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An Analysis of Certain Ecological Factors Affecting the Water Quality of Makhana Pond in Darbhanga, Bihar

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Abstract

Makhana thrives in areas with shallow water, such as ponds and marshes, and requires no chemical inputs, such as fertilizers or pesticides. Growing it is therefore both cost-effective and environmentally advantageous. The crop contributes to the preservation of aquatic habitats by maintaining water quality and providing habitat for aquatic species. Makhana's high level of climate adaption makes it a good option for regions at danger from climate change. Temperature, clarity, pH, dissolved oxygen, free carbon dioxide, total alkalinity, hardness, calcium, magnesium, chloride, phosphate, nitrogen, and organic matter were among the biological characteristics of Makhana Pond in the Darbhanga district that were examined. An average value for each parameter was established for every month of the twelve-month study. Makhana leaves were dispersed around the water's surface, making it difficult for sunlight to penetrate deeply, which hampered ambient air exchange. As a result, the dissolved oxygen level fell short of the required threshold. Over the summer, the water's hardness increases because to the huge buildup of bicarbonate caused by the extra free CO2 created by the dissolving of bottom deposits. As organic waste decomposed during the summer, the water's chloride content rose. Because decomposition was sluggish, high phosphate and nitrate levels were seen throughout the summer. Makhana Pond's biotic activities were the reason for the variation in the C/N ratio.

***Key words*:** *Euryale ferox*, Alkalinity, Transparency, Ecology, C/N ratio

The cultivation of Makhana (*Euryale ferox*) contributes organic matter to the ponds through the decay of plant material. This process enriches the water with nutrients, leading to eutrophication—a condition characterized by excessive nutrient concentrations that promote dense plant growth and subsequent oxygen depletion. Such an environment adversely affects aquatic life, including fish populations [1]. Makhana (*Euryale ferox*), an aquatic plant cultivated primarily in Bihar, grows in shallow stagnant water bodies like ponds and wetlands. The traditional method of Makhana cultivation involves several ecological processes that significantly impact water quality [2]. Water samples taken from the sea, rivers, lakes, ponds, springs, even drains or floods are typically analyzed for temperature, transparency, pH, dissolved oxygen, free carbon dioxide, total alkalinity, hardness, calcium, magnesium, chloride, phosphate, nitrogen, and organic matter. The research's proximity and importance, however, have limited the opportunities for industrial consideration to a pond in the Darbhanga district, where makhana was very prevalent. Makhana Pond in the Darbhanga district of Bihar, near Kamtaul, Jale block, was chosen for the intended study. This is a permanent, rectangular, shallow pond with a concave basin that will not be contaminated by the hazardous waste of any business. However, occasionally kids would swim in the pond and contaminate it. Because of these disruptions, the pond's trophic level rises, which encourages the growth of luxuriant, unwanted bacteria [3]. An attempt to manage the pond resulted in a low-quality assessment of ecological characteristics, despite its high recreational value and potential as a great supply of animal protein through fish farming. This prompted the author to investigate the ecological evaluations of water using fifteen characteristics, including conductivity, temperature, and transparency.

Calcium, magnesium, organic matter, pH, total soluble solid, carbonate and bicarbonate alkalinity, free CO_2 chloride, and calcium hardness. Numerous biological (biotic) and physico-chemical (abiotic) elements are thought to interact to produce productivity [4-5]. The productivity of several Bihar regions has been studied, but the main productivity of the pond in question appears to have not been recorded, which is why the current study was started.

MATERIALS AND METHODS

The perennial Makhana Pond is located near Kamtaul in the Jale neighbourhood of Darbhanga town at latitude 260 10'N and longitude 8602 64'E. It is approximately 1.48 hectares in size. With August (1.48 ha) having the biggest water spread area and May (1.36 ha) having the smallest, the water spread area ranged from 0.30 to 1.66 meters. From July to August, this pond was utilized for an integrated fish culture with Makhana (*Euryale ferox* Salisb.). A 2-liter plastic cane was used to collect a water sample from the bank two meters within during the second week of each month, between 10 and 11 a.m.

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Methods adopted for the study

In order to assess the biological properties of the water, samples were taken every month from July to August at the experimental pond location. Mercury thermometers are used to measure the temperature of air and water, while pH meters are used to monitor pH. The Secchi disc was used to measure the transparency. Other parameters such as calcium, magnesium, chloride, phosphate, nitrogen, total alkalinity, dissolved oxygen, free carbon dioxide, and hardness were measured using standard kit methods. The water at the pond's four sides was the subject of a physico-chemical investigation. Soil samples were taken every month.

The pH, organic carbon, nitrogen, phosphorus, and potassium contents of the air-dried samples were measured. They likely couldn't identify any significant changes in any of the characteristics they examined since wind speed and human and aquatic animal activity frequently mix the pond water. As a result, when generating interpretations, the average value of each parameter measured at the pond's four sides between July and August was taken into account.

RESULTS AND DISCUSSION

Every living thing, including plants and animals, is reliant on its surroundings. They develop and pick up their traits in a social setting. Both terrestrial and marine ecosystems' biotic and abiotic elements work together as a single "ecosystem." The physical and chemical characteristics of the water make up the abiotic component of a freshwater environment. The three physical characteristics listed above have been taken into account in this analysis. An average value for each of the above-mentioned parameters was established for each month after physical-chemical examinations of the pond water were conducted over the course of the twelve months in both observation years. The next section discusses the observation's specifics in light of the earlier workers' work:

Temperature

The open-space pond's water temperature varied from 16°C in January to 29°C in June, while the air temperature varied from 17°C in January to 28°C in June. From April to August, temperatures in the regions covered by the enormous E. ferox leaves varied from 25.50°C in April to 28°C in June. The temperature differential between the atmosphere and the water increased throughout the Makhana crop's main growth phase (April to June) because the leaves served as a blanket barrier between the two. In June, the largest temperature differential between the water and air in the covered areas was 2.50 °C. This disparity did, however, diminish over the July and August harvest season. However, February had the biggest temperature differential between the pond's open area and water (2.2 °C). Prior to the Makhana leaves emerging on the water's surface, there was less of a temperature differential because the air and water were in direct touch. However, during the grand development stage of the Makhana crop, the leaves covering the water surface caused indirect contact between the pond water and incident solar radiation, which increased the temperature difference between the two [6-8].

A water body's chemical and biological properties, such as gas solubility, chemical reactions, and the intensity of flavour and odour, are influenced by temperature. The temperature of the existing pond fluctuated significantly every year. They also came to the conclusion that the pond's shallowness is demonstrated by the high summer temperatures it encounters. Notably, due primarily to rain on the day of the observation, June temperatures were comparatively low rather than high as anticipated [9].

Transparency

The amount of light that has reached the water body is indicated by the purity of the pond's water. Measured in centimetres, the analyzed pond's Secchi disc transparency peaked in December at 68 cm and dropped to 37.2 cm in July. The pond water's transparency fluctuated significantly throughout the year, averaging 19.851 +2.9 cm per year. Its largest peak, measuring 38 cm, was attained in May, and its second peak, measuring 27 cm, was reached in October. It is average between February and July (18.953 -21.27 cm) and lowest in August (9.628 cm). Transparency gradually decreased from January to August, as E. ferox goes through its phonological cycle. However, there was a discernible decline in openness from July to December. There is a clear correlation between transparency and the existence of suspended organisms and inanimate particles in water. Due to turbulence and increased water wave activity during these monsoon months, as well as the retention of organic components in a state of suspension, the transparency values in July, August, and July were 36.2 cm, 48.4 cm, 43.2 cm, and 42.2 cm, respectively. Makhana Pond was less translucent in July and August. The high temperatures in May and June caused a high rate of organic matter breakdown, which led to transparency [10-15].

The lower temperatures throughout the winter, however, slow down the rate at which organic waste breaks down, increasing the transparency levels. Transparency was also somewhat impacted by the plankton population. More sunlight, improved light penetration, a moderate wind speed that maintains the water's calm, and a reduced percentage of dissolved and suspended particles are some of the elements that contribute to high transparency, or water clarity. The lowest transparency rating during rainy seasons may be caused by overcast skies, a lack of sunlight, and surface runoff that carries silt and other organic materials [16]. A discernible decrease in transparency was brought about by the unanticipated downpour that occurred during sample collecting in June.

pH

Measured throughout several months, the pH of the pond water ranged from 6.6 to 8.3, with June and December having the lowest and highest values, respectively. Between August and January, the pH increased, and between February and March, it decreased. The pond's water stayed neutral to slightly alkaline throughout the current inquiry, making it appropriate for Makhana production. The pH range of the water in the Makhana growing pond was alkaline to neutral. The concentration of OH-ions falls and the solution turns acidic as the hydrogen ion (H+) level rises. The negative logarithm of H+ ion concentration, or log10 H+ or log1/1x10-6, is actually what pH is. At pH 6 and pH 4, the potential of H+ ions, or pH, is 10-6, 10-4, and 10-4, respectively. This implies that there are ten times as many H+ ions at pH 6 as there are at neutral pH 6. Likewise, pH 8 has 10 times less H+ ions. A.P.H.A. [17] states that the pH of natural water is 6 at 260°C, 6.6 at 00°C, and 6.6 at 600°C.

Because so many acidic and basic salts are mixed together, natural water's pH ranges greatly, typically falling between 6 and 8. The great majority of biological processes and metabolic reactions are regulated by pH. The majority of plant and animal species are adversely affected by wide pH fluctuations because they have evolved to survive in a limited pH range. Even more important than oxygen availability are pH and carbon dioxide for aquatic plant and animal viability. The amount of O2 rises and the amount of CO_2 falls as photosynthesis proceeds. Alongside this, the pH also slightly increases. In natural rivers, pH changes are typically accompanied by changes in other physical-chemical characteristics [18].

Dissolved oxygen

The water's dissolved oxygen level ranged from 6.15 mg/l to 8.20 mg/l between June and February. Compared to open spaces, enclosed regions had lower dissolved oxygen concentrations. Between the two situations, June's D.O. level varied the most (0.64 mg/l), while May's varied the least (0.10 mg/l). From July to February, the D. O. readings increased steadily, with the exception of January, when they dropped to 6.90 mg/l [19].

Water contains dissolved oxygen. The atmosphere and the photosynthesis of aquatic green plants are the primary sources of dissolved oxygen in all bodies of water. Temperature, salinity, and exposed surface area all affect the amount of oxygen in water. When evaluating the quality of water, dissolved oxygen is an important consideration. There is extremely little dissolved oxygen in water that has a lot of organic contamination. A water system's ability to purify itself depends on how much oxygen is dissolved in it. When oxygen is used up faster than it is replenished, the water's quality begins to deteriorate [20].

Aquatic macrophytes have a lower D. O. content because they decompose organic materials. Because air oxygen is more soluble at colder temperatures, the dissolved oxygen levels were higher throughout the winter months of October through March. Once more, at low temperatures, less organic matter broke down, requiring less oxygen to do so. Nonetheless, the water's D. O. level increased during the winter due to the high rate of photosynthesis of submerged macrophytes and phytoplankton [21].

Free carbon dioxide

Free CO_2 concentrations were lowest in March (25.1 mg/l) and highest in June (31.4 mg/l in an open area and 33.1 mg/l in a covered area). The free carbon dioxide value in the covered regions increased during the Makhana crop's remarkable growth period (April to June), but it fell during the harvest season (July and August). In June, there was the biggest difference (2.5 mg/l) between the open and covered areas in terms of free carbon dioxide levels [22].

The breakdown of algae, submerged macrophytes, and bottom organic fertilizers was the cause of the summertime high in free CO_2. High levels of free CO_2 were recorded over the summer. The quantity and kind of biological activity in water are directly correlated with the concentration of free CO_2. The amount of free CO_2 in water rises when macrophytes decompose. Similar effects were seen in water bodies impacted by water hyacinth. Because there were more plants, the CO_2 content rose. During the winter, free CO_2 levels decreased as a result of the algae and submerged macrophytes' increased photosynthetic activity requiring CO_2. Once more, organic molecules decomposed more slowly at low temperatures, resulting in less free CO_2 being released into the water [23].

Toal alkalinity

In the covered areas, the water's total alkalinity (T. A.) ranged from 90.2 mg/l to 125 mg/l; the former was the value for March and the latter was the value for June. The content gradually decreased and then increased again between January and March, when the Makhana crop was still in the seedling stage. However, the total alkalinity content began to rise as soon as the grand growth stage began. By June, it had increased to 124.2 mg/l in open areas and 126.2 mg/l in covered areas from 116.2 mg/l in April and 118.2 mg/l in covered regions. Its content tended to decline between the June and August harvest season [24].

Alkalinity is a crucial metric for assessing water quality. It shows how productive the body of water is the current experimental pond was a nutrient-rich aquatic body based on the alkalinity-based classification of water bodies into low (40–60 ppm), moderately high (60–100 ppm), and high (100–200 ppm) productivity groups. The months of March and June had the lowest and greatest alkalinity levels, respectively. The insoluble forms of calcium and magnesium carbonates were converted to their soluble bicarbonate forms by the resultant carbonic acid [25].

Hardness

The range of the total hardness was 112.1–206.2 mg/l. The concentration was lowest in March and greatest in June (196.2 mg/l in the covered regions and 190.2 mg/l in the open areas). Its level decreased from 122.2 mg/l in January to 112.1 mg/l in March during the Makhana crop's January–March seedling stage. However, there was a steady rise from 162.2 mg/l in April to 190.2 mg/l (open regions) and 196.2 mg/l (covered areas) in June throughout the grand growth period (April to June). Its content gradually decreased throughout the harvest stage [26].

The amount of free CO_2 dissolved in water affects its hardness rating. An overabundance of free CO2 was created during the breakdown of bottom deposits, which most likely led to the conversion of insoluble carbonate into soluble bicarbonates. The hardness value increased as a result of the substantial amount of bicarbonates that accumulated over the summer. Singh [27] noted a similar relationship as well.

Calcium and magnesium

Calcium levels were lowest in March (2.2 mg/l) and greatest in June (40.17 mg/l in open portions and 42.67 mg/l in enclosed areas). The calcium concentration of the Makhana crop during the seedling phase was 24.13 mg/l in January, 30.20 mg/l in February, and 20.86 mg/l in March. However, its content increased significantly during the large growth stage (April to June), even though the Ca level dropped during the harvesting phase. From July through December, there was no obvious pattern. February had the greatest magnesium levels (16.87 mg/l), while August had the lowest (6.17 mg/l in covered portions and open sections). Magnesium content and calcium levels showed similar trends [28-30].

Less than 10 parts per million Ca+2 is considered poor water, 10 to 26 parts per million Ca+2 is considered medium water, and more than 26 parts per million Ca+2 is considered rich water. Consequently, the experimental pond has a high calcium concentration. Found that the ponds with macrophytes have a high calcium concentration. The results are corroborated by a reduced calcium content during the harvest phase and a higher calcium level throughout the large growth stage. The gradual rise in calcium levels over the summer could be explained by the substrate's organic components oxidizing fast. Its use by submerged macrophytes and phytoplankton may be the cause of the wintertime decline in its content. August had the lowest magnesium levels, while February had the highest.

Chloride

In covered areas, the water's chloride concentration ranged from 66.30 mg/l to 82.3 mg/l; the latter was the value for July, while the former was the number for March. Its content decreased as the seedling stage progressed. However, its content in the open spaces increased from April to June. In the covered sites, the tendency persisted until July. The level of chloride decreased steadily from July to October. However, it became much more concentrated in November and remained there until January.

During the main growth phase, which lasted from April to June, the current experimental pond displayed a high concentration of chloride. The amount of chloride increased during the summer. The breakdown of organic waste could be the cause of the summertime increase in chloride concentration. Because Makhana plants and other macrophytes are present, the pond under study has a high concentration of chloride. Ponds with macrophyte infestations have elevated chloride concentrations [31].

Phosphate

In February, the phosphate concentration was 0.236 mg/l; in July and June, it was 1.230 mg/l. During the crop's seedling period, the readings were 0.270 mg/l in January, 0.230 mg/l in February, and 0.920 mg/l in March. Throughout the major expansion period, which ran from April to June, its material gradually increased in both covered and open areas. In April, May, and June, the phosphate concentrations in open regions were 0.942 mg/l, 1.216 mg/l, and 1.230 mg/l, whereas in covered areas they were 0.930 mg/l, 1.210 mg/l, and 1.212 mg/l. Throughout the harvest season in July and August, the phosphate concentration gradually decreased. It decreased from 1.200 mg/l to 1.220 mg/l in covered areas [32].

Ponds with macrophyte infections have elevated phosphorus levels. Wetlands with weeds, however, have low content. Its content increased during the major growth phase and decreased during harvest. The significant bacterial breakdown of organic molecules at high summer temperatures may be the cause of the higher phosphate concentration. The low concentration in the winter might be caused by poor bacterial activity at lower temperatures and excessive nutrient absorption during macrophyte and phytoplankton photosynthesis [33].

Nitrogen

Measured in February and July, the water's nitrogen level varied between 0.970 and 0.170 mg/l. The nitrogen concentration rose to 1.250 mg/l in March after falling from 1.640 mg/l in July to 0.970 mg/l in February. The concentrations were 1.610 mg/l in open areas and 1.608 mg/l in covered areas till June. Both the open and covered regions had nitrogen concentrations of 1.397 mg/l in July; in August, the nitrogen concentrations were 1.381 mg/l in the former and 1.386 mg/l in the latter [35].

High nitrate levels are found in ponds that are infested with macrophytes. Marshes infested with weeds had low content. The range of its concentration was 0.970 mg/l to 1.650 mg/l. Because organic matter decomposes in hot summer temperatures, there was a noticeable nitrate level. Winter sedimentation, a decrease in the breakdown of organic materials, and biogenic uptake by macrophytes and phytoplankton could have all contributed to the low nitrate levels in the pond [36].

Pond soil

In July, August, November, and February, the pH of the pond soil stayed at 6.7 four times; in September, it fluctuated between 6.3 and 6.7. It is 6.4 in March, July, and August, 6.6 in December and January, and 6.2 in April and May. The pH readings were highest in December and January (6.8). It began to decline in February, and this pattern persisted until June, when the remarkable expansion period came to an end. However, as the harvest season went on, it’s worth rose [37].

The percentage of organic carbon dropped from the seedling phase to the grand growth phase; the values ranged from 0.620% to 1.116% in that sequence. It remained stable at 1.1% throughout August and September, 0.840% during October and December, and 0.610% during May and June. During the harvesting period, the percentage of organic carbon was 1.106% in August and 0.900% in July. From September (0.1%) to June (0.610%), its fraction gradually decreased, with the exception of December, when its content slightly climbed (0.840%).

The current pond's bacterial activity rate can be classified into four ranges: < 6, 6 to 10, 10 to 16, and > 16, in accordance with his assertion that bacterial activity is low when the ratio is less than 10 and high when the ratio is 20 or above. They found that bad output is indicated by a C/N ratio of less than 6, better production is indicated by a C/N ratio of 6 to 10, the optimal condition is indicated by a C/N ratio of 10 to 16, and less favourable conditions are indicated by a C/N ratio of more than 16. It seemed that a lower C/N ratio was more beneficial to aquatic productivity than a wide one [38].

CONCLUSION

Transparency and the number of suspended organisms and particle matter in the water are clearly correlated. Low transparency is caused by high temperatures and quick decomposition during the summer, particularly in the month of May and June. Conversely, cold temperatures during the winter slow down the breakdown of biological components, which increases transparency. During the grand development of *Euryale ferox* (Makhana), a drop in pH has been associated with an increase in water temperature, dissolved CO_2 pressure, and a decrease in dissolved oxygen content. Otherwise, because to submersion, the pH of the soil is neutral to slightly alkaline. A pH of neutral to slightly alkaline has been demonstrated to be advantageous. The scattered makhana leaves prevented sunlight from penetrating the water's surface deeply, which hindered ambient air exchange and prevented the dissolved oxygen concentration from rising to the appropriate level. The experimental pond's remaining empty area allowed the dissolved oxygen level to remain balanced. The submerged macrophytes absorb less free CO_2 for photosynthesis in the summer because there is less vegetation, which elevates the total alkalinity. Massive amounts of bicarbonate build up as a result of the extra free CO_2 created by the breakdown of bottom deposits, increasing the water's hardness over the summer. The decomposition of organic waste during the summer caused the water's chloride content to rise. Phosphate and nitrate concentrations are high in the summer due to a high rate of bacterial breakdown. However, because decomposition proceeds slowly in the cold, the value decreases.

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