



UNION OF ENGINEERS AND TEXTILE
TECHNICIANS OF SERBIA

VII INTERNATIONAL SCIENTIFIC CONFERENCE
**CONTEMPORARY TRENDS
AND INNOVATIONS IN THE
TEXTILE INDUSTRY**

VII MEĐUNARODNA NAUČNA KONFERENCIJA
**SAVREMENI TRENDOVI I
INOVACIJE U TEKSTILNOJ
INDUSTRIJI**

PROCEEDINGS

EDITOR:
Prof. dr **SNEŽANA UROŠEVIĆ**

Belgrade, 19-20th September, 2024
Union of Engineers and Technicians of Serbia
Dom inženjera „Nikola Tesla“



**UNION OF ENGINEERS AND TEXTILE TECHNICIANS
OF SERBIA**

AND

UNION OF ENGINEERS AND TECHNICIANS OF SERBIA
FACULTY OF TECHNOLOGY AND METALLURGY IN BELGRADE
FACULTY OF TECHNOLOGY, SHTIP, NORTH OF MACEDONIA
FACULTY OF MECHAICAL ENGINEERING, ALBANIA
SOCIETY FOR ROBOTICS OF BOSNIA I HERZEGOVINA
BASTE - BALKAN SOCIETY OF TEXTILE ENGINEERING, GREECE

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PREFACE

The 7th International conference "Contemporary Trends and Innovations in the Textile Industry" CT&ITI 2024, is co-organized by:

- Union of Engineers and Textile Technicians of Serbia,
- Union of Engineers and Technicians of Serbia,
- Faculty of Technology and Metallurgy in Belgrade, University of Belgrade, Serbia,
- Faculty of Technology, "Goce Delchev" University, Shtip, North Macedonia,
- Faculty of Mechanical Engineering, Polytechnic University of Tirana, Albania,
- Society for Robotics of Bosnia and Herzegovina and
- Balkan Society of Textile Engineering-BASTE of Greece.

The Ministry of Science, Technological Development and Innovation of the Republic of Serbia recognized the importance of this Conference, and thus, supported it.

The aim of this Conference is to consider current technical, technological, economic, ecological, R&D, legal and other issues related to the textile industry, then the application of contemporary achievements and the introduction of technical and technological innovations in the production process of fiber, textile, clothing and technical textile by applying scientific solutions in order to improve the business and increase the competitive advantages of the textile industry on the domestic and global market.

Leading scientists and experts from the Balkans and other countries, working at faculties, textile colleges and institutes, but also individuals who professionally deal with the issues at hand are taking part in this Conference.

The Conference program involves papers dedicated to the scientific and practical aspects of the following topics: Textile and Textile Technology, Textile Design, Management and Marketing in the Textile Industry and Ecology and Sustainable Development in the Textile Industry. The Conference program includes 66 papers, and a total of 158 participants from 17 countries: Albania, Australia, Bosnia and Herzegovina, Bulgaria, Croatia, Germany, Greece, India, North of Macedonia, Montenegro, Portugal, Romania, Serbia, Slovenia, Spain, Turkey and Ukraine.

Therefore, this Conference is an opportunity for establishing scientific, educational and economic cooperation of our country with other countries. Certain number of papers by domestic authors present the project results dealing with fundamental research and technological development, financed by the Ministry of Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

I would like to thank all those who have made it possible to organize the conference Contemporary Trends and Innovations in the Textile Industry and make it a success. First, I would like to thank the Scientific and Organizing Committee for working hard, spending countless hours and finding the best solutions for numerous organizational aspects of our Conference. I also thank all the other institutions that supported the Conference in various ways, because without their support, the Conference could not have been organized. Last but not least, I would like to thank plenary lecturers, all authors and co-authors and guests for their participation in the Conference.

On behalf of the Organizing Committee

Prof. dr Snežana Urošević, president



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LIMIT VALUES OF WASTEWATER EMISSIONS OF THE TEXTILE INDUSTRY AND THEIR INFLUENCE ON THE SUSTAINABLE MANAGEMENT OF WATER RESOURCES

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ABSTRACT: *The textile and clothing sector has been changing rapidly over the past years as a result of technological development and changes in economic conditions, as well as increasing competitive pressure, which also caused the restructuring of companies, modernization of production and adaptation to technological changes. As a consequence of this very development of technology and industrialization, major problems have arisen regarding the pollution of natural waters with various contaminants that are discharged from the technological processes of the textile industry into the recipients. Compliance with the legal regulations regarding the limit values of emission of polluting substances that are released into recipients is of exceptional importance in the preservation and sustainable management of water resources. In this regard, the aim of the work is to point out significant mechanisms and instruments for managing harmful substances present in the production processes of the textile industry, which are needed to ensure the sustainable management of water resources and indicate protective measures in this important segment of the environment. The obtained results indicate that this research can be successfully used as a model in the management of the quality of the working and living environment.*

Keywords: *chemical hazards, health of employees, working environment, textile industry.*

GRANIČNE VREDNOSTI EMISIJE OTPADNIH VODA TEKSTILNE INDUSTRIJE I NJIHOV UTICAJ NA ODRŽIVO UPRAVLJANJE VODNIM RESURSIMA

Savez inženjera i tehničara tekstilaca Srbije



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APSTRACT: Sektor tekstila i odeće tokom proteklih godina menjao se ubrzano kao rezultat tehnološkog razvoja i promena ekonomskih uslova, kao i sve većeg konkurentskog pritiska što je uslovalo i prestrukturiranje preduzeća, osavremenjivanje proizvodnje i prilagođavanje tehnološkim promenama. Kao posledica upravo tog razvoja tehnologije i industrijalizacije, javili su se i veliki problema oko zagađenja prirodnih voda najrazličitijim kontaminantima koji se ispuštaju iz tehnoloških procesa tekatilne industrije u recipijente. Karakteristike otpadnih voda koje u recipijente dospevaju iz proizvodnih procesa tekstilne industrije variraju u zavisnosti od izvora zagađenja, te poštovanje zakonske regulative u pogledu graničnih vrednosti emisije zagađujućih materija ima izuzetan značaj u očuvanju i održivom upravljanju vodnim resursima. S tim u vezi cilj rada je da ukaže na značajne mehanizme i instrumente upravljanja štetnostima prisutnim u proizvodnim procesima tekstilne industrije kako bi se osiguralo održivo upravljanje vodnim resursima i ukazalo na mere zaštite od zagađenja ovog važnog segmenta životne sredine. Dobijeni rezultati rada ukazuju, da se ovo istraživanje može uspešno koristiti kao model u upravljanju kvalitetom radne i životne sredine.

Ključne reči: zagađujuće materije, otpadne vode, granične vrednosti emisije, tekstilna industrija.

1. INTRODUCTION

The relationship between human and nature has changed significantly throughout history. The increase in the number of population, as well as the accelerated technological development at the global level, has significantly affected the quality of water, soil and air. Apart from the negative impact on the environment brought about by the modern way of life, the need for resources has also increased. In this regard, the global need for water of acceptable quality for the population and the economy has placed demands on society to analyze this problem and explore possibilities for its sustainable use [1]. It is a well-known fact today that both natural and anthropogenic sources of pollution have the greatest influence on water pollution. Natural sources of pollution largely depend on geographical location, climatic characteristics, etc., while anthropogenic sources of pollution come from the industry [2] whereas the textile industry occupies a special place.

The sector of the textile industry is one of the most complex production sectors of the industry. It is accompanied by a long tradition and rich historical development. More than 2.5 million workers are employed in over 100 countries where textile production is developed. The sector of this industry is composed of a large number of sub-sectors, starting from the production of raw materials, through semi-finished and finished products. Due to the differences in the production processes of such a branched industry, there is a realistic need to use a large number of chemical substances. Unfortunately, that trend is constantly growing, as a result of the increased demand and consumption of textile products that belong to the group of consumables, and are causally related to the increase in the number of inhabitants with a high standard of living [3].



The wide use of chemicals in the textile industry can be the cause of numerous side effects during the production itself, use and after-use of the product, i.e. during the entire life cycle of textile products. In order to establish a safe way of using chemicals in the textile industry, it is necessary to harmonize standards, make a systemic effort in innovation and ensure complete safe treatment of chemicals and waste water from production processes [4].

Considering the extent of use of chemicals, defining the limit values of the concentrations of chemicals that are released from the production processes of the textile industry is extremely important, first of all, in order to protect the environment, but also the health and safety of people [5].

Due to all of the above, in this paper, an analysis of the regulations related to the treatment of waste water was carried out, with a special emphasis on the limit values of the emission of polluting substances into water from the production processes of the textile industry.

2. TEXTILE INDUSTRY

2.1. Waste water from the production processes

The status of the textile industry from the aspect of sustainable development is not favorable. Globally, this branch of industry is still considered one of the biggest polluters of the environment, while textile waste is becoming an increasing environmental problem. Based on the conducted research, it was determined that more than 8,000 chemical substances are used in the technological processes of the textile industry, which means that there is literally no textile product that has not been chemically treated, i.e. it is not "chemical-free". The wide range of chemicals used in the textile industry can cause an unwanted impact on humans and the environment during the entire life cycle of textile products. Chemical substances from textile products can be emitted in several ways - migration, leaching, evaporation and emission [6]. Emissions from textile products depend on factors such as the physico-chemical properties of the substances, the integration of the substances into the materials, the nature of the fibers and the way the textile is handled. For most of these chemical substances, there are no reliable data on whether and to what extent they negatively affect the health of employees who are in direct contact with it in the production process, as well as the users. The currently available data show that the impact of these components on the environment is extremely large. Wastewater from production processes can be loaded with numerous chemical substances that are reliably known to be difficult to remove from water and require complex technological processing.

In regards to the above, a research was carried out on the legal regulations in the field of waste water in Serbia, with a special emphasis on the limit values of the emission of polluting substances in the waste water of the textile industry, the results of which are presented in this paper.

2.2. Legislative framework

EU directives on integrated pollution prevention and control (*Directive Concerning Integrated Pollution Prevention and Control, IPPC*) [7] and industrial emissions (*Directive on industrial emissions*) [7], and regarding the Water Framework Directive (*Water*

Framework Directive EU/WFD-2000/60/EC [7] laid the foundations of legal frameworks in the field of sustainable management of water resources and effluent parameters after the treatment.

The selected parameters set requirements for the implementation of various measures, especially with regard to water protection. The legislative framework on the protection of the environment and natural resources in the Republic of Serbia follows the current legislation of the European Union. The most important strategic document that determines the long-term directions in water management on the territory of Serbia is certainly the Water Management Strategy [8], and all the necessary reforms of the water sector with the aim of reaching standards are carried out on the basis of the Strategy as well as the Law on Water [9]. The Law on Water is the umbrella law of our legal system of water protection, and there is a whole set of laws and by-laws that deal with these issues. The Regulation on limit values of emission of polluting substances into water and deadlines for their achievement [10] is of particular importance in the segment of emission of polluting substances from industrial production facilities. The emission values for certain groups or categories are included in the annex to this Regulation, and within the framework of industrial waste water, the Regulation also includes waste water from the textile industry.

2.3. Limit values of waste water emissions from textile processing and production

In view of the above, and bearing in mind the complexity of the production process of textile product treatment, the emission of waste water from the plant must be at the lowest level of polluting substances. This can only be achieved if water is treated and reused, while the use of synthetic products, organic-complex compounds and surfactants and other similar materials is limited. Accordingly, it is necessary to carry out regular monitoring of waste water before mixing it with other waste water. The frequency and the methods applied in the purification or pretreatment process determine the frequency of examination of the composition, quantity and quality of wastewater. In accordance with the legal regulations, the limit values of the emission of chemical substances from the production processes of the textile industry at the point of discharge into surface water are determined, as shown in Table 1.

Table 1. Emission limit values at the point of discharge into surface waters [10]

Parameter	Unit	Emission limit value ^(II)
Temperature	°C	30
pH		6.5-9
Suspended matter	mg/l	80
Biochemical oxygen consumption (BOD5)	mgO ₂ /l	30
Chemical Oxygen Demand (COD)	mgO ₂ /l	200 ^(III)
Total Organic Carbon (TOC)	mg/l	60 ^(IV)
Mineral oils	mg/l	10
Adsorbing Organic Halides (AOH)	mgCl/l	0.5



Volatile chlorinated hydrocarbons (VOX)	mg/l	0.1
Phenols	mg/l	0.1
The sum of anionic and nonionic degenerates	mg/l	1.0
Aluminum	mg/l	3.0
Copper	mg/l	0.5
Zinc	mg/l	2.0
Cadmium	mg/l	0.1
Cobalt	mg/l	0.5
Tin	mg/l	2.0
Chrome total	mg/l	0.5
Chrome VI	mg/l	0.1
Nickel	mg/l	0.5
Lead	mg/l	0.5
Active chlorine	mg/l	0.3
Total chlorine	mg/l	0.5
Ammonia (as NH ₄ -N)	mg/l	20 ^(V)
Total inorganic nitrogen (NH ₄ -N, NO ₃ -N, NO ₂ -N)	mg/l	20 ^(V)
Total phosphorus	mg/l	1.0 ^(VI)
Sulfates	mg/l	1000
Sulfides	mg/l	1
Sulfites	mg/l	1.0
Toxicity to fish (TF)		2

According to the reports available to the Serbian Environmental Protection Agency, textile industry production plants most often enter the recipients of waste water that is burdened with increased concentrations of oils and fats and increased PH values, as a result of the presence of alkali and azo-dyes. The presence of chemical substances in wastewater certainly depends on the way these waters are treated, as well as on the specifics of the production processes, which can be complex and demanding, especially in dyeing, but also in the fine processing of textiles, which requires the use of phosphonates, polyacrylates and maleic acid copolymers [10]. Tables 2 and 3 show the measured values of wastewater emissions from the production processes of the textile industry at the point of discharge, respectively. The tests were carried out during 2023, and the data refer to waste water from the production process of the textile industry, which is discharged into recipients on the territory of the Jablanica administrative district.

Table 2. Measured values of wastewater emissions from production processes of the textile industry at the point of discharge into surface waters [11]

Sample name	Waste water - Textile industry			
<i>Field test data</i>				
Parameter	Unit	Determined value	Permissible value	Test method
Air temperature	°C	20.2	ND	US EPA 170.1:1974
Water temperature	°C	26.4	40.0	SRPS H.Z1.106:1970
pH value	-	11.65	6.50-9.00	SRPS EN ISO 10523:2016
Electrical conductivity	µS/cm	6870	ND	SRPS EN 27888:2009
Oil and fat content	mg/l	56.80	40	EPA 1664 revision A, 1999
Ammonia content (NH ₃)	mgN/l	<5	10	SMEWW 4500 NH ₃ C 24th edition, 2022
Chromium VI content (Cr ₆₊)	mg/l	<0.05	0.5	ISO 11083:1994
Content of anionic detergents	mg/l	0.17	10	SMEWW 5540 C 24th edition, 2022

Table 3. Measured values of metal emissions at the point of discharge into surface waters [11]

Parameter	Unit	Determined value	Emission limit value	Test method
Iron (Fe)	mg/l	<0.1	5	DM 107
Manganese (Mn)	mg/l	0.15	3	DM 107
Lead (Pb)	mg/l	<0.1	0.0012	DM 107
Copper (Cu)	mg/l	<0.1	1	DM 107
Zinc (Zn)	mg/l	0.05	2	DM 107
Cadmium (Cd)	mg/l	<0.02	0.00015	DM 107
Nickel (Ni)	mg/l	0.18	0.034	DM 107
Chromium (Cr)	mg/l	<0.1	1	DM 107

3. WASTEWATER OF THE TEXTILE INDUSTRY AND SUSTAINABLE MANAGEMENT

Water pollution, resulting from the discharge of industrial wastewater, is a current worrisome phenomenon due to its increasing impact on the health and safety of the environment [12]. Textile waste water produced in different stages of textile processing without appropriate treatment [13] usually contains huge amounts of azo dyes [14], the presence of sulfur, naphthol, sulfuric acid, soap, chromium compounds, heavy metals and certain chemicals that together make the effluent very toxic. Effluents are often of high temperature and pH, both of which are extremely harmful [15] and represent an eco-toxic hazard. In order to protect the environment and sustainably manage water resources, there are restrictions on the amount and type of chemical substances, some of which are even prohibited. To this end, numerous methods of waste water treatment are in use today in the production processes of the textile industry aimed at obtaining water of acceptable quality before mixing it with other waters. Table 4 shows existing and alternative methods of textile industry wastewater treatment [16].

Table 4. The existing and the alternative methods of textile industry wastewater treatment

Existing methods	Alternative methods
Deemulsification (1. flocculation, 2. coagulation)	Filters under pressure
Gravity settling/separation	Adsorption with activated carbon
Removal from the surface of wastewater	Ion exchange
Tubular separation	Air-stripping (separation of components from the liquid phase with the help of the gaseous phase)
Flotation (with dissolved air)	Activated sludge
Chromium reduction	Biofilm
Decomposition of cyanide	Membrane bioreactor
Chemical deposition	Electrodialysis
Filtration	Ultrafiltration
Sand filtration	Reverse osmosis

In practice, the current water management is still incomplete, primarily due to the lack of resources at all levels, and consequently, the degradation of the already existing, weak management system, and the waste water of the textile industry still represents a serious problem of water pollution.

Considering the sensitivity and essential importance of this sector of the environment, only with a responsible approach and effective implementation of the adopted plans and



measures it is possible to timely implement reforms in every sector of industry, in order to reach the required standards in water management.

4. CONCLUSION

Issues of environmental pollution with wastewater originating from the production processes of the textile industry due to a wide range of environmental and toxicological impacts have become increasingly significant in recent years. The adverse impact of wastewater on aquatic ecosystems is determined by its composition, quality and quantity. The most negative impact is certainly industrial waste water. Therefore, adequate waste water management of the textile industry implies continuous serious, conscientious and professional work, which, in addition to compliance with legal regulations, also implies constant monitoring and implementation of modern technical and technological solutions, as well as the production flow of textile industry facilities, with the reduction of water consumption and the introduction of new technologies and wastewater treatment plants in terms of compliance with local requirements and environmental quality standards. In this regard, it is necessary to continuously harmonize the legislation with European and world legislation in this area.

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