WASTEWATERS ORIGINATED FROM THE TEXTILE INDUSTRY

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Abstract: *Human population is growing so the amount of produced wastewaters has increased considerably. Such toxic wastewaters are dangerous for sea, lakes and groundwater, endangering the survival of life on Earth. They also promote the development of oxygen-consuming microorganisms that lead to fish death and the development of pathogenic microbes. The textile industry creates waste water in the production process and such water needs to be cleaned prior to discharge into the watercourse.*

Keywords: waste water, textile industry, pollution.

OTPADNE VODE TEKSTILNE INDUSTRIJE

Apstrakt: *Porastom broja stanovnika, otpadne vode su znatno povećale. Otpadne vode zagađuju mora, jezera, i podzemne vode čime je ugrožen i opstanak života na Zemlji. One pospešuju razvoj mikroorganizama koji troše troše kiseonik što vodi do uginuća riba te razvoja patogenih mikroba. Tekstilna industrija stvara otpadne vode u proizvodnom procesu i takve vode treba prečistiti pre ispuštanja u vodotokove.*

Ključne reči: otpadne vode, tekstilna industrija, zagađenje.

1. INTRODUCTION

Wastewater in the textile industry is generated in the process of preparing raw materials, dyeing fibers or fabric, in the processes of finishing and special processing of finished fabrics. For this reason, they contain a high content of organic or inorganic materials, high coloring, various minerals and metals, and often toxic and carcinogenic substances. Before releasing into the environment, they must be reduced to the maximum permissible values prescribed by law. The textile industry is responsible for up to 20 percent of industrial wastewater in the world. Although the textile industry is one of the largest producers of industrial wastewater, it is not alone: mining, petrochemicals, pharmaceuticals and agriculture all contribute to the problem. The United Nations estimates that the world produces as much wastewater every year as the entire human population consumes in 41 years. A landmark report, released last month by the Global Commission on Water Economics, found that only 20 percent of wastewater is currently treated, with much less recycled, contributing to a global shortage of clean water. The report predicts that freshwater demand will exceed supply (reserves) by 40 percent by 2030.

2. TECHNOLOGY

The technology of industrial waste water treatment of the textile industry is capable of extracting

Table 1: Wastewater, Serbia Wastewater

Waste water (refined and non-refined) according to treatment method and activity (thousands of cubic meters), 2022 year						
	Discharged wastewater in total	Discharged precise effluents	Precise waste water (example treatment)	Precise waste water (secondary treatment)	Precise waste water (tertiary treatment)	Tested imprecise waters
Textile industry	442	350	8	17	325	92

Source Republic Institute of Statistics Serbia, Wastewater
https://data.stat.gov.rs/Home/Result/25010302?languageCode=sr-Latn

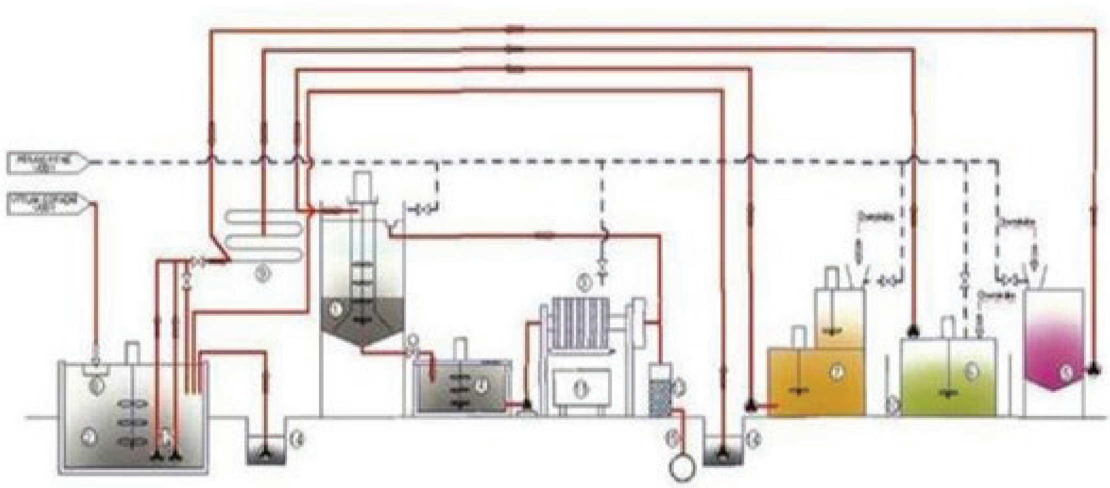
dyes, bleaching agents and mechanical impurities from waste water generated during production processes. The treatment of industrial wastewater is based on chemical stabilization, precipitation, sedimentation and subsequent filtration and dehydration on a filter press. The principle of operation of the wastewater treatment plant AS-ASLI The waste water that comes continuously from the production plant is homogenized in the storage tank, where mixing is done by a slow-moving mixer. Homogenization achieves equalization of water quality. The homogenized wastewater is pumped through the pipe mixer into the sedimentation reactor. Coagulation and flocculation agents as well as alkaline agents for pH correction are dosed in the tube mixer. In this way, the required pH value of the waste water is achieved for the further development of the purification process, and therefore the pH value for the discharge of water into the sewage network. Pollutants from wastewater are separated by a sedimentation process that is aided by the addition of a coagulation agent. Even better performance of filtration and removal of water from the sludge using the filter press is influenced by the dosing of the flocculating agent. Waste water treated in this way enables further treatment of waste water in a biological reactor.

These plants are installed in the following locations

Table 2. Installed wastewater treatment plant AS-ASLI

Investor	Location	Capacity (m^3/day)	Date of construction
MAXIS a.s.	Valašské Meziříčí, CZ	10	2005
LOANA a.s.	Rožnov pod Radhoštěm	150	2012

Technological scheme:



Legend: 1 Coagulation reactor, 2 Equalization tank, 3 Dehydration of sludge, 4 Homogenization tank for sludge, 5 Correction of pH value, 6 Preparation of coagulants, 7 Preparation of flocculants, 8 Mechanical pre-treatment, 9 Pipe mixer, 10 Receiving tank, 11 Container for sludge, 12 Sludge pumps, 13 Filter, 14 Thickening tank, 15 Outlet to the sewage network

2.1. Azo dyes

Azo dyes are insoluble dyes that are applied to the surface or in the fiber by mixing two soluble reactants that give an insoluble product in their reaction. In nature, they are very difficult to degrade, they are subject to bioaccumulation, and due to their allergic, carcinogenic, mutagenic and teratogenic properties, and they are a threat to human health and the preservation of the environment. The removal of azo dyes from wastewater often requires a lot of costs, the need to dispose of the resulting harmful sludge or the creation of toxic decomposition components. They are difficult to decompose and lose their color due to their artificial origin, extremely complex structure and pronounced stability, so they need to be removed from the water before it is released into nature. The removal of color does not always mean the removal of toxicity. Incomplete degradation and the formation of degradation products can even increase this toxicity. That's why it is important to check the success of dye decomposition by conducting ecotoxicological tests. Compounds resulting from the decomposition of azo dyes are an aesthetic problem and contribute to the mutagenicity of the soil and the underground and surface waters with which they come into contact. Biodegradability and toxicity to aquatic life (fish, bacteria, planktonic organisms such as Daphnia, algae) are of particular importance, and the fact is that these colors are not easily biodegradable. In many countries, strict legal requirements have been set for the disposal of colored wastewater. These conditions in developed and developing countries are constantly changing in terms of their tightening to the extent that industries, whose work produces waste water with the presence of dyes, are forced to purify it to the degree prescribed by legal regulations in accordance with environmental acceptability. Some studies show that dyes in natural water courses are sometimes present in a concentration of 1.56 mgl^{-1}, and the visibility of dyes in a clean river is already present in a concentration of 0.005 $mgl^{-1.}$ Since the legal requirements are becoming more and more strict, there is a need to quickly find technically feasible and economically acceptable methods of treating wastewater containing dyes. The new so-called eco-labels of textile products and the increasingly strict legal requirements for the output values of the components of the treated colored wastewater force the textile industry to reuse process water and chemicals. The removal of dyes from waste water should be carried out in order to achieve the reuse of purified waste water, which is an advantage from both an ecological and economic point of view, in order to reduce the pollution of surface waters and reduce the possibility of bioaccumulation of dyes and other chemicals. Due to the incomplete binding of dyes to the fibers, the fabric dyeing process is insufficiently efficient, so most of the waste water of the textile industry is dyed. During textile processing, 30% to 70% of the used amount of dye is hydrolyzed and discharged into waste water, and during the production of dyes, that amount amounts to 10% to 15% [1,2].

2.2 Heavy metals in waste water of the textile industry

Heavy metals (arsenic, lead, copper, mercury) in waste water from the textile industry are a big problem for the environment, especially if they are found on fabrics. They are good oxidants and a good agent for color stability. The toxic effects of heavy metals should be controlled during the production and processing of textile materials. Metals remain in the atmosphere from a few days to a few weeks, in water for months and years, in the Earth's crust for hundreds of years, in the oceans for thousands of years, and in marine sediments for up to 108 years. Heavy metals are very toxic because they are soluble in water in the form of ions or compounds and are thus very easily absorbed by living organisms. After absorption, these metals can bind to vital cellular components such as structural proteins and enzymes and thus interfere with their work. Some of these metals can cause serious physiological and health consequences in humans, even when they are present in very small amounts. They dilute very quickly in water and settle as soluble carbonates, sulfates or sulfides at the bottom of water surfaces. The appearance of various forms of allergies raises the suspicion that metals and other pollutants are one of the causes of their appearance. The sources of metal ions in the textile industry are different. Iron, copper, manganese, cobalt, zinc, arsenic, nickel, chromium are most often found on textile material. Man is in constant contact with textiles, and for this reason, special regulations have been passed on the permitted concentrations of metal ions on clothing, which determine the maximum permitted amount of certain metals on textile materials. Öko-Tex Standard 100 stands for "International Association for Research and Testing in the Field of Textile Ecology". The association was founded in 1992 by the Austrian Textile Research Institute and the German Hohenstein Research Institute. The purpose of the association was to create the core of an international organization for the development and unification of criteria for the ecological reliability of textiles and testing methods, in order to obtain the most objective ecological mark of verifiable reliability. They determined the relevant characteristics and maximum permitted amounts of harmful substances within the technical documentation of the environmental label. This standard applies to textile and leather products of all stages of processing. By applying the prescribed methods, the specified characteristics of textiles, i.e. textile products, are tested and, if the required requirements are met, the label "Reliable textiles - harmful substances tested according to Öko-Tex Standard 100" is placed on the textile [3,4,7,10].

Purification of colored wastewater

Wastewater from the textile industry differs in the amount and composition of waste pollutants, depending on the type of textile raw material and the method of processing. They are often intensely colored, alkaline, contain organic substances (high BOD5 and HPC values), heavy metals, significant amounts of fats and detergents. The decision on the method of efficient, ecological and economically profitable waste water purification is made after quantitative analysis of waste water and after water purification at a pilot plant or a semi-industrial plant. A smaller part of the pollution is removed by mechanical purification, while the larger part remains in the waste water and is removed by biological or physic-chemical purification [6,9].

3. NEW TECHNOLOGIES

Microbes that reduce the harmful impact of the textile industry Textile dyes are used in the process of dyeing textile materials. By themselves, they are very toxic compounds and can create a big problem if they are not disposed of properly. Statistics tell us that 20-25% of wastewater is SU IY TEXTILE industry. As the production process generates a large amount of waste water with textile dyes, this waste water represents an environmental problem of global proportions.

Textile dyeing is the second largest polluter of water surfaces in the entire world. Specifically in Serbia, there is a problem of endangering a large number of aquatic ecosystems throughout Belgrade, Novi Pazar, Priboj, Zrenjanin and other cities with a slightly more developed textile industry. Bacteria Streptomyces sp. by 286. produces an enzyme (protein), lactase. Its correct name is LAC BV 286. It has the ability to break down phenolic compounds – i.e. textile dyes. Lactase from this bacterial strain is important for application in the textile industry for a couple of reasons - primarily due to its high temperature stability and resistance to organic solvents. Temperature stability is important because we know that laccase can function even when there are large fluctuations in temperature, which is a common occurrence in industrial processes. Resistance to organic solvents is also important because organic solvents in this case cannot interfere with the decomposition of harmful compounds. Thus, lactase is really a very stable enzyme that is a perfect match for industrial use. Another microorganism capable of producing this enzyme is Pseudomonas putida F6. Lactases originating from this bacterium are called COP A and can also break down phenolic compounds, i.e. textile colors, but to a lesser extent. However, a small problem arises in the efficiency of the bacteria to produce laccase. Streptomyces sp. and Pseudomonas putida do not reproduce quickly and efficiently enough and do not produce the enzyme in sufficient quantity by themselves. It is necessary to provide optimal conditions for growth and a lot of time, and since environmental problems of a global scale should not hang without a solution for so long, we resort to different methods. What can overcome this problem is to transfer the laccase gene from our bacterium to a better, faster and more efficient bacterium. This is called genetic engineering. [8,11] We take the lacrase gene we need by cutting it out of the genome of one bacterium and inserting it into the gene sequence of another bacterium using certain molecular-biological methods. Now, our new bacterium is able to produce the enzyme, plus it reproduces quickly and is not too fussy! When lactase is produced in this way, it is much easier to use it for wastewater treatment. Currently, there are several scientific works that deal with this problem, and one important step that is currently missing is the method of applying lactase in polluted ecosystems. Polymers that remove dyes from textile wastewater Researchers at Khalifa University in Abu Dhabi have created a new nanomaterial that can clean these dyes and other pollutants from industrial wastewater. The material consists of tiny sand-like grains that collect pollutants on their surfaces and in their pores, says Enas Nashef, project leader and professor of chemical engineering at Khalifa University. The textile industry is responsible for up to 20 percent of the world's industrial wastewater, which is one of the reasons why Nashef and his team decided to focus their research efforts on dyes. The nanomaterial consists of polymers and mimics the "glue" that mussels use to stick to rocks. The team tested the nanomaterial on red-orange and published their findings earlier this year. "So far, there are no toxic effects," says Prof. Nashef adds that the polymer can be cleaned of contaminants and then reused. "At the same time, we look at both efficiency and the environment," he adds. They targeted "anionic dyes" because there aren't many effective methods for removing these types of dyes from water. Nashef hopes his high-efficiency material could solve the sector's dirty wastewater problem. He also hopes to come up with solutions for cleaning other, not just textile, dyes from water. Nashef is developing another nanomaterial that he says could remove viruses from hospital wastewater—an innovation that could help manage the spread of potential future pandemics. Water purification polymers can also help make desalination processes more sustainable, an important factor in the Middle East, where fresh water sources are scarce. Desalination plants use a lot of energy to remove salt from water. Professor Nashef says that using nanomaterials based on functionality in the pretreatment of water and dyes could reduce the energy needed to clean water. "If we can target that, it will reduce the load on the desalination plant," adds Prof. Nashef. He hopes his work in his lab will have a positive real-world impact on water supplies – and "do something important for future generations."

3. CONCLUSION

The textile industry is in the first place in the world according to the amount of waste water. In Serbia, they are not in the first place, but the amount is significant. Wastewater in the textile industry is generated in the process of preparing raw materials, dyeing fibers or fabric, in the finishing and special processing of finished fabrics. For this reason, they contain a high content of organic or inorganic pollutants, high coloring, various minerals and metals, and often toxic and carcinogenic substances. Before discharge into the recipient, they must be reduced to the maximum permitted values prescribed by law. The problem of water purification needs to be solved as soon as possible because the underground water, which is the main source of drinking water, is polluted to alarming levels. Water is renewable, but further uncontrolled pollution must be prevented in order to preserve existing reserves of drinking water.

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