

Self-purifying properties of the Ganges River Scoping Review

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Abstract

The Ganges is India's holiest and most revered river. Often referred to as "Mother Ganges", this river originates from the Gangotri glacier in the Himalayas, and provides a lifeline for the millions of people living along its banks, before emptying into the Bay of Bengal. Today, the river is among the world's most polluted, filled with untreated sewage, industrial waste, and pesticides. Amazingly, in spite of the pressures posed by modern India, the Ganges River supports a surprising amount of biodiversity thanks to its remarkable self-purifying and regeneration properties. Studies from as far back as 1896 have shown the unique antimicrobial properties of the Ganges against *Vibrio cholera*, the causative agent of cholera, which died within three hours in Ganges water, but persisted for 48 hours in distilled water. French scientist Félix d'Herelle later attributed this mystic characteristic to the action of bacteriophages—bacteria-killing viruses. Beyond fascinating science, bacteriophages may hold important implications in modern medicine. We live in an era where antibiotic resistance could become a global crisis, owing to the liberal and widespread use of antibiotics. Studies have shown that bacteriophages can be modified to target specific bacteria and provide long-lasting treatment for a vast array of infections. Scientists are now hopeful that the Ganges might provide clues for the design and synthesis of a new class of antimicrobial drugs.

Picture an ancient, beautiful, and life-sustaining river with dark green water that runs for hundreds of kilometers through some of the most diverse landscapes on Earth. Now picture that same river infused with a slew of chemical pollutants, garbage, pharmaceutical agents, farm pesticides, raw sewage, crematory ashes, and dead bodies. How do you think these contaminants would impact the river's purity and sustainability? Presumably, they'd be the river's demise, leading to an undrinkable and unusable aquatic trash heap. However, in the case of the Ganges River, which is highly polluted, you might be surprised to discover that it has a remarkable ability to

regenerate and self-purify, and is believed by some to be incorruptible.⁽¹⁾

The Ganges originates from the Gangotri glacier, high in the Himalayas, and runs for more than 2,500 kilometers through Northern India and Bangladesh, before reaching its delta on the hot and humid shores of the Bay of Bengal.⁽²⁾ The Ganges harbours a surprising amount of biodiversity, including the gorgeous Ganges river dolphin, the widely feared Ganges shark, and the awkward-looking gharial crocodile, which can be up to 20 feet in length.⁽³⁾ Unfor-

tunately, many of the interesting animals that inhabit the Ganges are endangered, and many others have long gone extinct.

In addition to housing diverse wildlife, the Ganges is a lifeline for the millions of people living along its banks, who use its water for drinking, cooking, and bathing, as well as for religious rituals.⁽²⁾ The Ganges is revered in Hindu culture as having the ability to spiritually cleanse and purify, and it is a popular site for funerals, with many believing that it helps liberate the soul.⁽⁴⁾ Although the religious beliefs surrounding the Ganges' mystical properties may seem easy to dismiss, it is worth exploring if in fact they hold any scientific validity. Indeed, the Ganges has long been known for its purity and resistance to putrefaction. For example, early British colonialists in India would collect large amounts of Ganges River water and lug it back to England because it remained "sweet and fresh," even after long periods of storage.⁽⁵⁾ The fresh taste is perhaps because the Ganges contains high amounts of dissolved oxygen, even in its most polluted parts, which could potentially help breakdown organic wastes that produce the characteristic bad smell and taste of stale water.⁽¹⁾

Interestingly, it is not just the taste of the Ganges that has drawn attention from visitors. The renowned English bacteriologist Ernest Hankin who worked in India throughout the late 1800s and early 1900s documented the unexpected antimicrobial properties of the Ganges, noting that the causative agent of cholera, *Vibrio cholera*, died within three hours in Ganges collected water, but thrived in tap water, even after 48 hours.⁽⁶⁾ This explains why isolated cholera outbreaks in the Ganges, often in places of pilgrimage, do not typically spread to downstream villages. 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, thus, is not a "magical" characteristic but rather a molecular one.⁽⁶⁾ The French scientist Félix d'Herelle later attributed the Ganges' antimicrobial

activity to bacteriophages (tiny bacteria-killing viruses), which exist in very high numbers in the Ganges.⁽⁷⁾

More recently, Chandra Shekhar Nautiyal, a scientist at the National Botanical Research Institute in India, studied the growth of the bacterium *Escherichia coli* in Ganges water. *E. coli* can cause serious infections in humans, such as haemorrhagic colitis, and is often used as an indicator of fecal pollution in natural waters.⁽⁸⁾ Nautiyal revealed that the age of a Ganges water sample influences the survival of *E. coli*, whereby more recently collected water is better at killing *E. coli* than older samples. But remarkably, even 16 year old samples still retained some anti-*E. coli* attributes.⁽⁸⁾ Scientists are now hopeful that the Ganges might provide clues for designing new antimicrobial drugs.⁽⁷⁾

We live in a time where the liberal and widespread use of antibiotics is undermining modern medicine.⁽⁹⁾ According to the World Health Organization, antibiotic resistance could become a global crisis, where even common infections and minor injuries prove difficult or impossible to treat.⁽¹⁰⁾ Certain scientists think we may soon enter a post-antibiotic era where deadly superbugs kill millions of people each year. We are in dire need for novel antimicrobial compounds, which are both versatile and remain effective over long periods of time. The Ganges River may hold some of the answers to developing these new compounds. For instance, bacteriophages are currently considered viable antidotes for antibiotic resistance: they are inexpensive to manufacture, are ostensibly safe for humans and other animals and, if used properly, can provide efficient and long-lasting treatment for a diversity of infections.⁽⁹⁾ Moreover, studies have shown that bacteriophages can efficiently target specific bacteria without affecting normal human flora.⁽⁷⁾

Even after a century of research, the purifying properties of the Ganges still hold many mysteries. Indian scientist Gokul Rajan, as part of his graduate research work, showed that selectively

eliminating bacterial populations from Ganges water samples completely eliminated the anti-bacterial properties of the water.⁽¹¹⁾ This means that features apart from bacteriophages, perhaps even bacteria themselves, are contributing to the Ganges' antimicrobial properties. Soon, scientists will likely uncover even more interesting aspects of the Ganges' remarkable regenerative abilities. More than 70 years ago, Sir Alexander Fleming, the discoverer of penicillin, warned of a day when the improper use of antibiotics would force us into a world without antibiotics.⁽¹²⁾ Perhaps the future of human health may be hidden within the ancient and revered waters of the Ganges River.

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