TREATED WASTE WATER USE IN CONSTRUCTION INDUSTRIES

Abstract

Utilizing treated water and advancements in wastewater treatment are vital in addressing water challenges and promoting sustainable water management practices. This abstract highlights key findings and takeaways related to treated water use, including its significance in construction industries, water requirements in construction projects, limitations of traditional water sources, processes involved in treating wastewater for reuse, parameters for assessing treated water quality, environmental benefits, economic advantages, and the production processes in the fly ash brick industry. Additionally, it emphasizes design considerations, local and national regulations, permitting and compliance requirements, incentives and support programs, emerging technologies in wastewater treatment, and research needs for further investigation. The abstract concludes with a positive outlook on the future, emphasizing the increasing adoption of treated water, technological advancements, the circular economy approach, digital solutions, climate change adaptation, public awareness, and stakeholder collaboration. The abstract provides a comprehensive overview of the importance, challenges, and potential of treated water utilization and wastewater treatment in ensuring sustainable water management.

Keywords: Wastewater, Cement, Construction Industries, Sewage Treatment, Sustainability.

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I. INTRODUCTION

The building sector appears responsible for a large quantity of freshwater use. Without considering additional water usage in the concrete industry, 1m3 of concrete requires around 150 liters [1]. Utilizing treated water and advancements in wastewater treatment is crucial in addressing water challenges and promoting sustainable water management practices. Water scarcity, increasing water demand, and environmental concerns necessitate exploring alternative water sources and implementing efficient treatment technologies [2]. Treated water generated through wastewater treatment is valuable for various industries and applications. This discussion will explore the background and significance of waste-treated water in construction and fly ash brick industries. We will examine the water challenges these industries face and the limitations of traditional water sources.

Additionally, we will delve into the processes involved in treating wastewater for reuse, the critical parameters for assessing treated water quality, and the environmental and economic benefits of utilising treated water. Furthermore, we will explore the specific water requirements in construction projects and discuss the applications of treated water in concrete production, mixing, construction site irrigation, and dust suppression. Additionally, we will provide an overview of brick production by fly ash and its connection to waste-treated water utilization [3].

1. Background and Significance of Treated Wastewater use in Construction Industries

- **Water Scarcity:** Water shortage is a continuing water catastrophe affecting approximately one million people yearly. Water shortage impacts both rural and urban populations, ecology, and agriculture. With a population of 1.3 billion people, India possesses just 4% of the world's freshwater resources [4]. For a long time, India has struggled with water shortages. Per capita, water availability is less than 1 1,700 m3, with the current number in India being 1,545 m3. According to the water ministry's forecast, water availability might drop to 1,341 m3 in 2025 and 1,140 m3 by 2050. However, global water use from industrial processes is expected to increase to 1500 billion m3 by 2030, up from 800 billion m3 in 2009 [2]. Water scarcity is a significant challenge faced by both industries, particularly in regions with limited freshwater resources. Construction projects require substantial water for concrete mixing, dust suppression, and equipment cleaning. Water scarcity can hinder the smooth operation of these industries and increase their reliance on alternative water sources. Utilizing treated wastewater in construction offers several benefits:
- **Resource Conservation:** Construction projects can use treated wastewater instead of freshwater to conserve precious freshwater resources. This becomes particularly significant in regions facing water scarcity or drought conditions [6].
- **Sustainable Development:** Incorporating treated wastewater into construction aligns with the principles of sustainable development, promoting responsible and efficient resource utilization. It helps reduce the strain on freshwater sources, ensuring their availability for other essential needs.
- **Cost Savings:** Using treated wastewater in construction can reduce costs associated with freshwater procurement and disposal of sewage.
- **Environmental Protection:** By reusing treated wastewater, construction activities can minimize their impact on local water bodies [7]. Discharging treated wastewater

back into rivers or lakes can lead to pollution and ecological damage, whereas its use in construction prevents such environmental degradation [8].

Overall, using treated wastewater in the construction industry effectively conserves water resources, reduces environmental impact, achieves sustainability goals, and improves cost-efficiency. It represents a significant step toward responsible water management and contributes to the overall sustainability of these sectors [9].

2. **Overview of the Water Challenges faced by these industries Environmental Regulations and Compliance:** The construction industry must comply with environmental regulations related to water usage and discharge. These regulations protect local water bodies from pollution and ensure sustainable water management practices. Adhering to these regulations can be challenging and require implementing advanced water treatment technologies or alternative water-sourcing strategies [10]. Many industries in India, including chemical, distillery, pulp & paper, sugar, textile, tannery, and others, generated 61754 MLD wastewater in 2019, up from 38000 MLD in 2016[11]. Addressing these water challenges requires a combination of strategies, such as implementing water-efficient practices, adopting water recycling and reuse systems, exploring alternative water sources like treated wastewater, and complying with environmental regulations. By proactively managing water resources and adopting sustainable practices, these industries can mitigate the impacts of water scarcity, reduce costs, and contribute to environmental conservation. Overall, this discussion aims to comprehensively understand the significance, challenges, and potential of utilizing treated water in various industries and applications. By exploring these topics, we can highlight the importance of sustainable water management practices and the role of treated water in mitigating water challenges and promoting a more environmentally conscious future.

II. WATER MANAGEMENT IN CONSTRUCTION INDUSTRIES

1. **Water requirements in construction projects**: Water is a vital resource in construction projects and is required for various purposes throughout the project lifecycle. The water requirements in construction projects can vary depending on the project size, scope, and specific activities involved. Here are some standard water requirements in construction:

   - **Concrete Mixing:** Water is an essential component in the production of concrete. It hydrates the cement, aggregate, and other additives, forming a workable mixture. The water-to-cement ratio in concrete is crucial for achieving the desired strength and workability.
   - **Dust Suppression:** Construction activities often generate dust, particularly during excavation, demolition, and earthmoving processes. Water is used to suppress dust by spraying it on dusty areas. This helps to reduce airborne particles and maintain a safe and healthy working environment.
   - **Equipment Cleaning:** Construction sites require regular cleaning of equipment, machinery, and vehicles to maintain efficiency and prolong lifespan.
   - **Construction Site Hygiene:** Construction sites need water for primary hygiene, such as handwashing, cleaning facilities, and sanitary needs. An adequate water supply is essential to maintain a safe and hygienic working environment for the construction workforce [12].

2. **Traditional Water Sources and their Limitations:** Traditional water sources typically used in construction projects include freshwater from surface water bodies (rivers, lakes) and groundwater from wells or boreholes. While these sources have been relied upon for many years, they have limitations.

   - **Water Scarcity:** In many regions, freshwater sources are limited and face increasing demands from various sectors, including agriculture, industry, and domestic use. Water scarcity poses a significant challenge in meeting the water requirements of construction projects, especially in areas prone to drought or with rapidly growing populations [13].
   - **Seasonal Variability:** Surface water sources, such as rivers and lakes, can experience seasonal variability in water availability. During dry seasons or periods of low rainfall, these sources may have reduced flow or even dry up completely. This can hinder construction activities that rely on a consistent water supply throughout the year.
   - **Environmental Impact:** Over-extraction of water from traditional sources can have adverse environmental impacts. Excessive groundwater pumping can deplete aquifers, leading to land subsidence and wells drying up. Diverting water from rivers and lakes without proper management can disrupt ecosystems, affect aquatic life, and lead to water quality degradation.
   - **Regulatory Restrictions:** Local regulations and permits govern the extraction and use of water from traditional sources. Obtaining permits and complying with regulatory requirements can add complexity and time to the construction process. Water extraction from specific sources may be restricted or subject to strict usage limits to protect the environment and ensure equitable distribution [14].

   Considering these limitations, it becomes essential for construction projects to explore alternative water sources, implement water-efficient practices, and adopt sustainable water management strategies to reduce reliance on traditional sources and mitigate their associated challenges.

3. **Introduction to waste-treated water as an alternative source:** Treated wastewater, reclaimed or recycled water, has undergone advanced treatment processes to remove impurities and meet specific quality standards for non-potable uses. It can be a viable alternative water source for various applications, including construction projects. Here is an introduction to waste-treated water as an alternative source:

   - **Advanced Treatment Processes:** Treated wastewater goes through advanced treatment processes to remove contaminants and pathogens, making it safe for non-potable uses. These treatment processes typically include physical, chemical, and biological treatments to remove solids, organic matter, bacteria, and other pollutants.
   - **Quality Standards:** Treated wastewater is subject to stringent standards and regulations to ensure its suitability for specific non-potable uses. These standards may vary depending on local rules and the intended application of the treated wastewater. The quality of treated wastewater is continuously monitored to maintain compliance with the required standards.
   - **Non-Potable Uses:** Treated wastewater is primarily used for non-potable applications and is not intended for human consumption. In construction projects, treated

wastewater can be used for various purposes, such as concrete mixing, dust suppression, equipment cleaning, compaction, and irrigation. It can replace freshwater in these applications, reducing the demand for traditional water sources.

- **Water Conservation:** Utilising treated wastewater as an alternative water source promotes conservation. By substituting fresh water with treated wastewater, construction projects can reduce their reliance on traditional water sources, which may be scarce or in high demand. This conservation of freshwater helps preserve valuable resources and ensures their availability for other essential needs.
- **Sustainability Benefits:** Incorporating treated wastewater into construction projects aligns with sustainability principles. It contributes to responsible water management by reducing the strain on freshwater sources and minimizing the environmental impact of traditional water extraction. It also supports the circular economy concept by recycling and reusing water resources, closing the water usage loop.
- **Cost Savings:** Using treated wastewater can result in cost savings for construction projects. Compared to procuring freshwater, treated wastewater is often more cost-effective, particularly in areas where freshwater is expensive or limited. By utilizing an alternative water source, construction projects can reduce operational expenses related to water procurement and potentially lower wastewater disposal costs.
- **Environmental Protection:** Reusing treated wastewater in construction helps prevent the discharge of untreated sewage into water bodies, reducing pollution and ecological damage. It protects local ecosystems and ensures water resources are used responsibly, contributing to environmental preservation and conservation.

Overall, treated wastewater offers a sustainable and viable alternative water source for construction projects. Its utilization can help address water scarcity, promote resource conservation, support environmental protection, and contribute to the overall sustainability of the construction industry [15].

III. WASTE TREATED WATER TREATMENT AND QUALITY STANDARDS

1. **Processes involved in treating wastewater for reuse:** consist of a series of techniques to remove impurities and contaminants to achieve the desired water quality for specific non-potable applications. The exact treatment processes may vary depending on the particular requirements and local regulations, but here are some common steps involved in treating wastewater for reuse:

   - **Screening:** The first step in the treatment process is screening, where large debris, such as rocks, sticks, and trash, is removed using screens or grates. This prevents damage to equipment and ensures smoother downstream processes.
   - **Primary Treatment:** In the primary treatment stage, physical processes remove larger suspended solids and organic matter. The wastewater flows into sedimentation tanks or clarifiers, allowing the heavier particles to settle at the bottom as sludge while the relatively more transparent water moves forward.
   - **Secondary Treatment:** Secondary treatment focuses on the biological breakdown of organic matter and the removal of dissolved solids. The wastewater undergoes biological processes, typically using bacteria or microorganisms, to further break down organic compounds. Standard secondary treatment methods include activated sludge processes, trickling filters, or sequencing batch reactors.

- **Tertiary Treatment:** Tertiary treatment is an advanced process that removes finer suspended solids, dissolved contaminants, and nutrients. Treatment methods include filtration, disinfection, chemical coagulation, and advanced oxidation processes. Filtration can involve rapid sand filters, membrane filtration (such as ultrafiltration or reverse osmosis), or granular media filters.
- **Disinfection:** Disinfection is crucial to eliminate or reduce harmful pathogens and microorganisms in the treated wastewater. Standard disinfection methods include chlorination, ultraviolet (UV) disinfection, ozone treatment, or advanced oxidation processes. The choice of disinfection method depends on the required level of microbial control and local regulations.
- **Storage and Distribution:** Once the wastewater has undergone the necessary treatment processes, it is stored in appropriate reservoirs or tanks before distribution for reuse. The treated wastewater may be delivered through a separate distribution system or blended with other water sources per the specific non-potable use requirements [16].

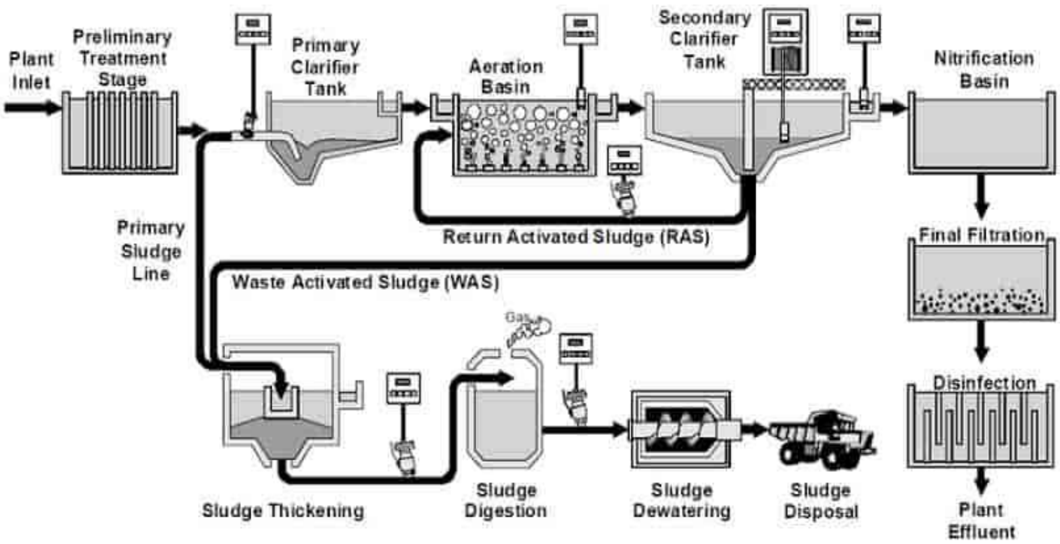

Figure 1: Sewage waste water treatment plant

- **Key Parameters for assessing the Quality of Treated Water:** Several key parameters are typically considered when determining the quality of treated water. These parameters help evaluate the effectiveness of the treatment process and ensure that the water meets the required standards for its intended reuse. Here are some important parameters for assessing the quality of treated water:

Figure 2: Sewage Water

2. Physical Parameters

- **Turbidity:** Turbidity measures the clarity or cloudiness of the water caused by suspended particles. Lower turbidity levels indicate more transparent water.
- **Color:** Color can indicate the presence of organic matter or specific contaminants in the water. Treated water should have an acceptable color based on particular standards.

3. Chemical Parameters

- **pH:** pH measures the acidity or alkalinity of the water. It is essential to ensure that the pH of the treated waterfallsis within an acceptable range for the intended reuse application. pH range of 7.2-7.3 is suitable for construction [17].
- **Total Dissolved Solids (TDS):** TDS represents the concentration of inorganic salts and minerals dissolved in the water. Elevated TDS levels can affect water quality and suitability for specific uses.TDS, TSS, chloride, sulfate, and alkali limitations in wastewater are set at 2000 ppm, 2000 ppm, 500 ppm, 1000 ppm, and 1000 ppm, respectively, to make it appropriate for concrete production [18].
- **Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD):** COD and BOD are indicators of organic pollution in water. Lower COD and BOD values indicate the effective removal of organic matter during treatment.
- **Specific Chemical Constituents:** Specific chemical parameters such as heavy metals, nutrients (nitrogen and phosphorus), and particular contaminants of concern must be monitored depending on local regulations and wastewater sources.

4. Other Parameters

- **Residual Disinfectant:** If the treated water has been disinfected, residual disinfectant levels, such as chlorine or ozone residuals, should be measured to ensure adequate disinfection and microbial control.
- **Odour:** The presence of unpleasant smells in treated water can indicate the presence of specific compounds or contaminants.

It's important to note that the specific parameters and their acceptable limits can vary based on local regulations, the intended reuse application, and the particular characteristics of the treated water. Regular monitoring and analysis of these parameters are essential to ensure that the treated water meets the required quality standards and is suitable for its intended

Table 1: Water quality parameter

Parameter	Portable Water (mg/l)	Treated Waste Water (mg/l)	Permissible Limit (mg/l)
pH	6.5 – 7.5	7.49	>6
DO	--	5.6	--
COD	10	46.7	3000
Chloride Content 250 59.98 2000	250	59.98	2000
Acidity	--	200	300
Alkalinity	280	480	>200
Sulphate Content	200	70	400
Calcium Content	200	1.72	75-200
Magnesium Content	100	0.307	30-100
Total Hardness as CaCO3	300	3	300
Electrical Conductivity		666µs	--

IV. BENEFITS AND CHALLENGES OF USING WASTE-TREATED WATER

1. **Environmental benefits of utilising treated water:** Utilizing treated water, also known as reclaimed or recycled water, offers several environmental benefits. These benefits contribute to sustainable water management and conservation efforts. Here are some key environmental advantages of utilising treated water:

   - **Conservation of Freshwater Resources:** Using treated water for construction reduces demand for freshwater sources. This conservation helps alleviate the pressure on natural water bodies, including rivers, lakes, and aquifers, which are often overexploited.
   - **Energy and Carbon Footprint Reduction:** Treating and reusing water requires less energy than treating freshwater sources to meet potable water standards. Using treated water instead of freshwater reduces energy consumption and associated greenhouse gas emissions related to water treatment and transportation, contributing to lower carbon footprints.
   - **Mitigation of Drought Impacts:** During drought or water scarcity, utilising treated water can help alleviate the strain on freshwater supplies. By diversifying water sources and incorporating treated water into the water supply mix, communities and industries can better cope with drought conditions and maintain essential water-dependent activities.

- **Encouragement of Circular Economy:** Utilising treated water in a closed-loop system supports the circular economy concept by recycling and reusing water resources. Instead of considering wastewater as waste, it is treated and given a new life, reducing the need for continuous freshwater input and minimising the overall water footprint.

These environmental benefits demonstrate how utilising treated water contributes to sustainable water management practices, protects ecosystems, reduces pollution, and promotes the efficient use of water resources, thus supporting long-term environmental sustainability [19].

2. **Economic advantages and potential cost savings:** Utilising treated, reclaimed, or recycled water can offer significant economic advantages and potential cost savings for various sectors. Here are some of the economic benefits and cost savings associated with the use of treated water:

- **Reduced Water Procurement Costs:** Treated water is often more cost-effective than freshwater sources. In regions where freshwater is scarce or expensive, utilising treated water can lead to substantial cost savings by reducing the need to purchase or extract fresh water for non-potable uses. Construction projects, industrial facilities, and agricultural operations can benefit from lower water procurement expenses.
- **Operational Efficiency and Cost Reduction:** Using treated water can enhance operational efficiency for various sectors. For example, in industrial processes, treated water can be used for cooling systems, equipment cleaning, or production processes, reducing the reliance on freshwater and minimising associated costs. Similarly, in agricultural applications, utilising treated water for irrigation can save costs by reducing dependence on freshwater sources or costly water pumping [20].

3. **Challenges and concerns related to treated water use:** While treated water is essential for various purposes, challenges and concerns are still associated with its use. Some of these challenges include:

- **Contaminant Removal:** The effectiveness of water treatment processes in removing contaminants can vary. Specific contaminants, such as emerging pollutants (e.g., pharmaceuticals, microplastics) or certain chemicals resistant to conventional treatment methods (e.g., some pesticides), may not be adequately removed. This raises concerns about the potential presence of these contaminants in treated water and their long-term impacts on human health and the environment.
- **Waterborne Diseases:** While water treatment processes aim to remove or inactivate pathogens, there is still a risk of waterborne diseases if the treatment is not properly carried out or if there are failures in the distribution system. Breaks in the water supply or cross-connections with contaminated sources can introduce pathogens into the treated water, leading to potential outbreaks of waterborne illnesses.

Disinfection Byproducts (DBPs): Using disinfectants, such as chlorine, in water treatment can lead to disinfection byproducts (DBPs). DBPs, including trihalomethanes (THMs) and haloacetic acids (HAAs), can pose health risks in high concentrations. Balancing effective disinfection while minimising DBP formation is a challenge faced by water treatment facilities.

- **Climate Change:** Climate change can affect the quality of treated water and the efficiency of treatment processes. Changes in precipitation patterns, rising temperatures, and extreme weather events can alter water availability, quality, and source water characteristics. These changes pose challenges for water treatment facilities in maintaining consistent and high-quality treated water supplies.

Addressing these challenges requires ongoing investment in water treatment infrastructure, research and development for improved treatment technologies, and comprehensive monitoring and regulation of water quality. Promoting water conservation and sustainable water management practices can also help mitigate some of these concerns related to treated water use [21].

V. APPLICATIONS OF WASTE-TREATED WATER IN CONSTRUCTION INDUSTRIES

1. **Concrete production and mixing:** Concrete production and mixing involve carefully blending various ingredients to create a durable and workable construction material. Water is crucial in concrete production as it hydrates the cement, enabling it to bind with the aggregates and other components. Here's an overview of the substantial output and the role of water in the mixing process:

- **Ingredients of Concrete**

  - **Cement:** Cement is the primary binding agent in concrete. It is a fine powder, typically made from limestone, clay, shale, or other materials, that reacts with water to form a solid matrix.
  - **Aggregates:** Aggregates, such as sand, gravel, crushed stone, or recycled concrete, provide bulk and strength to the concrete. They make up the majority of the concrete mixture [22].
  - **Water:** Water is added to the mixture to hydrate the cement and initiate the chemical reaction that causes it to harden and gain strength [23].

Table 2: Comparison of compressive strength of concrete

	Average Compressive Strength of Concrete (N/mm^2)		
	7 Days	14 Days	28 Days
Concrete Prepared with Treated Waste Water	46.2	47.5	54.8
Concrete Prepared with Portable Water	40.5	48.2	54.2

- **Admixtures:** Admixtures are optional additives used to modify the properties of concrete, such as improving workability, setting time, or durability. These may include chemical admixtures, mineral admixtures, or fibre reinforcements [24].
- **Workability Adjustment:** During the mixing process, the water content is adjusted to achieve the desired workability of the concrete. Workability refers to the ease with which the concrete can be mixed, placed, compacted, and finished. The amount of water added affects the concrete's consistency, plasticity, and flowability.

The water-to-cement (w/c) ratio is a critical parameter in concrete mixing. It represents the water's weight or volume relative to the cement's weight in the mixture. The w/c ratio influences the concrete's strength, workability, durability, and other properties. The correct w/c ratio is crucial to balance workability and strength. The w/c ratio is typically specified in the concrete mix design based on the desired strength and other requirements. A lower w/c ratio generally results in stronger concrete, which may make the mixture less workable. Achieving the optimal w/c ratio is essential to ensure the desired concrete performance.

2. **Water Quality and Consistency:** Water quality used in concrete mixing is essential. Potable water or water meeting specific quality standards is typically recommended to avoid potential adverse effects on the concrete's performance. Turbidity, pH, chloride ions, total solids, and sulfate content are the essential factors that must be within acceptable limits before being employed in concrete manufacturing [25]. Consistency of water supply is also crucial. Maintaining a consistent water source throughout the project helps ensure uniformity in the concrete mix, avoiding variations in hydration and resulting properties. Secondary and tertiary treated wastewater used concrete have higher setting time than control concrete [26].

3. **Sustainability Considerations:** Water conservation and sustainable practices are increasingly emphasized in concrete production. Using treated wastewater as an alternative water source in concrete mixing can help conserve freshwater resources and reduce the environmental impact of water extraction.

VI. CONCLUSION

In conclusion, utilising treated water and advancements in wastewater treatment offers significant opportunities for addressing water challenges, promoting sustainable practices, and ensuring efficient water management. The significance of treated water in industries such as construction lies in its potential to reduce reliance on traditional water sources and mitigate environmental impacts. By incorporating treated water systems, industries can benefit from reduced water consumption, cost savings, and compliance with regulations. The processes involved in wastewater treatment for reuse encompass various steps and technologies that remove contaminants and improve water quality. Monitoring key parameters is essential to ensure treated water meets quality standards and is safe for the intended applications. The environmental benefits of utilising treated water are substantial, including reduced freshwater depletion, minimised pollution, and conservation of ecosystems. Using treated water can result in cost savings on water procurement, wastewater treatment, and potential revenue generation through resource recovery.

Moreover, treated water can be effectively utilised in concrete production, mixing, site irrigation, dust suppression, and fly ash brick production, offering sustainable alternatives to traditional practices. However, successfully implementing treated water systems requires careful consideration of design aspects, adherence to local and national regulations, and compliance with permitting and reporting requirements. Incentives and support programs further encourage the adoption of treated water. At the same time, emerging technologies and ongoing research address challenges such as removing emerging contaminants, resource recovery, energy efficiency, and climate change adaptation. The future outlook is positive, with increasing adoption of treated water, technological advancements, and a growing emphasis on the circular economy, digital solutions, climate change adaptation, public awareness, and stakeholder collaboration. By embracing these opportunities, we can ensure sustainable water management practices, protect water resources, and build a resilient and environmentally conscious future.

REFERENCES

[1] F.S. Peighambarzadeh, G. Asadollahfardi, J. Akbardoost, the effects of using treated wastewater on the fracture toughness of the concrete, Aust. J. Civ. Eng. 18, 56–64, 2020.
[2] L.G. Zektser, S. Igor, Everett, Groundwater resources of the world and their use, UNESDO Digital Library 2004.
[3] H. Varshney, R.A. Khan, I.K. Khan, Sustainable use of different wastewater in concrete construction: A review, J. Build. Eng. 41,102411, 2021.
[4] K.P. Fattah, A.K. Al-Tamimi, W. Hamweyah, F. Iqbal, Evaluation of sustainable concrete produced with desalinated reject brine, Int. J. Sustain. Built Environ. 6 ,183–190, 2017.
[5] P.R. de Matos, L.R. Prudˆencio, R. Pilar, P.J.P. Gleize, F. Pelisser, Use of recycled water from mixer truck wash in concrete: effect on the hydration, fresh and hardened properties, Construct. Build. Mater. 230, 116981, 2020.
[6] M. Bhujbal, A. Deshmukh, K. Gaikwad, S. Boring, P. Dongare, Use of Industrial Waste Water in Concrete, Int. J. Eng. Res. Technol. 10,581–586, 2021.
[7] S. Mane, S. Faizal, G. Prakash, S. Bhandarkar, V. Kumar, Use of sewage treated water in concrete, Int. J. Res. Eng. Sci. Manag. 2 ,210–213, 2019.
[8] K.J. Kucche, S.S. Jamkar, P.A. Sadgir, Quality of water for making Concrete: a review of, Int. J. Sci. Res. Publ 5, 1–10, 2015.
[9] K. Meena, S. Luhar, Effect of wastewater on properties of concrete, J. Build. Eng. 21, 106–11, 2019.
[10] WWAP (United Nations World Water Assessment Programme), The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource, UNESCO, Paris, 2017.
[11] The Ministry of Water Resources, River Development, and Ganga Rejuvenation, Ministry of Jal Shakti, 2019.
[12] M.A.R. Shaikh, D.V.M. Inamdar, Study of Utilization of Waste Water in Concrete, IOSR J.Mech. Civ. Eng. 13,105–108, 2016.
[13] S. Tsimas, M. Zervaki, Reuse of waste water from ready-mixed concrete plants, Manag.Environ. Qual. An Int. J. 22 ,7–17, 2011.
[14] D. Freeda Gnana Rani, K. Arunkumar, S.R. Sivakumar, Physico-chemical analysis of wastewater from cement units, J. Ind. Pollut. Control. 21,337–340, 2005.
[15] P. Rama Mohan Rao, S.M.K. Moinuddin, P. Jagadeesh, Effect of treated wastewater on the properties of hardened concrete, Int. J. Chem. Sci. 12,155–162, 2014.
[16] K. Meena, S. Luhar, Effect of wastewater on properties of concrete, J. Build. Eng. 21,106–112, 2019.
[17] G. Reddy Babu, B. Madhusudana Reddy, N. Venkata Ramana, Quality of mixing water in cement concrete "a review, Mater. Today Proc. 5 ,1313–1320, 2018.
[18] B. Ahmadi, W. Al-Khaja, Utilization of paper waste sludge in the building construction industry, Resour. Conserv. Recycle, 32,105–113, 2001.
[19] M. Hegazy, Effect of using secondary treated wastewater in production and curing of concrete, J. Mater. Environ. Sci. 11,1493–1502, 2020.
[20] C.O. Rusănescu, G. Voicu, G. Paraschiv, M. Begea, L. Purdea, I.C. Petre, E.V. Stoian, Recovery of Sewage Sludge in the Cement Industry, Energies. 15,2022.

[21] M. and Manjunatha, M.R. Dhanraj, An Experimental Study on Reuse of Treated Waste Water in Concrete – A Sustainable Approach, Int. J. Latest Eng. Res. Appl. 02 ,124–132, 2017.
[22] A.N. Abbas, L.M. Abd, M.W. Majeed, Effect of hospital effluents and sludge wastewater on foundations produced from different types of concrete, Civ. Eng. J. 5, 819–831, 2019.
[23] O.O.I.S. Lee, M.R. Salim, M. Ismail, I. Ali, Reusing treated effluent in Concrete Technology, J. Teknol. 34 ,1–9, 2007.
[24] M. Shekarchi, M. Yazdian, N. Mehrdadi, Use of biologically treated domestic wastewater in concrete, Kuwait J. Sci. Eng. 39, 97–111, 2012.
[25] M.A.R. Shaikh, D.V.M. Inamdar, Study of the utilization of wastewater in concrete, IOSR J. Mech. Civ. Eng. 13,105–108, 2016.
[26] A.B. More, R.B. Ghodake, H.N. Nimbalkar, P.P. Chandake, S.P. Maniyar, Y. D. Narute, Reuse of treated domestic wastewater in concrete - a sustainable approach, Indian J. Appl. Res. 4 ,182–184, 2011.