

Rejuvenation, Restoration, and Resuscitation of the Yamuna River System: A Clarion Call

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Abstract

The Yamuna River, a lifeline of northern India, has long served as a symbol of cultural and ecological heritage. However, unbridled urban development, industrialization, and unregulated human activities have inflicted severe degradation upon this once mighty watercourse. The Yamuna River is facing severe problems such as increasing pollution, reducing water levels, and ecological imbalances in contemporary times. We need to hear the river's clarion call for immediate rejuvenation, restoration, resuscitation, and revival. Amidst these challenges, a beacon of hope emerges from the initiative and relentless endeavours of the Dayalbagh Educational Institute and Dayalbagh in Agra. This paper adjures for a clarion call to action for the rejuvenation, restoration, and resuscitation of the Yamuna River System. It underlines the urgency of addressing the challenges holistically, with a collaborative approach among stakeholders. By adopting sustainable practices, innovative technologies, and informed policies, we can pave the way for a revived Yamuna River that would sustain ecological balance, provide clean water for all, and retain its cultural and spiritual significance for generations to come.

Introduction

We all have heard the saying that “A river is nature at its best”. Nature has given us a spectrum of bounties in the form of mountains, landscapes, oceans, glaciers, flowers, trees, fruits, lakes, and rivers all over the world. No one has been able to escape the spellbound scenic beauty of colourful nature. India has also been bestowed with an enriching bouquet of physical nature, from the Himalayas to Cape Comorin. It has a wide variety of flora and fauna, like the diverse cultures and religions in India. The Indian subcontinent’s flora and fauna are eye candy for nature lovers [1]. Similarly, a river is a self-organizing system involving both biotic and abiotic interactions. This leads to the emergence of biodiversity, which supports a variety of life forms. The study of river ecosystems would require a framework based on nonlinear-stochastic systems exhibiting various features like emergent structures, bifurcation, multiple equilibria, etc. A recent study provides evidence of plant-driven self-organization leading to emergent buffering of river flows. In a wider context, it is known that the underlying stochasticity (both internal and environmental) plays a significant role, particularly when one is in the vicinity of critical points. Both continuous and discontinuous transitions may result in moving from a higher equilibrium state to another state, corresponding to lower equilibrium and poor water quality. Thus, a river ecosystem may be resilient up to a certain level of human intervention by way of exploitation of river resources. A river system provides a home to millions of people and characterizes widespread activities, e.g., agriculture, livestock, fisheries, manufacturing, etc. More than 40% of the total Indian population resides in the extensive catchment areas of the river systems.

The Ganges Foreland basin is the most magnificent landscape on the Indian subcontinent. Its origin is related to the Himalayan mountain building through time. Drained by numerous Himalayan and Cratonic-fed rivers, it is a densely populated and extensively cultivated area. In the basin, Ganga is the trunk river, and after confluence with Yamuna at Allahabad, it becomes the axial river of the basin. Before Allahabad, the Yamuna River was the axial river, which occupies the lowest elevation in the basins and drains parallel to the peripheral bulge. The cratonic Chambal, Betwa and Dhasan are the major tributaries of the Yamuna River (Fig.1). Therefore, the Yamuna River carries a mixed sediment load derived both from the Himalaya and the Craton. All these rivers are flowing incised into the doab surface, which is the most extensive and oldest geomorphic element of the Ganges Plain. Within the river valleys are the river terraces, which are the older sediments deposited during the period of higher discharge by the river occupying the valley.

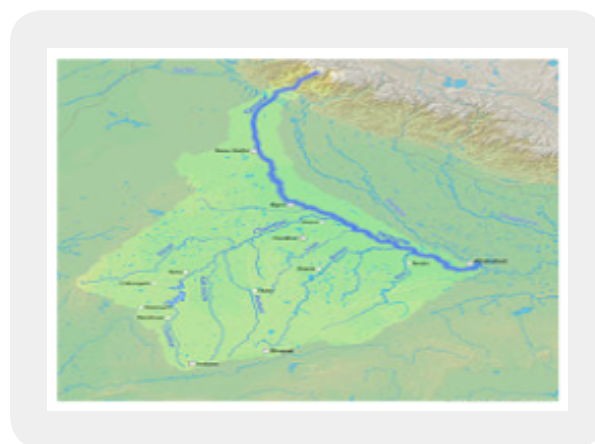


Figure 1

Near Agra, the Yamuna River is flowing following the SE slope. Its valley is very narrow, probably because of the incision. The valley is less than a kilometer wide. It shows distorted meanders both upstream and downstream of the Agra city, separated by a straight channel (Fig. 2). It has a very narrow flood plain. People have occupied the river valley terrace and even the abandoned floodplain areas, which is not a healthy practice, endangering the riverine environment. During the high-magnitude floods, these areas are flooded, causing loss of property and life. During the summer, mid-channel bars appear in the river. However, during floods, these bars are submerged. Along narrow stretches, the flow energy is higher, but due to the sediment load, the channels are constricted. At Agra, the river shows the channel shift, as evidenced by meandering cars and silted-up lakes.



Figure 2

It's bizarre and painful to see the plight of the present-day Yamuna River in Agra. A mammoth task lies ahead of the determined and dedicated citizens of Agra, who have a sense of belonging to the water. The significance of river rejuvenation relates to controlling floods and reducing the damage thus caused by their fury. A healthy river system has the capability to retain excess water, preventing flooding in downstream localities. As a consequence, many lives, property, and assets are saved. This has direct implications for water scarcity, improving water quality, restoring the ecosystem, and providing space for systematic development. During COVID-19, the shutdown across the globe observed a marked reduction in pollution load in the rivers. It saves mankind from consuming polluted water, which causes waterborne diseases and other health hazards.

Likewise, untreated sewage, untreated waste, and industrial waste all pollute our rivers. Rivers are not meant as dumping grounds. The burden of an ever-growing population along the river banks is intruding on the privacy of naturally flowing rivers. As a result, a holistic policy framework is recommended for re-establishing the livelihoods of riverine local communities.

Historical Perspective

The significance of 'water' as one of the *Panch Tatva* (air, water, earth, sky, and fire) is well known. It has been rightly said, "Pure water is the world's first and foremost medicine". It is also believed that "all water is holy water". Life cannot exist without water; it is humans that depend upon nature, not vice versa. In the words of Harrison Ford, "Nature doesn't need people; people need nature; nature would survive the extinction of the human being and go on just fine, but human culture, human beings, cannot survive without nature [2]". Therefore, it has been rightly affirmed by Loren Eiseley: "If there is magic on this planet, it is contained in water [3]".

Yamuna River is one of the seven sacred rivers of our nation. Historically, it is believed that the people of the Indus Valley civilization worshipped the rivers. The most significant rivers in the faith are the *Saptanadi* (the seven sacred rivers): the Ganges, Yamuna, Sindhu, Narmada, Godavari, Krishna, and Kaveri. The longest tributary of the Ganges in India, the Yamuna is an immensely significant river in its own right. It is believed to have originated from the *Yamunotri* glacier and travels for a distance of 1,376 km before it unites with the rivers Ganges and Saraswati and forms confluence (the auspicious *Sangam*) at Allahabad. Merging with the holy Ganges, it falls into the Bay of Bengal [4].

According to the *Puranas*, Yamuna is known as *Yami* in early texts, while in later literature, she is called *Kalindi*. In Hindu scriptures, she is the daughter of *Surya*, the Sun God, and *Sanjna*, the Cloud Goddess. Like the Ganges, the Yamuna River is highly venerated in Hinduism in the form of a river as the Goddess Yamuna. The Yamuna is considered a river of heaven. The *Rig Veda* includes the Yamuna River as one of the seven sacred rivers, along with the Ganges. There are many myths and legends related to this sacred river, the Yamuna. Other texts, however, say she was the daughter of *Brahma*. The twin sister of *Yama*, the God of Death, Yamuna is also associated with God *Krishna* and is mentioned as one of his eight consorts (*ashtabharya*). Lord *Krishna*, whom most Hindus worship, had a very close association with the river Yamuna. His birth in Vrindavan, situated on the banks of the sacred river Yamuna, and the homage it paid to Him by touching His feet as He was carried to *Gokul* across the river, and His childhood that was spent on its bank, are an inspiration and significant cause to maintain the sanctity of the holy river. Even the Mughal rulers loved the varying moods of the Yamuna and adorned its banks with magnificent buildings like the Red Fort in Delhi, the Agra Fort, and the Taj Mahal, the dream in marble. Delhi, the capital of our great nation, is also situated along the bank of this river. This sacred river surrounds the city of Taj and flows adjacent to the seventh wonder of the world - the Taj Mahal, the magnificent monument of the world that allures tourists.

Rejuvenation, Restoration, and Resuscitation of the River System

The restoration of the Yamuna River is crucial not only for slowing down its degradation but also for restoring its grandeur in various aspects, such as the green cover, water table, landscape, and biodiversity. Several measures need to be implemented to achieve this, including curbing untreated sewage discharge and promoting eco-friendly practices. The pouring of toxic chemicals into the river should be restricted, as they pollute the river with lethal chemicals like nitrate, heavy metals, lead, arsenic, etc. The agricultural produce grown in sewage water is a greater source of waterborne diseases and a threat to both humans and animals.

Despite efforts, the pollution levels in the Yamuna River have seen little reduction. Delhi, covering only 2% of the river's length, contributes to over 70% of its pollution. Therefore, restoring the river in Delhi is of utmost importance for its overall health and well-being. There is a need to sensitize people through education and training to have a value system of low concern for themselves and high concern for others. This value orientation will enable them to conserve water, minimize waste, prevent throwing waste—both solid and liquid—in the Yamuna river and show respect to Mother Earth and rivers.

The emphasis should be on prevention rather than damage control. We can contribute to improving the Yamuna River by using effective sewage treatment plants. Society and individuals must commit to planting trees along the riverbanks to increase the green cover. Afforestation will help prevent soil erosion and recharge the groundwater table. It will also aid in sequestering carbon dioxide and developing catchment areas. Promoting eco-friendly practices during the festivals, like using biodegradable materials for idols, can also be an effective step. These efforts will reduce pollution and restore the river's ecology. Moreover, conserving moisture will be crucial for the river's health and the well-being of people living around it. We can also boost livelihoods and income by promoting eco-tourism through the development of riverfronts and eco-parks. Raising awareness among the masses about water quality improvement and flow in the river is essential. Lastly, encouraging rainwater harvesting, reducing slums, and working together with neighbouring states are also vital for long-term rejuvenation. These are true objectives for the restoration and resuscitation of the lost pride of the Yamuna River. Digital technology, including remote sensing, artificial intelligence, machine learning, and data science, has proved valuable in scientific research and decision-making. Biosensors and IoT can help monitor biodiversity and river bank health. Real-time monitoring of water quality using advanced technology should be implemented to ensure the effectiveness of restoration efforts.



Figure 3

Dayalbagh as a community, together with DEI, under the tutelage of Revered Prof. Satsangi, is offering an impetus towards a sustainable solution based on local conditions with a scientific approach. A systems approach requiring an integrated effort combining groundwater management, biodiversity regeneration,

tree plantation, and organic farming is followed here. The local community at Dayalbagh has shown remarkable dedication and selflessness in their efforts to rejuvenate the River Yamuna in Agra. Embracing the principle of dignity of labour, they have come together to engage in a spirit of selfless service for the betterment of the community and the environment. With their unwavering commitment, they have transformed the once dull and polluted riverscape into a breathtakingly beautiful panorama. One of their significant contributions has been the planting of around 5000 medicinal and herbal plants along the riverbanks, envisioning a future enriched grove that will not only enhance the aesthetics but also bring numerous health benefits (Fig. 3). Through their collective endeavours, the Dayalbagh community sets an inspiring example of how individuals can make a positive impact and create sustainable change for their surroundings. Their actions serve as a reminder of the power of unity and the potential to revive and preserve our natural resources for generations to come.

The Science Behind the Self-Cleansing Properties of Ganges Waters

Ganga water is used as holy water in all Hindu rituals since it does not putrefy even after storage for long periods. It creates curiosity among the scientific community to know the main cause behind the purifying capacity of the Ganga River water. In this connection, the first time the presence of marked antibacterial activity against *Vibrio cholera* in Ganga River water was reported by Ernest Hankin in 1896. He recorded that *Vibrio cholera*, which is the causative agent of cholera died within three hours in Ganges water but persisted for 48 hours in distilled water [5]. Hankin also showed that the Ganges' anti-cholera properties disappeared after boiling the water, indicating that the antimicrobial agent can be destroyed by heat and is not a "magical" characteristic but rather a molecular one. Thus, the disinfecting property of the Ganga was mysterious over the decades for many around the globe. Later on, a French microbiologist named D'Herelles in 1922 used the attributed term bacteriophage (i.e., bacteria-killing viruses) for the invisible factor responsible for the antibacterial property of Ganges [6]. The bacteriophages destroy the pathogenic cholera bacteria present in the river Ganga. Regarding the source of these bacteriophages, it is believed this prokaryotic virus existed in the earlier time scale in the Himalayan permafrost conditions (where the river Ganga originates) as an abiotic particle that was gradually released with the arrival of melting climatic conditions. Several investigations have been carried out on the well-known self-cleansing properties of Ganges waters; almost all the investigators attribute the presence of characteristic bacteriophages in combination with the trace element abundances in the Ganges waters to provide the resilience for the Ganga water to remain characteristically clean in spite of the addition to its pollution coming from myriad sources [7,8].

Nautiyal conducted a study to understand a certain novel antimicrobial attribute that is responsible for the magically self-cleaning properties of the Ganga River water [9]. His experiments with Ganga water spiked with pathogenic *Escherichia coli* serotypes indicated the role of antimicrobial peptides (AMPs). AMPs are part of the innate immune system and an important component of immune defence. They are produced by plants, animals, insects, and single-celled organisms and possess antimicrobial properties. Over 70 years ago, Sir Alexander Fleming, the renowned discoverer of penicillin, warned about a potential future where the misuse of antibiotics would lead to a world without their effectiveness [10]. The Ganges River's ancient and revered water holds the promise of being a source of discovery for the future of human health.

The National Environmental Engineering Research Institute (NEERI) at Nagpur, in their report entitled “Assessment of Water Quality and Sediment to Understand Special Properties of the River Ganga, has come up with the following facts:

(A) Five pathogenic species of bacteria (*Escherichia*, *Enterobacter*, *Salmonella*, *Shigella*, and *Vibrio*) were isolated from the Ganga, Yamuna, and the Narmada, and their numbers were compared with the bacteriophages present in the river water. Because bacteriophages are a kind of virus that kills bacteria, they are frequently found in proximity to each other. (B) In the river Ganga, the bacteriophages were detected to be approximately three times more in proportion than bacterial isolates. (C) Samples drawn from the Ganga contained almost 1,100 kinds of bacteriophage, and proportionally, less than 200 species were detected in the samples obtained from the Yamuna and the Narmada.

River Thames: A Case Study

An innovative endeavour to purify the Yamuna River by the Dayalbagh community reminds me of something similar followed by the British to cleanse the Thames. An area of King George’s Park in Wandsworth celebrated the start of spring with new trees as part of the Queen’s Green Canopy initiative. Tideway, the company building London’s super sewer to remove more than 95% of sewage pollution from the capital’s river, is engaged in the tree plantation within the corner of the park that has been supporting the work to clean up the river. These trees will be a lasting legacy of the Queen’s Jubilee and will be there for the community to enjoy for generations. It’s fitting that this legacy sits alongside Tideway’s work to improve the river environment; contributing to the essential work everyone must contribute to sustain the planet Earth [11]. Who cleans whom may remain a matter of debate, but Nature brings us to a common platform: to serve humanity with sustainable goals.

Conclusion

How can we, as the natives of this wonderful city of Taj, allow an oxymoronic riverscape of the beautiful monument on one side and the polluted river Yamuna on the other side? Why has it turned out to be so repellent? Water, once contaminated, becomes harmful to all living beings. It is time for the greed and selfishness of man to be checked and enable the rivers to breathe and carry purity in their flow. The father of our nation, Mahatma Gandhi, has said, “The best way to find yourself is to lose yourself in the service of others.” We all need to revive the lost glory of the river. Both Dayalbagh and DEI which have been relentlessly serving mankind for more than a century and a half, have taken up the task of cleaning the banks of the Yamuna River at Agra. Dayalbagh holds the objective of establishing better worldliness and helping mankind reach its goal of life. Keeping in mind the well-being of the inhabitants of not only the city of Taj but also of those closely residing in the rural setups near the river, it initiated the drive to clean the banks of the river in April 2023. Now the serene banks of the tributary are visited by all age groups with families; they enjoy the kempt environment which is far from the madding crowd of the city. The cultural presentation of the tiny tots of Dayalbagh is the cherry on the cake. The motor boat and the manual boat ride with the melodious folk in the background, sponsored by the Dayalbagh, make one and all feel just out of the world. These activities of jollities are open to all. There is a need for suasion because the initiative of

the government to cleanse the holy Ganges imparts an incentive to purge the Yamuna River as well. We have to perform swiftly but firmly because we are racing against time. The heartbeat of unabated water flowing with roaring clamour down the stream gives a message for its inhabitants to let her smooth flow carry on without any hindrance. Only those who have a sense of commitment to saving water would be able to gauge her throbbing pulse and tell about the good work rivers have uncompensated towards the advancement of our civilization.

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