Source of Water Pollution

Subjects: Water Resources

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Water pollution is a severe health concern. Several studies have recently demonstrated the efficacy of various approaches for treating wastewater from anthropogenic activities. Wastewater treatment is an artificial procedure that removes contaminants and impurities from wastewater or sewage before discharging the effluent back into the environment. It can also be recycled by being further treated or polished to provide safe quality water for use, such as potable water.

Keywords: water pollution ; precipitation ; adsorption ; membrane

1. Introduction

There are generally three types of wastewater or sewage: domestic, industrial, and storm sewage [1]. Domestic wastewater, also called sanitary sewage, is wastewater either from blackwater (wastewater from toilets that contain feces, urine, or toilet paper) or greywater (water from sinks, baths, washing machines, and others) [2].

Pollution and exorbitant use seriously compromise the availability of fresh and clean water around the earth and may cause a critical impact in the future. It is mandatory to protect and produce healthy water of sufficient quality at an economical cost while conserving the ecosystems. Every country will release liquid and air emissions and solid wastes. Wastewater is essentially the water supply that comes from the people in the city after it has been used in various applications [3].

From a practical standpoint, wastewater includes dissolved and suspended organic solids. These are waste that contains organic matter capable of decomposition by microorganisms and of such a character and proportion that causes odors and the capability to attract or provide food for ecosystems like birds and other animals. Another principal physical characteristic of wastewater can be defined by its color and temperature [4]. The color function explains the basic condition of wastewater. Wastewater with the color light brown is less than 6 h old, while light to medium grey color is wastewater that has been processed in the collection system. Finally, the wastewater is typically septic, undergoing immeasurable germs decomposition under anaerobic conditions if the color is dark grey or black. Next, the wastewater temperature is frequently higher than that of the water supply because warm municipal water has been added. The temperature of wastewater will vary from different weather and also with geographical locations.

2. Classification of Water Pollutants

Wastewater consists primarily of water with the remaining solid, which can be in either dissolved solid or suspended solid form that may be classified as organic, inorganic, and biological [5]. In addition, there are also thermal and radioactive pollutants discharged from power plants, nuclear plants, and industries where water is used as a coolant, mining, etc. [6]. The types of contaminants found in the wastewater depend on the activities that release municipal, industrial, or agricultural wastewater. The four main types of water contaminants are suspended solids, microorganisms, and organic and inorganic pollutants. These contaminants in the water continue to exist in solvated, colloidal, or suspended forms.

2.1. Organic Pollutants

The organic matter in municipal wastewater originates primarily from residential and commercial food processing and urine and feces [7]. This pollutant, with a considerable concentration of biodegradable organic compounds, undergoes degradation and decomposition by bacterial activity [8]. Wastewater is processed by biological treatment to remove organic matter. However, approximately 30% of the organic matter is still not biodegradable and must be disposed of as waste sludge [9].

Some contaminants include synthetic pesticides, detergents, food additives, medicines, insecticides, paints, synthetic textiles, plastics, solvents, and volatile organic compounds [10]. There are also synthetic organic compounds found in wastewater due to various artificial activities such as agricultural and industrial activities. For instance, the wastewater discharged by the food industry may contain complex organic pollutants with a high concentration of BOD, and the coke plant wastewater may contain various polynuclear hydrocarbons. The wastewater of the chemical industry may contain various carcinogenic compounds like PCB (polychlorinated biphenyls, widely used as coolant fluids). The wastewater of the farmland may contain a high concentration of pesticides or herbicides [11]. Most toxic synthetic organic pollutants are resistant to decomposition by ordinary biological mechanisms. Carcinogenic PCB has been widely used in industries since the 1930s. It is fat-soluble and moves easily through the environment and within the tissues and cells with high stability to chemical reagents [12].

In addition, an oil complex mixture of hydrocarbons and degradable under bacteria action is also considered one of the organic pollutants [13]. Oil may enter the water body through oil spills, leakage of oil pipes, and wastewater produced from refineries and production factories. With a density lesser than water, it may spread over the surface of the water body, resulting in a decrease of dissolved oxygen and reduction of light transmission through the water surface and affecting the life of aquatic flora and fauna.

The two primary techniques used to determine the amount of organic matter are chemical oxygen demand (COD) and biochemical oxygen demand (BOD). One of the most crucial factors in the design and operation of sewage treatment facilities is the BOD, which measures the biodegradability of organic matter. Industrial sewage may have BOD levels many times than domestic sewage. Dissolved oxygen (DO) is an important water quality factor for lakes and rivers. The higher the concentration of DO, the better the water quality. When sewage enters a water body, decomposition of the organic matter begins as organic matter is served as food in the microorganism metabolism process. The microorganism's population will grow and lead to the increase in consumption of DO in the water body, which next may then affect the aquatic living organisms. A decrease of dissolved oxygen below 4.0 mg/L is considered pollution [14].

2.2. Inorganic Pollutants

Water quality is established and controlled by several inorganic components that are present in both natural and effluent. Natural water dissolves rocks and minerals with which they come in contact. Much of the inorganic matter in natural waters is also in wastewater. However, much of the inorganic matter is added via human activity, such as nitrite ions [15].

The inorganic pollutants include mineral acids, inorganic salts, trace elements, nitrates, phosphates, sulfates, fluorides, chlorides, oxalates, cyanides, etc. [16]. For example, municipal wastewater may contain excessive nitrates and phosphorus from phosphate builders in detergents [17][18]. The high phosphorus content may lead to the eutrophication of water bodies. The rapid growth of algae in the lake is harmful and has a negative effect on the entire food chain, as some of these algae may produce toxins. Another example of an inorganic pollutant is sulfate, where its ion in wastewater may reduce biologically to sulfide. It then combines with hydrogen to form hydrogen sulfide (H_2S), which is toxic to animals and plants. Toxic inorganic compounds such as copper, lead, silver, arsenic, boron, and chromium are classified as priority pollutants and are toxic to microorganisms [19][20]. These pollutants can kill off the microorganism needed for biological treatment in the wastewater treatment process.

The most prevalent inorganic water contaminants are also heavy metals. They are very poisonous, naturally carcinogenic, non-biodegradable, and may linger in the environment and food supply. The removal of heavy metal ions from diverse wastewater sources has been addressed using various approaches [21]. These procedures might be divided into categories such as adsorption, membrane-, chemical-, electric-, and photocatalytic-based therapy [22]. Among the heavy metals with a high atomic mass are plutonium, mercury, lead, cadmium, zinc, arsenic, and chromium. There is no safe amount of exposure to lead since it is a hazardous metal that originates through the exhaust of vehicles that use leaded gasoline [23]. **Table 1** shows some typical heavy metals in wastewater that affect human health.

Table 1. Common heavy metals found in wastewater, their origins, and the health problems they cause [22].

Heavy Metal	Main Sources	Main Organ and System Affected
Lead (Pb)	**Lead-based batteries, leaded gasoline, alloys, cable sheathing pigments, rust inhibitors, ammunition, glazes, and plastic stabilizers.**	**Bones, liver, kidneys, brain, lungs, spleen. Immunological, hematological, cardiovascular, reproductive system.**

Heavy Metal	Main Sources	Main Organ and System Affected
Arsenic (As)	Electronics and glass production.	Skin, lungs, brain, kidneys. Metabolic, cardiovascular, immunological, and endocrine systems.
Copper (Cu)	Corroded plumbing systems, electronic and cables industry.	Liver, brain, kidneys, cornea. Gastrointestinal, lungs, immunological, hematological system.
Zinc (Zn)	Brass coating, rubber products, some cosmetics, and aerosol deodorants.	Stomach cramps, skin irritations, vomiting, nausea, anemia, and convulsions.
Chromium (Cr)	Steel and pulp mills and tanneries.	Skin, lungs, kidneys, liver, brain, pancreas. Tastes, gastrointestinal, reproductive system
Cadmium (Cd)	Batteries, paints, steel industry, plastic industries, metal refineries, and corroded galvanized pipes.	Bones, liver, kidneys, lungs, testes, brain. Immunological, cardiovascular system.
Mercury (Hg)	Electrolytic production of chlorine and caustic soda, runoff from landfills and agriculture, electrical appliances, Industrial and control instruments, laboratory apparatus, and refineries.	Brain, lungs, kidneys, liver. Immunological, cardiovascular, endocrine, and reproductive systems.
Nickel (Ni)	Manufacturing of nickel alloys and stainless steel.	Kidney, pulmonary fibrosis, gastrointestinal problems, lung, and skin.

2.3. Microbes/Pathogens

Cholera, typhoid, polio, and hepatitis are examples of water-borne illnesses that can be spread by pathogenic microorganisms that enter a body of water by sewage discharge or through businesses like slaughterhouses [24][25]. Different kinds of bacteria that thrive in sewage might cause many ailments. Salmonella-causing bacteria, hepatitis A viruses, protozoa, fungus, algae, plankton, amoebas, and other worms like hookworm and whipworm are among the potentially dangerous germs. Escherichia coli, an intestinal bacterium secreted by all warm-blooded animals, is also measured to determine the presence of fecal contamination [26].

2.4. Suspended Solid and Sediments

Suspended solid normally is the first item to be extracted from wastewater at the beginning of the treatment plant through the screening process [27]. Items such as wet wipes, diapers, sanitary napkins, expired medication, medical packaging, and other items are flushed into the toilet even at the risk of causing blockages. Trash and garbage in the street may also be carried to the combined sewer system by stormwater runoff [28]. Industrial and storm sewage may contain more suspended solid waste than domestic sewage. In addition, the treatment plant's effectiveness in removing suspended solids also determines the efficiency of the treatment process [29].

3. Source of Pollution

3.1. Urban Pollution

Urban can be defined as the association of massively populated cities and the surrounding areas. From the definition, the crucial key of a city is that it has a lot of people, buildings, structures, and infrastructures. The smaller centered areas in the city, such as the waterways, will be affected and cause a negative impact on the environment since all people in the city share the same residential area, air, and water. Water resources in urban areas need to receive a lot of pollutants from various sources. For example, effluents from industry, vehicle sources such as oil, wastewater from housing, garbage, and rainwater are polluted due to urban landscapes [30].

The problems with the urban water can be described as 'too little, too much, too dirty.' This is because the populated areas have people intervene at high levels in the natural hydrological cycles to keep up with the water supply and storm water management. The systems for urban water are interconnecting with various systems; thus, it gets an impact indirectly and causes water issues that will also affect other problems [31].

As mentioned, there are a few sources of urban pollution, one of which is anthropogenic activities. Examples of anthropogenic activities are vehicle transportation and washing building surfaces. Based on a previous study, vehicle operation is the main cause of environmental pollution [32]. The operation includes the exhaust, fluid leakages, and washing vehicle. Exhaust gas from vehicles releases pollutants such as hydrocarbons from internal combustion engines. The leakages of the automotive fluids and the oil for the engine were reported to be likely the cause of BTEX pollutants. Other than that, washing vehicles also contribute to various chemical discharges and particles that attach to the car [33].

3.2. Agricultural Pollution

Agriculture can be expressed as the action of farming, working on the soil to produce a variety of plants, breeding livestock, and diverting the levels of preparation and marketing of the product produced. Agricultural activities have been done for thousands of years using the natural process, which does not affect soil fertility. Despite that, the current implementation of agriculture activities has been causing environmental pollution, unlike the previous agriculture practices [15][34]. This has caused the deterioration of the environment, land, and ecosystem.

The water pollution issues in agriculture modern practices are happening globally. It contemplates the possibilities of the growth of the human population and food demand increases. The result is estimated that the livestock demand will increase, mass production will occur, and the use of chemicals will intensify [35].

There are a few elements that cause water pollution from agricultural activities. The first is the soil fertilizers, be they artificial or organic; both fertilizers cause water contamination and affect aquatic ecosystems [15]. The content of nutrient in the fertilizers that helps fertilize the plants, lawns, and golf fields cause the immediate growth of algae. These algae are also known as an algal bloom, and when these algae die, they feed on the bacteria. The bacteria then will conquer the freshwater and causes the degradation of oxygen which reduce the survival rate of fish and plants in the water [36]. Furthermore, some algae can also produce toxins that can be dangerous to humans.

Apart from fertilizers, pesticides are also widely used in modern agricultural practices. The chemicals in pesticides are very toxic to insects but less toxic to mammals [37]. Based on a previous study, the substantial use of pesticides has contaminated the soil and drinking water in Central Asia. The dichlorodiphenyltrichloroethane (DDT) and lindane of organohalogen pesticides (OCPs) have been discovered in the water samples of the river. Four water samples were taken in the area where pesticides were applied. The results show that the OCPs found in the samples are hexachlorocyclohexane (HCH), DDT, and dichlorodiphenyldichloroethylene (DDE). These OCPs have been washed out from the soil and flow into the water [38].

3.3. Industrial Pollution

A large-scale business that produces goods is often correlated with the meaning of the industrial. About 19 percent of water was pulled out to be used for industrial purposes globally. For the past years until now, the industry has extensively influenced water pollution because it produces very dangerous contaminants to human beings and the environment [39]. The ecological environment in China has been facing serious impairment, particularly water pollution due to industrial activities. In addition, the physical and mental health, quality of life, and productivity of the citizens in China are also affected [40].

Some pollutants come from industrial activities, and one of them is oil. The petroleum industry is one of the major contributors towards the surface water and groundwater pollution. There are refineries that operate deep-injection wells to get rid of the wastewater produced in the plants, and some of the unusable water ends up in the groundwater [41]. The wastewater produced at the refineries is possibly greatly contaminated by looking at the total sources in contact with the procedure of the refinery. Polluted wastewater might be the product of desalting, cooling tower water, distillation water, or cracking [42].

Besides the petroleum industry, the radioactive industry also has a huge imprint on the water contamination issue. The atom is usually illustrated as the center of the nucleus with several electrons that rotate like the earth’s orbit around the sun. It comprises comparatively higher protons that convey the positive electrostatic and neutrons that have no charge. If the nucleus is unstable, it is not balanced, and the atoms can be radioactive. In order to get the internal balanced, the nucleus will give out alpha or beta particles, or also can be gamma radiation, or both. [43]. Radioactivity can affect drinking water by the occurrence when groundwater moves through the soil that contains radionuclides. This is because some areas are vulnerable to pollution when the soils and rocks are rich in phosphate. The contaminants from radionuclides in drinking water can result in bone radium concentrates, and cancers and are toxic to kidneys [44].

4. Wastewater Treatment Technology

Wastewater treatment can be divided into several units of operations or processes that are selected and combined to serve its designed purposes and cater to the area under its consideration. In general, it may be separated into primary, secondary, and tertiary treatments [45].

While secondary treatment focuses on the biological treatment of wastewater, primary treatment entails first purifying procedures of a physical and chemical character. Effluent that is low in solids and organics after the primary and secondary process is fit to discharge back into the receiving water after it has been treated. These include chlorination, UV treatment, or a range of filtration options that aim to disinfect, remove the nutrients, or alter the pH after considering the receiving environment for the effluent. In tertiary treatment processes, most pollutants are removed and wastewater is converted into safe quality water suitable for human consumption, industrial, medicinal, etc. supplies [46].

In a full water treatment plant, the units from all three of these processes are chosen and integrated to create high-quality, safe water while also considering total cost, including building operation and maintenance expenses [47][48]. The overall scheme of wastewater technologies and sludge treatment is summarized in **Table 2** below.

Table 2. Overall scheme of wastewater treatment technologies.

Primary	Secondary	Tertiary	Sludge Treatment and Disposal
-Screening -Centrifugal separation -Coagulation & flocculation -Floatation -Sedimentation, gravity separation	-Aerobic -Anaerobic -Encapsulation	-Oxidation/Advanced oxidation -Adsorption -Micro and ultra-filtration -Membrane bioreactor (MBR) -Reverse osmosis -Electrolysis -Electrodialysis -Precipitation -Distillation -Ion exchange -Crystallization -Evaporation -Solvent extraction	-Thickening -Digestion -Dewatering -Disposal

There are several techniques in use, and **Table 3** lists several regularly employed techniques for heavy metal removal [49]. **Table 3** compares several methods for removing heavy metals from wastewater.

Table 3. Comparison of technologies for heavy metal removal from wastewater.

Method	Advantage	Disadvantage	Reference
Chemical precipitation	Simple/Inexpensive The majority of metals can be eliminated.	Significant sludge production led to disposal issues	[15]
Chemical coagulation	Dewatering and Sludge settling	High price, large chemical use	[50]
Ion—exchange	high rate of material regeneration a metal-specific	High price fewer metal ions are eliminated	[51]
Electrochemical Method	a metal-specific No chemical consumption Pure metals are attainable.	capital coat high high ongoing expenses the pH of the starting solution and current density	[52]
Adsorption Using activated carbon	Most metals are easily removed. high effectiveness (99%)	Activated carbon price lacking regeneration Performance is influenced by the adsorbent	[18]
Using natural zeolite	Metals may generally be removed. reasonably affordable materials	low effectiveness	[53]

Method	Advantage	Disadvantage	Reference
Membrane process and ultrafiltration	**created a less solid waste less use of chemicals high effectiveness (>95% for a single metal)**	**high start-up and operating costs minimal flow rates Removal (9%) falls off when additional metals are present.**	**[8]**

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