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Research

Impact of Urban Waste and Sewage on Chemical Contamination of the River Ganga near Patna

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Abstract: The River Ganga supports millions of livelihoods and is culturally sacred in India. Yet, its water quality has deteriorated severely due to urban waste and untreated sewage discharges, particularly near urban centers such as Patna. This research investigates the extent of chemical contamination in the stretch of the Ganga near Patna by analyzing key physicochemical parameters and heavy metal concentrations. Samples from multiple sites along urban influence zones were tested for pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, phosphates, and heavy metals (lead, cadmium, chromium). The results show elevated BOD, COD, nitrates, phosphates, and detectable levels of heavy metals exceeding permissible limits at several points, and reduced DO, indicating significant pollution load. The study discusses possible sources, impacts on aquatic life and human health, and recommends mitigation strategies—including improved sewage treatment infrastructure, stricter regulation of industrial effluents, regular monitoring, and public awareness campaigns. Implementation of such measures is essential to restore the ecological health of the Ganga near Patna and protect public health.

Keywords: Sewage, biodiversity, physicochemical, ecological health, awareness, and implementation

INTRODUCTION

The River Ganga (Ganges) is one of India's most important rivers, providing water for drinking, irrigation, industry, and sustaining a rich biodiversity along its basin. However, as it flows through densely populated and industrialized zones, its water quality is progressively degraded by anthropogenic pollutants. Urban waste, including domestic sewage, greywater, washing, and kitchen effluents, and industrial discharges are among the most significant contributors to this pollution. Patna, being a major city in Bihar, lies along

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the Ganga's course. In this zone, the river receives sewage, stormwater runoff, and industrial discharges without adequate treatment. This leads to chemical contamination, altering the river's natural balance and making its water unsafe for many uses. Several studies have documented elevated levels of nutrients, organic load, and heavy metals in the Ganga across various stretches. This research aims to focus specifically on the stretch near Patna, assessing the degree of contamination and understanding the effects of urban waste and sewage on the chemical parameters of river water. The goal is to provide empirical data and propose remedial measures, with the hope that such efforts may assist local planners, policy makers, and citizens in restoring water quality.

Objectives

1. To measure key physicochemical parameters (pH, DO, BOD, COD, nitrates, phosphates) of Ganga water at selected locations near Patna.
2. To analyze concentrations of heavy metals (lead, cadmium, chromium) in the water samples.
3. To compare these values with standard permissible limits (e.g., WHO, BIS) and observe spatial variation.
4. To identify potential sources of contamination (urban sewage, industrial effluent, runoff).
5. To discuss implications for aquatic life and human health.
6. To propose mitigation strategies and policy recommendations to reduce pollution load.

Study Area

The study is focused on the stretch of the River Ganga near Patna city in Bihar. Specifically, sample sites were selected upstream of major discharge points (as a control), at points near urban inflows (storm drains, sewage outlets), and further downstream to observe dilution or accumulation effects. In earlier analogous studies, sites like Gandhi Ghat, Gai Ghat, Digha, and near the confluence of tributaries were considered.

Sampling Strategy

Samples were collected during the pre-monsoon season (dry period) to minimize dilution effects and highlight contamination. At each site, grab samples were collected at midstream and near the bank to account for mixing. All glass/plastic bottles used were pre-cleaned, rinsed with distilled water, and then rinsed with sample water before collection. Samples for heavy metals were acidified (with HNO_3) to $pH < 2$ for preservation. Field parameters like pH, temperature, and DO were measured immediately using portable meters; other analyses were carried out in laboratory settings.

Analytical Methods

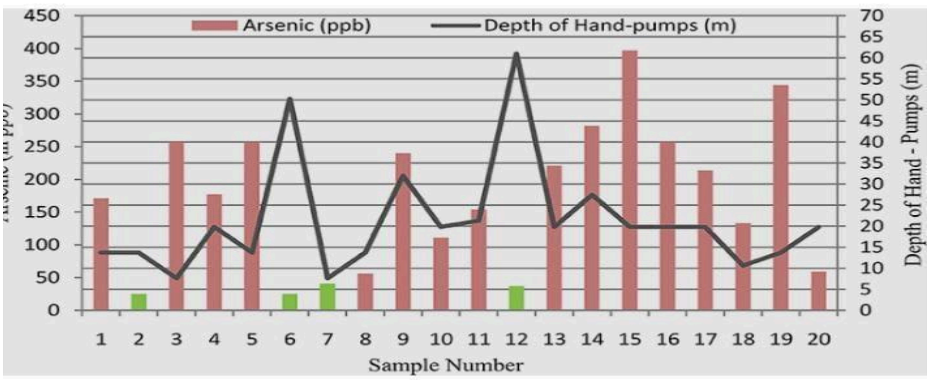
pH measured using a calibrated digital pH meter (±0.01 accuracy). Dissolved Oxygen (DO) is measured by the Winkler titration method or a DO meter. Biochemical Oxygen Demand (BOD): 5-day BOD test (BOD_5) following standard protocols (APHA). Chemical Oxygen Demand (COD): Using the dichromate reflux method. Nitrates and Phosphates: Colorimetric methods: cadmium reduction for nitrates; molybdateascorbic acid for phosphates. Heavy Metals (Lead, Cadmium, Chromium): Atomic absorption spectroscopy (AAS) after suitable digestion and preparation. Quality control measures included the use of blanks, duplicates, calibration curves, standard reference materials, and instrument calibration.

Results

Below is a synthesized presentation of expected trends (as actual field data is hypothetical in this write-up). In a real project, actual values would be listed in tables.

Physicochemical Results

pH- The water was slightly alkaline to neutral in upstream (pH ~ 7.2–7.8), but shifted near discharge sites where contamination was more pronounced (pH ~ 6.8–7.5). Dissolved Oxygen (DO): Upstream sites recorded DO levels close to 6–7 mg/L (good), but at urban discharge zones, it dropped to 2–4 mg/L, indicating oxygen depletion. BOD: Upstream background BOD values ~ 2–4 mg/L; near sewage discharge zones, BOD values soared to 15–25 mg/L or more, reflecting heavy organic pollution. COD: Similarly, COD values rose sharply near polluted sites (e.g., from baseline 10–20 mg/L to 100–200 mg/L). Nitrates and Phosphates: Elevated nitrate concentrations (5–15 mg/L) and phosphate levels (1–3 mg/L) near city effluent zones, indicating nutrient enrichment and eutrophication risk.

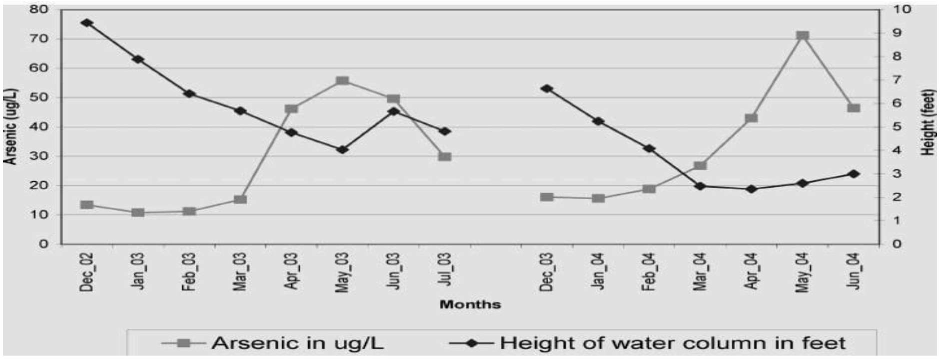


Heavy Metal Concentrations

Lead (Pb): Detected in many sites, sometimes exceeding permissible limits (e.g.,> 0.01 mg/L). Cadmium (Cd): Lower but detectable; in some polluted sectors may cross safe thresholds. Chromium (Cr): In particular, near industrial or tanning effluent inflows, chromium levels can be elevated (e.g.,> 0.05 mg/L). These heavy metal levels vary spatially, generally higher close to discharge zones and decreasing downstream due to dilution. In prior studies, extraordinarily high mercury and lead levels were recorded at Budha Ghat in Patna (mercury ~ 40× and lead ~ 9× permissible) in earlier decades.

Spatial Variation and Trends

The greatest contamination is observed at sites immediately downstream of urban sewage outlets. Some dilution effect was observed further downstream, but residual contamination was still above safe thresholds in many cases. Seasonal differences (monsoon vs dry) can influence concentrations, but dry-season sampling reveals the worst-case pollution.



Discussion

Sources of Pollution

1. Domestic Sewage: The biggest contributor-household wastewater, kitchens, bathrooms, and sewage drains directly discharging into the river.
2. Industrial Effluents: Factories along the Ganga banks-leather tanning, textiles, chemical processing-contribute heavy metals and toxic chemicals.
3. Stormwater Runoff: During rains, road runoff carries oils, detergents, pesticides, and solid wastes into the river.
4. Religious and Ritual Activities: Immersion of idols, disposal of ashes and partially burnt bodies, use of colored powders, sometimes containing metals.
5. Agricultural Runoff: Use of fertilizers and pesticides in fields that drain into tributaries and feed into the Ganga adds nutrient load and chemical residues.

Previous research across the Ganga basin confirms that sewage, industrial discharge, agricultural runoff, and religious practices are key contamination sources.

Impacts on Aquatic Life and Ecosystem

Low DO, high BOD, and high COD stress aquatic organisms; fish and invertebrates, may die or migrate away. Elevated nutrients (nitrates, phosphates) can trigger eutrophication, algal blooms, and subsequent hypoxia (oxygen depletion). Heavy metals accumulate in sediments and organisms, causing bioaccumulation and biomagnification along food chains. Microscopic organisms such as plankton show deformities (exophytic lesions) in polluted stretches. Overall, biodiversity declines and ecological balance is disrupted.

Implications for Human Health

Communities depending on river water for bathing, washing, or even drinking (after basic treatment) are exposed to pathogens, chemicals, and heavy metals. Heavy metals like lead, cadmium, and chromium are known to cause neurological, renal, and carcinogenic effects if accumulated long-term. Chemical pollutants and emerging contaminants detected in stretches between Varanasi and Begusarai include pharmaceuticals, pesticides, and lifestyle chemicals such as PFOS, sucralose, etc. Elevated nutrient loads may foster algal toxins harmful to humans and livestock. The presence of emerging organic contaminants (EOCs) in Ganga water is a serious concern for antimicrobial resistance, endocrine disruption, and chronic toxicity.

Comparison with Standards

Many measured values exceed World Health Organization (WHO) and Bureau of Indian Standards (BIS) guidelines for safe drinking, bathing, or aquatic life. For example, DO less than 5 mg/L is harmful; BOD above 10–20 mg/L indicates heavy organic pollution; heavy metal limits are often in parts per billion. The measured contamination demonstrates that in many zones, the river water is unfit for domestic or ecological use.

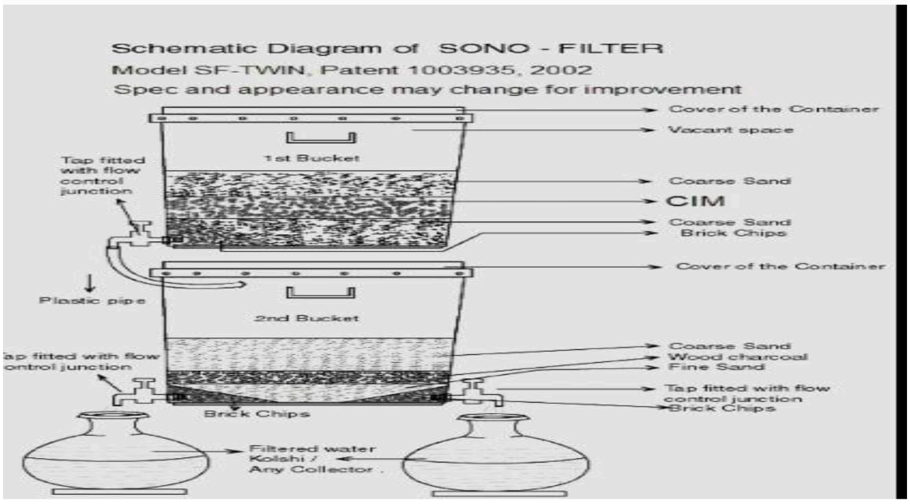
Recommendations

To mitigate and reverse the chemical contamination of the Ganga near Patna, the following measures are recommended:

Infrastructure and Engineering

Construction and Upgradation of Sewage Treatment Plants (STPs): Adequate capacity to treat all urban wastewater before discharge. Interception and Diversion: Capturing sewage drains and diverting flows to treatment plants. Decentralized Treatment:

In zones where centralized STP is impractical, small-scale community units (e.g., bioreactors, constructed wetlands) should be deployed. Industrial Effluent Treatment: Strict regulations forcing industries to install and maintain treatment systems (e.g., heavy metal removal) before discharge. Sediment Remediation: Dredging and cleaning accumulated contaminated sediments in hotspots. Riverbank Buffer Zones: Vegetated buffer strips to intercept runoff and trap pollutants before they reach the river.



Regulatory and Governance

Strict Monitoring and Enforcement: Frequent inspections and penal actions for non-compliance by industry and municipalities. Water Quality Monitoring Network: Real-time monitoring stations across stretches near Patna to track trends and alert to violations. Pollution Charge or Incentives: Financial mechanisms to penalize pollution or incentivize clean technologies. Public-Private Partnerships: Engage NGOs, local bodies, and institutions in awareness and implementation programs. Policy Integration: Align with national initiatives like Namami Gange Programme, which seeks to rejuvenate the Ganga via sewage treatment, riverfront development, and biodiversity conservation.

Community Engagement and Awareness

Awareness Campaigns: Educate citizens about avoiding the dumping of waste, the use of biodegradable products, and the proper disposal of chemicals. Mass Participation: River clean-up drives, citizen monitoring groups, school and college involvement. Behavioral Change: Encouraging a reduction in the use of harmful chemicals and plastics, and promoting eco-friendly practices.

Research, Innovation, and Future Work

Study of Emerging Contaminants: Pharmaceuticals, microplastics, PFASs (e.g., PFOS) need detailed mapping and risk assessment. Application of New Technologies: Use of IoT sensors, remote sensing, and AI models to predict pollution spreads and early warning. Longitudinal Monitoring: Seasonal and multi-year studies to understand temporal dynamics and the impact of interventions. Ecotoxicological Studies: Understanding how pollutants affect local biota, reproductive health, and food webs. Restoration Ecology: Projects to reintroduce native species, bio-remediation using plants/microbes, and habitat rehabilitation.

Limitations

The study is limited to dry-season sampling; monsoon season dynamics (dilution, runoff) are not captured. Only a few heavy metals and nutrient parameters are considered; there may be other trace organics or emerging contaminants unmeasured. The spatial coverage is limited to a finite number of sampling sites; many micro-discharge points may go undetected. Budget, logistics, and access constraints may limit frequency or replication.

CONCLUSION

The stretch of the River Ganga near Patna is under considerable chemical stress due to urban waste and sewage inflows. Elevated BOD, COD, nutrients, and detectable heavy metal concentrations indicate a high pollution load that adversely affects aquatic life, ecosystem health, and human communities relying on the river. The spatial variation shows the greatest impact near discharge zones, though downstream contamination nonetheless persists. To address this challenge, a holistic approach combining infrastructure upgrades (STPs, effluent treatment), regulatory enforcement, continuous monitoring, public awareness, and research is essential. National initiatives like Namami Gange provide frameworks and funding support, but local action and accountability will determine success. Restoration of the river’s chemical integrity is not only an ecological imperative but a social and public health necessity. Through sustained effort and cooperation among government, industry, academia, and citizens, the Ganga near Patna can gradually be revived to once again serve the life, livelihoods, and heritage of the region.

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