Impact of Industrialization on River Water Quality in Jharkhand: Causes and Consequences

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Abstract

Jharkhand became the 28th state in India in year 2000. Because it possesses so many minerals, it has become an important industrial centre. However, the water quality in its rivers has gotten a lot worse because industry has grown so quickly. The essay looks at the different ways that industrial growth and river water pollution are linked in Jharkhand. It looks at the main causes, which include mining, making steel, generating thermal power, and poor waste management systems. The study combines what we now know about pollution sources, water quality indicators, and environmental effects, and it also points out problems with present efforts to reduce pollution. The results show that the quality of water in important rivers like the Damodar, Subarnarekha, and Kharkai has gotten much worse, which is bad for both ecosystems and people's health. The evaluation ends with suggestions for better rules and more environmentally friendly company practices to deal with this big problem for the environment.

Keywords: Industrialization, water pollution, Jharkhand, mining, environmental degradation, river systems

1. Introduction

Jharkhand, in eastern India, has around 40% of India's mineral resources, which makes it an important industrial centre. Mining, steel manufacturing, and heavy industries are the main drivers of the state's economy. These sectors have helped the economy expand a lot, but they have also hurt the environment a lot. The Damodar, Subarnarekha, Kharkai, and its tributaries are the lifeblood of millions of people in the area, but they also suffer from a lot of industrial pollution.

Jharkhand has changed quickly from a mostly tribal, forested area to an industrial powerhouse since the 1950s. This change sped up after the state became a state in 2000. This growth in industry has created jobs and helped the economy grow, but it has also caused a lot of damage to the environment, especially to water supplies (Prasad et al., 2019). To make plans for

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sustainable development that balance economic growth with environmental conservation, we need to know how industrialisation and water quality are connected.

2. Literature Review

2.1 Historical Context of Industrialization in Jharkhand

The Tata Iron and Steel Company (TISCO) opened in Jamshedpur in 1907, which was the start of the systematic industrial use of the natural resources in Jharkhand (Chakraborty & Singh, 2020). After independence, industrial policies sped up development even further. For example, public sector companies like the Bokaro Steel Plant, Heavy Engineering Corporation (HEC), and many coal mining operations run by Coal India Limited subsidiaries were set up. Jharkhand has a lot of resources, like coal (27% of India's reserves), iron ore (26% of India's reserves), copper, uranium, and other important minerals (Geological Survey of India, 2019). This wealth has drawn investments from both inside and outside the country, resulting in the construction of more than 3,000 industrial units across the state, from big steel factories to tiny manufacturing units.

2.2 River Systems of Jharkhand

There are a lot of big rivers in Jharkhand that flow into the Bay of Bengal. The Damodar River starts in the Palamau hills and flows through major industrial areas including Bokaro, Dhanbad, and sections of the Jamshedpur region. It is often called the "Sorrow of Bengal" since it has flooded in the past. The Subarnarekha River system starts at Ranchi and passes through important industrial areas like Jamshedpur before entering West Bengal and Odisha (Mishra & Tripathi, 2017).
The Kharkai River, which is a tributary of the Subarnarekha, goes right into Jamshedpur, which makes it very easy for factories to pollute it. The South Koel, North Koel, and Brahmani are other important rivers in the area. They also play important roles in the region's water system and meet a variety of industrial, agricultural, and household water needs.

3. Major Industrial Pollution Sources

3.1 Mining Operations

Coal mining is the biggest industry in Jharkhand, with more than 200 working mines in areas including Dhanbad, Bokaro, Hazaribagh, and Ramgarh. Open-cast mining creates a lot of overburden material, which has minerals that contain sulphur that oxidise to make acid mine drainage (AMD). This acidic water, which has a pH level of less than 3.0, leaches heavy metals like iron, manganese, copper, and zinc into nearby bodies of water (Kumar et al., 2018). Iron ore mining in places like West Singhbhum and East Singhbhum pollutes the water by making iron-rich mine water and suspending tiny particles that make rivers more murky and cause sedimentation. Mining for bauxite in the Lohardaga and Gumla districts releases aluminum-bearing waste that changes the chemistry of the water and harms aquatic habitats (Pandey & Singh, 2019).

3.2 Steel and Metal Industries

The steel sector, which includes big plants like Tata Steel Jamshedpur and SAIL Bokaro as well as many smaller ones, is a major source of water pollution. Steel production creates many kinds of wastewater, such as coke oven effluents, blast furnace scrubber water, and rolling mill coolants. These wastes have suspended solids, oils, phenols, cyanides, and heavy metals like chromium, nickel, and lead (Sharma et al., 2020). Coke production, which is necessary for making steel, releases very harmful waste that contains polycyclic aromatic hydrocarbons (PAHs), ammonia, and other organic chemicals. Many older factories still dump partially treated or untreated waste into neighbouring bodies of water, even though they have treatment facilities.

3.3 Thermal Power Plants

Jharkhand is home to numerous large thermal power plants, such as Tenughat, Chandrapura, Koderma, and Maithon. Together, they can produce more than 5,000 MW of electricity (Central Electricity Authority, 2021). These plants release fly ash, bottom ash, and cooling water that affect the quality of river water. Fly ash has heavy elements including arsenic, mercury, and selenium in it. These metals can get into groundwater and surface water systems. Cooling water discharges make the water bodies that receive them warmer, which causes thermal pollution that impacts the amounts of dissolved oxygen and aquatic life. Chemical treatment of cooling water also adds biocides and corrosion inhibitors to the water (Ranjan & Kumar, 2019).

3.4 Chemical and Allied Industries

Fertiliser facilities, explosives manufacture, and other chemical processing units are all part of Jharkhand's chemical sector. These industries release waste that contains nitrogen compounds, phosphates, sulphates, and a variety of organic substances. Fertiliser plants, especially those that make urea and complex fertilisers, provide nutrients to water bodies, which leads to eutrophication (Verma et al., 2018).

4. Water Quality Impact Assessment

4.1 Physical Parameters

The rivers in Jharkhand have changed a lot because to pollution from factories. The levels of total suspended solids (TSS) in major rivers often go above what is allowed. For example, the Damodar River had average TSS levels of 180–250 mg/L during times when industrial waste was being dumped into it, which is lower than the Bureau of Indian Standards (BIS) limit of 500 mg/L for raw water treatment (Central Pollution Control Board, 2020). During the monsoon season, when mining runoff is maximum, the turbidity levels in the Subarnarekha River near Jamshedpur often go above 100 NTU. This is far higher than the desired levels of less than 10 NTU for drinking water sources. Rivers that get textile and chemical industry waste are especially affected by colour changes caused by industrial discharge.

4.2 Chemical Parameters

The most serious effect that industry has on river water quality is chemical pollution. When acid mine drainage flows into rivers, the pH values often drop below 4.0, which makes the

water unsafe for most uses and damages infrastructure. The Kharkai River, which gets waste from several steel mills, has a pH range of 6.2 to 8.8, which suggests that the patterns of industrial waste discharge change (Singh et al., 2019). Iron levels in rivers that have been damaged by mining often surpass 10 mg/L, which is far higher than the BIS drinking water standard of 0.30 mg/L. The standard for manganese is 0.10 mg/L, however values often go above 2.0 mg/L. Rivers that get industrial waste have higher amounts of harmful metals like chromium, lead, and cadmium, which is more worrying (Das & Mondal, 2020). In very polluted parts of rivers, dissolved oxygen (DO) levels often drop below 3.0 mg/L, which is less than the 5.0 mg/L needed to maintain aquatic life. Several river lengths have biochemical oxygen demand (BOD) levels higher than 10 mg/L, which means there is a lot of organic pollution (Water Quality Monitoring Network, 2021).

4.3 Biological Parameters

Biological indicators show that rivers that have been affected by industry are under a lot of stress in their ecosystems. Coliform bacteria levels are often higher than permissible levels since sewage isn't treated well enough and industries dump waste into the water. More importantly, the variety and number of aquatic macroinvertebrates, fish species, and other aquatic life have dropped a lot in contaminated river lengths (Ecological Survey of India, 2020).

Table 1: Industrial Pollution Sources and Water Quality Impacts in Jharkhand Rivers

Pollution Source	Primary Contaminants	Affected Rivers	Key Water Quality Parameters	Health/ Environmental Impact
Coal Mining	Acid mine drainage, Heavy metals (Fe, Mn, Cu, Zn)	Damodar, Tributaries	pH: 2.5-4.0, Fe: >10 mg/L	Ecosystem disruption, Corrosion
Steel Industry	Suspended solids, Phenols, Cyanides, Cr, Ni	Subarnarekha, Kharkai	TSS: 180-250 mg/L, BOD: >10 mg/L	Aquatic life decline, Toxicity
Thermal Power	Fly ash, Thermal discharge, Heavy metals	Damodar, Barakar	Temperature: +5-8°C, As, Hg traces	Fish mortality, DO reduction
Chemical Industry	Nitrogen compounds, Phosphates, Organics	Multiple systems	Nutrient loading, COD elevation	Eutrophication, Algal blooms

Note: Values represent typical ranges during peak pollution periods. BIS drinking water standards: Fe (0.30 mg/L), pH (6.5-8.5), TSS (<500 mg/L for raw water)

According to research, the number of different types of fish in the Subarnarekha River has dropped by about 60% in the last 30 years. Pollution-tolerant species have taken the place of

sensitive species. Other big rivers show similar tendencies, which means that industrial pollution has effects on the whole ecosystem (Fisheries Department Jharkhand, 2021).

5. Environmental and Socio-Economic Consequences

5.1 Ecosystem Impacts

The quality of river water has gotten worse, which has caused a lot of problems for ecosystems. Aquatic food chains have been hurt badly because of lower water transparency and the buildup of harmful metals, which has led to lower primary output. Riparian plants are showing signs of stress since many native species can't handle changes in the chemistry of the water (Forest Survey of India, 2020). Wetlands that are connected to rivers have lost and damaged their habitats. Pollution and changes in water flow have destroyed or seriously damaged many seasonal wetlands that used to be home to migrating birds and places where fish and amphibians could nest (Wildlife Institute of India, 2021).

5.2 Human Health Impacts

Water pollution has direct effects on people's health, especially for communities that rely on rivers for drinking water, irrigation, and other household needs. High levels of heavy metals can cause long-term health problems such renal damage, neurological issues, and cancer. Research in areas affected by mining shows that lung ailments, skin problems, and stomach problems are more common there. Fluoride pollution in groundwater, made worse by industrial operations, has caused dental and skeletal fluorosis in some areas. People who have been exposed to arsenic through mining or industrial waste face a long-term risk of getting cancer.

5.3 Agricultural Impacts

The quality of the water has gotten worse, which has had a big effect on how much food can be grown in farming systems that rely on rivers. Heavy metal pollution and high salt levels in irrigation water lower crop yields and can damage the land. Water quality problems have had a big impact on paddy production, which is the most common type of farming in river valleys. Heavy metals building up in crops is a food safety issue and makes it harder for agricultural items from affected areas to get into the market. This has economic effects on farming communities and adds to the problems in rural areas .

5.4 Economic Consequences

Water pollution costs the economy money in a number of ways, such as higher expenditures for treating water, healthcare, lower agricultural outputs, and lower productivity in fisheries. Environmental damage has had a big effect on the area's tourism potential, especially eco-tourism related to rivers and forests. Industries are also facing higher costs for treating waste, following environmental rules, and perhaps being held responsible for damage to the environment. Resource depletion and rising costs of environmental compliance put industrial growth at risk in the long term

6. Current Mitigation Efforts and Regulatory Framework

6.1 Regulatory Measures

The regulations that govern industrial pollution control in Jharkhand are the Water (Prevention and Control of Pollution) Act of 1974 and the Environment Protection Act of 1986. The Jharkhand State Pollution Control Board (JSPCB) is in charge of monitoring and enforcing the. Industries must show that they follow effluent regulations before they can start operations under the Consent to Establish and Consent to Operate processes. However, regulatory measures have not been very effective because of problems with enforcement, such as a lack of monitoring infrastructure, low technical capacity, and political pressure.

6.2 Treatment Technologies

Numerous companies have used different types of treatment technologies, such as primary, secondary, and tertiary treatment systems. Some common ways to remediate acid mine drainage are neutralisation, biological treatment for organic pollutants, and advanced treatment technologies including reverse osmosis and ion exchange for some contaminants. However, the effectiveness of therapy varies greatly amongst industries, and many smaller units don't have enough treatment facilities. The expensive expense of new treatment technologies plus the fact that not many people know how to use them make it hard for small and medium-sized businesses to use them.

6.3 River Restoration Initiatives

There have been several projects to restore rivers, like the Damodar River rejuvenation project and community-based river conservation schemes. The goal of these actions is to stop pollution at its source, restore habitats, and get people interested in safeguarding rivers. The National River Conservation Plan has ideas for developing treatment plants and cutting down on pollution. But the damage is so bad that it demands long-term, steady work with enough money and technical know-how.

8. Conclusion

The influence of industrialisation on the quality of river water in Jharkhand is a serious environmental problem that needs a number of solutions. Industrial growth has helped the economy grow and created jobs, but it has also caused a lot of pollution that is bad for ecosystems and public health. The work being done right now to remedy the situation isn't enough. Moving towards more environmentally friendly industrial practices is highly important. This involves thinking about the environment as you plan and do your business. This needs stronger standards, cleaner technologies, better management of watersheds, and more participation from the people who live there. Jharkhand's example can teach other places that are swiftly becoming industrialised a lot. Future studies should look into how to make treatment cheaper, what the long-term effects on ecosystems are, and how to judge different ways of restoring ecosystems. People from environmental science, engineering, economics, and social science will need to work together to do this.

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