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Physicochemical Water Quality in Diverse Fish-Holding Systems in Western Romania: Implications for Fish Health and Welfare

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Abstract: Water quality is a key environmental determinant of fish health and welfare, yet compliance with species-specific requirements may vary across fish-holding systems. This study characterized physicochemical water quality in 50 samples collected in Timiș and Hunedoara counties, Romania, from private aquaria and ornamental ponds (n = 23), outdoor fishponds (n = 20), and commercial facilities (n = 7). A semi-quantitative assessment of temperature, pH, hardness, alkalinity, carbonates, nitrites, nitrates, chlorine, selected metals, and other chemical indicators was conducted using commercial rapid tests and measuring devices. Results were evaluated against species-relevant recommended ranges. Differences among four fish-associated categories (ornamental fish, cyprinids, food or recreational fish, and mixed populations) and associations between parameters were examined using nonparametric tests. Most samples met the recommended ranges for temperature (94%), pH (78%), and nitrates (76%); however, noncompliance was frequent for total hardness (62%), carbonates (44%), total alkalinity (42%), and nitrites (36%). Iron, nitrite, and lead concentrations differed among fish categories ($p = 0.004$, 0.011, and 0.049, respectively), whereas the cumulative compliance score did not differ significantly ($p = 0.587$). Strong positive correlations were identified between pH and carbonates ($\rho = 0.882$), alkalinity and carbonates ($\rho = 0.874$), and pH and alkalinity ($\rho = 0.849$; all $p < 0.001$). Fish observed during sampling showed no overt abnormalities despite some physicochemical nonconformities. These findings support multi-parameter, species-adapted water monitoring as part of preventive fish-health management. Because sampling was limited to a single assessment and dissolved oxygen and direct health outcomes were not measured, the findings indicate potential welfare concerns rather than confirmed adverse effects.

Introduction:

Water is both the immediate environment and the principal medium through which farmed and ornamental fish exchange respiratory gases, electrolytes and metabolic wastes. The condition of this environment consequently affects physiological homeostasis, feeding, activity, growth and susceptibility to disease. Water quality is therefore an essential resource-based component of fish-welfare appraisal, but it is not itself a direct measure of the welfare state experienced by an individual fish. Relevant environmental variables include temperature, dissolved oxygen, pH, total alkalinity, hardness and nitrogenous waste compounds. Their suitability cannot be judged by one universal numerical target: requirements vary with species, developmental stage, acclimation, water source and the characteristics of the holding system. In intensive tanks and recirculating aquaculture systems, the interactions between biological filtration, feed inputs and microbial nitrification are particularly important. In open ponds, seasonal, meteorological and biological processes can generate appreciable fluctuations over the course of a day. Rapid commercial test kits provide accessible information for routine environmental screening across a wide range of premises. Such measurements require a different interpretation from calibrated instrumental or laboratory-confirmed analytical measurements, especially when the targeted analytes include trace metals. A numerical value displayed by a test chart does not itself indicate equivalent analytical precision.

Material and method:

A descriptive, non-interventional, observational survey examined 50 water samples collected from aquaria, ornamental ponds, commercial fish-holding facilities and outdoor fishing or aquaculture basins in Timișoara and additional locations in Timiș and Hunedoara counties, western Romania. Collection sites represented systems under routine operating conditions. The study did not include an experimental exposure, treatment assignment or controlled intervention.Sampling premises were classified by origin into three practical categories: private aquaria/ornamental ponds (23 samples), outdoor fishing ponds and fishery basins (20 samples) and retail fish-holding facilities (seven samples). Independently, the dissertation compared readings across four fish-assemblage categories: ornamental aquarium fish, cyprinids, food or recreational fish and mixed-species holdings. These two classifications are distinct and should not be treated as interchangeable.

Results and discussions:

The 50 samples originated predominantly from private aquaria and ornamental ponds (23/50; 46%), followed by outdoor fishing and aquaculture ponds (20/50; 40%). Seven samples (14%) came from five commercial premises. The 20 outdoor samples were identified in the dissertation as numbers 6, 7, 14, 24, 27, 32–44, 49 and 50; those samples were associated with ponds and lakes in Timiș and Hunedoara counties. The commercial premises accounted for samples 1–4 and 21–23, reflecting both retail ornamental tanks and live-fish holding systems.A major descriptive finding was the high proportion of outside-band total-hardness (62%), carbonate (44%) and alkalinity (42%) classifications. These variables represent related but distinct characteristics of the water matrix: total hardness broadly reflects dissolved calcium and magnesium, while alkalinity describes the capacity to neutralise acids; carbonate species contribute to that buffering system. They must therefore be considered together with pH, species composition and the stability of the system rather than regarded as three independent measures of water quality. The higher median hardness and alkalinity in cyprinid and food/recreational-fish categories may reflect water-source geology, substrates, conditioning, buffering practices or system differences, but none of these candidate explanations was measured systematically in the survey. An outside-band classification is not synonymous with toxicity: fish species and populations differ markedly in their tolerance and acclimation to water mineralisation. A water sample can also have a stable pH while its mineral composition differs from that of another apparently stable system. Monitoring programmes should therefore use species-appropriate target values, not a single pooled target across ornamental soft-water fish, cyprinids and salmonids.

Conclusions:

Semi-quantitative screening of 50 water samples from ornamental, commercial and outdoor fish-holding systems in western Romania revealed heterogeneous water conditions and frequent study-defined outside-band findings for total hardness (62%), carbonate (44%), alkalinity (42%) and nitrite (36%). Conversely, temperature, pH and nitrate screening results were within the selected reference bands in 94%, 78% and 76% of samples, respectively. Group-level median chemistry differed across fish assemblages, and the source analysis reported strong associations among the carbonate–alkalinity–pH indicators.The findings support broad, species-sensitive environmental monitoring rather than the use of any single parameter as a proxy for fish welfare. Because the measurements were semi-quantitative, apparent metal signals were not analytically confirmed, and no standardised animal-based welfare outcomes were assessed, the data do not establish contamination, clinical pathology or a causal deterioration in welfare. The primary contribution of the study is an exploratory field profile that identifies which water-quality domains warrant the greatest attention during routine assessment.