

Excessive Manure Impact on Rohu Mortality in Aquaculture

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Abstract

The intensification of freshwater aquaculture has increased the use of organic manures such as cow dung and poultry litter in carp culture, especially for Rohu (*Labeo rohita*). While moderate application enhances plankton production and supports natural food webs, excessive usage has become a major cause of water quality deterioration and fish mortality. This study evaluates the mechanisms by which excessive organic loading affects Rohu, including oxygen depletion, ammonia toxicity, algal blooms, pathogen proliferation, sediment accumulation, and heavy metal contamination. In addition, the economic and nutritional importance of Rohu, the comparative roles of cow dung and poultry litter, and the socio-economic dimensions of farmer costs and government extension services are discussed. The findings emphasize that balanced manure application, coupled with sustainable management practices, is essential to reduce mortality and improve ecological and economic stability in freshwater aquaculture.

Keywords: Ammonia toxicity, Algal blooms, Pathogen proliferation, Sediment accumulation, Heavy metals, Sustainable aquaculture

1. INTRODUCTION

Aquaculture has emerged as the fastest-growing food production sector globally, contributing significantly to nutrition, employment, and the economy. In India, freshwater aquaculture accounts for nearly **70% of inland fish production**, with carps such as Rohu (*Labeo rohita*), Catla (*Catla catla*), and Mrigal (*Cirrhinus mrigala*) forming the backbone of inland fish farming systems. Among these, Rohu holds a dominant position due to its high consumer demand, fast growth rate, and adaptability to diverse ecological conditions.

To sustain and increase production, farmers often rely on **organic manures such as cow dung and poultry litter** to enhance natural pond productivity. These manures act as cost-effective fertilizers, stimulating the growth of phytoplankton and zooplankton, which are essential natural food sources for carps. Their use is especially prevalent among small-scale farmers who cannot afford costly commercial feeds. Historically, the application of organic manures has

been one of the oldest and most trusted practices in carp culture, forming the foundation of traditional aquaculture systems.

However, the scenario has changed with the **intensification of aquaculture** in recent decades. To maximize yields and meet the rising demand for fish protein, many farmers apply manure excessively, often without considering pond carrying capacity, stocking density, or water quality. Such unscientific practices result in serious ecological imbalances. Excess manure leads to **oxygen depletion, ammonia buildup, harmful algal blooms, sediment accumulation, heavy metal contamination, and pathogen outbreaks**. Together, these factors not only increase fish mortality but also reduce overall pond productivity and profitability. This issue is particularly critical for Rohu culture, as Rohu is sensitive to water quality fluctuations. Mortality events caused by excessive manure use directly affect farmer incomes and threaten the sustainability of aquaculture operations. Moreover, poor manure management also raises environmental concerns by contributing to eutrophication, water pollution, and biodiversity loss in surrounding ecosystems.

Therefore, there is an urgent need to critically examine the **dual role of organic manure** in aquaculture — as a beneficial nutrient source when applied in moderation and as a potential ecological stressor when misused. This study specifically focuses on understanding the mechanisms through which excessive manure application contributes to Rohu mortality, while also highlighting economic, nutritional, and policy-related dimensions. It aims to provide insights into sustainable manure management strategies that ensure ecological stability, fish health, and farmer profitability

2. ECONOMIC AND NUTRITIONAL IMPORTANCE OF ROHU

Rohu is one of the most important species in freshwater aquaculture. Traditionally, it has been a dominant fish in Indian carp polyculture systems. According to **Jena et al. (2007)**, Rohu was already a major contributor to inland fish production over a decade ago. The **NFDB (2020)** reported that Rohu contributes nearly **30% of India's freshwater aquaculture production**. More recent statistics from **FAO (2022–2023)** indicate that India and Bangladesh together produce **over 3 million metric tons of Rohu annually**, reflecting its economic and cultural significance.

Nutritionally, Rohu contains **17–18% high-quality protein**, essential amino acids, omega-3 fatty acids, and vital vitamins and minerals such as calcium, phosphorus, and iron. Its affordability compared to other animal proteins makes it crucial for combating malnutrition in rural areas.

Economically, Rohu farming supports millions of small-scale farmers. Its omnivorous feeding habits reduce reliance on costly feeds, while its compatibility with **Catla** and **Mrigal** in polyculture ensures efficient use of pond resources. However, this economic potential is closely linked to water quality. Excessive use of organic manure disturbs ecological balance, causing stress, higher mortality, and reduced yield.

Statement of study: This study emphasizes that while Rohu is indispensable for nutrition and livelihoods, its culture is highly sensitive to environmental conditions. The overuse of organic manure directly undermines the sustainability of Rohu farming, highlighting the urgent need for scientific nutrient management.

3. ROLE OF MANURE IN AQUACULTURE SYSTEMS

Organic manures act as low-cost fertilizers in aquaculture, supplying essential nutrients like nitrogen and phosphorus that promote the growth of phytoplankton and zooplankton — the primary natural food for carps. Their use is particularly common among small and marginal farmers because they are inexpensive, easily available, and help reduce dependence on costly artificial feeds. By enhancing the base of the food web, manures indirectly improve fish growth and yield, making them an integral component of semi-intensive and extensive carp culture systems.

Recommended doses in carp culture:

- **Cow dung:** 5,000–10,000 kg/ha/year (split into weekly applications of 250–500 kg/ha).
- **Poultry litter:** 2,000–3,000 kg/ha/year (applied at 100–200 kg/ha/week).

Comparative role:

- **Cow dung** decomposes slowly and releases nutrients gradually, ensuring stable primary productivity but requiring larger quantities.
- **Poultry litter** is nutritionally richer, with higher nitrogen and phosphorus content, and accelerates plankton blooms more rapidly. However, due to its faster decomposition, it also increases the risks of oxygen depletion and ammonia toxicity if overdosed.

When applied judiciously, both manures support natural food webs, improve nutrient cycling, and lower feed costs, thereby enhancing economic returns for farmers. However, when applied in excessive amounts without scientific calculation, they disrupt pond ecology by over-enriching the water and increasing biological oxygen demand. This leads to water quality deterioration, higher disease prevalence, and ultimately reduced fish survival.

Additional perspective: Beyond pond productivity, manure application also plays a role in maintaining ecological sustainability when integrated with other farming systems. For instance, in **fish-rice or fish-duck integrated farming**, the waste from one component acts as input for another, reducing nutrient loss and optimizing resource use. Such integration minimizes environmental risks associated with manure overloading while maximizing farmer profitability. Therefore, the role of manure in aquaculture is not only to improve productivity but also to serve as a critical link in sustainable and integrated farming systems.

4. MECHANISMS OF MANURE-INDUCED FISH MORTALITY (Expanded with References)

Excessive application of organic manure severely alters the physicochemical and biological properties of pond water. These alterations create multiple stressors for Rohu, leading to poor health, suppressed immunity, and in many cases, mass mortality. The following mechanisms explain how manure overload impacts pond ecology and fish survival.

4.1 Oxygen Depletion

One of the most serious consequences of excessive manure application in fish ponds is **oxygen depletion**. When large amounts of cow dung or poultry litter are added, microbial populations multiply rapidly to decompose organic matter. This microbial activity sharply increases the **Biological Oxygen Demand (BOD)** of the pond. According to **Kumar & Yadav (2017)**, high organic loading significantly reduces dissolved oxygen (DO) levels, particularly in shallow water ponds. For Rohu, DO levels below **5 mg/L** already cause stress, while levels under **3 mg/L** can be fatal. In such conditions, fish show erratic swimming, surface gasping, and lethargy, while long-term exposure results in reduced growth and feed intake.

The problem intensifies at night when photosynthesis ceases, and both phytoplankton and microbes continue to consume oxygen. Several studies (Mishra et al., 2022; Das & Das, 2005) reported that Rohu exposed to prolonged hypoxia exhibit suppressed immune function, making them vulnerable to diseases. In extreme cases, sudden oxygen crashes can kill an entire stock overnight. Therefore, oxygen depletion is considered one of the primary pathways linking manure overload to Rohu mortality.

4.2 Ammonia Toxicity

Excessive decomposition of organic manure also leads to the release of nitrogenous compounds, mainly ammonia. Ammonia exists in ionized (NH_4^+) and un-ionized (NH_3) forms, the latter being highly toxic to fish. According to **Emerson et al. (1975)**, the toxicity of ammonia is strongly influenced by temperature and pH; warm, alkaline waters typical of manure-fertilized ponds shift the equilibrium towards un-ionized NH_3 . Even low concentrations of NH_3 (0.02–0.05 mg/L) can impair gill function, reduce oxygen uptake, and cause osmoregulatory imbalance (Rahman et al., 2018).

Prolonged exposure to ammonia not only causes physiological stress but also reduces feeding efficiency and growth. Chronic ammonia stress is known to cause **gill hyperplasia**, where excessive cell growth reduces gas exchange capacity, further worsening oxygen uptake (Mishra et al., 2022). Additionally, high ammonia levels suppress the immune system, making Rohu more prone to bacterial and parasitic infections. Thus, ammonia toxicity acts both as a direct lethal stressor and as an indirect factor increasing disease outbreaks in aquaculture ponds.

4.3 Algal Blooms

Another critical consequence of nutrient over-enrichment from manure is the formation of **algal blooms**, particularly cyanobacteria. When excessive nitrogen and phosphorus accumulate in ponds, they create favorable conditions for harmful algal species. According to **Padmavathi & Prasad (2003)**, dense cyanobacterial blooms are a common problem in manure-fertilized carp ponds. These blooms produce **microcystins**, which are potent hepatotoxins that can damage the liver, kidney, and nervous system of fish (Ahmed & Hossain, 2009). Additionally, thick algal mats block sunlight from reaching deeper waters, reducing photosynthetic activity of beneficial algae and aquatic plants. This imbalance affects the natural food chain, leading to poor feeding efficiency and stress in Rohu.

The problem becomes more severe when blooms collapse. Dead algal cells are decomposed by bacteria, which further increases the **Biological Oxygen Demand (BOD)** of the pond. This process

causes sudden drops in dissolved oxygen, leading to hypoxic or anoxic conditions. **Rahman et al. (2018)** reported that fish kills are often observed following bloom crashes because the simultaneous oxygen depletion and toxin release overwhelm the fish. Thus, algal blooms not only introduce toxins into the system but also cause extreme fluctuations in oxygen dynamics, making them one of the most dangerous outcomes of excessive manure loading in aquaculture ponds.

4.4 Pathogen Proliferation

Excess manure also stimulates the growth of opportunistic pathogens in aquaculture ponds. The high organic content provides an ideal environment for bacteria such as *Aeromonas hydrophila*, *Edwardsiella tarda*, and *Vibrio* spp. to proliferate (Choudhury & Pal, 2015). Under such conditions, Rohu, already stressed due to poor water quality, become highly vulnerable to diseases like **Motile Aeromonas Septicemia (MAS)** and **Columnaris disease**. According to **Singh & Sharma (2018)**, these diseases are responsible for heavy economic losses in carp culture because they spread quickly and can cause mortality in a large proportion of stocked fish. Pathogen outbreaks are often more severe in systems with high stocking densities and low oxygen availability, both of which are aggravated by manure overload.

Furthermore, manure-rich environments disrupt the natural balance between beneficial and harmful microbes. While probiotics and nitrifying bacteria play a role in maintaining water quality, excessive organic matter allows pathogenic species to dominate. Stressed Rohu display reduced immunity and often succumb to infections that they would normally resist. Once an outbreak begins, mortality can spread rapidly throughout the pond. Thus, pathogen proliferation acts as a secondary but highly destructive pathway linking manure overuse to fish mortality in aquaculture.

4.5 Sediment Accumulation and Habitat Alteration

Continuous application of manure causes large amounts of organic matter to settle at the pond bottom, leading to **sediment accumulation**. Over time, this buildup reduces effective pond depth and alters benthic habitats, limiting foraging space for fish. More critically, these sediments undergo **anaerobic decomposition**, producing toxic gases such as hydrogen sulfide (H₂S), methane (CH₄), and carbon dioxide (CO₂). According to **Bhattacharya et al. (2021)**, hydrogen sulfide is especially lethal to carps, even at very low concentrations, because it binds to gill tissues and prevents oxygen uptake. Sediment accumulation also fosters stratification, where bottom layers become oxygen-deficient, forcing fish to crowd near the surface. This overcrowding increases stress and promotes disease transmission.

In addition to water quality deterioration, sediment accumulation affects fish behavior and feeding. Rohu, being column and bottom feeders, often come into direct contact with these toxic sediments. Studies by **Gangadhara & Keshavanath (2003)** observed that fish in heavily manured ponds exhibited reduced feeding, slower growth, and higher mortality. Long-term accumulation also makes pond management difficult, as periodic drying and desilting become necessary to restore ecological balance. Therefore, sediment buildup not only destabilizes pond ecology but also directly threatens fish survival and farmer profitability.

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4.7 pH Imbalance and Carbon Dioxide Accumulation

Excessive decomposition of manure in ponds releases large amounts of **carbon dioxide (CO₂)**, which dissolves in water to form carbonic acid. This process lowers pond pH, creating acidic conditions. When pH drops below **6.5**, Rohu experience gill damage, reduced oxygen uptake, and impaired osmoregulation. On the other hand, intense photosynthesis during algal blooms can push pond pH above **9**, a condition that increases the proportion of toxic un-ionized ammonia (NH₃) in water. According to **Boyd (1990)**, such **daily pH fluctuations** are common in ponds with high organic loading and make the environment highly unstable for fish.

Prolonged exposure to unstable pH not only stresses Rohu but also reduces plankton diversity, affecting the natural food web. Acidic conditions dissolve toxic metals from pond sediments, while alkaline conditions aggravate ammonia toxicity (Mishra et al., 2022). Fish cultured in such fluctuating environments often display poor feeding, slower growth, and greater disease vulnerability. Thus, pH imbalance acts both directly, by damaging fish physiology, and indirectly, by amplifying the toxicity of other pollutants.

4.8 Temperature Rise and Greenhouse Gas Effect

Sediments enriched with organic matter from manure undergo anaerobic decomposition, releasing gases like **methane (CH₄)** and carbon dioxide (CO₂). These gases not only contribute to greenhouse emissions but also create localized warming in pond bottoms. According to **Sharma et al. (2020)**, elevated water temperature accelerates microbial decomposition, further depleting oxygen and intensifying ammonia release. This creates a feedback loop where high temperatures worsen oxygen stress, and oxygen depletion in turn exacerbates fish mortality.

Temperature rise also favors the growth of harmful cyanobacteria, increasing the frequency and intensity of algal blooms. Warmer conditions elevate the metabolic rate of Rohu, raising their oxygen demand at a time when oxygen availability is already low. This mismatch between oxygen demand and supply often results in mass mortality events. Hence, manure overloading indirectly contributes to **climate-like stressors** in aquaculture ponds, adding another layer of risk for Rohu survival.

4.9 Overall Synergistic Stress

The impacts of excessive manure are not isolated; rather, they act **synergistically**, compounding the stress on Rohu. For instance, algal blooms not only produce toxins but also lead to oxygen depletion and pH fluctuations simultaneously. Similarly, high ammonia levels suppress immunity, predisposing fish to bacterial infections that thrive in organic-rich environments. As highlighted by **Rahman et al. (2018)**, such multiple stressors act together to create conditions that fish cannot adapt to.

The combined effect of these stressors results in both **chronic sub-lethal impacts** (stunted growth, poor feed efficiency, reduced reproduction) and **acute lethal outcomes** (sudden mass mortality). This synergy explains why ponds with excessive manure often experience unpredictable and catastrophic fish kills, undermining the sustainability of Rohu farming. Understanding these interactions is therefore essential for designing effective mitigation strategies.

5. MITIGATION STRATEGIES AND BEST PRACTICES

5.1 Controlled Manure Application

The most effective way to reduce the harmful impacts of manure is its **judicious application**. Instead of bulk addition, manures should be applied in small, regular doses depending on pond size, stocking density, and seasonal conditions. Scientific recommendations suggest cow dung at **5,000–10,000 kg/ha/year** in split doses and poultry litter at **2,000–3,000 kg/ha/year** (applied weekly in smaller amounts) (Boyd & Tucker, 1998). Composting manure before application reduces harmful pathogens and ensures slow nutrient release. This prevents sudden surges in organic load, lowers oxygen depletion risk, and maintains better ecological stability in ponds.

5.2 Regular Monitoring of Water Quality

Routine monitoring of water parameters is essential to prevent mortality events. Farmers should frequently measure dissolved oxygen, pH, ammonia, and temperature using portable kits. According to **Kumar & Yadav (2017)**, dissolved oxygen should be maintained above **5 mg/L**, ammonia below **0.02 mg/L**, and pH between **7.0–8.5** for optimal Rohu culture. Early detection of imbalances allows corrective actions such as partial water exchange, use of aeration, or reduction in manure input before fish health deteriorates.

5.3 Aeration, Biofilters, and Probiotics

Aeration is one of the most practical technologies for mitigating oxygen depletion. Paddle wheel aerators, aspirators, and blowers improve oxygen circulation, prevent thermal stratification, and reduce fish mortality. Though costly, aeration significantly increases survival and growth rates, ultimately improving farmer income. Biofilters and probiotics offer biological solutions: they degrade organic matter, convert toxic nitrogenous compounds into safer forms, and stabilize microbial communities. Probiotics also improve fish gut health and immunity, making Rohu more resistant to stress and infections (Singh & Sharma, 2018).

5.4 Farmer Cost and Practices

For small-scale farmers, mismanagement of manure often leads to severe economic losses due to fish kills and reduced yields. The adoption of aerators, testing kits, or probiotics requires initial

investment, which is often a challenge for marginal farmers. Hence, there is a strong need for **cost-effective practices** such as proper composting, split-dose application, and the use of locally available biofilters. Studies (NFDB, 2023) highlight that even low-cost interventions like maintaining pond depth, liming, and periodic sludge removal can greatly improve water quality without heavy expenses.

5.5 Government Extension Services and Policy Role

Government support plays a vital role in helping farmers adopt sustainable manure management. Extension services can provide **training programs, awareness campaigns, and demonstration ponds** to show best practices in action. Subsidies for aerators, water testing kits, and probiotics can reduce the financial burden on farmers. Policy-level interventions, such as the creation of guidelines for safe manure use and the promotion of **integrated aquaculture systems**, ensure ecological safety and economic stability. As emphasized in NFDB (2023), farmer education combined with government support is critical for long-term aquaculture sustainability.

5.6 Natural and Integrated Solutions

Nature-based solutions also form an important part of mitigation. **Phytoremediation** using aquatic plants like duckweed, water hyacinth, and vetiver grass absorbs excess nutrients, controls eutrophication, and improves pond ecology (Sharma et al., 2020). Integrated farming systems such as fish-rice, fish-duck, or fish-pig culture recycle nutrients effectively, reducing the need for external manure input. These approaches not only minimize environmental risks but also enhance farm profitability by diversifying income sources.

6. CONCLUSION

Organic manures such as cow dung and poultry litter play an important role in carp culture by enhancing natural productivity and reducing feed costs. However, their excessive use destabilizes pond ecosystems, leading to oxygen depletion, ammonia toxicity, algal blooms, pathogen outbreaks, and accumulation of harmful sediments and heavy metals. These multiple stressors often act together, causing reduced growth, poor immunity, and sudden mortality in Rohu (*Labeo rohita*).

For sustainable aquaculture, it is essential to apply manure in recommended doses, regularly monitor water quality, and adopt eco-friendly practices such as aeration, probiotics, and phytoremediation. Farmer-level awareness, combined with government support through training, subsidies, and policy guidelines, is equally crucial. By balancing nutrient input with ecological capacity, Rohu farming can remain both economically viable and environmentally sustainable, ensuring food security and livelihood support for millions.

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