Urbanization and its Impact on Ganga Basin.

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Abstract- India is a land of rivers and due to the rapid rate of urbanization, the Indian cities are creating pressure on their rivers to cater to the demands of not only water needs but also waste disposal. Increasing urbanization in the river basin has several negative consequences for the river basin system's health. The most harmful effects observed as a result of urbanization include changes in the hydrology and geomorphology of streams, as well as deterioration of their water quality. This study investigates the trends of urbanization in India and its impact on the Ganga River concerning anthropogenic activities in the form of Physical, Chemical, and Biological effects on the river. Ganga is one of the sacred rivers of India but today urban development factors such as land use transformation degrade not only water quality but also increase the flooding in the urban areas. Hence, this paper also reviews the various problems towards improving the health of the river and recommendations for effective management of river health and retaining its character. The recommendations of this study could be used as initiatives for mitigating the negative effects of urbanization in the Ganga Basin.

Index Terms- Urbanization, Ganga Basin, Pollution, Surface Runoff, River Health.

I. Introduction

From the manuscripts of the historical evolution of mankind, the rivers were so important to the survival of humans and many of the world's early cities sprang up around them. Rivers provide water, power, support natural processes, provide habitat and resources for plants and animals, and have a cooling effect by influencing microclimate and releasing moisture into the air, lowering surface and air temperatures. Rivers also serve to bring people together by connecting towns, providing recreational opportunities, and bringing people together. However, due to the rapid rate of urbanization, humans started to avoid the importance of such natural gifts. The significant values of rivers got overlooked in the race to become developed. Not only on the governance level at the individual level, the anthropogenic (human) factor particularly that linked with disruptive activities in the form of pollution, dwindling of Streams, the collapse of biodiversity, and erosion of public's connection to rivers alarming factors. These disruptive behaviors seem to be more common in metropolitan cities as one of the side effects of urbanization in Indian Cities.

Urbanization is a shift of population from scattered areas to concentrated areas in search of ease of living. According to Kingsley Davis, urbanization is the process of moving from a spread-out pattern of human habitation to one of the concentrated urban areas. [1] In 1800, just approximately 3% of the world's population lived in cities with populations of 20,000 or more; by the mid-1960s, this had risen to about a quarter of the population. More than half of the world's population lived in cities by the early twenty-first century. [2] In the Indian Context according to the 1901 census, 11.4 percent of India's population lived in urban areas, rising to 28.53 percent by the 2001 census and now 34.69 percent in 2020, according to The World Bank [3]. As per the 2011 census, India has 53 cities with one million or more, with that number expected to climb to 87 by 2031. According to a UN survey, 40.76 percent of the country's population is predicted to live in urban areas by 2030. [4] To cater to such a population, the formation of agglomerations will become common in the near future which rings the alarm for the environment and natural ecosystem. For instance, as per World Bank, the health costs of water pollution in India amount to 3% of the country's GDP. It has also been stated that water-borne infections are responsible for 80% of all illnesses and one-third of all fatalities in India. [5]

In India, the major rivers originate from one of the three main watersheds namely The Himalaya and the Karakoram ranges, Vindhya and Satpura ranges and Chotanagpur plateau in central India, and Sahyadri or the Western Ghats in western India, and these watersheds compose Indian River System with ten major rivers along with their numerous tributaries. These rivers are Indus, Brahmaputra, Ganga, Yamuna, Narmada, Tapi, Godavari, Krishna, Kaveri and Mahanadi. The longest of these rivers is Ganga with its total length of 2525 kilometers out of these rivers. in India. [6] Due to the factor of Urbanization, water pollution in these rivers is exacerbating the problem. More than 30% of the major Himalayan Rivers in the Indian Subcontinent are biologically dead for fishing and human consumption. Another aspect affecting per capita water availability is population growth. In this regard, it's worth noting that in 1951, India had a water availability of 5177 cubic meters per capita per year, which had dropped to 1342 cubic meters per person per year by 2000. It must have become worse with the increase in population since

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2000. [5] Because the Indian Subcontinent's water supplies are monolithic in character, the shortfall has international repercussions. As a result, water issues must be addressed first and foremost, and keeping urbanization into consideration, cities in the basin play a critical role in the regeneration and replenishment of the rivers.

II. Urbanization and Ganga River

India is endowed with water resources of about 45,000 kilometers of riverine systems crisscrossing the length and breadth of the country. The Ganga river basin, which drains into 11 Indian states (Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh, and West Bengal), is the largest of the country's basins, with an area of 8,61,452 km2. There are numerous tributaries of the Ganga River, both in the Himalayan region before it enters the plains at Haridwar and further downstream before it reaches the Bay of Bengal. The drainage length of the basin is approximately 624235.73 km2. The Ganga basin's total water potential, comprising surface and groundwater potential, is roughly 525.02 km3 and 170.00 km3, respectively. Out of the total surface water potential, only 250.0 km3 is Utilizable water. The basin's culturable area is around 58.0 M.Ha, or 29.5 percent of the country's total culturable area. [7] The Ganga is the world's 41st longest in the world and Asia's 20th longest river. [8] Approximately 45% of India's population lives in the basin. In the graph below, population forecasting has been shown concerning the urban and rural populations. As per the projections, the Ganga basin's overall population is expected to grow by 45% from 485 million in 2011 to 706 million in 2040. [9]

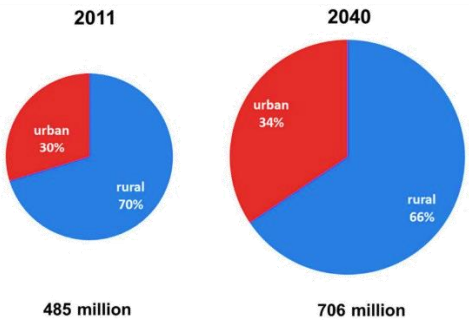

Figure 1: Forecasting of Population in Ganga Basin

The projection also shows that the rural population grows by 35%, from 341 million to 463 million people, while the urban population grows by 68 percent, from 144 million to 243 million people. [9] Growing population pressure in the Ganga basin has seriously harmed the ability of current water resources to effectively supply water to the current population. In the context of the rising population due to urbanization, the River Ganga is facing a severe threat in terms of Physical, Chemical, and Biological effects.

III. Physical Effects on Ganga River

In Physical effects, changes in the hydrology of the river basin as well as changes in the geomorphology and temperature of the rivers, are all effects of urbanization. Impermeabilization of cities due to landscape changes, such as the conversion of open vegetative spaces to impervious surface cover not only reduces infiltration rates but also increases direct runoff volumes, resulting in floods such as those seen in areas of the Ganga basin. Additionally, it also results in issues such as water scarcity, deterioration of water quality, basin closure shift of river course away from the city. Because of soil sealing which reduces the soil absorption capacity due to large-scale construction of impermeable surfaces (roads, concrete pathways, rooftops, and driveways), and so on during precipitation, the lag time in urban catchments shortens, and changes to stormwater drainage systems result in floods that peak more quickly. For instance, in the year 2017, Bihar experienced rains in the first week of June 2017 and then continuous rains in August 2017, combined with rising water levels in all of the Ganga's major tributaries, caused floods in Bihar, inundating more than 25 districts. In July 2017, the first wave of floods occurred. Flooding was caused by an increase in the water level of the Ganga and its tributaries in five districts of Bihar. [10]

Urbanization also contributes to raising water temperature by directly releasing fluid from industry furnaces into rivers or by adding surface water runoff throughout the summer. It has been discovered that it increases microbial activity in the river. Warming the water promotes algal growth in the spring and causes phytoplankton mortality in the late summer. Anthropogenic activities are followed by riverbank erosion like sand mining, which widens the waterways. The behavior of the river system is altered by the construction of dams, land-use changes throughout the basin, and the development of flood defense infrastructure. Due to the increased demand for anthropogenic needs in several parts of the basin, water tables are dropping at a rate of 0.20 m per year on average, and groundwater quality is degrading. [7] As a result of urbanization. Groundwater recharge is changing consistently, and existing natural balances are being in dramatic change. The majority of towns that are built on unconfined or semi-confined aquifers, rely on Ganga and groundwater for the majority of their water supply and discharge most of their liquid effluents and solid wastes into rivers and the ground.

IV. Chemical Effects on Ganga River

Chemical effects on the river can be analyzed by the level of pollutants mixing from a particular stretch of the river. Rivers are the easy source to dispose of wastewater and industrial waste and these Municipal and industrial discharges change the chemical characteristics of urban water bodies. Organic pollution, salinity, total suspended solids, heavy metals, nitrate, organic micro-pollutants, acidification, eutrophication, complete death of river life due to excess Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), and discharge of heavy metals such as lead in the river are all characteristics of urban rivers. Industrial effluents account for around 12% of total effluent entering the Ganges. Despite their small number, they are a serious source of worry because they are frequently poisonous and non-biodegradable. [5] According to estimates from the Central Pollution Control Board (CPCB), around 8,250 million liters per day (MLD) of wastewater is created from

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municipalities in the Ganga basin, but only 3,500 MLD of this effluent is treated, and roughly 2,550 MLD is dumped straight into the Ganga. Eutrophication produces an increase in COD and BOD in urban river water, resulting in the mortality of aquatic creatures such as fish. Water contamination in urban rivers is a severe issue. The recycling of organic matter within communities is one corrective measure. Anthropogenic contamination is indicated by the presence of metals such as Cu and Zn in river water. Hg, Ca, Cr, Ni, Co, K, Mg, Na, Fe, Al, Mn, Cu, Zn, and Pb are among the other metals. [11] The table I below shows data on dissolved oxygen (DO) and fecal coliforms (FC) levels for the Ganga along with their criteria from the year 2018 to 2021. From the table, it can be observed that the dissolved oxygen level is rising in Ganga in Uttar Pradesh, Bihar, and West Bengal but the Fecal Coliform is on the rise, particularly in Bihar and West Bengal. [12] According to the Fresno County Department of Public Health large amounts of fecal coliform bacteria in the water are not only dangerous, but they may suggest a higher chance of pathogens being present in the water. Ear infections, diarrhea, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A are some of the waterborne pathogenic disorders that may be associated with fecal coliform exposure.

Table I: Comparison of DO and Fecal Coliform

State	City	**Dissolved Oxygen** (mg/l) (Criteria ≥5.0 mg/l)				**Fecal Coliform** (MPN/100 ml) (Criteria ≤2500 MPN/100 ml)			
		2018	2019	2020	2021	2018	2019	2020	2021
UP	Varanasi (Assighat)	7.8	8.2	8.7	8.7	1300	800	1100	800
	Prayagraj (Sangam)	9	8.1	7.9	7.4	11000	10150	1100	1200
	Kanpur (Ranighat)	7.1	7.5	8.4	10.8	2950	2600	2600	2800
Bihar	Patna (Khurji)	7.95	8.1	7.8	9.45	3100	3600	22000	26000
	Buxar (Ganga Pul)	7.8	7.7	8.2	7.7	4400	6450	44500	35000
	Bhagalpur	8.3	8.2	7.1	9.0	7000	4500	17000	22000
WB	Dakshineshwar	5.4	5.8	6.4	7	300000	130000	80000	79000
	Shivpur (Howrah)	6.2	5.3	5.2	7	160000	80000	70000	49000
	Diamond Harbor	6.35	6.2	6.3	6.7	17000	1300	7450	6800

V. Biological Effects on Ganga River

The biological consequences of urbanization on river basins include changes in the natural habitat of native flora and fauna, biodiversity loss, and impairment of ecosystem processes. The river provides a habitat for a variety of organisms. The biotic homogeneity problem is a common occurrence in metropolitan waterways. The rise in the similarities of species over time is known as biotic homogenization. [11] The river is home to key aquatic faunal species such as the Gangetic river dolphin, gharial, otters, turtles, and a variety of aquatic and terrestrial birds, and it spans three ecologically distinct biogeographic zones. However, due to a variety of reasons originating from unsustainable resource use practices, the Ganga River's aquatic diversity and habitats are in jeopardy. Due to wastewater from home and industrial sources, as well as agricultural run-off, the water quality in the middle and lower segments of the Ganga River has deteriorated. The sections of the Ganga River from Farrukabad to Kanpur and from Allahabad to Varanasi have greater levels of all threats to aquatic diversity in the middle segment. The parts of the Ganga River from Sitab Diara to Ajimganj/Jiaganj and from Barrackpore to Falta were key locations with significant levels of risks in the lower reaches. [13] The ecosystem processes of urban rivers are influenced by urbanization-induced land-use changes, such as primary productivity, leaf decomposition, nutrient cycling, and ecosystem structure.

VI. Problems in Ganga Restoration

The problems due to urbanization led by mentioned physical, chemical, and biological effects are not just limited. Over-extraction of surface and groundwater for agriculture, industrial, and domestic use has a substantial impact on a river's ability to cleanse and replenish itself. Pollution levels in the Ganga River have also been exacerbated due to mismanagement of the river's water resources and inefficient use. The Upper Ganga Basin is home to a number of hydropower projects, with many more being built or planned. Current dam designs, on the other hand, have caused vast portions of the river to dry up, resulting in a slew of permanent ecological and societal costs.

The Ganga has a complicated series of issues that stem from the sheer size, course, and population it sustains, not only in urban but in rural areas also. Due to the presence of such resources, local villages around the river rely heavily on the river's resources and prosper on a water economy. Due to alluvial soil deposits, the region is also one of the most fertile belts, and agriculture makes for a significant percentage of the local economy which makes the river and its aquatic life to be under stress as a result of the farming practices and excessive use of fertilizers. Controlling the influx of waste as discussed in the chemical effects on Ganga, however, is only a part of the problem. Sand as a common mineral found in riverbeds that is in the growing market in the current construction sector. The system and size of its mining are frequently unscientific, resulting in severe effects on the riverbed's natural balance and downstream cascade effects such as floods. Today the scenario of shifting the river away from the ghats of cities is painting a clear picture of the harmful impact of sand mining along the river banks in major cities. Sand mining also has negative consequences for aquatic life, especially endangered species like the gharial and various turtle species. The river's path passes through a variety of bio-geographic zones, as well as a diversified culture and population and an elaborate network of institutions. River conservation planning is difficult due to the consequent complexity and human culture’s reliance on its supplies. [14] On the institution-level water is regulated by contradictory multi-sectorial policies, and the entities in charge act in isolation, pursuing their separate departmental missions while disregarding the big picture. Another factor of weak collaboration and correlation between the various development authorities simplifies the gap in strong measures for river restorations.

VII. Recommendations

As part of the National Mission for Clean Ganga (NMCG) under the Union Ministry of Jal Shakti, the Indian government has established an authorized body comprising of a committed team of officers (formerly known as Ministry of Water Resources,

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River Development, and Ganga Rejuvenation). Despite having such efforts from the Ganga Action plan started in 1985 to Namami Gange Project 2014 which suggests incorporating rivers in development plans of urban areas, the condition of Ganga has not got improved much. One of the major reasons for this is the degradation of the river's self-healing or self-purifying property. The schemes and programs are getting encircled on solid and liquid waste production and their disposal in the rivers but not on its natural flow. For instance during the winter and summer months, little to no water flows into the river from Rishikesh to Prayagraj. During these months, the only water available is wastewater, resulting in a stagnant sewer in the riverbed. Thus, for the restoration of Ganga, there must be proper monitoring, technological advancement, research, and imposition of strict regulations for returning over 80% of the river's water which is used for agriculture, and various hydro-power projects which dry out huge stretches of the river, increasing pollution levels dramatically. There must be an increase in the number of experts and professionals for the monitoring of river health. The technological advancements and research can lead to generating advanced eco-hydrological models which will assess the change in river hydrology and can help to monitor the chemical composition and ecology of the river affected by urbanization. Apart from these, public participation in decision-making and public-private partnership can lead to better implementation of projects. Participation of the general public in the mission can aid in identifying difficulties at a more grassroots level and assisting the communities concerned.

VIII. CONCLUSION

For a developing nation like India, urbanization plays a crucial role in both positive and negative aspects. While sustaining the economies it is badly affecting the urban areas from an ecological and environmental perspective as its remnants have to be absorbed by the rivers. The river Ganga is facing changes in its hydro-geomorphology of the streams induced by various effects of urbanization and despite the various efforts by the governmental initiatives the conditions are not improving at the desired pace. There are still a lot of problems prevailing that are directly affecting the riverbed's natural balance causing issues like flooding. Ganga is consistently losing its character of self-purification due to continuous urban discharges and extraction of water leaving the river to dry. Not only are these factors for retaining the character of Ganga, but monitoring and technological advancements still lacking. The professionals and experts when incorporated with local communities can lead to a significant improvement in river health.

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