Research Article

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Assessment of the physicochemical-water quality parameters and distribution of aquatic macrophytes present in Goenyeli Dam, Nicosia district, North Cyprus

Abstract

Macrophytes are essential components of the aquatic ecosystem that occur in all water bodies of all climate zone and they possess characteristic features that allow them to thrive in such environment. This study aimed to investigate the physiochemical-water quality parameters and diversity of the aquatic macrophytes present in Goenyeli Dam, Nicosia district, North Cyprus. This research carried out within a period of three months showed a seasonal variation in the physiochemical parameters of the water. Water samples were collected from multiple locations within the dam and analyzed for pH, temperature, dissolved oxygen, turbidity, and nutrient levels. Additionally, macrophyte samples were collected and identified using morphological characteristics. The presence of nutrient and dissolved oxygen played a crucial role in the species diversity and the physiochemical parameters of Goenyeli Dam fall under normal range which shows good water quality that supports the growth of aquatic macrophytes. The study revealed a mean pH of 7.47 in January, temperature of 26.0°C in February and March, dissolved oxygen of 4.7 mg/L in January, turbidity of 100% through the different periods. A total of 12 macrophytes species from 6 families were identified, with *Ruppia cirrhosa* being most prevalent. These findings provide valuable information on the current state of the Goenyeli Dam and can be used to inform management and conservation efforts in the future. The study also contributes to knowledge in the field of water quality and aquatic macrophytes

Keywords: physiochemical, goenyeli dam, aquatic macrophytes, water quality

Volume 12 Issue 1 - 2023

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Received: December 29, 2022 | **Published:** February 07, 2023

Introduction

Aquatic macrophytes are plants which grow in submerged or saturated soil.[1] They have adapted to living in aquatic environments (salt water and fresh water) and are referred to as hydrophytes or macrophytes. They are aquatic plants large enough to be seen with the bare eyes and are represented in 7 plant divisions: Cyanobacteria, Chlorophyta, Rhodophyta, Xanthophyta, Bryophyta, Pteriodophyta and Spermatophyta.[2] They can also be ferns or angiosperms. Aquatic macrophytes possess special adaptive features like possession of parenchyma, possession of tissues with large intercellular spaces or cavities which make them specially adapted to their environment.[3]

Aquatic plants are of two types namely aquatic microphytes and aquatic macrophytes.[4] Aquatic microphytes are those that are microscopic in nature and cannot be easily seen with the naked eyes, examples include phytoplankton, diatoms, etc.[5] These plants can grow only in water or soil that is constantly saturated with water. As a result, they are a common component of wetlands and rivers.[6] The depth and duration of flooding are the primary factors controlling the distribution of aquatic plants; however, other factors such as nutrient, disturbance from waves, and salinity may also influence their distribution, abundance, and growth form.[7] Macrophytes can be classified as embankment (oil palm), emergent (cattails), submerged (*Hydrilla spp*) and floating but attached free floating species. They also include macroscopic algae, aquatic bryophytes, pteriodophytes as well as angiosperms and herbs. Macrophytes occur in all water bodies including flowing and non-flowing of all climate zone and usually possess characteristic features that enable them to survive in such environment. Macrophytes are important component of the aquatic ecosystem.[8]

Aquatic macrophytes have a typical function to play in the production of food, primary productivity, diversification of habitat for other aquatic animals, oxygen generation, sedimentation, and erosion management.[9] Nutrition, temperature, pH, salinity, dissolved oxygen and biochemical oxygen requirements, alkalinity and heavy metals are important physical and chemical factors which affect the aquatic environment.[10] These parameters are limiting factor for the survival of aquatic organisms.[11] A decrease in a macrophyte community could suggest concerns with water quality and ecological change.[12] The consequence might be excessive turbidity, herbicides or salinization. In contrast, increased nutrition levels might produce an excess of macrophytes.[13] Some of the negative effects of aquatic macrophytes are; prevention of recreational activities such as swimming, fishing and boating, reduced population of fishes, provision of stagnant habitat ideal for mosquito breeding,[14] provision of toxic substance in water making it unsafe for drinking, decrease of aesthetic values and prevention of free flow of transportation.[15] Aquatic macrophytes play important roles in aquatic systems, where they provide habitat to fish, wildlife, and aquatic organism. They serve as a source food, stabilization of sediment, primary production, habitat diversification, competition, and production of oxygen.

This study investigates the macrophyte vegetation of Goenyeli Dam as influenced by physiochemical parameters of the water.

Materials and methods

Study area

Goenyeli Dam (Plate 1), also known as Goenyeli Dam or Gonyeli Baraji is a dam situated nearby to Eski Mandra, close to Kaptan Erbay Spor Tesisi with the rejoin font code of Russia/ Central Asia. It is located at an elevation of 144 meters above sea level and has a length of 0.22 kilometres. Its coordinates are 35013’60” N and 33018’0”E in DMS (Degrees Minutes Seconds) or 35.2333 and 33.3 (in decimal degrees). Its UTM position and its Joint Operation Graphics reference is N136-03. The dam has a storage capacity of approximately 45 million cubic meters of water, and it is one of the largest dams in North Cyprus. The area around the dam is characterized by a Mediterranean climate with hot summers and mild winters. The vegetation in the region is mostly composed of scrubland and grassland, with some small pockets of forests. The area around the dam is also home to a diverse range of plant and animal life, including aquatic macrophytes and fish. The Goenyeli Dam is surrounded by rural areas and the nearest city is Nicosia which is located 20km to the east.

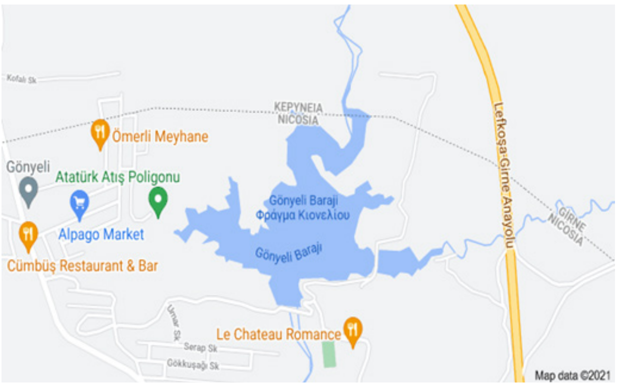

Plate 1 Map showing study area.

Sample Collection

Plant collection

Aquatic macrophytes were gathered along the riverbank of Goenyeli Dam in Northern Cyprus (plate 2 and 3) and on the water surface. Floating, submerged and emergent macrophytes were collected for the study. Macrophytes were identified from families to species.

Plate 2 Goenyeli Dam.

Plate 3 Goenyeli Dam.

Water collection

Water sample from Goenyeli Dam was collected following standard procedure as described by Mosley et al.[16] For the physiochemical study, a pre-cleaned polythene bottle was used to collect water samples. Containers for samples were marked with suitable codes and water samples were placed in an ice cooler packaged temporarily, transferred to the laboratory and stored in a refrigerator in about 40C before analysis. These samples were collected on a monthly basis for three consecutive months (January-March 2019).

Macrophyte abundance (MA)

The abundance of macrophytes was measured using a descriptive scale (Kohler scale), where 1= Rare, 2=Occasional, 3= Frequent, 4= Abundant and 5= Dominant.[17]

Analysis of physiochemical parameters

Water quality parameters including Dissolved Oxygen (DO), pH, Conductivity, Transparency, Total alkanity, Temperature, Total hardness, Biological Oxygen Demand (BOD), Calcium, Magnesium, Phosphate, Nitrate, Sulphate and Chloride.

Conductivity

Water sample was collected in a clean, labeled container. The conductivity meter (DDS-307 JENWAY) was calibrated. The meter was standardized using Potassium chloride (Kcl), then inserted into the water sample and allowed to attain a steady value, then recorded.

Hydrogen ion concentration (pH)

Hydrogen ion concentration, also known as acidity, is measured in a physiochemical analysis using the pH scale. The pH scale ranges from 0 to 14, with 7 being neutral, values less than 7 being acidic and values greater than 7 being basic. After water sample has been collected, the pH meter (Surgifield Medical England) was calibrated with a pH buffer set to 7, then dipped in a water sample until a constant value was read, and the pH values were recorded.

Temperature

Every time a trip to the site was made, a digital thermometer was used to measure the water temperature in-situ by dipping the thermometer into the water until a consistent value was observed, which was then recorded as the water temperature in degrees Celsius (°C).

Temperature is a measure of the thermal energy of a substance, and it can be measured in a variety of ways in a physiochemical analysis. The most common method is to use a thermometer. Every time a trip to the site was made, a digital thermometer was used to measure the water temperature in-situ by dipping the thermometer into the water until a consistent value was observed, which was then recorded as the water temperature in degrees Celsius (°C).

Dissolved oxygen (DO) and biological oxygen demand (BOD)

Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) are two important parameters in a physiochemical analysis of water. For Dissolved Oxygen (DO), the dissolved oxygen meter was calibrated and immersed into the water sample. The meter was turned on and kept for the reading to stabilize before recording. For Biological Oxygen Demand (BOD the initial dissolved oxygen (DO) level of the water sample was measured using the method described above. Seed culture was added to the water sample, and incubated at 20oC for 5 days. The final dissolved oxygen (DO) level of the water sample was measured and subtracted from the initial DO level to calculate the oxygen consumed by the microorganisms in the sample. The BOD reading was recorded.

Transparency

After the water sample was obtained. The Secchi disk was lowered into the water sample on a rope until it was no longer visible from the surface. The depth at which the disk disappears from view was noted and the disk was raised until it becomes visible again and the depth at which it reappears was noted. The average of these two depths was taken as the transparency reading.

Mineral analysis

Some chemical parameters of the water samples (Phosphate, Nitrate, and sulphate) were analyzed within an hour using ICP-OES spectrophotometer (Vista-Pro, Varian Inc., USA) while Chloride, Calcium and Magnesium, Total alkalinity and Total hardness were determined using titration method.

Statistical analysis

The statistical analysis of physiochemical parameters collected from Goenyeli Dam was performed using IBM SPSS Statistics (version 25). The data was checked for normality using the Shapiro-Wilk test. Descriptive statistics were calculated for all variables. One-way analysis of variance (ANOVA) was used to investigate the differences in the mean values of physiochemical parameters among different sampling locations. The significance level was set at $p<0.05$.

Result and discussion

The values of different physiochemical parameters recorded from Goenyeli Dam during the study period are summarized in Table 1. The metabolism of the biological community as a whole is regulated by dissolved oxygen and is utilized as an indicator for the tropical condition of water. The dissolved oxygen was highest in January and lowest in the month of February with a mean of 3.3mg/L showing a significant difference ($p<0.05$). Temperature has an important role in the aquatic ecosystem because it affects the organism including the physical and chemical properties of water. The water temperature was recorded lowest in January and highest in February and March with a mean of 26 °C with no significant difference ($p>0.05$). The pH value was recorded highest in January with a mean of 7.47 and lowest in March with a significant difference ($p<0.05$). pH denotes the acidic or basic nature of a solution and is controlled by the dissolved chemical compounds and biochemical processes in the solution. It is frequently monitored for assessment of aquatic ecosystem health, irrigation and drinking water sources, industrial waste dumps and surface water runoff. The pH value recorded was within the range 7.47-4.56, this implies that the dam is slightly acidic, giving it its freshwater nature. The value of alkalinity was highest in January and lowest in March with a mean value of 41.67mg/L with a significant difference ($p<0.05$) across the months. Conductivity is a water capacity metric for transmitting electric current. It indicates the total salt dissolved. The conductivity values observed to be the lowest in the month of January with a significant difference ($p<0.05$) and highest in the month of February with the mean of 112.4ms/m. The transparency was 100% clear during the study period with no significant difference ($p>0.05$). Hardness is the quality of the water that hinders the production of soap lather and increases the boiling point of water. Water hardness depends largely on the amount of calcium or magnesium salts or both. Hardness was highest in February with a significant difference ($p<0.05$) and lowest in January with a mean value of 16.67mg/L. Calcium was highest in March with a significant difference ($p<0.05$) and lowest in January and February with a mean value of 16.7mg/L. The value for magnesium was observed to be highest in the month of January with a significant difference ($p<0.05$) and a mean value of 8.0mg/L. Phosphorus is an essential nutrient and an anthropogenic biological pollution indicator. High phosphate concentrations primarily cause eutrophic conditions in a water body. Phosphate was highest in January with a significant difference ($p<0.05$) and lowest in February with a mean value of 4.03mg/L. The value for nitrate was observed to be highest in January with a significant difference ($p<0.05$). The values for chloride was observed to be highest in March with a significant difference ($p<0.05$) and a mean value of 0.16mg/L. Sulphate occurs naturally in water due to leaching from gypsum and other common minerals. Industrial waste discharge and household sewage tend to raise their level. It is rather frequent in water and does not have a significant influence on the soil but contributes to the total salt content. Sulphate was observed to be lowest in March with a significant difference ($p<0.05$) and highest in January with a mean of 167.4mg/L. BOD measures the quantity of oxygen needed in the aerobic bacterial decomposition process, to eliminate waste organic matter from the water. The BOD values were observed to be highest in February with a significant difference ($p<0.05$) and the lowest in the month of March with a mean value of 0.73mg/L. Physiochemical parameters examined in this study have been documented as having seasonal variation. The transparency was 100% all through the study period as objects could be seen with crystal clearness with no significant difference (p>0.05) (fig.1).

The levels of variation in percentage abundance of each species of aquatic macrophytes is shown in Table 2 and Fig. 2. Submerged species had the highest level of occurrence in the study area. Water transparency is presumably one of the major environmental factors underlying this trend, as radiation is a constraining factor for submerged species.[6] When transparency is not a limiting constraint, submerged species dominate both in shallow and deep waters.[18] All through the period of the study, a total of 6 families with different species of macrophytes were seen. The family *Ruppiaceae* had the highest number of species in the study area, whereas Lomariopsidaceae had *Nephrolepis exaltata* as the only available specie making it the least. *Nephrolepis exaltata* also referred to as Boston fern is an evergreen perennial herbaceous plant that can grow to a height of 0.4-0.9 meters, and in extreme cases up to 1.5 meters[19,20]

Table 1 Physiochemical parameters of Gonyeli dam water samples

Parameters	January	February	March
Total hardness (mg/L)	16.6 ± 4.62^{a}	22.0 ± 3.19^{b}	20.0 ± 5.47^{b}
Dissolved oxygen (mg/L)	4.7 ± 0.39^{a}	3.3 ± 0.49^{b}	4.00 ± 0.71^{a}
Total alkalinity (mg/L)	86.7^{a} ± 5.8	58.3 ± 4.56^{b}	41.7 ± 3.60^{c}
pH value	7.47 ± 0.078^{a}	4.65 ± 0.18^{b}	4.56 ± 0.20^{b}
Conductivity (ms/m)	62.4 ± 0.182^{a}	112.4 ± 0.06^{b}	111.7 ± 0.03^{b}
Chloride (mg/L)	0.142 ± 0.212^{a}	0.142 ± 0.212^{a}	0.160 ± 0.06^{b}
BOD (mg/L)	0.77 ± 0.20^{a}	0.83 ± 0.20^{b}	0.73 ± 0.60^{a}
Phosphate (mg/L)	5.7 ± 0.09^{a}	4.03 ± 1.36^{b}	4.10 ± 1.66^{b}
Calcium (mg/L)	16.7 ± 2.34^{a}	16.7 ± 3.00^{a}	20.0 ± 5.47^{b}
Magnesium (mg/L)	8.0 ± 2.64^{a}	5.3 ± 0.19^{b}	6.67 ± 3.16^{b}
Sulphate (mg/L)	167.4 ± 5.71^{a}	167.4 ± 5.70^{a}	125.6 ± 0.38^{b}
Nitrate (mg/L)	3.4 ± 0.7^{a}	2.9 ± 0.43^{b}	3.33 ± 0.85^{a}
Temperature (°C)	25.9 ± 0.019^{a}	26.0 ± 0.34^{a}	26.0 ± 0^{a}
Transparency (%)	100 ± 0^{a}	100 ± 0^{a}	100 ± 0^{a}

Values in each row are presented as mean ± SD, (i.e. n = 6). Using One-way ANOVA

Means in the same column in each parameter with a different superscript are significantly different (p < 0.05).

Table 2 Species of aquatic macrophytes recorded in Gonyeli dam, their families, life forms and percentage abundance. Life forms: SUB, Submerged; EME, Emergent; FLO, Floating; EM, Embankment

Taxa	Life forms	% Abundance		
		January	February	March
Ruppiaceae				
Ruppia maritima	SUB	3.1	2.0	0
Ruppia cirrhosa	SUB	74.9	64.1	47.0
Ruppia spiralis	SUB	15.1	16.0	19.8
Nymphaeaceae				
Nymphaea tetragona	FLO	30.3	12.4	12.0
Cabomba caroliniana	SUB	60.5	8.0	16.6
Lomariopsidaceae				
Nephrolepis exaltata	EM	63.6	76.8	85.0
Cyperaceae				
Cyperus rotundus	EME	6.0	3.8	0
Cyperus esculentus	EME	2.1	0	0
Zosteraceae				
Zostera marina	SUB	40.4	8.0	0
Zostera noltii	SUB	30.7	22.0	12.3
Ranunculaceae				
Ranunculus fluitans	SUB	38.6	32.5	25.0
Ranunculus repens	SUB	35.4	25.0	8.6

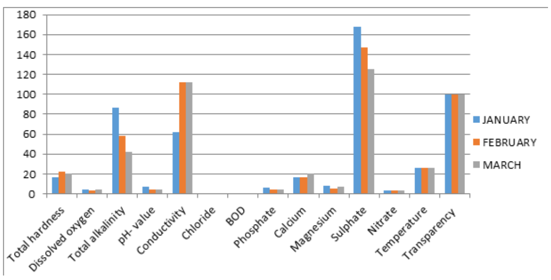

Figure 1 Summary of physiochemical parameters of the water sample.

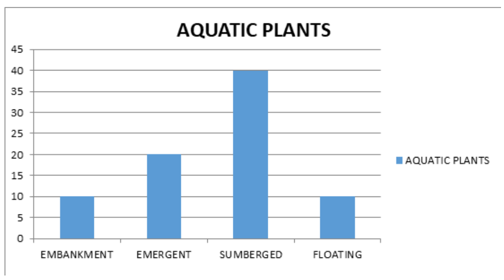

Figure 2 Percentage abundance of aquatic plants.

Cyperus esculentus (also called chufa sedge) grows in the wild, as a weed, and as a crop. In warm weather, it is commonly found in moist soils such as rice paddies and peanut plantations, as well as irrigated golf courses and lawns.[21] It is an annual or perennial plant that grows to 90 cm tall and has solitary stems that grow from a tuber. Seeds, creeping rhizomes, and tubers are used to reproduce the plant.[22,23] *Nymphaea tetragona* is a submerged herbaceous perennial with floating leaves that grows from a thick rhizome. A long, slender petiole is attached to the base of a long, V-shaped notch in the elliptic blades of the leaves.[24] Zostera marina also known as eelgrass and sea wrack is an aquatic plant that grows a long stem with hairy green leaves up to 1.2 cm wide and over 1.0 m long. It is a perennial plant, but it can also grow as an annual.[25] The rhizome spreads horizontally through the substrate, aligning itself with clusters of roots at nodes. The plant is monoecious, with each individual yielding both male and female flowers in different alternating clusters.[26] *Ruppia maritima* commonly known as beaked tassel weed, widgeon grass is a thread-thin, grass-like annual or perennial herb that grows from a rhizome anchored shallowly in the wet substrate. It has a long, narrow, straight, or loosely coiled inflorescence with two tiny flowers at the tip. The plant usually self-pollinates, but when the flowers float on bubbles, they release pollen that reaches neighboring plants.[2] Ruppia cirrhosa, common referred to as spiral ditch grass is a grass-like perennial herb that grows from a rhizome anchored in a moist substrate. It has a long, narrow inflorescence with two tiny flowers at the tip. Ranunculus fluitans (the river water-crowfoot) is a perennial water plant, that when in favourable conditions (such as fast flowing water,) and can grow up to a height of 20ft.[27] It has no floating leaves, instead it has long and narrow, tassel-like segments reaching up to 12 inches long.[28]

An emergent plant grows in water but pushes its surface into the air. This habit may have developed because the leaves can undergo photosynthesis more efficiently above the hue of cloudy water and competition from submerged plants, but the floral characteristic and associated reproductive activity are usually the dominant aerial trait. The emergent habit allows for pollination by wind or flying insects.[29] There are many species of emergent plants which includes the reed (*Phragmites australis*), Cyperus papyrus, Typha spp., and wild rice species. These can be found in fens, though not always successfully due to competition from other plants. Certain species, such as purple loosestrife, may emerge as emergent plants, but they can thrive in fens or simply in damp ground.[30] Floating-leaved macrophytes have roots that bind to the substrate or bottom of the water body and leaves that float on the surface.

Submerged macrophytes grow entirely under water, either with roots connected to the substrate (e.g. *Myriophyllum spicatum*) or with no root system (e.g. *Ceratophyllum demersum*). Macrophytes are aquatic plants found suspended on the water surface with their roots unattached to the substrate or bottom of a body of water. They are easily blown by air and serve as a breeding ground for mosquitoes.[31] Macrophyte levels are simple to measure, need no laboratory analysis and are readily utilized for basic metrics of abundance.

According to FAO[32] Aquatic plants provide a wide range of products and services that benefit habitat protection, nature conservation, and livestock production, as well as fisheries production and wildlife conservation, food and medicine, fertilizer and soil additives, industry, energy, and recreation/aesthetics. The socioeconomic significance of macrophytes cannot be overstated because they are important sources of fodder for animal production.[14,33] Some macrophytes are used in the construction of roofs. Aquatic macrophytes are used in food, medicine, and animal production.[34] Some aquatic macrophytes have recently emerged as valuable raw materials for industries. Some aquatic macrophytes are used to make jewelry, handbags, and hats, and they have the potential to be used in fertilizer production.[35] The essence of aquatic macrophytes in nature and to man lies mainly in wildlife conservation in which they provide food for water animals. Other important roles of macrophytes in aquatic systems include stabilization of sediment, primary production, detritus accumulation, nutrient release, and habitat diversification.[36]

Conclusion

In conclusion, this study assessed the physicochemical-water quality parameters and distribution of aquatic macrophytes in a specific water body. The results revealed that the water body had small levels of certain pollutants such as nitrogen and phosphorus, which may not significantly impact the growth and distribution of aquatic macrophytes. Additionally, the study identified a diverse range of macrophyte species present in the water body, with some areas exhibiting higher macrophyte abundance and species richness than others. These findings highlight the importance of monitoring and managing water quality to maintain healthy aquatic ecosystems. Further research is needed to investigate the potential impact of pollutants on macrophyte growth and to understand the relationships between water quality, macrophyte distribution, and ecosystem functioning in this and similar water bodies.

Competing interests

The authors have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

None.

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