



**UNIVERSITY OF NOVI SAD**  
**Technical faculty "Mihajlo Pupin"**  
**Zrenjanin, Republic of Serbia**

**In cooperation with partners**

*Industrial Engineering  
and  
Environmental Protection*

**I I Z S**  
*conference*

**PROCEEDINGS**

**X International Conference –  
Industrial Engineering And Environmental  
Protection (IIZS 2020)**

Zrenjanin, 8-9<sup>th</sup> October 2020.



University of Novi Sad  
Technical faculty “Mihajlo Pupin”  
Zrenjanin, Republic of Serbia



# **X International Conference Industrial Engineering and Environmental Protection (IIZS 2020)**

Proceedings

Zrenjanin, 8 – 9<sup>th</sup> October 2020.

# **X International Conference - Industrial Engineering and Environmental Protection (IIZS 2020)**

## **Organizer of the Conference:**

Technical faculty "Mihajlo Pupin", Zrenjanin, University of Novi Sad, Republic of Serbia

## **Reviewers:**

Ph. D Slavica Prvulovic, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph.D Bogdana Vujić, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph.D Eleonora Desnica, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph.D Ljiljana Radovanović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph.D Jasmina Pekez, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph. D Vladimi Šinik, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph.D Višnja Mihajlović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
Ph.D Snežana Filip, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

## **Publisher:**

Technical faculty "Mihajlo Pupin", Zrenjanin, University of Novi Sad

## **For publisher:**

Ph.D Dragica Radosav, Dean of Technical faculty "Mihajlo Pupin", Zrenjanin

## **Technical treatment:**

MSc Mića Đurđev, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
MSc Borivoj Novaković, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
BSc Luka Đorđević, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia  
MSc Ivan Palinkaš, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

The Conference is supported by the Ministry of Education, Science and Technological Development, Republic of Serbia

ISBN: 978-86-7672-340-9

CIP - Каталогизacija u publikaciji  
Biblioteke Maticе српске, Нови Сад

62:005.3(082)(0.034.4)  
502/504(082)(0.034.4)

## **INTERNATIONAL Conference Industrial Engineering and Environmental Protection (10 ; 2020 ; Zrenjanin)**

Proceedings [Elektronski izvor] / X International Conference Industrial Engineering and Environmental Protection (IIZS 2020), Zrenjanin, 8-9th October 2020. - Zrenjanin : Technical Faculty "Mihajlo Pupin", 2020. - 1 elektronski optički disk (CD-ROM) ; 12 cm

Nasl. sa naslovnog ekrana. - Bibliografija uz svaki rad.

ISBN 978-86-7672-340-9

a) Индустрijско инжењерство - Зборници б) Животна средина - Заштита - Зборници

COBISS.SR-ID 22384393

# CONTENTS

## PLENARY SESSION

THE INFLUENCE OF THE ADSORBENT HYDRATION ON COBALT ADSORPTION FROM WATER SOLUTIONS (Jovan Jovanović, Ivana Milošević, Sanja Kurćubić, Milan Milivojević) .....	3
EXTRACTS OBTAINED BY NATURAL DEEP EUTECTIC SOLVENTS (NDESs) EXTRACTION AS POTENTIAL FUNCTIONAL FOOD ADDITIVES (Rada Pjanović, Predrag Petrović, Ana Milivojević, Danijela Šeremet, Draženka Komes) .....	11
INTERACTIONS OF CLIMATE CHANGE WITH FOOD SECURITY AND GOALS OF SUSTAINABLE DEVELOPMENT IN AGROECOSYSTEM (Hosam Bayoumi Hamuda) .....	17

## I - INDUSTRIAL ENGINEERING

### Session 1. Mechanical Engineering

DEVELOPMENT OF INNOVATIVE AND ENTREPRENEURIAL COMPETENCIES OF FUTURE ENGINEERS THROUGH THE ITlab PROJECT AT THE TECHNICAL FACULTY “MIHAJLO PUPIN” ZRENJANIN (Dragica Radosav, Eleonora Desnica, Slavica Prvulović, Ljiljana Radovanović, Jasmina Pekez, Vladimir Šinik, Ivan Palinkaš) .....	30
INDUSTRIAL ENGINEERING METHODS AND TECHNIQUES IN INDUSTRY 4.0 (Mirjana Misita, Vesna Spasojević Brkić, Dragan D. Milanović, Martina Perišić) .....	36
PROCEDURE DEVELOPMENT OF FLIP STATION FOR POSITING DISC AND ROTOR TYPE PARTS (Miroslav Milutinović, Spasoje Trifković, Aleksija Đurić) .....	42
MODERN SWARM-BASED ALGORITHMS FOR THE TENSION/COMPRESSION SPRING DESIGN OPTIMIZATION PROBLEM (Mića Đurđev, Eleonora Desnica, Jasmina Pekez, Milošević Mijodrag, Dejan Lukić, Borivoj Novaković, Luka Đorđević) .....	49
ANALYSIS OF CROSS-SECTION INFLUENCE ON EIGENFREQUENCIES OF THE CRANES WITH LOADING-UNLOADING TROLLEYS (Spasoje Trifković, Nebojša Radić, Miroslav Milutinović) .....	54
NUMERICAL INVESTIGATION OF THERMAL AND MECHANICAL BEHAVIOR OF WAFER MOLD (Omer Sinan Sahin, Muharrem Hilmi Aksoy, Abdullah Sadik Tazegul) .....	62
AUTOMATION AND INDUSTRY 4.0 (Stanko P. Stankov) .....	70

DYNAMIC MODELLING AND CONTROL OF A REACTION WHEEL INVERTED PENDULUM USING MSC ADAMS AND MATLAB (Abdullah Çakan, Ümit Önen) .....	78
FORGE WELDING OF BIMETALIC AXE (Zoran Karastojković, Nikola Bajić) .....	83
VOCATIONAL KNOWLEDGE TRANSFER OF CRAFT MASTER SKILLS IN POST INDUSTRIAL ERA (Vlad Walter Veckie, Edward Anthony Veckie).....	89
USING THE LASER SCANNING FOR CONSERVATION OF CULTURAL HERITAGE BUILDINGS (Clara-Beatrice Vilceanu, Luisa Dungan, Sorin Herban, Francisc Popescu) .....	98

## **Session 2. Energetics and Process Technique**

MANUFACTURE OF THERMAL SOUND INSULATION PANELS FROM RASPBERRY AND BLACKBERRY CUTTINGS (Srećko Ćurčić, Sandra Milunović Koprivica, Milan Vesković) .....	106
GENERALIZED DIFFERENTIAL QUADRATURE METHOD FOR STUDYING THE IN-PLANE VIBRATIONS OF CURVED PIPES CONVEYING FLUID (Svetlana Lilkova-Markova, Dimitar Lolov).....	114
TECHNICAL AND TECHNOLOGICAL PARAMETER ANALYSIS OF HAMMER MILL CRUSHER (Slavica Prvulović, Jasna Tolmač, Milica Josimović, Vladimir Jakovljević, Aleksandra Božović)...	122
SMART AND NETWORKED VILLAGES - INFORMATION SYSTEM FOR RURAL DEVELOPMENT (Krešimir Lacković, Milan Ivanović).....	128
APPLICATION OF ORGANO-MINERAL AND MICROBIAL FERTILIZERS IN THE PROCESS OF RAISING RASPBERRIES (Srećko Curcic, Stevan Babic, Sandra Milunovic Koprivica, Momcilo Vujcic, Aleksandar Lepasovic) .....	137
OPTIMIZATION OF A SIMULATION FOR THERMOELECTRIC GENERATORS AND THEIR APPLICATION IN WATER BOILER SYSTEMS WITH COMBUSTION CHAMBER (Cristian Chirita, Momir Tabakovic).....	143
ALTERNATE FEEDSTOCKS IN THE REFINERY (James G. Speight, Ljiljana Radovanović) .....	152
MATHEMATICAL MODELS APPLIED FOR EXPERIMENTS ON BIOGAS PRODUCTION AT SMALL SCALE (Adrian Eugen Cioabla, Gabriela-Alina Dumitrel, Ana Maria Pană, Valentin Ordodi, Dorin Lelea, Mădălina Ivanovici, Francisc Popescu, Luisa Izabel Dungan).....	160

## **Session 3. Designing and maintenance**

TEMPERATURE MAPPING IN PHARMACEUTICAL WAREHOUSE – FRAMEWORK FOR PHARMACY 4.0 (Ilija Tabašević, Dragan D. Milanović, Vesna Spasojevic Brkić, Mirjana Misita) .....	171
---	-----

CLUSTER AS A MODEL OF ENTREPRENEURIAL INFRASTRUCTURE (Vlado Medaković, Bogdan Marić).....	176
MATHEMATICAL MODEL OF OPTIMIZATION OF VIBRO-DIAGNOSTICS PROCEDURES (Milica Josimovic, Ljubisa Josimovic, Slavica Prvulovic, Vladimir Šinik).....	182
THE STUDY OF FACTORS AFFECTING THE QUALIFICATION OF PHARMACEUTICAL FACILITIES (Ilija Tabašević, Dragan D. Milanović).....	191
ON PID CONTROLLER DESIGN FOR A HIGH-ORDER SYSTEMS (Saša Lj. Prodanović, Ljubiša M. Dubonjić).....	199
CBM CONCEPT-PREDICTIVE MAINTENANCE-VIBRATION ANALYSIS AND BALANCING PROCESS OF INDUSTRIAL FANS (Borivoj Novaković, Ljiljana Radovanović, Rade Ivetić, Vladimir Šinik, Mića Đurđev, Luka Đorđević).....	208
BRIEF REVIEW OF THE APPLICATION OF THE SPM METHOD IN ORDER TO IMPROVE PREVENTIVE MAINTENANCE OF BEARINGS (Luka Djordjević, Borivoj Novaković, Jasmina Pekez, Ljiljana Radovanović, Mića Djurdjev) .....	214

#### **Session 4. Oil and Gas Engineering**

OIL PREPARATION AND HEATING FOR PIPELINE TRANSPORT (Jasna Tolmac, Slavica Prvulovic, Marija Nedic, Dragisa Tolmac, Vladimir Sinik).....	221
TESTING AND CONQUERING INTERVAL TECHNOLOGY ON THE WELL (Milan Marković, Zvonimir Bošković) .....	226
INCREASING THE QUALITY OF SEPARATION IN THE PHASE OF PREPARATION OF OIL FOR TRANSPORT (Milan Marković, Jasmina Perišić).....	232

## **II – ENVIRONMENTAL ENGINEERING**

#### **Session 5. Health and Environmental protection**

CO <sub>2</sub> EMISSION ASSESSMENT OF CONSTRUCTION AND WASTE MATERIALS IN THE CONTEXT OF CIRCULAR ECONOMY: CASE STUDY OF PROJECT “CORRIDOR X” (Nikola Karanović).....	244
ENVIRONMENTAL IMPACT ASSESSMENT FROM SMALL INCINERATION FACILITY OF ANIMAL CARCASS AND MATERIAL (Sandra Kozomora Subotin, Dejan Ubavin, Bojan Batinić, Zoran Čepić).....	250
FIRE RISKS IN A SMALL INCINERATION FACILITY OF ANIMAL CARCASS AND MATERIAL (Sandra Kozomora Subotin, Dejan Ubavin, Jelena Radonić, Zoran Čepić).....	257
EPOXICONAZOLE AND TEBUCONAZOLE ADSORPTION IN TWENTY DIFFERENT AGRICULTURAL SOILS IN RELATION TO THEIR PROPERTIES (Nikola Bošković, Kerstin Brandstätter-Scherr, Petr Sedláček, Zuzana Bílková, Lucie Bielská, Jakub Hofman) .....	265

EMISSION OF GREENHOUSE GASES FROM “BUBANJ” LANDFILL IN NIŠ (Jasmina Radosavljević, Amelija Đorđević, Ana Vukadinović, Lidija Milošević).....	273
EFFECTS OF SUNSPACE GEOMETRY ON THE ENERGY PROPERTIES OF DETACHED APARTMENT BUILDINGS (Ana Vukadinović, Jasmina Radosavljević).....	280
CAUSE-AND-EFFECT RELATIONSHIP BETWEEN CARBON MONOXIDE CONCENTRATIONS IN AMBIENT AIR AND RESPIRATORY DISEASES IN PRESCHOOL CHILDREN (Amelija Đorđević, Ana Miltojević, Aca Božilov, Goran Janačković).....	287
MODEL FOR QUANTIFICATION OF ENVIRONMENTAL IMPACT OF TEXTILE PRODUCTS WITHIN WEBSHOPS (Nemanja Stipić, Jürgen Seibold).....	294
SYNTHESIS AND IMMOBILIZATION OF ZnO NANOPARTICLES DOPED BY WO <sub>3</sub> ON GLASS BED FOR DIAZINON REMOVAL FROM WATER (Afshin Maleki, Farzaneh Moradi, Reza Rezaee, Behzad Shahmoradi) .....	302
INFLUENCE OF MIXING INTENSITY ON ADSORPTION BEHAVIOUR OF ORGANIC POLLUTANTS ON MICROPLASTICS IN WATER (Maja Lončarski, Aleksandra Tubić, Sanja Vasiljević, Jasmina Agbaba).....	307
ARE WE AWARE OF MICROPLASTIC CONTENTS IN TOOTHPASTES? (Anja Bubik).....	313
WASTE LUBRICATING OILS, ENVIRONMENTAL IMPACT, RECYCLING AND STATE IN THE REPUBLIC OF SERBIA (Snežana Filip, Snežana Komatina).....	319
EXPERIMENTAL INVESTIGATION OF THE THERMAL DEGRADATION OF FOREST LITTER - PINE NEEDLES (Nikola Mišić, Milan Protić) .....	324
ANALYSIS OF SOUND LEVELS OF FOOD COURTS AND COFFEE HOUSES AT UNIVERSITY CAMPUS IN NOVI SAD (Selena Samardžić, Robert Lakatoš, Aleksandra Mihailović, Anja Ranković, Slavko Rakić, Savka Adamović, Dragan Adamović) .....	330
ASSESSMENT OF METHANE ENERGY RECOVERY POTENTIAL FROM THE MUNICIPAL SOLID WASTE LANDFILL OF ZRENJANIN (Una Marčeta, Bogdana Vujić, Višnja Mihajlović, Jelena Mičić) .....	335
IMPACT OF COVID-19 PANDEMIC CRISIS ON ENVIRONMENTAL PROTECTION EXPENDITURES OF LOCAL SELF GOVERNMENTS IN SERBIA (Nedeljko Ćurić).....	338
NO <sub>2</sub> AQI ANALYSIS AS A MEASURE OF AIR POLLUTION REDUCTION IN THREE CITIES IN SERBIA, CAUSED BY THE QUARANTINE DUE TO THE COVID 19 PANDEMIC (Veselin Bežanović, Mladenka Novaković, Dušan Milovanović, Dragan Adamović) .....	346
IMPACTS OF ORGANIC WASTE MATERIALS ON SOIL CHARACTERIZATION (Hosam Bayoumi Hamuda, Katalin Hrustinszki, Ágnes Róczy, Mungunzaya Ganbat) .....	351

INFLUENCE OF CLIMATE CHANGE AND URBAN DEVELOPMENT ON GNSS MEASUREMENTS (Alina Bălă, Luisa Dungan, Clara-Beatrice Vîlceanu, Sorin Herban).....	360
ANALYSIS OF PHOTOVOLTAIC SOLAR PANEL EFFICIENCY (Marija Stankov, Nataša Dabić, Ivan Palinkaš, Dušanka Milanov ) .....	366
PHARMACEUTICAL WASTE DISPOSAL PRACTICE AMONG THE CITIZENS IN THE MUNICIPALITY OF ZRENJANIN (Eleonora Terečik, Una Marčeta, Jelena Mičić, Višnja Mihajlović).....	374

## **Session 6. Environmental Management**

AN APPLICATION OF DELPHI METHOD IN SELECTION OF HOSPITAL MANAGER (Ali Reza Afshari, Milan Nikolić).....	383
ENVIRONMENT PRESERVATION AND ACHIEVING COMPETITIVENESS WITHIN THE FRAMEWORKS OF SUSTAINABLE DEVELOPMENT (Mihalj Bakator, Dejan Đorđević, Ljiljana Đorđević, Srđan Bogetić, Dragan Čočkaló).....	390
THE CRUCIAL ROLE OF INNOVATION IN ACHIEVING COMPETITIVENESS OF DOMESTIC ENTERPRISES (Dragan Čočkaló, Mihalj Bakator, Dejan Đorđević, Cariša Bešić, Sanja Stanisavljev) .....	396
EMPLOYEES' PERCEPTION OF ENERGY CONSUMPTION AND ENVIRONMENTAL PROTECTION (Ivana Dolga, Ladin Gostimirović, Aleksandra Mihailović, Nebojša M. Ralević) .....	402
LANDSCAPE CHANGE SURVEY IN THE GÖDÖLLŐ HILLS BASED ON HISTORICAL MAPS (Krisztina Demény) .....	409

## **Session 7. Occupational Safety**

FIRE IN INDUSTRIAL FACILITIES FROM THE ASPECTS OF FACILITY SAFETY AND EMPLOYEES HEALTH (Goran Bošković, Dejan Ubavin, Milana Ilić Mićunović, Zoran Čepić) .....	417
CONTRIBUTION TO THE SAFETY ANALYSIS DURING OPERATION WITH TRUCK-MOUNTED CRANE (Goran Bošković, Dejan Ubavin, Dragan Adamović, Zoran Čepić).....	422
AN APPROACH FORWARD TO DIGITALIZATION OF WORKPLACE RISK ASSESSMENT AND MONITORING (Mirjana Misita, Vesna Spasojević-Brkić, Martina Perišić, Marija Milanović, Ankica Borota-Tišma).....	427
GEOMETRIC CHARACTERISTICS OF PM PARTICLES TESTED WITH JMICROVISION SOFTWARE (Milana Ilić Mićunović, Zoran Čepić, Boris Agarski, Zorica Miroslavljević, Željko Santoši).....	434
THE EFFECTS OF ECONOMIC TRENDS AND SAFETY REGULATIONS ON OCCUPATIONAL INJURIES (Goran Janačković, Ivan Radojković, Amelija Đorđević, Jasmina Radosavljević, Dejan Vasović)....	441



PRELIMINARY DESIGN CALCULATIONS OF A SMALL WIND GENERATOR FOR THE SURROUNDINGS OF TOWN OF ZRENJANIN (Dimitar Petrov).....	447
EUROPEAN ONGOING INITIATIVES FOR TRANSFORMING COVID19 CRISIS INTO AN OPPORTUNITY FOR A SUSTAINABLE FUTURE (Kaja Primorac, Lucija Kolar, Anja Bubik, Daniela Tulone).....	457

## AN APPROACH FORWARD TO DIGITALIZATION OF WORKPLACE RISK ASSESSMENT AND MONITORING

Mirjana Misita<sup>1</sup>, Vesna Spasojević-Brkić<sup>1</sup>, Maritna Perišić<sup>1</sup>,  
Marija Milanović<sup>1</sup>, Ankica Borota-Tišma<sup>2</sup>

<sup>1</sup>University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

<sup>2</sup>Belgrade Business and Arts Academy of Applied Studies, Belgrade, Serbia

e-mail: [mmisita@mas.bg.ac.rs](mailto:mmisita@mas.bg.ac.rs)

**Abstract.** This paper presents an approach to the digitalization of the workplace risk assessment and monitoring process. Workplace risk was assessed using the “5x5” method. Workplace are spatially distributed in the observed factory. The summary risk assessment is presented visually and the high-risk workplace is marked. The map is made dynamically so that the job estimates on the diagram changes if there is a change in the input data for any of the identified sources of risk.

**Key words:** workplace, risk assessment, risk monitoring.

### INTRODUCTION

In the scientific and professional literature, the problem of automatic monitoring of danger and hazard in the workplace is a very current topic [3],[5],[9],[10]. However, with the development of information technologies, the model of automatic monitoring of danger and hazards in the workplace can be significantly improved. Numerous papers in scientific and professional literature testify that. Workers employed in manufacturing companies are particularly exposed to health dangers and hazards [15]. In construction as well, and therefore in the literature [4] it can be found papers of the necessity of development of the real-time safety risk assessment methodology for indentation dynamic evaluation of worker safety states on construction site.

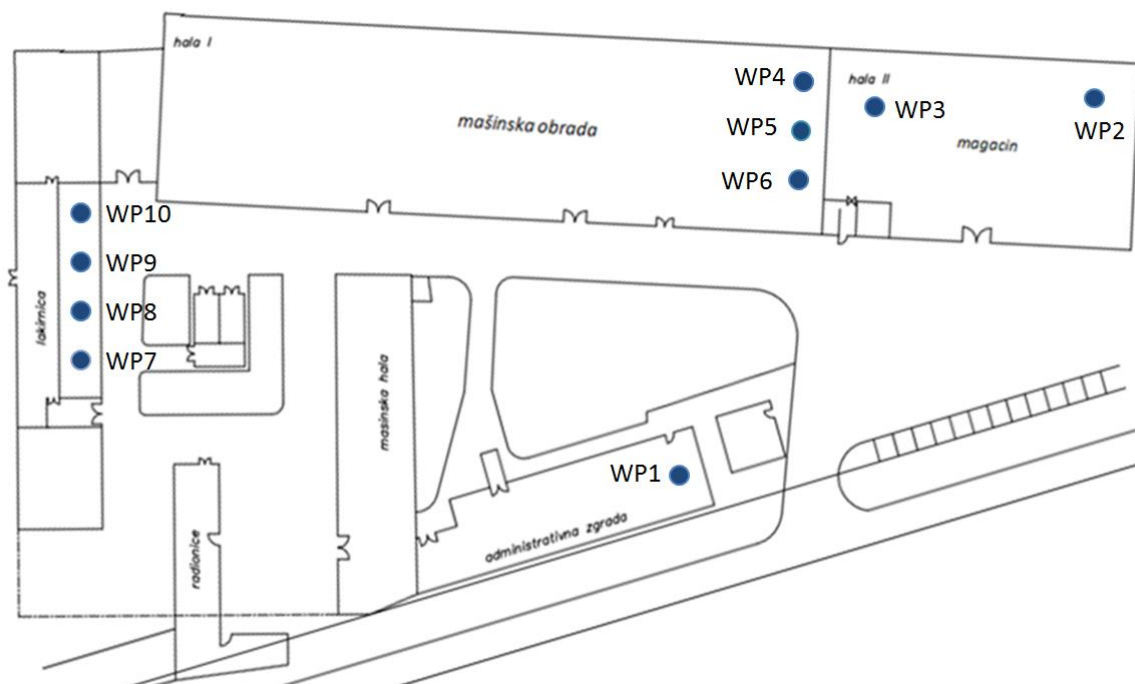
Mayer et al. [8] as result of trans-national project for assessment and management of risk for engineered systems and geohazards conclude that appropriate simulation procedures are indispensable and gives necessary information for risk evaluation, successful risk management and communication.

With the development of information technology and the creation of the I4.0 environment, numerous papers indicate the need to develop methodologies for risk assessment online [14], [2], [8], [1].

The aim of this research is to examine the possibilities digitization of monitoring of danger and hazards in the workplace by implementing modern information technologies in order to increase the quality of the process of monitoring and risk assessment as well as increasing the safety of workers in the workplace.

### METHOD OF WORKPLACE RISK ASSESMENT AND MONITORING

Workplace danger and hazard risk assessment is carried out using Kenny method or “5x5” matrix method. The methodology is based on expert identification of danger and hazard at each workplace in the observed factory. Factory INSA ad. - industry of watches, water meters and other measuring instruments was chosen as an example of application of methodologies. During the identification and assessment of dangers and hazards at the workplace and in the work environment, 85 workplaces were analyzed in the observed company. For the purpose of presenting the approach of the automated procedure of workplace risk assessment and monitoring, 10 jobs were selected. Those jobs are: president, storekeeper, foreman in the organizational unit machining, automatic lathe controller, metal lathe, auxiliary worker, grinder, technologist in surface protection, galvanizer, painter. All selected jobs were marked and coded consecutively as previously mentioned – WP – Workplace, and then entered their location on the spatial plan of the factory [6], Fig. 1.



**Fig. 1.** Workplace spatial layout

The next step is the application of the 5x5 methodology for the identification of danger and hazard in selected workplaces. Table 1 lists and numbers the different sources of risk identified for each workplace.

**Table 1.** Risk numeration by workplace

WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10
1.1.1.	2.1.1.	3.1.1.	4.1.1.	5.1.1.	6.1.1.	7.1.1.	8.1.1.	9.1.1.	10.1.1.
1.1.2.	2.1.2.	3.1.2.	4.1.2.	5.1.2.	6.1.2.	7.2.2.	8.1.2.	9.1.2.	10.1.2.
1.2.1.	2.2.1.	3.1.3.	4.1.3.	5.1.3.	6.1.3.	7.2.3.	8.1.3.	9.1.3.	10.1.3.
1.2.2.	2.2.2.	3.2.1.	4.1.4.	5.1.4.	6.1.4.	7.2.4.	8.2.1.	9.1.4.	10.1.4.
1.2.3.	2.2.3.	3.2.2.	4.1.5.	5.1.5.	6.1.5.	7.2.5.	8.2.2.	9.2.1.	10.2.1.
1.2.4.	2.2.4.	3.2.3.	4.1.6.	5.1.6.	6.1.6.	7.2.1.	8.2.3.	9.2.2.	10.2.2.
1.2.5.	2.2.5.	3.2.4.	4.1.7.	5.1.7.	6.1.7.	7.2.2.	8.2.4.	9.2.3.	10.2.3.
	2.2.6.	3.2.5.	4.1.8.	5.1.8.	6.1.8.	7.2.3.	8.2.5.	9.2.4.	10.2.4.
		3.2.6.	4.2.1.	5.2.1.	6.2.1.	7.2.4.	8.2.6.	9.2.5.	10.2.5.
		3.2.7.	4.2.2.	5.2.2.	6.2.2.	7.2.5.	8.2.7.	9.2.6.	10.2.6.
		3.2.8.	4.2.3.	5.2.3.	6.2.3.	7.2.6.	8.2.8.	9.2.7.	10.2.7.
			4.2.4.	5.2.4.	6.2.4.	7.2.7.		9.2.8.	10.2.8.
			4.2.5.	5.2.5.	6.2.5.	7.2.8.		9.2.9.	10.2.9.
			4.2.6.	5.2.6.	6.2.6.				
			4.2.7.	5.2.7.	6.2.7.				
			4.2.8.	5.2.8.	6.2.8.				
			4.2.9.	5.2.9.	6.2.9.				

The following is a description of the risk assessment for workplace number 9, WP8 – galvanizer. The list of tools used by the worker in this workplace is listed first, followed by the list of protective equipment required in this workplace.

Description of galvanizing tools [7]:

- Within the galvanization department, the following equipment is present:
- Nickel plating line
- Copper cyanide and high-luster plating line
- Brass line
- Cadmium plating line
- Zinc plating line
- Brass etching line
- Line for anodizing and passivation of aluminum
- Container for removing galvanic coats

Description of equipment for personal protection [5]:

- Work suit or acid-resistant clothing
- Rubber boots or ribbed rubber-sole shoes
- Work gloves
- Safety goggles with side protection
- Protective mask over mouth and nose if needed
- Protective cap if needed

Further, the source of risk for this workplace was identified. Since the workplace is designated as WP9, all risk sources are numbered 9.1.X for danger and 9.2.X for hazard.

### Recognition of risk and possible hazard in the workplace and environment -WP9

Danger recognition ( 9.1 ) [7]:

9.1.1. Danger of falling due to slipping on wet floor surfaces

9.1.2. Danger of being hit by a transportation vehicle (forklift).

9.1.3. Risk of direct contact with energized electrical components and equipment.

9.1.4. Risk of indirect contact with live electrical parts (if a fault between a live part and an exposed-conductive-part occurs).

Hazard recognition (9.2 ) [7]:

9.2.1. Chemical hazard caused by inhalation of various vapors, dust and fumes that occur during the work process in the galvanization department or during other technological processes that are performed near the workplace.

9.2.2. Chemical hazards that occur during work by direct contact with chemicals used in the process.

9.2.3. Physical hazards caused by noise.

9.2.4. Harmful effects of microclimate (temperature, air humidity and air flow).

9.2.5. Inadequate/Insufficient lighting conditions in the workplace.

9.2.6. Non-physiological body position (frequent standing).

9.2.7. Efforts in performing certain tasks causing psychological strain (stress, monotony, etc.).

9.2.8. Hazard related to work management (overtime work, working in shifts, night work, etc.).

9.2.9. Other possible hazards such as use of inadequate repromaterials, use of inadequate tools, instruments, change of workplace due to production process requirements.

Furthermore, for identified sources of risk, an assessment was conducted according to the “5x5” methodology.

**Table 2.** Risk assessment in terms of hazard and danger for galvanizer workplace [7]

Label	Hazard or danger description	Severity of injury or illness	Probability of occurrence	Risk level
9.1.1	Danger of falling due to slipping on wet floor surfaces	Moderate	Likely	Medium
9.1.2	Danger of being hit by a transportation vehicle (forklift)	Fatal	Unlikely	Medium
9.1.3	Risk of direct contact with energized electrical components and equipment	Moderate	Likely	Medium

**Table 2.** Risk assessment in terms of hazard and danger for galvanizer workplace [7] (continued)

9.1.4	Risk of indirect contact with live electrical parts (if a fault between a live part and an exposed-conductive-part occurs)	Moderate	Likely	Medium
9.2.1	Chemical hazard caused by inhalation of various vapors, dust and fumes that occur during the work process in the galvanization department or during other technological processes that are performed near the workplace	Significant	Very Likely	High
9.2.2	Chemical hazards that occur during work by direct contact with chemicals used in the process	Moderate	Very Likely	High
9.2.3	Physical hazards caused by noise	Minor	Likely	Medium
9.2.4	Harmful effects of microclimate (temperature, air humidity and air flow)	Moderate	Very Likely	High
9.2.5	Inadequate/Insufficient lighting conditions in the workplace	Negligible	Likely	Low
9.2.6	Non-physiological body position (frequent standing)	Negligible	Very Likely	Low
9.2.7	Efforts in performing certain tasks causing psychological strain (stress, monotony, etc.)	Negligible	Likely	Low
9.2.8	Hazard related to work management (overtime work, working in shifts, night work, etc.)	Minor	Likely	Medium
9.2.9	Other possible hazards such as use of inadequate repromaterials, use of inadequate tools, instruments, change of workplace due to production process requirements	Minor	Very Likely	Medium

According to above risk assessment it could be concluded that galvanizer is a high-risk workplace. Similarly, a risk assessment was conducted for other workplaces. All sources of risk (127 in total) for the observed 10 workplaces, and their dangers and hazards estimates were entered into the database, Table 2. Conditional formatting, the classification of risk sources with the terms 'LOW', 'MEDIUM' and 'HIGH' in appropriate format.

**Table 3.** Workplace risk assessment

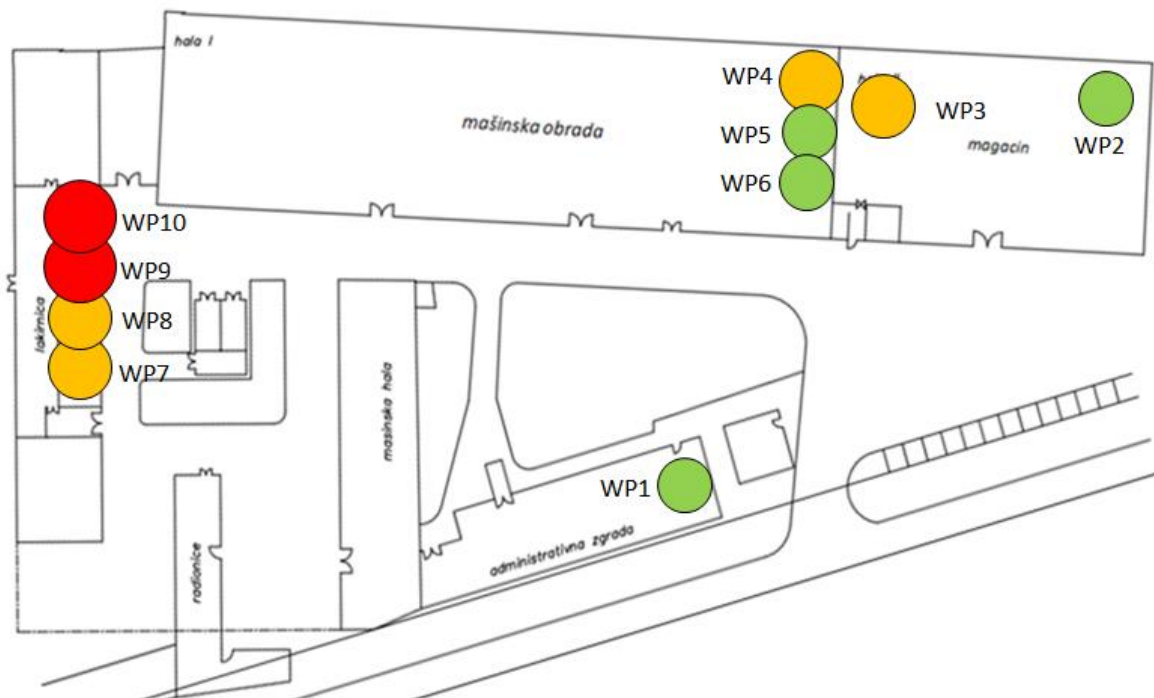
98	WP8	8.2.5.	Insignificant (no sick leave)	1	4	Likely	4	LOW
99	WP8	8.2.6.	Insignificant (no sick leave)	1	3	Possible	3	LOW
100	WP8	8.2.7.	Insignificant (no sick leave)	1	3	Possible	3	LOW
101	WP8	8.2.8.	Insignificant (no sick leave)	1	3	Possible	3	LOW
102	WP9	9.1.1.	Medium (sick leave over 3 working days)	3	3	Possible	9	MEDIUM
103	WP9	9.1.2.	Severe (long-term illness)	4	2	Rare	8	LOW
104	WP9	9.1.3.	Medium (sick leave over 3 working days)	3	3	Possible	9	MEDIUM
105	WP9	9.1.4.	Medium (sick leave over 3 working days)	3	3	Possible	9	MEDIUM
106	WP9	9.2.1.	Severe (long-term illness)	4	4	Likely	16	HIGH
107	WP9	9.2.2.	Medium (sick leave over 3 working days)	3	Rare Unlikely Possible		12	MEDIUM
108	WP9	9.2.3.	Easy (pain up to 3 working days)	2	Likely		6	LOW
109	WP9	9.2.4.	Medium (sick leave over 3 working days)	3	Almost certain		12	MEDIUM
110	WP9	9.2.5.	Insignificant (no sick leave)	1	3	Possible	3	LOW
111	WP9	9.2.6.	Insignificant (no sick leave)	1	4	Likely	4	LOW
112	WP9	9.2.7.	Insignificant (no sick leave)	1	3	Possible	3	LOW
113	WP9	9.2.8.	Easy (pain up to 3 working days)	2	3	Possible	6	LOW
114	WP9	9.2.9.	Easy (pain up to 3 working days)	2	4	Likely	8	LOW

Furthermore, data preparation was performed (Table 2), in which the coordinates of workplaces of the spatial distribution of the factory are given. And then the coordinates of the workplaces are linked to the table in Figure 1, by the the workplace risk assessment. Given that there are several sources of risk in one workplace, it was taken to alert the grades with highest value according to the “5x5” methodology, as the max RNP (calculated in Table 2).

**Table 4.** Data preparation table for online workplace risk assessment

data preparation				
x	y	wp	Description	Max
2,95	1,50	WP1	president	9
4,65	3,80	WP2	storekeeper	9
3,75	3,75	WP3	auxiliary worker	12
3,46	3,90	WP4	controller	12
3,45	3,60	WP5	metal lathe	9
3,44	3,30	WP6	auxiliary worker	9
0,5	2,20	WP7	grinder	12
0,5	2,50	WP8	technologist	12
0,5	2,80	WP9	galvanizer	16
0,5	3,10	WP10	painter	16

Figure 2, gives the final of the estimates on the spatial layout of the factory, which is used to monitor workplace risks. Workplace 9 and workplace 10 are the workplaces with high risks, and workplaces 3,4,7,8 are workplaces with medium risk, while workplaces 1,2,5,6 are workplace with low risk.



**Fig. 2.** Workplace risk monitoring

In this way, risk managers can easily identify high-risk workplaces and plan priority activities events and protect employees in the workplace. Also, the software application makes it possible to show separately the workplaces with the highest risk of dangers to the health of workers.

## CONCLUSION

The conducted research aims to increase the quality of the workplace risk assessment procedure as well as to more efficiently implement the procedure of protection of workers from unwanted events. Also, the proposed method of workplace risk assessment enables online monitoring of workplace risks, as well as visual representation and activation of alarm signals in order to prevent unwanted and dangerous events in the workplace, applicable for any any business-production company.

The research points to easier monitoring of workplace risk by using a database that automatically displays workplace risk assessment (low, moderate, high) as well as risk visualization by spatial layout, but the limitation of the model is the entering of input data for identified risks. Namely, the identification of risk sources for each job should be done by a professional risk assessor (this assessment is usually done on an annual basis), while the monitoring of certain risk sources can be carried out by trained staff, or automatically - through cyber physical systems for certain measurable risk sources.

However, further research should be focused on resolving the issues of entering input data (ie considering the possibility of implementing sensors for monitor parameters that affect risks at the workplace), development of expert knowledge base, data storage in the cloud, online access for the all relevant users, group decision-making in the case of multiple risk assessors and similar issues.

## ACKNOWLEDGEMENT

This paper is supported by grants from the Ministry of Education, Science and Technological Development, grants from project E!13300 and contract 451-03-68/2020-14/200105 (subproject TR 35017).

## REFERENCES

- [1] Aven, T., Risk assessment and risk management: Review of recent advances on their foundation, *European Journal of Operational Research*, Vol. 253(1), pp. 1-13, 2016.
- [2] Gašova, M., Gašo, M., Štefanik, A., Advanced industrial tools of ergonomics based on Industry 4.0 concept, *Procedia Engineering*, Vol.192, pp. 219-234, 2017.
- [3] Hahm, M., Lee, J., Lee, M., & Byeon, S.-H. (2016). Health risk assessment of occupational exposure to styrene depending on the type of industry: Data from the Workplace Environmental Monitoring Program in Korea. *Human & Ecological Risk Assessment*, 22(6), 1312–1322.
- [4] Hanchen, J., Peng, L., Qixiang, F., Maoshan Q., Real-Time Safety Risk Assessment Based on a Real-Time Location System for Hydropower Construction Sites, *Scientific World Journal Hindawi Publishing Corporation*, Vol.2014, Article ID 235970, pp.1-14, 2014.
- [5] Imangazin, M., Almatova, B. and Allanova, R. (2016) 'Identification and Risk Assessment of Hazard Occurrence at the Aksu Ferroalloys Plant During 2007-2012', *Metallurgist*, 59(11/12), pp. 1152–1156.
- [6] Insa a.d., Documentation about factory - Serbian manufacturer of clocks & other measurement instruments, 2020.
- [7] Insa a.d., Risk Assessment on Workplace and in a Working Environment, 2019.
- [8] Mayer, R., Plank, C., Bohner, A., Kollarits, S., Corsini, A., Ronchetti, F. at all, MONITOR: Hazard monitoring for risk assessment and risk communication, *Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards*, Vol. 2, pp. 195-222, 2008.
- [9] Moon, H.I., Shin, S., & Byeon, S.H. (2015). Exposure Monitoring and Health Risk Assessment of 1-Bromopropane as a Cleaning Solvent in the Workplace. *Human & Ecological Risk Assessment*, 21(3), 744–752.
- [10] Rajpradeesh, T., Venkumar, P., Hariraja, T., Nagarjun, J., & Manikandan, V. (2019). Hazard Identification on Cabtrim in Manufacturing Industry. *AIP Conference Proceedings*, 2128(1), 030004-1-030004-111.
- [11] Rout, B.K., Sikdar, B.K., Hazard Identification, Risk Assessment, and Control Measures as an Effective Tool of Occupational Health Assessment of Hazardous Process in an Iron Ore Pelletizing Industry, *Indian J Occup Environ Med.*, Vol. 21(2), pp. 56–76, 2017.

- [12] Shamsan A., Qasem, A.G., Development of Scoring Methodology for Ergonomic Risk Assessment in the Workplace, Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management, Detroit, Michigan, USA, August 10 - 14, ID 475. 2020.
- [13] Toffel, M. W., & Birkner, L. R. (2002). Estimating and Controlling Workplace Risk: An Approach for Occupational Hygiene and Safety Professionals. *Applied Occupational & Environmental Hygiene*, 17(7), 477–485.
- [14] Tupa, J., Simota J., Aspects of risk management implementation for Industry 4.0, *Procedia Manufacturing*, Vol.11, pp. 1223 – 1230, 2017.
- [15] Zaki, N.E.A.M, Rahman, M.N.A., Kamarudzaman, M., Ergonomic Risk Assessment Among Production Operators at Food Processing Industries: A Review, *Human Factors and Ergonomics Journal*, Vol.5(1), pp. 99 – 102, 2020.