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Analyzing the water quality and effects of aquatic plants

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Abstract
This study aims to characterize the water quality characteristics of Dipang lake, which is located in the Pokhara-Lekhnath Metropolitan city in the Kaski Province. This research illustrates the seasonal and aquifer-based shifts in the lake's many water quality metrics. Although fishing, farming, and residential use were all possible within the restrictions, they were all within the acceptable range. Certain plant species, including *Nelumbo lutea* (Yellow lotus), can only be found near the water inflow, where the ammonia concentration is between 18 and 14.03 parts per million, and this has been linked to the water characteristics. We use normalized difference vegetation index (NDVI) to analyze the growth or decline of aquatic vegetation in the research region, in addition to the water quality parameter. It has been determined from the yearly NDVI calculations that the extent of aquatic vegetation in the research region has decreased. The rate of aquatic vegetation degradation in the research region is estimated to be 2.84 acer (7.84%).

Keywords: Plants, water quality, aquatic plants**,** physico-chemical

Introduction
Wetlands are one of the most threatened ecosystems due to human activities, which is causing a decline in biodiversity and the inefficiency of the ecosystem as a whole. It is well accepted that eutrophication and heavy-metal ion contamination pose serious dangers to shallow lakes and ponds. The transition from clear water in which macrophytes can flourish to highly adverse conditions dominated by phytoplankton and filamentous algae has been regarded as a key driver of the loss of aquatic plants due to the enrichment of water bodies with phosphate derived from agriculture, sewage, and industry. Recent research suggests, however, that nitrogen availability may limit summer phytoplankton and that major changes in phosphorus budgets may have no repercussions for phytoplankton abundance in particular shallow lakes. The world is facing a crisis due to water pollution. Water loss is a problem for megacities everywhere. The worldwide threat and widespread discussion it has sparked is a direct result of the poisonous wastes thrown into water by major civilizations. Manufacturing waste, industrial chemicals, municipal solid trash, medical waste, and other hazardous waste dumped directly into water all contribute to a decrease in water quality, which in turn threatens the availability of potable water and may even kill off aquatic organisms.
First, one must accurately identify the species of interest before beginning any form of monitoring or evaluation program. Incorrect species identifications often occur because of insufficient documentation, such as a lack of herbarium specimens or high-quality digital photos. Correctly identifying both target and nontarget plants is essential for locating and mapping regions containing species of particular concern, and for determining the status of endangered or threatened plant species. Investing in the creation of an accurate species list for a specific body of water is crucial to the success of any management plan, and such lists are often needed for the creation of environmental impact statements and other necessary permits.

Literature Review
Xu Cheng *et al* (2018) Being a global issue, water contamination has far-reaching consequences for humanity. Many people and resources have been put towards environmental governance across the globe.

The advent of phytoremediation technology, with its low cost, more ecological, and environmentally friendly properties, represents a significant step forward in the fight against environmental degradation. This article provides a concise overview of the current state of water pollution, the methods used to remediate it, and the role that giant aquatic plants may play in reducing pollution in water. The selection principle of aquatic plants is also the basis of the debate, as is their role in reducing water pollution and allowing for the secure disposal of spent aquatic plants.

Inyinbor Adejumoke A. *et al* (2018) [5] Increased industrialisation, which supports urbanization, is placing a significant strain on our water environment and decreasing the supply of clean water. Polluted water poses serious problems for aquatic life, plant life, people, and the climate. The protection of our water ecosystem is essential to sustainable development and requires concerted effort from all facets of society. While efficient wastewater treatment has the potential to save the water environment, the water environment can be even better preserved through the incorporation of environmental policies into the core objectives of actor firms and through the periodic dissemination of information about the current and potential consequences of environmental/water pollution.

Matthew T. O'Hare *et al* (2017) Aquatic plants have several functions in aquatic environments and significantly improve their structure, function, and service supply. The vital role that aquatic plants play in marine environments has sparked a surge in study of these organisms. More than a hundred and twenty participants from twenty-eight nations and six continents attended the 14th International Symposium on Aquatic Plants in Edinburgh, Scotland, in September 2015. Several studies on aquatic plants, spanning many different species, systems, and topics, are included in this special issue of Hydrobiological. In this article, we provide a survey of the most pressing issues and promising avenues for exploration in the study of aquatic plants at the turn of the twenty-first century. The conservation and management of aquatic plants and the environments in which they are located face enormous difficulties despite significant advances in our knowledge of aquatic plant biology, the breadth of scientific concerns being investigated, and the depth of available research tools. The diversity of the continents and countries represented at the conference and in the papers published in this special issue attests to the importance of aquatic plant research in the first decade of the twenty-first century but also to the formidable obstacles that must be overcome by this rapidly expanding scientific field.

Dr. Soumen Sarkar (2017) [4] Water quality and quantity analysis is the first and most crucial stage in determining the origin of an environmental issue. Many illnesses in both rural and urban areas may be traced back to water contamination. Indeed, the health of rural residents has been devastated by the plethora of illnesses that have arisen as a direct result of water contamination. This dissertation focuses on the research of water plants in the Jamtara region of the Indian state of Jharkhand that may survive in polluted environments. The research relies on a collection and recording of 32 species of aquatic and semiaquatic plants from 22 different families. Regular field surveys were conducted to learn the floristic aspects of the study area, including habitat, botanical name, vernacular name, family, and short description. Some of the plant life is a blessing for both the aquatic ecosystem and human civilization since it may be utilized to filter out harmful chemicals in water.

Mahesh Kumar *et al* (2012) [2] –In order to analyze the different water quality characteristics and to create water quality index, research was conducted on the Godavari River. This report examines the temporal shifts in water quality indicators (WQIs) observed at the Rajahmundry and Dowlaiswaram stations in the Indian state of Andhra Pradesh between the study period (2009-2012) and the projected period (2012-2015). The WQI was derived from the monthly mean values of eight water quality parameters: pH, dissolved oxygen, electrical conductivity, total dissolved solids, total alkalinity, total hardness, calcium, and magnesium. In terms of statistical performance, the created models for each station fared well, with MAE=4.97 and 3.41, RMSE=7.31 and 5.82, and MAPE=5.15% and 3.48%. Significant shifts in DO levels were discovered to be the result of small changes in DO, despite the large weightage factor that small changes in DO carry. The results of this research indicate that the quality of the water in the River Godavari at the Rajahmundry and Dowlaiswaram stations would improve in the future. The Water Quality Index (WQI) is a useful instrument for transforming difficult-to-understand water quality data into knowledge that can be put to practical use by the public and policymakers.

Methods

Measurements of temperature, pH, conductivity, salinity, dissolved oxygen, and Secchi disk depth were taken directly in the field as part of the first phase of the experimental technique. Taking water samples and storing them for further analysis in a lab was a part of the project as well. The samples were analyzed for several elements and compounds, including DO, CO2, total hardness, alkalinity, nitrogen, phosphorus, ammonia, chlorine, and more. The Fisheries Research Lab in Begnas-Pokhara was used as the experimental location since it is located far from the lab on the Amrit campus and contamination during transit is a real possibility.

Field Sampling

The lake is just a few meters deep, therefore there was no need to collect samples very far down (below 1 meter) since oxygen and pH levels shouldn't change much as you go from the top to the bottom.

According to the availability of water, the study area was split into three sections: the entrance, the center, and the outlet of the lake. Each location had a total of three seasons of water samples taken; rainy, winter, and dry summer. Each season saw a total of fifteen BOD bottles and nine plastic bottles filled with water from a depth of one meter.

Water quality Test

- Water's color and odor were gauged by sniffing it, while its temperature and acidity were assessed using handheld devices.
- The Fisheries Research Laboratory at Begnas Lake followed Zobel *et al*. in measuring chemical properties of water, such as Dissolved Oxygen (D.O) and free carbon dioxide (1987).
- Digital water testing devices were used to assess the total hardness, alkalinity, nitrate (NO3-), phosphate (PO4-), chlorine (Cl), and ammonia (NH) levels in the

water at the Fisheries research facility in Begnas (exact ECO-CHECK).

Aquatic Flora and Fauna

Floating sampling quadrate of (1m x 1m) was made and thrown randomly in different sites. Macrophytes were directly observed, counted and noted to calculate the relative density, relative frequency and relative coverage and Important Value Index (IVI).

Importance Value Index (IVI)

The method provided by Zobel *et al*. for calculating the importance value index is used to determine which plant species are most dominant (in terms of relative density, relative frequency, and relative importance) in the research region (1987). The Important Value Index (IVI) is defined as [Relative Frequency (RF)] + [Relative Density (RD) + [Relative Coverage (RC)].

The phytoplankton were captured using a plankton net with a mesh size of 600. Several types of algal bloom were also gathered. These specimens were put into 5% formalin and sent off to the lab for analysis. These planktons were identified using Encarta (2006).

In order to catalog the indigenous and non-native fish species found in the lake, researchers used a questionnaire to collect fish samples and conduct interviews with local fishermen.

Data Analysis

Water Quality Analysis

Seasonal variability in physico-chemical parameters of water

A faint murky hue and a lack of odor characterize the water throughout the year. As compared to the rainy and winter seasons, the turbidity was somewhat higher during the rainy season, coming in at 7.1 NTU. Similarly, the average temperature was highest in the Rainy season (27.13 °C), then lowest in the Summer (22.14 °C), and highest in the Winter (0.95). The water was somewhat acidic throughout the year, although this was not statistically significant. Winter saw high levels of D.O, but free CO2 was discovered to be much higher in rainy i.e. 12.18 mg/l than in winter's 4.43 mg/l and summer's 5.2 mg/l. The total hardness was shown to be considerably (p 0.05) greater in the summer than in the winter, spring, or fall. The alkalinity and nitrate levels in wet seasons were very different from those in dry seasons. Seasonal fluctuations in the price of phosphate and chlorine are not statistically significant (Table 1).

Table 1: Mean ± SD values of water seasonally during rainy, winter and summer season. Different letters in subscript (small alphabets) implies significant difference in physiochemical water parameters among various season.

	S.N	Properties	Rainy	Winter	Dry Summer
Physical Parameters	1.	Colour	Muddy colour	Clear	Muddy colour
	2.	Odour	No	No	No
	3.	Turbidity (NTU)	7.1	4.8	6.3
	4.	Temperature (°C)	27.13 ± 1.76 [a]	10.95 ± 0.55 [b]	22.14 ± 2.07 [c]
Chemical Parameters	5.	pH	6.65 ± 0.24 [ab]	6.76 ± 0.21 [a]	6.51 ± 0.06 [b]
	6.	D.O (mg/l)	5.14 ± 1.73 [a]	7.76 ± 1.2 [b]	6.28 ± 0.65 [a]
	7.	Free CO_2 (mg/l)	12.18 ± 2.64 [a]	4.43 ± 0.6 [b]	5.2 ± 0.78 [b]
	8.	Total Hardness (ppm)	65.31 ± 3.64 [a]	32.30 ± 6.0 [b]	92 ± 11.06 [c]
	9.	Alkalinity (ppm)	29.61 ± 2.63 [a]	22.38 ± 2.9 [b]	14.14 ± 4.41 [b]
	10.	Nitrate (NO_3-) (ppm)	1.01 ± 0.33 [a]	7.51 ± 0.44 [b]	4.17 ± 3.54 [b]
	11.	Phosphate(PO_4) (ppm)	1.18 ± 0.58 [a]	0.39 ± 0.04 [a]	0.78 ± 0.12 [a]
	12.	Chlorine (ppm)	0.11 [a]	0.15 [b]	0.11 [a]
	13.	Ammonia(NH_3) (ppm)	0.26 [a]	6.02 [b]	0.09 [a]

Source wise variability in physico-chemical parameters of water

There are no statistically significant changes in the various physical water factors (such as color, odor, and temperature) that originate from different sources. pH, dissolved oxygen, free carbon dioxide, alkalinity, total hardness, and nitrate are all comparable chemical characteristics. By comparing the inlet, middle, and outlet values, the difference between the inlet's 18 mg/l and the middle's 0.207 mg/l and the outlet's 0.17 mg/l is statistically significant (p 0.05). (Table 2).

Table 2: Mean ± SD values of water based on water sources inlet, middle and outlet of the lake. Different letters in subscript (small alphabets) implies significant difference in physio-chemical water parameters according to source of water taken.

	S.N	Properties	Water sources Inlet	Middle	Outlet
Physical Parameters	1.	Colour	Clear	Slightly muddy	Slightly muddy
	2.	Odour	No	No	No
	3.	Temperature (°C)	18.76 ± 5.94^{a}	21.38 ± 7.05^{a}	21 ± 7.86^{a}
Chemical Parameters	4.	pH	6.62 ± 0.25^{a}	6.63 ± 0.26^{a}	6.56 ± 0.09^{a}
	5.	D.O (mg/l)	6.48 ± 1.7^{a}	6.3 ± 2.07^{a}	5.105 ± 2.05^{a}
	6.	Free CO_2 (mg/l)	7.89 ± 4.41^{a}	6.68 ± 3.04^{a}	6.23 ± 3.5^{a}
	7.	Total Hardness (ppm)	71 ± 7.6^{a}	64.57 ± 43.19^{a}	47.37 ± 37.98^{a}
	8.	Alkalinity (ppm)	9 ± 2.93^{a}	7.71 ± 2.19^{a}	29.25 ± 7.66^{a}
	9.	Nitrate (NO_3-) (ppm)	3 ± 3.63^{a}	3.01 ± 3.23^{a}	3.2 ± 3.36^{a}
	10.	Phosphate (PO_4)(ppm)	0.6 ± 0.62^{a}	0.105 ± 0.07^{a}	1.63 ± 0.19^{b}
	11.	Chlorine (ppm)	0.09 ± 0.08^{a}	0.06 ± 0.07^{a}	0.28 ± 0.05^{a}
	12.	Ammonia (NH_3) (ppm)	18 ± 14.03^{a}	0.207 ± 0.135^{b}	0.17 ± 0.06^{b}

Aquatic Flora and Fauna

The floating quadrate (1x1) m2 used for the random sample discovered eight distinct aquatic and amphibian plants in or around the lake. Its source wise Important Value Index (IVI) was determined based on their density, frequency, and coverage (Table 3).

Source-wise IVI for a few Dipang lake aquatic plants are listed below. IVI values of *Nelumbo lutea* (Yellow lotus), 82, and *Sagittaria sagittifolia* (Arrowhead), 34, were found to be greater than those of other plant species, but only in water inflow. You may find the invasive species *Schoenoplectus mucronata* (Bog bulrush), *Persicaria hydropiper* (Marsh pepper knotweed), and *Cyperus esculentus* (Yellow nutsedge) all across the lake (Table 3).

Table 3: Determined based on their density, frequency, and coverage

S.N	Name of species	IVI Inlet	Middle	Outlet
1	*Nelumbo lutea*	82	61	10
2	*Sagittaria sagittifolia*	34	6	0
3	*Schoenoplectus mucronata*	21	22	15
4	*Azolla imbricata*	48	47	26
5	*Hydrilla verticillata*	20	37	20
6	*Lemma minor*	55	59	26
7	*Persicaria hydropiper*	20	23	5
8	*Cyperus esculentus*	19	23	0

Common algal species were found in the lab study of the phytoplankton samples, including Spirogyra sp., Vaucheria sp., Nostoc sp., Chara sp., Gloeotrichia sp., Lyngbya sp., Oscillatoria sp., etc. *Labeo rohita* (Rohu), *Cyprinus carpio* (Common carp), *Ctenopharyngodon idella* (Grass carp), and *Aristichthys nobilis* (Noble carp) were the most prevalent fish species in the lake (Bighead Carp). *Oreochromis niloticus*: (Nile Tilapia). *Catla catla* (Bhakur), Tor putitora (Sahar), and *Clarias batrachus* (Asain Magur) are only a few of the other fish species that were recorded. Among them are the invasive fish species Nile Tilapia, Common Carp, and Bighead Carp.

Change detection of area of aquatic vegetation

The normalized difference vegetation index (NDVI) has been extensively utilized to investigate the connection between spectral variability and shifts in plant growth. It's also put to use in calculations about how much and what kinds of greenery are grown and how often.

The following formula may be used to get the Normalized Difference Vegetation Index (NDVI), which can be used to track the temporal changes associated with the evolution of plants:

NDVI= (NIR-RED)/(NIR + RED) or NDVI = (Band 4-Band 3)/ (Band 4 + Band 3),

Table 4: NDVI divided statistics of the wetland of March, 2016

NDVI value based category	NDVI value	% of category	Area of category
Non-Vegetation	0.03–0.15	6.87%	2.37 acre
Vegetation	0.15–0.50	93.12%	32.14 acre

The normalized difference vegetation index (NDVI) has a range of -1 to 1, with values close to 0 indicating non-vegetation classes like water, snow, urban areas, and barren regions, and values close to -1 indicating the most fertile soil and rock. Vegetation cover is indicated by NDVI values slightly over 0, whereas moderate and high values suggest stressed and healthy vegetation. Positive NDVI values are only seen in actively growing plants.

The NDVI analysis shows that a significant loss of aquatic vegetation cover has occurred in the studied region. It has been determined that there has been a loss of 2.84 hectares (7.84%) of aquatic vegetation in the research region. The chemical balance of lakes and ponds relies heavily on the presence of aquatic vegetation. That's because they're capable of sucking up water-borne nutrients that algae would otherwise consume. Aquatic plants provide shelter in the water as well. Little fish may find shelter in the submerged foliage from larger fish that might be a threat to them. So, it is essential to take measures and make plans to enhance the wetland's water quality so that the aquatic vegetation there may flourish and provide for the many species of aquatic wildlife that live there.

Conclusion

There was evidence of seasonal and etiological variation in the physicochemical water parameters measured across sample points. There was a clear seasonal pattern wherein the wet season had the highest average values for temperature, turbidity, free CO2, total hardness, alkalinity, and phosphate. Specifically, the Northerly water inflow showed the highest levels of dissolved oxygen, free carbon dioxide, total hardness, and ammonia. Agriculture areas located upslope from the lake's outlet contribute to the high ammonia content by way of runoff of fertilizers and pesticides. Wetland aquatic vegetation has been declining at an annualized rate of 2.8 acres since 2016, according to a change detection study of Sentinal-2A satellite data downloaded from the USGS website and analyzed using NDVI in QGIS. The authorities shall take action on the wetland based on the research and the results of the water quality observation in order to enhance the water quality of the wetland.

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