

QUALITY ASSESSMENT OF SOME WATER BODIES IN DONG NAI NATURE – CULTURE RESERVE USING ZOOPLANKTONIC INDICATORS

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ARTICLE INFO	ABSTRACT
Received: 18/02/2025	The research investigated water quality in important aquatic ecosystems vital to local biodiversity at the Dong Nai Nature and Culture Reserve. There were 121 zooplankton species in five major groups: Protozoa, Rotatoria, Cladocera, Copepoda, and Ostracoda. The Shannon-Wiener diversity score ranged from 1.1 to 3.68, indicating moderate to severe contamination in all sampling locations (β -mesosaprobic to polysaprobic). Chemical Oxygen Demand (COD) readings in water samples were grade D according to Vietnamese National Standard TCVN 08:2023/BTNMT, indicating polluted aquatic systems. In the study, pollution-indicator zooplankton species such <i>Brachionus calyciflorus</i> , <i>angularis</i> , <i>falcatus</i> , <i>Lecane lunaris</i> , <i>Diaphanosoma brachyurum</i> , <i>Thermocyclops hyalinus</i> , and <i>Keratella cochlearis</i> were widespread. Both biological and physicochemical indices yielded consistent results, however biological indicators were more sensitive to pollution levels. Zooplankton-based biotic indices are essential for ecological monitoring, allowing detailed assessments of aquatic ecosystem health and stability.
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KEYWORDS	
Dong Nai Nature-Culture Reserve Water quality assessment Zooplankton Biological indices COD index	

SỬ DỤNG CÁC CHỈ SỐ SINH HỌC CỦA PHIÊU SINH ĐỘNG VẬT ĐỂ ĐÁNH GIÁ CHẤT LƯỢNG NƯỚC TẠI CÁC THỦY VỰC THUỘC KHU BẢO TỒN THIÊN NHIÊN – VĂN HÓA ĐỒNG NAI

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THÔNG TIN BÀI BÁO	TÓM TẮT
Ngày nhận bài: 18/02/2025	Nghiên cứu thực hiện đánh giá chất lượng nước trong các thủy vực quan trọng có vai trò thiết yếu đối với đa dạng sinh học tại Khu bảo tồn thiên nhiên và văn hóa Đồng Nai. Có 121 loài động vật phù du trong năm nhóm chính: Protozoa, Rotatoria, Cladocera, Copepoda và Ostracoda được ghi nhận. Chỉ số Shannon-Wiener dao động từ 1,1 đến 3,68, cho thấy mức độ ô nhiễm từ trung bình đến nghiêm trọng ở tất cả các địa điểm lấy mẫu (β -mesosaprobic đến polysaprobic). Chỉ số nhu cầu oxy hóa học (COD) trong các mẫu nước là loại D theo Tiêu chuẩn quốc gia Việt Nam TCVN 08:2023/BTNMT, cho thấy các hệ thống thủy sinh bị ô nhiễm. Trong nghiên cứu ghi nhận các loài động vật phù du chỉ thị ô nhiễm như <i>Brachionus calyciflorus</i> , <i>angularis</i> , <i>falcatus</i> , <i>Lecane lunaris</i> , <i>Diaphanosoma brachyurum</i> , <i>Thermocyclops hyalinus</i> và <i>Keratella cochlearis</i> rất phổ biến. Cả các chỉ số sinh học và lý hóa đều cho kết quả nhất quán, tuy nhiên các chỉ số sinh học nhạy cảm hơn với mức độ ô nhiễm. Các chỉ số sinh học dựa trên động vật phù du rất cần thiết cho việc theo dõi sinh thái, cho phép đánh giá chi tiết về sức khỏe và tính ổn định của hệ sinh thái dưới nước.
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TỪ KHÓA	
Khu bảo tồn thiên nhiên – văn hóa Đồng Nai Đánh giá chất lượng nước Phiêu sinh động vật Chỉ số sinh học Chỉ số COD	

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1. Introduction

The Dong Nai Nature and Culture Reserve constitutes a component of Vietnam's designated special-use forests and cultural heritage framework. This area is part of the urgent ecological conservation sub-region (SA5 - Dong Nai River Basin—WWF) inside the Truong Son ecosystem, recognized as one of the 200 most significant ecological locations worldwide by the Vietnam Conservation Fund for prioritized conservation and development efforts. Additionally, UNESCO designated the Dong Nai Biosphere Reserve as a World Biosphere Reserve in 2011.

The reserve was created to rehabilitate the biodiversity of the natural forest ecosystem in the Dong Nai River Basin in southern Vietnam. This is regarded as the inaugural reserve in the nation to convert from production forests to special-use forests. Furthermore, the reserve creates an extensive natural ecological zone that links to Cat Tien National Park, promoting habitat preservation and genetic interchange for many wildlife species. Besides, the reservoir has facilitated energy provision for the economic and social advancement of 16 provinces and cities in southern Vietnam, guaranteeing industrial and domestic water supply for millions and irrigation water for over 20,000 hectares of farmland in the downstream regions. The aims encompass safeguarding natural resources, maintaining and promoting cultural and historical values, fostering ecotourism development, and facilitating international collaboration and investment in nature protection. Aquatic ecosystems, including reservoirs, rivers, and streams, are prevalent and essential habitats within the reserve, encompassing more than one-third of the total area [1].

The zooplankton community serves as a significant indicator for evaluating water quality owing to its brief life cycle, elevated reproductive rate, extensive distribution, and sensitivity to abiotic factors (temperature, salinity, turbidity, and nutrient levels) as well as biotic factors (food scarcity, predation, and competition) [2] - [4]. The biological community in contaminated water markedly varies from that in pristine water. Numerous studies indicate that zooplankton functions as a reliable indicator, particularly in aquatic bodies contaminated by organic pollutants and heavy metals. Zooplankton rapidly reacts to environmental alterations, precisely indicates ecosystem vitality, and is economically efficient [2], [5]. Small filter-feeding and predatory organisms such as Rotifera and Bosminidae thrive in environments rich in nutrients and suspended particles, which promote the proliferation of bacteria and protozoa [6]. Organisms such as *Mesocyclops* sp., *Brachionus* sp., *Polyarthra* sp., and *Lepadella* sp. are considered biological indicators of nutrient-rich environments [7]. *Daphnia dubia* is very sensitive to hazardous pollutants, rendering it an effective bioindicator for assessing water quality in aquatic environments impacted by direct or indirect wastewater discharge. Research has recorded the capacity of zooplankton in the Mediterranean coastal area to acquire 21 heavy metal elements. Human activities, including maritime traffic and industrial developments, affect this region. Zooplankton in surface waters exhibited heavy metal concentrations of up to 28 ppm (Co) and 10.9 ppm (Fe), with greater accumulation observed in species residing in deeper water strata [8].

Aquatic ecosystems, including reservoirs, rivers, and streams, are prevalent and vital habitats within the reserve, encompassing over one-third of the entire area. Among these, the Tri An Hydropower Reservoir is the most significant environment. The reservoir has supplied energy for the economic and social advancement of 16 provinces and cities in southern Vietnam, guaranteeing industrial and domestic water provisions for millions and irrigation for over 20,000 hectares of agricultural land in the downstream regions. The safeguarding of aquatic ecosystems is a crucial objective in the conservation and preservation of the reserve's biodiversity. Ongoing surveillance of water quality in the reserve is crucial for detecting anomalous variations that could impact biodiversity. Currently, the periodic assessment of water quality in the reserve exclusively measures physical and chemical parameters, neglecting the use of biological indicators. The study investigated the potential of zooplankton as biological indicators for assessing water quality in various aquatic environments. The objective was to establish a

scientific foundation for water management that would assist the region and its surroundings in addressing climate change and economic development.

2. Research methods

This study collected samples from 12 locations within water bodies in the research region, encompassing Ma Da stream, Tri An lake, Ba Hao lake, the Fire Prevention and Control Reservoir, and the Nursery Reservoir.

Sampling occurred at twelve locations as detailed below: Three samples from Ma Da stream (flowing water bodies: MD1, MD2, MD3) and nine samples from stationary water bodies (MD4–MD12) were collected during the dry season (March 2024) and the rainy season (September 2024) (Figure 1).

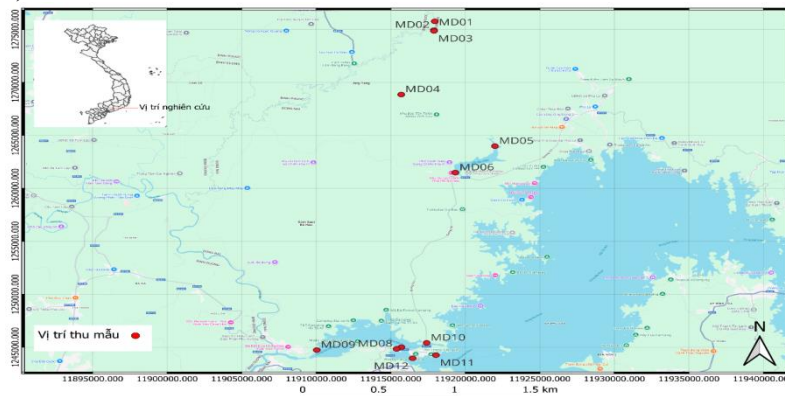


Figure 1. Locations of the 12 sampling sites

Qualitative and quantitative zooplankton samples were obtained utilizing a plankton net including a mesh size of 67 μm, a mouth diameter of 0.3 m, a net length of 0.8 m, and a rope length of 3 m. The net was towed seven times at a moderate velocity, and samples were put into containers and preserved with 10% formalin. Between each sampling, the net was cleansed to eliminate any residual zooplankton. Samples were maintained at ambient temperature and conveyed to the laboratory for examination.

Zooplankton species were identified utilizing the following references: The Rotifer Fauna of Wisconsin [10]; The Plankton of South Viet-Nam: Fresh Water and Marine Plankton [11]; Rotatoria: Die Rädertiere Mitteleuropas [12]; Vietnamese Fauna [13]; Freshwater Biology [14]; Free-Living Freshwater Protozoa [15]; and Copepoda – Calanoida – Diaptomidae [16]. Quantification of zooplankton was conducted with the Sedgwick-Rafter counting chamber technique.

Water samples were obtained from identical locations as the zooplankton sampling sites, maintained at a temperature of 20 °C, and evaluated for COD utilizing the potassium dichromate method [17] in the laboratory.

The research utilized biodiversity indices, such as the Shannon–Wiener diversity index (H'), to evaluate the variety of zooplankton populations in relation to pollution levels at the sample locations. The biodiversity indices were compared to the evaluation scale established by Staub et al. [18], as presented in Table 1.

Table 1. Water quality assessment by Shannon – Wiener index

Shannon – Wiener index	Pollution scales
0.0 – 1.0	Polysaprobic / high pollution
1.0 – 2.0	α Mesosaprobic / heaviest pollution
2.0 – 3.0	β Mesosaprobic / moderate pollution
3.0 – 4.5	Oligosaprobic / slight pollution

The research results were calculated and processed using Excel 2013 and Primer 6 software, employing a 95% confidence interval to compute biological indices. T-tests and ANOVA variance analyses were performed utilizing SPSS software, employing the LSD method at a 95% confidence level.

3. Results and discussion

3.1. Zooplankton composition

The study of zooplankton species composition across 12 sampling locations during two seasons identified 121 taxa distributed among 59 genera, 13 orders, and 5 groups. The Rotatoria group exhibited the highest representation, comprising 53 species (43.8%). This was followed by Protozoa with 30 species (24.79%), Cladocera with 18 species (14.88%), Copepoda with 15 species (12.4%), and Ostracoda, which had the lowest representation at 5 species (4.13%) (Figure 2).

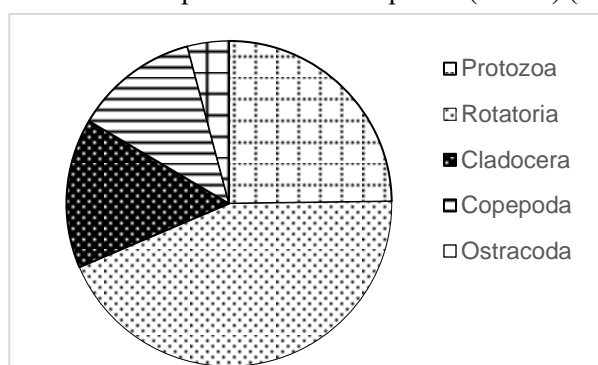


Figure 2. Zooplankton community structure at the sampling sites

In the dry season, the recorded proportions of zooplankton groups were as follows: Copepoda (21.51%), Protozoa (23.66%), Cladocera (16.13%), and Rotatoria, which had the highest percentage at 32.26%. The distribution among the groups during the dry season exhibited significant differences. Rotatoria had the highest species count, while Protozoa, Cladocera, and Copepoda displayed comparable species counts. Ostracoda recorded the lowest species count (p -value = 0.0004 < 0.05).

During the rainy season, a significant variation in species composition among zooplankton groups was observed. Rotatoria comprised 43.81%, Cladocera 19.85%, Copepoda 14.69%, and Protozoa 19.43%. Ostracoda continued to exhibit the lowest species count (p -value < 0.05). During the dry season, flowing water bodies exhibited a species composition of 23 species, surpassing the 17 species identified in standing water bodies. Flowing water bodies enable the transport of zooplankton across various regions, thereby enhancing distribution diversity. Flowing water bodies typically exhibit elevated dissolved oxygen concentrations as a result of continuous mixing. Conversely, standing water bodies frequently exhibit oxygen deficiency in deeper strata, which restricts zooplankton development. Both categories of water bodies experienced notable increases in species diversity. The number of species in flowing water bodies increased from 23 to 38, whereas standing water bodies experienced a rise from 17 to 36 species. This illustrates the beneficial effects of the rainy season, as enhanced water flow improves conditions for both categories of aquatic environments. Rain contributes to organic matter, stabilizes temperatures, enhances dissolved oxygen levels, and links various water bodies, facilitating the thriving and wider dispersion of zooplankton.

The species composition at the sampling points during the rainy season exhibited a diversity of 1.5 to 3 times greater than that observed in the dry season (Figure 3). The rapid increase in water levels and the influx of nutrients from the land into the water created conditions conducive to zooplankton development ($p = 0.004$). In the dry season, the Ma Da stream exhibits reduced

water flow, causing multiple sections of the stream to be disrupted. The MD3 site evolves into a pond-like entity, as several descending items augment the accumulation of organic detritus, leading to significant biodiversity. During the rainy season, the swift water flow in this area leads to a reduction in the number of species gathered. MD05 is situated at Ba Hao Lake, and during the rainy season, this region had an outbreak of *Ceratophyllum* algae that enveloped the whole lake surface, accompanied by strong winds that caused considerable perturbations in the aquatic environment during sample collection. This suggests that the zooplankton communities at the sampling locations are affected by flow, seasonal variables and the presence of organic matter in the aquatic environment. This study's findings align with earlier research conducted by [19]-[21], all of which observed seasonal variations in zooplankton communities. Statistical t-tests indicated significant differences in species composition between the two seasons for the Rotatoria group ($p = 0.001$), Protozoa group ($p = 0.002$), and Copepoda group ($p = 0.01$). No notable differences were detected among the other groups.

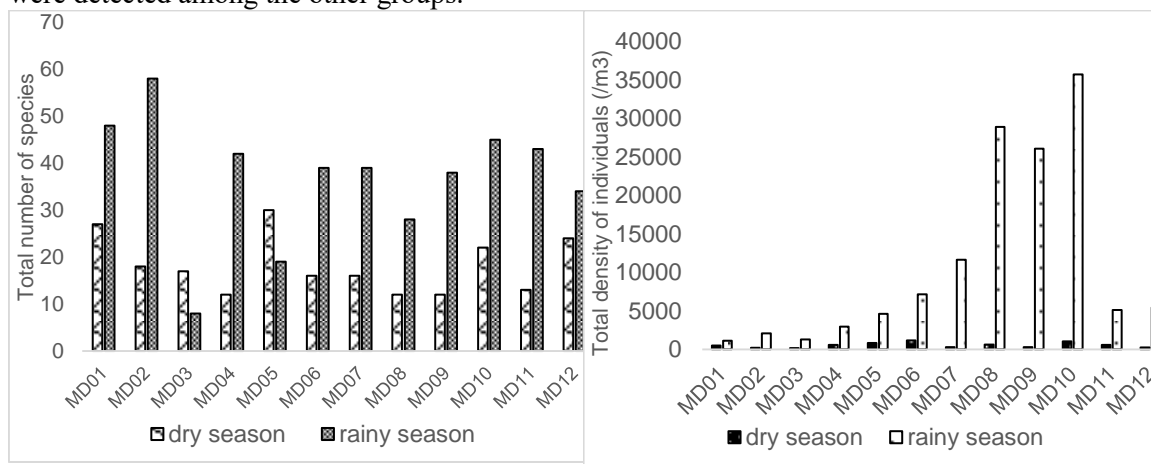


Figure 3. The total number of zooplankton species at the sampling sites in two seasons

Figure 4. The total density of zooplankton at sampling sites

3.2. Zooplankton density

Zooplankton density at the sampling points varied between 166 and 35,692 individuals/m³. Significant differences in individual density among the groups were observed, ranked as Rotatoria > Protozoa > Copepoda \approx Cladocera > Ostracoda ($p = 0.005$). The density of individuals was significantly higher during the rainy season compared to the dry season ($p = 0.004$). During the dry season, total density varied between 166 and 1,165 individuals/m³, with the maximum density observed in standing water bodies and the minimum in flowing water bodies. The average density in flowing water was 241 individuals/m³, which is lower than the density in standing water at 622 individuals/m³. During the rainy season, total density varied between 1,100 and 35,692 individuals/m³, with the maximum density recorded in standing water bodies and the minimum in flowing water bodies. The average density in flowing water rose to 1,165 individuals/m³, yet it was significantly lower than in standing water, which exhibited a density of 35,692 individuals/m³.

The research observed a notable variation in the total zooplankton population between the dry and rainy seasons, with the rainy season exhibiting an increase in individuals by a factor of 1 to 8 relative to the dry season (Figure 4). The observed difference is due to the continuous flow in aquatic environments, which frequently displaces zooplankton, leading to reduced densities. In contrast, standing water bodies, particularly reservoirs or fishponds, typically exhibit stable water conditions and are nutrient-rich, creating conducive environments for zooplankton proliferation. The rainy season enhances zooplankton density in both water body

types by introducing substantial nutrient loads through rainwater. The effects are especially significant in standing water bodies.

3.3. Water quality assessment

3.3.1. Shannon-Wiener Diversity Index

Shannon- Wiener index is a quantitative measure used to characterize species diversity in a community. It accounts for both abundance and evenness of the species present. The Shannon-Wiener diversity index (H') at sampling points varies between 1.1 and 3.68 (Figure 5). The index varies from 1.1 to 1.57 in the dry season and from 2.95 to 3.67 in the rainy season. The H' value is markedly reduced in the dry season compared to the rainy season. During the rainy season, environmental conditions favor the growth and development of zooplankton, resulting in increased species diversity and a higher H' index relative to the dry season. The comparison of the H' index with the water quality evaluation table (Table 1) indicates that water quality during both seasons varies from light pollution to contaminated pollution (α -polysaprobic). All sampling points in the dry season were classified as α -polysaprobic. During the rainy season, increased water flow results in slightly polluted water quality (oligosaprobic) in most aquatic bodies, with the exception of points MD03 and MD12, which exhibit moderate pollution levels (mesosaprobic). The results demonstrate a notable occurrence of indicator species linked to polluted environments, including *Arcella vulgaris*, *Diffugia levanderi*, *Brachionus calyciflorus*, *Brachionus angularis*, *Brachionus falcatus*, *Lecane lunaris*, *Diaphanosoma brachyurum*, *Thermocyclops hyalinus*, *Keratella cochlearis*. These species exhibit sensitivity to environmental changes and function as reliable indicators for evaluating ecosystem stress and informing water resource management. Rotatoria species reproduce asexually and exhibit strong adaptation to nutrient-rich aquatic environments, with their prevalence closely linked to nutrient levels in water bodies [22]. *Thermocyclops hyalinus* indicates nutrient-rich aquatic environments and is prevalent at the sampling sites [2].

3.3.2. Concentration of Organic Matter

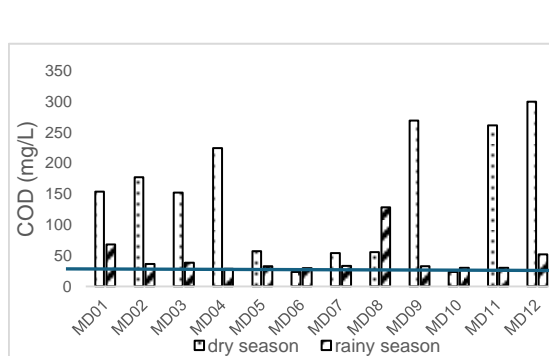


Figure 5. Shannon Wiener indices at the sampling sites at two seasons

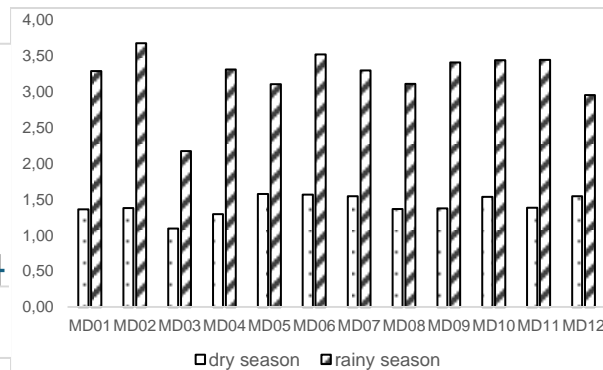


Figure 6. Concentration of organic matter at the sampling sites

In the dry season, chemical oxygen demand (COD) levels at all sampling sites surpass the documents [20], [21], which are the national water quality standard for surface water. Significant concentrations were recorded at the following locations: MD12 (300 mg/L) MD09 (269.23 mg/L) MD04 (224.62 mg/L). The elevated values suggest significant organic pollution. The primary factors are high temperatures during the dry season accelerate the decomposition of organic compounds in aquatic environments. A notable decrease in precipitation has resulted in lower water levels at sampling sites, leading to sediment concentration. In MD12, the highest COD level (300 mg/L) is linked to fishpond, a densely populated area where inadequate waste disposal

leads to elevated organic pollutants. In the rainy season, there is a significant decrease in COD levels at most sampling points (Figure 6). The observed reduction is likely attributable to dilution from rainfall. However, it remains above the standard (> 20 mg/L) [23]. The analysis indicates that the water quality in all surveyed water bodies is classified as D level according to [23], signifying a high degree of pollution and poor water quality conditions. Analysis of physicochemical and biological markers from zooplankton indicates that the conservation region must implement steps to mitigate pollution in aquatic bodies, especially in natural lakes, tourist destinations, and fish farming communities. Should the prevailing water quality outcomes endure for an extended duration, they will negatively impact initiatives aimed at conserving biodiversity within aquatic habitats.

4. Conclusion

The results indicated that the majority of the water bodies inside the reserve exhibited pollution when assessed by COD and were classified as moderately to severely contaminated based on biological indicators of zooplankton. This indicates that the sampling stations in the reserve require more regular water quality assessments due to the impact of economic development activities. Furthermore, incorporating biological indicators is essential for evaluating ecosystem health in the monitoring process, so providing a more precise perspective for management and conservation efforts. Biological indicators of zooplankton are effective instruments for evaluating ecosystem health, managing and conserving water resources, and ensuring ecosystem sustainability. The existence, absence, or alteration in zooplankton population structure directly signifies environmental changes in the aquatic ecosystem. Consequently, it establishes advantageous conditions for the efficient and sustainable management of water resources.

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