Research progress on the hazards and control of water pollution

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Abstract:

With the development of society, water pollution has become a hot topic and attracted human attention. In this paper, the present situation of water resource pollution and its treatment methods are reviewed. At present, the main sources of water pollution are point sources and non-point sources. In addition, the current main governance methods are ozone treatment, sustainable agriculture and reducing plastic waste, denitrification, and adsorption. The increasing contamination of water sources is causing pure water to become increasingly scarce with each passing day. This passage focuses on the source and hazards of water pollution, the present solution, and the future prospect of water pollution. What's more, this passage hopes that more people will know the dangers caused by water pollution. Also, let people learn some solutions to water pollution. This paper can effectively promote the development of water pollution control through the summary and discussion of the current research on water pollution control.

Keywords: Water pollution; harm; treatment.

1. Introduction

Water, as a fundamental component of natural resources, serves as the essential foundation for human activities and existence, ensuring the sustainable progress of society.The agricultural sector is a primary consumer of water resources. Water plays a crucial role in crop irrigation and sustaining livestock. Various methods like irrigation systems, spraying, flooding, and reliance on natural rainfall support agricultural practices. Reservoirs, canals, and wells serve as vital water sources for farming activities. Additionally, fisheries and open-water seafood harvesting demonstrate water's integral role in agriculture.

However, because of the rapid development of the technology and urbanization, there is a serious water scarcity and water pollution which appear nowadays. Residents' health and livelihoods have faced a devastating impact because of the unsanitary water. Additionally, water contamination also harms the ecological capacity to sustain life, resulting in issues like ecosystem acidification, eutrophication, and the decline of aquatic biodiversity. The surface water environment represents a critical focal point for controlling water pollution. The persistent issue of health risks associated with surface water pollution, notably the threat of carcinogens, has posed a longstanding challenge.

Multi-pollutant issues are also documented in numerous rivers across North America and Europe, partic-

ularly prevalent in densely populated regions. Looking ahead, food production could introduce additional contaminants into aquatic ecosystems, affecting both society (e.g., diarrhoea due to pathogen pollution) and the environment (e.g., detrimental algae blooms resulting from excessive nutrients) [1]. Various studies vary in their approaches to address water pollution stemming from food production.

Toxic waste is classified as harmful if it exhibits traits such as being poisonous, radioactive, explosive, carcinogenic (causing cancer), mutagenic (causing chromosome damage), teratogenic (causing birth defects), or bioaccumulative (increasing in concentration at higher levels of food chains). Sources of toxic chemicals include improperly disposed wastewater from industrial plants and chemical processing facilities (e.g., lead, mercury, chromium), as well as surface runoff containing pesticides used in agricultural areas and suburban lawns (e.g., chlordane, dieldrin, heptachlor). For a more extensive discussion on toxic chemicals, refer to information on poisons and toxic waste. The only way to make sure water is free of toxic chemicals is to prevent pollution at the source. If you think your water is contaminated, you can organize your community to map water sources and find problems with your water supply, and then to take steps to stop the pollution.

Rapid urbanization and industrialization have become closely intertwined with water usage and the generation of wastewater. Extracting resources from industrial wastewater has proven to be a valuable source of secondary raw materials, offering economic benefits, contributing to a clean and sustainable environment, and aiding in the achievement of sustainable development goals (SDGs) [2]. However, treating industrial wastewater for resource reuse poses challenges for decision-makers due to various obstacles and constraints, including inefficient treatment methods, high costs, inadequate infrastructure, limited financial support, and a lack of technical expertise.

Concepts like the circular economy (CE), partitions-release-recover (PRR), and the transformation of wastewater into bio-factories are expected to offer more viable solutions for addressing the challenges posed by industrial wastewater. These approaches have the potential to promote sustainable practices and mitigate the impact of industrial wastewater on the environment and public health [3]. Therefore, the present situation and treatment methods of water pollution are summarized in this paper, which is conducive to the treatment of water pollution.

2. Sources of water pollution

Water pollution can arise from two main sources: point source and non-point source. Point sources of pollution

are characterized by identifiable origins, such as pipes connected to factories, oil spills from tankers, and effluents discharged from industries like wastewater effluents (both municipal and industrial) and storm sewer discharges. These sources primarily affect the immediate surrounding areas.

Non-point sources of pollution, on the other hand, stem from various origins, with contaminants entering groundwater or surface water through multiple pathways from unidentifiable sources. Examples include runoff from agricultural fields and urban waste. Occasionally, pollution originating in a specific location can have extensive effects, spanning hundreds or even thousands of miles—a phenomenon known as transboundary pollution. For instance, radioactive waste can travel through oceans from nuclear reprocessing plants to neighboring countries.

Water pollutants can be classified into two main categories: organic and inorganic water pollutants. Organic water pollutants: These include insecticides, herbicides, organohalides, and various chemicals; bacteria from sewage and livestock farming; waste from food processing; pathogens; volatile organic compounds, and more. Inorganic water pollutants: These pollutants can originate from heavy metals found in acid mine drainage; silt from surface runoff, logging, slash-and-burn practices, and landfills; fertilizers from agricultural runoff containing nitrates and phosphates; and chemical waste from industrial effluents [4].

3. hazards of water pollution

Geogenic contamination sources, stemming from the geological composition of aquifers in certain regions, are a significant issue leading to the leaching of toxic elements into drinking water supplies. Elements of particular concern include arsenic, fluoride, selenium, chromium, and uranium. Among these geogenic contaminants, arsenic stands out due to its severe negative health impacts and global significance.

Bangladesh, for instance, faces a critical challenge with arsenic-contaminated groundwater affecting between 35 and 75 million individuals. Similarly, around 6 million people in West Bengal, India, are at risk. Regions such as the densely populated river deltas in Cambodia and Vietnam also experience significant concerns regarding arsenic contamination.

The problem of arsenic poisoning has emerged over the past decade in these regions as efforts were made to ensure safe drinking water. Prior to the 1970s, many inhabitants in rural areas relied on untreated water sources like rivers and ponds, which often carried infectious diseases. The alarming mortality rate, with up to 250,000 children per year in Bangladesh alone, prompted large-scale initia-

tives to install groundwater wells for safe drinking water access. Presently, over 95% of the population in these regions utilizes groundwater from approximately 10 million tube wells. However, about 60% of these wells along the Ganges-Brahmaputra River system in Bangladesh exceed the arsenic limit set by the World Health Organization.

Arsenic pollution is not confined to these regions alone; it is also a concern in other parts of the world, including the United States and Eastern Europe [5].

Chronic arsenic poisoning can lead to the accumulation of the element in the skin, hair, and nails, resulting in symptoms like pronounced pigmentation of the hands and feet (keratosis), high blood pressure, and neurological dysfunctions. Additionally, arsenic exposure poses a carcinogenic risk, increasing the likelihood of developing cancers affecting the skin, lungs, and other internal organs.

Mercury is utilized in various industries such as smelting, battery manufacturing, thermometer production, and in the creation of pesticides and fungicides. One of the most infamous instances of mercury pollution in the oceans dates back to 1938 when a Japanese factory discharged a substantial amount of mercury into Minamata Bay, ultimately contaminating the fish populations in the area. The effects of this contamination took several years to become apparent. By the time the impacts were evident, many local residents had consumed the contaminated fish, leading to around 2000 individuals being poisoned, with hundreds suffering fatalities or disabilities, as documented by Akio in 1992. This tragic event was termed "Minamata disease," attributed to the ingestion of fish laden with methyl mercury, which induces chromosomal abnormalities and neurological harm in humans.

Mercury demonstrates biological magnification within aquatic ecosystems. Cadmium, on the other hand, enters the human body through food crops grown in soil irrigated by contaminated effluents. In a study by Friberg et al. in 1974, it was observed that prolonged consumption of rice cultivated in affected fields by residents in regions of Japan contaminated with cadmium resulted in numerous renal diseases such as "itai-itai disease," nephritis, and nephrosis.

4. solution

Wastewater treatment is a crucial process designed to eliminate contaminants from wastewater, transforming it into an effluent suitable for reintroduction into the water cycle. This treated effluent not only ensures a minimal impact on the environment but also opens avenues for potential reuse, a practice known as water reclamation. This intricate process transpires in specialized facilities known as wastewater treatment plants, tailored to handle various types of wastewaters.

4.1 domestic wastewater

For domestic wastewater, the designated treatment plant is referred to as a Sewage Treatment Plant, synonymous with Municipal wastewater or sewage treatment. Industrial wastewater, on the other hand, undergoes treatment in either Industrial wastewater treatment facilities or in conjunction with sewage treatment plants post pre-treatment. Other specialized wastewater treatment plants include Agricultural wastewater treatment and leachate treatment plants, each catering to specific wastewater compositions. A fundamental practice within wastewater treatment is phase separation, exemplified by sedimentation processes. Additionally, biological and chemical methodologies, such as oxidation, play significant roles in the treatment process, alongside polishing techniques. The resulting by-product from these treatment plants typically manifests as a type of sludge, often requiring further treatment within the same facility or another wastewater treatment plant. In instances where anaerobic treatment is employed, biogas can emerge as another valuable by-product. The treated wastewater, known as reclaimed water, holds potential for reuse in various applications. The primary objective of wastewater treatment is to render the treated effluent safe for disposal or reuse. Prior to treatment, careful consideration of disposal or reuse options is imperative to ensure the selection of the most appropriate treatment processes for the specific characteristics of the wastewater at hand.

4.2 sustainable agriculture

In sustainable agriculture, addressing the contamination of surface water and groundwater is a critical objective. Large-scale agricultural operations often generate pollutants such as agrochemical runoff and pathogen-laden animal waste, which infiltrate water bodies, posing a threat to the ecosystem and human health[6]. Soil erosion further compounds the issue by compromising water quality and diminishing the availability of fertile topsoil, ultimately reducing crop productivity and arable land. To mitigate these detrimental impacts, farmers can adopt practices that minimize pollution and soil degradation. Techniques such as reducing tillage frequency and intensity, or transitioning to no-till methods, can help preserve soil structure and prevent erosion. When applying fertilizers and pesticides—be they organic or synthetic—farmers should exercise restraint, using them sparingly and preferably during dry conditions to curtail runoff. Prudent management of agricultural chemicals not only safeguards water quality but also minimizes air pollution stemming from airborne drift. Moreover, strategic planting of buffer vegetation

along waterways can serve as a natural filter, absorbing excess nutrients before they leach into aquatic environments. This proactive measure acts as a protective barrier, intercepting pollutants and fostering a healthier balance within ecosystems. By embracing these sustainable practices, farmers play a pivotal role in safeguarding water resources, promoting environmental health, and ensuring the long-term viability of agricultural landscapes.

4.3 reducing plastic waste

In the marine, there are a lot of plastic bottles or microplastic which strongly affect animals' life. What's more, it would affect human too. Since, the microplastic would transfer from the food chain to the human body, which will cause a huge health problem to them. To combat plastic pollution, it is crucial to minimize the use of single-use

plastics [7]. Advocate for legislation that restricts plastic production and waste. Ensure proper recycling practices are followed. Engage in beach or river clean-up initiatives to directly tackle plastic waste in natural environments. Steer clear of products containing harmful microbeads to prevent further contamination. Educate others about the importance of reducing plastic consumption. Back organizations dedicated to combating plastic pollution. Additionally, enhance wastewater management by investing in sustainable infrastructure that reduces plastic and chemical discharge into water bodies, safeguarding aquatic ecosystems and public health. By collectively embracing these actions, we can make significant strides in mitigating plastic pollution and preserving our planet for future generations.

Fig.1 water pollution status[8]

4.4 Denitrification

Denitrification plays a crucial role in ecosystem balance by addressing high nitrate levels in water. Elevated nitrate concentrations can lead to eutrophication, fostering excessive growth of algae and phytoplankton due to runoff, ultimately deteriorating water quality and exacerbating pollution concerns.

By facilitating the direct conversion of nitrates into nitrogen gas, denitrification effectively curtails the leaching of nitrates into soils. This process not only aids in mitigating groundwater contamination but also helps maintain a harmonious nitrogen cycle within ecosystems. By reducing nitrate levels in water bodies, denitrification contributes to the preservation of water quality, supporting the overall health and sustainability of aquatic environments.

4.5 Ozone water treatment

When ozone is utilized in gas form for drinking water treatment, its primary advantage lies in its potent oxidative properties. This strength enables ozone to effectively reduce or eliminate color, aftertaste, and odor in water. Crucially, ozone exhibits exceptional efficacy in swiftly eradicating bacteria and rendering viruses inactive, surpassing other disinfectants in speed and efficiency [9].

Moreover, ozone proves invaluable in oxidizing heavy metals present in water sources. By utilizing ozone oxidation, iron and manganese levels can be lowered to safe thresholds in water supplies. This process also aids in releasing organically bound heavy metals that are otherwise challenging to eliminate. Strategic application of ozone at the initial stages of water treatment prevents the formation

of halogenated compounds like Trihalomethanes (THMs), typically generated when chlorine interacts with water containing humic substances. Ozone, unlike chlorine, does not lead to THM formation, making it a preferred oxidant in later treatment stages. Globally, over 2,000 facilities leverage ozone for drinking water treatment, showcasing its effectiveness in disinfecting both municipal and industrial wastewater to comply with EPA regulations. Ozone's versatility extends to combatting various complex and toxic chemicals, although in some cases, coupling ozone treatment with ultraviolet light or ultrasound may enhance its efficacy by extending reaction times. The required ozone quantities and contact durations vary based on the chemical compound being targeted. In the late 1970s and early 1980s, the United States spearheaded the use of ozone for wastewater treatment, primarily for disinfection purposes. This approach is resurfacing as a viable alternative to chlorine as the primary disinfectant, emphasizing ozone's enduring relevance and potential in advancing water treatment practices.

4.6 plant some trees

Deforestation stands out as a significant contributor to water pollution, highlighting the pivotal role that healthy forests play in maintaining water quality. Forests function as natural filters that prevent pollutants from entering water bodies, stabilize soil to prevent erosion, and aid in nutrient absorption.Trees play a crucial role in safeguarding water quality by intercepting, storing, and utilizing rainfall, thereby reducing runoff that carries contaminants into rivers and lakes. By moderating stormwater flow, trees also help alleviate pressure on local storm sewers, mitigating the risk of flooding and pollution discharge.Planting trees emerges as a powerful strategy to combat water pollution. Urban areas, in particular, benefit from a robust tree canopy, which not only enhances aesthetics but also provides essential ecosystem services. Trees offer additional advantages such as regulating building temperatures, purifying air, and fostering biodiversity.

4.7 Adsorption

Adsorption, a widely recognized water treatment technology, involves the use of activated carbon as a versatile adsorbent to capture hazardous metal ions from various water sources, including ground, surface, and wastewater. This method proves effective in removing a range of pollutants, particularly dissolved impurities that can cause discoloration in water, thereby reducing or eliminating impurity concentrations. Activated carbon stands out as a common adsorbent utilized in adsorption processes for pollutant remove [10].

5. The prospect of water pollution control

The objective of Wastewater Treatment Plants (WWTPs) extends beyond pollutant removal to encompass the recovery of energy and resources simultaneously. Municipal wastewater contains organic matter, a valuable energy source estimated to have a modest Chemical Oxygen Demand (COD) of around 13–14 kJ per gram[5]. Currently, much of this energy potential is squandered through direct mineralization in conventional bioprocesses. Introducing carbon capture and conversion mechanisms into the treatment process shows promise in not only offsetting energy requirements but also enhancing overall sustainability.Advancements like autotrophic nitrogen removal and chemical dephosphorization have opened up avenues for bioenergy generation from organic carbon present in municipal wastewater. By integrating these processes into wastewater treatment protocols, it becomes feasible to harness the energy content of organic matter effectively, thereby maximizing resource recovery and promoting a more sustainable approach to wastewater treatment.

Membrane technology relies on the use of selective barrier pores that allow the passage of certain materials while blocking others from influent water. Various types of membrane technologies exist, with microfiltration, ultrafiltration, nanofiltration, and reverse osmosis being among the most common. By applying a potential gradient, unwanted substances are separated from the feed solution. Nanofiltration, in particular, has demonstrated exceptional capability in removing very small unwanted solutes compared to other membrane types. In environmental water purification treatments, membrane technology plays a pivotal role, especially in closed membrane reactor systems. Zhu et al. implemented gravity-driven biomimetic membrane (GDBM) technology in open natural water systems, showcasing a niche application that transitions membrane technology into a highly efficient and cost-effective ecological water treatment solution. In another instance highlighted by Petrinic et al., the combined use of ultrafiltration and reverse osmosis proved effective in the metal finishing industry. This approach successfully removed components like Nickel entirely, achieving removal efficiencies exceeding 90% for other metal ions and organic substances.

In the context of arsenic pollutant removal, ion exchange is a prevalent technique that falls under the physicochemical category. This method involves utilizing solid phase ions with identical ion numbers to those present in the polluted water, essentially replacing unwanted ions with alternative ones. Through electrostatic interactions, retained ions facilitate the extraction of contaminants from

wastewater or polluted water, aiding in water softening and reducing water hardness. However, the technology's ability to both eliminate and recover metal substances, achieving removal rates as high as 97.9% within a pH range of 3.5 to 7, underscores its substantial advantages.

6.Summary

According to the research, this passage discovers several solutions to water pollution. However, water pollution is still a very serious problem on Earth nowadays. Water pollution is a significant environmental issue caused by various factors, with industrial waste being a primary contributor. In addition to industrial waste, pollutants such as herbicides, pesticides, and atmospheric contaminants also play a role in contaminating water sources. Pathogens present in polluted water pose a serious health risk to humans, leading to the spread of diseases.

Research studies focus on specific types of pollutants or pollution problems in specific areas, and there is a lack of comprehensive and comprehensive research to fully understand all aspects of water pollution. In addition, with the acceleration of industrialization and urbanization, the emergence of new pollutants has increased, but the research on these new pollutants is insufficient, and the ability to understand and treat these pollutants is limited. Moreover, although some water pollution treatment technologies already exist, there is still a lack of research on effective treatment technologies and methods for some specific types of pollutants or complex pollution scenarios. Therefore, future researchers should do more research on new pollutants in water and keep improving the technique of treating water pollution. This passage brings some advanced solutions to water pollution and some normal solutions to water pollution to the other research. Therefore, this passage could help them to think about the future solution of water pollution.

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