Applied Biological Research 27(2): 173-181; (2025)
DOI: 10.48165/abr.2025.27.01.17

BIOMASS PRODUCTION OF INDIAN WHITE PRAWN (*Fenneropenaeus indicus*) AND PHYSICOCHEMICAL PROFILING OF WATER QUALITY IN SUBARNAREKHA RIVER, EAST SINGHBHUM, JHARKHAND (INDIA)

Paulomi Dutta, Shekhar Bihari Lal, and Shovit Ranjan*

University Department of Zoology, Kolhan University, Chaibasa - 833 201, Jharkhand (India)
*****e-mail: *shovit.ranjan@kolhanuniversity.ac.in*

(Received 29 December, 2024; accepted 24 May, 2025)

ABSTRACT

The Subarnarekha river, known as the "Golden river" of the Chotanagpur Plateau in Jharkhand (India), is adversely impacted by industrial effluents and anthropogenic activities, threatening its aquatic biodiversity. This study assessed the seasonal variations in physicochemical properties and their influence on the growth, survival and biomass of Indian white prawn (*Fenneropenaeus indicus*) at two sites in East Singhbhum, i.e. site I (Mango, Jamshedpur) and site II (Galudih, Ghatshila) from July 2019 to June 2022. The water quality related physiochemical parameters (temperature, pH, dissolved oxygen, and salinity) were monitored seasonally, and their correlations with prawn survival rate, mean body weight, length, and biomass production were analysed using Pearson's correlation coefficient and regression analysis. The results revealed notable seasonal fluctuations in physicochemical parameters, particularly water temperature and salinity, which exhibited strong positive correlations with prawn growth metrics. Site II consistently exhibited higher mean body weight, survival rate, and biomass production compared to site I, with optimal growth observed during spring season. Water temperature exhibited a strong positive correlation with growth metrics, while salinity also played a crucial role, particularly influencing survival and biomass. The findings highlight that physicochemical parameters, especially temperature and salinity, significantly impact the growth and productivity of *F. indicus* in Subarnarekha river. These findings underscore the importance of regular water quality monitoring for sustaining aquaculture practices in riverine ecosystems impacted by pollution. Effective management of pollution sources is essential to conserve the river's health and support the livelihoods dependent on its aquatic resources.

Keywords: Biomass production, *Fenneropenaeus indicus*, physicochemical properties, seasonal variation, Subarnarekha river, water quality

INTRODUCTION

The Subarnarekha river, often referred to as "golden river" of the Chotanagpur plateau in Jharkhand (India), traverses many Indian states, including Jharkhand, West Bengal, and Orissa, before merging into the Bay of Bengal. This river passes through the areas rich in ores, attracting numerous industries. Consequently, the discharge from industrial effluents, pollutants, and domestic wastes significantly impacts the aquatic fauna and environment. The river water quality is on decline due to the continuous release of untreated sewage, industrial waste, and other anthropogenic activities, including urbanization (Banerjee *et al*., 2015). This degradation profoundly affects the environment, disrupting ecosystems and leading to a decrease in species diversity and abundance (Alam *et al*., 2013).

In Jharkhand, pisciculture is prevalent, providing livelihood to local people. Despite Jharkhand contributing around 2% to the freshwater prawn production, prawns including the Indian white prawn (*Fenneropenaeus indicus*) are a dominant species in aquatic habitat (Dutta and Lal, 2021). However, water pollution has substantially decreased prawn production by affecting water quality parameters like temperature, pH, dissolved oxygen, and salinity. The monitoring of water quality is essential as water sources are increasingly threatened by pollution (Ahmad *et al*., 2010; Amadi, 2011). Several studies across India have examined aquaculture potential and environmental stressors in coastal and estuarine systems (Salunke *et al*., 2020), limited data exist on seasonal water quality variation and its correlation with prawn growth in an industrially impacted inland river ecosystem like Subarnarekha. Therefore, this study was aimed to assess the seasonal variations in physicochemical parameters of water in Subarnarekha river and analyse their impact on the survival rate and biomass production of *F. indicus* in Jharkhand, India. This study is innovative in integrating the seasonal water quality monitoring with growth performance metrics of a commercially important prawn species, thereby providing baseline data critical for sustainable aquaculture planning in riverine environments under pollution stress.

MATERIALS AND METHODS

Study area

The experiment was conducted seasonally from July 2019 to June 2022 at two freshwater sites along the Subarnarekha river in East Singhbhum, Jharkhand (India). For the purpose of seasonal analysis during the study period (July 2019 to June 2022), the seasons were categorized as follows: Monsoon (July to September), Autumn (October to November), Winter (December to February), and Spring (March to May). The two specific sites selected were Mango, Jamshedpur (site I) and Galudih, Ghatshila (site II) (Fig. 1). The Mango site, where the Subarnarekha river flows over a long distance from Ranchi to East Singhbhum, is a rain-fed river located at latitude 22.81760° N and longitude 86.20861° E. The Galudih site, situated on the river's banks in Ghatshila region, is positioned at latitude 22.64356° N and longitude 86.40535° E.

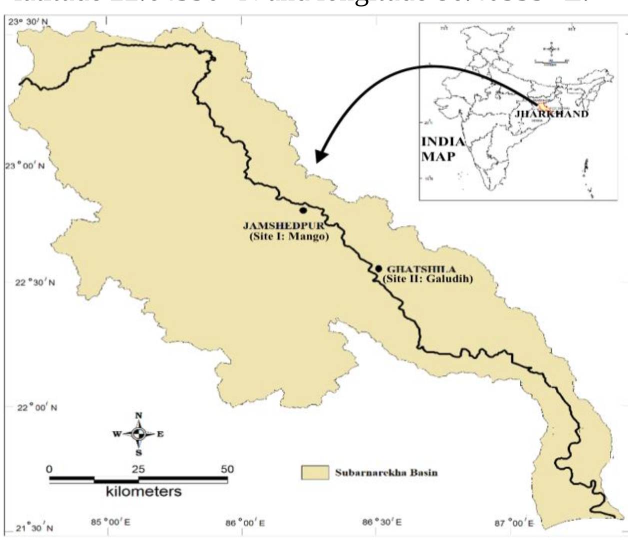

Fig. 1: llustrative map showing the study sites along the Subarnarekha river in East Singhbhum district, Jharkhand (India). The marked locations represent sampling points selected for seasonal water quality analysis and biomass assessment of *Fenneropenaeus indicus* during the study period (July 2019 to June 2022)

Experimental samples and spot reading

The specimens of *F. indicus* (Fig. 2) were collected early in the morning at both the sites with the assistance of local fishermen using drag nets and cast nets measuring 2 m in length with a mesh size of 35 mesh cm^{-1} (Fig. 3). To ensure consistency and minimize sampling bias, fishermen were instructed to use the same type of net (drag or cast net), in

Fig. 2: Photograph of *Fenneropenaeus indicus* specimen collected from the study sites along the Subarnarekha river in East Singhbhum district, Jharkhand (India)

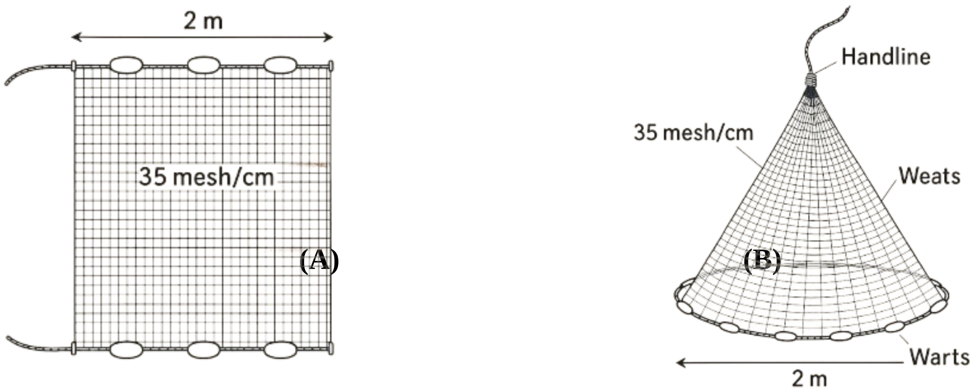

Fig. 3: Schematic diagram of fishing gears [drag net (A) and cast net (B)] used for the collection of Indian white prawn at the study sites along the Subarnarekha river

the same fishing area, and for the same time duration during each sampling event at all study sites throughout the study period. Live specimens were collected, and their total length measured on spot using calipers or rulers. Mean body weight (MBW) of live and wet prawns was measured by using electronic precision scales (± 0.0 g) by measuring the length and weight of live and wet prawns. MBW was calculated by dividing the total weight of prawns by the number of prawns. Growth performance, specifically the survival rate of *F. indicus*, was calculated using the following formula adapted from Brown (1957), Hopkins (1992), Zonnveld and Fadholi (1991) and Karim (2007):

$$\text{Survival rate (\%)} = \frac{\text{No.of live individuals at the end of the study}}{\text{No.of live individuals at the beginning of the study}} \; x\ 100$$

This formula calculates the percentage of prawns that survived from the initial stocking to the end of the sampling period in each season. Subsequently, biomass production was determined by multiplying the survival rate (%) with the mean body weight (g) of the surviving prawns, providing a quantitative measure of total prawn biomass yield per season.

The collection, on-site measurement or spot reading, and subsequent calculation were performed seasonally across four distinct seasons (i.e. monsoon, autumn, winter, and spring) each year. This seasonal sampling was carried out consistently over a three-year period (July 2019 to June 2022) for each parameter at each study site. The data were then averaged across the corresponding seasons over the three years to comprehend the seasonal trends and variations.

Physicochemical analysis

The water samples were collected using glass bottles and transported to the laboratory for further titration, performed seasonally. Water temperature was measured with a standard thermometer ranging from 0°C to 110°C, and pH was determined by using a digital pH meter. Dissolved oxygen was measured by using Winkler's method (APHA, 2012), and salinity by titration method using the Mohr-Knudsen procedure (Knudsen, 1901).

Statistical analysis

To ascertain the relationship between water quality factors and the mean body weight, length, survival rate, and biomass output of Indian white prawn at two distinct sites, average values of physicochemical seasonal data of 3 years gathered between July 2019 to June 2022 were utilized. The relationship between physicochemical parameters and the mean body weight, length, survival rate, and biomass production of *F. indicus* was analyzed by using the Karl Pearson correlation coefficient method (Pearson, 1907). Regression analysis was used to identify any significant effect on the values. Microsoft Excel was used for all statistical analyses, including the production of graphs and computation of mean, standard deviation (±), and standard error.

RESULTS AND DISCUSSION

Seasonal variation in physicochemical parameters

Monitoring and analysis of physicochemical parameters are essential for evaluating the ecological health and productivity of aquatic ecosystems (Foley *et al*., 2015; Bhateria and Jain, 2016; Pouso *et al*., 2018). In this study, seasonal assessments of water temperature, pH, dissolved oxygen, and salinity were conducted from July 2019 to June 2022 at two sites along the Subarnarekha river, i.e. site I (Mango, Jamshedpur) and site II (Galudih, Ghatshila). Substantial seasonal variation was observed in water temperature, dissolved oxygen, and salinity, while pH remained relatively stable (Fig. 4). At site I, water temperature varied from 17.8 ± 0.37° (winter) to 29.8 ± 0.52°C (spring); dissolved oxygen ranged from 4.16 ± 0.20 (monsoon) to 7.1 ± 0.72 mg L^{-1} (spring), and salinity ranged from 0.076 ± 0.01 (autumn) to 0.71 ± 0.63 ppt (spring). Site II showed similar patterns with water temperature ranging from 18.2 ± 0.26° (winter) to 28.8 ± 0.75°C (spring), dissolved oxygen from 4.23 ± 0.11 (monsoon) to 7.5 ± 0.45 mg L^{-1} (winter), and salinity from 0.063 ± 0.025 (monsoon) to 0.74 ± 0.54 ppt (spring).

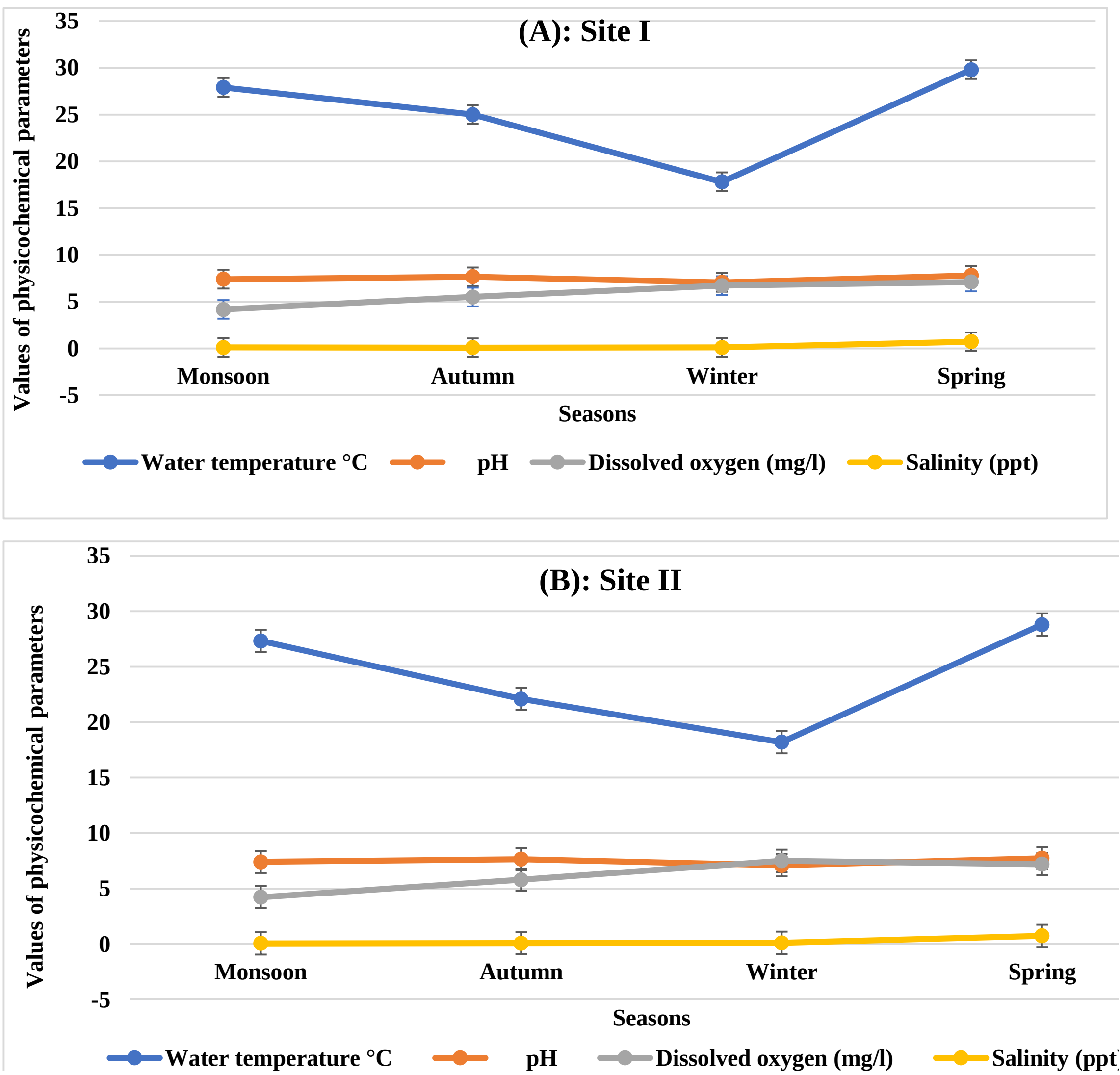

Fig. 4: Seasonal variation in physicochemical properties at site I (Mango) (A) and site II (Galudih, Ghatshila) (B) of Subarnarekha river from 2019 to 2022. The data represent the average seasonal values (monsoon, autumn, winter, and spring) over 3-years period.

The water temperature significantly affected the dissolved oxygen levels at both the sites, a pattern consistent with the known physiological responses of aquatic organisms to thermal fluctuations (Manush *et al*., 2004; Blaber, 2008). pH remained within a narrow neutral range (7.06-7.80), supporting biological stability, as previously noted by Welch (1952). Seasonal fluctuations in salinity reflected typical hydrological dynamics, with increase in parameter from winter to summer, aligning with the trends reported by Ghosh *et al*. (2011). Notably, the site I exhibited relatively lower dissolved oxygen and salinity levels, likely due to the anthropogenic activities, including industrial effluent discharge, which promote aquatic weed growth (e.g., *Eichhornia*, *Hydrilla*) that impede the oxygen availability through excessive respiration and decomposition (Ravindra and Kaushik, 2003).

Growth performance and biomass production of F. indicus

Growth performance metrics (i.e. mean body weight, length, survival rate, and biomass production) of *F. indicus* demonstrated pronounced seasonal variation at both sites (Fig. 5). At site I, mean body weight ranged from 2.3 ± 0.72 (winter) to 3.46 ± 0.80 g (spring), while length ranged from 6.66 ± 0.57 (autumn) to 13.16 ± 1.89 cm (spring). The survival rate varied from 50.62 ± 12.11 (winter) to 78.78 ± 10.82% (spring), and biomass production from 120.44±61.54 (winter) to 278.91 ± 106.1 kg m^{-2} (spring). At site II, superior growth performance was recorded: mean body weight ranged from 2.5 ± 0.01 (winter) to 3.96 ± 0.98 g (spring), length from 9.03±1.05 (winter) to 15.3 ± 0.57 cm (spring), survival rate from 52.18 ± 7.80 to 87.04 ± 6.68%, and biomass production from 130.46 ± 19.51 to 349.66 ± 116.07 kg m^{-2}. Growth patterns reflected seasonal environmental conditions, with

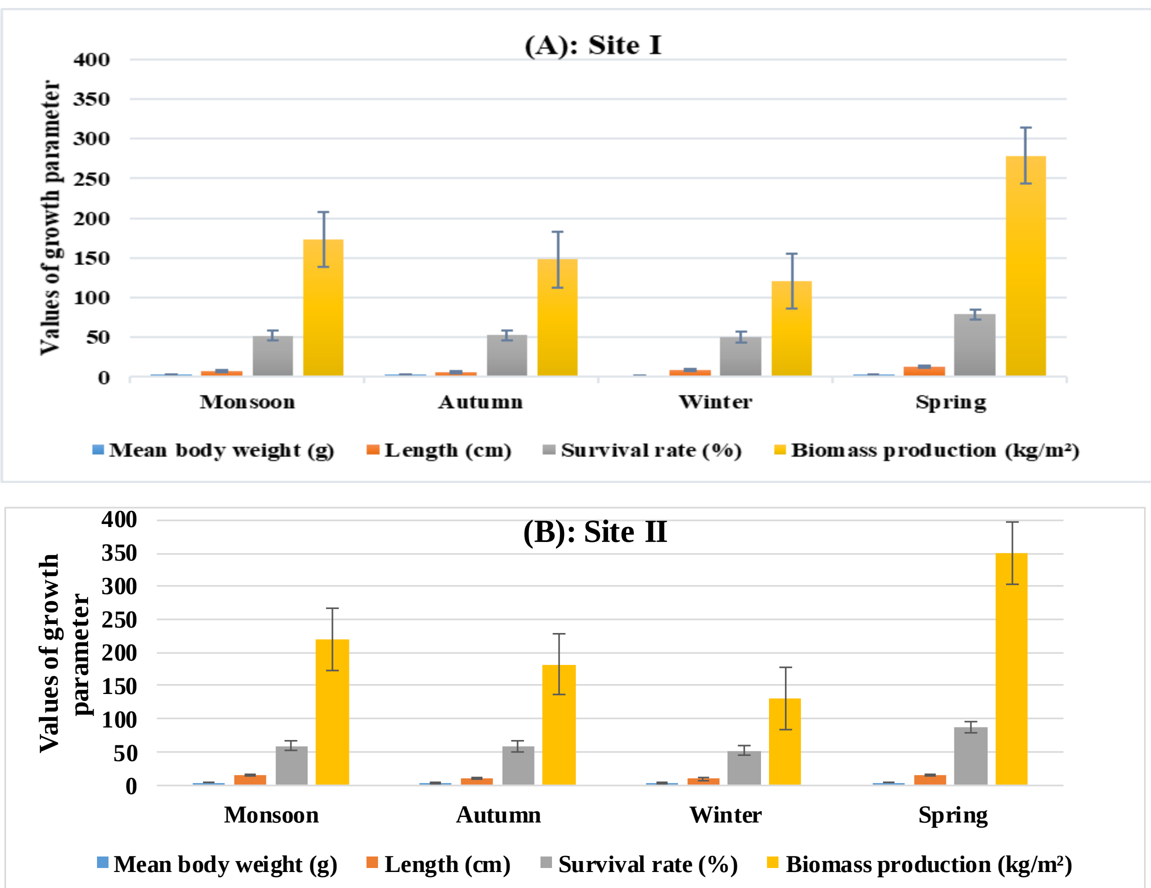

Fig. 5: Seasonal changes in mean body weight, length, survival rate, and biomass production of *Fenneropenaeus indicus* at site I (Mango, Jamshedpur) (A) and site II (Galudih, Ghatshila) (B) of Subarnarekha river from 2019 to 2022. The data represent the average seasonal values (monsoon, autumn, winter, and spring) over a three-years period.

optimal value of metrics observed during spring and lowest values in winter. These results corroborate with earlier studies showing that warmer temperatures promote higher metabolic efficiency and growth in crustaceans (Montagna, 2011; Crisp *et al*., 2017). Site II consistently outperformed site I, suggesting better water quality and lower industrial stress at Galudih, as also inferred from higher dissolved oxygen and salinity levels.

Correlation between physicochemical parameters and growth metrics of F. indicus

Statistical analysis using Karl Pearson's correlation coefficient (Table 1) revealed a strong and significant positive correlation between water temperature and mean body weight at both site I (r = 0.97) and site II (r = 0.99). Temperature also correlated positively with length (r = 0.98) at site II, and moderately with survival and biomass at both sites. These findings affirm the central role of temperature in shrimp physiology, including oxygen consumption and food assimilation (Niu and O'Hara, 2003; Sharma and Subba, 2005).

The pH showed a generally positive but non-significant correlation with all growth parameters. Despite its stability, its indirect influence on aquatic life processes cannot be overlooked, as demonstrated in studies involving *Macrobrachium villosimanus* (Rashed-un-Nabi *et al*., 2011; Duque *et al*., 2020).

Dissolved oxygen exhibited weak or negative correlations with body weight and length but a positive (though non-significant) association with survival and biomass. Its role in respiration and energy metabolism underscores the importance of maintaining optimal oxygen levels, as oxygen depletion can inhibit shrimp growth (Yang *et al*., 2008; Dutta and Lal, 2021).

Salinity emerged as another key driver, with significant positive correlations with survival and biomass at site I (r = 0.9), and a positive correlation with body weight and length at both sites. These findings align with literature reporting salinity tolerance and adaptability in euryhaline species such as *Penaeus* and *Macrobrachium* (Kumlu and Jones, 1995; Romano and Zeng, 2006).

Table 1: Karl Pearson correlation coefficients between physicochemical parameters and the mean body weight (g), length (cm), survival rate (%), and biomass production (kg m^{-2}) of *Penaeus indicus* from 2019 to 2022

Parameters	Water temperature		pH		Dissolved oxygen		Salinity	
	Site I	Site II	Site I	Site II	Site I	Site II	Site I	Site II
Mean body weight	0.976*	0.998*	0.707	0.717	-0.259	-0.398	0.588	0.602
Length	0.278	0.980*	0.313	0.547	0.779	-0.321	0.933	0.637
Survival rate	0.633	0.765	0.693	0.739	0.583	0.262	0.995*	0.964*
Biomass production	0.806	0.885	0.745	0.757	0.344	0.057	0.945*	0.896

*Correlation is significant at the 0.05 level (2-tailed).

Environmental impacts and management implications

The observed discrepancies between the two sites point toward anthropogenic influence, particularly at site I. Higher pollution levels, likely from industrial discharge in Mango site, resulted in poorer water quality and lower shrimp growth performance. These outcomes are consistent with previous studies linking nutrient enrichment and industrial effluents to reduced dissolved oxygen and ecological stress in aquatic fauna (Kenworthy *et al*., 2016; Nelson *et al*., 2019; Duque *et al*., 2022). To mitigate these effects, it is essential to adopt eco-friendly industrial practices, implement effluent treatment technologies, and enforce regulations to safeguard aquatic ecosystems. Sustainable aquaculture development in riverine systems like Subarnarekha hinges on maintaining optimal physicochemical conditions that support aquatic biodiversity and productivity.

Conclusion: The present study highlighted the critical influence of seasonal variations in physico-chemical parameters (particularly water temperature, salinity, dissolved oxygen, and pH) on the growth, survival, and biomass production of *Fenneropenaeus indicus* at two sites along the Subarnarekha river. The key limnological parameters, particularly dissolved oxygen and salinity, play a crucial role in proper nourishment and overall development of *F. indicus*. This study provided a comparative assessment of water quality between the two sites, revealing a stronger correlation between water quality parameters and the growth metrics of *F. indicus*. The Mango Jamshedpur site, being more industrialized, exhibited higher pollution due to industrial effluents, which negatively impacted the local aquatic fauna. In contrast, Galudih Ghatshila site showed better water quality and consequently healthier prawn development. Site-specific differences, especially those related to industrial pollution at site I, further emphasize the need for targeted environmental management strategies. Sustaining optimal water quality is essential not only for enhancing aquaculture productivity but also for preserving the ecological health of freshwater systems. Future efforts should focus on continuous water quality monitoring, pollution control, and the promotion of sustainable aquaculture practices to ensure the long-term viability of aquatic resources.

Declaration of competing interests: The authors have no competing or conflicting interests.

Acknowledgements: The authors express their sincere gratitude to Kolhan University, Chaibasa, for providing the necessary facilities and support for this study. We also extend our heartfelt thanks to the local fishermen at the study sites for their invaluable assistance and cooperation, which contributed significantly to the success of this work.

REFERENCES

Ahmad, M.K., Islam, S., Rahman, S., Haque, M. and Islam, M.M. 2010. Heavy metals in water, sediment and some fishes of Buriganga river, Bangladesh. *International Journal of Environmental Research*, **4**(2): 321-332.

Alam, M.S., Hossain, M.S., Monwar, M.M. and Hoque, M.E. 2013. Assessment of fish distribution and biodiversity status in Upper Halda river, Chittagong, Bangladesh. *International Journal of Biodiversity and Conservation*, **5**: 349-357.

Amadi, A. N. 2011. Assessing the effects of Aladimma dumpsite on soil and groundwater using water quality index and factor analysis. *Australian Journal of Basic and Applied Sciences*, **5**(11): 763-770.

APHA. 2012. *Standard Methods for the Examination of Water and Wastewater, Vol. 6* (22nd edn.). American Public Health Association/ American Water Works Association/ Water Environment Federation, Washington, USA.

Banerjee, S., Maiti, S.K. and Kumar, A. 2015. Metal contamination in water and bioaccumulation of metals in the planktons, molluscs and fishes in Jamshedpur stretch of Subarnarekha river of Chotanagpur plateau, India. *Water and Environment Journal*, **29**: 207-213.

Bhateria, R. and Jain, D. 2016. Water quality assessment of lake water: A review. *Sustainable Water Resources Management*, **2**: 161-173.

Blaber, S.J. 2008. *Tropical Estuarine Fishes: Ecology, Exploitation and Conservation*. John Wiley & Sons, Queensland, Australia.

Brown, M.E. 1957. Experimental studies on growth. pp. 361-400. **In**: *Physiology of Fishes, Volume I* (ed. M. E. Brown), Academic Press, New York, USA.

Crisp, J.A., Partridge, G.J., D'Souza, F.M., Tweedley, J.R. and Moheimani, N.R. 2017. Effects of temperature and salinity on larval survival and development of the western school prawn *Metapenaeus dalli*. *International Aquatic Research*, **9**: 1-10.

Duque, G., Gamboa-García, D.E., Molina, A. and Cogua, P. 2020. Effect of water quality variation on fish assemblages in an anthropogenically impacted tropical estuary, Colombian Pacific. *Environmental Science and Pollution Research,* **27**: 25740-25753.

Duque, G., Gamboa-García, D.E., Molina, A. and Cogua, P. 2022. Influence of water quality on the macroinvertebrate community in a tropical estuary (Buenaventura Bay). *Integrated Environmental Assessment and Management*, **18**: 796-812.

Dutta, P. and Lal, S. 2021. Studies on *Penaeus indicus* (white leg prawn) on the biomass production in reference with the physiochemical parameters at river Subarnarekha East Singhbhum, Jharkhand. *Biospectra*, **16**: 81-84.

Foley, M.M., Duda, J.J., Beirne, M.M., Paradis, R., Ritchie, A. and Warrick, J.A. 2015. Rapid water quality change in the Elwha river estuary complex during dam removal. *Limnology and Oceanography*, **60**: 1719-1732.

Ghosh, A., Bhaumik, U. and Satpathy, B. 2011. Fish diversity of Subarnarekha Estuary in relation to salinity. *Journal of Inland Fisheries Society of India,* **43**: 51-61.

Hopkins, K.D. 1992. Reporting fish growth: A review of the basics 1. *Journal of the World Aquaculture Society*, **23**: 173-179.

Karim, M.Y. 2007. The effect of osmotic various medium salinity of vitality of female mud crab (*Scylla olivacea*). *Journal Protein*, **14**: 65-72.

Kenworthy, J.M., Paterson, D.M. and Bishop, M.J. 2016. Response of benthic assemblages to multiple stressors: comparative effects of nutrient enrichment and physical disturbance. *Marine Ecology Progress Series,* **562**: 37-51.

Knudsen, M. 1901. *Hydrographical Tables*. G.E.C. Gad, Copenhagen, Denmark.

Kumlu, M. and Jones, D. 1995. Salinity tolerance of hatchery-reared postlarvae of *Penaeus indicus* H. Milne Edwards originating from India. *Aquaculture,* **130**: 287-296.

Manush, S., Pal, A., Chatterjee, N., Das, T. and Mukherjee, S. 2004. Thermal tolerance and oxygen consumption of *Macrobrachium rosenbergii* acclimated to three temperatures. *Journal of Thermal Biology,* **29**: 15-19.

Montagna, M.C. 2011. Efecto de la temperatura sobre la supervivencia y el crecimiento de los camarones dulciacuícolas *Macrobrachium borellii* y *Palaemonetes argentinus* (Crustacea, Palaemonidae). *Iheringia. Série Zoologia,* **101**: 233-238.

Nelson, J.A., Johnson, D.S., Deegan, L.A., Spivak, A.C. and Sommer, N.R. 2019. Feedbacks between nutrient enrichment and geomorphology alter bottom-up control on food webs. *Ecosystems,* **22**: 229-242.

Niu, Y. and O'Hara, M.J. 2003. Origin of ocean island basalts: A new perspective from petrology, geochemistry, and mineral physics considerations. *Journal of Geophysical Research: Solid Earth*, **108**(B4). [*https://doi.org/10.1029/2002JB002048*].

Pearson, K. 1907. On further methods of determining correlation. *Drapers Company Research Memoirs, Biometric Series,* **4:** 1-39.

Pouso, S., Uyarra, M.C. and Borja, Á. 2018. The recovery of estuarine quality and the perceived increase of cultural ecosystem services by beach users: A case study from northern Spain. *Journal of Environmental Management,* **212**: 450-461.

Rashed-Un-Nabi, M., Al-Mamun, M.A., Ullah, M.H. and Mustafa, M.G. 2011. Temporal and spatial distribution of fish and shrimp assemblage in the Bakkhali river estuary of Bangladesh in relation to some water quality parameters. *Marine Biology Research,* **7**: 436-452.

Ravindra, K. and Kaushik, A. 2003. Seasonal variations in physicochemical characteristics of river Yamuna in Haryana and its ecological best-designated use. *Journal of Environmental Monitoring* **5**: 419-426.

Romano, N. and Zeng, C. 2006. The effects of salinity on the survival, growth and haemolymph osmolality of early juvenile blue swimmer crabs, *Portunus pelagicus*. *Aquaculture,* **260**(1-4), 151-162.

Salunke, M., Kalyankar, A., Khedkar, C.D., Shingare, M. and Khedkar, G.D. 2020. A review on shrimp aquaculture in India: Historical perspective, constraints, status and future implications for impacts on aquatic ecosystem and biodiversity. *Reviews in Fisheries Science and Aquaculture*, **28**(3): 283-302.

Sharma, A. and Subba, B. 2005. General biology of freshwater prawn, *Macrobrachium lamarrei* (H. Milne-Edwards) of Biratnagar, Nepal. *Our Nature*, **3**: 31-41.

Welch, P.S. 1952. *Limnology*. Mc Graw-Hill Book Co. Inc, New York, USA.

Yang, X.E., Wu, X., Hao, H.L. and He, Z.L. 2008. Mechanisms and assessment of water eutrophication. *Journal of Zhejiang University Science B*, **9**: 197-209.

Zonneveld, N. and Fadholi, R. 1991. Feed intake and growth of red *Tilapia* at different stocking densities in ponds in Indonesia. *Aquaculture,* **99**(1-2): 83-94.