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REVIEW ARTICLE

Industrial Management of Wastewater in Textile Industry: A Brief Review

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ABSTRACT - The Malaysian textile industry is experiencing rapid development as a result of increased local demand, a robust export market, government backing, e-commerce expansion, and the expanding impact of social media. However, the industry also produces a significant amount of harmful wastewater, thus raising wastewater management as an environmental concern. The purpose of this review paper was to explore the industrial management of textile wastewater, including wastewater characteristics, treatment options, and sustainability initiatives. It analysed the present state of water sources in Malaysia, specifically focusing on the impact of wastewater from the textile industry. This was followed by a discussion of the trends in Malaysia's textile industry, the issues concerning the wastewater generated by this sector, and the use of industrial engineering and management in wastewater treatment. This concise review provides valuable information regarding future studies in wastewater treatment, with a specific focus on textile wastewater. Effective water resource management is crucial for ensuring sustainable industrial growth. Industrial management is an ongoing process that entails overseeing and coordinating all aspects of an organisation's production and operations.

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1. INTRODUCTION

Exponential growth in the agricultural and industrial sectors has resulted in significant and permanent environmental problems, mostly due to the discharge of agricultural runoff and untreated industrial waste into the ecosystem (Kumar et al., 2024). Untreated industrial effluents include toxic and hazardous persistent toxic elements (PTEs), such as arsenic (As), copper (Cu), cadmium (Cd), chromium (Cr), lead (Pb), and mercury (Hg). The textile industry is a significant contributor to wastewater generation in Malaysia, accounting for approximately 22% of the total industrial wastewater. The dyeing process of one kilogram (kg) of cloth commonly produces around 40–65 litres of effluent (Bogale et al., 2024). This high level of wastewater is primarily due to the dyeing and finishing processes, which are integral to textile manufacturing (Pang & Abdullah, 2013).

Other industries also contribute to wastewater generation. For instance, the oil and gas (O&G) industry produces wastewater as a byproduct of hydrocarbon extraction that contains a mixture of water, gas, and residual oil (de Araujo et al., 2024). The manufacturing industry produces industrial oily wastewater, which usually occurs in a floating, dispersed, or emulsified state depending on the particle size of the oil droplets (Ma et al., 2022). Commonly used techniques for separating emulsified oil-water mixtures are mainly divided into chemical, microbiological, and physical processes. The paper industry also produces wastewater during pulp processing, which contains lignin and colouring chemicals like dark brown (Haq et al., 2022). The dark brown colour has a negative impact on the aquatic environment as it prevents the natural photosynthesis process in water. Additionally, various metals like silver, titanium, and platinum are formed by electrolysis deposition, electroplating, anodising-cleaning, etching, and milling industries (Rezai & Allahkarami, 2021).

The Malaysian textile industry is developing rapidly and has significantly contributed to the country’s economic growth in the past ten years (Zahuri et al., 2023). Local textile manufacturing businesses are characterised by their outstanding versatility to produce a diverse range of textiles, including natural and synthetic fibres, natural and woven yarns, alongside knitted, woven, non-woven, bleached, dyed, completed, and printed fabrics (Singh et al., 2023). Dyeing is among the crucial steps in the process of making garments and clothes using natural or synthetic dyes. For this purpose, the textile industry requires an extensive use of water and various chemicals, resulting in the discharge of effluents that often contain harmful pollutants, including synthetic dyes and heavy metals. Such fact makes the industry worth exploring in this review study.

The primary issue with untreated textile wastewater is its chromaticity, which arises from the substantial concentration of colours present in the water. Past research stated that dyes possess a number of carcinogenic and mutagenic characteristics (Urbina-Suarez et al., 2024). Furthermore, untreated textile effluents are linked to several environmental issues, including an increase in pH, BOD, suspended solids, and COD levels in aquatic bodies. Malaysian textile producers are renowned for their capacity to provide pre-made clothing, household textile goods, and industrial textile

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items. Textiles include primary textiles and associated processes like polymerisation, spinning, weaving, knitting, and wet processing. Industrial waste often consists of liquid, gaseous, or solid substances that comprise both inorganic and organic matter. It is toxic and carcinogenic, difficult to manage, and causes injury. Meanwhile, chemical industrial waste varies depending on the specific sectors, methods, and raw materials.

In Malaysia, industrial management is innovative in the technology used as part of the efforts to manage and treat textile wastewater, such as physical, biological, and chemical treatments. However, these methods can be costly and often generate large amounts of sludge, necessitating the exploration of more efficient and sustainable treatment technologies (Singh et al., 2023). Innovations in technology wastewater treatment are being researched to enhance the treatment processes and reduce the environmental impact of textile wastewater. Environmental protection operations are done through the implementation of policies that promote the use of recycled waste in industry activities (Utit et al., 2015). This review study aims to provide a comprehensive analysis of industrial management practices in waste management, with a specific emphasis on wastewater-related concerns. It also examines how industrial engineering and management ideas are applied to the treatment of wastewater.

2. BRIEF REVIEW

2.1 An Overview of Water Sources Condition in Malaysia

Malaysia has ample water resources, with rivers and streams being the primary sources that account for approximately 98% of the overall water use, while groundwater constitutes the remaining 2% (Huang et al., 2015). There are more than 150 river systems, with the Rajang River (563 km) in East Malaysia being the longest and the Pahang, Kelantan, Terengganu, and Selangor rivers being the major rivers in Peninsular Malaysia. As of 2020, Malaysia has achieved almost complete access to piped water supplies, with 100% coverage in urban areas and 93% coverage in rural regions. The majority of water used for residential purposes comes from surface water sources such as rivers (99%), while the remaining 1% is sourced from groundwater. Surface water sourced from Sungai Langat, Sungai Selangor, and Sungai Kinta on the West Coast of Peninsular Malaysia is often used as a primary drinking water supply (Annua et al., 2020). Conversely, states like Kelantan, Terengganu, Pahang, Perlis, Kedah, Sabah, and Sarawak depend on groundwater as their primary source of drinking water.

Over the years, removing dye from wastewater produced by the textile and apparel industries has become a serious global concern. Despite having abundant water resources, Malaysia has enormous difficulties maintaining dependable and sustainable water management due to pollution, supply-demand deficiencies, and outdated infrastructure. The Department of Environment (DOE) has been introducing stricter laws regarding removing dyes from textile industry effluents due to its position as the primary source of water pollution (Zahuri et al., 2023). Similar initiative is also practised across many developed and industrialised countries.

2.2 Which Industry Generates Wastewater?

Industrialisation is indeed important to accelerate a nation's economic growth. It serves as a crucial economic undertaking that has the potential to enhance per capita income, employment prospects, and the overall quality of life across regions. The chemical industry stands as an essential sector that satisfies people's requirements and is often categorised based on factors like size, ownership, and the raw materials used in manufacturing (Timotius & Sukmarani, 2021). The paint business encompasses the production of a wide range of paint goods, such as paints, enamels, varnishes, lacquers, putties, wood fillers, sealers, and other related items like paint and varnish removers, as well as paint brush cleaners (Yadav & Dutta, 2024). Nevertheless, these vibrant and innovative creations of the paint sector also have a negative aspect, namely the generation of wastewater that contains a complex mixture of different chemicals, solvents, pigments, and heavy metals. The chemicals used in the production of paint and dye products pose a significant environmental hazard and endanger aquatic life when released into the environment via wastewater discharge from manufacturing facilities.

2.3 Trend Textile Industry in Malaysia

A 400% rise in water demand is predicted to occur in the industrial sector by 2050, which is anticipated to have significant adverse effects on the environment and ecosystems at both global and regional levels (Nahar et al., 2024). The textile industry is heavily dependent on water and stands as one of the world's top ten industrial sectors in terms of water consumption. Additionally, it is the second-largest contributor to pollution. The amount of water consumed in the textile industry varies depending on factors such as the type of cloth, processing equipment, dyestuffs, and management procedures. In September 2022, the textile manufacturing sector across ASEAN countries saw the most rapid growth in production, new orders, purchasing activity, and employment. Many Malaysian fashion designers eagerly anticipate the rise of the sector, which has led to the nation being acknowledged as an emerging global fashion hotspot. However, the sector faces competition from other neighbouring countries, including Indonesia, Vietnam, Pakistan, Sri Lanka, China, Cambodia, and Bangladesh. Malaysia responded to the emergence of cheaper competitors by implementing more intelligent procedures and adopting more efficient technologies for production and delivery, aiming to foster consistent and reliable income in the local textile manufacturing sector.

2.4 Issue in Wastewater by the Textile Industry

The efficient management of wastewater from industrial processes is essential for achieving sustainable industrial growth and reducing the negative impact on the environment. Utilising newly developed technology, optimising processes, and employing effective treatment methods may greatly reduce the adverse effects caused by the discharge of wastewater from industrial facilities. Examples of wastewater treatment technologies include coagulation, flocculation, ion exchange, adsorption, membrane separation, filtration, chemical oxidation, and biodegradation (Rezai & Allahkarami, 2021). Past research found that the extensive use of chemicals, electricity, and freshwater caused the ecological footprint of Bangladesh's wet processing facilities and/or composite textile units to be much higher than average (Nahar et al., 2024). It should be noted that the amount of freshwater needed to make one kilogram of fabric in Bangladesh is around 0.25–0.30 cubic metres (250–300 litres), which is approximately 80% or higher than the worldwide benchmark. The Bangladeshi textile industry uses around 1500 million cubic metres of groundwater annually and spends over 4 billion US dollars and approximately 980 million kWh of power to extract the necessary amount of water volume. Groundwater table levels have decreased in the majority of the country's textile clusters because of the heavy dependence on groundwater resources for the process's operation.

Hazards to the environment may be caused by improper disposal of sludge and leftover dye chemicals, which ultimately lead to the development of solid waste (Sebastian et al., 2024). Numerous problems are made worse by the fact that many companies do not have sufficient wastewater treatment facilities (Wang et al., 2022). As a result, untreated or partially treated wastewater is discharged into adjacent water bodies, putting aquatic life, ecosystems, and human health at risk. It also exposes local populations to hazardous chemicals and illnesses that are transmitted via water, resulting in significant health issues. However, industrial management faces several difficulties in the treatment of wastewater, stemming from both operational and regulatory challenges. Tackling these challenges requires the use of cutting-edge technology as well as strict adherence to rules, effective cost management, and substantial investments in personnel training and infrastructure enhancements.

Enhancing wastewater treatment methods can be accomplished by identifying and resolving issues while using facilitators. When combined with the most appropriate technology (Urbina-Suarez et al., 2024), these strategies will improve water quality and decrease the environmental consequences (Singh et al., 2023). Furthermore, it is crucial to address challenges associated with cost, energy consumption, and resource utilisation to implement wastewater treatment solutions that are both sustainable and economically advantageous. Preserving environmental and economic resilience requires one to embrace sustainable practices, promote efficient water usage, and implement new technology, while water shortages and pollution problems persistently escalate (Singh et al., 2023). This can be further assisted by promoting the reuse of treated wastewater from the facility's washing plant in the production process (i.e., garment washing and dyeing) via an effluent treatment plant (ETP) (Nahar et al., 2024). Finally, acknowledging and understanding the challenges can help policymakers establish appropriate laws and regulations to improve wastewater treatment procedures. This can be strengthened by integrating environmental protection initiatives into occupational safety and health (OSH) programs in the industrial business, thus ensuring long-term environmental durability (Utit et al., 2015).

2.5 Application of Industrial Engineering and Management Principles to the Treatment of Wastewater

The planning, design, operation, and maintenance of sophisticated wastewater treatment technologies may benefit from industrial engineering concepts (Singh et al., 2023). A comprehensive analysis of industrial wastewater management reveals the need for novel techniques to minimise pollution, promote circular economic concepts, and ensure compliance with severe requirements. Treatment systems are designed and optimised with the assistance of industrial experts. To achieve sustainable water management in enterprises, it is essential to use water-efficient technologies and effective wastewater treatment procedures. Providing support for policies, engaging stakeholders, advancing technology capabilities, and implementing sustainable practices are important components to provide a road map towards responsible and effective management of industrial wastewater.

In many sectors, the industrial engineers are responsible for delivering expert process engineering design and support services for the treatment of industrial wastewater (Timotius & Sukmarani, 2021). To deliver industrial wastewater treatment that is both cost-effective and efficient, we combine tried-and-true equipment and systems with the most recent technological advancements. When it comes to wastewater treatment, microalgae are more cost-effective than standard procedures, delivering substantial energy savings (Anagnostopoulou et al., 2024). Additionally, microalgae could effectively reduce the amount of nutrients that are present in wastewater. This ability is reinforced by the simultaneous creation of biomass that is characterised by increased amounts of lipids, carbohydrates, and proteins.

Furthermore, textile companies have developed wastewater treatment facilities (WWTPs), which comprise of physical, chemical, electrochemical, and biological unit processes. Chemical precipitation, coagulation/flocculation, adsorption, ion exchange, membrane separation, filtering, electrolysis, and advanced oxidation are all examples of physiochemical processes. There is a possibility of combining these therapeutic procedures, and biological processes may be used as subsequent steps, respectively (Bogale et al., 2024). The technique is expected to face a number of significant obstacles, with the most significant being the huge amount of power used during the process of treating wastewater (Sebastian et al., 2024).

3. CONCLUSION

The textile industry produces massive quantities of wastewater containing harmful dyes, chemicals, and heavy metals, which is a major contributor to water pollution. Therefore, it is essential to successfully treat wastewater from the textile industry prior to being discharged or reused to reduce the negative effect on the environment. The management of textile wastewater has made some progress; nevertheless, there is still a need for ongoing efforts to create treatment solutions that are both cost-effective and efficient. These solutions should be able to remove pollutants sufficiently and allow for safe disposal or reuse of treated water. To maintain compliance with strict rules, it is necessary to implement creative strategies that minimise pollution, promote concepts of circular economies, and ensure that industries continue to innovate and expand into new areas. Ongoing study and development in the field of industrial environmental issues, such as waste management, is also vital, and the short review is an integral part of that process.

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AVAILABILITY OF DATA AND MATERIALS

Not applicable

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

GENERATIVE ARTIFICIAL INTELLIGENCE DECLARATIONS

The author(s) declare that no generative AI or AI-assisted technologies were used in the writing of this manuscript. All content, including text, figures, and tables, was created by the author(s).

REFERENCES

Anagnostopoulou, C., Papachristou, I., Kyriakoudi, A., Kontogiannopoulos, K. N., Mourtzinos, I., & Kougias, P. G. (2024). Development of alginate beads loaded with bioactive ingredients from Chlorella vulgaris cultivated in food industry wastewaters. Algal Research, 80, 1-10.

Annua, Z. F., Azmi, W. N. F. W., Ahmad, N. I., Sham, N. M., Mahiyuddin, W. R. W., Veloo, Y., & Abdullah, N. A. (2020). Drinking water quality in Malaysia: a review on its current status. International Journal of Environmental Sciences & Natural Resources, 24(2).

Bogale, F. M., Teffera, B., & Aragaw, T. A. (2024). Recent developments in integrated anaerobic/aerobic (A/O) process for textile industry wastewater treatment: A review. Journal of Hazardous Materials Advances, 15, 1-17.

Haq, I., Kalamdhad, A. S., & Pandey, A. (2022). Genotoxicity evaluation of paper industry wastewater prior and post-treatment with laccase producing Pseudomonas putida MTCC 7525. Journal of Cleaner Production, 342, 1-14.

Huang, Y. F., Ang, S. Y., Lee, K. M., & Lee, T. S. (2015). Quality of water resources in Malaysia. Research and Practices in Water Quality, 3, 65-94.

Kumar, R., Kundu, D., Kormoker, T., Joshi, S., Rose, P. K., Kumar, S., Sahoo, P.K., Sharma, P. & Lamba, J. (2024). Phycoremediation of potentially toxic elements for agricultural and industrial wastewater treatment: Recent advances, challenges, and future prospects. Desalination and Water Treatment, 319, 1-18.

de Araujo, D. M., Segundo, I. D. B., Cardozo, J. C., Santos, J. E. L., Nascimento, J. H., Gondim, A. D., dos Santos, E.V. & Martinez-Huitle, C. A. (2024). Produced water electrolysis with simultaneous green H2 generation: From wastewater to the future of the energetic industry. Fuel, 373, 1-6.

Ma, F. X., Hao, B., Xi, X. Y., Wang, R., & Ma, P. C. (2022). Aggregation-induced demulsification technology for the separation of highly emulsified oily wastewater produced in the petrochemical industry. Journal of Cleaner Production, 374, 1-9.

Nahar, N., Haque, M. S., & Haque, S. E. (2024). Groundwater conservation, and recycling and reuse of textile wastewater in a denim industry of Bangladesh. Water Resources and Industry, 31, 1-14.

Pang, Y. L., & Abdullah, A. Z. (2013). Current status of textile industry wastewater management and research progress in malaysia: A review. In Clean - Soil, Air, Water, 41(8), 751–764.

Rezai, B., & Allahkarami, E. (2021). Wastewater Treatment Processes—Techniques, Technologies, Challenges Faced, and Alternative Solutions. In Soft Computing Techniques in Solid Waste and Wastewater Management. Elsevier. 35–53.

Sebastian, S. L., Kalivel, P., Subbiah, K., Murphy, M. A., David, J. J., & Palanichamy, J. (2024). Assessing titanium vs. aluminium electrodes for wastewater remediation in the small-scale industries (SSI) textile sector. Environmental Nanotechnology, Monitoring & Management, 21, 1-13.

Singh, B. J., Chakraborty, A., & Sehgal, R. (2023). A systematic review of industrial wastewater management: Evaluating challenges and enablers. Journal of Environmental Management, 348, 1-34.

Timotius, E., & Sukmarani, G. (2021). Industrial waste treatment management: A review. Journal of Science and Applied Engineering, 4(1), 1-8.

Urbina-Suarez, N. A., Angel-Ospina, A. C., Lopez-Barrera, G. L., Barajas-Solano, A. F., & Machuca-Martínez, F. (2024). S-curve and landscape maps for the analysis of trends on industrial textile wastewater treatment. Environmental Advances, 15, 1-21.

Utit, C., Saari, M. Y., Hassan, A., & Ismail, T. H. T. (2015). Measuring the embodied waste among industries in Malaysia. Procedia Environmental Sciences, 30, 228–231.

Wang, X., Jiang, J., & Gao, W. (2022). Reviewing textile wastewater produced by industries: Characteristics, environmental impacts, and treatment strategies. Water Science and Technology, 85(7), 2076-2096.

Yadav, D., & Dutta, J. (2024). Advancing environmental sustainability: recent trends and developments in treatment methods for paint industry wastewater. Journal of Water Process Engineering, 61, 1-13.

Zahuri, A. A., Abdul Patah, M. F., Kamarulzaman, Y., Hashim, N. H., Thirumoorthi, T., Wan Mohtar, W. H. M., ... & Wan-Mohtar, W. A. A. Q. I. (2023). Decolourisation of real industrial and synthetic textile dye wastewater using activated dolomite. Water, 15(6), 1-21.