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Sustainable Water Conservation Strategies for the Gandheswari River: Challenges and Solutions in Bankura District

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ARTICLE Abstract: Water is an essential resource sustaining life on Earth. Water scarcity and declining water quality is increasing due to over-extraction, mismanagement, and pollution. The Brundtland Commission (1987) defined sustainable development as meeting present needs without compromising future generations. Bankura district, West Bengal, is a water-stressed region, where water conservation is crucial for sustainable development. The Gandheswari River faces severe pollution due to rapid population growth, urbanization, and improper water management. This study reveals challenges and solutions for water conservation, restoring river health and long-term water security through field observations and water quality analysis.

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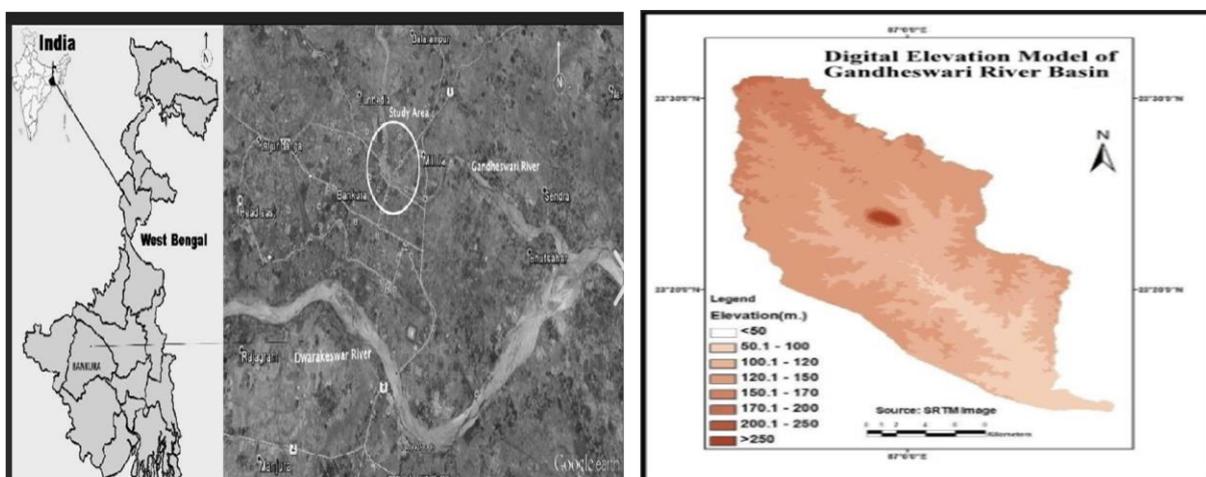
1. Introduction

Water is the life blood of human Civilization sustaining life, livelihood and environment. However, the world's freshwater resources are facing unprecedented threats, including climate change, pollution, and over-extraction. The consequences of unsustainable water management are far-reaching, from food and energy insecurity to ecosystem degradation and human migration.

The Gandheswari river are 49 km long tributary of the Dwarakeswar river plays a crucial role in the natural aquatic ecosystem of Bankura district, West Bengal, India. Flowing southwest of the Susunia Hill and north of Bankura, the river converges with the Dwarakeswar River near Bhuteshwar. The Gandheswari River geologically is the eroded plateau part, with the Susunia Hill for instance a monadnock. The river traverses four blocks in Bankura district, namely Bankura, Saltora, Chatna, and Gangajalghati, supporting diverse aquatic life and local ecosystems.

In India, the challenges of water scarcity, pollution, and mismanagement are particularly acute. The country's rapid urbanization, industrialization, and population growth have placed immense pressure on its water resources. The polluted river in Bankura district, West Bengal, is a stark example of the devastating impacts of unsustainable water management on local ecosystems and communities.

This paper explores sustainable water conservation strategies for the polluted river in Bankura district, with a focus on community-centric approaches. By examining the complex interplay between social, economic, and environmental factors, this research aims to contribute to the development of effective solutions for sustainable water management in rural India.



Sources: Google Map

Sources of pollution

River pollution has far-reaching consequences, extending beyond environmental degradation to pose significant socio-economic threats that necessitate urgent action (Dulo, 2008). Globally, anthropogenic activities such as the discharge of untreated sewage, washing, and bathing, as well as the release of industrial effluents, have severely compromised river water quality. Furthermore, the pressures of urbanization and rapid economic development have disproportionately deteriorated the water quality of urban rivers (Wang et al., 2012), exacerbating the need for effective pollution mitigation strategies. According to Jamal Uddin 2021, the river water are polluted due to industrial effect and agricultural activities as well as it is polluted also due to urbanization and mining activities near the river bank deplete also the quality of river water (Zhou et al., 2022).

The Gandheswari River water is contaminated with substantial amounts of natural faecal matter, primarily stemming from domestic effluents. This faecal matter comprises microbial biomass, organic vegetable waste, cellulose from toilet paper, and household chemicals like cleansers. In contrast, industrial wastewater, while containing lesser faecal matter, has higher concentrations of pollutants such as oil, grease, lubricants, detergents, and industrial chemicals. As the Gandheswari River flows through Bankura city, its water quality is deteriorating due to various anthropogenic factors that alter its physical and chemical properties. Agricultural activities in the region, where approximately 60-65% of the total district area is cultivable, contribute significantly to pollution. The excessive use of chemical fertilizers and pesticides by farmers seeking high yields has rendered these substances major pollutants of the river water.

Methods and Materials

Water samples were collected from selected spots of Gandheswari river and analysed by the standard protocol methods.

Water Quality Analysis

Sample collection:

To assess the river's water quality, sampling site was identified along its length for physicochemical analysis. Water sampling was conducted during morning hours (8:30 am -

12:00 noon). Samples were collected in airtight 1 l polythene bottle, with separate 250-ml glass bottles used for dissolved oxygen (DO) estimation. This bottle was previously shocked with nitric acid and also cleaned with detergent followed by rinsing with distilled water. All samples were refrigerated in the laboratory within 48 hours of collection.

Twelve physicochemical parameters were analyzed, including pH, electrical conductivity, DO, biological oxygen demand, total chlorides, total solids, total suspended solids, total dissolved solids, ammoniacal nitrogen, nitrate nitrogen, total phosphorus, and orthophosphate phosphorus. Analysis was performed for all four seasons (spring, summer, autumn, and winter) in 2007, with priority given to pH, conductivity, DO, nitrates, and phosphates. All analyses followed standard methods (APHA and AWWA, 1999).

Specific analytical methods employed included modified Winkler's method for DO, argentometric method (Mackerath et al., 1978) for total chlorides, salicylate method (CSIR, 1974) for ammoniacal nitrogen and nitrate nitrogen, and Stannous Chloride method (APHA, 1999) for total phosphorus and orthophosphate phosphorus.

Sample preservation:

This sample water was brought in the laboratory and preserved in lie old chamber which was kept in dark place.

Analysis of physico-chemical Parameters :

The Water Quality Index (WQI) serves as a vital tool for consolidating and simplifying various analytical data, providing a comprehensive indicator of the overall quality of water resources. (Finotti et al. 2015). So too many surface water indexes have a blocked and also eat applied to estimate the river water quality (Wu et al. 2018; Tian et al. 2019; Unda-Calvo et al. 2020).

Instrumentation and analysis procedure:

Temperature: Temperature was obtained on the sampling spot through calibrated mercury thermometer.

pH: Pencil pH meter was used for analysed pH of selected water sample.

Electrical conductance: it was done in chemical laboratory. Digital bridge conductivity meter was used for the measurement of collected various water sample.

Total Solids (TS): Total Solids was determined on the laboratory method.

Total dissolved Solid: The gravimetric method is used to the measurement of TDS.

Total suspended Solids (TSS): It can't be determined by the experimental method. It was calculated by the different between Total Solid and Total dissolved Solids.

Total Alkalinity: Water sample was determined by the titrimetric method.

Dissolved Oxygen: - The titrimetric method was used to determine of DO.

Chemical Oxygen Demand: - Water sample was determined by the titrimetric method.

Biological Oxygen Demand (BOD): -Water sample was determined by the titrimetric method.

Chloride (**Cl**): Chloride was measured by Argentometric Method.

Nitrate (**NO₃**): Colorimetric Method using UV-Vis Spectrophotometer at 420 nm (Intech double beam)

Sulphate (**SO₄²⁻**): Turbidimetric Method using UV-Vis Spectrophotometer at 420 nm (Intech double beam)
for the analysis of sulphate ion.

Following a comprehensive analysis of all selected parameters, the results were derived.

Presence of complexometric sulphate, nitrate and chloride ion concentrate in ground water of Bankura district:

Procedures:**Quality Control and Assurance**

The accuracy and precision of the analysis were evaluated using certified reference materials (LOBA) and standard solutions (Thermo Scientific). Calibration curves were validated using appropriate standard reference materials. Accuracy was assessed through the analysis of LOBA and standard solutions, while double-distilled water served as a blank (1 per 10 samples). Precision was determined through within-day replicate analysis of Standard Reference Materials (SRMs) and samples. The Ionic Balance Error was calculated to verify the accuracy of chemical analysis, with values below 10%. To ensure precise and reliable results, several Quality Assurance/Quality Control (QA/QC) protocols were implemented, including retesting and repeating every 20 samples.

Water Quality Parameters: Health Impacts

1. Sulphate (SO₄²⁻): High levels can cause gastrointestinal issues, such as cathartic or laxative effects, in consumers.

2. Nitrate (NO₃⁻): Excessive concentrations can lead to:
 1. Infant methemoglobinemia ("blue babies")
 2. Gastric cancer risks
 3. Adverse effects on the central nervous and cardiovascular systems

3. Chloride: Elevated levels can impact:
 1. Taste and palatability
 2. Indigestion issues
 3. Corrosion risks

Observation Table-I

| S.No. | Parameter's | Unit | Results |
|-------|-------------------------|-------|---|
| 1 | TEMPERATURE | °C | 23 ⁰ C |
| 2 | pH | | 6.62 – 7.7 (slightly acidic to neutral) |
| 3 | ELECTRICAL CONDUCTIVITY | µs/cm | 368 µs/cm |

| | | | |
|----|--|------|--|
| 4 | TOTAL DISSOLVED SOLID | mg/L | Max: 262.33 mg/L; Min: 49.26 mg/L |
| 5 | TOTAL ALKALINITY (as CaCO ₃) | mg/L | Max: 125 mg/L; Min: Trace |
| 6 | CHLORIDE | mg/L | 33.82 mg/L; Min: 2.55 mg/L |
| 7 | SULPHATE | mg/L | Max: 25.00 mg/L; Min: Trace |
| 8 | NITRATE | mg/L | Max: 2.90 mg/L; Min: Trace |
| 9 | DISSOLVED OXIGEN | mg/L | 2.11 mg/L |
| 10 | BIOLOGICAL OXYGEN DEMAND | mg/L | 11.61 mg/L |
| 11 | CHEMICAL OXYGEN DEMAND | mg/L | 13.97 mg/L |

Discussion

Water temperature fluctuated between 21.5°C and 24.0°C. pH levels indicated slightly acidic conditions across all samples, adhering to recommended standard values. However, dissolved oxygen (DO) levels were significantly lower than normal, falling below the recommended thresholds for good water quality. This finding is consistent with Glińska-Lewczuk et al. (2016), reported that an urban river decreased DO levels impacted by severe urban and agricultural activities. The reduced DO levels may be attributed to increased ammonium oxidation and organic matter decomposition. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) tests are crucial indicators of environmental health in water bodies. Elevated BOD and COD concentrations are often indicative of polluted water (Amneera et al., 2013). COD is widely employed to determine waste concentrations, particularly in pollutant mixtures like domestic sewage, agricultural, and industrial waste (Kazi et al., 2009). In this study, increased COD values signified severe water quality deterioration, potentially resulting from inadequate treatment of domestic waste and local industrial activities.

Health risk of river water pollution

River water pollution poses severe health risks, leading to a myriad of diseases including skin problems, diarrhoea, cholera, malaria, dysentery, and other epidemic diseases (Rushdy et al., 2012). Furthermore, contaminated river water emits unpleasant odours, contributing to odour pollution (Halder et al., 2015). The alarming rise in water pollution levels also increases the risk of cancer (Lu et al., 2015). Additionally, cremation activities near riverbanks exacerbate water quality degradation, resulting in elevated levels of Total Dissolved Solids (TDS), alkalinity, pH, and Biological Oxygen Demand (BOD), while diminishing Dissolved Oxygen (DO) levels (Kaur et al., 2011). Notably, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) serve as reliable indicators for assessing the extent of river water pollution (Li et al., 2022).

Solutions:

To effectively control river water pollution, several key strategies can be implemented:

1. Sustainable agriculture: Promote eco-friendly farming practices that minimize chemical fertilizer and pesticide use.
2. Rural energy and living conditions: Improve energy consumption patterns and living standards in rural areas to reduce pollution.
3. Wastewater management: Decrease wastewater discharges through efficient treatment and disposal systems.
4. Reduced chemical fertilizer use: Implement best practices to minimize chemical fertilizer application rates.
5. Green plant-based technologies, including phytoremediation, constructed wetlands, and algal pond systems, offer promising solutions for wastewater treatment. These eco-friendly approaches can effectively remove nutrients and toxic metals from wastewater, reducing pollution in rivers and water bodies. By adopting plant-based, low-cost technologies at the source of wastewater generation, it is possible to treat effluent to permissible levels,

preventing surface water pollution and enabling the reuse of treated water for irrigation, gardening, and other purposes. This sustainable approach can help conserve water resources while minimizing environmental impacts.

6. Excess nutrients in rivers can have far-reaching consequences, contributing to hypoxia and harmful algal blooms in downstream lakes and coastal zones. These issues are escalating globally, underscoring the urgent need for comprehensive nutrient management strategies. Scientific evidence highlights the significant problems caused by nutrient pollution in rivers, which severely impact ecosystem services and human well-being. By understanding the threshold responses of rivers to nutrient pollution, stakeholders can develop consensus-driven management goals. Current freshwater science enables the creation of site-specific management objectives that account for varying river uses, responses to pollution, and regional needs. Effective and cost-efficient strategies are available to mitigate nutrient pollution. Collaborative efforts among scientists, policymakers, and stakeholders are crucial to advancing nutrient management in rivers, ultimately protecting and enhancing the ecosystem services provided by rivers and downstream waters.

By adopting these measures, we can mitigate river water pollution and protect aquatic ecosystems.

Conclusion:

The Gandheswari River catchment, which holds significant ecological and socioeconomic importance, exemplifies the consequences of human activities on freshwater ecosystems. Historically, urbanization has been inextricably linked to the proximity of water sources, highlighting the fundamental importance of waterways in supporting human settlements and driving the growth of civilizations (Li et al. 2017). Analysis of the results reveals that the primary factors contributing to the deterioration of the Gandheswari River's water quality are increased nutrient and silt loads from the catchment, stemming from indiscriminate use of pesticides and fertilizers, unchecked encroachment and haphazard urbanization. Physicochemical analysis confirms an increase in water quality parameters, particularly nitrate nitrogen, ammoniacal nitrogen, total phosphorus, orthophosphate phosphorus, and BOD, from April to August. This surge in nutrients has altered the river's ecology, adversely affecting aquatic flora and fauna.

Consequently, oxygen content has decreased, impacting aquatic fauna, such as fish. The Gandheswari River serves multiple purposes, including domestic, agricultural, irrigation, and commercial uses, which further compromise water quality. This study reveals a substantial increase in pollution load, exacerbated by agricultural activities peaking in June and August, releasing large quantities of nitrogen and phosphorus into the river.

Heavy sewage ingress from commercial establishments, and residential areas in Bankura also contribute to the deteriorating water quality. Therefore, a sustainable integrated water management plan is essential for the Gandheswari river basin. Effective management and disposal of agricultural, domestic, and commercial wastes are essential. A mechanism for continuous monitoring of the Gandheswari River's land cover, hydrochemistry, biodiversity, and hydrology should be established to develop a robust conservation and restoration strategy.

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