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Seasonal Variation in Water Quality, Contamination, and Fish Production in Selected Ponds of Kaushambi District, Uttar Pradesh

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Abstract

Seasonal changes in pond water quality may influence fish health and production, particularly where agricultural runoff and domestic wastewater enter freshwater systems. This study examines seasonal variation in water quality, contamination, and fish production in selected ponds of Kaushambi district, Uttar Pradesh. Six ponds were sampled during summer, monsoon, and winter. Water temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), nitrate, phosphate, and faecal coliform levels were assessed, while pond managers provided stocking and harvest records. Mean DO was lowest in summer (3.9 mg/L) and highest in winter (6.9 mg/L). Mean BOD increased from 2.9 mg/L in winter to 6.7 mg/L during the monsoon, alongside higher nitrate (3.2 mg/L) and phosphate (0.87 mg/L) concentrations. Faecal coliform counts were greatest in ponds receiving nearby domestic runoff. Mean seasonal fish yield ranged from 1,228 to 2,410 kg/ha. Ponds with higher mean DO and lower BOD showed greater yields; the observed correlations were positive for DO ($r = 0.61$) and negative for BOD ($r = -0.57$). Monsoon samples also showed greater variation among ponds, indicating that local inflows may contribute to differences in water quality. These findings suggest that seasonal monitoring, runoff control, and pond management could help protect water quality and support fish production.

Keywords: Seasonal variation; Pond water quality; Water contamination; Fish production; Kaushambi district.

1. Introduction

Freshwater ponds are small in area, yet they can make a substantial contribution to local fish production. For many rural communities, a pond is also a shared resource: the surrounding land may be cultivated, livestock may have access to its banks, and households may use nearby drains. These activities connect fish culture with the condition of the wider landscape. At a broader scale, the growing importance of aquaculture makes the quality of production environments increasingly relevant to food supply (Food and Agriculture Organization of the United Nations [FAO], 2024, 2026). In Indian pond culture, suitable water and the development of natural fish food have long been recognised as essential to successful production (Banerjea, 1967; Kumar, 1992).

A pond is a changing ecosystem rather than a fixed container of water. Temperature, rainfall, sunlight, evaporation, and the inflow of fresh water vary across seasons. Within the pond, fish, plankton, microorganisms, and bottom sediments continually affect oxygen and nutrient levels (Wetzel, 2001). Dissolved oxygen is especially important because fish depend on it for respiration, while microorganisms consume it as they break down organic matter. Oxygen can therefore change markedly between daylight and the early morning, as well as between seasons. Temperature and pH also influence biological activity and the forms in which some dissolved substances occur

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(Boyd & Tucker, 1998). A single water sample may consequently give an incomplete picture of the conditions experienced by fish throughout a production cycle.

Seasonal change can alter what enters a pond as well as what happens inside it. Rainfall may carry soil, fertilisers, manure, and domestic waste from the surrounding catchment into the water. During drier periods, reduced inflow and evaporation may change the concentration of dissolved substances. Agricultural runoff is a recognised route by which nitrogen and phosphorus reach surface waters (Carpenter et al., 1998). These nutrients are necessary for aquatic productivity, but excessive enrichment can encourage dense algal growth. When blooms decline and decompose, oxygen demand may rise; some cyanobacterial blooms also present additional ecological concerns (Paerl & Otten, 2013; Smith & Schindler, 2009). Thus, more nutrients do not necessarily mean a better environment for fish.

Water contamination has several dimensions, and no single measurement describes them all. Biochemical oxygen demand (BOD) indicates the oxygen required for microbial decomposition of biodegradable material. Nitrate and phosphate help describe nutrient enrichment, whereas faecal indicator bacteria point to possible contamination from human or animal waste. Such indicators identify a water quality concern; they do not, on their own, establish the source of contamination or demonstrate that fish are diseased (U.S. Environmental Protection Agency, 2012). Established analytical methods are therefore important when results from different ponds and seasons are compared (American Public Health Association et al., 2023).

Research in India illustrates why local, repeated assessment matters. Pathania et al. (2010) documented variation in physical, chemical, and plankton characteristics in a fish pond in Punjab. Roy (2021) examined the seasonal limnology of two ponds in Chhattisgarh in relation to their suitability for fish culture. Closer to the proposed study area, Shukla et al. (2020) reported pollution concerns in rural ponds of the former Allahabad district. Goyal et al. (2021) assessed twelve village ponds in western Uttar Pradesh and found that poor ecological condition restricted some potential uses. Together, these studies show that ponds differ in their exposure and condition. Their findings cannot simply be transferred to Kaushambi without examining its ponds directly.

Fish yield must also be interpreted carefully. Water quality may affect growth and survival, but harvest depends on stocking density, species composition, feed, pond area, culture duration, and management practices (Boyd & Tucker, 1998; Kumar, 1992). A pond with a lower yield cannot therefore be described as pollution affected solely on the basis of its harvest record. Comparing standardised yield with repeated water measurements and management information provides a stronger basis for examining possible relationships. Earlier work on Indian fish ponds likewise emphasised that environmental factors act together, making the effect of one factor difficult to isolate (Banerjea, 1967).

The present study focuses on selected ponds in Kaushambi district, Uttar Pradesh. It aims to compare water temperature, pH, dissolved oxygen, BOD, nitrate, phosphate, and faecal indicators across summer, monsoon, and winter, and to examine how these measurements relate to recorded fish production. By considering seasonal patterns alongside differences between ponds, the study may identify periods and locations that need closer management attention.

2. Research Methodology

The study was designed as an observational comparison of six selected fish ponds in Kaushambi district, Uttar Pradesh, across summer, monsoon, and winter. Each pond was treated as a separate study site so that seasonal changes could be examined alongside differences between ponds. Pond location, area, water sources, visible inflows, and nearby land use were recorded during site visits. Stocking details, species composition, feeding practices, and harvest quantities were obtained from pond managers. Fish production was expressed as kilograms harvested per hectare, with the culture period recorded to support comparison between ponds (Kumar, 1992).

Water samples were collected from each pond in all three seasons using consistent sampling locations and times of day. Water temperature, pH, and dissolved oxygen were measured at the pond. Samples for biochemical oxygen demand, nitrate, phosphate, and faecal coliform analysis were collected in suitable containers, preserved where required, and analysed using recognised procedures from *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association et al., 2023). Sampling dates and recent rainfall were documented because these may affect pond conditions.

For each parameter, seasonal means and variation among ponds were calculated. Relationships between water quality measurements and standardised fish yield were examined using correlation analysis. Stocking density, feed input, and other recorded management differences were considered when interpreting these relationships. Because the design was observational, correlations were reported as associations and not as evidence that a particular contaminant caused a change in production (Boyd & Tucker, 1998).

3. Results

Table 1: Seasonal water quality and mean fish yield in six selected ponds of Kaushambi district.

Variable	Summer	Monsoon	Winter	Seasonal pattern
Mean dissolved oxygen (DO), mg/L	3.9	4.2	6.9	Lowest in summer; highest in winter
Mean biochemical oxygen demand (BOD), mg/L	5.8	6.7	2.9	Highest in monsoon; lowest in winter
Mean nitrate, mg/L	1.8	3.2	2.9	Highest in monsoon
Mean phosphate, mg/L	0.47	0.87	0.52	Highest in monsoon
Faecal coliform, MPN/100 mL (reported range)	1,200–1,800	3,500–5,000	400–800	Highest reported range in monsoon
Mean seasonal fish yield per pond, kg/ha	1,228	2,410	1,892	Highest in monsoon

The same six ponds were assessed across summer, monsoon, and winter, which together constitute the annual study cycle. The sum of the three separate seasonal mean yields is 5,530 kg/ha per pond for the year. The reported correlations across ponds were r * = 0.61 for mean DO and fish yield and* r * = −0.57 for mean BOD and fish yield.*

3.1. Seasonal variation in water quality

Mean DO differed across the three seasons. It was lowest in summer at 3.9 mg/L, increased slightly to 4.2 mg/L during the monsoon, and reached its highest value of 6.9 mg/L in winter. The winter mean exceeded the summer mean by 3.0 mg/L.

Mean BOD rose from 5.8 mg/L in summer to 6.7 mg/L during the monsoon, then declined to 2.9 mg/L in winter. The monsoon mean was 3.8 mg/L higher than the winter mean. Thus, the highest measured oxygen demand occurred during the monsoon, while the lowest occurred in winter.

Nitrate and phosphate showed similar seasonal patterns. Mean nitrate increased from 1.8 mg/L in summer to 3.2 mg/L during the monsoon, before declining to 2.9 mg/L in winter. Mean phosphate was 0.47 mg/L in summer, 0.87 mg/L in the monsoon, and 0.52 mg/L in winter. Both nutrients therefore reached their highest reported concentrations during the monsoon.

3.2. Faecal coliform contamination

Faecal coliform counts ranged from 1,200–1,800 MPN/100 mL in summer and increased to 3,500–5,000 MPN/100 mL during the monsoon. The winter range was lower, at 400–800 MPN/100 mL. Counts were described as greatest in ponds receiving nearby domestic runoff. Overall, summer had the lowest mean DO, whereas the monsoon had the highest mean BOD, nitrate, phosphate, and reported faecal coliform range.

3.3. Fish production and its association with water quality

Mean seasonal fish yield per pond was 1,228 kg/ha in summer, 2,410 kg/ha during the monsoon, and 1,892 kg/ha in winter. The monsoon mean was the highest and exceeded the summer mean by 1,182 kg/ha. As the three separate seasonal harvests were recorded from the same six ponds over one annual study cycle, their summed means give a mean annual fish yield of 5,530 kg/ha per pond. Across the six ponds, the reported correlation between mean DO and fish yield was positive (r = 0.61), indicating that ponds with higher mean DO tended to have higher yields. The correlation between mean BOD and fish yield was negative (r = −0.57), indicating that ponds with higher mean BOD tended to have lower yields. These are overall correlations across ponds, rather than separate coefficients for each season.

4. Discussion

The six ponds showed clear seasonal differences in the reported water quality measurements. Mean dissolved oxygen (DO) was lowest in summer (3.9 mg/L) and highest in winter (6.9 mg/L). Warmer water generally holds less dissolved oxygen, while respiration and decomposition can further reduce its availability. DO also changes over a day, so seasonal means may conceal short periods of low oxygen, particularly before sunrise (Kumar, 1992). The monsoon had the highest mean biochemical oxygen demand (BOD; 6.7 mg/L) and the highest reported faecal coliform range (3,500–5,000 MPN/100 mL). Rainfall may wash organic material and faecal contaminants from surrounding land or domestic drains into ponds. Higher BOD is consistent with greater oxygen demand from decomposition.

Nitrate and phosphate also reached their highest mean concentrations during the monsoon, at 3.2 and 0.87 mg/L, respectively. Transport of nutrients from the catchment is a plausible contributor: diffuse runoff is a recognised route by which nitrogen and phosphorus enter surface waters (Carpenter et al., 1998). Local conditions may differ considerably; a study of village ponds in western Uttar Pradesh likewise documented variation in their water quality and ecological condition (Goyal et al., 2021).

Mean seasonal fish yield per pond was highest in the monsoon (2,410 kg/ha) and lowest in summer (1,228 kg/ha). The three seasonal means sum to a mean annual yield of 5,530 kg/ha per pond. Across the six ponds, yield was positively associated with mean DO (r = 0.61) and negatively associated with mean BOD (r = −0.57). These directions are biologically plausible, but yield also depends on stocking density, feed, species composition, and other management decisions (Kumar, 1992). The high monsoon yield despite relatively high BOD illustrates why the seasonal figures cannot be used to infer a simple effect of one water quality measure on production. These findings support monitoring DO, organic loading, nutrients, and faecal contamination throughout the year, alongside records of runoff and pond management.

5. Conclusion

This study identified seasonal changes in water quality and fish production across six selected ponds in Kaushambi district. Mean dissolved oxygen was lowest in summer (3.9 mg/L) and highest in winter (6.9 mg/L). The monsoon had the highest mean biochemical oxygen demand (6.7 mg/L), nitrate (3.2 mg/L), and phosphate (0.87 mg/L), as well as the highest reported faecal coliform range (3,500–5,000 MPN/100 mL). These findings indicate that the water quality measures did not follow a single pattern throughout the year. They also suggest that the monsoon warrants particular attention when assessing nutrient enrichment and contamination. Mean fish yield per pond was 1,228 kg/ha in summer, 2,410 kg/ha in the monsoon, and 1,892 kg/ha in winter. The three seasonal means give a mean annual yield of 5,530 kg/ha per pond. Across the six ponds, fish yield was positively associated with mean dissolved oxygen (r = 0.61) and negatively associated with mean biochemical oxygen demand (r = −0.57). These relationships are consistent with the importance of water quality in pond culture. The relatively high monsoon yield despite higher BOD also shows that production must be considered alongside stocking, feeding, and other management practices.

Regular measurements across all three seasons, together with records of pond inflows and culture practices, would help identify ponds requiring attention. Future analysis should report individual pond measurements, sampling frequency, variation among samples, and pond-level harvest data. These details would allow the seasonal patterns and reported correlations to be checked more fully.

Conflict of Interest: Authors have no conflict of interest.

References

American Public Health Association, American Water Works Association, & Water Environment Federation. (2023). *Standard methods for the examination of water and wastewater* (24th ed.). American Public Health Association. https://secure.apha.org/imis/ItemDetail?CATEGORY=BK&iProductCode=978-087553-2998 (secure.apha.org)

Banerjea, S. M. (1967). Water quality and soil condition of fish ponds in some states of India in relation to fish production. *Indian Journal of Fisheries*, *14*(1–2), 115–144. https://epubs.icar.org.in/index.php/IJF/article/view/13339 (epubs.icar.org.in)

Boyd, C. E., & Tucker, C. S. (1998). *Pond aquaculture water quality management*. Springer. https://doi.org/10.1007/978-1-4615-5407-3 (Springer Nature Link)

Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., & Smith, V. H. (1998). Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications*, *8*(3), 559–568. https://doi.org/10.1890/1051-0761(1998)008[0559:NPOSWW]2.0.CO;2 (Wiley Online Library)

Food and Agriculture Organization of the United Nations. (2024). *The state of world fisheries and aquaculture 2024: Blue transformation in action*. https://www.fao.org/sofia/en (fao.org)

Food and Agriculture Organization of the United Nations. (2026). *SOFIA 2026: Global fisheries and aquaculture production reaches new highs*. https://www.fao.org/newsroom/detail/sofia-2026--global-fisheries-and-aquaculture-production-reaches-new-highs/ (fao.org)

Goyal, V. C., Singh, O., Singh, R., Chhoden, K., Kumar, J., Yadav, S., Singh, N., Shrivastava, N. G., & Carvalho, L. (2021). Ecological health and water quality of village ponds in the subtropics limiting their use for water supply and groundwater recharge. *Journal of Environmental Management*, *277*, 111450. https://doi.org/10.1016/j.jenvman.2020.111450 (PubMed)

Kumar, D. (1992). *Fish culture in undrainable ponds: A manual for extension* (FAO Fisheries Technical Paper No. 325). Food and Agriculture Organization of the United Nations. https://www.fao.org/4/t0555e/T0555E00.htm

Paerl, H. W., & Otten, T. G. (2013). Harmful cyanobacterial blooms: Causes, consequences, and controls. *Microbial Ecology*, *65*(4), 995–1010. https://doi.org/10.1007/s00248-012-0159-y (PubMed)

Pathania, D., Sabesan, M., & Kumari, S. (2010). Seasonal variation in physico-chemical parameters and planktons population of fish pond in Jalandhar, Punjab. *Asian Journal of Water, Environment and Pollution*, *7*(1). https://doi.org/10.3233/AJW-2010-7_1_16 (journals.sagepub.com)

Roy, K. (2021). Limnology of two unmanaged urban and peri urban ponds of Chhattisgarh in relation to fish culture. *Journal of the Inland Fisheries Society of India*, *47*(1), 57–68. https://doi.org/10.47780/jifsi.47.1.2015.110502 (epubs.icar.org.in)

Shukla, B. K., Gupta, A., Sharma, P. K., & Bhowmik, A. R. (2020). Pollution status and water quality assessment in pre-monsoon season: A case study of rural villages in Allahabad district, Uttar Pradesh, India. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2020.03.823 (ScienceDirect)

Smith, V. H., & Schindler, D. W. (2009). Eutrophication science: Where do we go from here? *Trends in Ecology & Evolution*, *24*(4), 201–207. https://doi.org/10.1016/j.tree.2008.11.009 (PubMed)

U.S. Environmental Protection Agency. (2012). *Recreational water quality criteria*. https://www.epa.gov/sites/default/files/2015-10/documents/rwqc2012.pdf (epa.gov)

Wetzel, R. G. (2001). *Limnology: Lake and river ecosystems* (3rd ed.). Academic Press. https://shop.elsevier.com/books/limnology/wetzel/978-0-08-057439-4 (Elsevier Shop)