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Fertilizers, Pesticides, Nitrates, Phosphates and Radioactive Substances in Water

PRABHAT PANDEY

Research Scholar, Rama Bai Government Post Graduate College, Akbarpur, Ambedkar Nagar, India

ABSTRACT: Water pollution occurs when harmful substances—often chemicals or microorganisms—contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.

This widespread problem of water pollution is jeopardizing our health. Unsafe water kills more people each year than war and all other forms of violence combined. Meanwhile, our drinkable water sources are finite: Less than 1 percent of the earth's freshwater is actually accessible to us. Without action, the challenges will only increase by 2050, when global demand for freshwater is expected to be one-third greater than it is now.

Water is uniquely vulnerable to pollution. Known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. It's the reason we have Kool-Aid and brilliant blue waterfalls. It's also why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution.

KEYWORDS-water,pesticides,fertilizers,phosphates,nitrates,radioactive substances

I. INTRODUCTION

Not only is the agricultural sector the biggest consumer of global freshwater resources, with farming and livestock production using about 70 percent of the earth's surface water supplies, but it's also a serious water polluter. Around the world, agriculture is the leading cause of water degradation. In the United States, agricultural pollution is the top source of contamination in rivers and streams, the second-biggest source in wetlands, and the third main source in lakes. It's also a major contributor of contamination to estuaries and groundwater. Every time it rains, fertilizers, pesticides, and animal waste from farms and livestock operations wash nutrients and pathogens—such bacteria and viruses—into our waterways. Nutrient pollution, caused by excess nitrogen and phosphorus in water or air, is the number-one threat to water quality worldwide and can cause algal blooms, a toxic soup of blue-green algae that can be harmful to people and wildlife.[1,2,3]

Used water is wastewater. It comes from our sinks, showers, and toilets (think sewage) and from commercial, industrial, and agricultural activities (think metals, solvents, and toxic sludge). The term also includes stormwater runoff, which occurs when rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways

More than 80 percent of the world's wastewater flows back into the environment without being treated or reused, according to the United Nations; in some least-developed countries, the figure tops 95 percent. In the United States, wastewater treatment facilities process about 34 billion gallons of wastewater per day. These facilities reduce the amount of pollutants such as pathogens, phosphorus, and nitrogen in sewage, as well as heavy metals and toxic chemicals in industrial waste, before discharging the treated waters back into waterways. That's when all goes well. But according to EPA estimates, our nation's aging and easily overwhelmed sewage treatment systems also release more than 850 billion gallons of untreated wastewater each year.

Big spills may dominate headlines, but consumers account for the vast majority of oil pollution in our seas, including oil and gasoline that drips from millions of cars and trucks every day. Moreover, nearly half of the estimated 1 million tons of oil that makes its way into marine environments each year comes not from tanker spills but from land-based sources such as factories, farms, and cities. At sea, tanker spills account for about 10 percent of the oil in waters

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around the world, while regular operations of the shipping industry—through both legal and illegal discharges—contribute about one-third. Oil is also naturally released from under the ocean floor through fractures known as seeps.

Radioactive waste is any pollution that emits radiation beyond what is naturally released by the environment. It's generated by uranium mining, nuclear power plants, and the production and testing of military weapons, as well as by universities and hospitals that use radioactive materials for research and medicine.[4,5,6] Radioactive waste can persist in the environment for thousands of years, making disposal a major challenge. Consider the decommissioned Hanford nuclear weapons production site in Washington, where the cleanup of 56 million gallons of radioactive waste is expected to cost more than $100 billion and last through 2060. Accidentally released or improperly disposed of contaminants threaten groundwater, surface water, and marine resources.

Categories of Water Pollution

To address pollution and protect water we need to understand where the pollution is coming from (point source or nonpoint source) and the type of water body its impacting (groundwater, surface water, or ocean water).

When contamination originates from a single source, it's called point source pollution. Examples include wastewater (also called effluent) discharged legally or illegally by a manufacturer, oil refinery, or wastewater treatment facility, as well as contamination from leaking septic systems, chemical and oil spills, and illegal dumping. The EPA regulates point source pollution by establishing limits on what can be discharged by a facility directly into a body of water. While point source pollution originates from a specific place, it can affect miles of waterways and ocean.[7,8,9]

Nonpoint source pollution is contamination derived from diffuse sources. These may include agricultural or stormwater runoff or debris blown into waterways from land. Nonpoint source pollution is the leading cause of water pollution in U.S. waters, but it's difficult to regulate, since there's no single, identifiable culprit.

It goes without saying that water pollution can't be contained by a line on a map. Transboundary pollution is the result of contaminated water from one country spilling into the waters of another. Contamination can result from a disaster—like an oil spill—or the slow, downriver creep of industrial, agricultural, or municipal discharge.

When rain falls and seeps deep into the earth, filling the cracks, crevices, and porous spaces of an aquifer (basically an underground storehouse of water), it becomes groundwater—one of our least visible but most important natural resources. Nearly 40 percent of Americans rely on groundwater, pumped to the earth's surface, for drinking water. For some folks in rural areas, it's their only freshwater source. Groundwater gets polluted when contaminants—from pesticides and fertilizers to waste leached from landfills and septic systems—make their way into an aquifer, rendering it unsafe for human use. Ridding groundwater of contaminants can be difficult to impossible, as well as costly. Once polluted, an aquifer may be unusable for decades, or even thousands of years. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans.[10,11,12]

Covering about 70 percent of the earth, surface water is what fills our oceans, lakes, rivers, and all those other blue bits on the world map. Surface water from freshwater sources (that is, from sources other than the ocean) accounts for more than 60 percent of the water delivered to American homes. But a significant pool of that water is in peril. According to the most recent surveys on national water quality from the U.S. Environmental Protection Agency, nearly half of our rivers and streams and more than one-third of our lakes are polluted and unfit for swimming, fishing, and drinking. Nutrient pollution, which includes nitrates and phosphates, is the leading type of contamination in these freshwater sources. While plants and animals need these nutrients to grow, they have become a major pollutant due to farm waste and fertilizer runoff. Municipal and industrial waste discharges contribute their fair share of toxins as well. There's also all the random junk that industry and individuals dump directly into waterways.

Eighty percent of ocean pollution (also called marine pollution) originates on land—whether along the coast or far inland. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities by streams and rivers into our bays and estuaries; from there they travel out to sea. Meanwhile, marine debris—particularly plastic—is blown in by the wind or washed in via storm drains and sewers. Our seas are also sometimes spoiled by oil spills and leaks—big and small—and are consistently soaking up carbon pollution from the air. The ocean absorbs as much as a quarter of man-made carbon emissions.[13,14,15]

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II. DISCUSSION

To put it bluntly: Water pollution kills. In fact, it caused 1.8 million deaths in 2015, according to a study published in *The Lancet*. Contaminated water can also make you ill. Every year, unsafe water sickens about 1 billion people. And low-income communities are disproportionately at risk because their homes are often closest to the most polluting industries.

Waterborne pathogens, in the form of disease-causing bacteria and viruses from human and animal waste, are a major cause of illness from contaminated drinking water. Diseases spread by unsafe water include cholera, giardia, and typhoid. Even in wealthy nations, accidental or illegal releases from sewage treatment facilities, as well as runoff from farms and urban areas, contribute harmful pathogens to waterways. Thousands of people across the United States are sickened every year by Legionnaires' disease (a severe form of pneumonia contracted from water sources like cooling towers and piped water), with cases cropping up from California's Disneyland to Manhattan's Upper East Side.

Meanwhile, the plight of residents in Flint, Michigan—where cost-cutting measures and aging water infrastructure created a lead contamination crisis—offers a stark look at how dangerous chemical and other industrial pollutants in our water can be. The problem goes far beyond Flint and involves much more than lead, as a wide range of chemical pollutants—from heavy metals such as arsenic and mercury to pesticides and nitrate fertilizers—are getting into our water supplies. Once they're ingested, these toxins can cause a host of health issues, from cancer to hormone disruption to altered brain function. Children and pregnant women are particularly at risk.[16,17,18]

Even swimming can pose a risk. Every year, 3.5 million Americans contract health issues such as skin rashes, pinkeye, respiratory infections, and hepatitis from sewage-laden coastal waters, according to EPA estimates.

In order to thrive, healthy ecosystems rely on a complex web of animals, plants, bacteria, and fungi—all of which interact, directly or indirectly, with each other. Harm to any of these organisms can create a chain effect, imperiling entire aquatic environments.[19,20,21]

When water pollution causes an algal bloom in a lake or marine environment, the proliferation of newly introduced nutrients stimulates plant and algae growth, which in turn reduces oxygen levels in the water. This dearth of oxygen, known as eutrophication, suffocates plants and animals and can create "dead zones," where waters are essentially devoid of life. In certain cases, these harmful algal blooms can also produce neurotoxins that affect wildlife, from whales to sea turtles.

Chemicals and heavy metals from industrial and municipal wastewater contaminate waterways as well. These contaminants are toxic to aquatic life—most often reducing an organism's life span and ability to reproduce—and make their way up the food chain as predator eats prey. That's how tuna and other big fish accumulate high quantities of toxins, such as mercury.

Marine ecosystems are also threatened by marine debris, which can strangle, suffocate, and starve animals. Much of this solid debris, such as plastic bags and soda cans, gets swept into sewers and storm drains and eventually out to sea, turning our oceans into trash soup and sometimes consolidating to form floating garbage patches. Discarded fishing gear and other types of debris are responsible for harming more than 200 different species of marine life.

Meanwhile, ocean acidification is making it tougher for shellfish and coral to survive. Though they absorb about a quarter of the carbon pollution created each year by burning fossil fuels, oceans are becoming more acidic. This process makes it harder for shellfish and other species to build shells and may impact the nervous systems of sharks, clownfish, and other marine life.[22,23,24]

We're all accountable to some degree for today's water pollution problem. Fortunately, there are some simple ways you can prevent water contamination or at least limit your contribution to it:

- Learn about the unique qualities of water where you live. Where does your water come from? Is the wastewater from your home treated? Where does stormwater flow to? Is your area in a drought? Start

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building a picture of the situation so you can discover where your actions will have the most impact—and see if your neighbors would be interested in joining in!

- Reduce your plastic consumption and reuse or recycle plastic when you can.
- Properly dispose of chemical cleaners, oils, and nonbiodegradable items to keep them from going down the drain.
- Maintain your car so it doesn't leak oil, antifreeze, or coolant.
- If you have a yard, consider landscaping that reduces runoff and avoid applying pesticides and herbicides.
- Don't flush your old medications! Dispose of them in the trash to prevent them from entering local waterways.
- Be mindful of anything you pour into storm sewers, since that waste often won't be treated before being released into local waterways. If you notice a storm sewer blocked by litter, clean it up to keep that trash out of the water. (You'll also help prevent troublesome street floods in a heavy storm.)
- If you have a pup, be sure to pick up its poop.

One of the most effective ways to stand up for our waters is to speak out in support of the Clean Water Act, which has helped hold polluters accountable for five decades—despite attempts by destructive industries to gut its authority. But we also need regulations that keep pace with modern-day challenges, including microplastics, PFAS, pharmaceuticals, and other contaminants our wastewater treatment plants weren't built to handle, not to mention polluted water that's dumped untreated.

Tell the federal government, the U.S. Army Corps of Engineers, and your local elected officials that you support water protections and investments in infrastructure, like wastewater treatment, lead-pipe removal programs, and stormwater-abating green infrastructure. Also, learn how you and those around you can get involved in the policymaking process. Our public waterways serve every one of us. We should all have a say in how they're protected.

III. RESULTS

Synthetic chemicals and pesticides, herbicides, fertilizers, pharmaceutical substances such as antibiotics, cosmetics and personal care products, detergents, toxic chemicals, and heavy metals can adversely affect aquatic ecosystems as well as making the water unusable for human contact or consumption. These compounds may come from municipal wastewater, industrial effluents, or agricultural and urban runoff.

Pathogenic microorganisms are important pollutants that directly affect human health. Water-borne pathogen contamination in ambient water bodies and related diseases are a major water quality concern throughout the world. Water-borne diseases (i.e., diarrhea, gastrointestinal illness) are caused by various bacteria, viruses, protozoa, algae, and fungi.

A major pathogen is fecal coliform bacteria (i.e., *Escherichia coli*) that is the bacteria that normally live in the intestinal tract of warm-blooded animals and indicate contamination by animal wastes. Other bacterial pathogens include *Vibrio cholera* which cause cholera, and *Shigella* and *Salmonella* that cause dysentery. Other types of microorganisms that could contribute to biological water pollution are: protozoa (such as *Cryptosporidium parvum*, *Giardia lamblia*, *Entamoeba histolytica* that cause diseases such as Cryptosporidiosis, Giardiasis, and Amoebiasis); viruses such as Coronavirus, Hepatitis A virus (HAV) that cause Hepatitis A, and Poliovirus which cause Poliomyelitis; algae such as *Desmodesmus armatus* that cause desmodesmus infection; and several fungi such as *Aspergillus* which most frequently affects the lungs. Some higher organisms such as nematodes could be present in water and lead to water-borne disease (Tortora et al., 2010).

Such species can be introduced into water bodies as the result of municipal and industrial wastewater discharges, or as a result of aquaculture activities. In addition to causing diseases, the presence of these organisms in water could alter the original microbial floral community in those water bodies.

Oil pollution can result from leak out of oil from huge tanker loaded with crude oil and cause water pollution with petroleum compounds.[26,27]

Acids and bases from industrial and mining activities can alter the water quality in a stream or lake to the extent that it kills the aquatic organisms living there, or prevent them from reproducing. Sulfur-laden water leached from mines, including old and abandoned mines as well as active ones, contain compounds that oxidize to sulfuric acid on contact with air (Davis and Cornwell, 2012; Manahan, 2000; Weiner and Matthews, 2003).

Oxygen-demanding materials and nutrients are pollutants of significant importance. Pesticides are among one of the major water pollutants . Agricultural practices including large-scale application of pesticides and herbicides in fields

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and forestry have led to fast growth of agrochemical industries worldwide. However, with the domestic activity of controlling pest, various pesticides and herbicides have entered into the surface and groundwater resources. Phosphate, often used in forms of pesticides or insecticides is water soluble and within a period of a few weeks, phosphate added to the soil converts to less soluble forms if it has not been taken up by plants and results in run-off [14]. As a consequence, phosphates are responsible for the eutrophication of fresh water resources thereby increasing algal growth and reducing other life forms in water [15].

Heavy metal ions are among the most harmful water pollutants. Heavy metals are essentially transition metals (e.g. Cd, Hg, Cr), elements in the lower left part of the periodic table (e.g. Pd, Sn), and some metalloids (e.g. As). The danger of these elements lies in their ability to bind to many functional groups found in the biomolecules such as carboxylic acid, amino or sulphur-containing groups. Therefore, they can bind to proteins and enzymes and disturb their functions. They can also precipitate phosphate biomolecules or promote their decomposition [58]. Heavy metals enter wastewater mainly from industrial, agricultural, or other human activities [59]. Many of these metals are toxic to humans even at very trace levels. Others cause serious health hazards to humans and living organisms. Therefore, heavy metal removal has become a critical goal in many wastewater treatment facilities. This led to the development of several methods for removing pollution caused by heavy metals. Nanotechnology has been widely employed in this field, and various types of nanomaterials have been powerful in purifying water from most heavy metals.[28,29]

IV. CONCLUSION

Because of their widespread presence and biological features, mussels are organisms of choice in monitoring coastal water pollutants. Apparently, some of these features make the dosimetry of DNA adducts, genetic lesions possibly induced by genotoxic pollutants, more difficult than in vertebrate organisms. The limited formation of DNA-reactive intermediate *via* mixed function oxygenase reactions might be counterbalanced by efficient filter-feeding activity (considerably increasing tissue concentration of different pollutants) and high ROS production in mussels. Following acute laboratory exposure, reproducible and doses-effect related induction of DNA adducts can be obtained with model genotoxic compounds, such as B[a]P, and evidence of DNA adduct formation also resulted from some field studies on *Mytilus galloprovincialis* and *Mytilus edulis.* [30]

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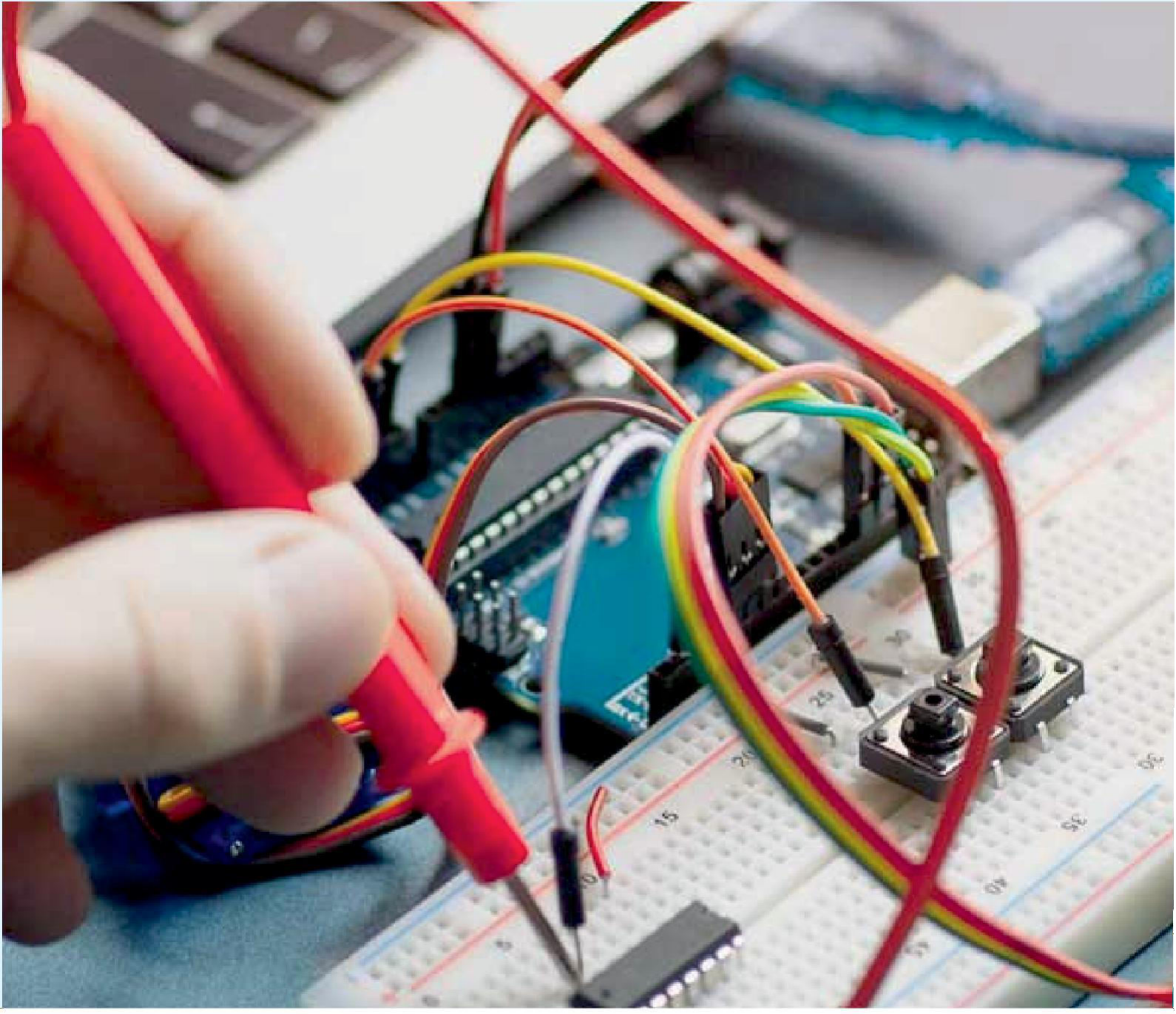

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