Pollution Crisis in the Ganges River Basin: Sources, Ecological Impacts, and Sustainable Management Strategies

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Abstract: **The Ganges River, known as "Maa Ganga" and seen as vital to life in India, is suffering from severe pollution. This situation threatens the environment, public health, and cultural traditions. West Bengal, Bihar, Jharkhand, Uttarakhand, and Uttar Pradesh are all traversed by the river, supporting millions of people and a variety of aquatic species. However, rapid urban growth, industrial development, population increases, and poor waste management have greatly reduced its water quality.**

This paper looks at the main sources and effects of pollution in the Ganges River basin, focusing on key areas like Kanpur and Varanasi. The basin produces about 12,000 million liters of sewage every day, but the treatment facilities are not enough. This leads to a large amount of untreated domestic waste entering the river. Industrial waste, which includes chromium from tanneries and waste from paper mills, distilleries, and sugar mills, introduces extremely toxic pollutants. While industrial waste is less in volume, its toxicity is significant.

The study also points out the environmental damage, such as the risk to over 140 fish species and the endangered Ganges river dolphin. There are additional pressures from climate change and melting glaciers. The paper suggests improving sewage treatment, enforcing stricter regulations on industries, promoting sustainable religious practices, managing riverbank development, and enhancing cooperation between institutions and the public to restore the river's health.

Index Terms-Ecological sustainability, Environmental degradation, Industrial effluents, Sewage discharge, Water pollution, Water quality.

I. INTRODUCTION

The Ganges River is one of the most important components of the vast riverine system in India, as it has a great deal of religious, social, and environmental significance. Of all the rivers in the country, the Ganges is marked by its high degree of cultural significance and symbolism, apart from being a natural resource that sustains human life in a vast geographical area. The river is a lifeline for the people living in its catchment area, as it sustains religious practices, festivals, and even day-to-day activities, apart from providing necessary utilities to the people living in the surrounding areas. A river traverses five major Indian states, namely West Bengal, Bihar, Jharkhand, Uttarakhand, and Uttar Pradesh, thus supporting a large number of people through its various routes, such as the supply of drinking water, irrigation, fishing, transportation, and other economic activities.

The Ganges River is the longest in India, measuring over 2,525 kilometers. The river's large size and catchment area make it home to a wide variety of ecosystems, making it a biodiversity hotspot. The river's ecosystem supports a wide variety of fish, amphibians, reptiles, and mammals, in addition to supporting vegetation along its banks. The Ganges River's ecosystem is, therefore, very important for maintaining ecological balance and for the continued existence of those who rely on it. Despite its importance, the Ganges River is under serious threats from increasing levels of pollution. Industrial effluent, untreated sewage, and human activities have led to serious deterioration in water quality, posing serious health risks to people and threatening the survival of aquatic life.

The most polluted parts of the Ganges River are the urban areas of Kanpur and Varanasi. Kanpur is seriously polluted, mainly due to tanneries that discharge toxic chromium and other toxic materials into the river, in addition to untreated sewage. Varanasi, which is a large urban settlement on the banks of the Ganges River, is seriously affected by the disposal of untreated sewage and industrial waste.

II. OBJECTIVE

1. To identify the major sources of the Ganges River Basin's pollution.

2. For suggest sustainable management strategies and interventions, to restore the ecological and socio-cultural integrity of the Ganges River.

III. MAJOR SOURCES

1. Domestic waste

Nearly all of the 50 major Indian cities along the Ganga's mainstem have a population of greater than 50,000. Just a small portion of the 3 billion liters of sewage produced daily by these towns and cities gets treated before it enters the river. Although 70–80% of the wastewater that enters the Ganga is from household sources, industrial effluents contribute 15%. Because of their poisonous character, industrial effluents have a significant negative influence on aquatic and human health. Additionally, mountains of uncollected trash contribute to the widespread pollution in most cities due to inadequate solid waste management.

2. Industrial waste

In addition to hospitals, slaughterhouses, distilleries, tanneries, chemical industries, and textile mills, the banks in the Ganges are home to a number of industrial cities, including Varanasi, Patna, Prayagraj, and Kanpur. By disposing of their untreated trash in the river, these cities and facilities actively contribute to its contamination.

600,000 tones of coal are burnt annually at one power plant based on coal station on the banks of a tributary of the Pandu River of the Ganges, which also generates 2,10,000 tones of fly ash. After this ash is deposited in the ponds, a mortar is created, filtered, combined with household waste, and finally discharged into the Pandu River. Lead, copper, and other hazardous heavy metals can be found in fly ash. Before it even reaches the Ganges, Pandu River has pluralized the amount of copper compared to pure water.

Approximately 12% of the garbage that reaches the Ganges is made up of industrial effluents. Because these effluents are frequently hazardous and non-biodegradable, even if this is a relatively small percentage, it is a serious concern.

3. Religious traditions

Because of the holy nature of the Ganges River in Hinduism, more than 70 million Hindu followers take dips in the Ganges River to wash away their past transgressions during festive seasons.

Food scraps, trash, and leaves are among the elements that end up in the river, causing pollution.

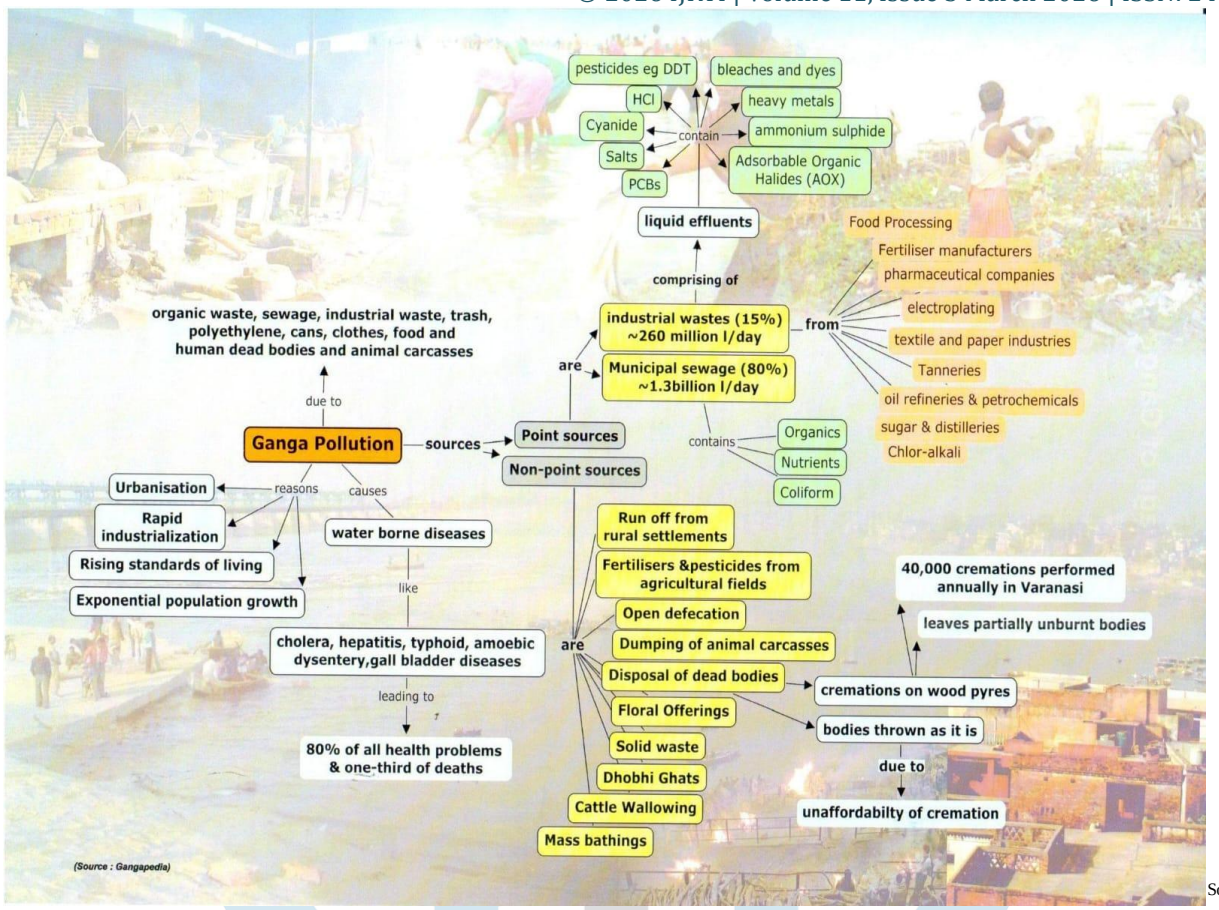
An estimated 40,000 bodies are burnt annually and dumped into the Ganges only in Varanasi, the sacred city of Hinduism. Many of the remains disposed of in the river are only partially incinerated since many families cannot afford the expensive price of enough cremation wood.

IV. POLLUTION CRISIS

Rapid population increase increased living conditions, as well as the rapid development of urbanization and industrialization processes possess exposed water resources, especially rivers, to different levels of deterioration. This also applies to the Ganga. Water quality degradation causes immediate negative impacts on people depending on the river for their day-to-day activities such as drinking, bathing, and irrigation. In most parts, especially during the lean season, the Ganga is not suitable for bathing. Apart from local pollution, global climate change, glacial melting that affects river discharge and upstream infrastructural development projects pose multi-faceted challenges that call for a comprehensive approach.

The Ganga river basin alone produces twelve million liters daily amount of sewage (MLD), while the capability for treatment is minimal about four thousand MLD. About three thousand MLD of wastewater is directly released enters the Ganga's main stem from class 1 and 2 towns lining the Ganga's banks, while The treatment capacity has only been determined to be around one thousand MLD so far. Directly released sewage from classes I and II towns beside the Ganga's banks contributes about three thousand MLD of sewage into the Ganga's principal stem, while there is now just a treatment capacity of roughly one thousand MLD so far. Approximately 20% of pollution comes from industrial sources of total volume of pollutants but there is more hazardous because of high toxicity and lack of biodegradability. Industrial clusters in the Kali and Ramganga river catchments In Kanpur, there are major causes of pollution. The primary sources are paper mills leather tanneries and distilleries in Kanpur, along with sugar mills within the waterways of the Kosi, Kali and Ramganga rivers.

The impacts of pollution on the Ganga are alarming. In 2007, the Ganga was listed as the world's fifth-most polluted river. Contamination threatens not just human life however, also the Ganges river dolphin, more than 140 fish species, and 90 amphibian species, which is an endangered species. The continuous degradation of the river highlights the need for better water resource management, increased sewage treatment capacity, better control of industrial effluents, and continuous conservation efforts to restore the ecological integrity of this life-giving river.



Source: Uttarakhand Pollution Control Board

V. CHALLENGES

1. Rapid urbanization and sewage overload

The growth of urban agglomerations along riverine tracts leads to a large amount of untreated sewage, and the treatment facilities for sewage are inadequate. This leads to a gap between the amount of sewage produced and the treatment capacity.

2. Industrial discharge and toxic pollutants

The concentration of industries, especially tanneries and paper mills in urban areas like Kanpur, leads to the release of chromium and other non-biodegradable substances that severely affect water quality and aquatic life.

3. Religious and cultural practices contributing to pollution

Idol immersion and religious waste disposal practices increase the concentration of heavy metals, organic pollutants, and oxygen depletion in river water, making it a complex problem that is further complicated by cultural considerations.

4. Ecological degradation and biodiversity loss

Pollution affects aquatic biodiversity, includes threatened species like the dolphin of the Ganges River as well as fish and amphibians, thus disturbing the ecological balance.

5. Climate change and hydrological stress

Glaciers melting, changes in hydrological cycles, and upstream infrastructure development affect dilution rates and sediment transport, thus aggravating the effects of pollution.

VI. SUGGESTION

1. Sewage Treatment Plant

To reduce water pollution, sewage treatment plants should be installed to remove waste materials from homes and industries. This will reduce pollution and allow for the reuse of water.

2. Idols should not be immersed in the river

Immersion of idols (especially those made of plaster of paris and chemical dyes) in river water causes severe water pollution, destroying aquatic ecosystems. It increases the concentration of heavy metals (lead, mercury, cadmium), oxygen depletion, and high acidity (TDS) in the water, which is fatal to aquatic life and makes the water toxic.

3. Public Awareness

India is a country of educated people. Its citizens should develop a sense of responsibility to keep their surroundings clean and also maintain a clean and

healthy environment, because following the rules is more important than simply making them, and this mindset must originate from within each individual.

4. Urbanization should be kept away from rivers

Urbanization away from rivers, or away from their banks, is essential to protect river ecosystems. Uncontrolled urbanization increases siltation, sewage and industrial waste in rivers, polluting, narrowing and degrading them. For safe and sustainable urban development, restricting construction in riverbanks and allowing them to flow naturally is the most effective way to reduce water pollution.

VII. CONCLUSION

The Ganges River is an important resource for a large number of people and is currently facing a serious pollution crisis that threatens not only the river but the entire environment surrounding it. The Ganges River has been severely polluted due to the degradation of natural resources such as soil, air, and water. Industrial effluent, sewage, and religious offerings are some of the major sources of pollution, and human negligence has been recognized as a major contributor to this pollution. The Ganges River has far-reaching effects due to its deterioration. The river's deterioration affects biodiversity, ecological patterns, and the availability of clean water for a large number of people who depend every day on the river.

In addition to its importance as an environmental resource, the Ganges River also has great cultural and religious significance. The Ganges River is worshipped as "Maa Ganga" in India, and various religious ceremonies, festivals, and practices are closely linked to this holy river. Activities such as taking baths in the Ganges or praying to the river are considered to be purifying rituals that represent life, faith, and devotion for a large number of people. The river's pollution not only affects its environmental significance but also its spiritual significance.

In light the Ganges River plays a critical role to sustaining life with strengthening cultural identity, it is a common responsibility to preserve and protect the Ganges River. Individuals, communities, and governments must take concrete steps to reduce pollution, conserve water, and restore the health of this critical waterway. The preservation of "Maa Ganga" is not only a critical environmental responsibility but also a moral and spiritual one that reflects respect for nature and cultural heritage.

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