http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2020.1055.1059

Research Article
Native Growth and Conservation of Duckweed (Lemnaceae) in Jordan

Maisa'a W. Shammout

Water, Energy and Environment Center, The University of Jordan, Amman 11942, Jordan

Abstract

Background and Objectives: Duckweeds are the world's smallest flowering plants. Its existence is affected by the water quality and availability. The increased water demand and water scarcity in most of the Mediterranean countries as Jordan have caused remarkable lowering in the water-table which reduced floods and disappearance of the seasonal lakes. Due to this, aquatic plants that grow on good quality of fresh water have disappeared totally. Therefore, this paper highlights the native growth and conservation of duckweed (Lemnaceae) in Jordan. It also focuses on the identification of water sources for duckweed's movement. **Materials and Methods:** Field surveys were conducted to identify water source for water bodies that contain duckweeds. These surveys included visits to the Zarqa river, dams, irrigation ponds and Jordan valley. The source of water for duckweed movement and availability was determined. Water samples from the targeted areas were analyzed for selected parameters as pH, EC, NO_3, PO_4, BOD_5, Zn, Pb, Cd and Cu. **Results:** The results showed that King Abdullah Canal and Zarqa river are the water sources that encourage the duckweeds growth. In Sukhnah, Jerash and Jordan valley areas, water analysis ranges (mg L^{-1}) are: NO_3 0.7-38, PO_4 0.3-7.6 and BOD_5 0-20. The pH range value is 7.1-8.1 and EC range value is 1.62-2.5 mS cm^{-1}. The heavy metals values are, Zn is <0.02 mg L^{-1}, Pb is <0.01 mg L^{-1}, Cd is <0.002 mg L^{-1} and Cu is <0.01 mg L^{-1}. **Conclusion:** It can be concluded that mitigation measures are highly needed to overcome and altering the quality of the natural water flowing and participation of governmental institutions is also required for the success of applying mitigation measures to preserve the aquatic plants.

Key words: Aquatic plants, duckweed (Lemnaceae), *Lemna* sp., mitigation measures, water ecosystem conservation

Citation: Maisa'a W. Shammout, 2020. Native growth and conservation of Duckweed (Lemnaceae) in Jordan. Pak. J. Biol. Sci., 23: 1055-1059.

Corresponding Author: Maisa'a W. Shammout, Water, Energy and Environment Center, The University of Jordan, Amman 11942, Jordan

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Jordan is a semi-arid country that is largely influenced by the range of mountains in the west. The western part of Jordan has a Mediterranean climate that is characterized by a hot, dry summer and a cool, wet winter that are separated by two short transitional periods. The southern and eastern parts are arid with hot, dry summers and cold and dry winters. Rainfall is the main source of water in the country. It is largely confined to the winter and early spring seasons, ranging from over 500 mm in the highlands to less than 50 mm in the east. Approximately 92.5% of total annual rainfall is lost through evaporation, while the rest flows as flood and recharges the ground water[1,2].

Concerning the Jordan fresh water ecosystems and aquatic plants: Jordan has only one river well known as the baptism place for the Holly Jesus Christ. Jordan river is running on a very shallow level with increasing situations in the winter times. In old days, before 1965 the river used to flood and forms sort of shallow seasonal swamps. These conditions have formed beautiful riparian vegetation dominated by shrubs and low trees[3]. Now-a-day, most valleys have slow running water and have polluted water with various types of influxes as treated wastewater. Due to this, edible and ornaments water plants that grow on good quality of fresh water have disappeared totally[3,4]. The Zarqa river is an important example in Jordan, where its flow mixed with treated wastewater and finally stored in King Talal Dam, which located at the outlet of the basin where the dam's water is used for irrigation in the Jordan valley[2]. The treated effluents are discharged into the Zarqa river altering the quality of the natural water flowing and causing disappearance of many aquatic plant species[4]. In addition, the increased water demand and water scarcity in most of the Mediterranean countries as Jordan have caused remarkable lowering in the water-table which reduced floods and disappearance of the seasonal lakes.

Richness in biodiversity is one of the important characteristics of Jordan especially, plant biodiversity. Duckweeds are one of the aquatic plants that have been recorded in Jordan[5]. Duckweeds are free-floating aquatic plants, characterized by continual rapid growth that can completely cover the surface of water in a thick, green layer. Duckweeds (Lemnaceae) are the smallest and fastest-growing plants in the world, frequently doubling their biomass in two days or less[6] under optimum conditions of nutrient availability, sunlight and temperature. They grow at water temperatures[7] between 6 and 33°C. Duckweed can tolerate a wide range of pH which varies[8] from 3.0-10.0. A 7.5 pH was found to be the most ideal for the successful establishment of a duckweed system and optimum pond performance. Duckweeds primarily reproduce by vegetative growth and exist as fronds. The fronds are green, leaf like structures, a few millimeters in size and each new daughter frond develops from mother frond[9]. The daughter frond repeats the history of its mother frond. This results in exponential growth, until the plants become crowded or run out of nutrients. Average growth rates tend to decrease from: nutrient scarcity, temperature and crowding by overgrowth of the colony[10]. Salinity is likely to be the major limiting factors for distribution of plant species in lakes environment[11].

In 1982, duckweed *Lemna* sp. has been found in water bodies of the Kingdom of Jordan[5] and in 1986, duckweeds *Lemna* sp. have been reported in the Flora Palaestina[12]. In the year 2015, field surveys have been conducted to find the water bodies that contain the recorded duckweed[13]. Therefore, this paper highlights the native growth of duckweeds in Jordan, with the aim of identifying the water source that encourages the native duckweeds growth and movement across the water flowing. In addition, it will provide mitigation measures to preserve water ecosystem and aquatic plants.

MATERIALS AND METHODS

Identification of water source for duckweed movement and availability: Field surveys were conducted with the goal of identifying water source of water bodies that contain duckweed plants. These surveys included visits to the water flow of the Zarqa river, dams, irrigation ponds and lowlands of the Jordan valley (Ghors).

The source of water for duckweed movement and availability was determined. Twenty water samples were collected from each targeted area for water analysis in order to determine the range of quantitative values (Table 1). The analysis of this study was conducted at the laboratories of the University of Jordan from February, 2015-July, 2016 according to the Standard Methods of the American Public Health ssociation[14]. The parameters of the analysis are Power of Hydrogen (pH), Electrical Conductivity (EC), Nitrate (NO_3), Phosphate (PO_4), Biological Oxygen Demand (BOD_5), Zinc (Zn), Lead (Pb), Cadmium (Cd) and Copper (Cu). The methods of analysis of pH, EC, NO_3, PO_4, BOD_5 are pH-Meter, Field Conductivity, 4500-NO_3 B-Spectrophotometric Method, 4500-P-D Stannous Chloride Spectrophotometric Method and 5210D Respirometric Method, respectively. The method of analysis for Zn and Cd is 3111B atomic absorption spectrometry. The method of analysis for Pb and Cu is 3111C atomic absorption spectrometry[14].

RESULTS AND DISCUSSION

Water source and duckweed movement identification: The results of field visits showed that the aquatic duckweed plants grow naturally at Sukhnah and Jerash areas based on the flow of Zarqa river. Duckweed also grows at different areas of the central Jordan valley, particularly in the irrigation ponds of several farms. Figure 1 showed the water source for duckweed growth. It can be seen from Fig. 1 that the water source for the irrigation ponds that contains duckweed at the central Jordan valley is the King Abdullah Canal. This canal is fed by the reservoir of the King Talal Dam, which is fed by the Zarqa river of the Zarqa Basin. The river consists mainly of its base flow and the flow of the effluent of domestic water treatment plants[15,16]. This means that the Zarqa river contributed a vital role in the environment that encourages the growth and movement of duckweed across the river. Zarqa river supported the duckweed's areas with preferable nutrients of NO_3 and PO_4 to grow naturally.

Table 1: Range of pH, EC, NO_3, PO_4 and BOD_5 that encourages the duckweed growth

Parameters	Numbers	Sukhnah, Jerash and central Jordan valley
pH	20	7.1-8.1
EC (mS cm^{-1})	20	1.62-2.5
NO_3 (mg L^{-1})	20	0.7-38
PO_4 (mg L^{-1})	20	0.3-7.6
BOD_5 (mg L^{-1})	20	0-20
Zn (mg L^{-1})	20	<0.02
Pb (mg L^{-1})	20	<0.01
Cd (mg L^{-1})	20	<0.002
Cu (mg L^{-1})	20	<0.01

Table 1 shows the range of pH, EC, NO_3, PO_4, BOD_5, Zn, Pb, Cd and Cu that encourage the duckweed growth. The range of pH at Sukhnah, Jerash and central Jordan valley areas is 7.1-8.1, whereas the Electrical Conductivity (EC) is between 1.62-2.5 mS cm^{-1}. The range of values of NO_3 is between 0.7-38 mg L^{-1} and PO_4 is between 0.3-7.6-mg L^{-1}. The range value of BOD_5 (mg L^{-1}) for these areas is between 0-20 mg L^{-1} and the heavy metals values are Zn is <0.02 mg L^{-1}, Pb is <0.01 mg L^{-1}, Cd is <0.002 mg L^{-1} and Cu is <0.01 mg L^{-1}. The

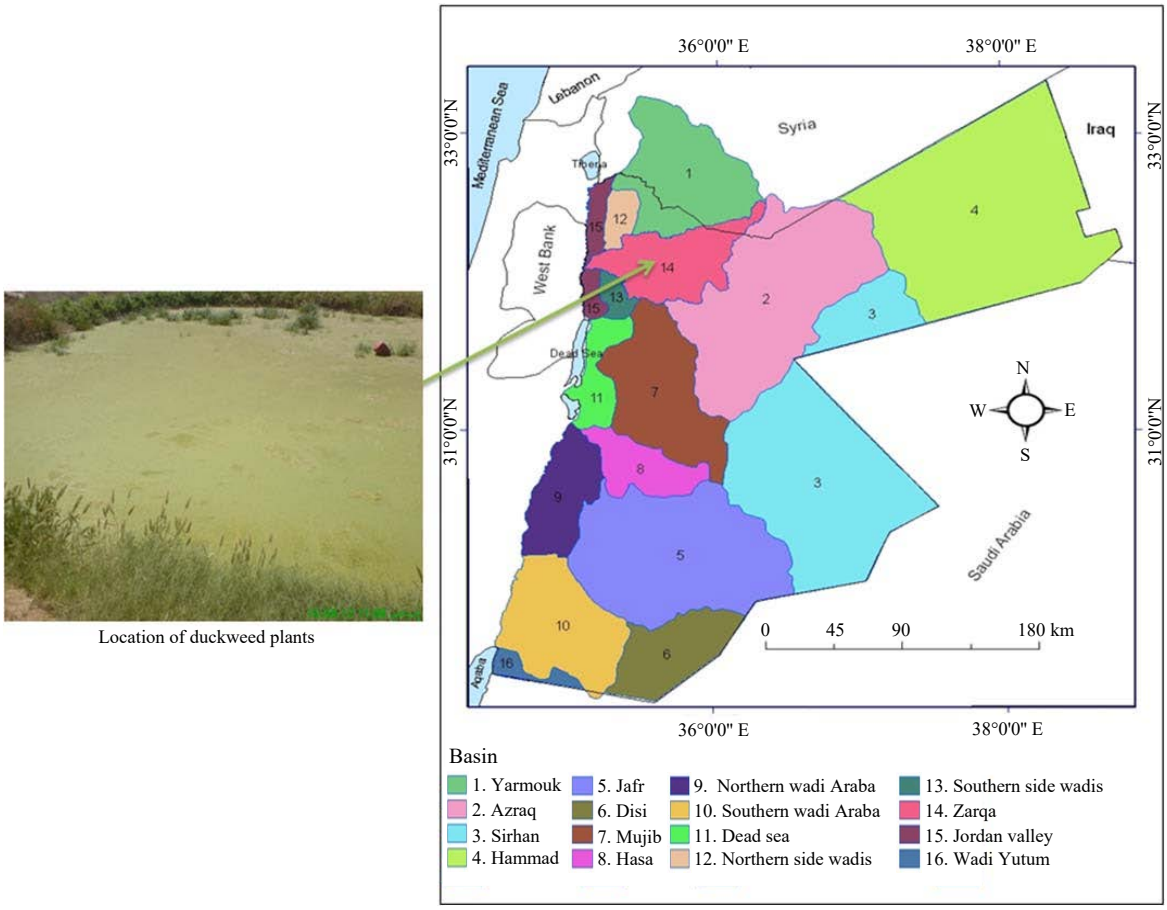

Fig. 1: Water source for duckweed growth

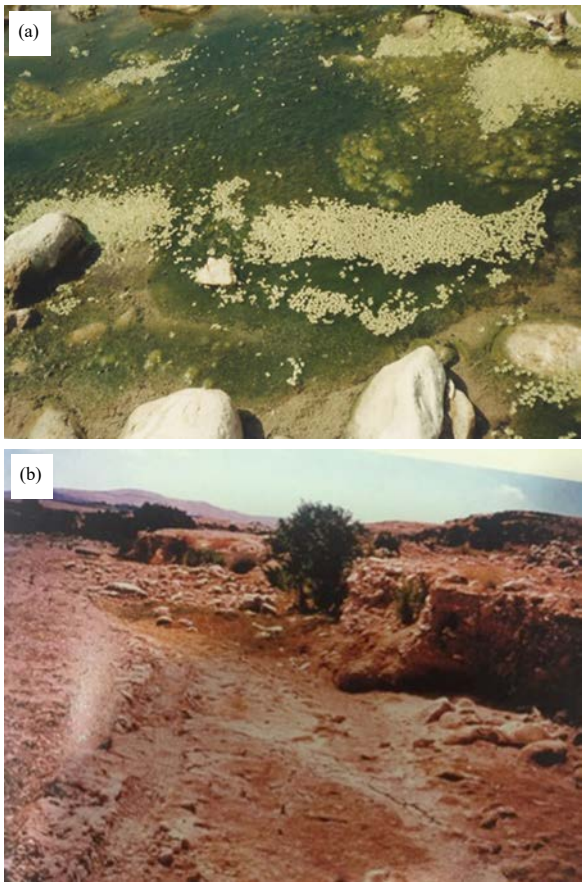

Fig. 2(a-b): Duckweed growth in Sukhnah according to fluctuation in water, (a) Wet and (b) Dry areas

variation in pH values at different areas of duckweed existence is due to the ability of duckweed to form a mat over the surface of water bodies. Biomass of duckweed mats of unmanaged colonies, enhances the pH variation. This is a competitive advantage of duckweed which reduces the production of carbon dioxide from other growing aquatic plants, thus, the reduction of CO_2 elevates the pH of the duckweed water. Whereas, the importance of EC variation is due to the duckweed's absorbance of nutrients which reduces water conductivity. The range of values of NO_3 and PO_4 are due to the flow of the treated domestic wastewater and also due to the crop fertilizers in irrigation water[15] as well as the BOD_5. In case of BOD_5 value is 0 mg L^{-1}, because the water is sometimes not stagnant as in irrigation ponds.

With regards to the duckweed availability in Jordan: Duckweed's growth rate varies from one month to another and from location to another. Its existence is highly affected by many environmental factors as fluctuation in water availability and quality. Where, Jordan is known for severe water scarcity as well as the heavy utilization of many springs by farmers for irrigation has seriously affected the river base flow. These situations have resulted in reducing the base flow of the Zarqa river from 5 m^3 sec^{-1} to lower than 1 m^3 sec^{-1} and the discharge of the springs reduces from an of average 317 MCM/year prior to 1985-130 MCM/year after 2000[2].

Figure 2 shows the duckweed growth in Sukhnah according to fluctuation in water, (a) Wet and (b) Dry areas. At Sukhnah and Jerash areas, it is noticed that during the month of June through October, duckweed plants tend to flourish, become green in color and healthy nature. From the month of October through winter time, the duckweed disappears based on the water availability. At central Jordan valley area, it is noticed that duckweed is available all year around. As long as water is present in irrigation ponds, duckweed will prosper and grow natively. During availability of water at Sukhnah, Jerash and central Jordan valley, duckweeds grow in a dense green aggregation that their fronds can completely hide the water giving impression of dry land. The roots of duckweed are serving chiefly as anchor to keep the fronds right side up and to protect colonies is dispersal by water motion.

Mitigation measures to preserve water ecosystem: It is known that there are many environmental factors and human interferences affecting the natural water ecosystem and causing disappearance of many aquatic plant species[5]. Thus, mitigation measures are highly needed to overcome the altering the quality of the natural water flowing[3]. Thereby, the mitigation measures are as follow:

- Reduction of ground water pumping to restore the balance to water ecosystem and aquatic plants
- Make sure that the quality of discharged wastewater is sufficiently treated before mixing with natural water flowing
- Governmental institutions involvement is highly important for the achievement of applying mitigation measures to preserve water ecosystem and aquatic plants
- It is recommended that the treated wastewater should be diverted for relevant uses as botanical gardens irrigation

CONCLUSION

The Zarqa river contributes a vital role in transferring duckweed across the river flowing. It supports the duckweed's areas with preferable environment to grow naturally. At areas of Sukhnah, Jerash and central Jordan valley, water analysis

ranges (mg L^{-1}) are: NO_3 0.7-38, PO_4 0.3-7.6 and BOD_5 0-20. The pH range value is 7.1-8.1 and EC is 1.62-2.5 mS cm^{-1}. The heavy metals values on average in mg L^{-1} are: Zn is <0.02, Pb is <0.01, Cd is <0.002 and Cu is <0.01.

Duckweed's growth rate varies from one month. Its existence is highly affected by fluctuation of water availability. As long as water is present, duckweed will prosper and grow natively.

Mitigation measures are highly needed to overcome the alterations the quality of water resources, such as, reduction of ground water pumping to restore the balance to the water ecosystem and aquatic plants and ensure that wastewater effluents are appropriately treated. In addition, participation of government and stakeholders are highly needed for the achievement of implementing mitigation measures.

Further studies of the preserve aquatic plants, particularly duckweeds (Lemnaceae) are a high priority. These studies should focus on water quality and availability to conserve water ecosystem.

SIGNIFICANCE STATEMENT

This study is unique in its nature. It focuses on the locations of duckweeds availability in Jordan. It also highlights the identification of water sources for duckweed's movement. As well as, the mitigation measures to conserve duckweeds (Lemnaceae) and the water ecosystem. This study will help the researchers in finding ways to restore the balance to the water ecosystem and aquatic plants. Thus, further studies of the preserve duckweeds and aquatic plants are a high priority. These studies should focus on water quality and availability.

ACKNOWLEDGMENTS

The author thanks editors and reviewers for their commitment to publication process.

REFERENCES

1. MWI., 2016. Water sector capital investment plan 2016-2025. Ministry of Water and Irrigation (MWI), Amman, The Hashemite Kingdom of Jordan. http://extwprlegs1.fao.org/docs/pdf/jor169840.pdf
2. Shammout, M.W., 2003. Land use options for surface water management in Zarqa river basin using modeling tools. Ph.D. Thesis, The University of Jordan, Amman, Jordan.
3. Al-Eisawi, D.M., 2012. Conservation of natural ecosystems in Jordan. Pak. J. Bot., 44: 95-99.
4. Al-Eisawi, D.M.H., 2004. Water scarcity in relation to food security and sustainable use of biodiversity in Jordan. Proceedings of the International Forum on Food Security under Water Scarcity in the Middle East: Problems and Solutions, November 24-27, 2004, Como, Italy.
5. Al-Eisawi, D.M., 1982. List of Jordan vascular plants. Mitt. Bot. Staatssamml. Münch, 18: 79-182.
6. Culley, Jr. D.D., E. Rejmankova, J. Kvet and J.B. Frye, 1981. Production, chemical quality and use of duckweeds (*Lemnaceae*) in aquaculture, waste management and animal feeds. J. World Aquacult. Soc., 12: 27-49.
7. Leng, R.A., J.H. Stambolie and R. Bell, 1995. Duckweed-a potential high-protein feed resource for domestic animals and fish. Livest. Res. Rural Dev., Vol. 7, No. 1.
8. Landolt, E., 1986. Biosystematic Investigations in the Family of Duckweeds (Lemnaceae): The Family of Lemnaceae-A Monographic Study. Vol. 2, Institut ETH, Zurich, Switzerland.
9. Gaigher, I.G. and R. Short, 1986. An evaluation of duckweed (Lemnaceae) as a candidate for aquaculture in South Africa. Aquaculture, 15: 81-90.
10. Skillicorn, P., W. Spira and W. Journey, 1993. Duckweed Aquaculture a New Aquatic Farming System for Developing Countries. World Bank Publications, Washington DC., USA., Pages: 76.
11. Ramadan, A.A., 2002. Population dynamics and multivariate analysis of vegetation in lake manzala, Egypt. Pak. J. Biol. Sci., 5: 842-852.
12. Feinbrun-Dothan, N., 1986. Flora Palaestina. Vol. 4, The Israel Academy of Science and Humanities, Jerusalem, Israel.
13. Shammout, M.W. and H. Zakaria, 2015. Water Quality and Growth Trend of Aquatic Plant Duckweed: Management and Benefits. In: Environmental Engineering and Computer Application, Chan, K. (Ed.). CRC Press/Taylor and Francis Group, Boca Raton, FL., USA., ISBN-13: 9781138028074, pp: 85-87.
14. APHA., 2012. Standard Methods for the Examination of Water and Wastewater. 22nd Edn., American Public Health Association, Washington, DC., USA., ISBN:9780875530130, Pages: 724.
15. Shammout, M.W., M. Shatanawi and S. Naber, 2013. Participatory optimization scenario for water resources management: A case from Jordan. Water Resour. Manage., 27: 1949-1962.
16. Iqbal, J., A. Javed and M.A. Baig, 2019. Growth and nutrient removal efficiency of duckweed (*Lemna minor*) from synthetic and dumpsite leachate under artificial and natural conditions. PLoS ONE, Vol. 14, No. 8. 10.1371/journal.pone.0221755.