134 English version

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INSTITUTE FOR MEDICAL RESEARCH AND OCCUPATIONAL HEALTH

2023.

Annual Report

ZAGREB, 2024

14. ORGANISATION OF THE INSTITUTE

Founded: 27 Dec 1947 in Zagreb.
Founder: Prof Andrija Štampar, PhD, president of the Yugoslav Academy of Sciences and Arts.
Status: public research institute under the Ministry of Science and Education of the Republic of Croatia.
Fields of research: toxicology, radiation and chemical weapon protection, environmental radioactive contamination, air quality, determination of drug abuse, occupational medicine, distribution of metals and inorganic and organic pollution in the environment, and the exposure of human beings to environmental contaminants, as well as various psychogenic factors.
Registered professional fields: scientific, professional, teaching, and publishing.

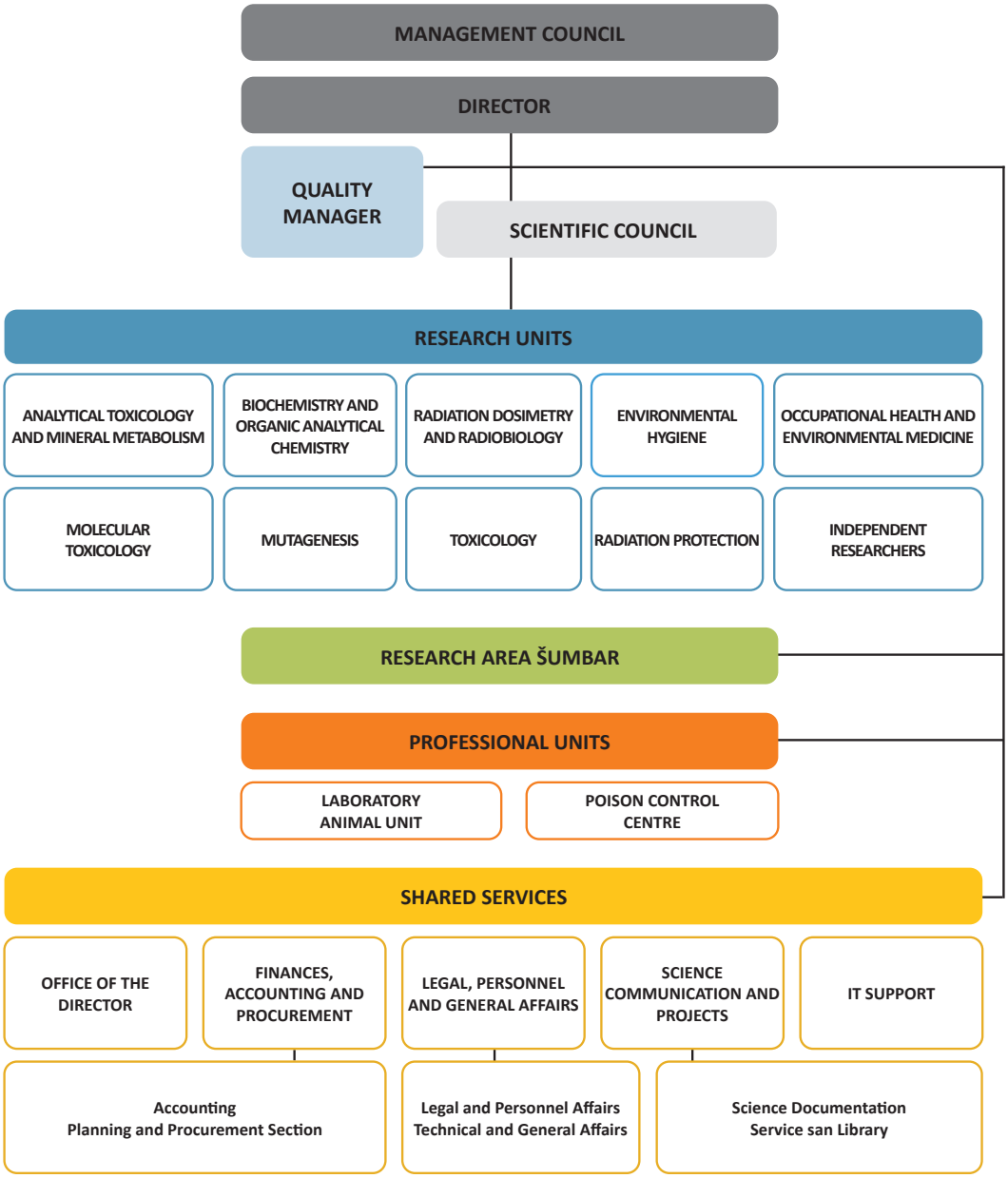
***The mission** of the Institute is to become:*

- a research institute of excellence in central and south-eastern Europe that shifts the boundaries of discovery regarding anthropogenic impacts on health and the environment
- a standard and role model for academic distinction and quality.

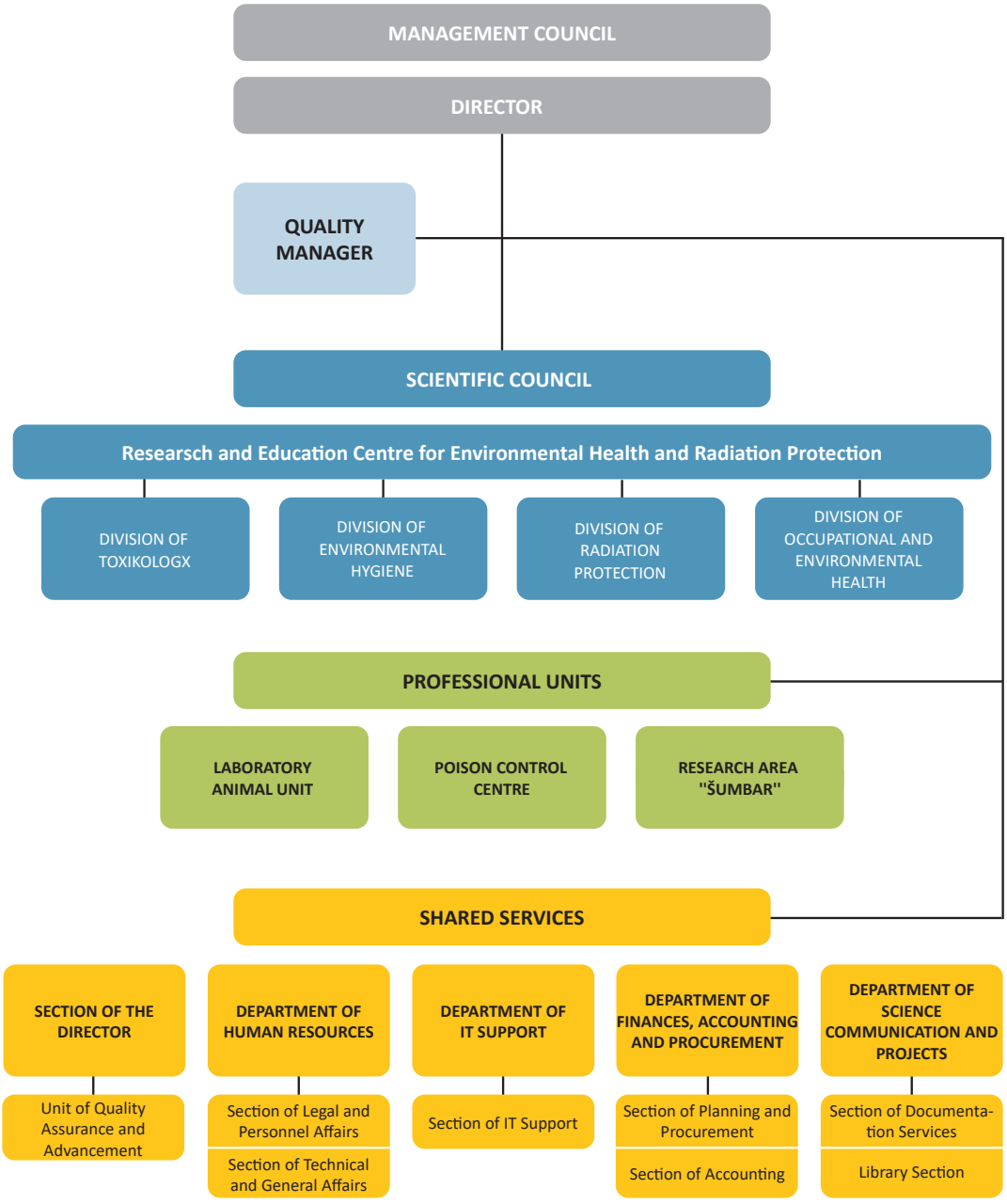
***The vision** of the Institute:*

- insist on high standards of scientific excellence
- create new values in science
- ensure the transfer of knowledge to the wider community
- contribute to the economy through research outcomes
- educate future experts in the fields of fundamental and applied sciences.

STRUCTURE OF IMROH'S EMPLOYEES (31 DEC 2023)		Number of employees	%
Distribution according to funding source	State budget IMROH Croatian Science Foundation	148 10 9	89 6 5
Distribution according to sex	Women Men	125 42	75 25
Employees with academic titles	PhD	72	43
Employees with teaching titles	Assist Prof (3); Assoc Prof (5); Prof (3); Primarius (1)	12	7
Employees with specialist titles	Epidemiology (1); Occupational Medicine and Sports (2)	3	2
WORK POSITIONS			
Employees on scientific work positions	Permanent Scientific Advisor Scientific Advisor Senior Scientific Associate Scientific Associate **Total**	16 13 17 16 **62**	9 8 10 10 **37**
Employees on associate work positions	Senior Research Assistant Research Assistant **Total**	14 7 **21**	8 4 **12**
Employees on professional work positions	Professional Advisor Senior Professional Associate Professional Associate **Total**	2 3 16 **21**	1 2 10 **13**
Employees on technical work positions		**27**	**16**
Employees in Shared Services		**36**	**22**
TOTAL NUMBER OF EMPLOYEES:		**167**	**100**



The organisational scheme of IMROH before 11 Oct 2023



The new organisational chart of IMROH (as of 12 Oct 2023)

MANAGEMENT

MANAGEMENT COUNCIL

Prof Stipan Jonjić, MD, PhD, Faculty of Medicine, University of Rijeka (Chair)
Prof Nada Čikeš, MD, PhD, School of Medicine, University of Zagreb (Deputy Chair)
Božo Pavičin, Croatian Chamber of Economy (Member)
Nevenka Kopjar, PhD (Representative of the IMROH's research staff)
Branka Roić, BEc (Representative of the IMROH's employees)

DIRECTOR

Prof Ana Lucić Vrdoljak, PhD

DEPUTY DIRECTORS

Assist Prof Irena Brčić Karačonji, PhD, ERT

SCIENTIFIC COUNCIL

Assoc Prof Branko Petrinec, PhD (Chair)
Davorka Breljak, PhD (Deputy Chair)

QUALITY MANAGER

Ranka Godec, PhD
Tomislav Meštrović (Deputy Manager)

ETHICS COMMITTEE

CHAIR

Prim Jelena Macan, MD, PhD

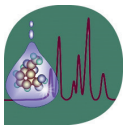
MEMBERS

Prof Selma Cvijetić Avdagić, MD, PhD
Assoc Prof Adrijana Bjelajac, PhD
Martina Piasek, MD, PhD
Prof Tomislav Mašek, DVM, PhD, Faculty of Veterinary Medicine, University of Zagreb
Jagoda Mandić (Secretary)

14.1. Ethics Committee Activity

The Ethics Committee received a total of 23 claims during 2023 and all were considered according to the criteria of the Code of Ethics of the Institute for Medical Research and Occupational Health. Applicants were issued 17 written opinions that were then officially registered, whereas five claims are still in consideration. In the meetings held in person and consultations via e-mail ethical principles were considered in a claim questioning the compliance of an Institute employee's behaviour with the Code of Ethics (1 claim); in doctoral thesis proposals (3 claims); in research projects with the participation of the Institute's researchers funded by EU HORIZON 2020 (2 claims); in research project proposals submitted by the Institute's researchers to Croatian Science Foundation calls (4 claims); in proposals for the Institute's in-house projects with leaders from the Institute, or through cooperation with other research institutions (10 claims); and in research proposed by other research institutions (3 claims).

15. RESEARCH UNITS



15.1. Analytical Toxicology and Mineral Metabolism Unit

EMPLOYEES OF THE UNIT

HEAD

Jasna Jurasović, PhD, permanent scientific advisor (Head of Unit until 11 Oct 2023)

RESEARCHERS

Zorana Kljaković-Gašpić, PhD, permanent scientific advisor
Alica Pizent, PhD, permanent scientific advisor
Ivana Vinković Vrček, PhD, Titular Associate Professor, permanent scientific advisor as of 26 Jul 2023
Maja Lazarus, PhD, scientific advisor
Nataša Brajenović, PhD, senior scientific associate
Tatjana Orct, PhD, senior scientific associate
Ankica Sekovanić, PhD, scientific associate
Antonija Sulimanec, PhD, scientific associate as of 1 Dec 2023
Buket Bakan, PhD, postdoctoral researcher until 5 Oct 2023
Maja Beus, PhD, postdoctoral researcher until 31 Mar 2023
Ivona Capjak, PhD, postdoctoral researcher (8h/week)
Nikolina Kalčec, PhD, assistant until 31 May 2023, postdoctoral researcher as of 1 June 2023
Anamaria Gojanović, DVM, assistant as of 1 Jan 2023
Matea Puđak, MSc, assistant (7 September–29 December 2023)
Borna Karnaš, MSc, professional associate until 31 October 2023
Lucija Božičević, MSc, PhD student-assistant
Nikolina Peranić, MSc, PhD student-assistant

TECHNICAL STAFF

Željka Punčec, BSc, senior technician as of 1 Nov 2023
Vesna Triva, senior technician until 7 Aug 2023
Mladen Komesar, senior technician
Snježana Mataušić, technician
Krešimir Nekić, technician

PARTICIPATING RETIRED RESEARCHER

Martina Piasek, MD, PhD, permanent scientific advisor

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

Long-term research activities

We continued processing and publishing results obtained within the completed research project

funded by the Croatian Science Foundation "Assessment of daily exposure to metals and maternal individual susceptibility as factors of developmental origins of health and disease" (METALORIGINS, HrZZ-IP-2016-06-1998) and the related in-house research project.

The results of the project were presented through an invited lecture at an international symposium held at the Institute (155). The results of the study on the interaction of toxic and essential elements and the related disruption of steroidogenesis during the prenatal period due to maternal cigarette smoking habits were published and presented at an international congress (71, 252). Based on findings of reduced levels of progesterone and estradiol in the umbilical cord serum of active smoking mothers, it was proposed that the levels of umbilical sex hormones could serve as an early indicator of disease burden during future life due to prenatal exposure to cigarette smoke. At the international congress, the results of the effect of cigarette smoking during pregnancy on the activity of antioxidant enzymes in connection with the levels of essential trace elements in the body compartments of the expectant mother and her offspring were presented (239). Furthermore, the combined results of a related study carried out as a part of the completed research projects METALORIGINS and the in-house project "Assessment of the effect of gene polymorphisms *MT2A* +838G/C and *MT2A* -209A/G on the levels of toxic and essential elements in healthy pregnant women" were also presented at an international congress. The study assessed the frequency of these three gene polymorphisms of metallothionein *MT2*A and their association with the levels of toxic and essential elements in the maternal-placental-fetal compartments, i.e., maternal blood, placenta, and umbilical cord blood (264). The results of research on the distribution of metal(loid)s in the aquatic environment (water, sediment, and fish) of the upper and middle reaches of the Raša River were also published with the aim of assessing the environmental quality of the sensitive karst water system under the long-term anthropogenic influence of the Raša coal mines (47). Additionally, we examined the distribution of elements in the liver and muscle tissue of eels, as well as the influence of various biological factors (length, weight, muscle lipid content, hepatosomatic index, and condition index) on the tissue element concentrations (46). The study findings were also disseminated through an invited speech at the mini-symposium titled "Pollutants of the indoor air" hosted at the Institute (159).

In-house research projects (Chapter 16.1.A.3.)

1. *Bioactive potential, metal and nicotine content in edible Boletus mushrooms regarding the toxic metal burden of soil*

An investigation of potentially toxic metals and radionuclides in edible Boletus mushrooms was conducted on a few locations in Croatia known for either high or low Cd, Hg, and Pb soil levels in collaboration with the Radiation Protection Unit and the Biochemistry and Organic Analytical Chemistry Unit. A minor portion (15%) of sampled Boletus mushrooms had Cd levels crossing the maximum levels set by EU laws, which originated from northern Croatia. Lead and Cs^{137} levels were below the legal limits in all of the samples (225). Compared to *Boletus* mushrooms imported to the EU from southeastern European countries, the Croatian samples had lower As, Hg, and Pb levels, but higher Cd and Cs^{137} (233). Headspace solid phase microextraction (HS-SPME) method coupled to gas chromatography with mass spectrometric detection was developed for nicotine quantification (42) to explore the potential paths of nicotine transfer to dry Boletus mushrooms. The naturally present low amounts of nicotine in Boletus mushrooms are enhanced during the process of drying undertaken by manufacturers to prolong the expiry date of this food item (207).

Other research activities and collaborations

Within the research project ALZ-BBB-STOPINNATETAU (HRZZ-IP-2019-04-3584), led by the Croatian Institute for Brain Research, we participated in a study investigating the association between toxic and essential element levels and biomarkers of Alzheimer's disease, and the results were published as an original research article (2).

In collaboration with the Ruđer Bošković Institute, as part of the research project BIOTOXMET (HRZZ-IP-2020-02-8502), we presented results on the content of metals and metallothioneins in the intestines and intestinal parasites of brown trout in relation to exposure to metals in

environmental water of the Krka River at a scientific meeting (297). Furthermore, we published a scientific paper (59) that examined the seasonal patterns of metal and semi-metal concentrations in water across various sites situated in the upper reaches of the Krka River watercourse, which is contaminated with inadequately purified effluents. Within the same collaboration, we authored a research paper in which we evaluated the possible influence and consequences of varying degrees of water pollution in the upper reaches of the Krka river on living species by employing two distinct toxicity tests. The primary objective of this study was to assess the capabilities and constraints of microbiotests in relation to the identification and measurement of environmental pollutant hazards. Additionally, the research sought to establish the connections between ecotoxicological findings and particular chemical parameters.

The results of the TEMPHYS research project (HRZZ-IP-2020-02-7585), in which we participate as a partner institution to Faculty of Science University of Zagreb, showed that high temperatures (global warming simulation) alter the nutritive value of broccoli seedlings. The plant's ability to adapt to temperature variation was reflected on the phytochemical, micro- and macroelement, antioxidant capacity and *in vitro* cytotoxic potential of broccoli extracts tested on five different cell lines (31, 309).

At national conferences with international participation, we presented results on the content of inorganic elements, phthalates, and PAHs in drinking water (208, 211, 241) as well as the preliminary results of an active sampling of indoor air directly onto gold coated polycarbonate filters, as well as analysis of microplastic particles using a Laser Direct Infrared (LDIR) Chemical Imaging System (248). These studies were performed within the research project JamINNO+ and in collaboration with our partner from the industry sector (Jamnica plus d. o. o.).

We continued to collaborate with Units within the Institute on various research topics. As part of a long-term collaboration with the Unit for Biochemistry and Organic Analytical Chemistry, the biological availability of inorganic elements and persistent organic pollutants in a karst river on the Adriatic's eastern coast was investigated for the first time using the European eel as a biological indicator of pollution. The findings of these experiments were presented in an original scientific paper (46). In collaboration with the Radiation Protection Unit, we found no differences in potentially toxic anthropogenic metals and radionuclides in bilberry fruits collected in Croatia compared to the ones from southeastern Europe. Bilberries had 2-7 times higher trace metal(loid)s level than cultivated blueberries at the same microlocation (214). We also participated in research on the toxic effects of ketamine on the HepG2 and human neuroblastoma cell line SH-SY5Y (43).

Within the framework of our long-term collaboration with the Faculty of Veterinary Medicine University of Zagreb and partners from Poland, we investigated the association of environmental pollutants (potentially toxic metal(loid)s) with reproductive and stress hormones in brown bear hair from Croatia and Poland (52). Brains of the brown bear, grey wolf, Eurasian lynx, and golden jackal from Croatia were used for studying the effects of biological and ecological factors on the level of potentially neurotoxic metal(loid)s (51). Temporal distribution of anthropogenic pollutants (Sr90, stable metal(oid)s) was investigated in the bones of the brown bear over the last 50-year period (80). Whole blood Pb was assessed as one of the most frequent anthropogenic chemical causing intoxications and death in the Kvarner population of the protected griffon vulture (292). Metal(loid) levels in two Croatian strictly protected felid species, the Eurasian lynx and European wildcat, were found to be below the known toxicity thresholds for mammals (291).

In collaboration with the Institute of Oceanography and Fisheries in Split and the Faculty of Food Technology and Biotechnology of the University of Zagreb, we continued to investigate the impact of body length and habitat on metal(loid) levels in fish muscle tissue; the results were presented at two scientific meetings with invited lectures (168, 234). Consumer preferences for fish consumption in the adult Croatian population were investigated (223) and the levels of metal(oid)s were compared in the muscles of the most commonly consumed freshwater and marine fish species (143).

In collaboration with the Faculty of Food Technology and Biotechnology, University of Zagreb, results of the proximate chemical composition, essential elements, and antioxidant potential of rowan fruits (*Sorbus aucuparia* L.) from a Croatian mountainous area were published (83). In another

collaborative research, we measured levels of macroelements and trace elements in hospital meals prepared for feeding patients using feeding tubes. The levels of Na, Mg, K, Ca, and Fe were compared with theoretical element values, calculated using the national food chemical composition database (304).

We conducted analyses of macro- and trace elements in propolis collected during 2023 as part of a two-year multidisciplinary study investigating organoleptic, chemical, and biological properties of propolis from different climate regions in Bavaria and Croatia, coordinated by the Friedrich-Alexander University Erlangen-Nurnberg, Germany (305).

In collaboration with the Institute of Organic Chemistry and Biochemistry, Ruđer Bošković Institute, using the ICP-MS method, we studied the stoichiometry of binding different divalent metal ions (Zn^{2+}, Cu^{2+}, Mn^{2+}, and Co^{2+}) to purified recombinant human dipeptidyl peptidase III (DPP III). A research paper on the binding and exchange of these physiologically relevant cations in the DPP III metaloenzyme was published (54).

In collaboration with the School of Medicine, University of Zagreb, we published a review paper on the genetic and epigenetic features of uveal melanoma, highlighting the challenges and clinical implications in its treatment (68).

In a collaborative research project with the Anthropological Institute in Zagreb, we analysed levels of Al, As, Cd, Co, Pb, Ni, and Sr in the blood, serum, femur bone, liver, kidney, small and large intestine, and brain of female rats after three months of oral administration of tribomechanically activated (TMAZ) and Panaceo-Micro-Activated (PMA) zeolite. The beneficial effects of clinoptilolite materials on the metal profile in laboratory animals were demonstrated, and a decrease in trace elements levels in the kidney, femur bone, and small and large intestine was observed (18).

RESEARCH PROJECTS FUNDED BY EXTERNAL SOURCES

National research projects (Chapter 16.1.)

1. Exposure to Pyrethroid and Organophosphate Insecticides in Children – Risk Assessment for Adverse Effects on Neuropsychological Development and Hormonal Status (PyrOPECh, HrZZ-IP)
2. Indirect effect of global warming on mammals physiological parameters via high temperature-stressed plant diet (TEMPHYS, HrZZ-IP)
3. Role of blood-brain barrier, innate immunity, and tau protein oligomerization in the pathogenesis of Alzheimer's disease (ALZ-BBB-STOPINNATETAU, HrZZ-IP)
4. Integrated evaluation of aquatic organism responses to metal exposure: gene expression, bioavailability, toxicity and biomarker responses (BIOTOXMET, HrZZ-IP)

International research projects (Chapter 16.2.)

1. Development of functional beverage in sustainable packaging (JamINNO+, EFRR)
2. Antimicrobial nanostructured biomaterials for complex wound healing (NABIHEAL, H2020)
3. Pharmaceutical Open Innovation Test Bed for Enabling Nano-pharmaceutical Innovative Products (PHOENIX, H2020)
4. Science-based Risk Governance of Nano-Technology (RiskGONE, H2020)
5. Safe-by-Design Approach for Development of Nano-Enabled-Delivery Systems to Target the Brain (SENDER, HrZZ-PZS)
6. Cancer nanomedicine – from the bench to the bedside (Nano2Clinic, COST)

Educational and science popularization project (Chapter 16.2.B.)

1. Meet toxicity – live safely (MeeTox, Erasmus+)

PROFESSIONAL SERVICES

Throughout 2023, the Unit continued to provide expert trace element analysis in clinical or

environmental samples to assess occupational or environmental exposure, deficiencies, and nutrient intake. The laboratory provides a specialist assay for about 20 individual elements in whole blood, urine, plasma/serum, liver/biopsies, and other biological matrices, using the atomic absorption spectrometry (AAS) or state-of-the-art inductively coupled plasma-mass spectrometry (ICP-MS) methods.

A total of 284 analyses of specific indicators of exposure and effect to toxic metals and essential trace element status in the humans were performed. The majority of these analyses were provided at the requests of companies and specialists in occupational medicine practices. Specifically, a total of 180 analyses of Pb exposure biomarkers [concentrations of Pb and erythrocyte protoporphyrin (EP) and activity of δ-aminolevulinic acid dehydratase (ALAD) in blood], and 16 analyses of other metals (Cd, As, Hg, Tl) in the blood of workers. For diagnostic purposes, the concentration of Cu in liver tissue biopsy samples (n = 10) was analysed. Upon individual requests, the concentration of Al, Ag, As, Cd, Co, Cr, Cu, Fe, Hg, I, Ni, Pb, Zn, and V was analysed in urine, blood, serum, and hair (78 analyses). In addition to analyses in biological samples, the mercury content in 4 samples of infusion or Ringer's solution was analysed.

ORGANISER	TEST	AREA	DATE
Frimley Health, NHS Foundation Trust, Guildford, Surrey, United Kingdom	UK NEQAS for Trace Elements	Analysis of elements in blood (As, Cd, Co, Cr, Hg, Mg, Mn, Pb, Se, Tl, Zn) and urine (As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se)	Jan–Mar 2023 (two samples of blood and urine per month)

A determination of the presence of iron in lyophilized samples (CON22002, AAA52103, AOMH001118, 1179-RLD, 1276-RLD, AOPH001289, AOPH00468) was carried out for the company CryoBIND Research d. o. o.

PROFESSIONAL ACTIVITIES OF EMPLOYEES

J. Jurasović

Member of the Presidency of the Croatian Society of Toxicology.

Z. Kljaković-Gašpić

Guest editor of the Special Issue on Biomonitoring of Elements in Wildlife Animals, *Toxics (Vol 11(1), 2023; ISSN 2305-6304).*

M. Lazarus

Member of the Professional group for chemical hazards in food and feed at the Croatian Agency for Agriculture and Food; Guest Editor of the Special Issue on Biomonitoring of Elements in Wildlife Animals, Toxics *(Vol 11(1), 2023; ISSN 2305-6304)*; Secretary of the Croatian Laboratory Animal Science Association (CroLASA, 2018–2023).

A. Pizent

Guest editor of the Special Issue on Oxidative Stress Induced by Environmental and Lifestyle Stressors: Impact on Reproductive Health and Development II and Oxidative Stress Induced by Environmental and Lifestyle Stressors: Impact on Reproductive Health and Development 3rd Edition, *Antioxidants*; Member of the Editorial Board of journal *Frontiers in Public Health* (associate editor for *Environmental Health and Exposome* Section); Member of the Editorial Board of journal *All Life*; Member of the Executive Editorial Board of the journal *Archives of Industrial Hygiene and Toxicology*.

A. Sulimanec

Member of the Scientific Committee of the 2nd International Conference Food and Climate Change, University North, Koprivnica, Hrvatska.

I. Vinković Vrček

Member of the Thematic Innovation Council for Health and Quality of Life of the Ministry of Economy of the Republic of Croatia; Member of the Working Group for Regulation in the Field of Novel Foods, Ministry of Health of the Republic of Croatia; Representative of the Republic of Croatia for the Network on Risk Assessment of Nanotechnologies in Food and Feed of the European Food Safety Agency (EFSA). Member of the Nanomaterials Expert Group (NMEG) of the European

Chemical Agency (ECHA – European Chemical Agency); Head of Delegation of the Republic of Croatia for Working Party on Manufactured Nanomaterials (WPMN) of OECD.

SCIENTIFIC, TEACHING AND ACADEMIC ADVANCEMENT OF EMPLOYEES

Scientific degree of permanent scientific advisor was gained by I. Vinković Vrček.
PhD degree was gained by N. Kalčec at the Faculty of Science, University of Zagreb.

15.2. Biochemistry and Organic Analytical Chemistry Unit

EMPLOYEES OF THE UNIT

HEAD
Snježana Herceg Romanić, PhD, permanent scientific advisor (Head of Unit until 11 Oct 2023)

RESEARCHERS
Assoc Prof Zrinka Kovarik, PhD, permanent scientific advisor
Goran Šinko, PhD, permanent scientific advisor as of
Anita Bosak, PhD, scientific advisor as of 13 Jul 2023
Maja Katalinić, PhD, scientific advisor as of 26 Jul 2023
Sanja Fingler Nuskern, PhD, senior scientific associate
Darija Klinčić, PhD, senior scientific associate
Gordana Mendaš Starčević, PhD, senior scientific associate
Assist Prof Sanja Stipičević, PhD, senior scientific associate
Marija Dvoršćak, PhD, scientific associate
Nikolina Maček Hrvat, PhD, scientific associate
Josip Madunić, PhD, scientific associate
Nikola Maraković, PhD, scientific associate
Antonio Zandona, PhD, scientific associate as of 7 Nov 2023
Tena Čadež, PhD, senior assistant as of 2 Jun 2023
Karla Jagić, PhD, senior assistant as of 1 Feb 2023
Ana Matošević, PhD, senior assistant as of 1 May 2023
Marija Bartolić, MSc, PhD student-assistant
Dora Kolić, MSc, PhD student-assistant
Ana-Marija Lulić, MSc, PhD student-assistant

TECHNICAL STAFF
Nikolina Medved, technician
Maja Meštrović, technician

PARTICIPATING RETIRED RESEARCHER
Prof Vlasta Drevenkar, PhD, permanent scientific advisor

RESEARCH

ACTIVITIES AND COLLABORATIONS WITH INSTITUTIONAL FINANCING

Scientific collaborations

An analysis of salivary cortisol and cortisone as biomarkers of stress reaction of subjects occupationally exposed to noise was completed (100). The research was part of the doctoral thesis of Roko Žaja, MD (School of Public Health "Andrija Štampar", School of Medicine, University of Zagreb).

Kinetics of spirotetramat degradation in different types of water used for spray preparation in crop treatments was performed. The research was part of the doctoral thesis of Anamarija Bokulić Petrić (Ministry of Agriculture of the Republic of Croatia). The possible effect of water property on the stability of insecticides susceptible to hydrolysis was presented (11).

Sampling continued within the framework of the MONET project, active since 2009 under the auspices of RECETOX, the Regional Center for Environmental Chemistry and Toxicology, Masaryk University, Brno, Czech Republic).

In-house scientific projects (Chapter 16.1.A.3.)

1. *Analysis of organic pollutants in biological systems and the environment*

The pollution of the Kupa River by polychlorinated biphenyls (PCB) was investigated through sediment analysis, and the results were processed using a mathematical model (bedload sediment transport model) (32). The results represent an excellent example of the persistency of PCBs in the environment. Research on Neretva River pollution began by PCB, organochlorine pesticide, (OCP), and polycyclic aromatic hydrocarbon (PAH) analysis in its sediments (238). The possible health risks associated with the levels of the herbicides terbuthylazine, atrazine, acetochlor, and metolachlor in drinking, surface, and underground waters of the Zagreb region were assessed (57, 298). It was concluded that there is no risk of cancerous or non-cancerous diseases due to exposure to herbicides in different waters. Using machine learning and artificial intelligence models, indoor and outdoor air quality was investigated (200). The applied models enabled a better understanding of air pollution and related ecological processes. In a review paper, we summarized the last few decades of investigation on persistent organic pollutants PCBs, OCPs, polychlorinated dibenzo-p-dioxins, and polychlorinated dibenzofurans in mother's milk from Croatia (33). Using the *in vitro* bioavailability method, preliminary studies of macroelements as nutrients and potentially toxic elements in breast milk were conducted (299). An overview of the results and comprehension about organic pollutants was briefly presented in thematic lectures at the University Career Week in Osijek, the County Professional Meeting of Nature/ Biology Teachers in Zagreb, and the ERASMUS+ ToxLearn4EU summer school in Zagreb.

Other research activities

In cooperation with Višnja Stepanić (Ruđer Bošković Institute, Zagreb) and Vesna Pehar (Dr Franjo Tuđman Croatian Defence Academy, Zagreb, Croatia), we tested selected commercially available herbicides as acetylcholinesterase (AChE) and butyrylcholinesterase (BChE) inhibitors. Given that herbicides can cause different types of toxicity – from reproductive toxicity, hepatotoxicity to neurotoxicity – cytotoxicity was tested on several selected cell lines (69).

Numerous compounds have been designed and synthetized to be more effective reactivators of covalently inhibited cholinesterase. Many of those new compounds fail because interactions formed within the AChE active site are not favourable ones that lead to a successful reactivation. The new approach in which the modelling of a phosphorylated oxime (POX), a product of successful reactivation in the AChE active site, may be a way to better understand the role of active site residues during the process of formation of the Michaelis type of complex between an inhibited enzyme and oxime. To study interactions between the AChE oxyanion hole and a phosphorylated oxime, an S203G mutant was used to position the POX close to the oxyanion hole. Molecular dynamics was used to test the stability of the near-attack conformation of the oxime derived from the POX structure (84).

Databases are important because of the unified presentation of information according to a specific subject. Publicly available databases have additional value due to easier access to knowledge and information. The article describes the database of protein structures, Protein Data Bank–PDB, its establishment, humble beginnings, and very important status in science. Particular emphasis is placed on the part of the database dedicated to professors and students that enables them to access the data and use it in their work or education (85).

PROJECTS FUNDED BY EXTERNAL SOURCES

National research projects (Chapter 16.1.)

1. Analyses of interactions between organophosphorus compounds and esterases and other targets for therapy in poisoning (OPEsterOX, HrZZ-IP)
2. Development of bioactive molecules for the treatment of neurodegenerative diseases (BioMol4ND, HrZZ-IP)
3. Molecular mechanisms underlying the toxicity of antidotes and potential drugs (CellToxTargets, HrZZ-UIP)

4. Establishment of a cellular model of the blood-brain barrier for in vitro assessment of the passage of potential drugs into the brain (HAZU)
5. Synthesis and biological evaluation of carbamates as potential cholinesterase inhibitors in the treatment of Alzheimer's disease (HAZU)
6. Development, validation and application of analytical methods for PBDE determination (DeValApp, HrZZ-UIP)
7. Polybrominated diphenyl ethers in the dust of public spaces – do they pose a risk to human health? (HAZU Foundation)

International research projects (Chapter 16.2.A.)

1. *In vivo* efficacy of novel uncharged bis-oximes in OP poisoning treatment, NIH, UCSD, SAD

Educational and science popularization projects (Chapter 16.2.B.)

1. Meet toxicity – live safely (MeeTox, Erasmus+)
2. About science through sport (STEMsport, ESF)

PROFESSIONAL ACTIVITIES OF EMPLOYEES

A. Bosak

Member of the Supervisory board of the Croatian Natural History Society.

T. Čadež

Member of the Organizing Committee of the International symposium on Environmental and Molecular Toxicology of Chemicals, Zagreb, Croatia

S. Fingler Nuskern

Member of the TO of CSI/TO 147 Water Quality at the Croatian Standards Institute.

Member of the Working Group for monitoring EU Action Plan "Towards Zero Air, Water and Soil *Pollution"*

S. Herceg Romanić

Member of the Working Group for monitoring and meeting the requirements of the Third National Plan for the Implementation of the Stockholm Convention on Persistent Organic Pollutants; Member of the provisional Workgroup for passing a scientific opinion on the exposure of Croatia's adult population to dioxins and dioxin-like polychlorinated biphenyls (DL-PCBs) from various food types.

M. Katalinić

Editorial Board Member of the journal Toxics, publisher MDPI; Guest Editor of the Special Issue "Future Perspectives of Cell-Based Research in Toxicology and Drug Discovery" of the journal International Journal of Molecular Sciences, MDPI; Member of the Court of Honour of the HDBMB; Member of the Committee for Public Relations of the HDBMB; Member of the Committee for Development and Cooperation of the HDBMB; editor of the website www.hdbmb.hr; Member of the Organizing Committee "The 22nd FEBS Young Scientists' Forum (YSF 2023)", Tours, France 6–8 Jul 2023; Member of the International Organizing Committee FEBS3+ Meeting, 25–28 Sep 2024, Pula, Croatia.

Z. Kovarik

Associate Editor of Biofactors, an IUBMB journal; Section Editor of Periodicum biologorum; Member of the Executive Board of the Croatian Chemical Society; Member of the Supervisory board of the Croatian Society of Natural Sciences and HDBMB; Member of the Working group "TWG on the Analysis of Biotoxins" of the Scientific Advisory Board of the Organization for the Prohibition of Chemical Weapons (SAB OPCW); Member of the Board for Chemistry, Agency for Science and Higher Education; Panellist and evaluator of the Croatian Science Foundation; Member of the NATO working group "Translating Medical Chemical Defense Research into Operational Medical Capabilities against Chemical Warfare Threat Agents"; Member of two expert boards: International Advisory Board on Cholinesterases and International Advisory Board on Cholinergic Mechanisms; Organizer of the "International symposium on Environmental and Molecular Toxicology of Chemicals", 7 Dec 2023,

Zagreb; Member of the Scientific Committee CBRNE Research & Innovation Conference, Strasbourg, 2024, France; Member of expert committees for evaluation of doctoral theses, Faculty of Science, University of Zagreb; Member of expert committees for evaluation scientific achievements, Ruđer Bošković Institute, Zagreb.

J. Madunić

Member of the Public Relations Committee of the Croatian Society of Biochemistry and Molecular Biology (HDBMB); Member of the expert committee for selection to a professional position at the Institute for Medical Research and Occupational Medicine, Zagreb; Member of the Committee for Gender Equality at the Institute for Medical Research and Occupational Medicine, Zagreb; Member of the Management Committee of COST actions 21113 and 21130.

G. Mendaš Starčević

Member of the Committee for Risk Assessment (RAC) at the European Chemicals Agency (ECHA); Member of RAC Drinking Water Working Group; Member of the configuration "Food, Bioeconomy, Natural Resources, Agriculture and Environment" of the Horizon Europe Programme Committee; Member of the Working Group for monitoring and meeting the requirements of the Third National Plan for the Implementation of the Stockholm Convention on Persistent Organic Pollutants; member of the Working Group for Codex Alimentarius, Food Contaminants Committee; Member of the provisional Workgroup for passing a Scientific opinion on the exposure of Croatia's adult population to dioxins and dioxin-like polychlorinated biphenyls (DL-PCBs) from various food types; Member of the provisional Workgroup for passing a scientific opinion on the exposure of Croatia's adult population to dioxins and dioxin-like polychlorinated biphenyls (DL-PCBs) from various food types; Member of the Working group for Action Plan for Further Improvement of the Implementation of Chemicals OECD ACQUIS.

S. Stipičević

Member of the Commission for Pesticides, Ministry of Agriculture of the Republic of Croatia; coordinator for the Information System of Science of the Republic of Croatia (CroRIS); Coordinator for the students' practice (the Career Center of the Faculty of Science, University of Zagreb); Member of the Court of Honour of the Croatian Society of Toxicology; member of the Commission for evaluating the doctoral thesis (J. Horvatinec, Faculty of Agriculture, University of Zagreb).

A. Zandona

Member of the HDBMB Youth Forum; Member of the HDBMB Finance Committee; Member of the Local Organizing Committee FEBS3+ Meeting, 25-28 Sep 2024, Pula, Croatia.

15.3. Radiation Dosimetry and Radiobiology Unit

EMPLOYEES OF THE UNIT

HEAD
Ivica Prlić, PhD, professional advisor in science (Head of the Unit until 11 Oct 2023)

RESEARCHERS
Ivan Pavičić, PhD, scientific advisor
Ana Marija Marjanović Čermak, PhD, scientific associate
Luka Pavelić, PhD, scientific associate as of 1 Dec 2023
Branimir Zauner, PhD, scientific associate as of 20 Mar 2023
Krunoslav Ilić, PhD, senior assistant
Ana Buinac, MSc, senior professional advisor in science (3h/week)
Martina Dragičević, MSc, senior professional associate in science until 1 Aug 2023
Tomislav Meštrović, MSc, senior professional associate in science
Jerko Šiško, MSc, senior professional associate in science
Paula Antonija Bačani, MSc, professional associate in science as of 7 Sep 2023
Mihovil Jurdana, professional associate in science

TECHNICAL STAFF
Selvije Sefić, BSc, senior technician
Silvija Kobešćak, MBA, technician

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

In-house scientific projects (Chapter 16.1.A.3.)

1. *Thermometry, thermography and sensory evaluation of electromagnetic radiation in medicine (TTSem2)*

We conducted research using experimental methods of IR thermography in the clinical departments of KBC Zagreb. We tried to continuously monitor the thermographic characteristics of female breasts with invasive ductal carcinoma. The continuation of the investigation of the thermographic characteristics of the healing of clavicle and humerus fractures in children (in cooperation with the KBC Zagreb and the Clinic for Children's Diseases, Zagreb) in pandemic working conditions is underway. The preliminary results obtained during 2019 and 2020 were processed for the purpose of publication. It is planned to continue clinical research on the topic of temperature symmetry mapping of skin regions in children and adults of both sexes. Measurements would be carried out during outpatient examinations in the polyclinic of the Clinic for Surgery of KBC Zagreb. The goal of this research is to standardise physiological deviations in a healthy population and determine standard deviations for individual anatomical regions. Until now, similar measurements have already been made, but without a study of differences by age. After creating the optimal number of thermometer sensors, the plan is to carry out the measurements in patients of the KBC Zagreb Surgery Clinic who are undergoing a standard fracture treatment procedure. A protocol is being prepared for the patient's consent to participate in the implementation of the project.

2. *Thermometry, thermography and sensory evaluation of electromagnetic radiation in medicine (TTSem3)*

New scientific research topics were formed on the TTSem3 project (W1 – W6):
W1 Thermometry of healing of forearm bone fractures in children.
W2 Thermometric monitoring of skin reinnervation after breast reconstruction with a free flap and implants.

On the above topic, in cooperation with the School of Medicine, Clinic for Plastic Surgery, documentation was prepared for the HrZZ research project application (IP-2022-10) entitled "Recovery of breast sensation following implant-based breast reconstruction (ReSens)" under the leadership of Prof Krešimir Bulić, MD, from the School of Medicine, University of Zagreb.

Other work packages continue with their activities that were disabled during the pandemic.

W3 Development of a human analgesic test model using the axo-axonal reflex and IR camera.

W4 Daily variations of frontal temperature in children.

W5 Frontal temperatures in obese children.

W6 Cooperation in the development of dosimetry methods and measurements during surgical procedures in the Clinic for Surgery and the Clinic for Interventional Neurology of KBC Zagreb, where X-ray radiation is used as standard for diagnosis and implementation of surgical procedures. During 2023, the material required for the implementation of intellectual property protection of the above-mentioned thermometric system developed at IMI in cooperation with external collaborators has been prepared; Alara uređaji d. o. o. and Haj-Kom d. o. o.

3. Development of UV radiation sensors (SUVIndex)

Field measurements were carried out using developed prototypes of UV sensors developed at IMROH in cooperation with our partners. The collection of data that could indicate certain UV behaviours at the time of pandemic restrictions and additionally, the harmonization of sensors with regard to the new climatological environmental conditions, especially in the continental part of the Republic of Croatia, considering that so far in research and experiments we have been oriented towards Adriatic Croatia.

Other research activities

National Program for Screening and Early Detection of Lung Cancer 2020–2024

Due to the pandemic operating conditions of the clinics, the implementation of the entire program of the Ministry of Health of the Republic of Croatia was largely postponed to the fall of 2022. In the part of the program related to the quality control of low-dose CT devices, the employees of the Unit performed measurements under the leadership of I. Prlić, coordinator of the Commission of the Ministry of Health of the Republic of Croatia for Implementation quality control of low-dose CT devices during the implementation of the National Program. The program officially started in October at the Jordanovac Lung Disease Clinic, KBC Zagreb. More about the project: https://zdravlje.gov.hr.

The evaluation of the results of the intercomparison of the thermoluminescent dosimeters received in the spring and autumn of 2022 and the spring of 2023 and the assessment of the necessary corrections in the method of determining the personal dose equivalent of Hp (10) and Hp (3) from photon radiation sources are in progress.

The process of preparation, measurements validation, intercomparison setup, and work instructions, calibration protocol and quality maintenance protocol creation was started for a new type of passive dosimeter, BeOSL (Beryllium Optically Stimulated Luminescence), for the use of which a completely new instrument was installed at the Institute, within our laboratory on the fourth floor of the Institute, and which will be the basis of research activities in the field of passive and active dosimetry of ionizing radiation covered by the Program Agreement financed by the European Union – NextGenerationEU (Program Agreement dated December 8, 2023) which is an internal project of the Unit led by Jerko Šiško, BSc, senior professional associate, Paula Antonija Bačani, MSc, professional associate, and Mihovil Jurdana, BSc, professional associate.

In the final phase (pilot project) is the development and test use of the new RODOS internal software system for monitoring, documentation, archiving, reporting, and other relevant and accredited technical processing of the entire personal dosimetry, which the institute carries out as an authorized Professional Technical Service for protection against ionizing radiation through accredited methods led by associates of the Institute for Radiation Protection established in October, Jerko Šiško, BSc, senior professional associate, Paula Antonija Bačani, MSc, professional associate, and Mihovil Jurdana, BSc, professional associate.

The evaluation of the results of the establishment of the Laboratory for Metrological X-ray Irradiation

will be led by Luka Pavelić, PhD. A protocol for the development of the entire instrumentation of the laboratory was developed through Monte Carlo simulations in the Geant4©CERN software package, as well as simulations validated by the calculation of the photon flux conversion factor in H*(10). The laboratory will be prepared in accordance with the ISO 4037-1:2019 Norm "Radiological protection X and gamma reference radiation for calibrating dosemeters and dose rate meters and for determining their response as a function of photon energy Part 1: Radiation characteristics and production methods"(Luka Pavelić, Kolokvij@IMI, November 10, 2023).

The mission of the afore mentioned newly established IMI laboratory is to:

- support the STS laboratory for radiation dosimetry,
- support the research group in the development of new instrumentation,
- support the research group in radiobiological tests,
- carry out special research (area of special irradiation),
- establish low-energy beams of X-ray radiation for research on the interaction of ionizing radiation with biological material,
- create and validate MC simulations of the laboratory setup for the needs of precise cell irradiation,
- test innovative concepts in radiation physics → new project proposal,
- develop new dosimetric instrumentation → reported projects,
- develop instrumentation for radiological imaging in diagnostic medicine → reported projects,
- test the performance of commercially available passive and, in particular, electronic, active dosimeters,
- examine the time effects and pulse modes of radiation on measuring instrumentation,
- type-test the new BeOSL dosimetry system → accreditation of new methods,
- harmonize measuring laboratories and new measuring quantities in the framework of the EU PIANOFORTE Partnership EURATOM HORIZON (2023-2027) programme (leader I. Prlić - WP 5 T3.2 PF).

In the framework of the Division for Radiation Protection at the beginning of 2023, the formation of a complete laboratory for non-ionizing electromagnetic (EM) radiation was started, which included all research (field measuring) equipment for measuring EM radiofrequency fields. New equipment has been added, which also enables laboratory irradiation of biological material with non-ionizing radiation of given frequencies in the so-called TEM and GTEM chambers for the needs of research in radiobiology. Of particular importance are the results obtained from work on the e-school projects that have been ongoing since 2015 in cooperation with the CARNET academic network.

During 2023, the Unit's employees also worked on an internal project of the Institute entitled "Extraction and cultivation of mesenchymal stem cells from rat bone marrow and the influence of low dose ionizing radiation on their properties", which at the end of the year served as the basis for shaping radiobiological research tasks as part of the EBDIZ project application "Ecological, biological and dosimetry aspects of ionizing radiation: exposure and protection" from the programme funding system.

RESEARCH PROJECTS FUNDED BY EXTERNAL SOURCES

International research projects (Chapter 16.2.A.)

1. Research Partnership of the European Union in the field of radiation protection - PIANOFORTE; European Partnership for Radiation protection research (PIANOFORTE: EURATOM Work program 2021-2022 HORIZON Europe – Eu cofound 46 million € total budget – Institute is the Program Manager for the Republic of Croatia appointed by the Ministry of Science and Education (head of WP 3 Task 2.1 and cooperating institution on WP 5 Task 2.3)
2. Science-based Risk Governance of Nano-technology (RiskGONE, H2020)
3. Safe-by-Design Approach for Development of Nano-Enabled-Delivery Systems to Target the Brain (SENDER, HrZZ-PZS)
4. Single layer gamma-ray polarimeter for medical imaging applications and fundamental physics research (SiLGaP, HrZZ-PZS)

PROFESSIONAL SERVICES

During 2023, the same protocols for IMROH employees in the field of radiation protection were implemented as in the previous year. The implementation of field work, especially those carried out by the Unit's associates as part of the Authorized Expert Technical Service for Radiological Safety (IMROH STS), was made somewhat difficult during a part of the year for users in the Republic of Croatia. The prescribed epidemiological measures to alleviate pandemic living and working conditions, especially in health care institutions (clinical hospitals) in the Republic of Croatia, significantly prolonged the performance of certain quality control tasks and the implementation of QA/QC procedures with sources of ionizing radiation carried out by the Unit's employees. Despite this, all contractual obligations of the IMROH STS were successfully fulfilled. Employees who process personal dosimeters additionally collected and processed dosimeters that professionals used in hospitals, in the so-called COVID departments. For the health safety of its employees, the Unit has introduced special protocols and the disinfection and chemical treatment of dosimeter carriers.

Activities of the Authorized Expert Technical Service for Ionizing Radiation (IMROH STS)

Natural radioactive materials (NORM) – residues from oil and gas

Tasks for the INA Group, related to: i) the development of a protocol for the implementation of business activities during oil and gas exploration on the territory of the Republic of Croatia, which include the manipulation of natural radioactive materials (NORM), especially residues, ii) the preparation of an activity plan in the event of an extraordinary event, which involves radiological risks and iii) determination of the need for specialist professional training and the implementation of safety measures related to ionizing radiation and the appearance of residues at the production locations of the INA Group, additional jobs were contracted for the preparation of several studies, four of which were specialized reports during 2022 for the needs of activities carried out by STSI d. o. o., a member of the INA Group, and field surveys and monitoring of radiological works were carried out at the gas production sites of Molva and Gola. The result of the business cooperation with the INA Group will also be visible through an additional project.

The research activities of the Radiation Protection Unit, whose employees are developing an environmental model for residue monitoring in the gas and oil production industry using samples from the research production fields of the INA Group, with special research focus on the impact of residues on the biota of the locations where these facilities are located. During 2022, foundations were lain for the continuation of the project professional-technical, innovation, and research cooperation between INA and IMROH. Many years of experimental work at the location of STSI d. o. o. in Stružec resulted in the development of an in-house research project, the experimental development part of which was carried out during 2023 under the strictest pandemic restrictive measures in the field and in cooperation with external collaborators ALARA uređaji d. o. o. and Haj-Kom d. o. o. The aforementioned activities are a link to the sustainability of the IPPSO project, financed by EU structural funds.

An experimental measuring system with the working name ALARA UAV (English Unmanned Aerial Vehicle) was tested in practice and is being developed. Documentation is being prepared for the application of that pilot project for funding and experimental technological development in full experimental form (research/technological development of measuring instrumentation) and congress announcements have been sent as the first step of publishing complete works.

Professional risk assessment studies

CONTRACTOR	AUTHOR OF THE REPORT
Poliklinika Sv. Nikola, Varaždin	T. Meštrović
Dom zdravlja Senj	T. Meštrović
OB dr. Tomislav Bardek, Koprivnica	T. Meštrović, B. Zauner
Specijalna bolnica za ortopediju i rehabilitaciju "Martin Horvat", Rovinj	T. Meštrović, B. Zauner
Poliklinika Aviva, Zagreb	T. Meštrović, B. Zauner
Dom Zdravlja Ozalj	T. Meštrović
Specijalna bolnica dr. Nemec, Matulji	T. Meštrović, B. Zauner
OB Gospić	T. Meštrović, B. Zauner
Nastavni zavod za javno zdravstvo "Andrija Štampar", Zagreb	I. Prlić, B. Zauner
Dentex d. o. o., Zadar	T. Meštrović
Dr. Rigo Dental Clinic, Rovinj	T. Meštrović
Dom Zdravlja Dubrovnik	T. Meštrović
ODM Ivana Krišto, dr. med. dent., Kaštel Gomilica	T. Meštrović
Poliklinika Ident, Zagreb	T. Meštrović, J. Šiško, M. Jurdana
Stomatološka ordinacija Dentorium, Rijeka	T. Meštrović
Ordinacija dentalne medicine Milan Arnautović, dr. med. Dent., Zagreb	T. Meštrović
Privatna ordinacija dentalne medicine Marko Vukić dr. med. Dent., Zagreb	T. Meštrović, B. Zauner
Specijalistička stomatološka ordinacija za ortodonciju Dr. Ebtehaj Navaey, Samobor	T. Meštrović, B. Zauner
Privatna stomatološka ordinacija Dubravko Jurišić, dr. med. Dent., Dubrovnik	T. Meštrović
Stomatološka poliklinika dr. Blašković, Rijeka	T. Meštrović
Digital Smile Academy d. o. o., Zagreb	T. Meštrović, B. Zauner
Uljanik brodogradnja 1856 d. o. o., Pula	T. Meštrović, B. Zauner
Radež d. d., Blato	T. Meštrović, B. Zauner
Đuro Đaković Termoenergetska Postrojenja d. o. o, Slavonski Brod	T. Meštrović
Sano – Suvremena hranidba životinja d. o. o., Popovača	T. Meštrović, B. Zauner
Specijalna bolnica Radiochirurgia Sv. Nedelja	I.Prlić

As many as 25 risk assessment studies were carried out for activities with sources of ionizing radiation in dental medicine, research, and industry for different contractors. Several studies are in the process of creation.

Expert studies on the implementation of protection against ionizing radiation

CONTRACTOR	AUTHOR OF THE REPORT
Zagreb Faculty of Science, Department of Physics	T. Meštrović, B. Zauner
KBC Zagreb-Rebro III project	I. Prlić
KBC Zagreb- Centar za istraživanje i rano otkrivanje karcinoma pluća – Klinika Jordanovac	I. Prlić
Radiochirurgia, Sv. Nedjelja – linear accelerator	I. Prlić
Sveučilište u Zagrebu, -FESB- , Centar za nerazorna ispitivanja	I. Prlić
Klinika za infektivne bolesti „dr. Fran Mihaljević", Zagreb	I. Prlić

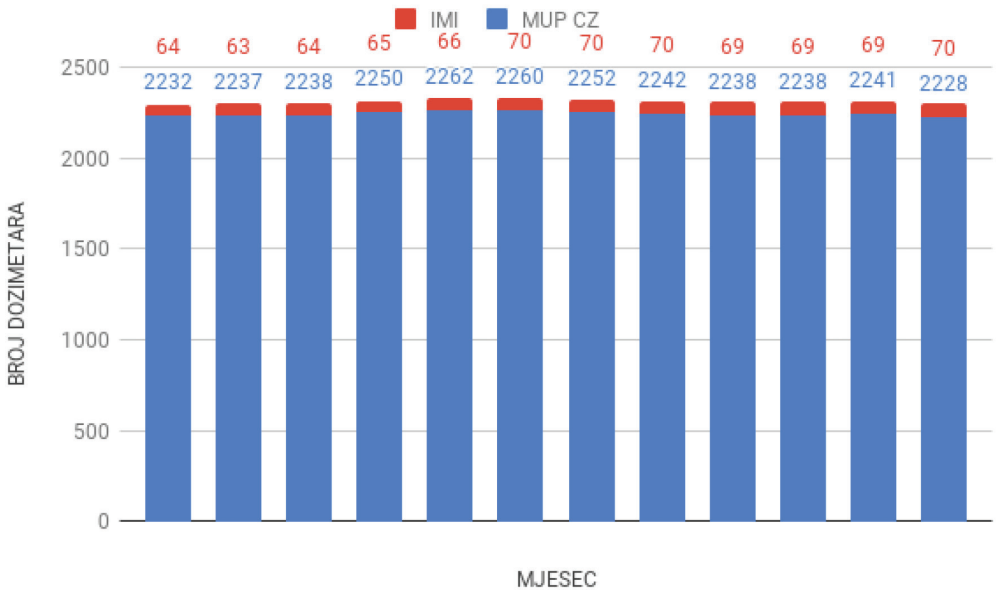
Professional reports of personal dosimetry and employee categorization

On the basis of the contract on personal dosimetric monitoring and testing of sources of ionizing radiation, during 2023, in compliance with the prescribed epidemiological measures, the Unit carried out personal dosimetric monitoring, radiological monitoring of the workplace and testing of sources of ionizing radiation for 181 contracted users from various fields of activity.

In 2023, more than 2,300 categorizations of exposed workers were created for contractual users of personal dosimetric monitoring.

CONTRACTOR	AUTHOR
Categorization of exposed employees	J. Šiško
Total contractually required categorizations	> 2300

During 2023, more than 26,000 dosimetric measurements were carried out, based on which more than 3,000 dosimetric reports were prepared for contractual users of personal dosimetric monitoring.



The unit finalized the IMI e-dosimetry protocol, which will enable the transition to online delivery of dosimetry reports to users of the Authorized Technical Service of IMI and thereby further modernize and the relationship with users of services by including the personal dosimetry we perfom in the Republic of Croatia e-Citizens system. This expert project is in the initial implementation phase II and is being worked on by the expert associates of the Unit. The IMI e-dosimetry project continues in 2024 with the testing of all relevant IT components and certificates for the protection of users' personal data so that during 2024 all the necessary data are connected into the new dosimetry software system (Big Data dosimetry IMI).

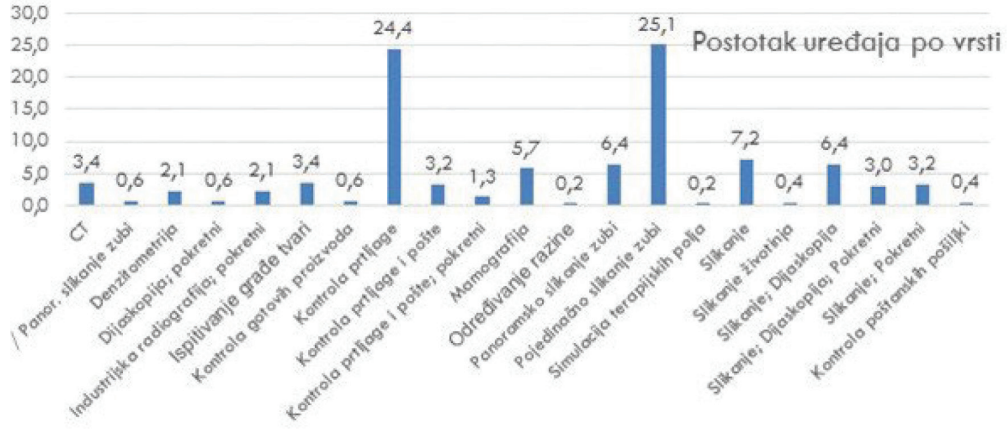
I. PROTOCOL: e-dosimetry IMI	RESPONSIBLE AUTHOR
Upgrade (programming) of the TLD dosimetry system with programming and updating of HOLOGRAM IMI©® dosimetry according to current regulatory regulations and maintenance of the SQL database of all dosimetry data required for preparation online forms in the e-Građani system	J. Šiško (implementation) I. Prlić (advisor)
Preparation of the introduction of new software solutions for processing TL dosimeters that would be compatible with the future BeOSL dosimetry system that was delivered at the end of 2022 and during 2023. was in a trial research paper. A new RODOS software system was developed, which is being pilot tested at institutes from the end of 2023.	P. A. Bačani, J. Šiško, M. Jurdana, I. Prlić (advisor), S. Sefić

Overview of users of personal dosimetry services by activity

CONTRACTOR	RESPONSIBLE AUTHOR
Clinical hospital centers in the Republic of Croatia Dental polyclinics Dental medicine practices Health centers in the Republic of Croatia Companies Institutes in the Republic of Croatia Universities and faculties Factories	J. Šiško M. Jurdana P. A. Baćani I. Prlić (advisor)
All accompanying dosimetry documents and invoices	S. Sefić
Additional control of dosimetry reports	M. Jurdana
Total contract reports for 181 users	> 3000
Processing of all contractual and implementation documentation for all contractors	S. Kobešćak

Expert reports on quality control of sources of ionizing radiation

In 2023, with the continuation of the strictest observance of epidemiological measures in the field and with respect for the mobility of people and goods between counties in the Republic of Croatia, more than 680 field tests – quality control and measurements as part of radiological monitoring of the workplace were made for about 595 electrical devices that produce ionizing radiation (X-ray devices and linear accelerators) and close to 58 radioactive sources/isotopes used in medicine, industry and scientific institutions. Over 1,300 expert reports and 1,340 expert opinions were prepared based on the tests performed.



Percentage of tested X-ray devices by purpose during 2023

The unit has worked and will continue to work as part of the Division of Radiation Protection on the further modernization of the IMI e-radiation sources protocol, which will enable the transition to online delivery of reports on the implementation of QA/QC measurements for the users of the authorized IMI STS and thereby additionally modernize the business and the relationship with the users – customers of services by including the sending of electronically signed reports. This expert project of the Unit will also be in the test implementation phase during the next year. The plan is to test all relevant IT components and certificates for the protection of users' personal data, methods of accepting/storing and sending documentation and reporting to the regulatory body of the Ministry of Interior of the Republic of Croatia.

II. PROTOCOL: Control of sources of ionizing radiation	RESPONSIBLE AUTHOR
Excell database for all sources of ionizing radiation for which STS IMI implements QA/QC protocols, revisions and upgrades Excel sub-databases that serve as worksheets in which input data about devices and performed measurements are entered, and then a corresponding report (pdf) suitable for electronic signature and online delivery to users is generated.	T. Meštrović, M. Jurdana, J. Šiško, I. Prlić

List of international comparative laboratory tests

ORGANIZER	TEST NAME	SCOPE	DATE„
„Jožef Stefan" Institute Ljubljana, Slovenia	PRIMER 2023 - primerjalne meritve hitrosti doze in spektrometrije gama	Measurement of the rate of ambient dose equivalent H*(10)/t	September 2023
„Jožef Stefan" Institute Ljubljana, Slovenia	Area dosimeter intercomparison NDS2023area FINAL REPORT With the participation of 4 institutions from two EU MS with a total of 7 dosimetry systems.	Ambient dose equivalent H*(10)/t	April to July 2023.

List of accredited methods

METHOD	TYPE OF EXAMINATION, RANGE
ME-608-001 (own method)	Personal dosimetry of photon radiation with TL range dosimeters 85 μSv - 100 mSv and in the radiation energy range 33 keV - 1.3 MeV
ME-608-002 (own method)	Determination of the rate of the spatial (ambient) dose equivalent; H*(10)/t dose rate 100 nSv/h - 100 mSv/h and radiation energy range 36 keV - 1.3 MeV
ME-608-003 (own method)	Ring dosimetry of ionizing radiation by thermoluminescence dosimeters in the range 170 μSv to 500 mSv and in the range of radiation energies 33 keV to 1.3 MeV
ME-608-004 (own method)	Environmental dosimetry of photon radiation by thermoluminescence dosimeters in the range 180 μSv to 100 mSv and in the range of radiation energies 33 keV to 1.3 MeV

Unit quality manager: *J. Šiško until 11 Oct 2023; M. Jurdana as of 12 Oct 2023.*

Expert contribution of radiobiology

All types of asbestos in solid materials were identified according to the model of the International Organization for Standardization (General requirements for the competence of testing and calibration laboratories International Standards Organization (ISO) Geneva: 1999). Five analyses of solid materials sent from interested companies were performed to determine the presence and type of asbestos. The material was analysed using the standardized method for stereomicroscopy and polarization microscopy MDHS 77-HSE (Document Method for the Determination of Hazardous Substances; series 77 – Asbestos in bulk materials, in: HSG 248 Asbestos: The analysts' guide for sampling, analysis and clearance procedures Appendix 2: Asbestos in bulk materials: sampling and identification by polarized light microscopy).

Equipping and preparing new laboratory spaces and research equipment

As part of the implementation of the Project (ReC-IMI, KK.01.1.1.02.0007), the entire year 2023 was used for the preparation of the research space on the fourth floor of the newly built building of the Institute. As part of the building permit, instructions were given to implement protection against

ionizing radiation in the laboratory spaces. The installation of the new research equipment spanned from mid-2022 to 2023. The equipment was installed, tested, and the employees were trained to work with it.

PROFESSIONAL ACTIVITIES OF EMPLOYEES

T. Meštrović

Specialist in protection against ionizing radiation for the areas of personal dosimetric monitoring – assessment of external exposure, personal dosimetric monitoring – assessment of internal exposure, activities in medicine, dental medicine and veterinary medicine where electrical devices that produce ionizing radiation are used, activities in medicine and veterinary medicine where they are used radioactive sources, activities in industry and science where radioactive sources and/or electrical devices that produce ionizing radiation are used.

L. Pavelić

Associate member of the European Radiation Dosimetry Group (EURADOS); member of the Working Group WG3-S2; member of the Board of Directors of the Croatian Nuclear Society.

I. Pavičić

Member of the Working Group for the preparation of the position of the Republic of Croatia in the area of protection against electromagnetic fields.

I. Prlić

Appointed member of the Reference Group of the Ministry of Health of the Republic of Croatia for cooperation with the EU EURATA; member of the Scientific Expert Group ART 31 EURATOM contract; of the European Commission (2020 – 2025); member of the Scientific Expert Group ART 37 EURATOM contract; of the European Commission (2020 – 2025); member of IRPA (International Radiation Protection Association – Task Group on Radioactive Source Security, national nomination of the Republic of Croatia 2019-2024

Expert-advisor of the group for the creation of the Position of the Republic of Croatia in the field of protection against non-ionizing radiation, Working Group for 5G technological solutions; member of the Commission of the Ministry of Health for the implementation of the Health Strategy of the Republic of Croatia – National Program for Screening and Occupational Detection of Lung Cancer 2020-2025; member of the Working Group of the State Institute for Standardization (DZN) and the Ministry of Health for work on legal metrology in the field of medical equipment (especially radiating equipment); member of the Board of Directors of the Croatian Biomedical Engineering and Medical Physics Society; member of the Project Committee and Education and Training Committee of the European Federation of Organizations for Medical Physics (EFOMP); member of the International Atomic Energy Agency (IAEA); member of the Working Group EC Environmental Radiation-Effect: International Perspectives - part of the project for Croatia; member of the Commission of the Ministry of Health for review and evaluation of studies in the field of use of non-ionizing radiation sources; member and expert group of the European ALARA Network for Naturally Occurring Radioactive Materials (EAN NORM); international expert for the International Road Transport Union and the International Labor Organization; member of the Board of Directors of MELODI (Multidisciplinary European Low Dose Initiative); member of the Board of Directors of the international project CONCERT (H2020), member of the Board of Directors of ALLIANCE (The European Radioecology Alliance), Croatian member of the Task Group on Radioactive Source Security, ICRP (International Committee for Radiation Protection).

J. Šiško

Associate member of the European Radiation Dosimetry Group (EURADOS); member of the Working Group WG3-S2, specialist in protection against ionizing radiation for the areas of personal dosimetric monitoring – assessment of external exposure.

15.4. Environmental Hygiene Unit

EMPLOYEES OF THE UNIT

HEAD

Assoc Prof Gordana Pehnec, PhD, scientific advisor (Head of Division of Environmental Hygiene as of 11 Oct 2023)

RESEARCHERS

Ivan Bešlić, PhD, scientific advisor
Ranka Godec, PhD, senior scientific associate
Silva Žužul, PhD, senior scientific associate
Silvije Davila, PhD, scientific associate
Ivana Jakovljević, PhD, scientific associate
Jasmina Rinkovec, PhD, scientific associate
Iva Smoljo, MSc, PhD student-assistant
Suzana Sopčić, PhD, professional associate in science
Valentina Gluščić, MSc, professional associate in science
Nikolina Račić, MSc, professional associate in science
Zdravka Sever Štrukil, MSc, professional associate in science
Tajana Horvat, MSc, PhD student, as of 1 Feb 2023
Marija Jelena Lovrić Štefiček, MSc, PhD student, as of 1 Feb 2023

TECHNICAL STAFF

Samuel Ljevar, senior technician
Gordana Pršlja, senior technician
Magdalena Vincetić, MSc, senior technician
Karmenka Leš Gruborović, technician
Ivan Marić, technician
Martin Mihaljević, technician
Tereza Puzjak, technician (from 16 Feb to 31 Dec 2023)
Martina Šilović Hujić, MSc, technician

PARTICIPATING RETIRED RESEARCHERS

Krešimir Šega, PhD, permanent scientific advisor
Vladimira Vađić, PhD, permanent scientific advisor
Mirjana Čačković, PhD, senior scientific associate

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

Long-term research activities

Measurements of polycyclic aromatic hydrocarbons (PAH) in airborne particulate matter were carried out at several locations with different characteristics (234). By parallel sampling of the PM_{10} particle fraction and measurement of PAHs bound to particles, carcinogenic activity was assessed for urban residential, urban industrial and urban background locations in Croatia (205), and the dominant air pollution sources were assessed at the same locations (206). For PAHs bounded to PM_{10}, the human health risk was estimated for three ways of exposure, inhalation, ingestion and absorption through the skin, as well as the toxicological effect of PAHs on the environment through atmospheric deposition (37). Seasonal variations of different groups of organic pollutants in airborne particulate matter were also studied (235).

Measurements of elemental (EC) and organic (OC) carbon in samples of $PM_{2.5}$ particle fraction continued at locations with different characteristics (urban background, urban traffic, and rural measuring stations).

The investigation of the anhydrosugars in PM_{10}, $PM_{2.5}$, and PM_1 samples continued at measuring stations of different characteristics (urban background, urban traffic, rural measuring station) (236). Seasonal variations of carbohydrates at the background rural measuring station were monitored and studied, as well as the relationship between carbohydrates and polycyclic aromatic hydrocarbons, with the aim to determine their air pollution sources (237).

Development and optimization of a method for determining volatile organic compounds in the air based on the principle of thermal desorption coupled with gas chromatography with a mass spectrometer has started. The optimized method will be applied for measurements of volatile organic compounds in households within the EDIAQI (*Evidence-driven indoor air quality improvement*) project (201, 202)

In the urban area of the city of Zagreb, the levels of water-soluble ions (Cl^-, NO_3^-, SO_4^{2-}, CH_3COO^-, $HCOO^-$, $C_2O_4^{2-}$, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}) in the $PM_{2.5}$ fraction of particulate matter were measured. The results indicated the presence of different primary (mobile and stationary) and secondary sources of air pollution at measuring stations in the western and northern part of the city, regardless of the classification of the measuring station. At all of the measuring stations, the differences in mass concentrations were observed depending on the day of the week (196).

At the urban measuring station located in the northern part of the Adriatic, the levels of mass concentrations of $PM_{2.5}$ particle fraction and mass concentrations of water-soluble ions (Cl^-, NO_3^-, SO_4^{2}, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}) and elemental (EC) and of organic (OC) carbon bound to $PM_{2.5}$ were monitored. Their seasonal distribution was examined. The calculated characteristic mass ratios of individual pollutants indicated the presence of secondary sources, and the results of the factor analysis indicated the presence of other dominant sources of air pollution (195).

Measurements of metals in the PM_{10} fraction of particulate matter and in total deposited matter continued at locations with different sources of pollution (244).

Data on the levels of pollutants with an offensive odour (hydrogen sulphide, mercaptans) in the vicinity of the Central Wastewater Treatment Plant of the City of Zagreb were analysed (231). Data on the airborne pollutant levels from the measuring stations of the Croatian State Network for Air Quality Monitoring and the local measuring network of the City of Zagreb were evaluated, and the air quality assessment was carried out according to current regulations and compared with the guidelines of the World Health Organization (166, 227).

Scientific collaborations

Cooperation with the Biochemistry and Organic Analytical Chemistry Unit, started through the HrZZ project "Development, validation and application of analytical methods for the determination of PBDEs – DeValApp", continued. As part of joint research, the PAH content was determined in household dust samples collected in Zagreb and its surroundings, as well as in dust samples collected from the interior of cars, offices of different companies, kindergartens, and schools (154). As part of the institutional project *Analysis of organic pollutants in biological systems and the environment* (leader S. Herceg Romanić), the optimization of measurement methods for the determination of PAHs in different types of samples (sediment, soil, floating particles, total sediment, breast milk, fish) continued (235, 238).

In cooperation with the Mutagenesis Unit, research was carried out within the HUMNap project: *Air pollution and biomarkers of effect in humans*. Data on the levels of pollutants in the ambient air from different locations (Zagreb, Slavonski Brod, Vinkovci) were statistically processed and the association with biomarkers of effect in humans at the same locations was observed (189, 197, 209, 217, 261, 263, 279, 295). Available data from earlier years were also analysed 151, 194, 251, 252). As part of the EDIAQI (*Evidence Driven Indoor Air Quality Improvement*) project, research on the connection between indoor air quality and biomarkers of effect in humans has begun (192).

As part of cooperation with the Radiation Protection Unit, the content of total potassium (K^+) and its natural radionuclide (^{40}K) in total deposition, dry deposition, and precipitation (197) was measured at measuring stations in the northern and western parts of Zagreb. At one measuring station in Zagreb, the total beta activity and the levels of lead and thallium in PM_{10} were determined in parallel (248). The impact

of desert sand intrusion on the ambient dose equivalent rate, total beta activity, PM_{10} levels and PM_{10} metal content was also studied at several locations in Croatia (227). Radon measurements in households started through the EDIAQI project (183).

In cooperation with the Faculty of Agriculture of the University of Zagreb, the nitrogen balance in agroecosystems was investigated (245). The quality of urban soils in Zagreb was studied with regard to pollution with polycyclic aromatic hydrocarbons (144, 310). The research of platinum, palladium, and rhodium in environmental samples continued, as well as the study of the seasonal and spatial distribution of the mentioned metals in the above-ground layers of plants (*Plantago lanceolata* L. and *Dactylis glomerata* L.) as well as in different soil depths. It was found that Plantago lanceolata L. has indicator properties for Pd and that there is a depth distribution of the mentioned metals in the soil (232). The influence of improvers on the phytoremediation of cadmium and mercury from the soil by the grass *Miscanthus x giganteus* (146) was also investigated.

In cooperation with the Faculty of Forestry of the University of Zagreb, research was carried out on the difference in measurements when determining mass concentrations of wood dust by gravimetric and optical methods, as well as the potential need for a correction factor (16).

As a continuation of the collaboration established through the project *Determining Long Term Time Trends of Air Pollution Source Tracers by Nuclear Techniques* (RER/7/012, IAEA, ended in 2022), an inversion method was developed to quantify the emission fluxes of certain sources of aerosol pollution in a wide region, mainly in Europe and Western Asia. The aerosol contribution factors were determined using the PMF model on the data set which consisted of the chemical composition of $PM_{2.5}$ from 16 European and Asian cities for the period from 2014 to 2016 (94).

Research of the characteristics and potential of low-budget sensors in air quality monitoring, especially in relation to conventional measurement methods, continued. Through the project *Deployment of lower-cost ambient air quality sensor systems in urban environments* (ENV.C3/SER/2019/0010, JRC), cooperation was established with the Flemish Institute for Technological Research (VITO, Belgum), the Flemish Environment Agency (VMM, Belgium), and Norwegian Air Research Institute (NILU). After the end of the project in 2022, data processing continued, as well as publication of research results (92, 187). For the purposes of the EDIAQI project, sensors for monitoring outdoor air quality were installed at two locations in parallel with reference methods (215).

In cooperation with the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb, research of the relationship between air and soil pollution at certain locations has started (72). In cooperation with Mario Lovrić, PhD from the Institute of Anthropology, data on air pollution in the Zagreb area were analysed (229). The development of a model that describes the interrelationships of pollutants in the air, total deposition and soil started. The relationship between gas consumption, traffic density, and meteorological parameters with concentrations of metals and polycyclic aromatic hydrocarbons in PM_{10} was analysed in order to better understand their origin and interactions.

In-house scientific projects (Chapter 16.1.A.3.)

Organic content of PM_1 particle fraction

24-hour samples of the PM_1 particle fraction collected during the period 2018-2022 at IMROH and in the centre of Zagreb were analysed. In the collected samples, organic and elemental carbon, water-soluble organic carbon, levoglucosan, polycyclic aromatic hydrocarbons, and black smoke index were determined. The obtained data were processed and the results were systematized. PM_1 organic composition research and the comparison with the PM_{10} and $PM_{2.5}$ fractions were presented at an international meeting (198, 236).

Molecular markers of organic carbon – biomass burning indicators

In 2023, the internal project which included analyses of samples of particulate matter fractions PM_{10}, $PM_{2.5}$, and PM_1 at the IMROH measuring station was completed. Two methods of high-performance anion exchange chromatography with pulsed amperometric detection were developed for carbohydrate analysis. The mass concentrations of three groups of carbohydrates were determined. All three groups, anhydrosugars, sugar alcohols and primary sugars originated from different sources. The statistical

analysis was carried out with the goal to determine their seasonal and spatial variations. Results were compared with the concentration of organic carbon as well as polycyclic aromatic hydrocarbons. Project results were presented at six scientific and professional conferences and one research paper is in the publication process.

RESEARCH PROJECTS FUNDED BY EXTERNAL SOURCES

National research projects (Chapter 16.1.)

1. Biochemical responses of the surface layer in the oligotrophic area of the Adriatic to atmospheric sedimentation (BiREADI, HrZZ-IP)
2. Air pollution and human biomarkers of effect (HUMNap, HrZZ-IP)

International research projects (Chapter 16.2.A.)

1. Project of extension and modernisation of the national network for continuous air quality monitoring (AIRQ, ERDF)
2. Development of functional beverage in sustainable packaging (JamINNO+, ERDF)
3. Evidence Driven Indoor Air Quality Improvement (EDIAQI, Horizon Europe)
4. Partnership for the Assessment of Risks from Chemicals (PARC, Horizon Europe)

PROFESSIONAL SERVICES

The monitoring of air pollution continued in Zagreb at six measuring stations of the local measuring network. At the Zagreb stations, the Unit measured different pollutants in the air: sulphur dioxide, black carbon, PM_{10} fraction, metals arsenic (As), cadmium (Cd), nickel (Ni), lead (Pb), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), PAHs in PM_{10} fraction, $PM_{2.5}$ fraction, nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), benzene, total deposited matter, and metals As, Cd, Ni, Pb, and Tl in the total deposited matter.

According to contracts with the Ministry of Economy and Sustainable Development and the Meteorological and Hydrological Service of Croatia, following the Air Protection Act (127/19, 57/22), the Unit as a reference laboratory performs the sampling of particulate matter (PM_{10} and $PM_{2.5}$) and its physical and chemical analysis at measuring sites within the Croatian State Network for Air Quality Monitoring. The Unit also carries out equivalency of non-reference methods for the determination of particulate matter mass concentration (PM_{10} and $PM_{2.5}$) in the air. Air pollutants were measured at the monitoring sites Zagreb-1, Zagreb-3, Zagreb-4, Sisak-1, Slavonski Brod-1, Slavonski Brod-2, Plitvička jezera, Ksaverska cesta PPIPM2,5, Velika Gorica, Rijeka-2, Rijeka-PPIPM2,5, Osijek-2, Osijek-PPIPM2,5, Polača, Split-3 and Split-PPIPM2,5.

Equivalence studies were performed for non-reference measuring methods of PM_{10} and $PM_{2.5}$ at measuring stations Slavonski Brod-1 and Plitvička jezera, for $PM_{2.5}$ at measuring station Kutina-2, and for PM_{10} at measuring stations Zagreb-1, Zagreb-3, Kutina-1, and in Potpićan and Našice..

The monitoring of air, water, soil, agricultural, and forest ecosystems and control of wild animals in the vicinity of the Central Gas Station (CGS) Molve continued. In 2022, in cooperation with the Institute of Public Health of the Koprivnica-Križevci County, the Institute performed measurements of hydrogen sulphide, mercaptans, and sulphur dioxide at five locations in the proximity of the CGS Molve.

The monitoring of air quality within the zone of influence of the Wastewater Treatment Plant in Zagreb continued. The monitoring of levels of hydrogen sulphide, ammonium, and total mercaptans and meteorological parameters was carried out at five measuring stations. In 2022, the measurements of these pollutants continued at two additional locations in the possible zone of influence (Resnik i Ivanja Reka, Croatia) as well.

Near the Jakuševec landfill, the levels of PM_{10} and mercaptans are continuously measured. During different seasons, levels of metals Pb, As, Ni, Cd and PAHs in PM_{10} fraction were also measured as well.

Measurements of PM_{10} fraction and PAHs in PM_{10} fraction were carried out at a measuring site within Zagreb International Airport, Croatia.

Special purpose measurements were carried out in Zagreb in Ogulin.

Measurements of total deposited matter were carried out at two locations at the "Brezovi Rebar" sand excavation site near Karlovac and in the area of the asphalt base in Našice.

List of intercomparisons

ORGANISER	TEST	AREA	DATE
INERIS	215504 - 2783613 - v1.0 Interlaboratory comparison for the analysis of PAHs in ambient air	Determination of mass concentrations of benzo[a]anthracene, benzo[k]fluoranthene, benzo[j]fluoranthene, benzo[b]fluoranthene, benzo[a]pyrene, dibenzo[a,h]antracene, benzo[g,h,i]perylene, and indeno[1,2,3 – c,d] pyrene in particles on filter	September/ October
HLNUG, WHO CC, JRC, LANUV	Protocol for Inter-laboratory Comparison Exercise $PM_{2.5}$/PM_{10}	Inter-laboratory Comparison Exercise for PM10 and $PM_{2,5}$ in ambient air	October/ November

List of accredited methods

METHOD	TYPE OF TEST, RANGE
HRN EN 12341:2014 (EN 12341:2014)	Determination of mass concentration of PM_{10} and $PM_{2.5}$ particle fractions
HRN EN 14212:2012 (EN 14212:2012), HRN EN 14212:2012/Amend. 1:2014 (EN 14212:2012/AC:2014)	Determination of the concentration of sulphur dioxide in the ambient air
HRN EN 14625:2012 (EN 14625:2012)	Determination of the concentration of ozone in the ambient air
HRN EN 14211:2012 (EN 14211:2012)	Determination of the concentration of nitrogen oxide in the ambient air
HRN EN 14626:2012 (EN 14626:2012)	Determination of the concentration of carbon monoxide in the ambient air
HRN EN 14902:2007 (EN 14902:2005), HRN EN 14902/AC:2007 (EN 14902:2005/AC:2006)	Determination of the concentration of Pb, Cd, As and Ni in the PM_{10} fraction of suspended particulate matter
HRN EN 16909:2017 (EN 16909:2017)	Determination of the mass concentration of elemental and organic carbon in the suspended particulate matter in the ambient air
HRN EN 15549:2008 (EN 15549:2008)	Determination of the concentration of benzo(a)pyrene in the ambient air
HRI CEN/TR 16269:2017 (CEN/TR 16269:2011)	Determination of the mass concentration of anions and cations in the suspended particulate matter
VDI 4320 Part 2: 2012 (VDI 4320 Part 2:2012)	Determination of the dust deposition according to the Bergerhoff method
HRS CEN/TS 16645:2016 (CEN/TS 16645:2014)	Determination of the concentrations of benz(a)anthracene, benzo(b) fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, dibenz(a,h) anthracene, indeno(1,2,3-cd)pyrene and benzo(ghi)perylene in ambient air
HRN EN 15841:2010 (EN 15841:2009)	Determination of arsenic, cadmium, lead, and nickel in atmospheric deposition
In-house method OP-610-UTT-Tl Edition 01 2020-01-28	Determination of thallium in atmospheric deposition
HRN EN 16913:2017 EN 16913:2017)	Determination of the mass concentration of anions and cations in $PM_{2.5}$ as deposited on filters

The Unit's quality manager: *R. Godec.*

PROFESSIONAL ACTIVITIES OF EMPLOYEES

I. Bešlić

Member of the Croatian Air Pollution Prevention Association's Presidency; member of the Working Group in charge of monitoring the activity plans of the Croatian Meteorological and Hydrological Service and the Institute for Medical Research and Occupational Health at the national network for continuous air quality monitoring at the Ministry of Economy and Sustainable Development of the Republic of Croatia; member of the Commission for Reference Laboratory Work Monitoring at the Ministry of Economy and Sustainable Development of the Republic of Croatia; member of the Commission for the Selection of the Measuring Stations in the National Air Quality Monitoring Network; member of the Working Group for Air of the Croatian Accreditation Agency; member of the TO-146 Air Quality Committee of the Croatian Standards Institute; member of the Executive Editorial Board of the journal *Archives of Industrial Hygiene and Toxicology.*

S. Davila

Member of the Croatian Air Pollution Prevention Association's Presidency; member of the Organizing Committee of International Conference and 13th Croatian Scientific and Professional Meeting "Air Protection 2023".

R. Godec

President of the Croatian Air Pollution Prevention Association; member of the TO-146 Air Quality Committee of the Croatian Standards Institute; president of the Organizing Committee of International Conference and 13th Croatian Scientific and Professional Meeting "Air Protection 2023".

I. Jakovljević

Treasurer and member of the Croatian Air Pollution Prevention Association's Presidency (as of 2 Mar 2023), member of the Organizing Committee of International Conference and 13th Croatian Scientific and Professional Meeting "Air Protection 2023"; delegate of the Croatian Standards Institute in the Ad-hoc group (SRAHG "Ambient air").

G. Pehnec

International coordinator and member of the Croatian Air Pollution Prevention Association's Presidency; president of the European Federation of Clean Air and Environmental Protection Associations (EFCA); member of the Working Group in charge of monitoring the activity plans of the Croatian Meteorological and Hydrological Service and the Institute for Medical Research and Occupational Health at the national network for continuous air quality monitoring at the Ministry of Economy and Sustainable Development of the Republic of Croatia; member of the Commission for Air Quality Improvement Monitoring in the area of Slavonski Brod; member of the Working Group for Air of the Croatian Accreditation Agency; president of the Scientific Committee of International Conference and 13th Croatian Scientific and Professional Meeting "Air Protection 2023", member of the Scientific Committee of the Challenges in meteorology 9 conference.

G. Pršlja

Member of the Organizing Committee of International Conference and 13th Croatian Scientific and Professional Meeting "Air Protection 2023".

J. Rinkovec

Member of the Commission for Reference Laboratory Work Monitoring at the Ministry of Economy and Sustainable Development of the Republic of Croatia; member of the WHO Task Force on Health Aspects of Long-range Transboundary Air Pollution; member of the Organizing Committee of International Conference and 13th Croatian Scientific and Professional Meeting "Air Protection 2023".

Z. Sever Štrukil

Treasurer and member of the Croatian Air Pollution Prevention Association's Presidency (as of 2 Mar 2023).

S. Sopčić

Delegate of the Croatian Standards Institute in international/European working group CEN/TC 264/WG 21, Ambient Air-PAHs

S. Žužul

Member of the Croatian Air Pollution Prevention Association's Presidency.

15.5. Occupational Health and Environmental Medicine Unit

EMPLOYEES OF THE UNIT

HEAD

Prim Jelena Macan, MD, PhD, permanent scientific advisor
(90% of working hours and 10% in the Institute's company), Head of Division of Occupational and Environmental Health as of 11 Oct 2023

RESEARCHERS

Prof Selma Cvijetić Avdagić, PhD, MD, permanent scientific advisor
Veda Maria Varnai, PhD, MD, permanent scientific advisor
Željka Babić, PhD, scientific associate
Assoc Prof Adrijana Bjelajac, PhD, senior scientific associate
Jelena Kovačić, PhD, scientific associate
Zrinka Franić, MD, PhD, postdoctoral researcher
Marija Macan, MSc, assistant
Patricia Tomac, MSc, assistant
Marija Kujundžić, BSc, professional associate in science
Franka Šakić, MSc, professional associate in science (90 % of working hours)

TECHNICAL STAFF

Silvija Bošković, BSc, senior technician
Monika Vuletić, MSc, senior technician
Jagoda Mandić, nurse, technician
Adrijana Gustovarac, MSc, senior technician as of 8 May 2023

PARTICIPATING RETIRED RESEARCHERS

Assist Prof Biserka Ross, PhD, permanent scientific advisor

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

In-house scientific projects (Chapter 16.1.A.3.)

The in-house project "Sleep quality in different age groups in Croatia before and during COVID-19 pandemic (CoV-Sleep) continued with the analysis of data on sleep quality before and during the COVID-19 pandemic in a sub-sample of the working population in Croatia. Results have shown that most of the examined sleep quality parameters changed during the pandemic, and some of the observed changes were also dependent on the status of recovery from COVID-19 (213). Compared to the period before the pandemic, the duration of sleep was shorter and the frequency of nightmares was higher during the pandemic, whereas this difference was not dependent on the status of recovery from the disease. Subjective sleep quality, daytime sleepiness, and fatigue were significantly different during the pandemic compared to the period before the pandemic; both people who recovered from COVID-19 and those who did not recover reported poorer sleep quality and greater daytime sleepiness and fatigue during the pandemic. In these variables, the deterioration was more pronounced for persons who recovered from COVID-19. The frequency of dreaming was slightly higher in persons who recovered from COVID-19. The remaining project activities will be completed within the new project of the Division of Occupational and Environmental "Interactions between human and environmental health: determinants for health preservation (HumEnHealth)".

The analysis of the data of the internal project "Determination of body composition and chronic stress by the method of bioimpedance", which was completed in 2022, continued. Data on the correlation between body composition and heart rhythm variability (HRV) as an indicator of the autonomic nervous system function, in young and healthy men, have shown that physical activity and consequently good muscle mass can compensate for the negative interaction between adipose tissue and HRV (15). Among older subjects, the high prevalence of osteosarkopenic adiposity (OSA) coincided with the high prevalence of malnutrition and the risk of malnutrition, which is more likely caused by potentially poor quality nutrition in nursing homes rather than the COVID-19 pandemic (14).

The in-house project „Effects of recreational headphone noise on hearing in young adults (RecNoise)" continued with the recruitment of younger adults. In 2023, additional 35 participants were recruited and examined. Therefore, until the end of 2023 a total of 75 participants were included in the study. The aims of the project are: 1) to determine the habits of recreational use of headphones in young people aged 18 to 25 years; 2) to determine the sound levels in the headphones that the participants usually use; 3) to determine the hearing level using the audiometry method; 4) to determine the relation between the headphone use are possible hearing damage. The project is carried out in cooperation with the Department of Electroacoustics, Faculty of Electrical Engineering and Computing, University of Zagreb. The remaining project activities will be completed within the new project of the Division of Occupational and Environmental "Interactions between human and environmental health: determinants for health preservation (HumEnHealth)".

RESEARCH PROJECTS FUNDED BY EXTERNAL SOURCES

National research projects (Chapter 16.1.)

1. Exposure to pyrethroid and organophosphate insecticides in children – risk assessment for adverse effects on neuropsychological development and hormonal status, PyrOPECh, Croatian Science Foundation (IP-2019-04-7193)

National professional projects (16.1.C)

1. National plan for the development of broadband approach in Republic of Croatia in the period 2021-2027, measure M3 – Informing and education of public about electromagnetic fields (Ministry of Health, Republic of Croatia).

International research projects (Chapter 16.2.)

1. Partnership for the Assessment of Risks from Chemicals, PARC, HORIZON.2.1 – Health (Grant agreement ID: 101057014)
2. Sleep disorders related to coronavirus infection and confinement during COVID-19 Pandemic (ICOSS-2), international cooperation without founding
3. COST ACTION CA 21122 "PROmoting GeRiAtric Medicine IN countries where it is still eMerGing (PROGRAMMING)"
4. Meet toxicity- live safely (MeeTox, 2022-1-RS01-KA210-ADU-000083718)

Educational and science popularization projects (16.2.B)

1. Science through sport (STEMsport, UP.04.2.1.10.0160)

Professional projects (16.2.C)

1. Single Market Programme (SMP), European Commission (call "SMP-FOOD-2022-BIOCIDES-PESTICIDES-IBA")

PROFESSIONAL SERVICES

The professional activities of the Occupational Health and Environmental Medicine Unit included the organisation and implementation of teaching modules for medical doctors, residents in occupational and sport medicine. Jelena Macan was appointed as the main supervisor by the Croatian Ministry of Health for 16 residents in occupational and sports medicine. For pupils in secondary schools, lectures were delivered in the field of skin health and the analysis of pesticide residues in food.

PROFESSIONAL ACTIVITIES OF EMPLOYEES

Ž. Babić

Member of the Committee for safe use of medicines of the Agency for Medicinal Products and Medical Devices of Croatia, member of the Working Party on Hazard Assessment of the The Organization for Economic Cooperation and Development (OECD), substitute member of the Biocidal Products Committee of European Chemicals Agency (ECHA)

A. Bjelajac

Member of the Committee for propaedeutics of the Croatian Chamber of Psychotherapists; member of the Ethical Committee of the Society of Gestalt and Integrative Psychotherapists of Croatia; member of the Executive Committee of the journal Archives of Industrial Hygiene and Toxicology.

Z. Franić

Member of the Croatian toxicology society and Croatian Medical Chamber

J. Kovačić

Statistical editor and Executive Committee member of the journal Archives of Industrial Hygiene and Toxicology; external associate of the Agency for Medicinal Products and Medical Devices of Croatia; Adviser of the Member of the Committee for Risk Assessment (RAC) at the European Chemicals Agency (ECHA).

J. Macan

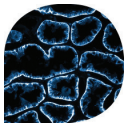
Full member of the Croatian Academy of Medical Sciences, Collegium of Public Health; member of the Croatian Society of Occupational Health Management Committee; member of the Croatian Society of Medical Court Expertise Management Committee; member of the European Initiative for Prevention of Occupational Skin Diseases at the European Academy for Dermatology and Venereology; member of the Committee for Medical Ecology, the Working Group for developing national positions in the field of protection from electromagnetic fields, and the Working Group for climate changes and health at the Ministry of Health, Republic of Croatia; permanent court expert witness in occupational medicine; member of the Croatian Association of Court Expert Witnesses and Valuers; assistant editor and Executive Committee member of the journal Arhiv za higijenu rada i toksikologiju; member of the Croatian Medical Chamber.

P. Tomac

Member of the Croatian Psychological Chamber; Member of the Croatian Psychological Society; Member of the Zagreb Psychological Society; Member of the Croatian Association for Behavioral-Cognitive Therapies; Member of the European Sleep Research Society

V. M. Varnai

Member of the Committee for Risk Assessment (RAC) at the European Chemicals Agency (ECHA). Deputy member of the Commission for drafting the Law on Amendments to the Law on the Implementation of Regulation (EC) no. 396/2005 on maximum levels of pesticide residues in and on food and feed of plant and animal origin. Member of the Working Group for the development of an Action Plan for the effective implementation of OECD legal instruments in the field of chemicals and risk assessment.



15.6. Molecular Toxicology Unit

EMPLOYEES OF THE UNIT

HEAD
Davorka Breljak, PhD, scientific advisor (Head of the Unit until 11 Oct 2023)

RESEARCHERS

Marija Ljubojević, PhD, scientific advisor as of 15 Jul 2023
Ivana Vrhovac Madunić, PhD, senior scientific associate
Dean Karaica, PhD, senior scientific associate until 31 Mar 2023

TECHNICAL STAFF
Ljiljana Babić, technician

PARTICIPATING RETIRED RESEARCHER
Ivan Sabolić, MD, PhD, permanent scientific advisor

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

We continued long-standing national and international scientific collaborations within which research papers and abstracts were published in WoS-indexed journals as well as Abstract Books, various thesis (bachelor and PhD) were defended under our mentorships, several activities were carried out in order to popularize science, and researcher mobility (inside/outside of IMROH) was stimulated.

Long-term research activities

In the frame of international collaboration with the research group led by Prof M. Tzvetkov (Institute for Pharmacology, Center of Drug Absorption and Transport, University of Medicine, Greifswald, Germany), results of pharmacokinetic analysis of various drugs carried out in rat animal model were presented at the international meeting "89th Annual Meeting of the German Society for Experimental and Clinical Pharmacology and Toxicology (DGPT)/8th German Pharm-Tox Summit" (Ulm, Germany) and were published in the WoS-indexed journal (262).

Other research activities

Cooperation with the University of Zagreb including the Faculty of Science continued through teaching activities (Methods in Immunology, held by I. Vrhovac Madunić) as well as one diploma thesis was defended under the mentorship of M. Ljubojević (142). Also, through joint efforts with the Faculty of Food Technology and Biotechnology, University of Zagreb, one diploma thesis was also defended under the co-mentorship of D. Karaica (138). Furthermore, through joint efforts with the Department of Biotechnology, University of Rijeka, one PhD thesis was successfully defended under the mentorship of D. Breljak (136). Finally, several science popularization activities were carried out (Chap. 11) and researcher mobility was promoted (Chap. 12).

RESEARCH PROJECT FUNDED BY EXTERNAL SOURCES

Within the joint Croatian-German project (Chap. 16.2.A.4.), we continued international collaboration with Prof Mladen V. Tzvetkov (Institute for Pharmacology, Center for Drug Absorption and Transport, University of Medicine, Greifswald, Germany) and performed planed research activities that were presented and published at the symposium "Cell-Based Research in Toxicology and Drug Design" (Zagreb, Hrvatska) (172). Furthermore, in the frame of research projects funded by the Croatian

Science Foundation (DANIOTRANS, IP-2019-04-1147) (Chap. 16.1.B.1.), we continued the long-standing scientific collaborations with the research group led by T. Smital (Ruđer Bošković Institute, Zagreb), and published one scientific article in a WoS-indexed journal (45). In the frame of international collaboration with the research group led by Prof I. Kalajzić (Department of Reconstructive Sciences, Center for Regenerative Medicine and Skeletal Development, Farmington, USA), one scientific article was published in a WoS-indexed journal (74). Also, in the frame of completed research project funded by the Croatian Science Foundation "Adverse effects of single and combined mycotoxins" (MycotoxA, IP-09-2014-5982), results were presented at the international meeting "13th Congress of the Serbian Society of Toxicology with international participation & 1st TOXSEE Regional Conference" (Belgrade, Serbia) and published in the Book of Abstracts (303).

National research projects (Chapter 16.1.)

1. Molecular Mechanisms Underlying the Toxicity of Antidotes and Potential Drugs (CellToxTargets, UIP-2017-05 7260, HrZZ)
2. Understanding the (eco)toxicological role of selected SLC and MATE transport proteins in zebrafish (Danio rerio) using functional genomics tools (DANIOTRANS, IP-2019-04-1147, HrZZ)

International research projects (Chapter 16.2.B.)

1. Pharmaceutical Open Innovation Test Bed for Enabling Nano-pharmaceutical Innovative Products (Phoenix, Obzor 2020)
2. Evidence Driven Indoor Air Quality Improvement (EDIAQI, Obzor 2020)
3. Modelling immunotherapy response and toxicity in cancer (IMMUNO-model, COST)
4. 3Rs concepts to improve the quality of biomedical science (IMPROVE, COST)
5. Personalized medicine in chronic kidney disease: improved outcome based on Big Data (PerMediK, COST)
6. EUropean network to tackle METAbolic alterations in HEART failure (EU-METAHEART, COST)
7. Identifying Interactions of Renal and Hepatic Organic Cation Transporters (OCTs) with Oximes, Antidotes in Treatment of Organophosphate Poisoning (Bilateral CRO-GER)
8. On Science Through Sport (STEMsport, ESF)

University projects (Chapter 16.2.A.5.)

1. Metformin and Sodium glucose co-transporters of Glucose (M. Tzvetkov (Institute for Pharmacology, Centre of Drug Absorption and Transport (C_DAT), University Medicine Greifswald, Germany) & I. Vrhovac Madunić (IMI, Zagreb, Croatia)
2. Generating new RGS5 mouse model for lineage tracing (Internal project of University of Connecticut, Department of Reconstructive Sciences, Center for Regenerative Medicine and Skeletal Development, Farmington, SAD)

PROFESSIONAL ACTIVITIES OF EMPLOYEES

D. Breljak

Member of the evaluation panel of the Croatian Science Foundation.

D. Karaica

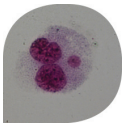
Management Committee Member for the COST Action "Modelling immunotherapy response and toxicity in cancer".

M. Ljubojević

Management Committee Member for the COST Action "EUropean network to tackle METAbolic alterations in HEART failure".

I. Vrhovac Madunić

Member of the Executive Committee of the Croatian Society of Biochemistry and Molecular Biology; Management Committee Member for the COST Action "3Rs concepts to improve the quality of biomedical science"; Management Committee Member for the COST Action "Personalized medicine in chronic kidney disease: improved outcome based on Big Data".



15.7. Mutagenesis Unit

EMPLOYEES OF THE UNIT

HEAD
Nevenka Kopjar, PhD, permanent scientific advisor (Head of Unit until 11 Oct 2023)

RESEARCHERS
Vilena Kašuba, PhD, permanent scientific advisor
Prof Davor Želježić, PhD, ERT, permanent scientific advisor
Mirta Milić, PhD, scientific advisor
Goran Gajski, PhD, senior scientific associate
Marko Gerić, PhD, senior scientific associate as of 13 Jul 2023
Luka Kazensky, PhD, assistant as of 1 Feb 2023
Katarina Matković, PhD student-assistant

TECHNICAL STAFF
Maja Nikolić, senior technician

PARTICIPATING RETIRED RESEARCHER
Prof Vera Garaj Vrhovac, PhD, permanent scientific advisor

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING
Long-term research activities

Research on populations (biomonitoring)

Results regarding the effect of dietary preferences on genome stability in humans were conducted (25, 26, 277). The influence of obesity on the level of DNA damage was investigated (91). The same topic was the subject of a doctoral thesis (140). In cooperation with researchers from Mexico, a paper was published on the effects of air pollution on the level of DNA damage in mother-new-born pairs (61) and two papers on DNA damage caused by occupational exposure to pesticides (77, 90).

Research on animal models

Investigations of the effects of inhalation anaesthetics alone or in combination with ionising radiation (doses 1 Gy and 2 Gy) were conducted on the Swiss albino mouse model. In two papers, the results of research into the level of DNA damage in liver cells (8) and brain cells (7) were published. Similar topics were presented at scientific meetings (182, 220). The results of the paper published in collaboration with the Biology Department of the Faculty of Science, University of Zagreb (49) showed that sodium metasilicate, a cleaning agent, led to damage to the cells of the mesoglea of the green hydra, which contains symbiotic green algae and non-symbiotic brown hydra in its cells. Mesoglea cells are important due to their polypotency. At the same time, sodium metasilicate leads to lesions on the tentacles. All damages were significantly higher in brown non-symbiotic hydra indicating the fact that symbiotic green algae help the green hydra to protect against the toxic effects of chemical compounds.

Research on plant models

The toxic effects of bisphenol A were investigated on the *Allium cepa* plant root cell model, and their association with gibberellic acid and oxidative stress was established (95).

Research on *in vitro* models

Studies of the harmful effects of mycotoxins were conducted on different cell models. The effects of deoxynivalenol and zearalenone were tested on HepG2 cells (19). Cytotoxic, genotoxic, and pro-inflammatory effects of combinations of Aspergilli (*Flavi* + *Nigri, Versicolores* + *Nigri*) isolated from air samples (38) were investigated on the model of human adenocarcinoma cells (A549) and THP-1 macrophages. The toxic effects of silver nanoparticles were investigated in a model of mammalian kidney cells (9). Effects of Wells-Dawson polyoxotungstate, a promising contrast agent, were investigated on a model of human peripheral blood lymphocytes (272). On the same model, the effects of *Arbutus unedo* L. honey on reducing the levels of DNA damage caused by the cytostatic irinotecan (41) were investigated. The effects of rosemary and dandelion extracts were investigated on CAL 27 cells (34). The biocompatibility of the hydrophobic low-temperature eutectic solvent (283) was investigated on the astrocytoma cell line model 1321N1.

In-house scientific projects s (Chapter 16.1.A.3.)

The final processing of the data collected in the previously completed project "Investigation of the interaction between irinotecan and tetrahydrocannabinol in laboratory rodents by integrating biochemical, molecular-biological, pathohistological and analytical methods" resulted in the publication of a congress abstract (175), which referred to a lecture at the topic of research on interactions between conventional cytostatics and cannabinoids, focusing on the importance of knowing the metabolism for a better understanding of the biological (pharmacological or therapeutic and/or toxic) effect of the drug.

Other research activities

Part of the specific research during 2023 was focused on the study of probiotic bacteria with high antioxidant and anti-inflammatory potential (48). The effects of different bioactive compounds from plants were also investigated (273). Research on specific biomarkers and improvement of the protocol continued, and a paper on the measurement of DNA modifications using the comet assay was published (13). A review paper on the genoprotective effects of bioactive molecules of animal origin was also published (79). In the field of regulatory toxicology, two publications were published on the safety and efficacy of food additives (115, 116). Two chapters in the book with topics from radiobiology were published (3, 4). One conference abstract (193) refers to the application of the Metafer system in the analysis of chromosomal damage and its possible application in cases of radiation accidents.

RESEARCH PROJECT FUNDED BY EXTERNAL SOURCES

National research projects (Chapter 16.1.)

1. Air pollution and human biomarkers of effect (HUMNap, HrZZ-IP)
2. Structure and bonding surface modification on the materials and hard dental tissue (MODIBIODENT, HrZZ-IP)
3. Statistical tools for assessing the impact of air pollution on cytogenotoxicity in human cells under in vitro conditions (HAZU Foundation)

International research projects (Chapter 16.2.A.)

1. Evidence Driven Indoor Air Quality Improvement (EDIAQI, 1 EUROPEAN RESEARCH AND INNOVATION FUND, Horizon 2020/Horizon Europe)
2. European Venom Network (EUven, COST)
3. Spread of antibiotic resistance genes in wastewater treatment plants in Croatia and China (MSE).

Educational and science popularization projects (Chapter 16.2.B.)

1. Innovative Learning for Europe (ToxLearn4EU, Erasmus+)

PROFESSIONAL SERVICES

The professional services which the Mutagenesis Unit offers on the market include the following analyses: chromosomal aberration analysis, micronucleus assay, sister chromatid exchange (SCE) analysis, comet assay and cell viability assay. We perform these services through cooperation with occupational medicine specialists, polyclinics that carry out health examinations of employees of various professions professionally exposed to physical mutagens (ionising and non-ionising radiation) and/or chemical mutagens (cytotoxic drugs and other genotoxic agents), and others institutions that need assistance from the Unit's field of expertise.

As part of professional activities in 2023, in collaboration with the Public Health Institute of Brod-Posavina County (Department of Health Ecology), biomonitoring was conducted on 32 subjects using the comet and micronucleus test methods. One expert report regarding the activities performed was published (334).

Additionally, within the scope of professional tasks, an analysis was performed on a billed portion (60) out of the agreed total of 100 received frozen blood samples from the University of Navarra, Spain, using the alkaline and modified alkaline Fpg comet test methods. The remaining samples will be analysed, billed, and results delivered in the year 2024.

PROFESSIONAL ACTIVITIES OF EMPLOYEES

G. Gajski

Head of the International Comet Assay Working Group (ICAWG) within the European Environmental Mutagenesis & Genomics Society (EEMGS); Member of the Supervisory Board of the Croatian Society for Cancer Research (HDIR); Member of the Editorial Board of the Medicine® journal (Wolters Kluwer Health, Inc.); Member of the Working Group for "Biotechnology" of the Committee for Applied Genomics of the Croatian Academy of Sciences and Arts (HAZU); Member of working groups [Working Group on Communications (WGC), Working Group on Sustainability (WGS)] of the International Society of Radiation Epidemiology and Dosimetry (ISoRED); Member of the Scientific Committee of the 51st EEMGS Congress, Malaga, 2023; Member of the Scientific Committee of the Air Protection Congress 2023, Mlini, 2023; Member of the Scientific Committee of the 13th Symposium of the Croatian Radiation Protection Society. Poreč, 2023; Member of the Scientific and Organizing Committee of the 1st Summer School Toxlearn4EU, Zagreb, 2023.

M. Gerić

Head of the New Investigators group within the European Environmental Mutagenesis and Genomic Society (EEMGS) until Mar 2023; Member of the New Investigators group within the European Environmental Mutagenesis and Genomic Society (EEMGS) since Apr 2023; Member of the working group (Awards) of the International Society of Radiation Epidemiology and Dosimetry (ISoRED); Member of the council of the International Association of Environmental Mutagenesis and Genomics Societies (IAEMGS); Member of the Supervisory Board of the Croatian Radiation Protection Society (HDZZ); Member of the Scientific Committee of the 51st EEMGS Congress, Malaga, 2023; Member of the Organizing Committee of the Air Protection Congress 2023, Mlini, 2023; Member of the Scientific Committee of the 3rd GenuBiH Congress, Sarajevo, 2023; Member of the Scientific and Organizing Committee of the 1st Summer School Toxlearn4EU, Zagreb, 2023; Member of the Organizing Committee of the 13th Symposium of the Croatian Radiation Protection Society. Poreč, 2023; Guest Editor of Mutagenesis Special Issue: *EEMGS New Investigators–Rising stars in environmental mutagenesis* 2023.

N. Kopjar

Member of the Presidency of the Croatian Society of Toxicology; Member of the Governing Council of the Institute of Anthropology; Member of the Scientific Committee of the 13th Symposium of the Croatian Society for Radiation Protection, Poreč, 2023.

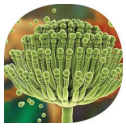
M. Milić

Member and member of the presidency of the Croatian Toxicological Society (CTS); Member of

the Croatian Genetic Society; Member of the Croatian Radiation Protection Society; Member of the Scientific and Organizing Committee of the 1st Summer School Toxlearn4EU, Zagreb, 2023; Editorial Board Member of Toxics Journal; Guest Editor: Special Issue "Biological Risk Monitoring of Exposure to Chemical Pollutants and/or Physical Agents I" in the journal Toxics; Guest Editor: Special Issue "Biological Risk Monitoring of Exposure to Chemical Pollutants and/or Physical Agents II" in the journal Toxics; Section Board Member of Toxics Journal; Advisory Board member of Heliyon Journal on Biological Toxicity; Member of the editorial board of the journal Mutation Research - Genetic Toxicology and Environmental Mutagenesis; Co-editor in the journal Frontiers in Public Health, section Radiation and Health, linked to the Research Topic: Research on Low Dose Ionizing Radiation Health Effects; Associate Editor for Radiation and Health in the Journal Frontiers in Public Health; Review Editor for Environmental Health and Exposome in the Journal Frontiers in Public Health.

D. Želježić

Member of the editorial board of the scientific journal BioMed Research International; Member of the editorial board of the scientific journal Toxics; Member of the Committee for the Socio-Economic Analysis of the toxic chemicals as of Jun 2023 and an expert for the methods of the toxicity testing in the Member State Committee of European Chemicals Agency (ECHA); Expert for toxicological and clinical trials of the Novel Foods & Nutrient Sources, genotoxicity assessment expert of the Working Group for Toxicology of the European Food Safety Authority (EFSA).



15.8. Toxicology Unit

EMPLOYEES OF THE UNIT

HEAD

Assist Prof Irena Brčić Karačonji, PhD, ERT, scientific advisor, Deputy Director (Head of Division of Toxicology as of 11 Oct 2023)

RESEARCHERS

Prof Ana Lucić Vrdoljak, PhD, permanent scientific advisor (Director)
Ivana Novak Jovanović, PhD, scientific advisor
Anja Katić, PhD, senior scientific associate as of 16 Mar 2023
Dubravka Rašić, PhD, senior scientific associate
Blanka Tariba Lovaković, PhD, senior scientific associate
Suzana Žunec, PhD, senior scientific associate
Andreja Jurič, PhD, scientific associate as of 7 Nov 2023

TECHNICAL STAFF

Jasna Mileković, senior technician
Lea Stančin, technician

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

Long-term research activities

In collaboration with the Faculty of Chemistry of the University of Belgrade, the effect of drying on the sugar and vitamin C content in germs and microgreens was determined (282).

The application of 3D-printing in the production of functional products based on the strawberry tree fruits (*Arbutus unedo* L.) and optimization of extraction conditions of phenolic compounds from strawberry tree fruits using green extraction techniques were investigated in collaboration with the Faculty of Food Technology and Biotechnology of the University of Zagreb (6, 103, 179, 180, 181, 300, 301).

In cooperation with the Faculty of Medicine of the University of Rijeka, we investigated the effect of fir (Abies alba Mill.) honeydew honey on the growth of *Campylobacter jejuni* (73).

In collaboration with the Faculty of Chemistry and Chemical Engineering of the University of Maribor, the concentrations of 27 amino acids in the protein hydrolysate of poultry feathers were measured (86). This study aimed to evaluate the efficiency of the isolation procedure of high molecular weight keratin from poultry feathers considering the wide possibilities of using keratin for various biomedical applications.

In collaboration with the School of Medicine, University of Zagreb, the effects of different doses of simvastatin and fenofibrate on malondialdehyde (MDA) and reduced glutathione (GSH) in the plasma, liver, and brain of male normolipidemic (Wistar) and hyperlipidemic (Zucker) rats were investigated (96).

In-house scientific projects (Chapter 16.1.A.3.)

Investigation of toxic effects of new psychoactive substances by biochemical and molecular-biological methods

The effects of exposure to clinically relevant levels of ketamine on the occurrence of oxidative and DNA

damage were examined on human neuroblastoma (SH-SY5Y) and hepatocellular carcinoma (HepG2) cell lines (43).

At an international meeting, a lecture on the contamination of hemp and hemp products with mycotoxins was held (230).

Assessment of the effects of prenatal exposure to α-cypermethrin on epigenetic programming and endocrine disruption of reproduction and development in experimental rats

Markers of oxidative stress were measured in the blood, brain, and placentas of female rats exposed to α-cypermethrin during gestation, which encompassed the research part of the master thesis submitted to the Department of Chemistry at the Faculty of Science, University of Zagreb. Epigenetic, immunohistochemical, and histopathological analyses were continued on the Wistar rat offspring prenatally exposed to α-cypermethrin (210, 254, 285).

Bioactive potential, metal and nicotine content in edible boletes regarding the toxic metal burden of soil

We developed and validated the method for quantification of mass concentration of nicotine in edible dried boletes using solid phase microextraction (HS-SPME) followed by gas chromatography-mass spectrometry (GC-MS) (42). The origin of nicotine in samples of fresh and dried boletes was investigated (207).

Other research activities

We published results on the cyto-/genoprotective properties of strawberry tree (*Arbutus unedo* L.) honey on effects induced by cytostatic drug irinotecan in human peripheral blood lymphocytes in vitro (41).

The impact of smoking as a source of exposure to lead and cadmium on the activities of antioxidant enzymes (SOD, GPx) and sex steroid hormones was evaluated in a research including healthy parturients in samples taken right after full-term delivery. The mothers' smoking status was established by measuring the level of cotinine, the primary metabolite of nicotine, in their urine using GC-MS (71, 155, 239, 253).

We continued the investigation of the sub chronic toxicity of low doses of tembotrione by determining the concentration of essential elements and antioxidant status in testis and epididymis of male Wistar rats after oral exposure (310).

The concentrations of seven phthalate esters in commercially available carbonated and non-carbonated natural mineral water were measured (208, 235). The migration of phthalate esters from plastic packaging into drinking water was evaluated under normal storage conditions and in case of product exposure to elevated temperatures and direct sunlight up to 30 days.

In corroboration with the Molecular Toxicology Unit, results of ochratoxin A and citrinin accumulation and effects on organic anion, cation and other physiological important transporters in kidneys of adult Wistar rats were published (303).

At the mini-symposium "Indoor Pollutants", the concentrations of 18 trace elements measured in dust samples from family houses/apartments, kindergartens, and cars from the city of Zagreb were presented (170). Based on dust analysis data, possible internal sources of elements and health risks associated with their intake were assessed in preschool children. Also, the results of the analysis of 7 congeners of polybrominated diphenyl ethers (PBDEs) in dust samples from the city of Zagreb and human milk were presented, and it was determined that the estimated daily intake of PBDEs did not represent a health risk for infants and mothers (153). The results of this project will be presented to the general population through the Erasmus+ project "Meet the toxicity – live safely" (167).

Working in collaboration with the Unit for Mutagenesis (HUMNap project, IP-2020-02-1192), the relationship between air pollution, exposure biomarkers, and early biological effects was examined by determining the levels of benzene, toluene, ethylbenzene, and isomers of xylene in the blood and urine of participants from urban, rural, and industrial areas (209, 217, 252, 279, 295).

As part of a graduate thesis, the cytotoxic effect and genome stability of a newly created lipophilic eutectic solvent were tested on the human astrocytoma cell line 1321N1 in order to determine its

biocompatibility by measuring primary DNA damage (283).

The residues of organophosphate and pyrethroid pesticides in various food samples were measured as part of the PyrOPECh project, IP-2019-04-7193, in order to evaluate the exposure to pesticides in the diet of Croatian adolescents in the Zagreb region (163).

As part of a PhD thesis, we investigated the phenolic content and cytotoxic and pro- and antioxidative effects of the propolis ethanol extract *in vitro* (204).

At the symposium "Cell-Based Research in Toxicology and Drug Design", a lecture was held on plans for new prospective tests based on determining the metabolic stability and biotransformation of new chemical entities with special emphasis on compounds designed to act on cholinesterases (175).

In cooperation with the University North, a study was conducted on a syngeneic colon tumour model in mice in order to test the effectiveness and safety of simultaneous treatment with the cytostatic irinotecan and the cannabinoid tetrahydrocannabinol (THC) (101) .

We published results on the electrochemical characterisation and antioxidant activity against superoxide radical anion of synthetic amino/amidino-substituted phenylbenzothiazoles (65).

RESEARCH PROJECT FUNDED BY EXTERNAL SOURCES

National research projects (Chapter 16.1.)

1. Development of Bioactive Molecules for Neurodegenerative Diseases Treatment (BioMol4ND, HrZZ-IP)
2. Exposure to Pyrethroid and Organophosphate Insecticides in Children–Risk Assessment for Adverse Effects on Neuropsychological Development and Hormonal Status (PyrOPECh, HrZZ-IP)
3. Development, validation and application of analytical methods for PBDE determination (DeValApp, HrZZ-UIP)
4. Endocrine-disruptive effects of a pyrethroid insecticide on steroidogenesis (HAZU)
5. Biological monitoring of volatile aromatic hydrocarbons influence (BTEX) on the population health of Primorje-Gorski Kotar County (UNIRI)

International research projects (Chapter 16.2.A.)

1. Development of functional beverage in sustainable packaging (JamINNO+, EFRR)
2. European Partnership for Radiation Protection Research (PIANOFORTE, Euroatom)

Educational projects and science popularization (Chapter 16.2.B.)

1. Rivers of knowledge (ESF)
2. About science through sport (STEMsport, ESF)
3. Meet the Toxicity–Live Safely (MeeTox, Erasmus+)

PROFESSIONAL SERVICES

Drugs of abuse from the amphetamine and opiate groups, methadone, and cocaine were determined in four hair samples (seven analyses in total). A total of 32 queries were received regarding the analysis of drugs of abuse via the e-mail address infodroge@imi.hr.

Participation in intercomparison programmes

ORGANISER	TEST	AREA	DATE
Society of Hair Testing, Strasbourg, France	Proficiency Test 2023	Analysis of drugs of abuse in hair	6/2023 and 12/2023 (two times per year, on three hair samples)

PROFESSIONAL ACTIVITIES OF EMPLOYEES

I. Brčić Karačonji

Member of the Presidency of the Croatian Society of Toxicology; Member of the Working Group

on the Early Warning System on New Psychoactive Substances in the Republic of Croatia at the Croatian Institute for Public Health; Member of the Strategic Board for Research Infrastructure at the Ministry of Science and Education of the Republic of Croatia; Croatian delegate of the European Research Infrastructure Consortium (ERIC) Committee; Associate Editor of the journal Archives of Industrial Hygiene and Toxicology; Academic Editor of the journal Food Safety and Health; Member of the Editorial Board of the journal Microbiology.

A. Jurič

Member of the Working Group on the Early Warning System on New Psychoactive Substances in the Republic of Croatia at the Croatian Institute for Public Health; Member of Executive Editorial Board of journal Archives of Industrial Hygiene and Toxicology.

A. Lucić Vrdoljak

Member of the Working Group in charge of monitoring the activity plan for the National Network for Permanent Air Quality Monitoring of the Meteorological and Hydrological Service at the Ministry of Economy and Sustainable Development of the Republic of Croatia.

D. Rašić

Member of the Presidency of the Croatian Society of Toxicology; Secretary of CST (until 13 Nov 2023); President of CST (as of 14 Nov 2023); Member of Organizing and Scientific Committee of international conference "2nd International conference 'Food & Climate Change'".

S. Žunec

Member of the Court of Honour of CST and the Committee for Public Relations of HDBMB.

15.9. Radiation Protection Unit

EMPLOYEES OF THE UNIT

HEAD
Assoc Prof Branko Petrinec, PhD, senior scientific associate (Head of Division of Radiation Protection as of 11 Oct 2023)

RESEARCHERS
Dinko Babić, PhD, permanent scientific advisor
Tomislav Bituh, PhD, senior scientific associate
Davor Rašeta, PhD, postdoctoral researcher until 22 Jul 2023
Iva Franulović, MSc, senior professional associate in science
Milica Kovačić, MSc, senior professional associate in science
Tea Čvorišćec, MSc, professional associate in science
Dragutin Hasenay, mag. chem, professional associate in science as of 3 May 2023
Petra Tagliaretti, mag. chem, professional associate in science as of 1 March 2023

TECHNICAL STAFF
Mak Avdić, MSc, senior technician
Jasminka Senčar, senior technician until 26 May 2023
Ljerka Petroci, technician

RESEARCH

The Radiation Protection Unit continuously studies radioactive contamination of the environment by natural and fission radionuclides.

Research with regard to metals and radionuclides in brown bears continued (80), as did that on the radiological impact of bioash on sunflower yield (67). Furthermore, we analysed the existing models for radiological impact assessments of NORM (27, 28, 29).

Radiochemical and measurement methods for monitoring radioactivity in various media are being developed. Through monitoring, new knowledge in the field of radiation science and radiation protection, as well as in metrology and sampling, procedures, were standardized and methods coordinated through the implementation of quality assurance procedures. Appropriate radiation protection measures are developed in the event of a nuclear/radiological accident, with an emphasis on the role of mobile radiological measurement laboratories in order to achieve better and faster responses in such situations by collecting data timely.

Special attention was paid to quality control. Accreditation in accordance with the international General Requirements for the Competence of Testing and Calibration Laboratories (HRN EN ISO/IEC 17025 standard) has become a widely accepted method of quality management and objective evidence of the technical competence, knowledge, and skills of testing and calibration laboratories.

PROFESSIONAL SERVICES

Radioactivity Monitoring in the Republic of Croatia, IMI-CRZ-103
Civil protection directorate of the Republic of Croatia Ministry of the Interior,
B. Petrinec
Radioactivity Monitoring in the Republic of Croatia – Measurements of the ambient dose equivalent, IMI-CRZ-104
Civil protection directorate of the Republic of Croatia Ministry of the Interior,

B. Petrinec
Results of Monitoring of Environmental Radioactivity in Vicinity of Plomin Coal-Fired Power Plant, IMI-P-514
HEP proizvodnja, Thermal power plant Plomin I, Plomin
B. Petrinec
Results of Radioactivity Measurements at Gas FIeld Molve, IMI-P-516
Koprivnica-Križevci County, Koprivnica
B. Petrinec
Results of measurement of radioactivity in Nature park Medvednica, IMI-P-518
Nature park Medvednica, Zagreb

RESEARCH PROJECTS FUNDED BY EXTERNAL SOURCES

International research projects (Chapter 16.2. B.)

1. Improving Environmental Monitoring and Assessment for Radiation Protection in the Region (IAEA)

List of international intercomparisons

ORGANISER	TEST	AREA	DATE
IAEA	IAEA-TERC-2023-2	Determination of radioactiv-ity in waterand swipe sam-ples	5/2023 – 11 /2023
IAEA	IAEA-RML-2023-1	Determination of radioactiv-ity in sea water	9/2023 on-going
BfS	BfS Radon exposure	Determination of activity concentration of ^{222}Rn in air	3/2023 – 5 /2023.
IMI	IMROH-INT-2023	Determination of activity concentration of ^{222}Rn in air	4/2023 – 7/2023.

List of accredited methods

TEST METHOD	TYPE OF TEST, RANGE
RU-602-5.4-1 (In-house method)	Determination of radionuclides by high-resolution gamma-ray spectrometry in energy range 40–2000 keV
RU-602-5.4-4 (In-house method)	Determination of Sr^{90} activity concentration
RU-602-5.4-5 (In-house method)	Determination of Ra^{226} activity concentration

The Unit's quality manager: *Tomislav Bituh (until 11 Oct 2023); Iva Franulović (as of 12 Oct 2023)*

PROFESSIONAL ACTIVITIES OF EMPLOYEES

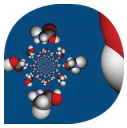
T. Bituh
Partner (Deputy Representative of the Republic of Croatia) on the IAEA project RER7014 Improving environmental monitoring and assessment for radiation protection in the region; member of the Management Board of the Croatian Radiation Protection Association; member of the Editorial Board of the Journal Archives of Industrial Hygiene and Toxicology.
D. Babić
Member of the Radon action plan 2019–2024 committee (Ministry of the Interior of the Republic of Croatia, The Civil Protection Directorate, Zagreb).
I. Franulović
Member of the Management Board and treasurer of the Croatian Radiation Protection Association.
B. Petrinec
Member of the Education, Science and Culture Committee of the Croatian Parliament; Vice-president and member of the Management Board of the Croatian Radiation Protection Association; member

of the TO-45 (Nuclear instrumentation) of the Croatian Standards Institute; member of the Editorial Board of the journal *Vatrogastvo i upravljanje požarima*; quality manager of the Firefighters Community of the Town of Ivanić-Grad; Senior firefighting officer 1st class; firefighter with special authorizations and responsibilities; member of the Croatian Nuclear Society; member of the Editorial Board of the Journal Archives of Industrial Hygiene and Toxicology; Deputy Member of the working group Smart Croatia, member of the University Council of the University of Zagreb.

D. Rašeta

Member of the Croatian Nuclear Society; member of the IAEA Nuclear Safety Standards Committee IAEA NUSSC.

15.10. Independent researchers



15.10.2. Jasmina Sabolović, PhD
scientific advisor

RESEARCHER

Jelena Pejić, MSc, PhD student-assistant (HrZZ)

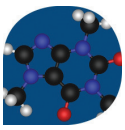
RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

Scientific collaborations

During 2023, the quantum-chemical studies of neutral bis(amino acidato)copper(II) [$Cu(AA)_2$] coordination compounds, which are the physiological species of copper(II) amino acid compounds in blood plasma, continued in collaboration with Prof Michael Ramek from the Graz University of Technology, Austria (111, 266)). In general, experimental studies of these low-molecular-weight compounds do not provide reliable results regarding their complete structures in solutions, while the structural properties can be reliably predicted by molecular modelling methods. A decade-long investigation of the structural properties of the physiological parent $Cu(AA)_2$, where AA stands for L-histidine (His), L-threonine, L-asparagine, L-cysteine, and L-glutamine (Gln), and ternary Cu(His)(AA) compounds, completed with the study on the prediction of structural properties of $Cu(Gln)_2$ and Cu(His)(Gln) in aqueous solution (111). Neutral Cu(His)(Gln) has been established as the most abundant ternary copper(II) amino acid compound of the exchangeable copper(II) pool in blood plasma. To determine the geometries of $Cu(Gln)_2$ and Cu(His)(Gln) that coexist in solutions, the energy landscapes for the conformers in different coordination modes, and a structure–magnetic parameters relation were predicted by the density functional theory (DFT) calculations (111, 266). We assumed a glycine-like coordination of Gln (other coordination patterns were dismissed because of steric reasons), and three His in-plane copper(II) binding modes. The conformational analyses were performed in the gas phase and implicitly modelled aqueous solution to get an insight into the influence of water medium on the geometries and relative energies The reliability of the DFT relative electronic and Gibbs free energies of the aqueous Cu(His)(Gln) conformers was confirmed by benchmarking against the corresponding energies obtained by the domain-based local pair natural orbital coupled-cluster method with singles, doubles, and perturbative triples [DLPNO-CCSD(T)]. Several cis- and trans-Cu(His)(Gln) conformers with His in the histaminate-like and glycine-like modes had low Gibbs free energies, and the greatest estimated metal-binding affinities. The magnetic parameters were predicted by applying several different combinations of the density functionals and basis sets. The DFT-calculated magnetic parameters of the low-energy conformers best reproduced the experimental electron paramagnetic resonance parameters measured in aqueous solutions for *trans*- and *cis*- $Cu(Gln)_2$ conformers with two oxygen atoms (either from Gln or water molecules) at the apical positions (111, 266) and Cu(His)(Gln) conformers with His in the histaminate-like mode with an apically placed carboxylato oxygen atom (111). The comparison of the ability for forming apical Cu–donor bonds, and intra- and inter-ligand hydrogen bonds in the studied physiological compounds yielded the prediction that a degree of conformational flexibility of Cu(His)(AA) may be connected with their physiological abundance, and the role in copper(II) exchange reactions in blood plasma (111).

Doctoral student J. Pejić, employed on the Project for career development of young researchers – training of new doctors of science, DOK-2015-10-4185 (funded by the Croatian Science Foundation) was on maternity leave for the whole of 2023 with her work on the dissertation put on hold.



15.10.3. Ante Miličević, PhD
permanent scientific advisor

RESEARCH

RESEARCH ACTIVITIES WITH INSTITUTIONAL FINANCING

In 2023, another paper related to the internal project "Investigation of electrochemical properties and antioxidant activity of polyphenolic compounds and their complexes with essential elements" which ended in 2021, was published (62). In this paper, I tested our previously developed models for the estimation of oxidation potentials based on spin populations and differences in atomic charges on a set of 35 flavonoids. The electrochemical oxidation potentials of six additional flavonoids (5,6,7-trihydroxyflavone, 3,3',4',7-tetrahydroxyflavone, 3,7-dihydroxyflavone, 4',7-dihydroxyflavone, 4',5,7-trihydroxyisoflavone, and 6-hydroxyflavone) were also measured in our laboratory and added to the previously published set of 29 flavonoids. The model based on the average values of atomic charge differences, derived from three possible mechanisms of flavonoid oxidation: "single electron transfer-proton transfer" (SET-PT), "sequential proton loss electron transfer" (SPLET), and "hydrogen atom transfer" (HAT), was once again shown significantly better than models based on charge differences calculated from each mechanism separately. The result confirmed the conclusion that all three mechanisms are equally important, indicating that the electrochemical oxidation of flavonoids occurs through all three mechanisms simultaneously.

16. PROJECTS

16.1. NATIONAL PROJECTS

16.1.A. RESEARCH PROJECTS LED BY IMROH RESEARCHERS

16.1.A.1. Croatian Science Foundation projects

Research projects (4 projects)

LEADER (IMROH)	PROJECT	DURATION
Zrinka Kovarik	Analyses of interactions between organophosphorus compounds and esterases and other targets for therapy in poisoning (OPEsterOX, IP-2022-10-6685)	2024–2027

IMROH ASSOCIATES: T. Čadež, D. Kolić, N. Maček Hrvat, G. Šinko
OTHER ASSOCIATES: V. Gabelica Marković (University of Zagreb), V. Stepanić (IRB), Z. Radić (University of California at San Diego, La Jolla, USA)

SUMMARY

The aim of this project is to utilize known (e.g. tabun, methamidophos, and fenamiphos) and new compounds (A-agents) to gain a better understanding of the mechanistic basis of cholinesterase family interactions and their limitations and find new effective leads for treatment. The biochemical mechanism of enzyme interactions will be comprehensively studied on a molecular level with *in silico*, *in vitro*, and *ex vivo* methods to define the binding affinities, kinetic constants of inhibition, and efficiency of reactivation of both enzymes. The possible mechanisms of toxicity of selected OPs will be studied at cell-culture level, and on mice exposed to OP. The neuroinflammatory effect of OP as well as neuroprotective effectiveness of oxime therapy will be examined on the mouse brain by monitoring specific markers of astrogliosis, microgliosis and neuron viability. These comprehensive analyses will undoubtedly contribute to knowledge on phosphoroamidate interactions and improved therapeutics in OP poisoning.

LEADER (IMROH)	PROJECT	DURATION
Goran Gajski	Air pollution and human biomarkers of effect (HUMNap, IP-2020-02-1192)	2021–2025

IMROH ASSOCIATES: M. Gerić, M. Milić, V. Kašuba, K. Matković, L. Delić, G. Pehnec, S. Davila, I. Jakovljević, M. Nikolić
OTHER ASSOCIATES: A. Cvitković, A-M. Domijan, I. Guseva Canu, N. Hopf, M. Sanković, A. Šumanovac, P. Wild

SUMMARY

Clean air is crucial to our health and the environment. Rising industrial and energy productions, the burning of fossil fuels and biomass, as well as the rise in road traffic all contribute to air pollution in our cities. Hence, air pollution leads to serious health and environmental problems. Urban air is a complex and variable mixture of many different chemicals whose exact mechanisms of action is not known, although oxidative stress and inflammation are suspected. Human biomonitoring is an essential tool for assessing whether and to what extent environmental substances affect the human population and as such can provide valuable data on environmental exposure and help identify potential health risks. Therefore, HUMNap will determine possible associations between air pollutants and biomarkers of exposure and early biological effect. The project will start with investigations at multiple locations with different air pollution levels and origins followed by measurement of various environmental airborne pollutants. The next step will be a detailed assessment of different biomarkers of exposure and early biological effects (genomic instability and oxidative stress) in human populations living in those locations. HUMNap will promote state-of-art techniques and research approaches to developing risk assessments of human exposure to airborne pollutants. The results from HUMNap will demonstrate how airborne pollutants affect early molecular events important for disease development in different human cells. It will also provide an assessment of cancer risk among human populations affected by polluted urban areas. Moreover, HUMNap aims to draw the attention of many stakeholders such as leading scientists, policy makers, industry, and the public in order to raise awareness regarding air pollution and develop monitoring regimes. Finally, HUMNap will provide new datasets necessary for scientifically based risk assessments of human populations exposed to urban air pollution. The project activities carried out during

2023 resulted in the publication of announcements at scientific meetings (151, 194, 209, 217, 251, 252, 261, 263, 278, 279, 294).

LEADER (IMROH)	PROJECT	DURATION
Veda Marija Varnai	Exposure to pyrethroid and organophosphate insecticides in children–Risk assessment for adverse effects on neuropsychological development and hormonal status (PyrOPECh, IP-2019-04-7193)	2020–2025

IMROH ASSOCIATES: J. Macan, Ž. Babić, A. Bjelajac, J. Bobić, S. Cvijetić Avdagić, A. Jurič, J. Kovačić, M. Macan, M. Piasek, R. Turk, A. Sulimanec, P. Tomac
OTHER ASSOCIATES: M. Jergović, G. Jurak, T. Petričević Vidović, and M. Posavec ("Andrija Štampar" Teaching Institute of Public Health, Zagreb), B. Krnić (Institute for the Public Health of the Zagreb County, Zaprešić), E. A. Delale (Institute for Anthropological Research, Zagreb), I. Bebek (Solvias AG, Kaiseraugst, Switzerland), K. Dumić Kubat and S. Kralik Oguić (University Hospital Centre Zagreb), J. Garvey (Backweston Laboratory Campus, The Pesticide Control Laboratory, Ireland), R. Gjergja Juraški (Srebrnjak Children's Hospital, Zagreb), I. Keser (Faculty of Food Technology and Biotechnology, University of Zagreb), M. Matek Sarić (Department of Health Studies, University of Zadar), B. McNulty (UCD Institute of Food & Health, University College Dublin, Ireland), B. Murray (Department of Agriculture, Food and the Marine, Irish Ministry for Agriculture, Ireland), V. Musil (School of Public Health "Andrija Štampar", Zagreb), A. Nugent (Institute for Global Food Security, Queens University Belfast, UK), S. Sekušak Galešev (Faculty of Education and Rehabilitation Sciences, University of Zagreb)

SUMMARY

The main objective of the project is to assess inadequately explored risks of pyrethroid (PYR) and organophosphate (OP) insecticide exposure to neuropsychological development and hormonal status in prepubertal and pubertal boys in a 2-year cohort study, while controlling for potential confounders, and using only non-invasive methods. In the third project period, the first wave of an epidemiological cohort study was conducted among fifth-grade elementary school students in Zagreb and the surrounding area. The methodology and results of the research were presented at three international meetings via four oral presentations (163, 171, 242, 243). A graduate thesis, based on the results of the project, was prepared and defended (137). The statistical processing of the data and the submission of the manuscripts for publication have begun.

The research is expected to increase the knowledge on possible risks of PYR and OP insecticide exposure for neurodevelopment and hormonal status in pubertal boys; help recognise deficiencies and assess available methodology for evaluation of developmental neurotoxicity and endocrine disruption within the framework of regulatory toxicology; improve insufficient methodology for exposure assessment of non-bioaccumulative pesticides; and contribute to the better characterisation of pesticide exposure in the Croatian population.

LEADER (IMROH)	PROJECT	DURATION
Anita Bosak	Development of bioactive molecules for neurodegenerative diseases treatment (BioMol4ND, IP-2020-02-9343)	2020-2024

IMROH ASSOCIATES: M. Bartolić, Z. Kovarik, A. Matošević, A. Zandona, S. Žunec
OTHER ASSOCIATES: K. Komatović, D. Opsenica and S. Šegan (Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia)

SUMMARY

Research continued according to the work plan of the project. It was shown that 4-aminoquinoline derivatives with an n-octylamino link at C(4) with different substituents on the terminal amino group are very strong inhibitors of both cholinesterases with inhibition constants in the low micro to nanomolar range that could pass the blood-brain barrier by passive transport. They also show a percentage of inhibition of BACE1 activity that is within the assumed therapeutic range and possesses the ability to chelate biometals. Compounds with 3-fluorobenzyl, 3-chlorobenzyl, and 3-methoxy benzyl substituents on the terminal amino group stood out as the most promising for the treat-ment of Alzheimer's disease (55, 185, 267, 268). A group of monocarbamates was synthesized. They show very rapid inhibition of human cholinesterases, some of which proved to be selective towards butyrylcholinesterase, non-toxic towards selected cell lines, and capable of chelating Fe, Cu, and/or Zn ions (218, 219, 296). Compounds from the O-alkyloxime group (176) proved to be a promising structural basis for the design of drugs intended for use in the middle and late stages of Alzheimer's disease. A series of benzoquinones was synthesized as a pilot study in which the possibility of using these compounds as possible multi-target drugs that preferentially act as cholines-terase inhibitors and which have additional activity and chelation of biometals that accumulate in the brain as part of the complex pathophysiology of Alzheimer's disease was tested (224). As part of the project, one doctoral dis-sertation (135) and one graduate thesis (145) were defended.

Members of the project team held seven public lectures for the scientific public: a plenary lecture (268), an invited lecture at an international meeting (147), a lecture at an international meeting (219), a lecture at a domestic meeting, three lectures for the scientific public and one popular scientific lecture.

Installation research projects (2 projects)

LEADER (IMROH)	PROJECT	DURATION
Maja Katalinić	Molecular mechanisms underlying the toxicity of antidotes and potential drugs (CellToxTargets, UIP-2017-05-7260)	2018–2023

IMROH ASSOCIATES: A.-M. Lulić, J. Madunić, N. Maraković, I. Vrhovac Madunić, A. Zandona
OTHER ASSOCIATE: S. Pirkmajer (Institute for Pathophysiology, Ljubljana, Slovenia)

SUMMARY

During the final year of the project, we continued to summarize all the results obtained so far and set guidelines for the continuation of research. During this period, the effects on the cell level of the aldoxime, quinuclidine and nicotinamide series were tested using various assays, and the compounds that showed significant dependence on structure and toxicity were characterized in more detail in order to define the mechanism of action. The research was completed with an *in silico* analysis of the structure-activity relationship, which resulted in guidelines for the design and synthesis of new compounds. Furthermore, testing of the effects of polybrominated diphenyl ethers, ketamine, codeine, morphine, synthetic opioids, and some herbicides continued (43, 69). In the last year of the project, we completed research on the physiological role of the NRE (PNPLA7) enzyme in human cells and assessed the possibility of using it as a new therapeutic measure for poisoning with organophosphorus compounds and published part of the obtained results (53, 63).

The results of the project this year were presented at congresses and symposia through invited lectures, summaries and five published scientific papers. In addition, the final symposium of the project was organized, where the overall results of this project were presented, during which scientists from Croatia, Slovenia, Austria, France, and Portugal presented their research.

LEADER (IMROH)	PROJECT	DURATION
Darija Klinčić	Development, validation and application of analytical methods for PBDE determination (DeValApp, UIP-2017-05-6713)	2018–2023

IMROH ASSOCIATES: M. Dvoršćak, K. Jagić, A. Jurič

SUMMARY

During the final year of the implementation of the project, the main goal of which was the analysis of polybrominated diphenyl ethers (PBDE) in house dust and human milk (105, 274, 280) research on the levels of PBDEs in dust samples collected in school premises was also conducted (281). This completes the data on the exposure of another age group to PBDE compounds in dust from different indoor spaces where they stay during the day. In cooperation with colleagues from the Faculty of Technology from Novi Sad, the presence of PBDE compounds in dust samples from households in northern Serbia was investigated for the first time. Research on PBDE compounds was extended to the analysis of two animal species, one from the aquatic and the other from the terrestrial environment. First are the samples of eels collected in the Raša River, and these samples are interesting for analysis from two aspects; due to their specific life cycle, they are a very good bioindicator of environmental pollution, and are also used in human nutrition (46). Others are brown bear adipose tissue samples for which there is generally very little data in the literature. Research on the effects of PBDEs on human neuroblastoma cell line SH-SY5Y and HEK293 kidney cells was also continued (287).

An overview of the research carried out as part of this project was presented at a short symposium entitled "Indoor Pollutants" (150, 153, 154, 158, 159, 167, 170, 173). The results of the implemented project were presented to the general public through science popularization activities, including the design of an information leaflet.

16.1.A.2. Croatian Academy of Science and Art Foundation (6 projects)

LEADER (IMROH)	PROJECT	DURATION
Katarina Matković	Statistical tools for assessing the impact of air pollution on cytogen-otoxicity in human cells under in vitro conditions	2023–2024

IMROH ASSOCIATES: G. Gajski, M. Gerić, M. Milić, L. Delić, G. Pehnec, J. Rinkovec

SUMMARY

Air pollution is an escalating ecological and public health problem, increasingly associated with numerous respiratory diseases and premature mortality. Air is a complex mixture of various chemical compounds, including suspended particles, toxic metals, and polycyclic aromatic hydrocarbons, the mechanisms of which are not fully understood regarding their impact on human cells. The challenge lies in the complex interactions of these compounds, necessitating the development of advanced statistical models and tools to assess the effects of air pollution on human cells and the stability of their genome. The aim of this project is to establish advanced models for evaluating the effects of air pollution on human cells under *in vitro* conditions. The results of this project will contribute to understanding the mechanisms of harmful effects of air compounds and the development of statistical models for predicting such effects on human cells.

LEADER (IMROH)	PROJECT	DURATION
Josip Madunić	The effect of oximes on the induction of autophagy in human neuroblastoma cells	2023–2024

IMROH ASSOCIATES: M. Katalinić, A.-M. Lulić, I. Vrhovac Madunić, A. Zandona

SUMMARY

The aim of this project is to analyse the effect of newly synthesized oximes, potential antidotes for organophosphorus (OP) compounds, on human cells *in vitro*. Our previous research on various newly synthesized oximes revealed that certain oximes induce cell death as well as damage DNA molecules by forming double-strand breaks. To examine the mechanism of cell death induction, the proposed project would analyse the possibility of the autophagy process as a result of treatment with selected oxime antidotes for OP compounds. Autophagy, a process essential for cellular health and homeostasis, is still understudied in the context of OP poisoning and oxime therapy. Also, the oximes themselves as can pose danger to human health. The described research would clarify the mechanisms of action of oximes at the cellular level. The explanation of these processes would help in a more efficient use of oximes as antidotes for OP compounds. Furthermore, the obtained results could open new perspectives for the research of oximes as inducers or inhibitors of autophagy. On the other hand, work on this research would contribute to the education of not only the project associates, but also the students who would be involved in this project.

LEADER (IMROH)	PROJECT	DURATION
Anja Katić	Endocrine-disruptive effects of a pyrethroid insecticide on steroido-genesis	2023–2024

IMROH ASSOCIATE: I. Brčić Karačonji
OTHER ASSOCIATES: M. Hohšteter and D. Vlahović (Faculty of Veterinary Medicine, University of Zagreb), A. Katušić Bojanac and D. Krsnik (School of Medicine, University of Zagreb)

SUMMARY

The aim of the project is to investigate the effects of prenatal exposure to the pyrethroid α-cypermethrin, as a potential endocrine disruptor, on steroidogenesis in laboratory rat offspring at the onset of puberty. For this purpose, hormone levels in the serum and protein expression of steroidogenic enzymes in the reproductive organs of offspring at the beginning of puberty will be determined. In addition, the endocrine disruption parameters of development and reproduction of the offspring until puberty will be monitored, and histopathological changes in the reproductive organs of the offspring at the beginning of puberty will be determined.

LEADER (IMROH)	PROJECT	DURATION
Antonio Zandona	Establishment of a cellular model of the blood-brain barrier for *in vitro* assessment of the passage of potential drugs into the brain	2022–2023

IMROH ASSOCIATES: M. Katalinić, A.-M. Lulić
OTHER ASSOCIATE: M. Cavaco, V. Neves (Institute of Molecular Medicine, Lisbon, Portugal)

SUMMARY

The aim of this project was to assess whether the *in vitro* blood-brain barrier model based on HBEC-5i cells can be used to evaluate the passage of potential drugs as cholinesterase inhibitors to their target site of action. During the project, several compounds were tested as potential drugs and the results obtained indicated the positive and negative sides of this model, i.e. the sensitivity of cells to the toxic effects of certain compounds, which determines the maximum concentration that can be tested. The results contributed to the general understanding and established a prerequisite for the use of this *in vitro* model in evaluation of the possibility of the passage of new compounds through the blood-brain barrier, which implies a possible reduction of the necessary *in vivo* tests.

LEADER (IMROH)	PROJECT	DURATION
Karla Jagić	Polybrominated diphenyl ethers in the dust of public spaces – do they pose a risk to human health?	2022–2023

IMROH ASSOCIATES: M. Dvoršćak, D. Klinčić

SUMMARY

Selected congeners of polybrominated diphenyl ethers (PBDEs) in dust from different indoor places where people spend part of their time, apart from their household, were determined. Medians of the sum of PBDEs (∑PBDE) were similar for samples from kindergartens, workplaces and cars, while in the case of schools the median ∑PBDE was lower. The levels of PBDEs in dust from public places, e.g. churches, theatres, bookstores, were similar to the median ∑PBDE for workplaces. The estimated daily intake of PBDE compounds was the highest for children of kindergarten age, which was expected considering that they are exposed to a significantly higher intake of PBDEs compared to school children (281) due to their frequent bringing of hands and various objects to the mouth, and contact with floors, while adults were the least exposed group (150). The detected levels of PBDEs did not represent a health risk for the investigated population groups.

LEADER (IMROH)	PROJECT	DURATION
Ana Matošević	Synthesis and biological evaluation of carbamates as potential cholinesterase inhibitors in the treatment of Alzheimer's disease	2022–2023

IMROH ASSOCIATES: M. Bartolić, A. Bosak

SUMMARY

The goal of this project was the synthesis of carbamates with satisfactory kinetic and toxicological properties that would have the potential for further evaluation as drugs in the treatment of Alzheimer's disease. As part of this project, eight carbamates were successfully synthesized and their inhibitory potential against human cholinesterases and the rate of spontaneous decarbamylation of cholinesterases were tested. For all newly synthesized compounds, the cytotoxic effect on neural, liver and kidney cells was determined, and the ability to pass through the blood-brain barrier by passive transport was assessed *in silico*. The results of this research enabled setting guidelines for structural modifications in the synthesis of new series of carbamates with the aim of finding more effective cholinesterase inhibitors in the treatment of Alzheimer's disease.

16.1.A.3. In-house research projects (11 projects)

LEADER (IMROH)	PROJECT	DURATION
Marija Kujundžić	**Effects of recreational headphone noise on hearing in young adults (RecNoise)**	**2022–2024**
IMROH ASSOCIATES: S. Cvijetić Avdagić, J. Macan, Z. Franić, S. Bošković, J. Mandić, J. Mandić **OTHER ASSOCIATES:** S. Fajt (Faculty of Electrical Engineering and Computing, University of Zagreb), D. Šušković (Microton LtD)		
Adrijana Bjelajac	**Sleep quality in different age groups in Croatia before and during COVID-19 pandemic (CoV-Sleep)**	**2021–2023**
IMROH ASSOCIATES: J. Macan, S. Cvijetić Avdagić, P. Tomac, J. Mandić, B. Ross **OTHER ASSOCIATES:** E. A. Delale (Institute for Anthropological Research), D. Lučanin (University of Applied Health Sciences)		
Irena Brčić Karačonji	**Investigation of toxic effects of new psychoactive substances by biochemical and molecular-biological methods**	**2020–2024**
IMROH ASSOCIATES: N. Brajenović, A. Jurič, M. Katalinić, N. Kopjar, A. Lucić Vrdoljak, J. Madunić, K. Nekić, M. Nikolić, A. Pizent, D. Rašić, L. Stančin, B. Tariba Lovaković, V. Triva, A. Zandona **OTHER ASSOCIATES:** I. Canjuga, G. Kozina, M. Neuberg (University North, Koprivnica), N. Benco, I. Hižar, J. Leniček Krleža, J. Obuljen, A. Rešić, M. Zrilić (Children's Hospital Zagreb), M. R. Meyer (Saarland University, Homburg, Saar, Germany)		
Ranka Godec	**Organic content of PM_1 particle fraction**	**2018–2024**
IMROH ASSOCIATES: G. Pehnec, I. Bešlić, I. Jakovljević, Z. Sever Štrukil, I. Šimić, S. Sopčić		
Snježana Herceg Romanić	**Analysis of organic pollutants in biological systems and the environment**	**2021–2024**
IMROH ASSOCIATES: G. Mendaš Starčević, S. Fingler Nuskern, S. Stipičević, D. Klinčić, M. Dvoršćak, N. Medved, G. Pehnec, I. Jakovljević, I. Smoljo **OTHER ASSOCIATES:** M. Matek Sarić (University of Zadar Department of Health Studies), G. Jakšić (AQUATIKA, Karlovac), G. Jovanović and T. Milićević (Institute of Physics Belgrade, Serbia), A. Popović (University of Belgrade Faculty of Chemistry, Serbia), D. Stanković (Vinča Institute of Nuclear Sciences, Serbia)		
Anja Katić	**Assessment of the effects of prenatal exposure to α-cypermethrin on epigenetic programming and endocrine disruption of reproduction and development in experimental rats**	**2020–2023**
IMROH ASSOCIATES: A. Lucić Vrdoljak, V. Micek, A. Sulimanec, S. Žunec **OTHER ASSOCIATES:** M. Himelreich Perić, A. Katušić Bojanac, D. Krsnik (School of Medicine, Zagreb), I. Canjuga, G. Kozina, M. Neuberg, R. Ribić (University North, Koprivnica)		
Maja Lazarus	**Bioactive potential, metal and nicotine content in edible boletes regarding the toxic metal burden of soil**	**2021–2023**
IMROH ASSOCIATES: I. Brčić Karačonji, A. Jurič, S. Mataušić, B. Petrinec, D. Rašeta, A. Sekovanić, J. Senčar, S. Stipičević **OTHER ASSOCIATES:** D. Šamec (University North, Koprivnica), I. Širić and N. Šprem (Faculty of Agriculture, University of Zagreb)		
Branko Petrinec	**Development and implementation of hybrid gamma-ray spectrometry methods for enhancing the capacity of environmental radiological monitoring around nuclear power plants - RAINSTORM**	**2022–2025**
IMROH ASSOCIATES: L. Pavelić, J. Šiško, M. Jurdana, D. Babić, D. Rašeta, I. Pavičić, T. Meštrović		
Ivica Prlić	**Development of UV radiation sensors**	**2015–2024**
IMROH ASSOCIATES: J. Macan, L. Pavelić, J. Šiško, M. Jurdana **OTHER ASSOCIATES**: M. Hajdinjak (Haj-kom d. o. o.), Z. Cerovac (ALARA d. o. o.), KBC Zagreb		
Ivica Prlić	**Thermometry, thermography and sensory evaluation of electromagnetic radiation in medicine (TTSem3)**	**2014– 2024**
IMROH ASSOCIATES: L. Pavelić , I. Bešlić, J. Šiško, S. Kobešćak, M. Jurdana, M. Dragičević **OTHER ASSOCIATES:** : KBC Zagreb, Zagreb Children's Hospital (A. Antabak), Plastic Surgery Clinic (K. Bulić), OB Karlovac, M. Hajdinjak (Haj- kom d. o. o.), Z. Cerovac (ALARA d. o. o.)		
Suzana Sopčić	**Molecular markers of organic carbon – biomass burning indica-tors**	**2021–2023**
IMROH ASSOCIATE: G. Pehnec, I. Jakovljević, R. Godec		

16.1.B. COLLABORATION ON RESEARCH PROJECTS OUTSIDE THE INSTITUTE

16.1.B.1. Croatian Science Foundation
Research projects (7 projects)

LEADER	PROJECT	DURATION
Ivana Miletić, Faculty of Dentistry, University of Zagreb	**Structure and bonding surface modification on the materials and hard dental tissue (MODIBIODENT)**	**2023–2027**

IMROH ASSOCIATES: D. Želježić

SUMMARY

Contemporary approaches to disease therapy are increasingly based on the use of materials that try to restore the damaged tooth structure or stimulate the tissue response to healing. An ideal material that would fully meet all re-quirements has not yet been found, as an attempt is made to find a balance between optimal mechanical properties, while the material acts preventively and therapeutically, taking into account the complex and changing oral microen-vironment. Therefore, the goal of this project is to examine new experimental and commercially available bioactive materials in interaction with hard dental tissue, and the influence of modification of the bonding surface of hard dental tissues on their behaviour under dynamic conditions. Through our research, we will concentrate on two groups of materials; glass-hybrid and their modifications with bioactive glass and calcium silicate cements. The pro-posed research requires, in addition to extensive knowledge of the clinical sciences of dental medicine, basic labora-tory tests of biocompatibility, which is why the interdisciplinary nature of the team is necessary. The research pro-posed by this project proposal would contribute to a better understanding of the physical properties of these mate-rials and their behaviour in contact with hard dental tissues. This would create guidelines for selecting the most suit-able materials for certain clinical situations.

The results of research conducted in collaboration with the Faculty of Dentistry of the University of Zagreb and the School of Medicine of the University of Split resulted in joint publication (87). We determined that in patients aged 10 to 20 years, who underwent restoration of carious lesions with amalgam fillings, the number of micronuclei, nu-clear buds and binuclear cells in the epithelial cells of the buccal cavity was significantly higher compared to patients of the same age whose lesions were repaired with composite materials. It was concluded that, compared to compo-site fillings, amalgam fillings are more genotoxic and affect cell division.

LEADER	PROJECT	DURATION
I. Šola, Faculty of Science, University of Zagreb	**Indirect effect of global warming on mammals physiological parameters via high temperature-stressed plant diet (TEMPHYS, IP-2020-02-7585)**	**2021–2025**

IMROH ASSOCIATE: M. Lazarus

SUMMARY

The chain interactions between temperature shift, plant biochemical traits, and the physiology of mammals fed with those plants will be assessed employing a targeted specific metabolomics approach for plant analyses, biosafety, and bioactivity tests on mammals, and statistical data analyses and modelling in order to construct a model showing a tentative pattern of the temperature's indirect (through plant diet) effect on mammal physiology. Results showed high temperature (simulation of global warming) changes the nutritive value of broccoli seedlings. Plants' ability to adapt to temperature variation is reflected on the phytochemicals, micro- and macroelements, antioxidant capacity and *in vitro* cytotoxic potential of broccoli extracts tested on five different cell lines (31, 309).

LEADER	PROJECT	DURATION
V. Filipović-Marijić, Ruđer Bošković Institute, Zagreb	**Integrated evaluation of aquatic organism responses to metal exposure: gene expression, bioavailability, toxicity and biomarker responses (BIOTOXMET, IP- 2020-02)**	**2020–2025**

IMROH ASSOCIATE: Z. Kljaković-Gašpić

SUMMARY

All actions scheduled for the second project period (December 28, 2021-June 27, 2023) were carried out as

planned, and all of the planned targets were met, resulting in the project receiving the highest grade possible – A. As a result, an extension of the project was allowed until February 27, 2025. The state of the aquatic environment in the upper reaches of the Krka River, as well as the effects of metal exposure on the content of metals and metallothionein in the intestines and intestinal parasites of brown trout, were assessed in conjunction with the results of other project participants. The study results were presented at an international scientific symposium (297) and in an original paper (59). Within the same collaboration, a publication was prepared and sent to a journal indexed in the WoS database, in which the potential impact and effects of different levels of water pollution on living organisms in the upper reaches of the Krka were investigated using two different toxicity tests. The study aimed to assess the potential and limits of microbiotests for detecting and quantifying environmental pollutants, as well as discovering the interrelationships between ecotoxicological findings and particular chemical parameters.

LEADER	PROJECT	DURATION
T. Smital, Ruđer Bošković Institute, Zagreb	**Understanding the (eco)toxicological role of selected SLC and MATE transport proteins in zebrafish (*Danio rerio*) using functional genomics tools (DANIOTRANS, IP-2019-04-1147)**	**2020–2024**

IMROH ASSOCIATES: D. Karaica

SUMMARY

Following the project's research plan, we continued research activities aimed at determining the phenotype of the oatp1d1, oct1, oat3, and mate7 zebrafish mutants in various tissues and organs using the RT-PCR, Western blot as well as immunohistochemical analyses, and results of these investigations were published in the *WoS*-indexed journal (1). Also, within the frame of project's activity, the graduation thesis by A. Dananić was completed and successfully defended under the co-mentorship of D. Karaica (138).

LEADER	PROJECT	DURATION
G. Šimić, Croatian Institute for Brain Research, Zagreb	**Role of blood-brain barrier, innate immunity, and tau protein oligomerization in the pathogenesis of Alzheimer's disease (ALZ-BBB-STOPINNATETAU, IP-2019-04-3584)**	**2020–2024**

IMROH ASSOCIATE: A. Sekovanić

SUMMARY

We continued to investigate the association of biomarkers of Alzheimer's disease (AD) in cerebrospinal fluid (CSF) and element levels in plasma and CSF of patients with Alzheimer's patients, patients with mild cognitive impairment, and healthy individuals. Simple correlation, as well as machine learning algorithms [redescription mining and principal component analysis (PCA)], showed a positive association between element levels in plasma and CSF and phosphorylated tau isoforms, VILIP-1, S100B, NFL, and YKL-40 in AD patients (2).

LEADER	PROJECT	DURATION
S. Miko, Croatian Geological Institute, Zagreb	**Sediments between source and sink during a Late Quaternary eustatic cycle: the Krka and the mid-Adriatic Deep System (QMAD, IP-04-2019-8505)**	**2019–2023**

IMROH ASSOCIATE: B. Petrinec

SUMMARY

The proposed project aims to improve the knowledge of the thus far poorly explored submerged landscapes of the eastern Adriatic shelf, as well as late Quaternary sediments deposited along the eastern part of the central Adriatic Basin (MAD). The study of the Pleistocene floodplain of the Krka River will provide insight into the stratigraphic sequence of sediments with the development of the delta system and estuaries, which were formed by the interaction of eustatic sea level changes and local factors such as sediment yield and tectonic activity. Continuous marine sedimentation during the late Quaternary and the yield of material from the Krka River Basin will be investigated in the eastern part of the MAD. By applying high-resolution geophysical methods and sedimentological, petrophysical, geochemical, micropaleontological, and aDNA methods on samples from sediment cores, it will for the first time be possible to monitor paleoenvironmental evolution from rivers/lakes to deep-sea environments on a profile shorter than 100 km. Appropriate climatic and environmental indicators will be identified and insight will be gained into the migration and environmental adaptation of hunters and gatherers who lived on the eastern Adriatic coast during the late Palaeolithic, where the Krka River floodplain probably existed. The obtained results on sea level and landscape changes will enable an understanding of the

possible interaction among people from the wider study area during the time of systemic tracts of falling, low and rising sea levels. This will explore the possible role of the Krka River as a land/floodplain "bridge" for human migration. Special attention will be paid to the assessment of the new sedimentation rate, the recognition of the characteristics of submerged landscapes, and the calculation of the rate of accumulation of organic carbon and terrestrial components of sediments, as well as potentially toxic elements.

LEADER	PROJECT	DURATION
S. Frka Milosavljević, Ruđer Bošković Institute, Zagreb	**Biochemical responses of oligotrophic Adriatic surface ecosystems to atmospheric deposition inputs (BiREADI, IP-2018-01-3109)**	**2018–2023**

IMROH ASSOCIATES: I. Bešlić, R. Godec, S. Žužul, I. Šimić, G. Pehnec (advisor)

SUMMARY

The aim of the project was to assess the impact of atmospheric deposition on complex biochemical responses of oligotrophic systems, considering the importance of promotion and inhibition effects on phytoplankton, and the consequent altering of the surface water chemistry, including the sea surface microlayer at the air-water interface. Within the project, the concentrations, sources, and deposition fluxes of atmospheric constituents are evaluated as well as the nature of enrichments of macro-nutrients, trace metals and organic pollutants within the sea surface layers. At the measuring station in the central Adriatic, the content of nitrogen (N) and phosphorus (P) in the total deposited matter, precipitation and particle fraction PM_{10}, as well as the mass concentrations of metals in PM_{10} were determined. By monitoring the content of atmospheric deposition, the impact of local fires on complex biogeochem-ical processes within the microlayer itself and/or climatic processes associated with the surface microlayer was as-sessed (221, 222, 246, 276, 325). In total atmospheric deposition and wet deposition, the content of water-soluble ions (Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}) was measured and their seasonal distribution was examined. Special attention was devoted to the research of the impact of special air pollution episodes (such as Saharan dust intrusions and local fires that are characteristic of the entire coastal area) on the acidity of atmospheric deposition. Using statis-tical tools, the contributions of dominant sources to total air pollution in the central Adriatic area were estimated (30). The final meeting of the project and workshop were held on March 10, 2023. All activities were successfully completed in accordance with the deadlines and all of the planned goals have been achieved.

16.1.B.2. University projects (3 projects)

LEADER	PROJECT	DURATION
A. Bulog, Faculty of Medicine, University of Rijeka, Rijeka	**Biological monitoring of volatile aromatic hydrocarbons influence (BTEX) on the population health of Primorje-Gorski Kotar County (UNIRI)**	**2019–2023**

IMROH ASSOCIATE: I. Brčić Karačonji

SUMMARY

The project includes measurements of volatile aromatic hydrocarbons, benzene, ethylbenzene, toluene and xylene isomers (BTEX) in the urine of the respondents living in industrial area which will be compared with those in the control areas. The data obtained in the urine of the respondent will correlate with the data of concentrations of the same pollutants in the surrounding air as well as with immunological, enzymatic, epidemiological, and respiratory data on the health status of respondents.

LEADER	PROJECT	DURATION
I. Gobin, Faculty of Medicine, University of Rijeka, Rijeka	**Opportunistic premise plumbing pathogens: new challenge for water treatment (UNIRI)**	**2019–2023**

IMROH ASSOCIATE: I. Brčić Karačonji

SUMMARY

The aim of the project is to examine, through an interdisciplinary approach, the conditions that lead to the survival of opportunistic bacteria in water and the formation of biofilm in water supply systems as well as to investigate the antimicrobial potential of natural substances.

LEADER	PROJECT	DURATION
S. Kalanj Bognar, School of Medicine, University of Zagreb, Zagreb	**Gangliosides and the sodium-potassium pump – old doubts, new answers**	**2023–2024**

IMROH ASSOCIATE: N. Maček Hrvat

SUMMARY

The project encompassed research into the effects of gangliosides on the functions of membrane proteins in a model of GD3 synthase-deficient mice whose phenotypic features are the inability to synthesize b- and c-series gangliosides, memory disorders, worsening of neurological deficits, etc. It was assumed that the phenotype is due to the effects of a changed lipid composition of complex membrane systems of nerve cells to the functions of protein pumps responsible for maintaining ion homeostasis. The influence of different concentrations of selected gangliosides on the function of sodium-potassium ATPase was tested in tissue samples of brain tissue of a mouse model, in control tissue samples and in a solution of the purified enzyme, using spectrophotometric, and kinetic methods. The results indicate a significantly lower activity of sodium-potassium ATPase in the brain of mice without GD3-synthase and the establishment of physiological activity of the enzyme by exogenous addition of those gangliosides that are missing in the aforementioned mouse model.

16.1.C. PROFESSIONAL PROJECTS

PROJECT	CONTRACTOR	LEADER
Service provider: Environmental Hygiene Unit		
Monitoring air pollution in the City of Zagreb (from 1963)	City of Zagreb, City Office for Energy, Environmental Protection and Sustainable Development	G. Pehnec
Monitoring of the Total Effects of CPS Molve on the Ecosystem (from1998)	INA-Naftaplin and Institute for Public Health of the Koprivnica-Križevci County	G. Pehnec
Monitoring Air Quality at the CWWTP Construction Site in Zagreb (from 2003)	Zagrebačke otpadne vode	G. Pehnec
Monitoring Air Pollution at National Network Stations for the Purpose of Continued Air Quality Monitoring (from 2015)	Ministry of Economy and Sustainable Development and Meteorological and Hydrological Service of Croatia	G. Pehnec
Drafting Equivalency Studies at Measurement Stations of the National Network for Continued Air Pollution Monitoring (from 2015)	Ministry of Economy and Sustainable Development and Meteorological and Hydrological Service of Croatia	I. Bešlić
Service provider: Radiation Protection Unit		
Radioactivity Monitoring in the Republic of Croatia, IMI-CRZ-103	Civil protection directorate of the Re-public of Croatia Ministry of the Interior	B. Petrinec
Radioactivity Monitoring in the Republic of Croatia – Measurements of ambient dose equivalent, IMI-CRZ-104	Civil protection directorate of the Re-public of Croatia Ministry of the Interior,	B. Petrinec
Results of Monitoring of Environmental Radioac-tivity in Vicinity of Plomin Coal- Fired Power Plant, IMI-P-514	HEP proizvodnja, Thermal power plant Plomin I, Plomin	B. Petrinec
Results of measurement of radioactivity in Na-ture park Medvednica, IMI-P-518	Nature park Medvednica, Zagreb	B. Petrinec
Results of Radioactivity Measurements at Gas Fleld Molve, IMI-P-516	Koprivnica-Križevci County, Koprivnica	B. Petrinec

Service provider: Radiation Dosimetry and Radiobiology Unit		
Determination of the radiological status of the working environment in IPNP (Phase IV)	INA Group	I. Prlić
Determination of the radiological status of pro-duction tubing during maintenance processing (Phase V)	INA Group and STSI	I. Prlić
ELABORATE o meet the test conditions of spe-cial basic requirements related to ionizing and non-ionizing radiation during the preparation of architectural proposals for the construction of new and reconstruction of existing facilities, hospital centers and facilities in the Republic of Croatia	IMROH	I. Prlić
Service provider: Division for Occupational and Environmental Health		
National plan for the development of broad-band approach in Republic of Croatia in the period 2021-2027, measure M3- Informing and education of public about the electromagnetic fields	Ministry of Health, Republic of Croatia Teaching Institute for Public Health Dr. Andrija Štampar	J. Macan (associate from IMROH)

16.2. INTERNATIONAL PROJECTS

16.2.A. SCIENTIFIC RESEARCH PROJECTS

16.2.A.1. EUROPEAN UNION PROGRAMS

EUROPEAN REGIONAL DEVELOPMENT FUND
Operational Program Competitiveness and Cohesion (3 projects)

European Union
European Regional Development Fund

INSTITUTION (Leader)	PROJECT	DURATION
Jamnica plus, Zagreb (S. Lovković)	Development of functional beverage in sustainable packaging (JamINNO+, KK.01.2.1.02.0305)	2020–2023

IMROH ASSOCIATES: J. Jurasović (coordinator), I. Bešlić, N. Brajenović, I. Brčić Karačonji, S. Davila, G. Pehnec, I. Jakovljević, A. Jurič, Z. Kljaković-Gašpić, T. Orct, A. Sekovanić, I. Smoljo, A. Sulimanec, B. Tariba Lovaković, S. Žužul
PARTNERS: Faculty of Pharmacy and Biochemistry University of Zagreb, IMROH and Ruđer Bošković Institute

SUMMARY

In the final year of the project's activities, additional air sampling for microplastic analysis was performed utilizing an automatic and manual air sample collection method. The air samples collected during 2022 and 2023 were analysed using a previously developed method for the analysis of microplastics in floating air particles using chemical imaging with laser direct infrared spectroscopy (LDIR).

Research findings on metal(loid)s, phthalates, and PAHs in water were presented as posters at a national conference with international participation (208, 211, 241), while the preliminary results of active sampling of indoor air directly on gold-coated polycarbonate filters and LDIR analysis of microplastic particles, were presented as a poster at an international conference (247).

Furthermore, results on the levels of metal(loid)ss, phthalates, and PAHs in artesian well water, water treatment tanks, and bottled products immediately after filling were also prepared for publication and submitted to a journal indexed in the WoS database.

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (A. Lucić Vrdoljak)	Research and Educational Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the IMROH (ReC-IMI, KK.01.1.1.02.0007)	2018–2023

IMROH ASSOCIATES: S. Stankić Herman, B. Roić, S. Barbarić, M. Herman

SUMMARY

Funding amounting to 30,871,627.94 EUR was granted for the purposes of this project, during whose implementa-tion the Institute was expanded with a new building of 6,785.15 m^2, while its existing building of 2,067.41 m^2 was renovated and the Institute's capacities were improved with modern research and IT equipment for all of its units.

During 2023, the renovation of the older building was fully completed and returned to its old function. Apart from construction works, the Institute also finished all of the required public procurement procedures for research and IT equipment. By the end of the year, the project was successfully completed and the final report was approved.

INSTITUTION (Leader)	PROJECT	DURATION
Meteorological and Hydrological Service of Croatia (J. Škevin Sović)	Project of extension and modernisation of the national network for continuous air quality monitoring (AIRQ, KK.06.2.1.02.0001.)	2017–2023

IMROH ASSOCIATES: G. Pehnec (coordinator), R. Godec, I. Bešlić, S. Žužul, S. Stankić Herman, B. Roić, S. Barbarić, M. Herman

SUMMARY

The purpose of the project is to improve and optimize the system for managing and monitoring air quality in urban areas, zones, and agglomerations. The project aims to support the implementation of the legislative framework for air quality and environmental protection. The project will receive a grant in the amount of HRK 125.1 million (85% funded by the ERDF OP Competitiveness and Cohesion, 15% by the Environmental Protection and Energy Efficiency Fund). The project will result in: 5 new and 19 modernized measuring stations at full functionality; a developed and functional model for the assessment of ground level concentrations of pollutants; additional equipment for DHMZ and IMROH chemical laboratories for measurements in accordance with the National Programme for measuring the level of air pollution in the national network for continuous air quality monitoring; with additional equipment for a laboratory for calibrating air quality measures and related measurement sizes. In 2019 and 2020 IMROH finished in full all planed procurements and all equipment have been put into operation. Two advanced trainings, planned in the laboratory of an equipment manufacturer abroad in 2020, which were postponed due to the COVID-19 pandemic, were carried out in 2023. The project was fully implemented and successfully completed in September 2023.

EUROPEAN UNION SOLIDARITY FUND (2 projects)

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (M. Herman)	Strengthening and Renovation of the Earthquake-damaged Central Building of the Institute for Medical Research and Occupational Health (FSEU.2021.MZO.038)	2021–2023

IMROH ASSOCIATES: S. Barbarić, A. Lucić Vrdoljak, B. Roić, S. Stankić Herman

SUMMARY

Following the earthquake that took place in Zagreb on 22 Mar 2020, the Croatian Ministry of Science and Education opened a call to fund the strengthening and renovation of the damaged infrastructure. Within this call, the Institute submitted a project to fully strengthen and renovate its central building. The project grant of 13,212,021.60 HRK went toward repairing and strengthening the central building, built in 1947, for the purpose of increasing its resilience against earthquakes. During 2023, all administrative procedures regarding the completion of the project were finalised and the final report was accepted by the relevant authority.

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (M. Herman)	Strengthening and Renovation of the Northern Building of the Institute for Medical Research and Occupational Health (FSEU.2021.MZO.071)	2021–2024

IMROH ASSOCIATES: S. Barbarić, A. Lucić Vrdoljak, B. Roić, S. Stankić Herman

SUMMARY

Following the earthquake that took place in Zagreb on 22 Mar 2020, the Croatian Ministry of Science and Education opened a call to fund the strengthening and renovation of infrastructure damaged by the earthquake. Within this call, the Institute also submitted a project to fully strengthen and renovate its northern building. The project grant of 6,687,750.00 HRK will go toward repairing and strengthening the northern building, built in 1961, for the purpose of increasing its resilience against earthquakes.

The project grant was officially awarded on 5 Nov 2021 and during 2023 construction began on renovating the entire building. Construction works are expected to be completed by summer of 2024.

EUROPEAN RESEARCH AND INNOVATION PROGRAMME
Horizon 2020/Horizon EUROPE/Euroatom (6 projects)

INSTITUTION (Leader)	PROJECT	DURATION
Consorcio centro de investigacion biomedica en red m.p. Spain	**Antimicrobial nanostructured biomaterials for complex wound healing (NABIHEAL, n° 101092269)**	**2023–2026**

IMROH ASSOCIATES: I. Vinković Vrček, A. Gojanović, N. Kalčec, N. Peranić, L. Božičević

SUMMARY

In the first year of the project, a regulatory and methodological framework was established for the design, production, characterization, and testing of the effectiveness and safety of innovative biomaterials for healing deep wounds. A research group from IMROH was involved in the analysis and the efficacy and safety testing plan.

INSTITUTION (Leader)	PROJECT	DURATION
French Agency for Food, Environmental and Occupational Health & Safety (ANSES)	**Partnership for the Assessment of Risks from Chemicals, (PARC, Grant agreement ID: 101057014)**	**2022–2029**

IMROH ASSOCIATES: V. M. Varnai, J. Jurasović, I. Vinković Vrček, J. Kovačić, G. Pehnec, G. Gajski

SUMMARY

PARC aims to bring together a broad community of research establishments and health agencies to advance, share knowledge, and improve skills in chemical risk assessment. PARC brings together ministries and national public health and risk assessment agencies, research organisations, and academia from almost all EU Member States, as well as representatives of Directorates-General of the EC and EU agencies involved in the monitoring of chemicals and the assessment of risks.

Specific objectives are: an EU-wide sustainable cross-disciplinary network to identify and agree on research and innovation needs and to support research uptake into regulatory chemical risk assessment; joint EU research and innovation activities responding to identified priorities in support of regulatory risk assessment for chemicals; strengthening existing capacities and building new transdisciplinary platforms to support chemical risk assessment.

INSTITUTION (Leader)	PROJECT	DURATION
Institute for Radiological Protection and Nuclear Safety – IRSN, Fontenay-aux-Roses, Francuska (J.-C. Gariel)	**European Partnership for Radiation Protection Research (PIANOFORTE, Grant Agreement ID 101061037)**	**2022–2027**

IMROH ASSOCIATES: I. Prlić (coordinator for CRO, WP3T2 Coordinator, PoM-Program manager Contact Point, member of the Consortium Management Board), L. Pavelić, N. Kopjar, I. Brčić Karačonji, A. Lucić Vrdoljak, J. Macan, B. Petrinec, M. Herman
Partner: Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb (Ž. Veinović)
Consortium: 58 national managers and program owners from 22 EU member states and Norway, 7 associations in the field of radiation protection: MELODI, ALLIANCE, EURAMED, NERIS and EURADOS, SHARE and MEENAS

SUMMARY

PIANOFORTE research partnership aims to improve knowledge and promote innovation in the field of radiation protection for the benefit of a better protection of the public, patients, workers, and the environment in all scenarios of exposure to ionizing radiation.

The European Partnership for Radiation Protection Research will contribute to improving the protection of the public, workers, patients, and the environment from environmental, occupational and medical exposure to ionizing radiation. It brings together 58 partners representing 22 European Union countries as well as the United Kingdom and Norway, and is coordinated by the French Institute for Radiation Protection and Nuclear Safety (IRSN). It is co-financed by the European Union's EURATOM program and the governments of the participating countries. Through the research activities that will be carried out within its framework, PIANOFORTE will contribute to the implementation of European policies such as the European plan to combat cancer, the green pact for growth, and the implementation of the roadmap for reducing industrial and natural risks.

INSTITUTION (Leader)	PROJECT	DURATION
The Lisbon Council for Economic Competitiveness and Social Renewal, Brussels, Belgium (F. Mureddu)	Evidence Driven Indoor Air Quality Improvement (EDIAQI, 101057497)	2022–2026

IMROH ASSOCIATES: G. Gajski (WP5 Leader), M. Gerić, K. Matković, M. Milić, V. Kašuba, L. Delić, G. Pehnec, V. Micek, I. Vrhovac Madunić, D. Breljak, T. Horvat, M. J. Lovrić, S. Davila, I. Jakovljević, I. Smoljo, M. Nikolić

SUMMARY

Indoor air pollution, an emerging threat recognized by European society, is claiming millions of lives annually. In the heat of the recent COVID-19 pandemic, elevated exposure to indoor air pollutants due to increased time spent indoors further faced a significant increase in negative effects on both physical and mental health and well-being not only in Europe, but also worldwide. When it comes to indoor air quality itself, serious knowledge gaps remain in understanding the complex nature of indoor-outdoor pollution relationships, pollution sources and exposure pathways, health effects of emerging pollutants, and ventilation of indoor spaces on wide spatial and long temporal scales. This is mainly because air quality monitoring in the EU is primarily focused on outdoor air quality, which paradoxically is a result of regulatory target compliances that are lacking for indoor environments. To increase the resilience of EU for emerging threats of indoor air pollution and to promote living and working in healthy environ-ments, EDIAQI aims at conducting characterization of sources and routes of exposure and dispersion of chemical, biological, and emerging indoor air pollution in multiple cities in EU. Quantification of the main properties of pollu-tants and processes that governs its fate in indoor environments will be investigated on two levels: a) the-state-of-the-art, small-scale, high-intensity scientific focus measurement campaigns; and b) long-term, large-scale monitor-ing of target indoor air pollutants. The chosen project strategy for developing, characterization, and deployment of cost-effective/user-friendly monitoring solutions, together with the-state-of-the-art scientific instrumentation will allow to create new knowledge on sources, routes of exposure, and body burdens of indoor multipollutant. The project activities carried out during 2023 resulted in the publication of publications in electronic editions (130, 133) and abstracts presented at scientific meetings (192,189). Results of project activities were presented on the "57th Congress of the European Societies of Toxicology (EUROTOX)", and were published in a WoS-indexed journal (251).

INSTITUTION (Leader)	PROJECT	DURATION
MyBiotech (N. Günday-Türeli) and Luxembourg Institute for Science and Technology (T. Serchi)	Pharmaceutical Open Innovation Test Bed for Enabling Nano-pharmaceutical Innovative Products (Phoenix, Grant Agreement ID 953110)	2021–2025

IMROH ASSOCIATES: I. Vinković Vrček (coordinator), N. Kalčec, N. Peranić, L. Božičević, A. Gojanović
Consortium: 12 EU Member States

SUMMARY

During 2023, the research group from IMROH participated in the implementation of the activities foreseen in the work plan of Work Package 3 (WP3) and Work Package 5 (WP5). The activities within WP3 were focused on the development of services for evaluating the efficacy and safety of nanomedicines, while the activities of WP5 were focused on the implementation of regulatory guidelines for the development of nanomedicines.

INSTITUTION (Leader)	PROJECT	DURATION
Norwegian Institute for Air Research, Kjeller, Norway (M. Dusinska)	Science-Based Risk Governance of Nanotechnology (RiskGONE, Gran Agreement ID 814425)	2019–2023

IMROH ASSOCIATES: I. Vinković Vrček, L. Božičević
Consortium: 15 EU Member States and USA, and Iran

SUMMARY

During 2023, project activities were successfully completed, and final reports were prepared, submitted, and finally accepted by the European Commission. The project received excellent marks and resulted in a methodological framework for managing risks from nanomaterials in a coherent and scientifically sound manner.

EUROPEAN SOCIAL FUND

Operational Programme Efficient Human Resources
Croatian Science Foundation – Scientific Cooperation Programme
(2 projects)

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (I. Vinković Vrček)	Safe-by-Design Approach for Development of Nano-Enabled-Delivery Systems to Target the Brain (SENDER, HrZZ-PZS-2019-02-4323)	2019–2023

IMROH ASSOCIATES: N. Kalčec, N. Peranić, L. Božičević
PARTNER: Universiy of Melbourne, Victoria, Australia

SUMMARY

HRZZ accepted the final report for the SENDER project, and during the evaluation process, the project was rated as successful. PhD student Nikolina Kalčec, employed on that project, gave an oral lecture at the Final Conference of the Program of Cooperation with Croatian Scientists in the Diaspora "Scientific Cooperation" and presented the main conclusions that were obtained during the project. In 2023, one scientific paper was published in the journal *ACS Applied Nanomaterials*, while three other papers are under submission. Two symposia were organized and the group's members participated in two international scientific meetings. Nikolina Kalčec defended her doctoral dissertation entitled "Design and characterization of gold and selenium nanoparticles as potential systems for the delivery of levodopa and dopamine" at the Faculty of Science of the University of Zagreb and was employed as a postdoctoral researcher at the Institute for Medical Research and Occupational Health. From April 2023, Maja Beus, PhD continued her scientific career at Duke University, Duke, USA. During 2023, members of the group participated in two workshops and attended professional training at scientific and health institutions.

INSTITUTION (Leader)	PROJECT	DURATION
Department of Physics, Faculty of science, Zagreb (M. Makek)	Single layer gamma-ray polarimeter for medical imaging applications and fundamental physics research (SiLGaP, HrZZ-PZS-2019-02-5829)	2019–2023

IMROH ASSOCIATES: L. Pavelić
PARTNER: University of Sydney, New South Wales, Australia

SUMMARY

Information about the polarization of gamma radiation is important in many areas of modern physics research. In the field of fundamental research, an example is the phenomenon of quantum coupling, which can be studied by analysing the relative polarizations of three gamma-photons from the decay of ortho-positronium. In the field of applications, an important case is biomedical imaging using positron emission tomography (PET), where simulation studies have shown that the polarization information not used in PET systems has the potential to improve image quality. The polarization of the gamma photon can be determined via Compton scattering, which results in a scattered electron and a scattered gamma particle. To reconstruct the Compton scattering, position and energy sensitive detectors are needed, which usually consist of two layers: the first one for the detection of electrons and the second one for the detection of the scattered photon. However, in many applications, where the detectors are highly segmented and contain a large number of channels, as in PET, a system based on two-layer detectors would have a relatively high cost. The plan of this project is to create a new, modular system for measuring the polarization of gamma-photons, based on single-layer detectors for measuring Compton scattering. Individual modules will consist of a matrix of scinuntilation detectors, read by silicon photomultipliers. Compared to two-layer systems, this concept offers the possibility of constructing more affordable, compact, and multifunctional devices. In the project, we will set up a system of sixteen modules that will then be applied through two studies. In the first research, the possibility of using information about the polarization of gamma radiation in PET will be tested experimentally for the first time, as an important step towards a new generation of efficient devices for medical imaging. In the second, azimuthal correlations of three gamma-photons from ortho-positronium decay will be analysed in order to investigate quantum coupling as a fundamental physical concept.

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
COST ACTION Programme (10 projects)

INSTITUTION (Leader)	PROJECT	DURATION
University Hospital Wurzburg, Wurzburg, Njemačka (Cristoph Maack)	EUropean network to tackle METAbolic alterations in HEART failure (EU-METAHEART, CA22169)	2023– 2027

IMROH ASSOCIATE: M. Ljubojević (Management Committee Member)

SUMMARY

The aim of this COST Action is to bring together researchers from Europe to contribute to a broad spectrum of scientific expertise, cutting-edge technologies, scientific exchange, and education to foster breakthrough science that moves the field forward towards improving the treatment of patients with heart failure (HF). Sharing diverse expertise that covers not only conventional analyses, but also omics-based techniques with integrated approaches in this COST Action, will allow for the development of a comprehensive and cutting-edge approach towardsa deeper understanding of metabolic dysfunction in HF. The focus is on four key scientific areas in which metabolic or mitochondrial dysfunctions are central. The first meeting of the Management Committee was held in Brussels, where the heads of the working groups were appointed, and the next one is scheduled to be held in Turkey.

INSTITUTION (Leader)	PROJECT	DURATION
The Germans Trias i Pujol Research Institute (IGTP), Badalona, Spain (E. Martinez-Balibrea)	Modelling immunotherapv response and toxicity in cancer (IMMUNO-model, CA21 135)	2022–2026

IMROH ASSOCIATE: D. Karaica (Management Committee Member)

SUMMARY

The aim of this COST Action is to foster research and innovation in the field of preclinical immuno-oncology models with the ultimate goal of advancing the treatment of cancer patients and their quality of life.

INSTITUTION (Leader)	PROJECT	DURATION
AIT-Austrian Institute of Technology GmbH, Vienna, Austria (W. Neuhaus)	3Rs concepts to improve the quality of biomedical science (IMPROVE, CA21139)	2022–2026

IMROH ASSOCIATE: I. Vrhovac Madunić (Management Committee Member)

SUMMARY

In the frame of this COST Action a network of scientists has been established to improve and promote the 3Rs (Replacement, Reduction, and Refinement) concepts, data and documents, in order to improve the quality of biomedical sciences. The project brings together a unique network of scientists from basic and biomedical sciences, regulatory authorities and the education sector. The IMPROVE action implements and supports the implementation of the EU directive 2010/63/EU on the protection of laboratory animals used for scientific purposes. The meetings were held in a hybrid format. The preparation of a document with regard to the interpretation of the 3R principle in animal research is currently in progress.

INSTITUTION (Leader)	PROJECT	DURATION
Hellenic Society for the Study and Research of Aging, Agia Paraskeui, Grčka	PROmoting GeRiAtric Medicine IN countries where it is still eMerGing (PROGRAMMING, CA21122)	2022 – 2026

IMROH ASSOCIATE: S. Cvijetić Avdagić

SUMMARY

A questionnaire on education in geriatric medicine, dedicated to the care of older adults, has been translated into Croatian and the online distribution of questionnaires to health and other institutions dealing with the elderly has begun.

INSTITUTION (Leader)	PROJECT	DURATION
GENyO, Pfizer-University of Granada, Granada, Spain (K. Benabdellah)	Genome Editing to Treat Humans Diseases (GenE-Humdi, CA21113)	2022–2026

IMROH ASSOCIATES: J. Madunić

SUMMARY

During the past year, the GenE-HumDi project continued with its planned activities aimed at integrating and popularizing the results of genome editing (GE) research with pharmaceutical, academic, and educational institutions to enhance the general application of GE in disease treatment. Working groups held hybrid or online meetings focused on key areas to advance GE research, foster collaboration, and improve understanding. The meetings also addressed challenges related to GE work, protocol development, and publication. The first scientific congress, along with a workshop, was organized in March in Granada, Spain, followed by a two-week training school on GE using CRISPR/Cas technology held in Aarhus, Denmark. Throughout the year, Short-Term Scientific Missions (STSM) and educational webinars tailored for young researchers in all working groups were organized, covering key areas of GE research. Conference grants were awarded, and the project established a presence on social media, as well as its official website (www.genehumdi.eu).

University of Ferrara, Ferrera, Italy (E. Adinolfi)	P2X receptors as a therapeutic opportunity (PRESTO, CA21130)	2022–2026
University of Ferrara, Ferrera, Italy (E. Adinolfi)	P2X receptors as a therapeutic opportunity (PRESTO, CA21130)	2022–2026

IMROH ASSOCIATE: J. Madunić

SUMMARY

Over the past year, the scientific project witnessed significant advancements across its four working groups. Working Group 1 fostered fruitful collaborations among institutions from Germany, Italy, Spain, France, and the UK, focusing on the impact of the P2X7 receptor in inflammation and cancer. Meanwhile, Working Group 2 diligently pursued network expansion efforts and data collection to establish reference intervals of P2XR concentrations in body fluids. Working Group 3 managed to forge new collaborations to explore monoclonal antibody characterization in Alzheimer's disease models and material sharing for Ca2+ flux assays. Lastly, Working Group 4, successfully hosted two events at the University of Pisa, including a training school and an Action meeting, which stimulated constructive discussions and the initiation of new ventures. These collective efforts underscore the project's commitment to advancing scientific knowledge and its potential impact on diverse fields ranging from inflammation and cancer research to neurodegenerative diseases and tissue regeneration.

INSTITUTION (Leader)	PROJECT	DURATION
University Hospital RWTH Aachen, Aachen, Germany (J. Jankowski)	Personalized medicine in chronic kidney disease: improved outcome based on Big Data (PerMediK, CA21165)	2022–2026

IMROH ASSOCIATE: I. Vrhovac Madunić (Management Committee Member)

SUMMARY

The aim of this COST Action is to support the development of a path towards personalized medicine in chronic kidney disease (CKD), based on multidimensional -omics data (Big Data). This field is mature enough (through the existence of ample molecular data, promising therapeutic targets, and markers) to move to the next step of clinical implementation. The meeting of the Management Committee was held in Cyprus, and the next one is scheduled to be held in Prague.

INSTITUTION (Leader)	PROJECT	DURATION
Stazione Zoologica Anton Dohrn, Napoli, Italy (M. V. Modica)	European Venom Network (EUVEN, CA 19144)	2020–2024

IMROH ASSOCIATE: G. Gajski (Management Committee member substitute)
PARTNERS: 27 European countries, Tunisia, Armenia, Belarus, Russia, and Morocco

SUMMARY

The overarching aim of the EUVEN COST Action is to foster venom investigation at the European level. The Action will identify priority targets and promising innovative approaches, develop best practice pipelines ensuring consistency across Europe and provide international standards in venom research. Furthermore, it provides a novel platform to promote synergistic interactions between the academia, industry, and society, and to nurture a new generation of venom researchers with a multidisciplinary expertise. Building a gender, age and geographically balanced network involving all the relevant stakeholders will be the fundamental prerequisite to leverage the extraordinary biochemical warfare enclosed in animal venoms, with an enduring scientific, technological, and socioeconomic impact. As part of the project collaboration, a review paper was published in which current insights, new methods and future perspectives in biological and applied research on animal poisons are presented.

INSTITUTION (Leader)	PROJECT	DURATION
University of Trieste, Italy (S. Pricl)	Cancer nanomedicine – from the bench to the bedside (NANO2CLINIC, CA17140)	2018–2023

IMROH ASSOCIATE: I. Vinković Vrček

SUMMARY

At the beginning of 2023, all activities of the COST action were successfully completed, and the final report was submitted and accepted by the COST office.

16.2.A.2. Other european and international collaborations

EUROPEAN SLEEP RESEARCH SOCIETY

International collaboration without founding

INSTITUTION (Leader)	PROJECT	DURATION
International COVID-19 Sleep Study Collaboration Group (ICOSS-2)	ICOSS 2nd Survey: Sleep disorders related to coronavirus infection and confinement during COVID-19 Pandemic (ICOSS-2)	2021–2023

IMROH ASSOCIATES: A. Bjelajac (leader for Croatia), J. Macan, S. Cvijetić Avdagić, P. Tomac, J. Mandić, B. Ross
PARTNERS: 31 coordinators from 19 states worldwide

SUMMARY

The goal of the ICOSS-2 research collaboration was to determine the prevalence and incidence of sleep disorders and symptoms associated with the coronavirus infection and to analyse the effects of the infection independently of the other effects of the COVID-19 pandemic. The survey was conducted online and distributed through various channels in 16 countries around the world. In total, we collected the responses of 16,899 participants, of which the data of 15,813 adults were appropriate for further analyses. The articles that were published online in 2022 were published in print in 2023 (10, 58). Four additional papers were then published showing that 1) short sleep duration was consistently associated with a higher risk of post-COVID in individuals vaccinated with two doses of the mRNA vaccine (97); 2) the risk of developing post-COVID was higher in habitually short sleepers who in addition to a COVID-19 infection had pre-existing medical conditions (104); 3) lower levels of self-assessed health were associated with recovery from COVID, especially more severe forms, as well as with more post-COVID symptoms, and changes in sleep duration after recovering from COVID (56); and 4) people who had insomnia before the pandemic more often had post-COVID symptoms, as well as that insomnia occurred in a significant number of cases after illness from COVID-19 , more often in those who developed post-COVID symptoms (12). The work of the collaboration takes place without additional financial support.

16.2.A.3. UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)
International Atomic Energy Agency (IAEA) (2 projects)

INSTITUTION (Leader)	PROJECT	DURATION
Department of Nuclear Sciences and Applications IAEA TC Project Water and Environment	Improving Environmental Monitoring and Assessment for Radiation Protection in the Region (TC RER7014)	2020–2024

IMROH ASSOCIATES: I. Prlić (leader), T. Bituh

SUMMARY

The objective of the project is to contribute to the radiological protection of the public and the environment in different exposure situations in the region. The project's activities include: 1) building technical and managerial expertise in analytical and sampling techniques for radionuclide analysis, 2) review the status of environmental radiation monitoring programmes and technical capabilities, 3) increase awareness, visibility, and outreach, 4) draft national project action plans to establish or optimize environmental radiation monitoring programmes, 5) develop capacities in designing and implementing environmental monitoring programmes, 6) participate in IAEA Proficiency Tests (PT) on radionuclide measurements, 7) develop and apply QA/QC procedures, 8) conduct data analysis, interpretation, reporting, and communication, 9) develop recommendations to improve the legal framework and regulations for environmental radiation monitoring.

INSTITUTION (Leader)	PROJECT	DURATION
Environmental Radioactivity Monitoring Department Greek Atomic Energy Commission, Athens, Greece (K. Karfopoulos)	Enhancing Regulatory and Metrological Infrastructures Needed to Ensure Radiation Safety in Naturally Occurring Radioactive Materials Industry (TC RER9155)	2019–2024

IMROH ASSOCIATE: I. Prlić

SUMMARY

The objective of the project is to enhance the regulatory and metrological infrastructures in reference to industries involving NORM ensuring the radiation protection of the workers and the environment in compliance with the IAEA BSS.

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INSTITUTION (Leader)	PROJECT	DURATION
University of Opole, Poland (Malgorzata Rajfur)	Using Honeybees, Honey and Other Hive products for Biomonitoring of Low-radioactive phosphogypsum Tailings (BeeWatch)	2023-2024

IMROH ASSOCIATE: T. Bituh, B. Petrinec

16.2.A.4. GOVERNMENT PROJECTS
National Institutes of Health (NIH), USA

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (Z. Kovarik) University of California at San Diego, La Jolla, USA (Z. Radić)	*In vivo* efficacy of novel uncharged bis-oximes in OP poi-soning treatment	2022–2024

IMROH ASSOCIATES: D. Kolić, N. Maček Hrvat

SUMMARY

Three zwitterionic bis-oximes are evaluated as reactivators of cholinesterases inhibited by organophosphorus compounds (OP). Due to their physico-chemical properties, three oximes are expected to be effective

reactivators in the central nervous system and contribute to the protection of the nervous system from the long-term consequences of OP poisoning.

Ministry of Science and Education, Republic of Croatia
Scientific and Research Bilateral Cooperation in Science and Technology
(4 projects)

MINISTARSTVO ZNANOSTI I OBRAZOVANJA REPUBLIKE HRVATSKE

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (I. Vrhovac Madunić) Institute for Pharmaco-logy, University Medicine Greif-swald, Germany (M. Tzevtkov)	Identifying interactions of renal and hepatic organic cati-on transporters (OCTs) with oximes, antidotes in treat-ment of organophosphate poisoning (Bilateral CRO-DE)	2022–2023

IMROH ASSOCIATES: . Čadež, M. Katalinić, Z. Kovarik, J. Madunić, A. Zandona

SUMMARY

The main goal of this project was to determine whether organic cation transporters (OCTs) mediate the transport of oximes, antidotes in the treatment of organophosphate poisoning. Clarifying these OCTs and oxime interactions represent a key step in further consideration of oximes as potential drugs in the organophosphate poisonings. In the first project year, we selected two oximes that are currently in clinical use as well as three newly synthesized oximes whose transport was evaluated in renal HEK293 cells. We determined the permeability of the passive membrane to oxime using the PAMPA test, performed extensive experiments on the oxime transport (uptake) in the OCT1- and OCT2-transfected HEK293 cells, and determined the basic kinetic parameters of transport including Km and Vmax. Furthermore, we determined the inhibitory power of atropine and its inhibition mode (competitive, allosteric, etc.) as well as the oxime toxicity in the OCT1- and OCT2-transfected HEK293 cells. Finally, the LC-MS/MS method was established for a precise quantification of very small amounts of oximes in these experiments. In September 2023, S. Römer stayed at IMROH, where she was involved in the cytotoxicity experiments, while T. Čadež and A. Zandona stayed at the Institute of Pharmacology in Greifswald, where they were involved in "uptake" and LC-MS/MS experiments. Furthermore, in September 2023, J. Madunić presented the project's results at the Greifswalder Transporttage 2023 conference. In addition, a part of these results was also published (172). In December 2023, a hybrid meeting was held where all of the project results were presented, as well as future experiments and further writing publications planned. Finally, at the end of 2023, a hybrid final meeting of the project was held during the working visit of S. Römer and V. Rönnpagel to IMROH.

INSTITUTION (Leader)	PROJECT	DURATION
IMROH Zagreb (M. Katalinić) Institute for Pathophysiology, University of Ljubljana, Ljubljana, Slovenia (S. Pirkmajer)	Effect of oxime analogues on skeletal muscle cell viability (Bilateral CRO-SI)	2020–2023

IMROH ASSOCIATES: A. Bosak, A. Matošević, N. Maraković, I. Vrhovac Madunić, A. Zandona

SUMMARY

The project focused on studying the effect of two oxime analogs, reactivators of acetylcholinesterase, on muscle cells for the purpose of early assessment of their possible negative impact. On the Croatian side, this bilateral colaboration was based on the installation grant of the Croatian Science Foundation "Molecular mechanisms underlying the toxicity of antidotes and potential drugs, CellToxTargets" (2018-2023, PI M. Katalinić). The obtained results were published in four scientific papers and were presented in the form of 7 presentations at international congresses/workshops. During the project, PhD student A.-M. Lulić also attended several months of training with project collaborators in Ljubljana. Project collaborators participated in the symposium "Cell-Based Research in Toxicology and Drug Design" in Zagreb in early 2023. The duration of the project was extended due to problems caused by the SARS-COV2 virus pandemic as well as other unforeseen circumstances until the end of February 2023.

INSTITUTION (Leader)	PROJECT	DURATION
IMROH, Zagreb (Z. Kovarik) Research Center for Eco-environmental Sciences, Chinese Academy of Sciences, Beijing, China (Q. Xie)	Effects of selected pesticides on neuronal acetylcholinesterase expression (Bilateral project CRO-CN)	2020–2023

IMROH ASSOCIATES: T. Čadež, M. Katalinić, A. Zandona

SUMMARY

This collaboration focused on organophosphorus pesticides and their toxicity with an aim to determine whether their toxicity depends on the interaction with acetylcholinesterase or depends on its expression. Two mutual visits enabled us to intensify our collaboration. We organized two scientific symposia, while four conference abstracts and two publications are in preparation.

INSTITUTION (Leader)	PROJECT	DURATION
Ruđer Boškovic Institute, Zagreb (S. Orlić) Chinese Academy of Sciences (A. Hu)	Distribution of antibiotic resistance genes in waste water treatment plants and receiving environments of China and Croatia (Bilateral CRO-CN)	2019–2024

IMROH ASSOCIATE: G. Gajski

SUMMARY

The project goal is to evaluate the types and concentrations of typical new organic pollutants in the coastal cities and the receiving environment and their temporal and spatial distribution characteristics, migration patterns, and country differences. The abundance and community composition of typical antibiotic resistance genes in sewage plants and receiving environments in the two countries and their temporal and spatial distribution characteristics, migration patterns and country differences. Besides, the project will clarify the coupling relationship between new organic pollutants and antibiotic resistance genes and assess ecological risk.

16.2.A.10. UNIVERSITY PROJECTS (3 projects)

INSTITUTION (Leader)	PROJECT	DURATION
Institute for Pharmacology, Centre of Drug Absorption and Transport (C_DAT), University Medicine Greifswald, Germany (M. Tzvetkov)	Metformin and Sodium glucose co-transporters of Glucose	2023–2024

IMROH ASSOCIATE: I. Vrhovac Madunić

SUMMARY

The project started in 2023 during the eight-month stay of I. Vrhovac Madunić at the Institute of Pharmacology (Greifswald, Germany) at the invitation of Prof M. Tzvetkov (Institute of Pharmacology, Greifswald, Germany). Since the exact mechanism of action of metformin, frequently used in therapy for type 2 diabetes, is still unknown, the main goal of this project is to investigate the interaction of metformin and the glucose transporter (SGLT) in order to resolve the important question – which is the main target organ of metformin action.

INSTITUTION (Leader)	PROJECT	DURATION
UConn Health, University of Connecticut, Farmington, USA (I. Kalajzic)	Generating new RGS5 mouse model for lineage tracing	2019–2023

IMROH ASSOCIATE: I. Vrhovac Madunić

SUMMARY

The project commenced in 2019/2020 during the postdoctoral training of I. Vrhovac Madunić at the Laboratory of Prof I. Kalajzić of the University of Connecticut Health Center (Connecticut, USA). The objective was to develop a novel transgenic mouse model (RGS5-CreERT2) for lineage tracing in bone remodeling and regeneration, with the

aim of elucidating cell origin and fate. The primary goal of the project was to evaluate the suitability of the RGS5 mouse model in delineating mesenchymal progenitor cells, specifically in identifying perivascular cells within the periosteum both *in vitro* and *in vivo*. Findings were published in a WoS-indexed journal (74).

INSTITUTION (Leader)	PROJECT	DURATION
Department of Genetics, Kemerovo State University, Kemerovo, Russia (V. Druzhinin)	**Relationship of the respiratory microflora composition with the human genome activity and integrity in the residents of coal industrial region**	**2018–2023**

IMROH ASSOCIATE: A. Fučić

SUMMARY

The susceptibility for lung cancer (LC) is modified by genetic variations in xenobiotic detoxification and DNA repair capacity The aim of the study was to investigate the association between *GSTM*1 (deletion), *APEX1 (rs1130409)*, *XPD (rs13181)* and *NBS1 (rs1805794)* gene polymorphisms and LC risk in patients who worked in coal mines.

16.2.B. EDUCATIONAL AND SCIENCE POPULARIZATION PROJECTS

European Union programs

European Social Fund

INSTITUTION (Leader)	PROJECT	DURATION
Croatian Judo Federation, Zagreb (R. Kerep)	**About science through sport (STEMsport, UP.04.2.1.10.0160)**	**2022–2024**

IMROH ASSOCIATE: S. Stipičević (coordinator), I. Vrhovac Madunić, M. Kujundžić, Z. Franić, S. Žunec, V. M. Varnai, L. Božičević; consultants: J. Macan, I. Brčić Karačonji, I. Vinković Vrček
Partners: IMROH, Zagreb; Institute for Popularization of Science, Zabok; Professor Baltazar Association, Zagreb; Elementary school of Dr. Ante Starčević, Zagreb
Project grant: 322.867.45 EUR

SUMMARY

Project activities were presented at the 6th Congress of the Slovenian Society of Toxicology "Prohibited substances in human and animal sport" (Jan 26, 2023, Ljubljana, Slovenia) (286). An educational material for STEMsport training was provided, including a curriculum, a lessons' plan, a manual and six digital presentations on topics that connect IMROH's science with sports and sustainable lifestyle. Two topics of the STEMsport curriculum (toxicology of nutritional supplements for athletes and tattoo inks) were presented at the 7th European judo science and research symposium & 6th Scientific and professional conference "Applicable research in judo" (Jun 19 and 20, 2023, Poreč, Croatia) (113, 114). Ten STEMsport interactive exhibits were designed and built to be used in different project workshops.

Erasmus+ (2 projects)

INSTITUTION (Leader)	PROJECT	DURATION
Institut National Polytechnique de Toulouse, Toulouse, France (B. Pourrut)	**Toxicology Innovative Learning for Europe (ToxLearn4EU, ref. 2021-1-FR01-KA220-HED-000030081) Cooperation partnerships in higher education**	**2022–2025**

IMROH ASSOCIATE: G. Gajski, M. Gerić, M. Milić, K. Matković
Partners: 11 partners from Europe
Project grant: 399,998.00 EUR

SUMMARY

The Erasmus ToxLearn4EU project was built by a consortium of 7 HEIs and 3 research centres and laboratory. It aims to modernize Toxicology and Ecotoxicology teaching in Europe and has several objectives

and target audiences: 1) develop and use innovative and free educational resources (interactive courses, online PBL) in order to develop high quality digital education, 2) provide innovative content on current hot topics in the field of toxicology/Ecotoxicology to fit with recent evolution of European Policy (Action Plan: "Towards Zero Pollution") and with job market needs, 3) stimulate the interest of students for those fields and limit dropping out of school by putting students back at the centre of teaching through the use of active pedagogies adapted to digital practice to recreate interactions between students, between students and teachers, and by stimulating their motivation through playful approaches.

As part of the ToxLearn4EU project, the 1st Summer School was held at the Institute for Medical Research and Occupational Health in Zagreb from July 3 to 14, 2023. As part of the Summer School, we had more than 20 lecturers from all over Europe in whose lectures more than 30 students from all over Europe participated. The Summer School consisted of lectures and problem-based learning in the field of toxicology, and participants had the opportunity to visit the Plitvice Lakes National Park and the Zagreb wastewater treatment plant as part of the field activities.

INSTITUTION (Leader)	PROJECT	DURATION
Serbian Society of Toxico-logy, Belgrade, Serbia (D. Đukić-Ćosić)	**Meet the Toxicity – Live Safely (MeeTox, ref. 2022-1-RS01-KA210-ADU-000083718)**	**2021–2023**

IMROH ASSOCIATE: S. Stipičević (coordinator), D. Rašić (coordinator), IMROH's Poison Control Center and other CST members (M. Peraica, I. Brčić Karačonji, M. Dvoršćak, Z. Franić, M. Gerić, K. Jagić, A. Jurič, A. Katić, D. Klinčić, N. Kopjar, M. Lazarus, A. Sulimanec Grgec, B. Tariba Lovaković, A. Pizent, S. Žunec, A. Katić)
Partners: IMROH, Faculty of Pharmacy, University of Belgrade, Serbia, Croatian Toxicoogical Society (CTS)
Project grant: 60,000.00 EUR

SUMMARY

A survey on the knowledge and attitudes of the general population about toxicity and the daily safe use of various products was designed and distributed in printed and digital form to the Croatian and Serbian adult public. A dissemination campaign was carried out between June and December 2023 through kindergartens, schools, professional associations, clinics, educational agencies, etc. The MeeTox Mini symposium was organised during the 13th Congress of the Association of Toxicologists of Serbia and the 1st TOXSEE Regional Conference (May 10-12, 2023, Belgrade, Serbia). Preliminary results of the survey and the application of digital technologies in education were discussed during the partner's meeting (Jul 14, 2023, online) and the MeeTox Symposium (Sep 14 and 15, 2023, Zagreb, Croatia). More info: https://www.imi.hr/hr/2023/06/02/meetox-meet-the-toxicity-live-safely-erasmus/.

16.2.C. PROFESSIONAL PROJECTS

PROJECT	CONTRACTOR	LEADER
Service provider: Radiation Dosimetry and Radiobiology Unit		
ENA – European NORM association. A joint project between EAN NORM & European ALARA Network. Continuation of TREN/H4/51/2005 of the European Commission (EC) (since 2017)	IAF-Radioökologie GmbH, Dresden, Germany	I. Prlić (for CRO) L. Pavelić
PROJECT	**CONTRACTOR**	**LEADER**
Service provider: Occupational and Environmental Health Unit, Poison Control Centre		
"Single Market Programme (SMP)", call "SMP-FOOD-2022-BIOCIDES-PESTICIDES-IBA" (April 2023)	European Commission	Ž. Babić

17. PROFESSIONAL UNITS

17.1. Laboratory Animal Unit

EMPLOYEES OF THE UNIT

HEAD
Vedran Micek, DVM, PhD, professional associate

TECHNICAL ASSOCIATE
Patricija Topol, veterinary technician

WORK

The Laboratory Animal Unit of the Institute breeds laboratory rats, strain HsdBrlHan: Wistar, in accordance with the Animal Welfare Act (OG 102/17) and other applicable laws, guidelines and policies. Animals are bred under strictly controlled conditions, under surveillance of authorised personnel (DVM), and then used as a model in scientific and experimental research. The Unit has facilities that are consistent with legislation and guidelines concerning the breeding and housing of laboratory animals. From 2016, the Laboratory Animal unit is authorized for performing in vivo experiments over a ten-year period.

The living conditions of animals are appropriate and contribute to their health and welfare. The housing, feeding, animal care and experimental procedures are managed by a veterinarian in accordance with contemporary veterinary practices. The animals are kept in steady-state micro environmental conditions and fed with standard GLP certified laboratory food and water ad libitum with altering 12 h light and dark cycles. Sanitation of facilities is performed on a weekly basis in order to reduce the possibility of any external contamination. Breeding colony health monitoring is provided by the Croatian Veterinary Institute, Zagreb.

17.2. Poison Control Centre

EMPLOYEES OF THE CENTRE

HEAD
Željka Babić, PhD, research associate

ASSOCIATES
Researchers of the Occupational and Environmental Health Unit (Chapter 15.5.).
Researchers of the Analytical Toxicology and Mineral Metabolism Unit (Chapter 15.1.)

WORK

During 2023, the telephone information service of the Croatian Poison Control Center (CPCC) was consulted for 3228 cases of poisoning and suspected poisoning, by health professionals and the general public. Annual reports on poisoning statistics continued to be published in the journal Archives of Industrial Hygiene and Toxicology (126). In addition, based on data collected in 2018-2020, as part of the multicenter epidemiological research of European poison control centers entitled "Study on Viperidae Family Snake bites in Central and Eastern European Countries" (CEE-VIPER; leader: M. Brvar, PhD, MD, Slovenian poison control center), a paper was published in a scientific journal on the characteristics of poisoning by venomous snakes in central and southeastern Europe (17). Press releases aimed at preventing oleander and nicotine poisoning were published through the IMROH website (131, 132). Collaboration with the Agency for Medicinal Products and Medical Devices of Croatia in monitoring of drug poisonings (pharmacovigilance) continued.

Following requests from the industry, 25 toxicological evaluations were prepared for the registration of pesticides according to the Plant Protection Products Act and Regulation (EU) No. 1107/2009 on placing plant protection products on the market. Following enquiries from the industry, 22 evaluations for the purpose of biocidal product registration were prepared according to the Biocidal products Act and Regulation (EU) No. 528/2012 concerning the placement on the market and use of biocidal products. The CPCC project "Boosting Croatian capacities for authorizations of biocidal products" with the aim of strengthening capacities for toxicological assessments and thus ultimately protecting the health of consumers has been approved for financing from the European Union program "Single Market Program (SMP)" (tender deadline SMP-FOOD-2022-BIOCIDES-PESTICIDES-IBA, April 2023). In addition, at the request of the Ministry of Agriculture, Veda Marija Varnai, PhD, MD was appointed as a deputy member of the Commission for Drafting the Law on Amendments to the Law on the Implementation of Regulation (EC) no. 396/2005 on the maximum levels of pesticide residues in and on food and feed of plant and animal origin, and at the request of the Ministry of Health as a member of the Working Group for the development of an Action Plan for more effective implementation of OECD legal instruments in the field of chemicals and risk assessment. For the European Chemicals Agency, as the rapporteur of the Risk Assessment Committee, an evaluation of the proposed occupational exposure limits (OELs) for nitrosamines was prepared (the report was adopted in November 2023, but not yet published on ECHA's official website.

18. RESEARCH AREA ŠUMBAR

HEAD

Josip Tončić, DVM, MSc, professional associate in science

WORK

The Šumbar Research Area is where control activities for improving the stability and preservation of the ecosystem are carried out in collaboration with the Division of Environmental Hygiene, Division of Radiation Protection, the Faculty of Agriculture, and the Veterinary Institute. Current activities include research into air, water, soil, and biological material, all of which continued throughout 2023, primarily related to anthropogenic pollution of the environment and with the fundamental goal of preserving the health of people and animals and protecting endangered bird and animal species. According to the current research program, water sampling and measurement of total sediment, metals, and polycyclic aromatic hydrocarbons continued. The Division of Radiation Protection continued measurements of background ionising radiation using the reference measuring station installed onsite, which measures radiation and transmits the data to the central database via wireless communication, with the help of the Alara portable digital dosimeter. In cooperation with the Faculty of Agriculture, the Enetwild project, an international project in which a number of European universities and institutes take part, is being implemented in Šumbar. The goal of the Enetwild project is to determine the distribution and population density of wild animal species. The method for estimating the population density of wild animals is the Random Encounter Model (REM) using surveillance cameras that are distributed over the entire surface of the Area (about 1,800 ha). This method of monitoring wild animals by their density could help monitor diseases transmitable to humans, zoonoses, and other diseases that can have a negative impact on the country's economy, such as African swine fever (ASF), which is easily transmitted from wild boars to domestic animals. In the event of an outbreak of an infectious disease such as ASF, data on the number and activity of the population could help in a more successful eradication of the disease. Due to the occurrence of ASF and avian influenza in some parts of Croatia, we are implementing all the prescribed biosecurity measures prescribed by the Directorate for Veterinary Medicine at the Ministry of Agriculture. All samples regarding the detected deaths are sent for diagnosis to the Veterinary Institute. Prescribed measures arising from the hunting practices that take place within the Area and concerning wild animals and protected species are implemented and are subject to inspection on an annual basis. The monitoring and supervision of protected species is carried out according to the guidelines of the Ministry of Economy and Sustainable Development, which informs us about the species and numbers observed over the year. Regular activities ensure the maintenance of hunting technical facilities and the regular feeding of individual species of animals. In mid-July, Šumbar was hit by a storm that caused considerable damage to the technical facilities, and over the following months we managed to repair it. With the help of the relevant forestry department, we cooperate in habitat preservation and the removal of illegal waste dumps.

19. COMPANY OF THE INSTITUTE

Occupational Health Polyclinic of the Institute for Medical Research and Occupational Health Ltd., Ksaverska cesta 2, Zagreb

DIRECTOR

Prim Jelena Macan, MD, PhD, permanent scientific advisor (90% of working hours at the IMROH, 10% at the Polyclinic)

ASSOCIATE

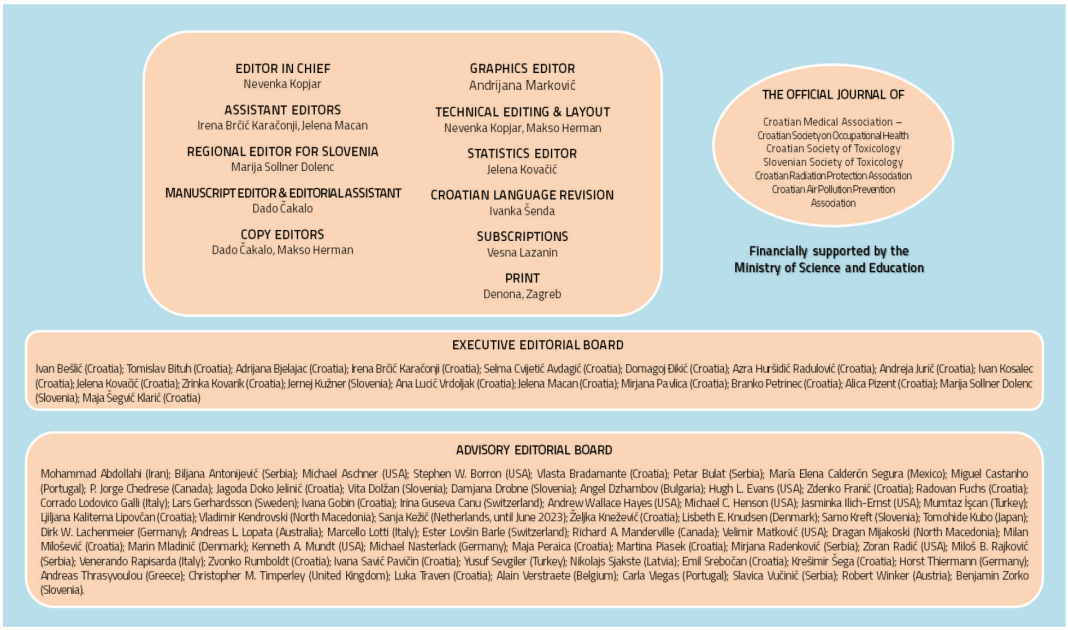
Franka Šakić, MSc, senior professional associate in science (90% of working hours at the IMROH, 10% at the Polyclinic)

BUSINESS RESULTS

The professional activity of the Occupational Health Polyclinic of the Institute for Medical Research and Occupational Health Ltd continued in 2023, providing services in the domain of occupational and sports medicine. The outpatient clinic provided a total of 241 medical services for 58 customers. An occupational medicine specialist delivered 12 medical expertises for the Administrative Courts in Zagreb, Osijek and Rijeka, Municipal Courts in Zadar, Slavonski Brod and Sisak, Municipal Civil Court in Zagreb, Municipal Labour Court in Zagreb, and Commercial Court in Zagreb. The Psychotherapy Office led by Assoc Prof Adrijana Bjelajac, PhD, psychologist and psychotherapist, continued working within the company. The company operated positively in 2023.

20. PUBLISHING

The Institute is the publisher of the scientific journal *Arhiv za higijenu rada i toksikologiju – Archives of Industrial Hygiene and Toxicology*, print: ISSN 0004-1254, online: ISSN 1848-6312.



General information about the journal

Articles from the fields of occupational health, toxicology, ecology, chemistry, biochemistry, biology, pharmacology, and psychology are edited in line with modern standards. The journal's publication is financially supported by the Ministry of Science and Education and, to a smaller extent, subscriptions. The Archives is issued four times a year.

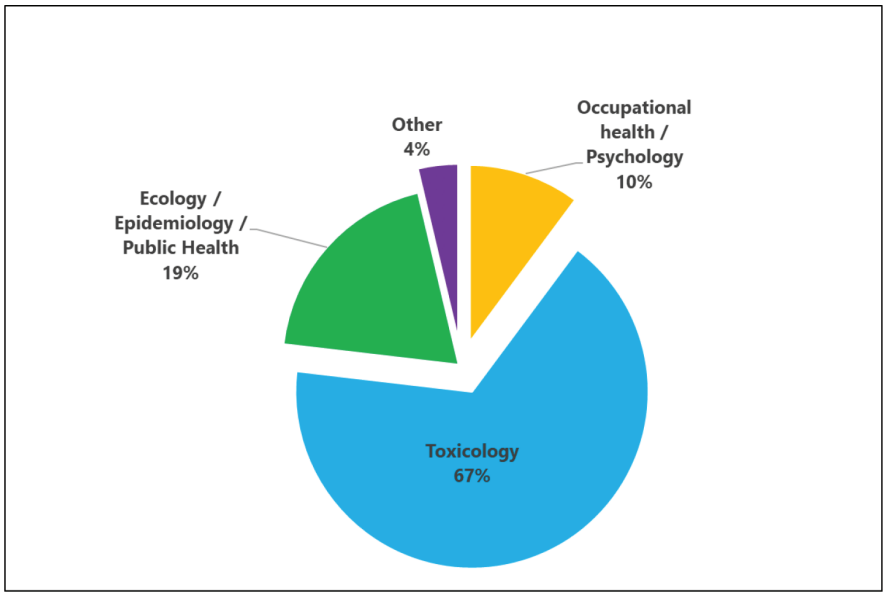
The *Archives* is indexed in SCI-Expanded, Medline/PubMed, Scopus, and many other databases. The Impact Factor (IF) for 2023 was 2.100, which is the highest IF value since the journal was listed in InCites Journal Citation Reports (Clarivate Analytics). The *Archives* is currently ranked within the third quartile (Q3) in the Public, Environmental & Occupational Health area and the fourth quartile (Q4) in the Toxicology area.

IF values of the Archives since its listing in InCites Journal Citation Reports (Clarivate Analytics)

Year	*Impact Fac-tor*
2022.	**2,100**
2021.	2,078
2020.	1,948
2019.	1,727
2018.	1,436
2017.	1,117
2016.	1,395
2015.	0,971
2014.	0,932
2013.	0,727
2012.	0,674
2011.	1,048
2010.	0,826

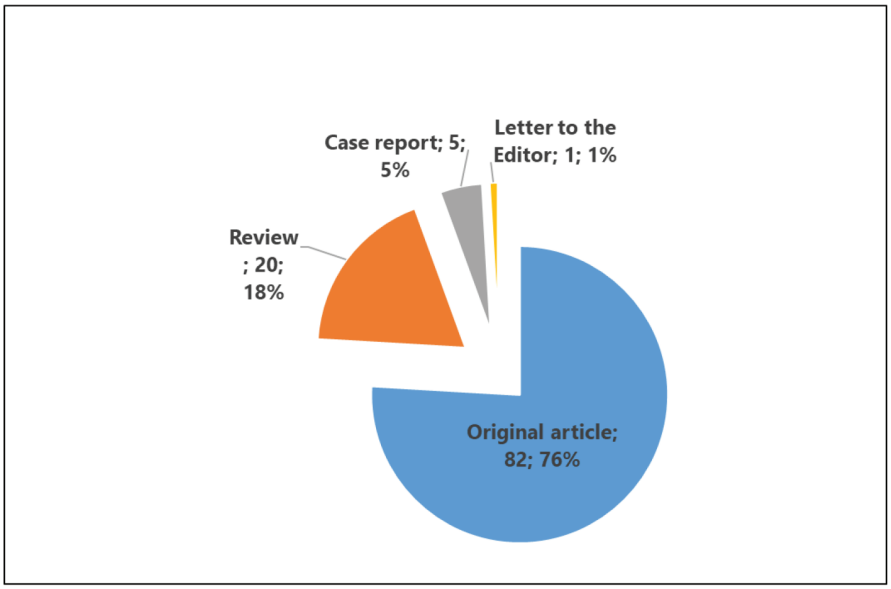
The citation report of the *Archives* in 2023 was very good. As of 2 Jan 2024, the Web of Science database recorded 8,555 citations of articles published since 2008, when the journal was included in the database. The h-index of the *Archives* for the period 2008 - 2023 according to the Web of Science database is 38.

During 2023, the Editorial Office of the *Archives* received 108 submissions, most of which were submitted through the journal's online system available at https://arhiv.imi.hr and the remainder by e-mail (arhiv@imi.hr). Most of the submissions covered topics from toxicology.



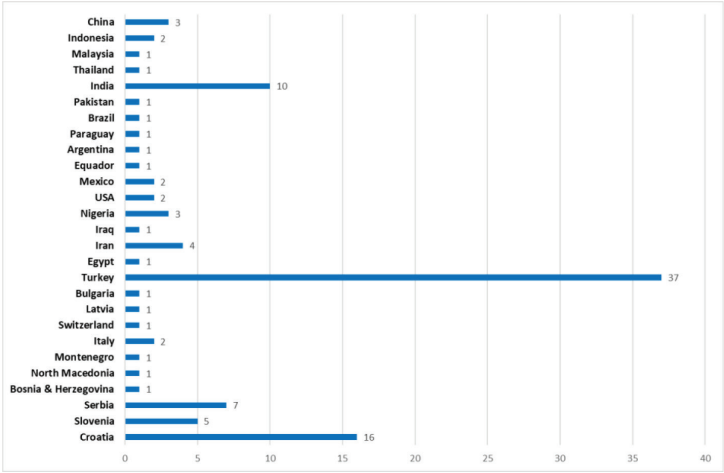
Distribution of articles submitted in 2023 according to research areas

Most of the manuscripts received (76 %) referred to original scientific papers.



Distribution of manuscripts submitted in 2023 according to article type

The manuscripts were submitted by authors from 27 different countries. The largest number of manuscripts was submitted from Turkey and Croatia.



Distribution of articles submitted in 2023 according to country of corresponding author's origin

The rejection rate was 63% (68 of 108 manuscripts received were rejected). A larger proportion (72%) was rejected due to negative reviews, and the rest by the Editor-in-Chief or Editorial Board decision because of poor quality or failure to meet the minimum criteria for review.

Each submission is screened for plagiarism by the iThenticate Plagiarism Detection Software. The contained Crossref Similarity Check is used to check the authenticity of a submission against a vast database of scientific literature published worldwide. Access to the aforementioned software system is enabled through the journal's cooperation with its online publisher Sciendo.

In 2023, four regular issues of volume 74 were published, containing articles published in four categories: Original article (25), Review/Mini-Review (5), Letter to the Editor (1), Case Report (2), Technical Paper (1).

Cover pages of all of the Archives' issues published in 2023 (Volume 74)

In addition to the mentioned manuscripts, in the 74th volume of the Archives other contributions were also published: In memoriam (1), project report (1), reports from scientific and professional meetings (8) and a report from the Annual Assembly of the Croatian Society of Toxicology. A book review was published in issue 2.

Abstracts of the symposium "Cell-Based Research in Toxicology and Drug Design" (held on January 26, 2023 in Zagreb) were published in issue 1. Abstracts of the "Indoor pollutants" symposium (held on September 8, 2023 in Zagreb) were published in issue 3. Abstracts of the International Symposium on Environmental and Molecular Toxicology of Chemicals – ToxChem2023 (held on December 7, 2023 in Zagreb) were published in issue 4.

According to the attendance on the Portal of Scientific Journals of the Republic of Croatia (HRČAK) during 2023, the Archives holds a high position in relation to other journals in the fields of biomedicine and health and the natural sciences. The total number of visits to the Archives through the HRČAK website was 4,905,194 on 2 Jan 2024.

Throughout 2023, the journal continued to operate in accordance with high standards of editorial work comparable to foreign journals. The Archives is a regular member of the Committee on Publication Ethics (COPE) and the Editors are members of the Mediterranean Editors and Translators and European Association of Science Editors (EASE).

The regular publication of the journal, and its successful operation during 2023 was achieved by the enthusiasm of the Editorial Office, and due to their large number of working hours spent in daily activities such as language and technical editing, print layout preparation, maintenance of the online submission system and manuscript management, digitalization of old volumes, and other administrative duties within the journal.

The journal is available free of charge to the foreign and domestic public through the link https://hrcak.srce.hr/aiht (all regular issues published from 1946 to the present and the most important supplements are available). Full text articles in PDF format are also available through Sciendo's service (https://content.sciendo.com/view/journals/aiht/aiht-overview.xml). Full text articles since 2020 are available on PubMed Central as well (https://www.ncbi.nlm.nih.gov/pmc/journals/3972/).

21. PRILOZI

A. OVLAŠTENJA INSTITUTA

- Ministarstvo zdravstva RH – ovlaštenje za provođenje Programa specijalističkog usavršavanja doktora medicine u području medicine rada i sporta, u dijelu programa Profesionalne bolesti, bolesti u svezi s radom i profesionalna toksikologija. Ovlaštenje od prosinca 2018. vrijedi do izdavanja novog rješenja.

Ovlaštenje od prosinca 2018. vrijedi do izdavanja novog rješenja.

- Ministarstvo gospodarstva i održivog razvoja RH – dozvola za obavljanje djelatnosti praćenja kvalitete zraka.

Ovlaštenje vrijedi do 10. prosinca 2025.

- Ministarstvo gospodarstva i održivog razvoja RH – dozvola za obavljanje djelatnosti osiguranja kvalitete mjerenja i podataka kvalitete zraka (referentni laboratorij) za metode:
  - HRN EN 12341:2014 (EN 12341:2014): Određivanje masene koncentracije PM_{10} i $PM_{2,5}$ frakcije lebdećih čestica
  - HRN EN 14902:2007 (EN 14902:2005), HRN EN 14902/AC:2007 (EN 14902:2005/AC:2006): Određivanje koncentracije Pb, Cd, As i Ni u PM_{10} frakciji lebdećih čestica
  - HRN EN 16909:2017 (EN 16909:2017): Određivanje masenih koncentracija elementnog i organskog ugljika u lebdećim česticama u vanjskom zraku
  - HRN EN 15549:2008 (EN 15549:2008): Određivanje koncentracija benzo(a)pirena u vanjskom zraku
  - HRI CEN/TR 16269:2017 (CEN/TR 16269:2011): Određivanje masenih koncentracija aniona i kationa u lebdećim česticama
  - HRS CEN/TS 16645:2016 (CEN/TS 16645:2014): Određivanje koncentracija benzo(a)antracena, benzo(b)fluorantena, benzo(j)fluorantena, benzo(k)fluorantena, dibenzo(a,h)antracena, indeno(1,2,3-cd)pirena i benzo(ghi)perilena u vanjskom zraku
  - HRN EN 16913:2017 (EN 16913:2017): Određivanje masenih koncentracija aniona i kationa u lebdećim česticama $PM_{2,5}$ sakupljenim taloženjem na filtrima.

Ovlaštenje vrijedi do 10. prosinca 2025.

- Ministarstvo unutarnjih poslova, Ravnateljstvo civilne zaštite – ovlaštenje za obavljanje poslova radiološke sigurnosti:
  - mjerenje operativnih dozimetrijskih veličina potrebnih za procjenu osobnog vanjskog ozračenja osoba
  - redovito godišnje ispitivanje zatvorenih radioaktivnih izvora i/ili električnih uređaja koji proizvode ionizirajuće zračenje u medicinskim djelatnostima i ispitivanje zatvorenih radioaktivnih izvora i/ili električnih uređaja koji proizvode ionizirajuće zračenje u nemedicinskim djelatnostima te davanje mišljenja na osnovi mjerenja i proračuna
  - radiološki nadzor mjesta rada i ispitivanje uvjeta rada te izrada dokumenata iz kojih je vidljivo udovoljava li radni okoliš, prostorije i uvjeti rada propisanim uvjetima radiološke sigurnosti
  - ispitivanje i praćenje vrste i aktivnosti radioaktivnih tvari u zraku, tlu, moru, rijekama, jezerima, podzemnim vodama, oborinama, vodi za piće, hrani i potrošačkim proizvodima i
  - ispitivanje koncentracije radona i radonovih potomaka u zraku.

Ovlaštenje vrijedi do 10. prosinca 2025.

- Ministarstvo poljoprivrede RH – ovlaštenje za obavljanje analiza: hrana, hrana za životinje, prirodna mineralna, prirodna izvorska i stolna voda. Ovlaštenje od travnja 2016. vrijedi do izdavanja novog rješenja.

B. SURADNE USTANOVE

Sporazumi o suradnji

RED. BR.	NAZIV USTANOVE	GODINA POTPISIVANJA
1.	Institut za istraživanje i razvoj održivih eko sustava	2005.
2.	Medicinski fakultet Sveučilišta J. J. Strossmayera u Osijeku	2013.
3.	Sveučilište u Rijeci	2013.
4.	Sveučilište u Zagrebu	2013.
5.	Grad Zagreb	2014.
6.	Institut „Jožef Stefan"	2014.
7.	Nastavni zavod za javno zdravstvo „Dr. Andrija Štampar"	2014.
8.	Sveučilište u Mostaru	2014.
9.	Sveučilište u Zadru	2014.
10.	Veterinarski fakultet Univerziteta u Sarajevu	2014.
11.	Hemijski fakultet Univerziteta u Beogradu	2015.
12.	Hrvatski zavod za javno zdravstvo	2015.
13.	Institut za fiziku	2015.
14.	Ministarstvo unutarnjih poslova RH	2015.
15.	Agencija za lijekove i medicinske proizvode RH	2016.
16.	Ericsson Nikola Tesla d. d.	2016.
17.	Klinički bolnički centar Zagreb	2016.
18.	Rudarsko-geološko-naftni fakultet Sveučilišta u Zagrebu	2016.
19.	Sveučilište Sjever	2016.
20.	Grad Kaštela	2017.
21.	Nuklearna elektrana Krško	2017.
22.	Institut za hemiju, tehnologiju i metalurgiju, Beograd, Srbija	2018.
23.	Metalurški fakultet Sveučilišta u Zagrebu, Sisak	2018.
24.	Prirodno-matematički fakultet Univerziteta u Novom Sadu, Srbija	2018.
25.	Prirodno-matematički fakultet Univerziteta u Sarajevu, BiH	2018.
26.	Sveučilište Jurja Dobrile u Puli	2018.
27.	Javna ustanova „Park prirode Medvednica"	2018.
28.	Institut za higijenu i tehnologiju mesa, Beograd, Srbija	2018.
29.	AVANCO d. o. o.	2019.
30.	Prehrambeno-tehnološki fakultet Sveučilišta J. J. Strossmayera u Osijeku	2019.
31.	Medicinski fakultet Sveučilišta u Zagrebu	2019.
32.	Javna ustanova „Park prirode Kopački rit"	2019.
33.	Agronomski fakultet Sveučilišta u Zagrebu	2020.
34.	Fakultet medicinskih znanosti, Univerzitet „Goce Delčev", Štip, Sjeverna Makedonija	2020.
35.	Hrvatski geološki institut, Zagreb	2020.
36.	Prirodoslovno-matematički fakultet Sveučilišta u Zagrebu	2020.
37.	Veterinarski fakultet Sveučilišta u Zagrebu	2020.
38.	Visoka škola Ivanić-Grad	2020.
39.	Institut za jadranske kulture i melioraciju krša, Split	2021.
40.	Međimursko veleučilište u Čakovcu	2021.
41.	Hrvatska agencija za poljoprivredu i hranu, Osijek	2021.
42.	Hrvatski zavod za javno zdravstvo, Zagreb	2021.
43.	Institut „Ruđer Bošković"	2021.
44.	Fakultet šumarstva i drvne tehnologije Sveučilišta u Zagrebu	2022.

45.	Farmaceutski fakultet Univerziteta u Beogradu	2023.
46.	Fakultet za dentalnu medicinu i zdravstvo Sveučilišta J. J. Strossmayera u Osijeku	2023.
47.	Srednja škola Petrinja	2023.

Ostale znanstvenoistraživačke i stručne suradnje

USTANOVE U REPUBLICI HRVATSKOJ

1. Agencija za lijekove i medicnske proizvode (HALMED)
2. Agronomski fakultet Sveučilišta u Zagrebu
3. Aquatika – slatkovodni akvarij Karlovac
4. CARNet, Zagreb
5. Državni hidrometeorološki zavod, Zagreb
6. Ekonerg d. o. o., Zagreb
7. Fakultet elektrotehnike i računarstva Sveučilišta u Zagrebu
8. Fakultet kemijskog inženjerstva i tehnologije Sveučilišta u Zagrebu
9. Fakultet šumarstva i drvne tehnologije Sveučilišta u Zagrebu
10. Fakultet zdravstvenih studija Sveučilišta u Rijeci
11. Farmaceutsko-biokemijski fakultet Sveučilišta u Zagrebu
12. Fond za zaštitu okoliša i energetsku učinkovitost, Zagreb
13. Gekom d. o. o., Zagreb
14. Hrvatska agencija za poljoprivredu i hranu, Osijek
15. Hrvatski institut za istraživanje mozga, Zagreb
16. Hrvatski judo savez, Zagreb
17. Hrvatski sindikat male privrede, obrtništva, uslužnih djelatnosti i stranih predstavništava, Zagreb
18. Hrvatski veterinarski institut, Zagreb
19. Hrvatski zavod za javno zdravstvo, Zagreb
20. Institut „Ruđer Bošković", Zagreb
21. Institut za antropologiju, Zagreb
22. Jamnica plus d. o. o.
23. Kaznionica u Lepoglavi
24. Klinička bolnica Merkur, Zagreb
25. Klinički bolnički centar „Sestre milosrdnice", Zagreb
26. Klinički bolnički centar Osijek
27. Klinički bolnički centar Zagreb (KBC Zagreb)
28. Klinika za dječje bolesti, Zagreb
29. Klinika za ženske bolesti i porode, KBC Zagreb
30. Medicinski fakultet Sveučilišta u Rijeci
31. Medicinski fakultet Sveučilišta u Zagrebu
32. Ministarstvo gospodarstva i održivog razvoja RH, Zagreb
33. Ministarstvo unutarnjih poslova RH, Ravnateljstvo civilne zaštite, Sektor za radiološku i nuklearnu sigurnost
34. Nastavni zavod za javno zdravstvo „Dr. Andrija Štampar", Zagreb
35. Nastavni zavod za javno zdravstvo Primorsko-goranske županije, Rijeka
36. Nezavisni sindikat znanosti i visokog obrazovanja, Zagreb
37. Odgojni zavod Turopolje, Velika Gorica
38. Odjel za biotehnologiju Sveučilišta u Rijeci
39. Petrokemija d. d., Kutina
40. Prehrambeno-biotehnološki fakultet Sveučilišta u Zagrebu
41. Prehrambeno-tehnološki fakultet, Sveučilište J. J. Strossmayera u Osijeku
42. Prirodoslovno-matematički fakultet Sveučilišta u Splitu
43. Prirodoslovno-matematički fakultet Sveučilišta u Zagrebu
44. Sabor RH, Zagreb
45. Stomatološki fakultet Sveučilišta u Zagrebu
46. Sveučilište J. J. Strossmayera u Osijeku, Odjel za kemiju
47. Sveučilište u Zadru, Odjel za ekologiju, agronomiju i akvakulturu
48. Sveučilište u Zadru, Odjel za zdravstvene studije

49. Škola narodnog zdravlja „A. Štampar", Medicinski fakultet Sveučilišta u Zagrebu
50. Veterinarski fakultet Sveučilišta u Zagrebu
51. Zavod za javno zdravstvo Brodsko-posavske županije, Slavonski Brod
52. Zavod za javno zdravstvo Istarske županije, Pula
53. Zavod za javno zdravstvo Koprivničko-križevačke županije, Koprivnica
54. Zavod za javno zdravstvo Osječko-baranjske županije, Osijek
55. Zavod za javno zdravstvo Zadarske županije, Zadar

USTANOVE U INOZEMSTVU

1. Academic Medical Centre, Amsterdam, Nizozemska
2. Backweston Laboratory Campus, Ministarstvo poljoprivrede, hrane i pomorstva Republike Irske
3. Bundesamt fur Strahlenschutz, Salzgitter, Njemačka
4. Center of Drug Absorption and Transport, Institute of Pharmacology, University of Greifswald, University of Medicine, Greifswald, Njemačka
5. Department of Biology and Pharmaceutical Botany, Medical University of Łódź, Łódź, Poljska
6. Faculty of Science, University of Hradec Králové, Češka
7. Fakulteta za kemijo in kemijsko tehnologijo Univerza v Ljubljani, Slovenija
8. Florida State University, Tallahassee, FL, SAD
9. Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Njemačka
10. Helmholtz Zentrum München Deutsches Forschungszentrum für Gesundheit und Umwelt, München, Njemačka
11. Hemijski fakultet Univerziteta u Beogradu, Beograd, Srbija
12. Hungarian Institute for Public Health, Budimpešta, Mađarska
13. Institut de Recherche Biomédicale des Armées, Brétigny-sur-Orge cedex, Francuska
14. Institut für Chemie, Universität Graz, Austrija
15. Institut für Physikalische und Theoretische Chemie, Technische Universität Graz, Graz, Austrija
16. Institut für Soziale Ökologie, Alpen-Adria-Universität Klagenfurt, Austrija
17. Institut za fiziku Univerziteta u Beogradu, Beograd, Srbija
18. Institut za hemiju, tehnologiju i metalurgiju, Univerzitet u Beogradu, Beograd, Srbija
19. Institute for Nuclear Research, Hungarian Academy of Sciences, Debrecen, Mađarska
20. Institute of Basic Medical Sciences, University of Oslo, Oslo, Norveška
21. Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic, Prag, Češka
22. Institute of Nature Conservation of Polish Academy of Sciences, Krakow, Poljska
23. Institute of Organic Chemistry and Biochemistry of the CAS, Prag, Češka
24. Instituto de Medicina Molecular, Faculdade de Medicina, Universidade de Lisboa, Lisabon, Portugal
25. Inštitut za biokemijo, Medicinska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija
26. Inštitut za patološko fiziologijo, Medicinska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija
27. International Atomic Energy Agency, Beč, Austrija
28. Joint Research Centre of the European Commission, Bruxelles, Belgija
29. Max Planck Institute for Chemistry, Njemačka
30. Nacionalni inštitut za biologijo, Ljubljana, Slovenija
31. Nacionalni inštitut za kemiju, Ljubljana, Slovenija
32. NILU – Norwegian Air Research Institute, Norveška
33. NMR laboratórium, Pannon Egyetem, Veszprém, Mađarska
34. Normandie Univ, UNIROUEN, INSA Rouen, CNRS, COBRA (UMR 6014), Rouen, Francuska
35. Paul Scherrer Institute, Švicarska
36. Prirodno-matematički fakultet, Univerzitet u Kragujevcu, Srbija
37. Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Peking, Kina
38. Tehnološki fakultet, Sveučilište u Novom Sadu, Novi Sad, Srbija
39. The Scripps Institute of Science, CA, SAD
40. Udruženje toksikologa Srbije, Beograd, Srbija
41. Uhasselt University Belgium, Campus Diepenbeek, Agoralaan Gebouw H, Diepenbeek, Belgija
42. Umweltbundesamt (UBA), Langen, Njemačka
43. Universidad Autónoma de Tlaxcala, Universidad Nacional Autónoma de México, Meksiko
44. Universität Osnabrück, Osnabrück, Njemačka

45. Universitätsklinikum Hamburg-Eppendorf (UKE), Hamburg, Njemačka
46. University of California at San Diego, La Jolla, CA, SAD
47. University of Melbourne, Melbourne, Victoria, Australia
48. University of Rouen, Mont-Saint-Aignan, Francuska
49. University of Strasbourg, Strasbourg, Francuska
50. Univerzita Hradec Králové, Hradec Králové, Češka
51. VITO – Flemish Institute for Technological Research, Belgija
52. VVM – Flemish Environment Agency

C. PRIHODI INSTITUTA

RED.BR.	VRSTA PRIHODA	IZNOS (EUR)	%
I	**PRIHODI IZ DRŽAVNOG PRORAČUNA**	**6.400.136**	**47,66**
1	Plaće i rashodi za zaposlene	4.441.506	33,08
2	Programsko financiranje Instituta	509.787	3,80
3	Nacionalno sufinanciranje Projekta REC-IMI i konstrukcijske obnove	1.011.667	7,53
4	Bilateralni projekti	8.495	0,06
5	Potpore za prijavu projekata, održavanje znanstvenih skupova, popularizaciju znanosti i izdavanje časopisa	25.465	0,19
6	Projekti i doktorandi Hrvatske zaklade za znanost	403.216	3,00
II	**PRIHODI OD PRUŽENIH USLUGA NA TRŽIŠTU**	**1.521.961**	**11,33**
7	DHMZ – Program mjerenja razine onečišćenosti u Državnoj mreži	449.934	3,35
8	Gradski ured za gospodarstvo, energetiku i zaštitu okoliša, Zagreb	211.244	1,57
9	Klinički bolnički centar Zagreb	104.504	0,78
10	Ministarstvo unutarnjih poslova RH, Zagreb	64.111	0,48
11	Klinički bolnički centar "Sestre milosrdnice", Zagreb	71.595	0,53
12	Zagrebačke otpadne vode d. o. o., Zagreb	54.231	0,40
13	Klinička bolnica Dubrava, Zagreb	40.332	0,30
14	Nuklearna elektrana Krško	33.000	0,25
15	Eurofins Croatiakontrola Zagreb	33.247	0,25
16	Hrvatski zavod za zdravstveno osiguranje, Zagreb	22.660	0,17
17	CARnet - Hrvatska akademska i istraživačka mreža, Zagreb	96.888	0,72
18	HEP Proizvodnja	13.876	0,10
19	European Commision	18.700	0,14
20	Međunarodna zračna luka Zagreb d. d.	14.807	0,11
21	Zagrebački holding d. o. o. Zagreb	14.361	0,11
22	Opća bolnica Varaždin	22.499	0,17
23	Rockwool Adriatic	9.508	0,07
24	Zavod za javno zdravstvo Brodsko posavske županije	10.560	0,08
25	Opća bolnica Šibensko kninske županije	10.162	0,08
26	Nexe d. d. Našice cement	12.068	0,09
27	Ispitivanje i mjerenje radioaktivnosti uzoraka	33.084	0,25
28	Ocjena ekološke prikladnosti objekata	16.582	0,12
29	Dozimetrija izvora zračenja	120.342	0,90
30	Laboratorijske usluge (pacijenati)	20.555	0,15
31	Laboratorijske analize i toksikološke ocjene uzoraka	20.375	0,15
32	Pretplata *Arhiv*	2.736	0,02
III	**PRIHODI OSTVARENI IZ OSTALIH IZVORA**	**5.505.695**	**41,00**
33	Prihodi iz EFRR, FSEU i NPOO za financiranje projekta REC-IMI, konstrukcijsku obnovu središnje i sjeverne zgrade i programsko financiranje	5.085.875	37,88
34	EU projekti	189.920	1,41
35	Međunarodni projekti	77.606	0,58
36	Donacije	88.560	0,66
37	Prihodi od dividendi, kamata i pozitivnih tečajnih razlika	12.372	0,09
38	Refundacije troškova	47.445	0,35
39	Ostali prihodi i sufinanciranje troškova	3.917	0,03
I+II+III	**UKUPNI PRIHOD**	**13.427.792**	**100,00**

D. PUBLIKACIJE DJELATNIKA INSTITUTA U 2023. GODINI

KATEGORIJA PUBLIKACIJE	BROJ RADOVA
D.1. Znanstveni, pregledni i stručni radovi (+ prihvaćeni za objavu u 2024.)	**103 (+11)**
Radovi u časopisima indeksiranim u bazi *WoS*	101
Radovi u časopisima indeksiranim u bazi *WoS* prihvaćeni za objavu u 2024.	11
Radovi u časopisima indeksiranim u ostalim bazama	0
Radovi u neindeksiranim časopisima	0
Radovi u zbornicima skupova održanih u RH i virtualno	2
Radovi u zbornicima skupova održanih u inozemstvu i virtualno	0
D.2. Knjige, časopisi, zbornici	**11**
Autor ili urednik knjige	0
Rad ili poglavlje u knjizi	2
Urednik časopisa ili zbornika	9
D.3. Ostale publikacije	**8**
Tiskana izdanja	4
Elektronička izdanja	4
D.4. Kvalifikacijski radovi	**13**
Radovi djelatnika Instituta	3
Radovi pristupnika s mentorom/sumentorom na Institutu	10
D.5. Kongresna priopćenja na skupovima održanim u RH i virtualno	**105**
Sažetci u časopisima indeksiranim u bazi *WoS*	29
Sažetci u ostalim časopisima i knjigama sažetaka	74
Sažetci u elektroničkom izdanju	2
D.6. Kongresna priopćenja na skupovima održanim u inozemstvu i virtualno	**63**
Sažetci u časopisima indeksiranim u bazi *WoS*	15
Sažetci u elektroničkom izdanju u časopisu indeksiranom u bazi WoS	1?
Sažetci u ostalim časopisima i knjigama sažetaka	45
Sažetci u elektroničkom izdanju	2
D.7. Izvještaji stručne djelatnosti	**22**
Nacionalni projekti, ugovori i suradnje	20
Međunarodni projekti, ugovori i suradnje	2
UKUPAN BROJ RADOVA OBJAVLJENIH U 2023. (+ prihvaćenih za objavu u 2024.)	**325 (+11)**

D1. ZNANSTVENI, PREGLEDNI I STRUČNI RADOVI

Radovi u časopisima indeksiranim u bazi WoS

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3. BAMPIDIS V, AZIMONTI G, BASTOS MD, CHRISTENSEN H, DUSEMUND B, DURJAVA MF, KOUBA M, LÓPEZ-ALONSO M, PUENTE SL, MARCON F, MAYO B, PECHOVÁ A, PETKOVA M, RAMOS F, SANZ Y, VILLA RE, WOUTERSEN R, AQUILINA G, SVENSSON K, ŽELJEŽIĆ D, ANGUITA M, BROZZI R, GALOBART J, ORTUÑO J, PIZZO F, REVEZ J, TARRÉS-CALL J, PETTENATI E. Safety and efficacy of the feed additive consisting of 6-phytase (produced by *Aspergillus oryzae* DSM 33699) (RONOZYME® Hiphos GT/L) for poultry, pigs for fattening, weaned piglets and sows (DSM Nutritional Products Ltd). EFSA J 2023;21(1):e07698. (znanstveni rad, Q2)
4. BAMPIDIS V, AZIMONTI G, BASTOS MD, CHRISTENSEN H, DUSEMUND B, DURJAVA M, KOUBA M, LÓPEZ-ALONSO M, PUENTE SL, MARCON F, MAYO B, PECHOVÁ A, PETKOVA M, RAMOS F, SANZ Y, VILLA RE, WOUTERSEN R, BORIES G, GROPP J, MARTELLI G, SVENSSON K, ŽELJEŽIĆ D, ANGUITA M, CASANOVA JO, GALOBART J, HOLCZKNECHT O, INNOCENTI ML, MANINI P, PETTENATI E, VETTORI MV, PIZZO F. Safety and efficacy of a feed additive consisting of 25-hydroxycholecalciferol (produced by *Pseudonocardia autotrophica* DSM 32858) for all pigs, all poultry for fattening and ornamental birds and other poultry species (Huvepharma NV). EFSA J 2023;21(6):e08050. (znanstveni rad, Q2)
5. BANKOGLU EE, CHAPMAN F, GERIĆ M. EEMGS New Investigators: rising stars in environmental mutagenesis. Mutagenesis 2023;38:1-2. (**editorial Q2, Q3**)
6. BEBEK MARKOVINOVIĆ A, MILOŠEVIĆ S, TESLIĆ N, PAVLIĆ B, PUTNIK P, BRČIĆ KARAČONJI I, JURICA K, LASIĆ D, BURSAĆ KOVAČEVIĆ D. Development of a pressurized green liquid extraction procedure to recover antioxidant bioactive compounds from strawberry tree fruit (*Arbutus unedo* L.). Plants 2023;12:2006. (znanstveni rad, Q1)
7. BENKOVIĆ V, MILIĆ M, ORŠOLIĆ N, HORVAT KNEŽEVIĆ A, BROZOVIĆ G, BOROJEVIĆ N. Brain DNA damaging effects of volatile anesthetics and 1 and 2 Gy gamma irradiation *in vivo*: Preliminary results. Toxicol Ind Health 2023;39:67-80. (znanstveni rad, Q4)
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9. BEUS M, PONGRAC IM, CAPJAK I, ILIĆ K, VRČEK E, ĆURLIN M, MILIĆ M, MARJANOVIĆ ČERMAK AM, PAVIČIĆ I. Particle surface functionalization affects mechanism of endocytosis and adverse effects of silver nanoparticles in mammalian kidney cells. J Appl Toxicol 2023;43:416-30. (znanstveni rad, Q2)
10. BJORVATN B, MERIKANTO I, REIS C, KORMAN M, KOSĆEC BJELAJAC A, HOLZINGER B, DE GENNARO L, WING YK, MORIN CM, ESPIE CA, BENEDICT C, LANDTBLOM AM, MATSUI K, HRUBOS-STRØM H, MOTA-ROLIM S, NADORFF MR, PLAZZI G, CHAN RNY, PARTINEN M, DAUVILLIERS Y, CHUNG F, FORTHUN I. Shift workers are at increased risk of severe COVID-19 compared with day workers: Results from the International COVID Sleep Study (ICOSS) of 7141 workers. Chronobiol Int 2023;40:114-22. (znanstveni rad, Q2)
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15. CVIJETIC S, MACAN J, BOSCHIERO D, ILICH JZ. Body fat and muscle in relation to heart rate variability in young-to-middle age men: a cross sectional study. Ann Hum Biol 2023;50:108-16. (znanstveni rad, Q3)
16. ČAVLOVIĆ AO, BEŠLIĆ I, PERVAN S, PREKRAT S. Characteristics of thermally modified hardwood dust in determining workers' occupational exposure. BioResources 2023;18:3923-37. (znanstveni rad, Q2)
17. DOBAJA BORAK M, BABIĆ Ž, CAGANOVA B, GRENC D, KARABUVA S, KOLPACH Z, KRAKOWIAK A, KOLESNIKOVA V, LUKŠIĆ B, PAP C, PULJIZ I, PIEKARSKA-WIJATKOWSKA A, RADENKOVA-SAEVA J, VUČINIĆ S, ZACHAROV S, EDDLESTON M, BRVAR M. Viper envenomation in Central and Southeastern Europe: a multicentre study. Clin Toxicol (Phila) 2023;61:656-64. (znanstveni rad, Q2)
18. DOLANC I, FERHATOVIĆ HAMZIĆ L, ORCT T, MICEK V, ŠUNIĆ I, JONJIĆ A, JURASOVIĆ J, MISSONI S, ČOKLO M, KRALJEVIĆ PAVELIĆ S. The impact of long-term clinoptilolite administration on the concentration profile of metals in rodent organisms. Biology 2023;12:193. (znanstveni rad, Q1)
19. DOMIJAN A-M, HERCOG K, ŠTAMPAR M, GAJSKI G, GERIĆ M, SOKOLOVIĆ M, ŽEGURA B. Impact of deoxynivalenol and zearalenone as single and combined treatment on DNA, cell cycle and cell proliferation in HepG2 cells. Int J Mol Sci 2023;24:4082. (znanstveni rad, Q1)
20. DREVENKAR V, MENDAŠ G. Environmental monitoring and analysis of persistent organic pollutants. Toxics 2023;11:535. (editorial, Q1)
21. ERCEG I, STRASSER V, SOMERS N, JURKOVIĆ M, KONTREC J, KRALJ D, BARBIR R, VINKOVIĆ VRČEK I, LASGORCEIX M, LERICHE A, DUTOUR SIKIRIĆ M. Insight into the interactions of albumin with TiO_2 nanomaterials and calcium phosphate-based biomaterials by kinetic adsorption and spectroscopic studies. J Mol Liq 2023;383:122122. (znanstveni rad, Q1)
22. FRANIĆ Z, LJUBOJEVIĆ HADŽAVDIĆ S, BABIĆ Ž, MACAN J. Incidence and prevalence of occupational contact dermatitis in hairdressing apprentices: A 3-year prospective cohort study. Contact Dermatitis 2023;89:153-60. (znanstveni rad, Q1)
23. FUČIĆ A, KNEŽEVIĆ J, KRASIĆ J, POLANČEC D, SINČIĆ N, SINDIČIĆ DESSARDO N, STARČEVIĆ M, GUSZAK V, CEPPI M, BRUZZONE M. Interleukin-2 gene methylation levels and interleukin-2 levels associated with environmental exposure as risk biomarkers for preterm birth. Croat Med J 2023;64:320-8. (znanstveni rad, Q3)
24. FUČIĆ A, MANTOVANI A, VENA J, BLOOM MS, SINCIC N, VAZQUEZ M, AGUADO-SIERRA J. Impact of endocrine disruptors from mother's diet on immuno-hormonal orchestration of brain development and introduction of the virtual human twin tool. Reprod Toxicol 2023;117:108357. (znanstveni rad, Q2)
25. GAJSKI G, GERIĆ M, JAKAŠA I, PEREMIN I, DOMIJAN A-M, VUČIĆ LOVRENČIĆ M, KEŽIĆ S, BITUH M, MORAES DE ANDRADE V. Inflammatory, oxidative and DNA damage status in vegetarians: is the future of human diet green? Crit Rev Food Sci Nutr 2023;63:3189-221. (znanstveni rad, Q1)
26. GAJSKI G, MATKOVIĆ K, DELIĆ L, GERIĆ M. Evaluation of primary DNA damage in young healthy females based on their dietary preferences. Nutrients 2023;15:2218. (znanstveni rad, Q1)
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32. HERCEG ROMANIĆ S, JAĆIMOVIĆ N, MENDAŠ G, FINGLER S, STIPIČEVIĆ S, JAKŠIĆ G, POPOVIĆ A, JOVANOVIĆ G. Bedload sediment transport model for revealing the multi-year trend of polychlorinated biphenyl contamination in the river sediment (Kupa, Croatia). Environ Geochem Health 2023;45:8473-87. (znanstveni rad, Q1)
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D.6. KONGRESNA PRIOPĆENJA NA SKUPOVIMA ODRŽANIM U INOZEMSTVU

***Sažetci u časopisima indeksiranim u bazi* WoS**

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