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Analytical study on physical and chemical aspects of water at sahipul of Gomti River

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Abstract
The Gomti River, a crucial tributary of the Ganga, sustains rich biodiversity but faces severe contamination from agricultural pesticides and industrial effluents. This study evaluates the ecological impact of in secticides and fungicides on its freshwater fish ecosystem. The Pesticide Toxicity Index (PTI), heavy metal analysis, plankton surveys, and toxicity tests were applied to assess organophosphate pesticides and neonicotinoids, with special focus on Trichogaster fasciata (banded gourami). Results reveal high pesticide residues in water, sediments, algae, and fish tissues, leading to reduced plankton diversity, histopathological changes in fish reproductive organs, and significant alterations in aquatic ecosystem structure.

Keywords: Gomti River, pesticide toxicity Index, organophosphates, imidacloprid, aquatic biodiversity

1. Introduction
Pesticide usage in the Gomti River basin has escalated due to intensive agriculture, especially rice-prawn systems. Runoff, leaching, and spray drift introduce persistent chemicals such as organochlorines, organophosphates, and carbamates into the river, threatening aquatic biodiversity and human health. Fish, as bioindicators, reveal the cumulative effects of these pollutants due to their high bioaccumulation potential.

For many amphibian ecological systems, the greatest threat comes from pollution caused by things like farming, residential colonies, and industry. Surface and groundwater contamination from pesticide overflow may occur as a result of haphazard and unplanned agricultural practices. The repeated application of different pesticides in agricultural settings causes these chemicals to be released into the environment by numerous means, including as floatation, run-off, seepage, and others. As time goes on, these accumulations make their way to rivers and beachfront waterways, canal waters, and even groundwater, proving that activation may occur and deposits can be detected in places unrelated to their intended usage.

Many people in rural regions are worried about pesticide-induced water, silt, and habitat pollution used for non-agricultural uses national and international scales. Water, sediment, and marine organisms get contaminated with an extensive selection of herbicides and their degradation products. Tireless Organ chlorine pesticides, contamination of the environment with substances like PCBs, DDTs, and HCHs is widespread and bio accumulates mostly via developed forms of life. They are natural poisons that affect every part of the global biological system. There are benefits to using pesticides, but there is also a global problem with the harmful environmental effects of pesticide usage, care, and transfer tactics.

Making a pesticide that is easy to apply, has little environmental effect, and has optimal biological efficiency is the fundamental goal of the formulation process. To get the right formulation, active compounds are combined with solvents, adjuvants (boosters), and fillers. Many different physical forms or formulations of pesticides are possible. Their forms may range from solid or liquid baits to emulsifiable concentrates, dusts, aerosols, solutions, and water dispersible granules. The benefits they provide to their usage are what drive their sales in various forms. How a substance settles into soil or a plant's surface is affected by its formulation. Their subsequent actions may control how much of it the plant absorbs or how it moves through the soil to the top layers. The features of a pesticide's wash-off or runoff in

rainwater or irrigation water are also determined by its formulation.

The downside is that pesticides have this quality, which means they may linger for extended periods of time, potentially making their way into water supplies and continuing to harm aquatic creatures. Because rains and irrigation may wash pesticides from application locations, these chemicals end up in various bodies of water. The chemicals may build up in the bodies of fish and invertebrates, making their way up the food chain to animals and eventually to people.

2. Literature review

Bano, Farah & Serajuddin, Mohammad. (2016) [1]. The present study aimed to evaluate where the icthyo-faunal biodiversity stands along the 940 km of the Gomti River, a Ganga River tributary in the Lucknow area now. Over forty-one genera, nine orders, and twenty-one families have 56 species recorded according to the research. There were 33.91 percent more species in the Cypriniformes order than in the Siluriformes, according to the species count with 30.32%), the Perciformes with 17.85%, the Ophiocephaliformes with 5.37 %, the Mastacembeliformes with 3.59%, the Clupeiformes with 3.59%, the Mugiliformes with 1.79%, the Beloniformes with 1.79%, and Tet-raodontiformes with 1.79%. Species such as Nearly all of these species—Even though most of these species— 46 out of 66—are categorised as Least Concern by the IUCN, a few are in risk of extinction: Ompok bimaculatus, Ompok pabda, Wallago attu, Bagarius bagarius, and Ailia coila.

Gupta, Neha & Thakur, Ravindra (2022) [2]. In response to the problem of water quality decline due to pesticide overexposure, this paper seeks to develop an easyto-understand analytical technique for detecting and quantifying several pesticides in water samples from the Gomti river. We used an analytical methodology called methods for dispersive liquid microextraction using vortex-assisted ultrasonication and solidifying organic droplets in suspension to optimize one parameter at a time, which yielded results with a recovery of 69.45-114.15%. The LOD is between 0.0011 and 0.0111 g/L, the LOQ is between The data was subjected to measurement error, risk analysis, and multivariate statistics in order to confirm that the new analytical method was reliable.

Kumar, Sangam & Chaturvedi, Vijeta & Varma, Deepak & Yadav, Hira & Vats, Dr. Shailendra. (2023) [3]. Due to growing agricultural activity, industry, and urbanization—which depletes water quality—this study paper attempts to provide an accessible with a clear method for analysing water samples from the Gomti River in order to detect and measure herbicides belonging to many classes. The reason for this is because water contamination is becoming an issue on a global scale. An improved method called VAUS-DLLME-SFO, which stands for Micro extraction of dispersed organic droplets using vortex-assisted ultrasonic technology and subsequent solidification, was achieved by adjusting each parameter consecutively.

Tahir, Nimra & Akhtar, Aadab & Batool, Dr& Ain, Qurat. (2023) [7]. Chemical compounds with specific physical and chemical characteristics are known as pesticides, and they are used to eliminate insects, rodents, fungus, and undesired plants. Their chemical make-up, function, and the species they prey on are just a few of the ways they are categorized. These may be used for many different things, such managing of illnesses by eliminating mosquitoes and other vectors, and increasing agricultural output. Nevertheless, several non-targeted creatures, particularly fish, are very under danger from these chemicals' toxicity. Even at doses below the threshold for death, these substances may impact the activities of fish organs and cause their death if consumed in an unregulated and irregular manner.

Kumar, S., & Singh, S. K. (2023) [5]. The study analyzed pesticide residues in sediment and water samples using analytical grade chemicals and reagents from Sigma-Aldrich The 10 OPPs obtained from Sigma-Aldrich were Equamphon, acephate, chlorpyrifos, diazinon, dimethoate, ethion, fenitrothion, fenthion, malathion, methyl-parathion and quinalphos. Using the primary response curve (PRC) approach in the CANOCO Software, the data sets for phytoplankton, zooplankton, and macro invertebrates were evaluated program. The PRC approach isolates stressor-induced variance in community composition from the total variance using the time as a co-variable, the treatment regimen as an explanatory factor, and the date of the sample as a dependent variable. The physicochemical characteristics of the Gomti River water revealed in this review research show it is unfit for potable consumption. The river system is unfit for the existence of aquatic life as there is less Dissolve Oxygen (DO) Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), and Total Dissolved Solids (TDS) all remained elevated in river water. Lead, cadmium, and chromium are heavy metals that pose serious risks to both human and environmental health

Swati Singh (2015) [8]. A particular reference to physico-chemical properties and planton-type algae was carried out in the Varana River at Varanasi and the Gomti river at Jaunpur. There was also study of diversity in terms of river pollution. The members were prominent in Bacillariophyceae, while in winter months Cyanophyceae prevailed. Members of Euglenophyceae were poor lyrepresented although Chlorophyceae members were not very prominent. In quite good number, desmids also occurred. The comparative research of physicochemistry variables shows that the Varuna River is contaminated by human activities along Varanasi River compared to those of the Gomti River. In the Varuna River there was also a greater algal population than the Gomti River.

Syafrudin, Muhammad & Ayu, Risky (2021) [6]. The global problem of pesticides in aquatic habitats is garnering attention because these chemicals may accumulate in the bodies of aquatic creatures and in the soil, where they might potentially harm human health. The exponential expansion of the pesticide industry across the globe is highly associated with the widespread use of pesticides in both public and private spaces. A plethora of novel pesticide formulations have resulted from this. Pesticides get up in the water supply because of runoff from farms and factories. The rainwater drained the soil of its water-soluble pesticides, which eventually found their way into both underground and surface water sources. Water quality declines and the supply of potable water drops as a consequence. Extended exposure to the low pesticide dosage did not cause carcinogenesis. Phase transfer based approaches, including as coagulation-flocculation, adsorption, filtration, and sedimentation, are often used for pesticide treatment. Secondary pollutants, such as sludge development, and high operational costs are usual outcomes of such methods. Advanced oxidation processes (AOPs) and other clean technologies are generally agreed upon for the purpose of removing POPs from water. Its broad

applicability and thermodynamic viability have led to its recent acceptance in order to purify water. How often are pesticides found in water supplies? and potential solutions are examined in detail in this study article.

3. Materials and Methods

Study Area: Six sampling sites across Jaunpur city, including Sahipul. Three stations were designated on the left side of Sahipul, while three were designated on the right side.

Sampling Period: January - December 2022.

Parameters Measured: Physicochemical (pH, Turbidity, Temperature, Dissolved Oxygen, CO2, Alkalinity, hardness), Biological (plankton, macrophytes, algae, aquatic insects, fish diversity), and Chemical (Zn, Cu, Fe, Cd, Ni, and pesticide residues including imidacloprid, chlorpyrifos, cypermethrin).

Toxicity Testing: Microcosm studies on imidacloprid's effects on invertebrates and chlorpyrifos toxicity on banded gourami embryos, larvae, and adults.

Data Analysis: PTI (Median and Sensitive indices), NOEC, LC50, and histopathology.

4. Results

Pesticide Contamination: Median PTI > 1 in most S3 (mixing zone) samples; 96% of such samples showed 0% Ceriodaphnia dubia survival.

Heavy Metals: Sediments > algae > water in metal content, with Zn and Fe highest.

Biological Impact: Reduced phytoplankton and zooplankton diversity at high pesticide concentrations; imidacloprid altered macroinvertebrate community structure and slowed organic matter breakdown; chlorpyrifos caused developmental deformities in gourami embryos and histopathological degeneration in gonads.

Fish Diversity: Decline in sensitive species; increase in tolerant species near polluted zones.

Fig 1: Map of study sites

Table 1: Monthly variations in Physico-chemical parameters during January 2022 to December 2022 of Gomti River water near Jaunpur city Site- S1 (East of Sahipul)

Physico- chemical Parameters	Months											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov.	Dec.
Water colour	Greenish	Bluish Green	Brownish Green	Bluish Green	Straw	Clear	Muddy	Muddy	Light Muddy	Light Muddy	Light green	Light Green
pH	7.1	7.1	7.3	7.8	8.1	8.0	7.6	7.4	7.4	7.3	7.1	7.0
Turbidity (ppm)	390	360	360	350	330	350	560	640	610	500	410	400
Water temperature (˚C)	21	22	24	28	30	28	26	27	24	23	22	20
Dissolved oxygen (mg/L)	6.5	6.0	5.2	4.5	4.3	4.6	5.5	5.6	5.5	6.0	6.2	6.6
CO2 (ppm)	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.3	2.2	2.2	2.1	1.8
Alkalinity (ppm)	280	280	310	310	350	340	280	210	220	255	260	280
Total hardness(mg/L)	120	110	120	100	90	80	150	170	140	130	140	120

Table 2: Monthly variations in Physico-chemical parameters during January 2022 to December 2022 of Gomti River water near Jaunpur city Site- S2 (East of Sahipul)

Physico-chemical Parameters	**Months**											
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov.**	**Dec.**
Water colour	Greenish	Bluish Green	Bluish Green	Bluish Green	Straw	Clear	Muddy	Muddy	Light Muddy	Light Green	Light green	Light Green
pH	7.0	7.1	7.2	7.5	8.1	8.0	7.6	7.5	7.4	7.3	7.2	7.1
Turbidity (ppm)	385	390	375	370	360	350	550	650	640	500	430	400
Water temperature (˚C)	21	22	24	28	28	29	26	27	26	23	23	21
Dissolved oxygen (mg/L)	6.0	6.2	5.4	4.6	4.3	4.6	5.7	5.6	5.4	6.0	6.2	6.8
CO2 (ppm)	1.8	2.0	2.1	2.2	2.3	2.4	2.5	2.3	2.2	2.2	2.1	1.9
Alkalinity (ppm)	285	285	310	310	360	340	280	210	220	255	260	270
Total hardness(mg/L)	125	110	120	100	90	80	160	170	140	130	135	120

Table 3: Monthly variations in Physico-chemical parameters during January 2022 to December 2022 of Gomti River water near Jaunpur city Site- S3 (East of Sahipul)

Physico-chemical Parameters	Months											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov.	Dec.
Water colour	Greenish	Light Green	Bluish Green	Bluish Green	Clear	Straw	Muddy	Light Muddy	Muddy	Light Green	Light green	Light Green
pH	7.3	7.1	7.2	7.8	8.2	8.0	7.6	7.5	7.4	7.3	7.1	6.9
Turbidity (ppm)	380	390	385	380	345	355	540	610	600	570	430	400
Water temperature (˚C)	21	23	24	28	30	29	26	28	26	23	23	20
Dissolved oxygen (mg/L)	6.6	6.0	5.4	4.6	4.2	4.6	5.8	5.6	5.4	6.0	6.2	6.5
CO2 (ppm)	2.1	2.2	2.1	2.2	2.3	2.6	2.5	2.3	2.2	2.2	2.1	1.8
Alkalinity (ppm)	270	280	310	310	360	340	280	210	230	255	250	290
Total hardness(mg/L)	135	110	120	100	90	80	170	180	140	130	135	125

Table 4: Monthly variations in Physico-chemical parameters during January 2022 to December 2022 of Gomti River water near Jaunpur city Site- S4 (West of Sahipul)

Physico-chemical Parameters	**Months**											
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov.**	**Dec.**
Water colour	Greenish	Bluish Green	Brownish Green	Bluish Green	Straw	Clear	Light Muddy	Muddy	Light Muddy	Light Muddy	Light green	Light Green
Ph	7.2	7.1	7.4	7.8	8.6	8.2	7.6	7.5	7.4	7.4	7.2	7.1
Turbidity (ppm)	410	390	390	370	300	360	560	650	670	510	430	400
Water temperature (˚C)	21	22	25	28	29	28	26	25	24	23	22	21
Dissolved oxygen (mg/L)	7.0	6.0	5.2	4.6	4.3	4.6	5.5	5.6	5.4	6.0	6.2	6.9
CO2 (ppm)	2.4	2.3	2.4	2.5	2.3	3.4	2.5	2.3	2.2	2.2	2.1	2.1
Alkalinity (ppm)	280	280	310	310	370	340	280	210	220	255	260	290
Total hardness(mg/L)	110	110	120	100	90	80	150	170	140	130	140	130

Table 5: Monthly variations in Physico-chemical parameters during January 2022 to December 2022 of Gomti River water near Jaunpur city Site- S5 (West of Sahipul)

Physico-chemical Parameters	**Months**											
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov.**	**Dec.**
Water colour	Bluish Green	Bluish Green	Brownish Green	Bluish Green	clear	Clear	Light Muddy	Muddy	Light Muddy	Light Muddy	Light green	Light Green
pH	7.1	7.1	7.2	7.6	8.5	8.2	7.6	7.5	7.4	7.3	7.2	7.1
Turbidity (ppm)	380	390	390	370	300	360	510	640	660	500	390	400
Water temperature (˚C)	21	22	24	28	29	29	26	27	26	23	22	20
Dissolved oxygen (mg/L)	7.3	6.1	5.3	4.6	4.4	4.7	5.5	5.6	5.4	6.0	6.2	6.8
CO2 (ppm)	2.1	2.4	2.4	2.5	2.3	3.1	2.6	2.3	2.2	2.2	2.1	1.8
Alkalinity (ppm)	285	280	310	310	340	345	280	210	220	255	260	270
Total hardness(mg/L)	120	110	120	100	90	80	150	160	140	130	130	120

Table 6: Monthly variations in Physico-chemical parameters during January 2022 to December 2022 of Gomti River water near Jaunpur city Site- S6 (West of Sahipul)

Physico-chemical Parameters	**Months**											
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov.**	**Dec.**
Water colour	Bluish Green	Bluish Green	Brownish Green	Bluish Green	clear	Clear	Light Muddy	Muddy	Light Muddy	Light Muddy	Light green	Light Green
pH	7.2	7.1	7.2	7.8	8.4	8.2	7.6	7.5	7.4	7.4	7.2	7.4
Turbidity (ppm)	400	380	370	370	290	320	560	640	650	510	450	430
Water temperature (˚C)	21	23	24	28	30	29	26	27	26	23	22	20
Dissolved oxygen (mg/L)	6.9	6.1	5.3	4.7	4.4	4.7	5.5	5.6	5.4	6.0	6.2	7.1
CO2 (ppm)	1.8	2.3	2.4	2.5	2.3	3.2	2.5	2.3	2.2	2.2	2.1	2.2
Alkalinity (ppm)	290	280	310	310	380	345	280	210	220	255	260	280
Total hardness(mg/L)	130	110	120	100	90	80	150	160	140	130	120	120

Table 7: The percentage (%) of acute and chronic RQs >1 (highest RQs) of OPPs in surface water and sediment for different aquatic organisms.

Pesticide	Surface water							Sediment		
	Acute RQ fish	Acute RQ Daphnia	Chronic RQ fish	Chronic RQ Daphnia	Chronic RQ algae	Acute RQ fish	Acute RQ Daphnia	Chronic RQ fish	Chronic RQ Daphnia	Chronic RQ algae
Acephate	0	0	0	0	0	0	0	0	0	0
Chlorpyrifos	52 (700)	a100 (9100)	52 (650)	b100 (3033)	0	67 (425.7)	100 (5533)	58 (395.3)	100 (1844)	0
Diazinon	0	35 (900)	0	33 (160.7)	0	3 (3.3)	100 (10167)	2 (1.5)	100 (1816)	0
Dimethoate	0	0	0	0	0	0	12 (4.4)	7 (2.2)	30 (22.2)	0
Ethion	0	0	0	0	0	0	0	0	0	0
Fenitrothion	0	30 (57)	0	c100 (563.2)	0	0	38 (64.7)	0	100 (639.6)	0
Fenthion	0	30 (50)	0	0	0	2 (2.5)	35 (342)	0	0	0
Malathion	28 (17.8)	d100 (400)	0	e100 (533.3)	0	30 (17.3)	100 (390)	0	100 (520)	0
Methyl parathion	0	25 (41)	0	0	0	0	92 (457)	0	0	0
Quinalphos	45 (142)	100 (1076)	0	0	0	48 (117.7)	100 (891.5)	0	0	0

4. Discussion

The findings demonstrate strong correlations between pesticide concentrations and ecosystem degradation. PTI proved effective in predicting in-situ toxicity, and both chronic and acute effects were evident in fish physiology and reproduction. The rice-prawn system, though economically important, serves as a major pesticide source. Heavy metals further exacerbate stress in aquatic organisms.

Overall, the study underscores the urgent ecological risks posed by indiscriminate pesticide use and inadequate waste management. While pesticides contribute to agricultural productivity, their persistence and mobility create downstream consequences for aquatic ecosystems and human populations. Integrating agricultural best practices, such as buffer zones and integrated pest management (IPM), along with advanced water treatment technologies (as suggested by Syafrudin & Ayu, 2021) [6], can help mitigate these impacts. The findings therefore serve as both a scientific baseline and a call for policy interventions to safeguard the ecological integrity of the Gomti River.

5. Conclusion

According to an analysis of the body of research on the subject, pesticide contamination is pervasive in India's freshwater ecosystems. In India, it is crucial to strictly enforce current regulations and create mitigation plans since aquatic creatures may be a vector for the bioaccumulation of harmful chemicals in the food web.

The present study demonstrates that intensive agricultural activities and pesticide usage in the Gomti River basin near Jaunpur have led to significant alterations in water quality, sediment chemistry, and aquatic biodiversity. Monthly monitoring across six sites revealed seasonal fluctuations in physicochemical parameters, with turbidity and alkalinity peaking during the monsoon and dissolved oxygen declining to critical levels. Heavy metals such as Zn and Fe were consistently present in higher concentrations in sediments and algae than in the water column, indicating bioaccumulation potential.

Pesticide risk assessment showed that organophosphates and neonicotinoids, particularly chlorpyrifos and imidacloprid, posed acute and chronic ecological risks. Toxicity tests confirmed their detrimental effects on invertebrates and fish, including reduced survival, developmental deformities, and histopathological degeneration. Plankton and macro invertebrate diversity were suppressed in polluted sites, while fish community composition shifted toward more tolerant species, reflecting ecosystem-level stress.

These findings corroborate earlier reports of pesticide-driven biodiversity decline in the Gomti and other Indian rivers, but provide new evidence by linking pesticide residues, heavy metals, and biological responses in an integrated manner. The results highlight the urgent need for stricter regulation of pesticide application, better agricultural runoff management, and promotion of eco-friendly alternatives. Establishing riparian buffer zones, adopting integrated pest management (IPM), and strengthening water quality monitoring programs can help restore ecological balance and safeguard both biodiversity and human health in the Gomti River basin.

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