Water Pollution, Its Treatment, and Its Adverse Impact on Humans

Okechukwu Ozueigbo

Abstract -- World Health Organization (WHO) refers polluted water as water, which has been impaired by anthropogenic pollutants that render it unsafe for both domestic and other essential purposes like agriculture and industrial uses. These main pollutants, which include bacteria, viruses, parasites, fertilizers, pesticides, pharmaceutical bye-products, nitrates, phosphates, plastics, fecal waste (both human and animal), heavy metals, and even radioactive substances harm human health and natural environment and cause diseases like diarrhea, cholera, dysentery, typhoid, and poliomyelitis. The main problem caused by water pollution is that it disrupts the natural food chain as well as kills organisms and animals like fishes, crabs, birds and seagulls, dolphins, and many other animals that depend on these water bodies. These contaminants do not always change the color of the water, meaning that they are often invisible pollutants: That's why small samples of water are usually tested for dissolved chemicals and aquatic organisms to determine its quality. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water.

Keywords— algae blooms, aquatic organisms, poliomyelitis, plant nutrients, pathogens, pollutants, wastewater

.

1 INTRODUCTION

Water is one of the most **important** substances on earth. **It** covers over 70% of the Earth's surface and is a very **important** resource for people and the environment. All plants and animals must have **water** to survive. Apart from drinking it to survive, people have many other uses for **water**. They depend on safe water for their health and livelihood. Contaminated water leads to millions of deaths and even life threatening illnesses every year. If there were no **water** there would be no life on earth. Water, which is an essential resource for all life on earth, can be polluted through the activities of human or nature: such human activities include the discharging of improperly treated or untreated domestic and industrial effluent, leakages from **septic** tanks, dumping of marine, radioactive wastes, heavy metals, and industrial waste into bodies of water. Natural phenomenon sometimes occurs when mercury filters from the Earth's crust polluting oceans, rivers, lakes, canals and reservoirs. Water is commonly polluted when it gets in contact with microorganisms like bacteria, viruses, and chemicals like pesticides, pharmaceutical bye-products, nitrates, phosphates, **plastics**, fecal waste (both human and animal), heavy metals, and even radioactive substances. It is also polluted when toxic substances enter **water** bodies such as lakes, rivers, oceans and so on, getting dissolved in them, leaving them suspended in the water or depositing them on the water bed. This degrades the quality of **water** and may cause the domestic use of this contaminated water to become toxic to humans and the environment and can lead to health issues in humans, like diarrhea, hepatitis, cholera, dysentery, typhoid, poliomyelitis cancer, cardiovascular other medical conditions. The United Nation estimates that 80% of wastewater returns to the ecosystem without being treated or reused. There are countless species of plants and animals which depend upon **water** for their survival, making them **the** most susceptible to water pollution, drinking water supplies, food chain disruption, agriculture, and economic downturns

2 POSSIBLE SOURCES OF WATER POLLUTION

2.1 Sewage and Wastewater

After being used, water becomes wastewater. Wastewater can be domestic, such as water from toilets, sinks, or showers, or from commercial, agricultural, or industrial use. Wastewater also refers to rainwater that washes oil, grease, road salt, debris, or chemicals from the ground into waterways. In 2017, the UN found that about 2 billion people worldwide did not have access to facilities such as toilets or latrines. The organization also discovered that 673 million people openly defecate outside and says that more than 80% of the world's sewage finds its way into seas and rivers untreated.

Domestic sewage is the primary source of pathogens (disease-causing microorganisms) and putrescible organic substances. Because pathogens are excreted in feces, all sewage from cities and towns is likely to contain pathogens of some type, potentially presenting a direct threat to public health. Putrescible organic matter presents a different sort of threat to water quality. As organics are decomposed naturally in the sewage by bacteria and other microorganisms, the dissolved oxygen content of the water is depleted. This endangers the quality of lakes and streams, where high levels of oxygen are required for fish and other aquatic organisms to survive. Sewage-treatment processes reduce the levels of pathogens and organics in wastewater, but they do not eliminate them comphepatitis, cholera, dysentery, ty-

phoid, poliomyelitis, cancer, cardiovascular, arsenicosis, trachoma (Eye Infection), schistosomiasis, other medical conditions. There are countless species of plants and animals which depend upon water for their survival, making them the most susceptible to water pollution. Water pollution can have disastrous effects on the environment as well as affects the entire food chain: Fishes and the other aquatic animal mistake these pollutants for food, consume them and later pass them to humans when eaten. Also, fishing in polluted waters and the use of waste water for livestock farming and agriculture can introduce toxins into foods which are harmful to our health when eaten, The consequences of water pollution include the destruction of biodiversity, which results in the depletion of aquatic ecosystems and triggers unbrified as organic pollutants, inorganic pollutants, pathogens, suspended solids, nutrients and agriculture pollutants, thermal, radioactive, and other pollutants.

2.2 Inorganic Pollutants

Inorganic pollutants are mainly discharged from industrial effluents into the water bodies. Environment Protection Agency (EPA) of the United States has listed. a few of these inorganic materials as arsenic, antimony, boron, beryllium, barium, chloride, calcium, copper, cadmium, chromium, cobalt, lead, iron, fluoride, manganese, molybdenum, magnesium, mercury, nitrate, nickel, nitrite, phosphates, potassium, phosphorus, salmonella, selenium, silica, sodium, silver, sulfate, sulfide, tin, tellurium, thallium, titanium, uranium, tritium, vanadium, zinc, and so on. These materials, in the form of elements or in combination with other compounds, may be considered as inorganic pollutants if their limit exceeds permissible values, which in turn harms the environment. Heavy metal and other inorganic pollutants such as trace elements, mineral acids, sulfates, inorganic salts, metals, complexes of metals with organic compounds, and cyanides of higher concentrations pollute water bodies. These inorganic impurities are non-biodegradable and pose threats to aquatic flora and fauna and public health (Ghangrekar, 2012).

2.3 Organic Pollutants

Organic pollutants include bacteria and other organic pollutants from sewage, fertilizers, agricultural runoffs, forestry, food processing, tree and brush debris, industrial waste, and so on.. Detergents, Disinfection byeproducts found in chemically disinfected drinking water, such as chloroform, Food processing waste, which can include oxygen-demanding substances, fats and grease, Insecticides and herbicides, a huge range of organohalides and other chemical compounds, ,Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion byproducts, from storm water runoff, Volatile organic compounds, such as industrial solvents, from improper storage., Chlorinated solvents, which are dense non-aqueous phase liquids, may fall to the bottom of reservoirs, since they don't mix well with water and are denser, Polychlorinated biphenyl (PCBs), Trichloroethylene, Perchlorate. Various chemical compounds found in personal hygiene and cosmetic products, Drug pollution involving pharmaceutical drugs and their metabolites, this can include antidepressant drugs or hormonal medicines such as contraceptive pills. These molecules can be small and difficult for treatment plants to remove without expensive upgrades.

2.4 Pathogens

Disease-causing microorganisms are referred to as pathogens. Pathogens can produce waterborne diseases in either human or animal hosts.[25] Coliform bacteria, which are not an actual cause of disease, are commonly used as a bacterial indicator of water pollution. Other microorganisms sometimes found in contaminated surface waters that have caused human health problems include: Burkholderia pseudomallei, Cryptosporidium parvum, Giardia lamblia, Salmonella, Norovirus and other viruses, Parasitic worms including the Schistosoma type

2.5 Oxygen

Oxygen depleting substances may be natural materials such as plant matter (e.g. leaves and grass) as well as man-made chemicals. Other natural and anthropogenic substances may cause turbidity (cloudiness) which blocks light and disrupts plant growth, and clogs the gills of some fish species.[2]

Alteration of water's physical chemistry includes acidity (change in pH), electrical conductivity, temperature, and eutrophication. Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as anoxia (oxygen depletion) and severe reductions in water quality may occur, affecting fish and other animal populations.

3 DIFFERENT TYPES/CATEGORIES OF WATER POLLUTION

3.1 The Different Types of Water Pollution

- **Chemical pollution.**

The most common type of water pollution, chemicals can infiltrate both underground water sources and those sitting on the Earth's surface. ...

- **Groundwater pollution.** ...
  - Microbiological pollution. ...
  - Nutrient pollution. ...
  - Oxygen-depletion pollution.
  - Surface water pollution ...

3.2 Categories of Water Pollution

- **Surface water**. ...
- **Ocean water.** ...

- **Point source**

Point source is a pipe or channel, such as those used for discharge from an industrial facility or a city sewerage system. Point sources of water pollution are easier to control than dispersed sources because the contaminated water has been collected and conveyed to one single point where it can be treated.

- **Nonpoint source**

Nonpoint source is a very broad, unconfined area from which a variety of pollutants enter the water body, such as the runoff from an agricultural area. Pollution from dispersed sources is difficult to control, and, despite much progress in the building of modern sewage-treatment plants, dispersed sources continue to cause a large fraction of water pollution problems. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands.[3] Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest is also cited as examples of non-point source poletely.

- **Domestic sewage**

Domestic sewage is also a major source of plant nutrients, mainly nitrates and phosphates. Excess nitrates and phosphates in water promote the growth of algae, sometimes causing unusually dense and rapid growths known as Harmful Algal Blooms (HABs) that produce toxins associated with dementia, amnesia, neurological damage, and rapid death. When these algae die, dissolved oxygen in the water decreases because microorganisms use oxygen to digest algae during the process of decomposition (*see also* biochemical oxygen demand). Anaerobic organisms (organisms that do not require oxygen to live) then metabolize these organic wastes, releasing gases such as methane and hydrogen sulfide, which are harmful to the aerobic (oxygen-requiring) forms of life. The process by which a lake changes from a clean, clear condition—with a relatively low concentration of dissolved nutrients and a balanced aquatic community—to a nutrient-rich, algae-filled state and thence to an oxygen-deficient, waste-filled condition is called eutrophication. Eutrophication is a naturally occurring, slow, and inevitable process. However, when it is accelerated by human activity and water pollution (a phenomenon called cultural eutrophication), it can lead to the premature aging and death of a body of water).

- **Agriculture**

The agriculture industry is one of the biggest consumers of fresh water. In the U.S., it is responsible for around 80% of the nation's water consumption. Agriculture is also the main source of pollution in rivers and streams in the U.S. One way that agriculture causes water pollution is through rainwater. When it rains, pollutants, such as fertilizers, animal waste, and pesticides get washed from farms into waterways thereby contaminating the water. Contaminates from agriculture usually contain high amounts of phosphorous and nitrogen, which encourage the growth of algal blooms. These blooms produce toxins that kill fishes, seabirds, and marine mammals, as well as harming humans. Additionally, when these algal blooms die, bacteria produced as the algae decompose use up oxygen in the water. This lack of oxygen causes "dead zones" in the water where fishes cannot live or survive. The United Nations Educational, Scientific and Cultural Organization (UNESCO) estimate that there are roughly 245,000 square kilometers of dead zones globally.

- **Plastics and garbage**

Globally, it is estimated that 1.4 billion tons of waste is produced each year. Of this annual waste, 10% comprise plastics. Due to the widespread use of plastics, experts estimate that 4.8–12.7 million tons of waste enters the ocean each year. Plastic and garbage can enter the water in many ways such as debris falling off ships, trash blowing into the ocean, from landfills, garbage swept into the sea via rivers from people discarding used items such as food packages, and people throwing their trash on to the beach. Once in the water, these plastic and garbage can harm marine life and human health. Fish may eat trash, mistaken it for food, and end up dying. As these plastic slowly breaks apart into micro-plastics form that are less than 5 millimeters in size, fishes may consume them; Humans may in turn consume these fishes and end up coming down with serious medical conditions like cancer. The UN states that plastic debris in the ocean causes the deaths of over a million seabirds each year. Plastic debris is also responsible for the deaths of more than 100,000 marine mammals annually.

- **Oil**

Oil pollution can occur when oil tankers spill their cargo. However, oil can also enter the sea via factories, farms, and cities, as well as via the shipping industry. The transportation and storage of oil and its derivatives is subject to leakage that pollutes our water resources. Accidental oil spills are also a source of oil pollution—as in the devastating spills from the tanker *Exxon Valdez* (which released more than 260,000 barrels in Alaska's Prince William Sound in 1989) and from the Deepwater Horizon oil rig (which released more than 4 million barrels of oil into the Gulf of Mexico in 2010). Oil slicks eventually move toward shore, harming aquatic life and damaging recreation areas.

- **Radioactive waste**

Radioactive waste can endure in the environment for thousands of years, making safe disposal difficult. If improperly disposed of, it can enter the water, making it hazardous to humans, marine life, and the environment.

- **Groundwater**

Water contained in underground geologic formations called aquifers—is a source of drinking water for many people. For example, about half the people in the United

States depend on groundwater for their domestic water supply. Although groundwater may appear crystal clear (due to the natural filtration that occurs as it flows slowly through layers of soil), it may still be polluted by dissolved chemicals and by bacteria and viruses. Sources of chemical contaminants include poorly designed or poorly maintained subsurface sewage-disposal systems (e.g., septic tanks), industrial wastes disposed of in improperly lined or unlined landfills or lagoons, leachates from unlined municipal refuse landfills, mining and petroleum production, and leaking underground storage tanks below gasoline service stations. In coastal areas, increasing withdrawal of groundwater (due to urbanization and industrialization) can cause saltwater intrusion: as the water table drops, seawater is drawn into wells aquifer. The process of saltwater intrusion into a coastal aquifer depends on how much water has been removed from the freshwater aquifer. Aquifers whose waters are periodically recharged are able to keep salt water from intruding.

- **Fracking**

Fracking is the process of extracting oil or natural gas from rock. The technique uses large amounts of water and chemicals at high pressure to crack the rock. The fluid created by fracking contains contaminants that can pollute underground water supplies.

- **Deforestation**

Felling forests can exhaust water resources and generate organic residue which becomes a breeding ground for harmful bacteria. It can also lead to rising global temperatures caused by CO_2 emissions heat the water, reducing its oxygen content. Deforestation can also lead to sedimentation

- **Sediment**

Sediment (e.g., silt) resulting from soil erosion can be carried into water bodies by surface runoff. Suspended sediment interferes with the penetration of sunlight and upsets the ecological balance of a body of water. Also, it can disrupt the reproductive cycles of fish and other forms of life, and when it settles out of suspension it can smother bottom-dwelling organisms.

- **Thermal pollution**

Thermal pollution is the rise or fall in the temperature of a natural body of water caused by human influence. Thermal pollution, unlike chemical pollution, results in a change in the physical properties of water. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Elevated water temperatures decrease oxygen levels, which can kill fish and alter food chain composition, reduce species biodiversity, and foster invasion by new thermophilic species. Urban runoff may also elevate temperature in surface waters. Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers.

- **Industry**

Chemical dumping from these sectors is one of the main causes of eutrophication of water. Waste is considered toxic if it is poisonous, radioactive, explosive, carcinogenic (causing cancer), mutagenic (causing damage to chromosomes), teratogenic (causing birth defects), or bio accumulative (that is, increasing in concentration at the higher ends of food chains). Sources of toxic chemicals include improperly disposed wastewater from industrial plants and chemical process facilities (lead, mercury, chromium).

4 IMPACT OF POLLUTED WATER ON HUMAN HEALTH

4.1 Ingesting Micro-plastics

A person may ingest micro-plastics via drinking water or through eating contaminated seafood. At Tokyo Bay in 2016, scientists examined 64 anchovies for micro-plastic consumption: 77% had micro-plastics in their digestive systems. People have also discovered them within salt, beer, and other food items. Studies show micro-plastics may cause oxidative stress, inflammatory reactions, and metabolic disorders in humans. However, further research is needed to confirm these effects.

4.2 Consuming Water Contaminated by Sewage

The WHO note that, globally, around 2 billion people use a drinking water source with fecal contaminants. Contaminated water can harbor bacteria, such as those responsible for diarrhea, cholera, dysentery, typhoid, hepatitis A, and polio. According to the UN, every year, approximately 297,000 children under five die from diseases linked to poor sanitation, poor hygiene, or unsafe drinking water.

4.3 Drinking water containing chemical waste

Chemical pollutants, such as pesticides, fertilizers, and heavy metals can cause serious health problems if ingested. In 2014, residents in Flint, Michigan, experienced water contamination due to inadequate testing and treatment of their water supply. The contaminated water caused rashes, hair loss, and itchy skin. Lead levels in the bloodstream of children who drank the water doubled. A person who ingests chemical toxins in their water can be at risk of the following: cancer, hormone disruption, altered brain function, damage to immune and reproductive systems, and cardiovascular and kidney problems Swimming also in contaminated water can also trigger the following: rashes, pink eye, respiratory infections, and hepatitis.

4.4 Other Health Effects

Also, drinking water contaminated with arsenic, lead, hydraulic fracking chemicals, and pesticides can lead to the under listed medical conditions than can range from subtle to severe, depending on the chemical and total exposure.

Arsenic – a known human carcinogen associated with skin, lung, bladder, kidney, and liver cancer[3]

Lead – behavioral and developmental effects in children; and cardiovascular and kidney problems[4]

Hydraulic fracturing (fracking) chemicals – damage to the immune[5] and reproductive systems[6]
Pesticides – neurodevelopmental effects and Parkinson's disease[7]

5 CONTROL/TREATMENT OF WATER POLLUTION

5.1 Control of Water Pollution

Water pollution is measured by analyzing water samples. Physical, chemical and biological tests can be conducted. Control of water pollution requires appropriate infrastructure and management plans. The infrastructure may include wastewater treatment plants. Sewage treatment plants and industrial wastewater treatment plants are usually required to protect water bodies from untreated wastewater. Agricultural wastewater treatment for farms and erosion control at construction sites can also help prevent water pollution. Nature-based solutions are another approach to prevent water pollution. Effective control of urban runoff includes reducing speed and quantity of flow. In the United States, best management practices for water pollution include approaches to reduce the quantity of water and improve water quality.
In urban areas of developed countries, municipal wastewater (or sewage) is typically treated by centralized sewage treatment plants. Well-designed and properly operated systems (i.e., with secondary treatment steps or more advanced treatment) can remove 90 percent or more of the pollutant load in sewage. Some plants have additional systems to remove nutrients and pathogens, but these more advanced treatment steps get progressively more expensive.
Nature-based solutions are also being used instead of (or in combination with) centralized treatment plants.
Cities with sanitary sewer overflows or combined sewer overflows employ one or more engineering approaches to reduce discharges of untreated sewage, including: utilizing a green infrastructure approach to improve storm water management capacity throughout the system, and reduce the hydraulic overloading of the treatment plant.
Effective control of urban runoff involves reducing the velocity and flow of storm water, as well as reducing pollutant discharges. Local governments use a variety of storm water management techniques to reduce the effects of urban runoff. These techniques, called best management practices for water pollution (BMPs) in the U.S., may focus on water quantity control, while others focus on improving water quality, and some perform both functions.
Pollution prevention practices include low-impact development techniques, installation of green roofs and improved chemical handling (e.g. management of motor fuels & oil, fertilizers and pesticides). Runoff mitigation systems include infiltration basins, bioretention systems, constructed wetlands, retention basins and similar devices.
Thermal pollution from runoff can be controlled by storm water management facilities that absorb the runoff or direct it into groundwater, such as bioretention systems and infiltration basins. Retention basins tend to be less effective at reducing temperature, as the water may be heated by the sun before being discharged to a receiving stream.

5.2 Treatment of Wastewater

Wastewater treatment technologies are mainly classified as eco-technologies, activated sludge technologies, anaerobic technologies, biofilm technologies, advanced oxidation processes, and membrane technologies.
Complete treatment of effluents generated in the various chemical industry units in effluent treatment plant is essential and the principles of process intensification (PI) can be used for the effluent treatment. Several physical, chemical, and biological processes have been considered for treatment of wastewater obtained from chemical, biological, food, pharmaceutical, pulp and paper, dye and textile industries. The choice of methods for treatment of wastewater is based on the type, nature, and concentration of contaminants. The treated effluent should be eco-friendly and reusable
PI is the chemical engineering approach toward smaller, safer and cost-effective development in process industry which may be at the plant level or equipment level. This approach can be successfully implemented for the treatment of inorganic pollutants from wastewater. PI is used in chemical and allied industries to increase the output/efficiency of chemical units, reduce carbon footprint and wastes, increase plant safety, and decrease capital cost and energy consumption.

5.3 Industrial Wastewater Treatment

Some industrial facilities generate wastewater that is similar to domestic sewage and can be treated by sewage treatment plants. Industries that generate wastewater with high concentrations of organic matter (e.g. oil and grease), toxic pollutants (e.g. heavy metals, volatile organic compounds) or nutrients such as ammonia, need specialized treatment systems. Some industries install a pre-treatment system to remove some pollutants (e.g., toxic compounds), and then discharge the partially treated wastewater to the municipal sewer system. Industries generating large volumes of wastewater typically operate their own treatment systems.

5.4 Agricultural wastewater treatment

Regarding non-point sources, sediment (loose soil) washed off fields is the largest source of agricultural pollution in the United States. Nutrients (nitrogen and phosphorus) are typically applied to farmland as commercial fertilizer, animal manure, or spraying of municipal or industrial wastewater (effluent) or sludge. Nutrients may also enter

runoff from crop residues, irrigation water, wildlife, and atmospheric deposition. Farmers can develop and implement nutrient management plans to reduce excess application of nutrients and reduce the potential for nutrient pollution. To minimize pesticide impacts, farmers may use Integrated Pest Management (IPM) techniques (which can include biological pest control) to maintain control over pests, reduce reliance on chemical pesticides, and protect water quality. Farmers may, also, utilize erosion controls to reduce runoff flows and retain soil on their fields. Common techniques include contour plowing, crop mulching, crop rotation, planting perennial crops and installing riparian buffers. Farms with large livestock and poultry operations, such as factory farms, are often point source dischargers. These facilities are called "concentrated animal feeding operations" or "feedlots" in the US and are being subject to increasing government regulation. Animal slurries are usually treated by containment in anaerobic lagoons before disposal by spray or trickle application to grassland. Constructed wetlands are sometimes used to facilitate treatment of animal wastes. Some animal slurries are treated by mixing with straw and composted at high temperature to produce a bacteriologically sterile and friable manure for soil improvement.

5.5 Other Sundry Measures

Other sundry measures include reducing plastic usage and recycling plastics when possible, properly disposing of household chemicals, keeping up with the maintenance of their vehicle to ensure it is not leaking harmful substances, avoiding using pesticides, making sure to clean up dog waste, making sustainable choices regarding food and drinks, considering going vegan or vegetarian, reducing CO_2 emissions to prevent global warming and acidification of the oceans, reducing the use of chemical pesticides and nutrients on crops, restricting the use of single-use plastics that end up floating in rivers, lakes and oceans, many as micro-plastics, encouraging sustainable fishing to ensure the survival of species and avoid depletion of the seas, avoiding pouring fat from cooking or any other type of fat, oil, or grease down the sink, avoiding disposing of household chemicals or cleaning agents down the sink or toilet, and avoiding flushing pills, liquid or powder medications or drugs down the toilet.

6 CONCLUSIONS

Water pollution is a serious environmental issue that can be caused by many contaminants. These contaminants result mainly from the unchecked activities of humans, ranging from the discharge of untreated or partially treated domestic sewage, or agricultural wastes, or chemical wastes, or industrial wastes, or even radioactive substances into water bodies. When human beings get in contact with these pollutants either by consuming, entering, or washing in polluted water, they can come down with diseases like diarrhea, cholera, dysentery, typhoid, and poliomyelitis, cancers, hormone disruption, altered brain function, and other serious medical conditions. The main problem caused by water pollution is that it disrupts the natural food chain as well as kills organisms and animals like fishes, crabs, birds and seagulls, dolphins, and many other animals that depend on these water bodies for survival. It also destroys biodiversity, contaminates food chain, leads to insufficient potable water, causes diseases and infant mortality, and leads to economic downturn. Therefore, appropriate governmental agencies charged with the responsibilities of safeguarding water bodies should formula laws and policies that should stipulate the removal, at the source of production, most of these contaminants from the effluent before their eventual discharge into water bodies.

REFERENCES

[1] *West, Larry (March 26, 2006). "World Water Day: A Billion People Worldwide Lack Safe Drinking Water". About.com.*

[2] *Pink, Daniel H. (April 19, 2006). "Investing in Tomorrow's Liquid Gold". Yahoo. Archived from the original on April 23, 2006.*

[3] *Moss, Brian (2008). "Water Pollution by Agriculture". Phil. Trans. R. Soc. Lond. B. 363 (1491): 659–666. doi:10.1098/rstb.2007.2176. PMC 2610176. PMID 17666391.*

[4] *Goel, P.K. (2006). Water Pollution - Causes, Effects and Control. New Delhi: New Age International. p. 179. ISBN 978-81-224-1839-2.*

[5] *Laws, Edward A. (2018). Aquatic Pollution: An Introductory Text (4th ed.). Hoboken, NJ: John Wiley & Sons. ISBN 9781119304500.*

[6] UN-Water (2018) World Water Development Report 2018: Nature-based Solutions for Water, Geneva, Switzerland

[7] *"Ch. 5: Description and Performance of Storm Water Best Management Practices". Preliminary Data Summary of Urban Storm Water Best Management Practices (Report). Washington, DC: United States Environmental Protection Agency (EPA). August 1999. EPA-821-R-99-012.*

[8] *Kelland, Kate (October 19, 2017). "Study links pollution to millions of deaths worldwide". Reuters.*

[9]. *Global Oceanic Environmemtal Survey*. Retrieved *September 1,* 2019.

[10] *Resources". GOES Foundation*. Retrieved *September 10,* 2019.

[11] *Dryden, Howard. "We have 10 years to save the seas". Global Oceanic Environmental Survey*. Retrieved *September 1*, 2019.

[12] *An overview of diarrhea, symptoms, diagnosis and the costs of morbidity" (PDF). CHNRI. 2010. Archived from the original (PDF) on May 12, 2013.* ^ "China says water pollution so severe that cities could lack safe supplies". Chinadaily.com.cn. June 7, 2005.

[13] *Kahn, Joseph; Yardley, Jim (August 26, 2007). "As China Roars, Pollution Reaches Deadly Extremes". New York Times.*

[14] *Fact Sheet: 2004 National Water Quality Inventory Report to Congress (Report). EPA. January 2009. EPA 841-F-08-003.*

[15] *Nemecek, T.; Poore, J. (June 1, 2018). "Reducing food's environmental impacts through producers and consumers". Science.360(6392):987:2018Sci...360..987P.doi:10.1126/science.aaq0216.ISSN 0036-8075. PMID 29853680.* ^ *Jambeck, Jenna R.; Geyer, Roland; Wilcox, Chris (February 12, 2015). "Plastic waste inputs from land into the ocean" (PDF). Science.347(6223):769.Bibcode:2015Sci...347..768J.:10.1126/science.1260352. PMID 25678662. S2CID 206562155*. Retrieved *August 28*, 2018.

[16] *Christian Schmidt; Tobias Krauth; Stephan Wagner (October 11, 2017). "Export of Plastic Debris by Rivers into the Sea" (PDF). Environmental Science & Technology. 51 (21): 12246–12253.Bibcode:2017EnST...5112246S. doi:10.1021/acs.est.7b02368. PMID 29019247. The 10 top-ranked rivers transport 88–95% of the global load into the sea*

[17] *Harald Franzen (November 30, 2017). "Almost all plastic in the ocean comes from just 10 rivers". Deutsche Welle*. Retrieved *December 18*, 2018. *It turns out that about 90 percent of all the plastic that reaches the world's oceans gets flushed through just 10 rivers: The Yangtze, the Indus, Yellow River, Hai River, the Nile, the Ganges, Pearl River, Amur River, the Niger, and the Mekong (in that order).*

[18] *Zaikab, Gwyneth Dickey (March 28, 2011). "Marine microbes digest plastic". Nature. doi:10.1038/news.2011.191. ISSN 0028-0836.*

[19] *Ground Water and Surface Water: A Single Resource (Report). Denver, CO: United States Geological Survey (USGS). 1998. Circular 1139.*

[20] United States. Clean Water Act (CWA), section 502(14), 33 U.S.C. § 1362 (14).

[20] U.S. CWA section 402(p), 33 U.S.C. § 1342(p)
EPA. "Protecting Water Quality from Agricultural Runoff." Fact Sheet No. EPA-841-F-05-001. March 2005.
25 ^ *Harrison, Roy M., ed. (2001). Pollution: Causes,Efects and Control (4th ed.). Cambridge, UK: Royal Society of Chemistry. p. 60. ISBN 0-85404-621-6.* ^ USGS. Reston, VA. "A Primer on Water Quality."