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REVIEW ARTICLE

Physicochemical and Biological Contaminants in Drinking Water: Human Health Implications

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ABSTRACT

Water consumption is increasing in lockstep with the world's population. Human activities and climate change are disrupting natural water cycles, placing freshwater environments under duress. The negative effects of poor water management, pollution, infrastructure development, and resource exploitation on our freshwater systems are exacerbated by poor water management, pollution, infrastructure development, and resource exploitation. Water benefits the skin's health and attractiveness. If there is a lack of water, the skin may become more vulnerable to skin disorders and premature ageing. Water contaminants can also cause a variety of health issues, including gastrointestinal illness, pregnancy complications, and neurological issues. The most significant cause of pollution in our streams and oceans is urban runoff, which comprises pollutants such as motor fluids, trash, and pesticides. Water from streams and reservoirs is progressively contaminated by impurities from manufacturers or the ecosystem is used by towns, farming, and commerce. The objective of this paper is to discuss about water contamination, its cause and impacts on human wellbeing. It is advised that water quality be checked in a periodic manner to prevent negative impacts on human wellbeing. Water quality at the point of use is being emphasized, including measures to enhance water quality.

Keywords: *Water Contamination, Human Health, Cancer, Pesticides, Pollution*

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INTRODUCTION

Water is a gaseous, liquid, and solid combination of the chemical elements hydrogen and oxygen. It is one of the extremely prevalent and necessary chemicals. It is a tasteless and unscented liquid with the critical capacity to dissolve a wide range of other compounds at room temp. Water consumption is increasing in lockstep with the world's population. Human activities and climate change are disrupting natural water cycles, placing freshwater environments under duress. The negative effects of poor water management, pollution, infrastructure development, and resource exploitation on our freshwater systems are exacerbated by poor water management, pollution, infrastructure development, and resource exploitation [1-2].

Water's adaptability as a solvent is critical to the survival of living beings. Living organisms depend on water mediums for biological functions such as blood and digestive juices, which are thought to have originated in the globe's oceans' aquatic solutions. Water may be found both inside and beyond the solar system on other planets and moons. Water appears colourless in small amounts, but it possesses an inherent blue colour due to light absorption at red wavelengths. Water is essential for life. Freshwater is needed for drinking and sanitation, as well as for providing crops, animals, and industry, as well as for the formation and preservation of ecosystems on which all life depends. Freshwater that is readily available, such as that found in rivers, lakes, wetlands, and aquifers, makes up less than 1% of the total amount of water on the planet [3-4].

The demand for water grows in lockstep with the global human population. Natural water cycles are being interrupted by human activities and climate change, putting freshwater habitats under stress (**Fig.1**). Poor

water management, pollution, infrastructure development, and resource exploitation compound the negative consequences on our freshwater systems [5-6].

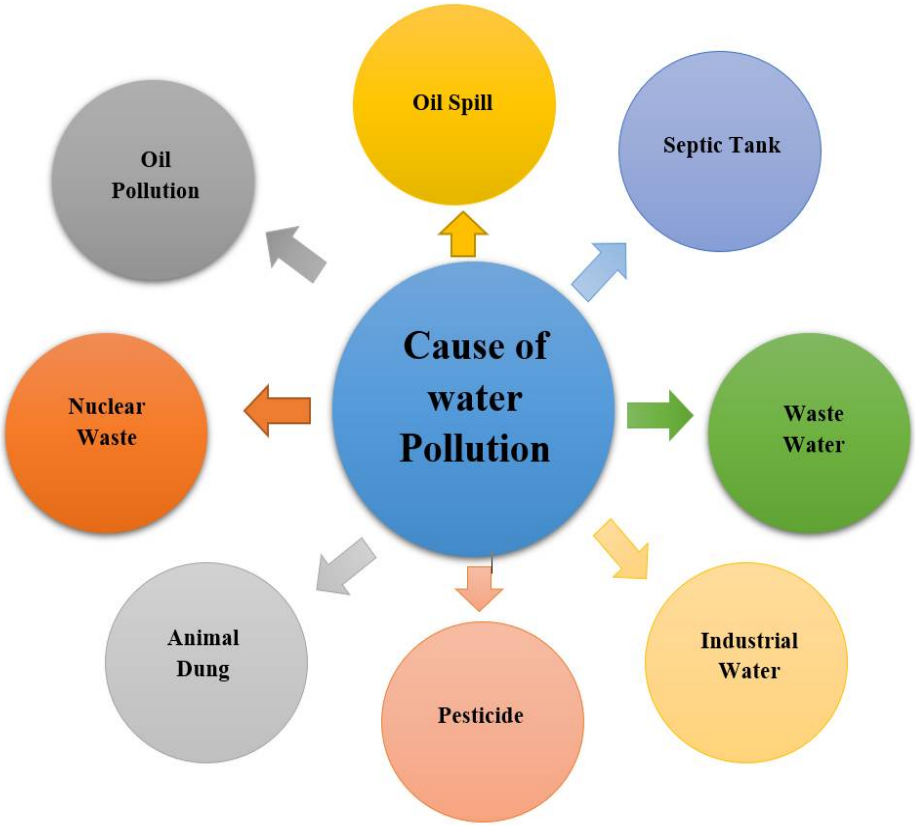

Fig.1 Cause of Water Pollution

Water has its own set of significant values:

- ✓ The digestive system need water to function properly. For proper intestine function, water is essential. Dehydration, on the other hand, can lead to digestive problems, constipation, and a stomach that is too acidic. As a result, heartburn and stomach ulcers are more frequent.
- ✓ The joints are lubricated by water. In human bodies, the water content of cartilage, which is found in joints and spinal discs, is around 80%. Long-term dehydration can occur as a result of water loss, which reduces the shock-absorbing capacities of joints and increases the risk of joint discomfort.
- ✓ The brain, spinal cord, and other delicate structures are cushioned by water. A shortage of water may impair the anatomy and function of the brain. Because water contributes in the creation of hormones and neurotransmitters, a person who has been dehydrated for a long time may have difficulties thinking and reasoning.
- ✓ Water delivers oxygen throughout the body. Our blood, which is made up of more than 90% water, transports oxygen throughout our bodies.
- ✓ Water benefits the skin's health and attractiveness. If there is a lack of water, the skin may become more vulnerable to skin disorders and premature ageing. While drinking adequate water can help skin glow, dehydration can make it appear lifeless.
- ✓ The body's temperature is regulated by water. Perspiration is produced as the body heats up and water contained in the middle layers of the skin rises to the surface. As it evaporates, it cools the body. According to some experts, when the body is dehydrated, heat storage increases and a person's ability to endure heat stress decreases.
- ✓ Water aids in the maintenance of blood pressure. When we drink less water, our blood hardens, and our blood pressure rises.
- ✓ Water facilitates the absorption of minerals and nutrients. Minerals and various nutrients frequently dissolve in water, allowing them to reach various sections of the body where they are required.
- ✓ During exercise, water improves performance. Drinking extra water, according to some experts, can help you perform better during strenuous exercises. This is especially true for longer workouts over 30 minutes.

- ✓ Weight reduction is aided by water. It is possible to reduce weight by drinking water instead of sugary beverages like sodas. Drinking water before meals might help people eat less since it gives them a sensation of fullness.

There is a plethora of factors for water contamination:

Water cannot sink into the earth when soil is covered. Storm drains systems channel water that runs over hardened ground, which discharges directly into streams and seas. This contaminated water is known as urban runoff. The most significant cause of pollution in our streams and oceans is urban runoff, which comprises pollutants such as motor fluids, trash, and pesticides. Garbage, microbes from animal waste and ancient septic tanks, faecal microbes, garbage, pesticides and herbicides, dirt from automobile brake pads, and other contaminants all have an effect on our nearby rivers, streams, beaches, and groundwater aquifers. Stormwater contamination may be avoided by disposing of chemical and material waste properly and implementing green infrastructure initiatives that treat and clean our waterways. Natural chemicals and minerals, regional land use practices, industry operations, and sewerage overflows or wastewater emissions can all pollute water. Water contaminants can also cause a variety of health issues, including gastrointestinal illness, pregnancy complications, and neurological issues. Certain pollutants may be especially dangerous to infants, young children, pregnant women, the elderly, and individuals with weaker immune systems as a result of AIDS, chemotherapy, or transplant medications **[1-7].**

Sources of Water Contamination

Water from streams and reservoirs is progressively contaminated by impurities from manufacturers or the ecosystem is used by towns, farming, and commerce (**Fig.2**).

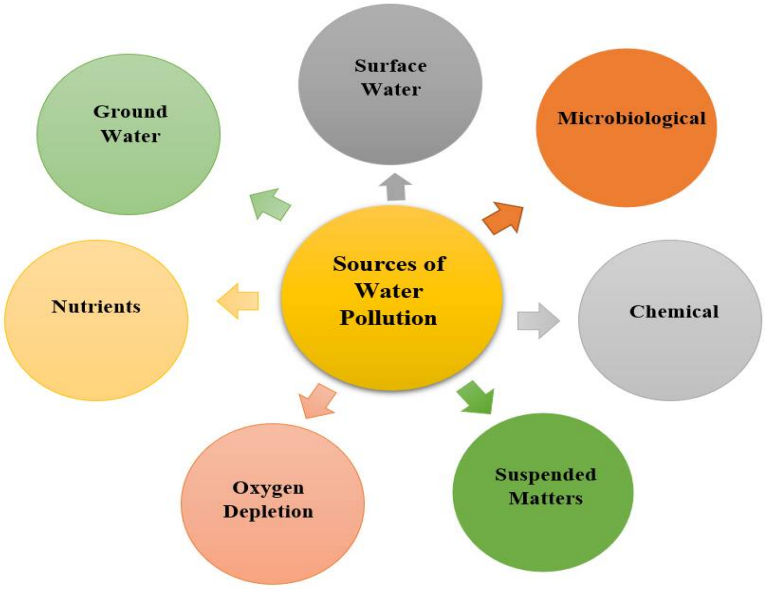

Fig.2 Sources of Water Contamination

Manures can seep into streams, while flooding pollutes surface water because the volume extends across places that are not normally exposed to water. Because of these impurities, water must be cleaned before it is utilized for human consumption. Even though the water seems clear, it may not be pure, which is why municipalities need a testing and remediation program for any pollution **[8-9].**

Ground Water

Contaminated Land- Soil has been polluted by a range of inorganic and organic pollutants, especially heavy metals, hydrocarbons, and organic solvents, which can cause major groundwater contamination. In comparison to other nations, polluted soil is a significant cause of groundwater contamination in the United Kingdom. The legacy of contamination caused by past and contemporary human activity has resulted in and will continue to result in major groundwater pollution incidents. **[10-12].**

Heavy Metals- Heavy metals are typically found in trace amounts in groundwater. Mining, municipal and industrial pollutants, farming pollutants, wastewater sludge, fertilizers, and fossil fuels are the most prevalent causes of pollution. Heavy metals are hazardous because they tend to accumulate in the body. Bioaccumulation is defined as a rise in the concentration of a chemical in a biological organism over time in comparison to the concentration of the chemical in the ecosystem. Even in low quantities, heavy metals

may be exceedingly harmful to humans. In nature, heavy metals such as chromium, mercury, lead, cadmium, zinc, arsenic, copper, and nickel are more poisonous **[9-13].**

Surface Water

Microbes that induce various sorts of waterborne infections are one of the most serious threats posed by surface water contamination to people. These are derived from both human excrement and industrial origins, including organic compounds plus toxic metals. Pollution happens most usually when food is cooked with tainted water or when someone drinks it. This is a common source of sickness, especially in underdeveloped nations. Because of microbial contact, surface water pollution can also result in harmful compounds staying in fish. Municipal water distributors must seek the expertise of surface-water treatment services in order to detect and cure the problem before it poses a big health threat **[14-16].**

Colour and Turbidity

When there is pollution, the colour and turbidity of the water is impacted. Tannins are often created from organic materials such as branches, dirt, fish, and detritus. The tannin type will be determined by the area and kind of pollution. Several are tough to perceive, thus it is critical to do frequent water supply monitoring. Turbidity arises when particles settle or obscure the appearance of the liquid in the presence of sediments in the water. This is not always hazardous. Because surface water lacks the natural filtering found in groundwater, turbidity is more prevalent. Working with a municipality's water treatment specialist, such as AOS, to solve the problem would enhance the supply's quality. To ensure a safe supply of water and decrease the danger of pollution, local authorities should rely on the knowledge of water treatment providers. Surface water is subject to a variety of pollutants depending on its area, thus frequent checks and treatments will help to enhance quality **[11-16].**

Environment

Good environments rely on an intricate network of fauna, flora, microbes, and fungus to exist, which interacting with one another, indirectly and directly. Little damage to any of these creatures can set off a chain reaction that threatens whole marine atmosphere. When aqua contamination generates an algal bloom in a reservoir or ocean, the expansion of freshly supplied nutrients drives flora and algae development, depleting the water's oxygen levels. Eutrophication, suffocates flora and fauna, can result in "dead zones," or region of water that are practically without life. In certain situations, these hazardous algal blooms can also create neurotoxins that kill animals, also whales and sea turtles **[1-7].**

Watercourses are polluted by chemicals and heavy metals from industrial and municipal wastes. These toxins are hazardous to marine species, lowering a microbe’s life cycle and capacity to breed, and they move up the food chain when predators devour prey. This is how tuna and other large fish amass large amounts of poisons like mercury. Ocean litter, which may choke, smother, and starve creatures, is also a hazard to aquatic habitats. Much of this solid material, like plastic bags and soda cans, is pushed into sewage and storm drains before being washed out to ocean, turning our oceans into trash soup and occasionally congregating to form motile filth patches. More than 200 kinds of aquatic life have been injured by abandoned fishing gear and other sorts of garbage. Nevertheless, sea acidification makes it more difficult for shellfish and coral to thrive. Oceans are growing increasingly acidic, despite the fact that they absorb around a quarter of the carbon pollutants produced annually by the combustion of fossil fuels **[12-15].**

Microbiological Pollution of Water

Water can be contaminated by microorganisms including microbes, virus, protozoa, and helminths. According to the W.H.O, polluted water causes eighty percent of all infections in underdeveloped nations. Untreated and badly treated sewerage, fauna excrement in farming lands and feedlots near rivers, meat packing and tanning businesses that leak untreated fauna excrement into water, and some wildlife genera that transmit waterborne illnesses are the main sources of infectious agents. Water spreads a diverse range of harmful and possibly pathogenic bacteria. The causal agents of intestinal disorders are the most common. Disorders of viral origin, like contagious hepatitis, poliomyelitis, aseptic meningitis, and ailments of the respiratory and gastrointestinal tracts, fall under this category. Because water is not tested for the presence of viruses and conventional microbial examination fails to identify them, they represent a significant hazard to humans and animals **[18-20].**

Organic and Inorganic Pollutants

Organic matter resulting from various human activities is the primary cause of organic pollution in streams. This includes home and industrial drainage, agricultural and animal excrement, food processing plants, and others. Several poisonous organic compounds are non-biodegradable or degrade slowly, allowing them to persevere in the environment; a few are amplified in the food chain; several can induce cancer in humans; others are transformed into carcinogens when they react with chlorine used to decontaminate water; some affect and even kill fish and other marine species; and several are nuisances, imparting an offensive taste or odour to water and fish. Acidification of inland waterways by sulphur and nitrogen-containing acidifying

chemicals degrades water quality and harms marine habitats, particularly fish. Another global issue is freshwater eutrophication. The richness of water with nitrogen and phosphorus causes eutrophication. Phosphorus emissions are mostly caused by home and industrial pollutants, although farming also contributes significantly **[15-21].**

Human health

As stated by study released in The Lancet, it was amenable for 1.8 million losses of life in 2015. Yearly, over 1 billion individuals become ill as a result of polluted water. Also, poor communities are unreasonably exposed since their lodgings are often located nearest to the most polluted industries. Aqua borne microbes, such as disease-causing microorganisms and infections derived from human and animal excrement, are a primary source of sickness caused by polluted drinking water (**Table 1**). A contaminated water supply can carry cholera, giardia, and typhoid. Even in wealthy nations, unintended or unauthorized sewage treatment facility emissions, agriculture and urban runoff, contribute dangerous microbes to watercourses. Toxicants, if taken, can lead to various health problems, ranging from cancer to hormone disturbance to impaired brain function. Kids and expectant women are more exposed. Even swimming may sometimes be dangerous **[5-15].**

Table. 1 Source, Disease/Contaminant, and Symptoms due to Water Contamination

Sources	Disease/Contaminant	Symptoms
Microbial	Amoebic dysentery	Stomach Pain, Diarrhoea, dysentery.
	Campbylobacteriosis	Acute diarrhoea.
	Cholera	Sudden diarrhoea, vomiting. Dangerous if not treated.
	Cryptosporidiosis	Stomach cramps, nausea, dehydration, headaches. Can be dangerous for vulnerable populations.
Chemical/ Heavy Metal.	Lead	Impairs development of nervous system in children; adverse effects on gestational age and foetal weight; blood pressure.
	Arsenic	Carcinogenic (skin and internal cancers).
	Nitrates and nitrites	Methemoglobinemia (blue baby syndrome).
	Mercury	Mercury and cycloidians are known to induce higher incidences of kidney damage, some irreversible.
	Persistent organic pollutants	These chemicals can accumulate in fish and cause serious damage to human health. Where pesticides are used on a large scale, groundwater gets contaminated and this leads to the chemical contamination of drinking water.

IMPACTS OF WATER CONTAMINATION (Fig.3)

Water Contamination and Diarrhoea

Diarrhoea is the most prevalent illness induced by water contamination and a typical sign of gastrointestinal ailments. Diarrhoea is a primary cause of disease and mortality in kids less than the age of 5 in low-income countries. Diarrhoea illnesses kill 21% of youngsters under the age of five in underdeveloped nations annually. Several pathogenic pathogens linked to diarrhoea are linked to polluted water. Parasitical worms contained in non-purifying potable water cause illnesses when swallowed by humans. For all ages, it was discovered that treated water from water treatment facilities was related to a decreased incidence of diarrhoea than untreated water **[8-17].**

In the southern part of Brazil, for instance, the researchers discovered that characteristics related to a higher risk of death from diarrhoea include a shortage of piped water, a shortage of toilet facilities, poor living facilities, and overcrowded homes. Infant mortality from diarrhoea was 4.8 times greater in families without piped water than in households with piped water. Enteroviruses can be found in water habitats. More than 100 pathogenic viruses are expelled in human and animal waste and disperse across the ecosystem via groundwater, estuary water, seas, streams, wastewater treatment facilities, inadequately treated water, drinking water, and private wells. Research in Pakistan discovered coliform contamination in various water sources. The primary sources of drinking water contamination include improper sewage and solid garbage discharge, high pesticide and fertilizer usage, and failing pipeline networks. Water contamination from coliform bacteria is the primary source of water-borne disorders in this region, including gastroenteritis, dysentery, diarrhoea, and viral hepatitis. As a result, the primary aim of sanitation and water health measures is to prevent the spread of diarrheal diseases from the ecosystem to individuals **[1-5].**

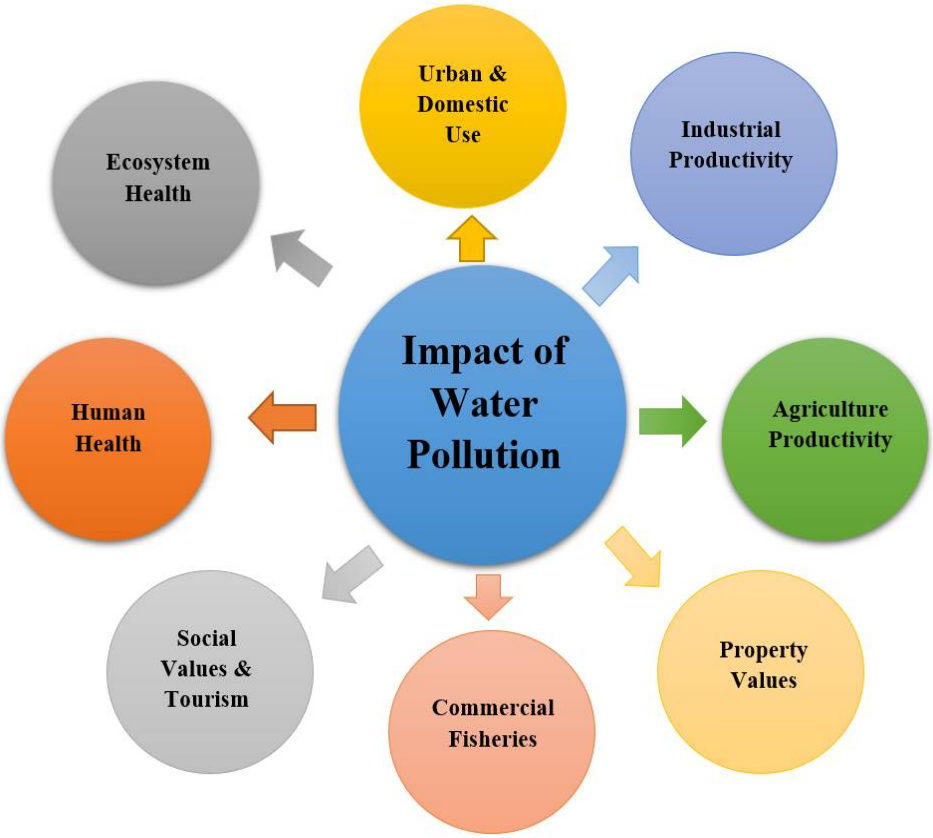

Fig. 3 Impact of Water Pollution

For water quality and diarrhoea investigations, meta-analyses are the most widely utilized strategy. It was discovered that boosting water supply and sanitation lowered total diarrhoea incidence by 26%. Freshwater and hygiene were related to an 82% decrease in child mortality among Malaysian new-borns, particularly among non-breastfed infants. All water quality and hygiene treatments lowered the risk of diarrhoeal illness considerably, while water quality measures were discovered to be far more beneficial than earlier anticipated. Several approaches (such as water, sanitary, and hygienic initiatives) did not outperform single-focus initiatives. Efforts to enhance water quality lowered the rate of diarrhoea in kids and the danger of E. coli pollution of stored water. Measures to enhance water quality are often beneficial in avoiding diarrhoea in children of all ages, particularly those under the age of five. However, other experiments demonstrated high variability, which might be attributed to the research methodologies and circumstances **[22-25].**

Water Contamination and Skin Diseases

Despite common assumptions, research conducted as in the 1950s revealed that the total sickness frequency in the swimming group was much higher than in the non-swimming group. According to the poll, sickness is more common in children under the age of ten than in those above the age of ten. Kin illnesses account for a fraction of the total. A speculative clinical assessment of beach water contamination was directed in Hong Kong during the summer of 1986-1987. Swimmers on Hong Kong's Sea coast were shown to be more likely to report systemic ailments for instance skin and eye problems than non-swimmers. Swimming in increasingly contaminated beach waters increases the chance of developing skin and other ailments. The prevalence of swimming-associated illness symptoms was shown to be associated with beach hygiene **[10-18].**

A survey of arsenic-affected areas in Pakistan's southern Sindh region found that skin illnesses were caused by bad quality of water. The survey of the relationship between elevated arsenic in potable water caused by water contamination and skin diseases discovered that when compared to individuals who drank urban low-arsenic potable water, the arsenic levels in the hair of individuals who drank high-arsenic potable water enhanced substantially. The amount of arsenic in drinking water has a direct impact on local individuals' health, and skin infection is the more prevalent medical consequence of arsenic toxicity. There is a link between arsenic levels in biological samples from individuals with skin illnesses and drinking water

polluted with arsenic. Another Bangladesh survey found that stream contamination causes scabies in many people. In addition to that, industrial water contamination can cause skin cancer.

According to meta-analysis research, exposure to contaminated ocean recreational waters might have negative impacts, like regular skin irritation (rash or itching). A number of harmful bacteria can cause skin problems in swimmers. People who were exposed to microbial concentrations over a certain threshold had a greater relative chance of acquiring skin illness, and microbial concentrations in the ocean were closely connected with skin symptoms. According to research, swimmers are 3.5 times more likely than non-swimmers to experience skin problems. This disparity might be due to a "risk perception bias" at work among swimmers, who are more likely to recognize and complain skin diseases since they are typically aware that such exposure can have negative health consequences. Swimmers may possibly have overstated their symptoms, claiming diseases that others would not consider real skin problems **[15-24].**

Water Contamination and Cancer

$1/5^{th}$ of all worldwide illnesses will acquire cancer within their lifetime, according to the latest statistics. Carcinogen kinds and levels in potable water will differ based on where they arrive: polluted water resources, water treatment procedures, or when the water is provided to consumers. Arsenic, nitrate, chromium, and other contaminants in water are strongly linked to cancer. Arsenic in potable water can cause skin cancer, as well as kidney and genetical cancer. The population's risk of cancer from arsenic in the US water supply may be equivalent to the danger from cigarette smoke and radon in the residential surroundings. People's sensitivity to arsenic's carcinogenic impact, however, fluctuates. Research has also revealed a synergistic impact of smoking and arsenic in potable water on the development of lung cancer. High arsenic concentrations in potable water were also linked to the growth of liver cancer, however, this impact was not substantial at levels less than 0.64 mg/L. Trihalomethane (THM) concentrations in drinking water have been linked to cancer mortality. THM levels were positively connected with bladder and brain cancers in both men and women, as well as non-lymphoma Hodgkin's and kidney cancer in males, while bladder cancer mortality had the greatest and most consistent connection with the THM exposure index. Carcinogens may be introduced into the water treatment process during chlorine treatment, and drinking water has been linked to all cancers, urine cancers, and gastrointestinal cancers. Chlorinated byproducts of chlorine usage in water treatment have been linked to a higher risk of bladder and rectal cancer, with around five thousand instances of bladder and eight thousand cases of rectal cancer developing in the U.S annually **[1-20].**

The effect of contaminants in potable water on cancer is complicated. Potable water toxins such as chlorinated byproducts, nitrates, arsenic, and radionuclides have been linked to cancer in humans, according to epidemiological research (**Table 2**). The primary groundwater contaminants include lead, cadmium, uranium, fluoride, and tritium, and they are one of the probable causes of cancer. Many additional water contaminants, such as herbicides and pesticides, as well as manures that hold and release nitrates, are also deemed carcinogenic. Furthermore, the influence of watershed water contamination on cancer is geographically diverse due to the time-lag impact. Because of the influence of previous water pollution, the death rate of oesophageal cancer induced by water contamination is much greater downstream than in other places.

Table. 2 Pollutants, Sources and Their Impacts on Human Health due to Water Contamination

Pollutants	Sources	Their Impacts
Metallic Pollutants: Hg, Cd, As, Cu, Pb, Zn, Cr, Al, Co	Industries	Cancer, neurological ailments, lung diseases etc.
Industrial effluents	Waste products from factories	These are toxic substances.
Pesticides	Enter into water from the soil	Poisonous substances.
Fluorides	Industries	Dental & skeletal fluorosis.
Oil	Oil tankers travelling through sea	Oil spread over seawater surface.
Fertilizers	Washed out of soil by rain to rivers.	Increase toxicity of the water.
Detergent	Washing of clothes	Depletes the oxygen of water endangering aquatic life.
Sewage waste	Untreated human excreta into rivers	Diseases such as cholera, typhoid, jaundice, diarrhoea etc.

Water Contamination and Children Wellbeing

Diarrhoea is a frequent childhood illness. Diarrhoeal infections (also cholera) kill 1.8 million people annually, 90 percent of whom are kids less than the age of five, with the majority of deaths occurring in underdeveloped nations. Insufficient water supply, sanitation, and hygiene are responsible for 88% of diarrhoeal illnesses. A major number of these are caused by microbiologically contaminated water and food, and diarrhoea in babies and young kids can result in malnourishment and decreased immunological response, raising the risk of protracted and recurring diarrhoea **[1-5].**

Contamination exposure during crucial stages of development in children is linked to adult height decrease. Water and sanitation-related diseases, paired with hunger, cause other causes of mortality, like measles and pneumonia. Child malnutrition and stunting will continue to plague more than 1/3rd of the world's kids owing to a lack of clean water and sanitation. According to research conducted in rural India, kids living in families with running water had much-reduced sickness prevalence and duration **[10-14].**

Finally, water contamination is a major source of paediatric disorders. In 2016, air, water, and soil contamination killed 940,000 kids globally, 2/3 of which were less than the age of five, with the great majority dying in low- and middle nations. In less developed nations, the severity of industrial organic aqua contamination is strongly connected with infant and child mortality, and industrial water contamination is a major cause of newborn and child mortality. Furthermore, arsenic in drinking water may pose a carcinogenic danger to youngsters. Goitre in children can be caused by nitrate exposure in drinking water **[18-25].**

Micro plastics ingestion

Drinking water or eating polluted seafood can introduce micro plastics into the body. According to a study conducted in Tokyo Bay in 2016, 77 percent of 64 anchovies in the area contained micro plastic in their digestive tracts. Other dietary products, such as salt and beer, have also been found to contain them. Research indicates that micro plastics cause oxidative stress, inflammation, and metabolic abnormalities in humans. It is still necessary to conduct more research to confirm these findings **[5-8].**

Consuming water contaminated by sewage

WHO estimates that around 2 billion people drink feces-contaminated water worldwide. There are many types of bacteria that can live in polluted water, including those that cause diarrhoea, cholera, dysentery, typhoid, hepatitis A, and polio. Inadequate cleanliness, poor hygiene, and unsafe drinking water cause nearly 297,000 deaths each year among children under the age of 5 **[12-19].**

Potable Water Containing Chemical Waste

Several chemical pollutants can cause serious health problems when consumed, including pesticides, fertilizers, and heavy metals. In Flint, Michigan, residents faced water pollution in 2014 because their water supply was not adequately tested or treated. All of these effects were caused by the polluted water, including rashes, hair loss, and itchy skin. A more than doubled concentration of lead was found in the blood of children who drank the water **[18-25].**

CONCLUSION

It is recommended that water quality be investigated in a periodic manner to prevent negative impacts on human wellbeing. Residential and agricultural trash should not be discarded untreated. Authorities should enhance water intervention management and implement treatment strategies to enhance water quality and lessen the impact of water contamination on human wellbeing. Based on a WHO report, water quality problems cause over 50 ailments, causing 80% of all illnesses worldwide and 50% of child deaths. Concerns have been raised about the quality of potable water in developing nations. Water pollution's harmful health consequences continue to be the top cause of illness and death in developing nations. Measures to improve water quality should be emphasized at the point of use. Source contamination from manufacturing, consumption, and transportation should be avoided and controlled in all societies. Promote environmental education, educate citizens about safe drinking water via newspapers, journals, tv, the Internet, and other media, and raise public awareness about public health.

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