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Effects of Toxic Chemical Build-up on Fish Growth and Yield in North 24 Parganas Inland Fisheries, West Bengal

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Abstract: *This study examines the impact of toxic chemical accumulation on fish growth and yield in the inland fisheries of North 24 Parganas, West Bengal. Persistent contamination from anthropogenic sources has led to the accumulation of hazardous substances in aquatic environments. Results indicate that elevated chemical residues correlate with significant reductions in fish growth rates and overall yield. The findings underscore the urgent need for sustainable management and pollution mitigation to protect fish health and local aquaculture productivity.*

Keywords: *Toxic chemicals, Fish growth, Yield, Inland fisheries, North 24 Parganas*

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Introduction

Inland fisheries serve as a cornerstone for food security, employment, and economic stability within rural West Bengal. North 24 Parganas, in particular, stands out as a major center of aquaculture, supported by an extensive network of sewage-fed wetlands and fish ponds. These systems predominantly cultivate species such as Labeo rohita (Rohu), Catla catla (Catla), and Oreochromis niloticus (tilapia), all of which are economically significant in the region.

Yet, the district faces escalating challenges from rapid urbanization, intensive agricultural practices, and insufficiently regulated effluent discharge. These pressures have led to notable contamination in local aquatic environments. Recent findings indicate that concentrations of heavy metals—including lead (Pb), cadmium (Cd), chromium (Cr), and arsenic (As)—as well as pesticide residues like chlorpyrifos and cypermethrin, are increasingly present in water, sediments, and fish tissues across various zones of West Bengal. When these substances surpass safe thresholds, they interfere with fish metabolism, diminish feed conversion efficiency, and ultimately reduce yields. Seasonal dynamics, especially during the monsoon, intensify chemical influx through agricultural runoff and untreated sewage.

Although previous studies, such as Banerjee et al. (2023), have documented heavy metal accumulation and its biological consequences in the East Kolkata Wetlands, comprehensive data on North 24 Parganas' inland fisheries remain sparse. This study was therefore designed to systematically quantify heavy metal and pesticide residue levels in water, sediments, and fish tissues from aquaculture systems within North 24 Parganas, and to evaluate their impact on fish growth and yield.

Materials and Methods

Study Area and Period

The present study was carried out over a full year (April 2023 to March 2024) in six inland fish ponds situated in North 24 Parganas, West Bengal. These ponds are positioned near agricultural fields and semi-urban areas, both known for potential chemical contamination.

Sampling Design

Sampling was structured around four seasonal phases: pre-monsoon (April–June), monsoon (July–September), post-monsoon (October–December), and winter (January–March). Water samples were taken from a depth of approximately 30 cm using pre-cleaned polyethylene bottles to ensure minimal contamination. For sediment, the top 10 cm was collected with a grab sampler, as this layer most readily accumulates pollutants. Fish species sampled included *Labeo rohita, Catla catla,* and *Oreochromis niloticus*, collected every 60 days to assess seasonal variation in both contaminant bioaccumulation and fish growth.

Laboratory Analysis

In the laboratory, water and sediment samples underwent acid digestion and were analyzed for lead (Pb), cadmium (Cd), chromium (Cr), and arsenic (As) using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), following APHA (2017) protocols. Pesticide residues—specifically chlorpyrifos and cypermethrin—were extracted via solvent methods and quantified using Gas Chromatography-Mass Spectrometry (GC-MS). The fish tissue samples (muscle, liver, and gill) were similarly processed to evaluate metal and pesticide accumulation.

Fish Growth and Yield Measurement

Fish growth performance was evaluated by measuring **weight gain (WG)**, **specific growth rate (SGR)**, and **survival rate (SR)**:

$$SGR(\%/day) = \frac{\ln W_f - \ln W_i}{t} \times 100$$

where W_f and W_i are the final and initial fish weights (g), and t is the culture period (days). The total yield was expressed in kilograms per hectare (kg/ha).

Statistical Analysis

Differences in contaminant concentrations and growth metrics across seasons were evaluated using ANOVA. Correlation analysis (Pearson's r) was performed to assess the relationship between contaminant levels and fish growth/yield. All data analyses were conducted using SPSS 25.0.

Results

Heavy Metal and Pesticide Contamination

The water and fish samples revealed significant seasonal variations in heavy metal concentrations, with monsoon showing the highest levels due to surface runoff. The seasonal mean concentrations of Pb, Cd, Cr, and As are summarized in Table 1.

Table 1. Seasonal Average Concentration of Heavy Metals in Water and Fish Muscle

(mg/L for water, mg/kg for fish muscle)

Season	Pb (Water)	Pb (Fish)	Cd (Water)	Cd (Fish)	Cr (Water)	Cr (Fish)	As (Water)	As (Fish)
Pre-monsoon	0.08 ±0.02	0.15 ±0.03	0.02 ±0.01	0.05 ±0.01	0.12 ±0.04	0.20 ±0.04	0.06 ±0.02	0.10 ±0.03
Monsoon	0.34 ±0.06	0.45 ±0.08	0.09 ±0.02	0.18 ±0.03	0.28 ±0.05	0.42 ±0.09	0.21 ±0.05	0.32 ±0.06
Post-monsoon	0.20 ±0.04	0.30 ±0.06	0.05 ±0.02	0.12 ±0.02	0.18 ±0.03	0.30 ±0.05	0.10 ±0.04	0.20 ±0.05
Winter	0.12 ±0.03	0.18 ±0.04	0.03 ±0.01	0.07 ±0.02	0.14 ±0.02	0.22 ±0.04	0.07 ±0.02	0.12 ±0.03

Pesticide residues (chlorpyrifos: 0.03–0.07 mg/kg, cypermethrin: 0.02–0.05 mg/kg) were consistently detected, with highest values during the monsoon season.

Fish Growth and Yield

Fish growth was notably reduced in ponds with high contamination levels. The average growth performance and survival rates for major species are presented in Table 2.

Yields ranged from **1,600–1,800 kg/ha** in low-contaminant ponds compared to **1,150–1,300 kg/ha** in highly contaminated ponds

. **Table 2. Growth Performance of Cultured Fish (Mean ± SD)**

Species	Pond Type	Initial Weight (g)	Final Weight (g)	SGR (%/day)	Survival Rate (%)
Labeo rohita	Low-contam.	45 ±5	410 ±25	2.10 ±0.12	92 ±2
	High-contam.	46 ±6	320 ±20	1.65 ±0.10	84 ±3
Catla catla	Low-contam.	55 ±7	470 ±30	2.18 ±0.15	91 ±3
	High-contam.	54 ±6	340 ±22	1.70 ±0.11	85 ±4
O. niloticus	Low-contam.	40 ±4	350 ±18	2.15 ±0.10	93 ±2
	High-contam.	41 ±5	270 ±15	1.62 ±0.08	84 ±3

Discussion

Recent findings paint a concerning picture for North 24 Parganas: toxic chemical accumulation is clearly undermining fish growth and productivity. The research notes a pronounced spike in heavy metal concentrations during the monsoon, which echoes trends reported in the East Kolkata Wetlands (Banerjee et al., 2023) and points toward untreated runoff and effluent discharge as primary culprits.

Particularly alarming are the lead (Pb) and cadmium (Cd) levels detected in some fish muscle samples, which surpass FAO/WHO safety thresholds and raise legitimate health concerns—especially for children who may consume this fish. The detrimental effect on fish-specific growth rate and yield is consistent with Garai et al. (2021), whose work shows that chronic Pb and Cd exposure disrupts key metabolic and enzymatic processes, leading to stunted growth. Pesticide residues, such as chlorpyrifos, have also been implicated in inducing oxidative stress and compromising fish immunity (Dutta et al., 2022).

Economically, the impact is substantial: farmers are facing up to 30% yield losses in ponds with high contaminant levels. These outcomes underscore the urgent need for mitigation strategies—including pre-treatment of runoff, minimizing chemical inputs, and providing farmer education on sustainable aquaculture methods. Finally, stricter enforcement of the West Bengal Inland Fisheries Act (1984) is necessary to safeguard water quality and protect both public health and livelihoods.

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