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EMERGING TECHNOLOGIES FOR WASTEWATER TREATMENT IN THE TEXTILE INDUSTRY: FUTURE PROSPECTS

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Abstract: *The textile industry is one of the largest water-consuming industries, and it generates a significant amount of wastewater that needs to be treated before being discharged into the environment. To address this challenge, there has been a growing interest in the development of state-of-the-art technologies for wastewater treatment in the textile industry. Physical treatments such as sedimentation, flotation, and filtration are commonly used to remove suspended solids and organic matter from textile wastewater. Chemical treatments such as coagulation/flocculation and oxidation are effective in removing dyes and other colorants. Biological treatments such as aerobic and anaerobic treatments have been shown to be effective in treating organic matter and other pollutants. Moving Bed Biofilm Reactor (MBBR) technology has become increasingly popular in the textile industry for treating wastewater. This technology uses a combination of biological and physical processes to effectively remove pollutants from textile wastewater. The use of MBBR technology in textile industry wastewater treatment has several benefits. It is highly efficient in removing pollutants, including organic matter, color, and suspended solids. It can also handle high variations in flow and organic loads, making it suitable for the highly variable wastewater generated by the textile industry. The use of MBBR technology in the textile industry offers a cost-effective, efficient, and sustainable solution for treating wastewater, making it an increasingly popular option for textile manufacturers worldwide.*

Key words: *wastewater, textile industry, MBBR, treatment technologies*

1. INTRODUCTION

The textile industry is one of the largest polluters in the world, and one of the main contributors to water pollution. Textile production requires large amounts of water, and the wastewater produced by textile manufacturing processes contains a variety of pollutants that can have significant environmental and health impacts. The main pollutants found in textile industry wastewater include chemicals such as dyes, detergents, surfactants, and finishing agents [1]. These chemicals are used in the production process to achieve specific colors, textures, and properties, but they can be harmful to the environment and human health when they are released into water bodies.

One of the most significant pollutants in textile industry wastewater is synthetic dyes [2]. These dyes are widely used in textile production and can cause serious environmental problems when they are discharged into water bodies. Synthetic dyes are typically made from petroleum-based chemicals and are not biodegradable, meaning they can persist in the environment for a long time. Other common pollutants in textile industry wastewater include heavy metals such as lead, cadmium, and chromium. These metals can be toxic to aquatic life and can cause serious health problems in humans if they are ingested or absorbed through the skin. Textile industry wastewater also contains organic pollutants such as polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). These compounds are produced during the production process and can cause respiratory problems and other health issues in humans and animals.

Recent statistics show that textile industry wastewater is a major source of water pollution. According to the World Bank, the textile industry is responsible for up to 20% of global industrial water pollution, and in some regions, textile production can account for up to 90% of all wastewater generated. In addition, a report from the United Nations Environment Programme (UNEP) found that textile dyeing and finishing processes are responsible for up to 17-20% of industrial water pollution globally. The report also notes that up to 72 toxic chemicals are released in the process of textile dyeing and finishing, with some of them being highly persistent in the environment and bio-accumulating in aquatic organisms.

The current state of the art for wastewater treatment involves a combination of physical, chemical, and biological processes to remove pollutants from wastewater. Some of the latest advancements in wastewater treatment technology include the use of membrane filtration [3], advanced oxidation processes, and innovative biological treatment methods such as anaerobic digestion and bio-electrochemical systems, and adsorption method, using specialized adsorbent materials [4](Fig. 1). In addition, there is increasing interest in decentralized and sustainable wastewater treatment approaches, such as constructed wetlands and ecological sanitation systems. Overall, continued research and development in wastewater treatment technologies are essential for improving the efficiency, sustainability, and cost-effectiveness of wastewater treatment processes.

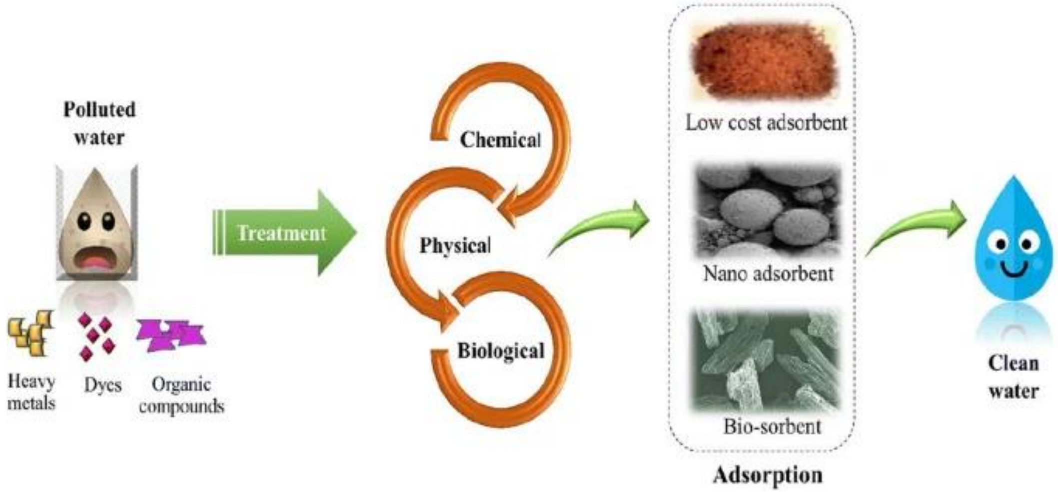

Fig. 1: Wastewater treatment technology using adsorption method
(Source: Rashid et al., 2021)

2. CURRENT TREATMENT TECHNOLOGIES

The textile industry is known to be one of the most polluting industries globally, generating large volumes of wastewater with a high concentration of organic and inorganic pollutants. Wastewater treatment for the textile industry is crucial to reduce the negative impact on the environment and public health. In recent years, several treatment methods have emerged to address this issue. One of the most common methods used for textile wastewater treatment is the physical-chemical process. This process involves the use of chemicals to coagulate and flocculate the suspended solids and then separate them through sedimentation or filtration. The treated water can be further treated by activated carbon adsorption, reverse osmosis, and UV radiation for final polishing. This method has been widely used due to its effectiveness in removing both organic and inorganic pollutants. However, the use of chemicals can lead to the formation of sludge, which requires proper disposal (Fig 2).

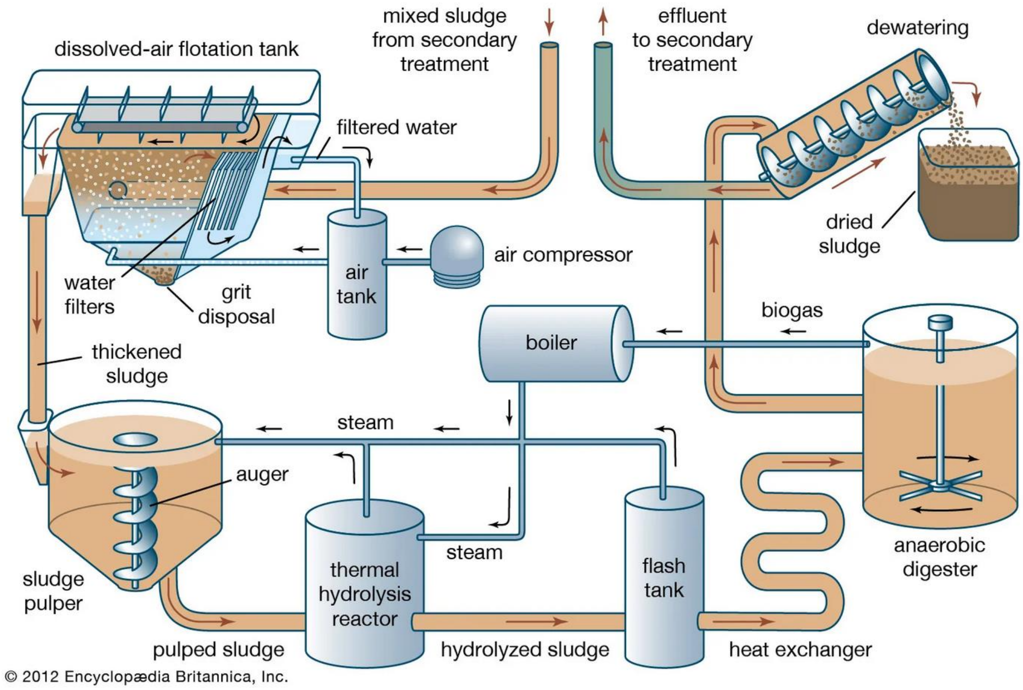

Fig. 2: Scheme for sewage sludge treatment
(Source: www.britannica.com)

Another method used for textile wastewater treatment is biological treatment. This method involves the use of microorganisms to break down the organic pollutants in the wastewater. The most commonly used biological treatment methods are activated sludge, biofiltration, and anaerobic digestion. Activated sludge is a widely used method, which involves the use of aerobic microorganisms to break down the organic matter. Biofiltration is another method that uses microorganisms in a fixed-bed reactor, where the wastewater is passed through a filter bed that contains microorganisms. Anaerobic digestion is a process that involves the decomposition of organic matter in the absence of oxygen. This method is particularly useful for high-strength wastewater with a high concentration of organic matter [5].

In recent years, advanced treatment methods such as membrane filtration, electrocoagulation, and ozone treatment (Fig 3) have gained popularity for textile wastewater treatment. Membrane filtration involves the use of a semi-permeable membrane to separate the pollutants from the wastewater. This method is particularly useful in removing dyes and other small molecules from the wastewater. Electrocoagulation is a process that involves the use of an electric current to coagulate and flocculate the suspended solids. Ozone treatment involves the use of ozone gas to oxidize the pollutants in the wastewater. This method is effective in removing color, odor, and taste from the wastewater.

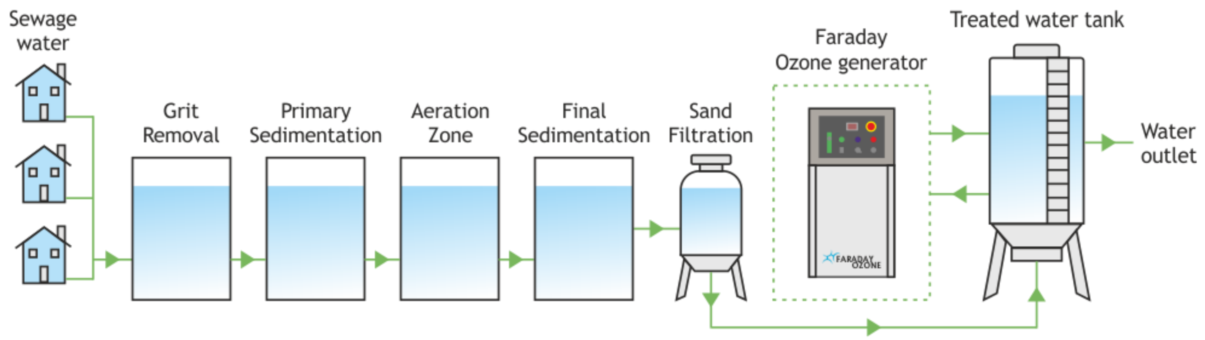

Fig. 3: Faraday Ozone company treatment technology
(Source: www.faradayozone.com)

3. MBBR TREATMENT TECHNOLOGY

Moving Bed Biofilm Reactor (MBBR) is a biological wastewater treatment technology that uses a combination of suspended and attached growth bacteria to treat organic and inorganic pollutants from wastewater [6]. The technology was first developed in the late 1980s and has since become widely used in the treatment of municipal and industrial wastewater. The working principle of MBBR technology involves the use of plastic carriers, known as media, to provide a surface for bacterial growth (Fig. 4). These carriers are designed to be kept in motion through the reactor by the use of aeration and mixing systems, which promote the transfer of oxygen and nutrients to the bacteria. As wastewater passes through the reactor, bacteria attach themselves to the surface of the media and form a biofilm. The bacteria in the biofilm then metabolize and break down the pollutants in the wastewater, converting them into less harmful byproducts.

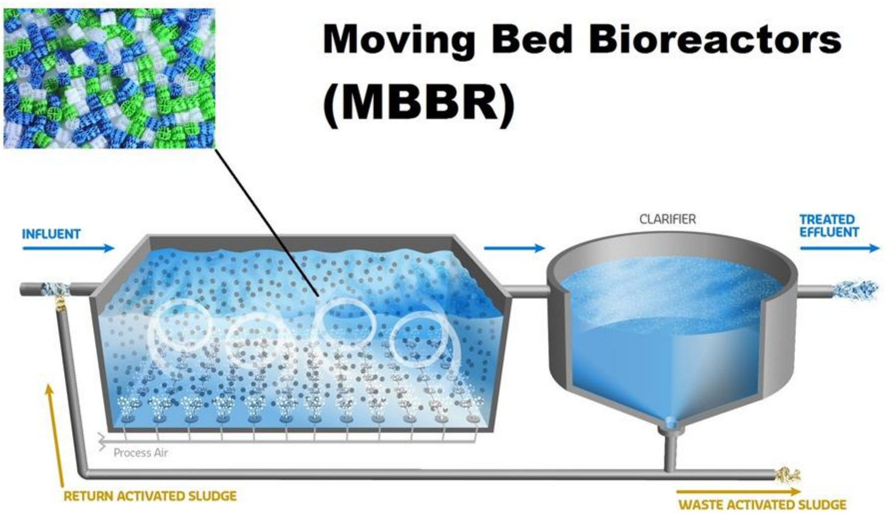

Fig. 4: MBBR treatment principle (by Hebei Lanyu company, China)
(Source: www.gustawater.com)

The textile industry is a major contributor to global water pollution due to the large volumes of wastewater generated by its manufacturing processes. Many textile companies have turned to

Moving Bed Biofilm Reactor (MBBR) technology to treat their wastewater, as it offers an efficient and cost-effective solution for removing pollutants. MBBR technology is becoming an increasingly popular choice for textile companies seeking to reduce their environmental impact and comply with local wastewater discharge regulations. With the help of companies such as OxyMem, EnviTec Biogas AG, and Aqua-Aerobic Systems (which involves a complex system based on biological treatment, cloth media filtration and ultrafiltration membranes – Fig 5), textile companies can implement efficient and effective MBBR systems to treat their wastewater and reduce their impact on the environment [7].

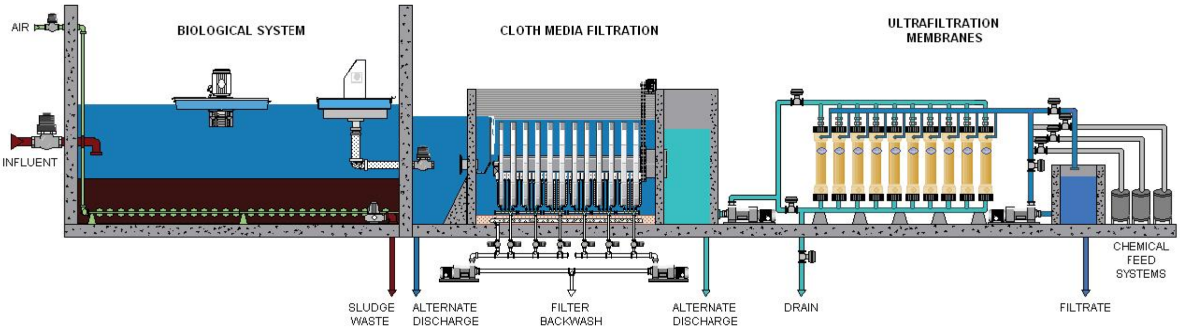

Fig. 5: Aqua-Aerobic Systems' wastewater treatment technology
(Source: www.aqua-aerobic.com)

National R&D Institute for Textile and Leather (Bucharest, Romania) carried out a research project called "Exploiting fungi potential for recalcitrant compounds removal from cellulosic wastewaters", acronym Funcell, within Manunet III international competition, with parners from both Romania and Italy. The main objective of the project was the development of an innovative mycobased tertiary treatment for tannery and papermill wastewaters efficient in removing tannins and absorbable organic halogen (AOX), not depleted by consolidated bacterial based processes. One of the results of the project were the development of new generations of HDPE carriers, based on talcum, for MBBR treatment systems, by Romanian SME DFR Systems (Fig. 6).

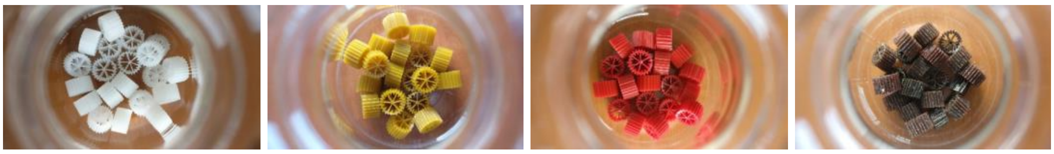

Fig. 6: Novel HDPE cariers manufactured by DFR Systems (Romania)
(Source: www.dfr.ro)

MBBR technology has several advantages over other wastewater treatment technologies. It is highly efficient, compact, and requires less space than traditional treatment systems. It is also highly adaptable and can be easily modified to handle different types and volumes of wastewater. MBBR systems can achieve a high level of treatment efficiency, with removal rates of up to 90% for organic matter and 70% for nitrogen. Additionally, MBBR technology is relatively low cost, making it an attractive option for many applications. Overall, MBBR technology offers an effective and reliable solution for the treatment of wastewater in a variety of industries. MBBR systems produce less sludge compared to other processes, due to the fact that the bacteria in the biofilm are self-immobilized and do not require the use of settling tanks.

4. CONCLUSIONS

In conclusion, the textile industry is a major contributor to water pollution, with textile industry wastewater containing a variety of harmful pollutants. It is important for the industry to adopt more sustainable practices and for governments to regulate and enforce environmental standards to reduce the impact of textile production on the environment and human health. As a treatment technology, MBBR is an innovative and effective solution for removing organic and inorganic contaminants from wastewater. The use of MBBR technology offers several advantages for textile industries. Firstly, it is a cost-effective and efficient solution for the treatment of high-strength wastewater. Secondly, it requires less space and produces less sludge than traditional treatment methods. Thirdly, it is a scalable technology that can be easily adapted to meet the changing needs of the textile industry. Overall, MBBR technology is a highly effective and efficient wastewater treatment process that is widely used in a variety of industries. Its ability to handle variable flow rates and organic loads, low energy consumption, small footprint, minimal sludge production, and easy maintenance make it an attractive option for wastewater treatment plants and industries around the world.

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