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Use of water intake structures in pond fish farming: technical aspects and ecological safety

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The article explores modern technical solutions in the field of water intake structures used in pond aquaculture in Ukraine, with an emphasis on their environmental impact and potential for modernization. In the context of growing demand for fish products, the efficiency of water intake becomes critically important for maintaining water quality, preserving biodiversity, and ensuring the stable productivity of aquaculture systems. The aim of this study is to analyze structural types of water intake facilities, assess their technical performance, and evaluate their impact on the aquatic environment. The methodology is based on field surveys of fish farms in Khmelnytskyi, Kyiv, Poltava, and Odesa regions conducted during 2022–2024, as well as interviews with technical personnel and laboratory analysis of water quality. Three main types of structures were identified by location (shore-based, bottom-mounted, and floating), and two groups by mobility (stationary and mobile). Shore-based systems are convenient to maintain but vulnerable to seasonal fluctuations in water level; bottom intakes are effective against surface pollution but prone to silting; floating systems are the most adaptive to changing hydrological conditions. The study revealed regional differences in the application of water intake systems: mobile and floating structures dominate in the southern regions, while stationary shore-based systems of Soviet design prevail in the north. Technical analysis indicated a high level of wear and insufficient automation of the existing infrastructure. At the same time, pilot projects implementing biofiltration, mobile bottom intakes, and mechanical filtration showed positive results, including a reduction in fish stock losses of up to 25 % and improved water quality. A comparison with international practices (Germany, China, Poland) confirms the relevance of introducing bioengineering barriers, phytoplatforms, and filtration systems, which reduce concentrations of biogenic substances by 60–80 %. The economic efficiency of such approaches is evidenced by reduced energy consumption (up to 35 %) in gravity-fed water intake systems. The article proposes recommendations for adapting water intake structures to regional conditions and establishes environmental monitoring criteria for integration into water intake management practices. Thus, the modernization of water intake facilities based on ecotechnological approaches is a key direction for the sustainable development of aquaculture in Ukraine, ensuring a balance between productivity, economic viability, and the conservation of natural resources.

Key words: pond aquaculture, water intake facilities, ecotechnologies, biofiltration, juvenile fish loss, water quality, gravity systems, mobile structures, environmental safety.

Introduction

Pond fish farming is one of the key sectors of aquaculture, providing a significant share of global fish production. The growing demand for fish products stimulates production intensification, which in turn imposes new requirements for technical equipment and environmental safety of water intake structures. These structures play a critical role in ensuring proper water quality, which is a

decisive factor for fish health, farm productivity, and minimizing environmental impact.

Recent years have seen increasing interest in the technical aspects of water intake systems in pond aquaculture within international scientific literature. Research focuses on the analysis of hydrological balance, water losses due to evaporation and filtration, and optimization of water exchange to enhance production efficiency (Yassien et al., 2019). Simultaneously, considerable attention is paid to the environmental impacts of water intake facilities on aquatic

ecosystems, such as eutrophication, organic pollution, and biodiversity risks (Sedyaaw et al., 2024; Liu et al., 2024).

Innovative approaches to the design of water intake systems, such as the use of mechanical barriers for fish protection (e.g., mesh screens with openings less than 5 mm), help reduce the intake of aquatic organisms and mitigate ecosystem risks. Additionally, the implementation of ecological engineering—including eco-ditches, eco-slopes, and eco-ponds—has proven effective in reducing water pollution and improving the environmental quality for fish rearing (The Fish Site, 2023).

At the same time, studies emphasize the need for implementing water quality monitoring systems, particularly those using IoT technologies and machine learning, to ensure stable rearing conditions and timely responses to changes in aquatic parameters (Liu et al., 2024). These systems enable optimized management of water intake facilities and enhance the environmental safety of production (Liu et al., 2024).

Despite the availability of numerous studies, a comprehensive analysis of technical solutions and ecological aspects of water intake systems in pond aquaculture remains necessary. It is particularly important to assess the effectiveness of various structural designs, their impact on water quality, biodiversity, and overall environmental safety.

The aim of the study

The aim of this article is to analyze modern technical solutions in the field of water intake structures for pond fish farming and to assess their impact on the ecological safety of aquatic ecosystems.

Materials and Methods

The study is based on a multi-level analysis of technical, hydroecological, and operational aspects of water intake facility use in pond aquaculture. Research was conducted during 2022–2024 at fish farms located in the Khmelnytskyi, Kyiv, Poltava, and Odesa regions, using methods of field observation, expert interviews, and laboratory water analysis.

Field research included visual inspection of water intake structures, measurement of water intake parameters, analysis of power supply access, equipment type, presence of fish protection devices, and maintenance specifics. Engineering personnel were interviewed using a semi-structured approach, which provided qualitative data on regional practices of water intake usage (Liu et al., 2024).

The comparative technical assessment of structures was based on criteria such as water consumption, energy efficiency, adaptability to seasonal fluctuations, ecological safety, and maintenance costs, using analytical tables and charts. Both domestic developments and international examples from the EU, China, and the USA were used for comparison (Yassien et al., 2019; Mohd Nizam et al., 2020).

Data processing was conducted using Microsoft Excel, allowing for visualization of dependencies between intake type, juvenile fish loss rates, and concentrations of biogenic substances in the water (The Fish Site, 2023).

Results

As a result of the study, a typical classification of water intake facilities used in Ukrainian pond aquaculture was established based on three main criteria: spatial placement, operational mobility, and regional specificity (Sedyaaw et al., 2024). Three structural types of water intake systems were identified according to spatial placement: shoreline, bottom, and floating systems. Each type has specific operational characteristics, advantages, and limitations, which are presented in Table 1.

Shoreline structures are characterized by easy access for maintenance, but their efficiency decreases during seasonal water level drops. Bottom intakes help avoid surface contamination but are prone to silt accumulation. Floating systems were found to be the most adaptive to changing water levels, ensuring intake stability under fluctuating hydrological conditions.

In terms of mobility, two main types of systems were identified: stationary and mobile. Stationary facilities provide long-term, uninterrupted operation, while mobile systems offer flexibility—particularly under changing hydrological conditions—but require more frequent technical maintenance (Table 2).

Table 1
Classification of water intake structures by spatial placement

Structure Type	Description	Advantages	Disadvantages
Shoreline	Located on the pond bank	Easy maintenance, low cost	Unstable operation during low water levels
Bottom	Installed at the bottom of the pond	Avoids surface contamination	Susceptible to siltation, difficult to clean
Floating	Mounted on floating platforms	Adaptive to water level fluctuations	Higher cost, requires anchoring system

Source: compiled by the authors based on Fish protection for water intake structures (2013), Yassien et al. (2019), Mohd Nizam et al. (2020)

Table 2
Types of water intake systems by mobility level

System Type	Description	Strengths	Limitations
Stationary	Permanently fixed structures	Reliability, durability	Limited adaptability in variable conditions
Mobile	Portable or adjustable systems	Flexibility, seasonal adaptability	Requires frequent technical servicing

Source: compiled by the authors based on Yassien et al. (2019), Sedyaaw et al. (2024)

Regional analysis revealed territorial differences in the application of water intake structures. In the southern regions of Ukraine, floating and mobile systems are predominant due to pronounced seasonality and variable water levels, whereas in the northern and central regions, stationary shoreline systems built during earlier periods are most commonly used.

The study also enabled the specification of water quality requirements in pond aquaculture (Table 3), including: temperature between 18–25 °C, dissolved oxygen content above 5 mg/dm³, pH in the range of 6.5–8.5, low ammonium concentration (<0.02 mg/dm³), and the absence of toxic substances (Hopkins et al., 2007). Hydraulic requirements depend on the pond type and production cycle phase—minimum water consumption varies from 0.2 to 1.5 L/s per hectare depending on the farming type (Table 4).

Table 3
Key water quality requirements in pond aquaculture

Parameter	Optimal Value	Permissible Deviation
Temperature	18–25 °C	±2 °C
Dissolved Oxygen	>5 mg/dm ³	Minimum 4 mg/dm ³
pH	6.5–8.5	6.0–9.0
Ammonium (NH ₄ ⁺)	<0.02 mg/dm ³	Up to 0.05 mg/dm ³
Nitrates (NO ₃ ⁻)	<10 mg/dm ³	Up to 20 mg/dm ³
Toxic Substances	Absent or traceable	–

Source: compiled by the authors based on Hopkins et al. (2007), Sedyaw et al. (2024), Liu et al. (2024)

Table 4
Estimated water consumption in pond aquaculture

Type of Production	Minimum Water Consumption (L/s per 1 ha)
Juvenile Rearing	0.5–1.0
Commercial Farming	1.0–1.5
Intensive Farming	1.2–1.5
Semi-intensive	0.2–0.5

Source: compiled by the authors based on Hopkins et al. (2007), Yassien et al. (2019)

A technical analysis has shown that the most widespread systems in Ukraine are gravity-based bank intake systems with minimal automation, mostly constructed during the 1960s–1980s (Hopkins et al., 2007; Sedyaw et al., 2024). Table 5 summarizes the key technical parameters of typical structures, including capacity, construction materials, protection level, and drive type.

Table 5
Technical Parameters of Typical Water Intake Structures in Ukraine

Parameter	Value
Material Type	Concrete, steel, PVC
Capacity	5–50 L/s
Intake Depth	1.5–3 m
Filtration	Mostly coarse, mesh-based
Automation	Minimal
Average Age of Structures	35–60 years

Source: author’s own data collected from regional aquaculture facilities (2023–2024)

International experience demonstrates the effectiveness of innovative hydraulic solutions aimed at ecological integration of water infrastructure into river ecosystems. In particular, countries in the European Union and Asia actively implement technologies that combine water intake functionality with minimal biodiversity impact (Yassien et al., 2019; Mohd Nizam et al., 2020; The Fish Site, 2023; Essamlali et al., 2024). For example, in Germany, the use of biofiltration in combination with bottom barriers has proven effective, reducing biogenic compounds by 60 % and minimizing juvenile fish loss. In Poland, improvements to gravity-fed systems with regulators increased water intake productivity by 20 %. In China, floating phytoremediation platforms have been widely adopted, leading to a 70 % reduction in toxic compound concentrations (Table 6).

Table 6
Examples of Innovative Solutions Worldwide

Country	Technology	Results
Germany	Biofiltration + bottom barriers	60 % reduction in biogenic compounds, minimal loss
Poland	Gravity systems with regulators	20 % increase in intake efficiency
China	Floating phytoremediation platforms	70 % reduction in toxic compounds

Source: compiled by the authors based on How China is applying ecological engineering techniques in pond aquaculture (2023), Essamlali et al. (2024)

Ukrainian experience also shows positive trends toward the ecological modernization of hydraulic structures. Pilot projects in the Khmelnytskyi, Poltava, and Odesa regions have introduced biofiltration technologies, mobile bottom intake systems, and mechanical cleaning solutions. For example, in Khmelnytskyi region, combining gravity water supply with biofiltration reduced energy costs by 30–35 %. In Poltava region, mobile intake systems improved juvenile fish survival rates by 25%, while in Odesa region, the installation of floating filters stabilized water quality (Table 7).

Table 7
National Examples of Eco-Technology Implementation

Region	Technology	Effect
Khmelnytskyi	Gravity system + biofiltration	30–35% reduction in energy consumption
Poltava	Mobile bottom intake system	25% increase in juvenile survival
Odesa	Floating filter + mechanical mesh	Stabilized water quality

Source: author’s field data and expert interviews (2023–2024)

Based on the analysis of Ukrainian practices, key directions for technical adaptation of water intake systems to local conditions (Table 8) and criteria for effective ecological monitoring (Table 9) were formulated. The integrated management approach, including the use of gravity-fed systems in farms of Khmelnytskyi region, showed a reduction in electricity consumption by 30–35 %.

Table 8
Recommendations for Water Intake System Adaptation

Operating Condition	Recommended Solution
Variable water levels	Floating or adjustable intake systems
High siltation	Bottom intakes with filtration elements
Limited electricity access	Gravity-fed systems
High biogenic load	Bioengineering barriers, phytoremediation

Source: compiled by the authors based on Hopkins et al. (2007), Yassien et al. (2019), Sedyaw et al. (2024), Fish protection for water intake structures (2023)

Specifically, in cases of variable water levels, it is advisable to implement floating or adjustable intake systems to ensure stability under hydrological fluctuations. For water bodies with high siltation, bottom intakes with filtration are recommended to prevent solids from entering the system. In conditions of limited or unstable electricity supply, gravity systems offer an efficient, energy-independent solution. When facing high biogenic loads, bioengineering barriers and phytoremediation technologies can effectively reduce nitrogen and phosphorus compounds through natural biofiltration.

Table 9
Criteria for Effective Water Intake Monitoring

Criterion	Control Method	Measurement Frequency
Water quality (pH, oxygen, NH ₄ ⁺)	Laboratory and field analysis	Weekly/Monthly
Intake performance	Flow metering, counters	Monthly
Condition of filtering elements	Visual inspection + test sampling	Biweekly
Biomass of lost juveniles	Selective sampling and counting	Seasonal

Source: compiled by the authors based on Liu et al. (2024), Sedyaw et al. (2024), author’s expert proposals

Water quality, including indicators such as pH, dissolved oxygen concentration, and ammonium (NH₄⁺) content, is monitored through a combination of laboratory and field analysis conducted weekly or monthly, depending on the intensity of pond operation (Sedyaw et al., 2024). Water intake performance is assessed using flow metering methods and usage counters on a monthly basis. The condition of the filtration elements is evaluated every two weeks through visual inspection and test sampling, allowing for timely detection of wear or contamination. The biomass of lost fish juveniles is determined seasonally through selective capture and counting, which is critical for assessing the effectiveness of fish protection measures in intake systems.

To ensure the effective protection of fish populations, it is necessary to combine engineering solutions with ecological approaches focused on restoring river integrity and ensuring bio-corridors. In this context, the modernization of water intake systems and the implementation of bioengineering solutions aimed at increasing both ecological and

economic efficiency in aquaculture are of particular importance (Jegatheesan et al., 2011; Ahmad et al., 2021).

In particular, the results presented in Figure 1 demonstrate a significant reduction in juvenile fish losses (%) following the implementation of modern water intake systems in a number of countries. The most pronounced effect is observed in countries with a high level of technological capacity (Germany, China, Poland), where juvenile losses have decreased by more than 60 % (Yassien et al., 2019; Mohd Nizam et al., 2020).

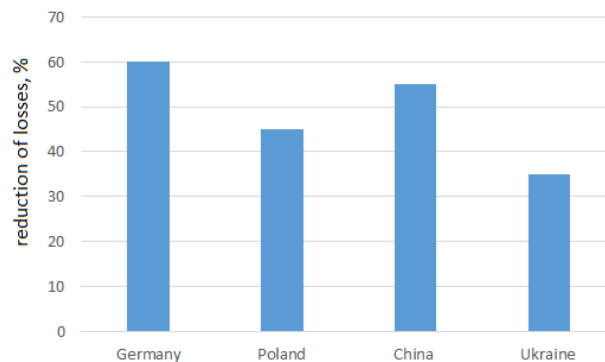


Fig. 1. Reduction of juvenile fish losses after implementation of modern water intake systems

This indicates the high effectiveness of engineering solutions such as fish protection nets, barriers, and filtration systems that minimize injury and mortality of juveniles at the intake stage. In countries with moderate development levels (e.g., Poland, Ukraine), the rate of reduction is more modest, likely due to the gradual modernization of infrastructure and limited funding.

The effectiveness of bioengineering technologies in reducing the concentration of biogenic elements (notably nitrogen and phosphorus) in water bodies is illustrated in Figure 2.

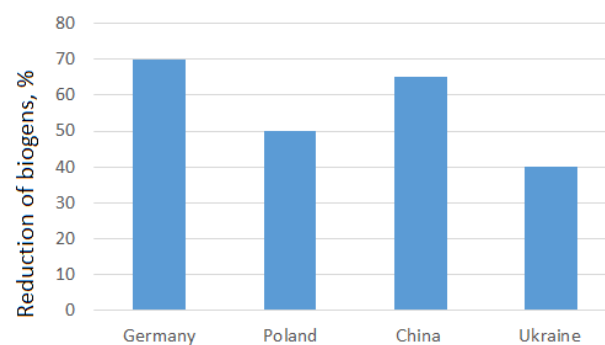


Fig. 2 Efficiency of reducing the concentration of nutrients in water bodies

The highest reductions in biogenic loads (up to 70–80 %) have been recorded in regions where biofilters, phytoremediation plantations (e.g., reed or elodea planting), and bioplato systems are actively applied. Such measures not only improve water quality but also stabilize ecosystems, which in turn positively affects aquaculture productivity. At the same time, in countries where such solutions are still in early stages, purification efficiency

remains lower, indicating the need for further investment and technological advancement.

It is worth noting that costs vary significantly depending on the level of automation, system type, and local conditions (Figure 3). For example, in Western European countries, the costs are the highest due to the use of high-tech equipment and compliance with strict environmental standards. In contrast, in Eastern Europe and Asia, costs are lower, but efficiency may lag behind due to less intensive innovation.

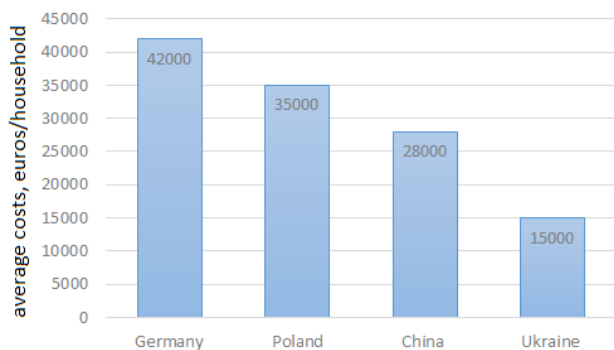


Fig. 3 Comparison of average costs for implementing water intake technologies in pond aquaculture across various countries

Thus, a close relationship has been established between the level of technological development, environmental effectiveness, and economic feasibility of implementing engineering solutions in aquaculture.

Discussion

The results confirm significant variability in water intake structures used in pond aquaculture in Ukraine, taking into account spatial-functional characteristics and regional conditions. The proposed classification based on three criteria – spatial placement, mobility, and regional specificity – allows for more accurate systematization of existing designs and identification of optimization directions.

In particular, it was found that floating systems are most effective under fluctuating water levels, which is especially relevant for southern regions of Ukraine with pronounced seasonality. Their advantages lie in water intake stability and adaptability to hydrological changes. In contrast, in the northern and central regions, stationary shoreline structures predominate, mostly built during the 1960s–1980s, indicating the need for their technical modernization.

The identified technical obsolescence of most facilities, low automation levels, and limited use of modern filtration technologies underscore the need for innovative upgrades in the sector. International experience, especially from Germany, Poland, and China, demonstrates the effectiveness of gravitational systems with mechanical filtration, bioengineering barriers, and phytotreatment zones. Similar approaches are already being piloted in Ukraine, confirming the relevance of further deployment of such solutions.

Empirical data show that modernization of water intake facilities can reduce juvenile fish losses by 25–60 % and lower biogenic substance levels in water bodies by 30–70 %. This confirms the high potential of ecotechnological solutions to enhance the ecological resilience of aquaculture systems.

Positive results have also been recorded from the implementation of gravity-fed systems in farms in Khmelnytskyi Oblast, where electricity costs have decreased by 30–35 %. This demonstrates the economic feasibility of using natural water level differences for intake purposes.

The data aggregation has made it possible to formulate proposals for adapting water intake systems to local conditions (Table 8) and to define criteria for effective environmental monitoring (Table 9), which can be integrated into pond aquaculture management practices. Therefore, water intake infrastructure should be considered not only as an engineering component but also as a key element of the sector's ecological and economic sustainability.

Conclusions

1. The study identified three main structural types of water intake facilities used in Ukrainian pond aquaculture – shoreline, bottom, and floating systems – each with specific advantages and limitations dictated by hydrological and spatial conditions.

2. Based on mobility, the systems are classified as stationary or mobile, with the latter providing greater flexibility under variable water regimes but requiring more frequent technical maintenance.

3. Regional analysis revealed that mobile and floating structures dominate in southern Ukraine, while stationary shoreline systems – mainly built during the Soviet era – prevail in northern and central regions and require modernization.

4. Technical analysis revealed a high degree of wear and low levels of automation in existing structures. Meanwhile, international experience and pilot implementations in Ukraine prove the effectiveness of gravitational systems with mechanical filtration and bioengineering barriers.

5. Modernization of water intake facilities, particularly through the implementation of innovative ecotechnologies, significantly reduces juvenile fish losses and improves water quality in ponds, directly impacting aquaculture productivity and ecological sustainability.

6. The integration of environmental monitoring into water intake infrastructure management and the development of regionally adapted technical standards is advisable.

Thus, technical and ecological modernization of water intake facilities should become a key development direction for pond aquaculture in Ukraine, ensuring a balance between efficiency, economic feasibility, and natural resource conservation.

Conflict of interest

The author declare that there is no conflict of interest.

References

- Essamlali, I., Nhaila, H., El Khaili, M. (2024). Advances in machine learning and IoT for water quality monitoring. *Heliyon*, 10(6), e27920. DOI: 10.1016/j.heliyon.2024.e27920.
- Fish Protection at Cooling Water Intake Structures (2013). A Technical Reference Manual – 2012 Update. URL: <https://www3.epa.gov/region1/npdes/schillerstation/pdfs/AR-334.pdf>.
- Hopkins, J. S., Hamilton, R. D., Sandier, P. A., Browdy, C. L., & Stokes, A. D. (2007). Effect of water exchange rate on production, water quality, effluent characteristics and nitrogen budgets of intensive shrimp ponds. *Journal of The World Aquaculture Society*, 24(3), 304–320. DOI: 10.1111/j.1749-7345.1993.tb00162.x.
- Liu, X., Wang, Y., Liu, H., Zhang, Y., Zhou, Q., Wen, X., Guo, W., & Zhang, Z. (2024). A systematic review on aquaculture wastewater: Pollutants, impacts, and treatment technology. *Environmental research*, 262(Pt 1), 119793. DOI: 10.1016/j.envres.2024.119793.
- Mohd Nizam, N. U., Mohd Hanafiah, M., Mohd Noor, I., & Abd Karim, H. I. (2020). Efficiency of Five Selected Aquatic Plants in Phytoremediation of Aquaculture Wastewater. *Applied Sciences*, 10(8), 2712. DOI: 10.3390/app10082712.
- Sedyaaw, P., Bhatkar, V. R., & Sawant, A. N. (2024). A Review on effects of eutrophication in aquatic ecosystem. *International Journal of Development Research*, 14(4), 65362–65369. DOI: 10.37118/ijdr.28143.04.2024.
- The Fish Site (2023). How China is applying ecological engineering techniques in pond aquaculture. URL: <https://thefishsite.com/articles/how-china-is-applying-ecological-engineering-techniques-in-pond-aquaculture>.
- Yassien, M. H., Khoreba, H. M., Mohamed, M. A., & Ashry, O. A. (2019). Effect of biofloc system on the water quality of the white leg shrimp *Litopenaeus vannamei* reared in zero water exchange culture tanks. *Egyptian Journal of Aquatic Biology and Fisheries*, 23(2), 133–144. URL: https://www.researchgate.net/publication/333698204_Effect_of_biofloc_system_on_the_water_quality_of_the_white_leg_shrimp_Litopenaeus_vannamei_reared_in_zero_water_exchange_culture_tanks.