. Discussion

Azolla filiculoides community distributions correlated with water temperature, one of the environmental variables that influenced the distribution and abundance of this species was necessary. Electrical conductivity can also be involved in variations in the distribution of these species by dissolved salts in water within the marsh. In addition, the overlapping of living and non-living influences, either directly or indirectly affects the distribution and movement of Azolla filiculoides throughout aquatic environments (Dudgeon, 1995).

The findings gave a simple picture of A. filiculoids density in all stations, with variations in water levels at each station. Azolla filiculoides form thick mats and outcompete native plant species, characterized by the dominance of this plant in stations 2 and 3. These infestations will reduce the amount of light below the mats and cause the water column and any vegetation cover to be shaded, as well as cause water plants and algae to die off and reduce the level of water oxygenation levels with serious impacts on fish and other fauna (Olguin et al.2002) .

Not only does very little survive under such circumstances, but the consistency of the water, induced by bad odors, color, and turbidity, is decreased. A. filiculoides are capable of blocking canals, drains, and overflows and may increase the risk of flooding.

The spatial variations in water temperature among stations may be due to the change in the sampling time or due to the change in depth of water at each station.

DO concentrations rely on several factors, including the amount of rainfall, water temperature, Salinity, decomposition of organic waters, aquatic vegetation. The increasing in quantities of water , that may due to the rainfall and increasing water flow, thus lead to increase the DO concentrations in water. Moreover, the rising in temperature from June until November months lead to the decline of DO concentration in water, also the highly in EC values during hot months caused the decreasing in solubility of oxygen gas in water. In addition to lowest values of DO this may due to low water levels in the study area because lack of water flow from the Tigris River input to marsh, thus high consumption rate and decomposition activities that coincided with the decline in gas solubility.

The results showed increase total hardness in water from period June to September, that may be due to the decreasing in quantities of water flowing into the marsh of the feeding Rivers, the high evaporation rate due to high temperatures in these months. The  an increase in calcium values during cold months (December, January and February), this might be due to the increase in water levels because of the rain falls that bring salts including calcium leading to increase $Ca^{+2}$ concentration in water, also the decrease of temperature helps at $CO_2$ increasing in the water and forming carbonic acid that helps in dissolution the salts of calcium (Maulood ,et al.,1990; Al-Nimrawee, 2005).

Nitrate concentrations were increased in the spring and summer months because the high concentration of nitrate may be due to water temperature that increases algal growth and decomposition of death algal or may due to influx nitrogen rich flood water that brings large amounts of contaminated sewage water (Pradeep , et al., 2012).

Coverage of vegetation is a significant component of wetland ecosystems, and the contribution of wetland vegetation to carbon sinks and carbon sources can be quantified by biomass (Janes , et al., 1996). In addition, wetland biomass estimation plays an important role in understanding complex changes in the ecology of wetlands (Liao , et al.,.2013).

Nitrogen and phosphorus are the two main nutrients that determine plant growth (Esteves 1998 and Trindade , et al., 2012), and the main sources to fixation nutrients for A. Filiculoides in a column of water. Therefor the biological fixation by cyanobacteria results in the bulk of nitrogen in the tissues of plant (Arora and Singh 2003 and Cheng , et al., 2010). Since the nitrogen requirement of the macrophyte is fulfilled by the symbionts phosphorus is the most essential (i.e. limited) nutrient for Azolla (Biswas , et al., 2005). However, despite the fact that the establishment of Azolla runs parallel to marshland eutrophication in Al-Hawizeh marsh, a significant relationship between its vegetation cover and phosphate concentration in the water was not identified.

A lack of phosphorus causes a broad breakdown in plant metabolism, which leads to the formation of pigments (Adalberto , et al., 2004). A high concentration of P, on the other hand, boosts the plant's C and N accumulation and accelerates its growth, boosting the production of blooms (Cheng , et al., 2010 and Carrapico, 2006). Additionally, Plant growth in freshwater is limited by the availability of essential nutrients, at least during the growing season .The findings showed that the availability of the nutrient decreases in the atmosphere if the plant raises the amount of this nutrient in the tissues. The high coverage of the marsh surface by A. filiculoides (more than 50% throughout the year) supports the hypothesis that this macrophyte is important for nutrient regulation in this ecosystem. The lack of association between water nitrogen and plant nitrogen, however, indicates that this nutrient is supplied by cyanobacteria symbiosis (Trindade , et al., 2012).

Several factors, including temperature, photosynthetically active radiation, water level, nutrients, and the availability of organic carbon (Trindade , et al., 2012 and Camargo , et al.,.2003), influence the biomass productivity of aquatic macrophytes, however, the greatest biomass values were reported during the warmest months (summer season).

In this research, Positive associations between biomass and water temperature occurred with A. filiculoides. where the highest value of biomass for the plant was 138 g DW during summer season, probable that the growth season of the macrophyte began during this period.The findings are consistent with the hypothesis that the health of floating macrophytes may be determined by temperature as a significant factor(Netten, et al. 2010 and Peeters , et al., 2013) .

During the winter, warm temperatures can open "windows of opportunity" that encourage the rapid growth of Azolla mats before submerged macrophytes are formed in spring season. A positive increase in the fitness of floating species (Azolla among others) in response to local warming has also been described in temperate areas.

Furthermore, the early expansion of Azolla mats during late winter and early spring might enhance its own growth by warming up the top layer of water through the absorption of irradiance, and reducing water mixing through a reduction in wind action (Netten , et al.,. 2010 and Room & Kerr, 1983). The presence of A. filiculoides throughout the year (more than 50%) supports the concept that this macrophyte is crucial for nutrient management in this ecosystem. This approach could be useful in wind-protected places or open waterways where Azolla mats can be rather huge. As a result, there could be a positive loop between Azolla growth and warming.

Disruptions that occur in some wetlands, such as water depletion of nutrients and lack of sediment content, especially nitrogen and phosphorus, play an important role in reducing the average biomass accumulation in aquatic plants (Barko , et al., 1991 and Wang & Yu 2007). Thus, the highest biomass values were recorded at station 2 (Um Al-Nia'aj) of which have relatively low salinity compared with the biomass of the aquatic plants in station 4 (Al-Adaim), that due to the variations in water flow levels entering to the stations, depth water among stations, decrease the densities of plants in this station, and provided the nutrients .

The findings describe seasonal and spatial differences in aquatic plant biomass values. In the present study, the highest biomass levels were studied in the summer season compared to the winter season (Table 2), the fact that plants get peaks in growth and storage of organic matter occurs during the summer months, especially in August that due to result availability all the necessary components of intensity solar radiation and the availability of nutrients and high - degrees, whereas (Kufel & Kufel ,2002) has reported that the plant biomass at the end of autumn and winter seasons was reaching to almost half the value of the crop in August, meaning that half the amount of nutrients stored in plants to the season next growth .

Some biotic variables, such as inter-specific rivalry and co-existence, are important factors for population structuring in the ecosystem of aquatic plants (Van gerven , et al., 2015 and Moura Junior , et al., 2016). Furthermore, the response of aquatic plant biomass to water level fluctuations gives divergent results with respect to plant species (Byun , et al., 2017) .

The ability of aquatic macrophytes to absorb and convert $NO_3$ and/or $PO_4$ to organic compounds is linked to their biomass productivity, according to (Camargo , et al., 2003, Bottino , et al., 2013).

In addition, the response of aquatic macrophyte biomass to limnological changes after water level fluctuations, increases or decreases, depending on the variable or species (Moura Júnior , et al., 2019). In general, vegetation cover has a role in influencing on biomass values. The biomass values of A.filiculoides was associated with the percentage of coverage in stations during the study period within the marsh and at the time of year that as shown in (Table (2)).

## 5. Conclusion

Azolla filiculoides community in Al-Hawizeh marsh has a positive correlation with water temperature, also the density and vegetation cover of this species increased more through summer than the winter season, where the highest average cover vegetation of Azolla filiculoides done 67.25% in summer, but lowest average of cover was 33.5% in winter. As well as, the highest mean and standard deviation (mean± standard deviation) of biomass for A. filiculoides achieved 126.5 ± 13.12 gm/m2 during the summer, whilst the lowest value was 60 ± 10.65 gm/m2 occurred during the winter as shown in (Table (3)).

From the results of the current study, observed the vegetation cover values were positively correlation with biomass values in all the study seasons within marsh. Additionally, the vegetation cover of the marsh surface by A. filiculoides throughout the study period and the nutritional status of the plant demonstrate the importance of the cycling of nutrients by macrophytes in this aquatic environment.

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