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Drinking Water and Liquid Waste Treatment

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A B S T R A C T

This study seeks to explain the treatment processes of drinking water and wastewater, along with water source conservation practices in schools to sustain clean water availability. The approach combines literature review, policy analysis, and case studies of applied water treatment technologies. Findings indicate that drinking water treatment includes coagulation–flocculation, sedimentation, filtration, and disinfection, while wastewater undergoes primary, secondary, and tertiary stages. Case studies highlight the effectiveness of electrocoagulation, filtration, and plasma methods in reducing pollutants. In school settings, conservation is implemented through efficient water use, environmental greening, and plastic waste management. Overall, integrating treatment technologies with conservation initiatives contributes to improved health, quality of life, and environmental sustainability.

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INTRODUCTION

Clean water is a fundamental human need that cannot be replaced. Its availability is crucial not only for domestic consumption but also for industrial activities and the survival of other living organisms, such as animals and plants. Water quality directly affects public health, economic productivity, and environmental balance (Kaawoan et al., 2022; Legawa et al., 2024).

In recent years, the deterioration of water resources has become increasingly evident. Unsustainable agricultural practices, including the excessive use of pesticides and chemical fertilizers, coupled with the discharge of untreated household and industrial wastewater, have been identified as major sources of water and soil pollution. These practices lead to the accumulation of hazardous chemicals in both surface water and soil layers, thereby degrading environmental quality and threatening the sustainability of natural resources (Maulidya & Ihsan, 2025).

Given the declining quality of raw water, effective drinking water and wastewater treatment is essential to ensure that water remains safe for daily use. At the same time, water conservation efforts particularly within school environments play a strategic role in safeguarding long-term water availability. Therefore, integrating treatment technologies with school-based conservation programs emerges as a necessary approach.

The novelty of this study lies in combining modern water treatment methods, such as electrocoagulation, filtration, and plasma technologies, with practical conservation strategies implemented in schools, including water-use efficiency, greening initiatives, and plastic recycling. Previous research has primarily addressed technical treatment processes or conservation practices separately (Wahyudi et al., 2021). By bridging these two perspectives, this study offers a comprehensive framework that contributes not only to improving water availability but also to embedding environmental conservation values among students.

Several earlier studies highlighted the importance of water, sanitation, and hygiene (WASH) facilities in improving health outcomes (Hasrianti et al., 2024). Local studies have also examined water conservation initiatives in higher education institutions (Wahyudi et al., 2021). However, research focusing on the integration of water treatment technologies with conservation practices at the school level remains limited. This study aims to address this research gap by proposing an integrated and contextually relevant approach to ensure sustainable access to clean water in educational environments.

LITERATURE REVIEW

Biochemical Oxygen Demand (BOD)

BOD refers to the amount of dissolved oxygen required by microorganisms to decompose organic matter in water. A high BOD value indicates a high level of organic pollution in wastewater (Kaawoan, 2022).

Chemical Oxygen Demand (COD)

COD measures the total oxygen demand needed to chemically oxidize both organic and inorganic compounds in water. Elevated COD values indicate the presence of complex pollutants that are difficult to break down biologically (Legawa, Darma, & Putra, 2024).

Total Suspended Solids (TSS)

TSS represents the amount of suspended solids present in water. High TSS levels increase turbidity, reduce light penetration, and disrupt aquatic ecosystems. Therefore, TSS reduction is a key target in wastewater treatment (Syuhada et al., 2021).

pH of Wastewater

pH indicates the acidity or alkalinity of wastewater. Acidic (<6) or alkaline (>9) conditions may harm ecosystems and pose risks to human health. Environmental standards generally require wastewater pH to remain neutral (6–9) (Legawa et al., 2024).

Electrocoagulation

Electrocoagulation is a wastewater treatment method that uses an electric current to release metal ions from electrodes. These ions form flocs that precipitate pollutants. This method is effective in reducing BOD, COD, TSS, and stabilizing pH (Legawa et al., 2024).

Filtration

Filtration is the process of passing wastewater through porous media (such as sand, zeolite, activated carbon, or membranes) to remove suspended solids and some dissolved organic matter. It plays a crucial role in reducing TSS, BOD, and COD (Syuhada et al., 2021).TSS represents the amount of suspended solids present in water. High TSS levels increase turbidity, reduce light penetration, and disrupt aquatic ecosystems. Therefore, TSS reduction is a key target in wastewater treatment (Syuhada et al., 2021).

Plasma Technology

Plasma technology generates free radicals and ozone that degrade complex organic compounds in wastewater. This method is effective in reducing COD and stabilizing pH, making it a promising innovation in wastewater treatment in Indonesia (Legawa et al., 2024).

METHODOLOGY

Research Location and Time

This research was conducted from August 25, 2024 to October 1, 2024 at SMP Negeri 1 Sei Bingai, Langkat Regency, North Sumatra Province.

Research Design

This study adopts a descriptive qualitative design supported by a literature-based approach. The design aims to analyze drinking water and wastewater treatment processes by integrating theories, regulatory frameworks, and relevant case studies, with a particular focus on applications within school contexts.

Data Sources

The research draws on three main sources: Literature review, Case studies from indexed journals and Contextual observation at SMP Negeri 1 Sei Bingai

Data Collection Techniques

Data collection relied on document analysis and an extensive literature review to capture prior findings and identify research gaps, while field observations provided supporting evidence of conservation efforts in schools.

Data Analysis

The data were then analyzed through content analysis, which involved three main steps: reducing data to focus on relevant information, classifying data into themes such as water treatment, wastewater management, and conservation, and synthesizing findings into a conceptual model.

Content Analysis

To ensure the credibility of the findings, triangulation was applied by comparing multiple data sources (literature, regulations, and school observations) and cross referencing different theoretical perspectives on water treatment and educational conservation.

RESEARCH RESULTS

Literacy Review Results

Raw Water Sources

Water sources that can be used in water treatment include the following raw water sources:

1. Rainwater. Abundant rainwater, which sometimes causes flooding, is a water source that must be managed properly and provides many benefits.
2. Surface Water. Raw water sources used in drinking water treatment can include surface water such as rivers, lakes, and reservoirs. By damming rivers, this is the primary method most water utilities use to obtain water sources.
3. Groundwater. Groundwater serves as a supplement to surface water supplies. Groundwater tends to have better quality as it is less contaminated by pollutants.

The drinking water treatment process will be influenced by the raw water source used. A good-quality raw water source will make the treatment process easier and require lower costs compared to a low-quality raw water source, which will inevitably require higher treatment costs. (Juwono & Subagio, 2017)

Government Policies and Regulations

Law of the Republic of Indonesia No. 7 of 2004 concerning water resources stipulates government policies and regulations on water resources. Drinking water produced from the treatment process must meet the Drinking Water

Quality Standards set by the government. Minister of Health Regulation No. 2 of 2023 stipulates standards and parameters for water that is safe for consumption.

According to Kusnaedi (2010), water that is suitable for drinking must meet the following physical, chemical, and microbiological requirements:

1. Physical requirements: the water must be colourless, at normal temperature, tasteless, odourless, clear, not cloudy, and free of solid substances.
2. Chemical requirements: neutral pH of 6.5–8.5, no toxic chemicals, no salts or metal ions, and no organic substances.
3. Microbiological requirements: no pathogenic or non-pathogenic bacteria.

Drinking Water Treatment Process

The water treatment process aims to turn raw water, which often contains various contaminants, into water that is safe to drink. Typically, this process involves several steps. Drinking water treatment varies depending on the water source and the types of compounds it contains.

According to Mardizal et al. (2024), the stages of coagulation-flocculation, sedimentation, filtration, and disinfection are typically included in the drinking water treatment process.

According to Situmorang (2012), the following methods are used to treat water from groundwater sources:

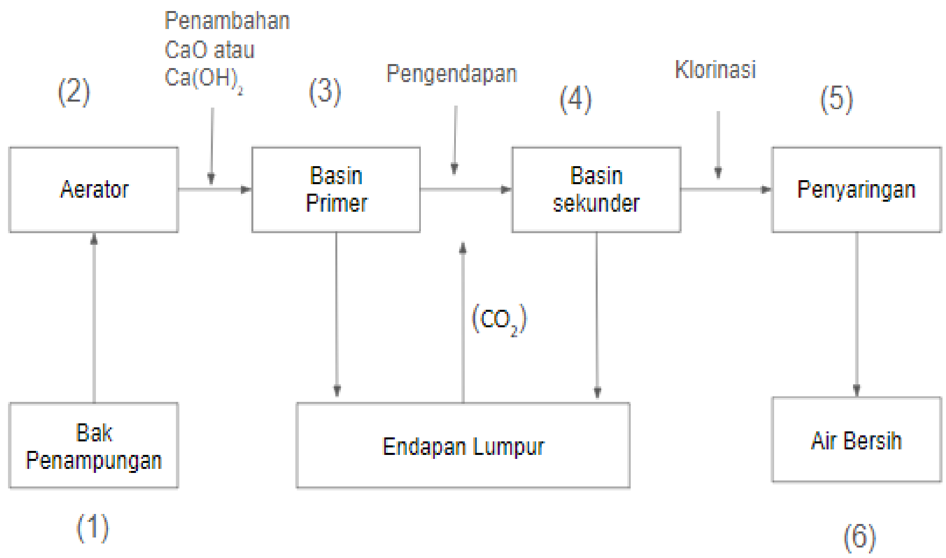

Figure 1. Schematic diagram of water treatment from groundwater sources into drinking water. Image source: (Situmorang, 2012)

First, water is poured into a storage tank and cleaned of solids and debris. Then, the water is fed into an aerator to remove gaseous chemical compounds. If necessary, oxygen can be added to oxidise the compounds into oxidisable chemical compounds. To increase the pH of the water, CaO or $Ca(OH)_2$ is added in the next step. This causes small particles to settle in the primary basin, where many solid compounds are in suspension. To help them settle, alum is added.

After CO_2 is added and the pH drops, the secondary basin will settle. The addition of chlorine to eliminate bacteria is the final stage of drinking water treatment. After being filtered again, the resulting water can be distributed to consumers. Depending on the condition of the raw water source and the technology used, drinking water treatment can be carried out in various ways. Water treatment is carried out in the most cost-effective manner. Not only for drinking water, but also for household and industrial needs, water treatment can be carried out in several stages.

1. First, the solid matter is removed. Then, the colloidal solids are precipitated with alum ($Al_2(SO_4)_3.18H_2O$). Using precipitated aluminium hydroxide compounds, precipitation can be accelerated by using ferrous sulphate ($FeSO_4.7H_2O$) and polyelectrolyte compounds.
2. Removing Water Hardness. Removing water hardness is very important because it causes damage, such as reducing the effectiveness of detergent when washing clothes and causing scale build-up on industrial equipment that uses water as a coolant. Adding soda and soda ash to precipitate calcium and magnesium in the form of calcium carbonate and magnesium carbonate can help remove water hardness.
3. Eliminating pathogenic bacteria: Chlorine and ozonisation can be used to purify water. (Situmorang, 2012)

Liquid Waste Treatment Process

Liquid waste, especially that containing hazardous chemicals, must be treated to ensure that it is safe for the environment when disposed of. One type of waste produced by human activities is liquid waste. This includes household, industrial, agricultural, and mining waste. According to Situmorang (2012), there are three stages in the treatment of liquid waste.

1. Primary waste treatment: At this stage, liquid waste is separated from solid materials that are insoluble in water, such as faecal matter. For smaller particles that cannot be caught in the screen, grid removal is used. Next, primary sedimentation is carried out by adding chemical compounds to enable the separation of pollutants such as fats.
2. Secondary waste processing
   In secondary waste treatment, microorganisms are commonly used to clean dissolved organic compounds in water. One method of waste treatment is to spray the waste onto rocks or other solid containers filled with microorganisms, so that the microorganisms can consume the waste in an aerated state and obtain an unlimited amount of oxygen.
3. Tertiary waste treatment
   To remove all pollutants present in tertiary wastewater, treatment is carried out to remove these substances. This includes removing suspended solids, dissolved organic matter, and dissolved inorganic matter. (Situmorang, 2012)

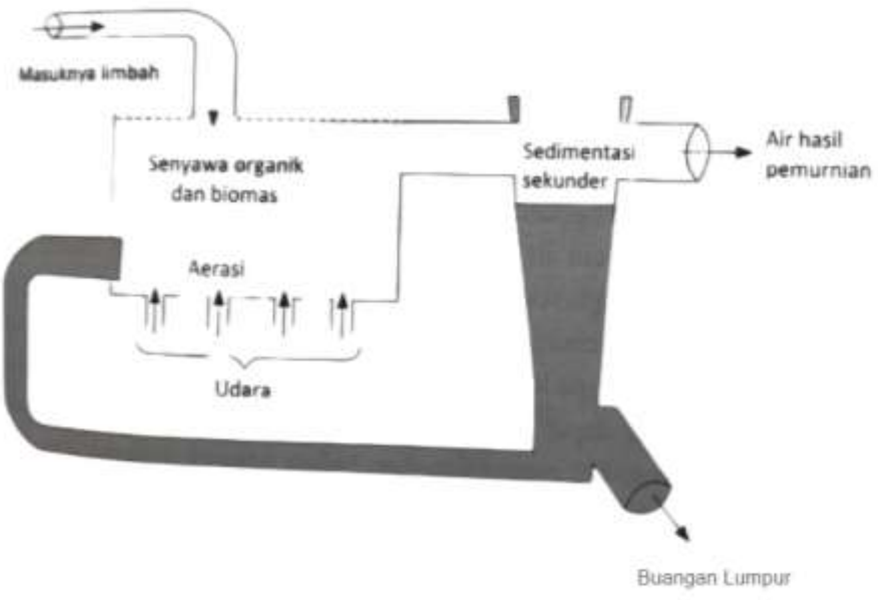

Figure 2. Schematic diagram of liquid waste treatment using activated sludge. Image source: (Situmorang, 2012)

The sludge activation process involves introducing microorganisms into the waste treatment tank. This method is highly effective in that the gas produced can be used as fuel and fertiliser. Microorganisms convert organic waste into biomass and CO2, while organic compounds containing nitrogen are converted into ammonium ions or nitrates. (Situmorang, 2012)

Case Study: Drinking Water and Liquid Waste Treatment

To enhance the understanding of water and wastewater treatment, several scientific studies have provided relevant case analyses. First, **Kaawoan et al. (2022)** found that wastewater from Langowan traditional market contained organic matter levels exceeding the BOD quality standard. Second, **Legawa et al. (2024)** demonstrated that electrocoagulation, filtration, and plasma methods improved the quality of health center wastewater by significantly reducing BOD, COD, TSS, and coliform values, with COD reduced by 95.87%, TSS by 94.67%, turbidity by 94.61%, and total coliform by 99.58%. Finally, **Syuhada et al. (2021)** reported that in Sukajadi Village, limited access to clean water was exacerbated by the community's lack of knowledge about water treatment. Through community service activities such as training, outreach, and appropriate technology application, residents' awareness and skills in household water treatment increased substantially.

Implementation of Water Conservation in Schools to Maintain the Availability of Clean Water for Drinking Purposes.

The water source in the vicinity of SMP Negeri 1 Sei Bingai is of excellent quality because it is located in the highlands, but over time, the quantity of water has decreased, as can be seen from the amount of water in the wells during the dry season. This is inseparable from the activities of the surrounding community, who have replaced many annual crops such as durian, mangosteen and others with oil palm trees. To ensure the availability of water sources as the primary source of drinking water, the school has implemented the following programmes:

1. Water conservation culture.
   It is very important to accustom students to using water efficiently at school. Students are taught to use water efficiently. They are encouraged to turn off the tap when the water tank is full and to turn off the tap when it is no longer in use. Another measure that is taken is to use a water pump to pump water into a reservoir located at a high place. In addition to saving electricity, this also saves water.

2. Greening of the school environment
   The school greening programme is carried out through the strengthening of the Pancasila Student Profile (P5) project with the theme of sustainable lifestyles. Students are facilitated to plant hardy plants and vegetables. This greening is expected to preserve water sources in the surrounding environment.

3. The plastic waste utilisation programme is also carried out through the strengthening of the Pancasila Student Profile (P5) project with the theme of sustainable living. Students are facilitated to utilise plastic waste into recycled products. In addition to addressing waste issues that can disrupt water sources, recycling waste into reusable products also enhances students' creativity. Excess plastic waste is also collected by school staff, sold for recycling back to processing plants, and besides addressing plastic waste issues, this activity also generates economic benefits.

DISCUSSION

The findings highlight that the quality of raw water plays a central role in determining the efficiency of drinking water treatment. Clean sources such as groundwater or well-managed surface water reduce treatment complexity and costs, which aligns with Juwono and Subagio (2017). Yet, the declining water quantity near SMP Negeri 1 Sei Bingai, caused by land-use changes, shows that conservation is as critical as treatment itself.

Government regulations, such as Law No. 7/2004 and Ministry of Health Regulation No. 2/2023, reinforce the need for water to meet physical, chemical, and microbiological standards. In this context, the school's initiatives promoting water-saving habits, greening activities, and plastic recycling reflect practical steps toward sustainability, echoing Kusnaedi's (2010) view that water quality depends not only on technical processes but also on community awareness.

Technological approaches like coagulation, sedimentation, filtration, and disinfection remain effective in improving water quality (Mardizal et al., 2024; Situmorang, 2012), while advanced methods such as electrocoagulation, filtration, and plasma show strong results in reducing pollutants (Legawa et al., 2024). However, this study adds value by emphasizing the integration of technology with school-based conservation programs—an area rarely explored in current literature. Such integration suggests that sustainable water management requires both technical solutions and cultural shifts in daily practices.

CONCLUSIONS AND RECOMMENDATIONS

The treatment of drinking water and liquid waste so that it can be used by the community is a step that can be taken. Drinking water and liquid waste are processed using various methods according to the conditions of the raw water source. The stages of drinking water treatment from groundwater begin with the water entering a storage tank and then being fed into an aerator. To increase the pH, the treated water is stored in a primary basin and allowed to settle. Then, carbon dioxide is added to the secondary basin to lower the pH of the water. To kill disease-causing bacteria, the final stage of water treatment involves adding chlorine.

Wastewater is processed in three stages: primary wastewater treatment, secondary wastewater treatment, and tertiary wastewater treatment. The water is expected to be safely released into the environment after undergoing wastewater treatment.

The results of several case studies using various methods and technologies for drinking water and liquid waste treatment have enhanced understanding and knowledge of advancements in drinking water and liquid waste treatment methods. School programmes as educational tools for preserving clean water sources include water conservation practices, greening the school environment, and recycling inorganic products such as plastic that is difficult to break down by microorganisms.

To ensure the availability of clean water, the conservation of water resources and the development of technologies for drinking water and wastewater treatment are essential parts of efforts to maintain clean water availability. The public must be educated about the importance of protecting the environment for a better life. Constructive criticism and suggestions are highly appreciated for the sake of perfection.

ADVANCED RESEARCH

Future research should examine the long-term effectiveness of combining water treatment technologies with school-based conservation programs across different settings such as urban, rural, and coastal schools. It is also important to explore how student behavior, community involvement, and economic feasibility shape the sustainability of these initiatives. Finally, considering the impacts of climate change on water availability would make future studies more relevant to global challenges.

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