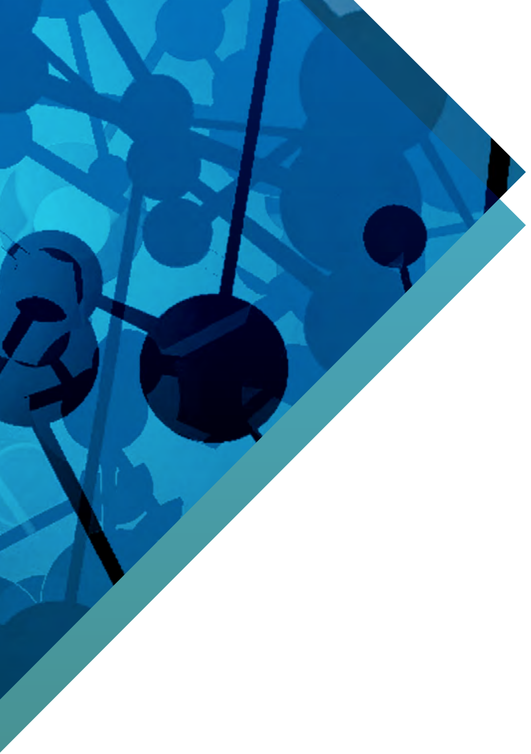

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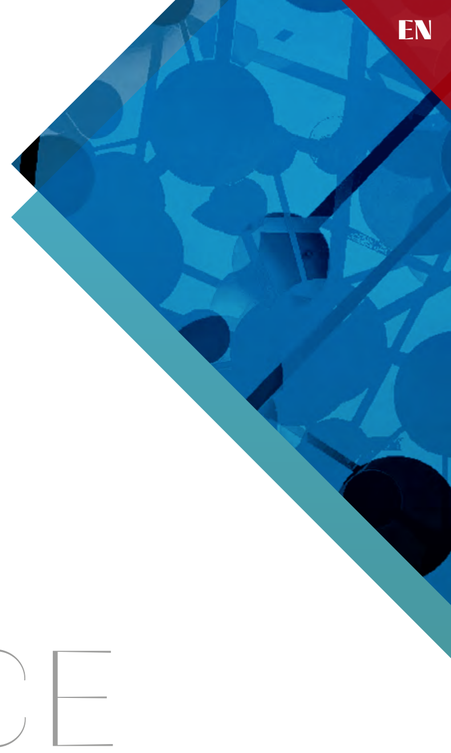
2021 EXCELLENCE IN SCIENCE

SLOVAK RESEARCH AND DEVELOPMENT AGENCY

MINISTRY OF EDUCATION, SCIENCE, RESEARCH AND SPORT OF THE SLOVAK REPUBLIC



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Published in 2024 EXCELLENCE IN SCIENCE

Published in 2024

EXCELLENCE IN SCIENCE

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FOREWORD

Dear friends,
we feel honoured to invite you to read the egihth publication The Excellence in Science by which the Agency presents the implementation of projects achieving outstanding level. The publication should meet the needs of everybody who is interested in finding more information on research support in Slovakia.

The publication informs about the implementation and results of several years lasting work of Slovak experts on projects from 2019 up to 2023 in the basic and applied research of natural, technical medical, agricultural, social sciences and humanities. Of course, the publication and its content cannot compete with the electronic sources of latest information that are much faster and updated. However, it definitely has certain positives, it enabled us to sum up all the activities conducted by project teams and co-operating institutions within a scientific community in Slovakia. As we have already published the eighth publication, we believe it can clearly present the progress achieved in particular fields of science in which the projects presented in this publication ware implemented.

Since its establishment the Slovak Research and Development Agency has been a significant part of the state aid for basic and applied research and development in Slovakia. We are very pleased by the fact you can hardly find anyone from research and development that does not know the name of our Agency. However, it remains our goal to improve every year and support more projects that end up at an excellent level of solution.

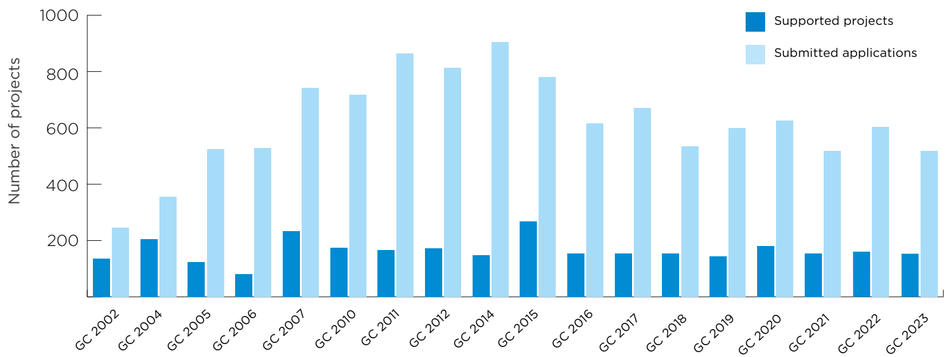
Finally, our deepest thank you belongs to all solvers of the projects presented in the publication as well as to those who contributed to the preparation of the eighth publication of the research projects with excellent level 2024.

JUDr. Stanislav Mydlo
Director

Dr. Ing. Robert Mistrík
Chairperson

INTRODUCTION

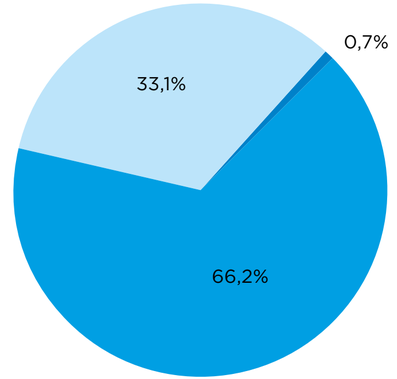
Summary of applications submitted and supported projects in the general calls in the years 2002 – 2023



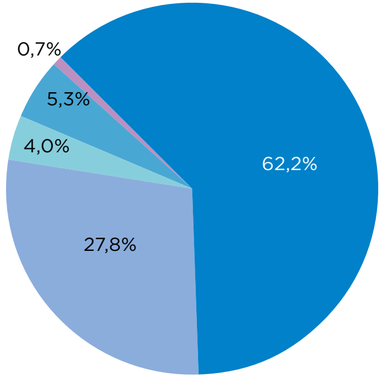
Department of Science and Technology	Registered applications	Financed projects	Success Rate (%)
Natural sciences	99	32	32,3%
Technical sciences	195	53	27,2%
Medical sciences	59	15	25,4%
Agricultural sciences	64	17	26,6%
Social sciences	73	22	30,1%
Humanities	37	12	32,4%
Total	527	151	28,7%

Success rate of applications supported by GC 2018 as per scientific departments.

The projects presented in this publication have been submitted within the general call to the Slovak Research and Development Agency marked GC 2018. General Call GC 2018 had no limitations on the substantive focus of the projects. Specific focus, objectives and contents of the research and development were determined by the applicants themselves. Applications could be submitted by legal entities as well as natural persons – entrepreneurs without limitation as per sector of research and development. 527 applications for funding were received and registered as part of the general call GC 2018, in order to resolve research and development projects and 151 applications were supported. Start of the project solution was 1. 7. 2019. Latest date of completion of project solutions was 30. 6. 2023. In 2023 subsequently completed projects were evaluated by different scientific councils on the basis of the final reports on projects submitted by the principal investigator within 30 days of the end of solution.
In this publication the Slovak Research and Development Agency presents the selection of the most successful completed and subsequently evaluated projects from the general call GC 2018 in all sectors of Slovak science and technology.



Percentage rate of projects supported as per the nature of the research



Breakdown of funded projects as per sector

NATURAL SCIENCES

Uncertainty modelling: extensions and generalizations of some particular methods and applications

Principal investigator
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Applicant organisation
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Term of solution
07/2019 - 06/2023
Budget from agency
180 000 €
Project ID
APVV-18-0052

Research Subject

Project was focused on extensions and generalizations of some special methods in uncertainty modelling and on some applications. Besides the study of aggregation on lattices and investigations and constructions of special classes of functions with modified properties, project was focused on copulas and quasi-copulas. Also a detailed study of integral-based aggregation functions was involved, as well as the study of implicitly given aggregation functions. The applied part of project was focused on image processing, time series modelling and scientometric evaluations.

Aim of the Research

The goals and aims of the proposed project can be shortly described as follows: Development of implicitly given aggregation functions and related functions; New construction methods for copulas, and quasi-copulas; Deep study of aggregation on Riesz spaces, including integral-based methods; Construction methods for aggregation and related functions on particular lattices; New construction methods for (pre-)aggregation functions and (pre)-implications; Generalization of functions related to special properties; A detailed study of integral-based aggregation functions; Applications in image processing, time series modelling and scientometric evaluations.

Achieved Results

Our project was focused on uncertainty modelling and its application. The working plan was divided into 8 stages, see above. All our aims and goals were successfully realized, and in several cases even significantly exceeded. This claim is supported by over 100 papers published in distinguished journals evaluated in WoS database. One should mention also a growing number of citations. Actually, our results have obtained over 200 citations covered in Google Scholar database. Among our most distinguished results, recall first a complete parametric description of 5-order (the first non-trivial case) polynomial 2-copulas. In an important extension of Bonferroni's approach to aggregation we have prepared a basis for a better criteria interaction modelling. We have significantly moved and enlarged the tools for uncertainty modelling dealing with BUI granules (x,c). In the project framework, we have proposed and applied several construction methods for copulas, implications and other special functions on different scales. New types of properties we have introduced, such as new monotonicity properties, expand the modelling abilities, with several applications already realized. E.g., our directional monotonicity is a theoretical background for some image processing methods, which were later applied in medicine (e.g., MMR issues). Note also that our paper on expected values of intuitionistic fuzzy sets was awarded as the best IJGS paper for the year 2021.

Benefits for Practise

Our new results cover several domains of uncertainty modelling and application. Results dealing with copulas and related topics have already several quotations and positive reactions in the statistical modelling where the observed values correspond to the realizations of random vectors. As one of our inspiring ideas we mention the correlation matrices. Standard, they are based on pairwise Pearson's correlations. Our original approach deals with rank-dependent parameters, such as Kendall's tau and Spearman's rho. The next important domain considering our results concerns multicriterial decision support. Several of our constructions lead to the flexible utility functions not only in the case of standard real-valued scales, but also in new types of scales, such as linguistic, interval, intuitionistic and related scales, but also when dealing with BUI (Basic Uncertainty Information) scales proposed and studied in some of our papers. Several our results with positive reaction concern lattice-valued scales. A substantial part of our results concerns generalized integrals. Their applications were realized in the domain of optimization and decision based on decomposition integrals, integrals on bipolar scales, etc. Application of our results from the domains of t-norms, uninorms and related operations on different scales have a big potential in the area of many-valued logics, in expert systems and in evaluation systems. Though the majority of our original results belong to the basics of mathematics, their orientation is and will be frequently exploited in information sciences. This fact is documented by distinguished journals presenting our res, such as InfFus, INS, IJAR, IJGS, IEEE TFS, ESA, etc.

Fig. 1 / Original images in RGB and their corresponding segmented images

Fig. 2 / Structure of the truncated function <Π,M>[θ] given by for the parameters θ

Fig. 3 / Ultimate utility values of options for different sets of criteria weights

Fig. 1

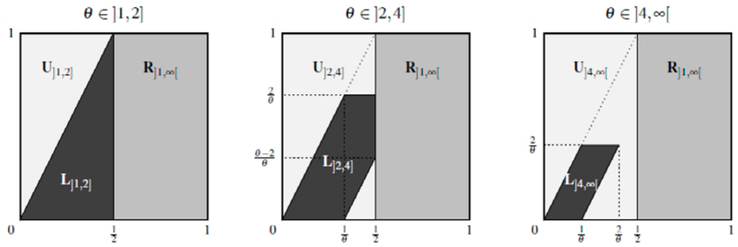

Fig. 2

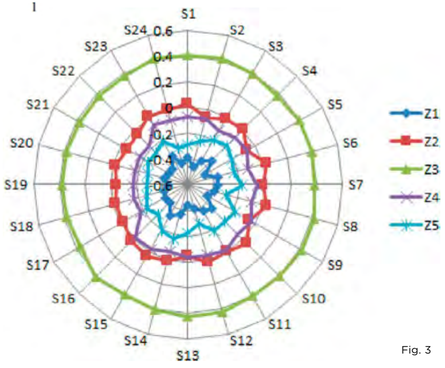

Fig. 3

Co-transcriptional folding of pre-mRNA, model of structural motifs required for exon definition

Principal investigator
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Applicant organisation
Centre of Biosciences SAS
Participating organisation
Slovak Academy of Sciences, Institute of Chemistry
Term of solution
07/2019 - 06/2023
Budget from agency
178 954 €
Project ID
APVV-18-0096

Research Subject

Ribonucleic acid (RNA) plays an important role in the regulation of gene expression and evolution. Unlike deoxyribonucleic acid (DNA), the RNA molecule is single-stranded and can form complex structural forms with regulatory roles within many cellular processes. In eukaryotic cells, RNA undergoes many post-transcriptional modifications, including the most complex pre-messenger RNA (pre-mRNA) splicing. It is a highly dynamic process that removes non-coding sequences (introns) from the primary transcript. Subsequent ligation of protein-coding segments (exons) creates mRNA, which transfers genetic information about the sequence of amino acids from DNA to the site of protein synthesis. RNA splicing contributes significantly to transcriptome and protein diversity (Fig. 1) however its disruption, for example, due to a mutation in the splicing site or regulatory sequence, often underlies the development of various human disorders. Despite the essential position of RNA splicing in gene expression, the mechanism of exon selection is still not fully understood.

Aim of the Research

In this project, we aimed to elucidate the dynamics of conformational changes that occur in pre-mRNA to determine the structural RNA motifs crucial for exon definition. To fulfill the aim, we employed a range of state-of-the-art cellular, genetic, biochemical, biophysical, and computational techniques (Fig. 2).

Achieved Results

To define the mechanism by which pre-mRNA achieves the structure necessary for its efficient splicing, we used as a model the F8Alu exon. A mutation associated with hemophilia resulted in the inclusion of this exon into the primary transcript of the human *F8* gene. The exon is derived from *Alu* retrotransposons, mobile sequences that are present in the genome of all primates and contribute significantly to the coding variability of mRNA. The *Alus* can be exonized because they are localized in the intronic regions of genes, and only a minimal number of nucleotide changes are required for their inclusion in the primary transcript (Fig. 3). However, their presence in mRNA can also lead to the production of a non-functional protein with pathological consequences. *Alu* RNAs form a specific RNA structure essential for SRP9/14 protein heterodimer binding. This interaction assists in the formation of the RNA conformation, which is critical for Alu RNA's proper function in many cellular processes. Our results demonstrated that this complex is also essential in the splicing regulation of Alu-derived exons. Moreover, we have shown that this process can be modulated by interaction with RNA helicase DHX9. This enzyme is involved in the modulation of the secondary structure of RNA, for example, in the processes of translation, ribosome formation, or RNA splicing.

Benefits for Practise

The project has the character of basic research. The output includes six original papers in scientific journals with a high impact factor. The published results contribute to the knowledge mainly in molecular and evolutionary biology, providing a unique insight into the mechanisms of RNA structure formation, which is crucial for RNA splicing regulation. Our retrospective analysis of the succession of changes required for the exonization process of F8Alu may help to understand splicing regulatory motifs and their interactions with protein/RNA partners. Modeling of the splicing code based on these data may facilitate the development of reliable *in silico* prediction tools to identify splicing-affecting mutations in genetic diagnostics.

Fig. 1 / Constitutive RNA splicing is the process of removing introns and ligation of exons in the order in which they occur in the gene (A). Alternative splicing is an alteration from this process when some exons are skipped. It leads to the expression of alternative forms of mature RNA that allow the production of variable proteins encoded by a single gene (B).

Fig. 2 / Schematic representation of the basic methodological procedures used in the project.

Fig. 3 / During primate evolution, the exonization of the *Alu* sequence (left) was allowed by mutations that impair the formation of the *Alu-specific* three-dimensional structure (right) promoted by the interaction of SRP9/14 heterodimer. The process of exonization is associated with a reduction in SRP9/14 binding and an increase in dependence on DHX9 helicase.

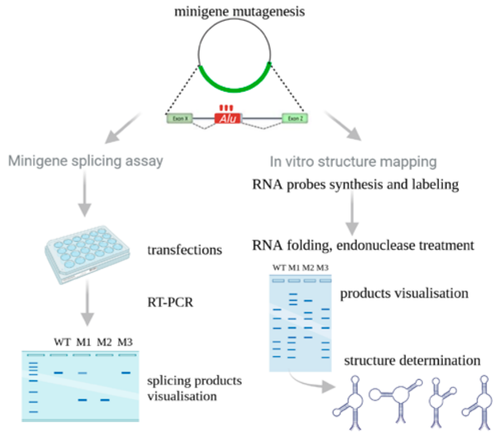

Fig. 1

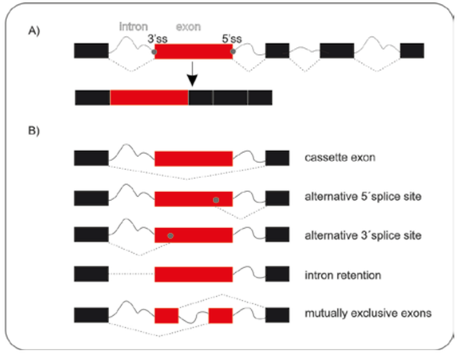

Fig. 2

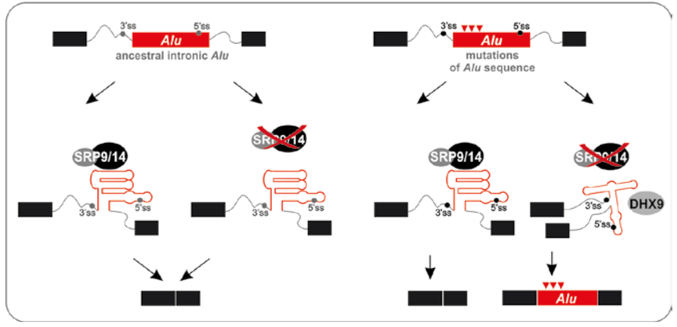

Fig. 3

Asymmetric cell division during bacterial endospore formation

Principal investigator
RNDr. Barák Imrich, DrSc.
Applicant organisation
Slovak Academy of Sciences, Institute of Molecular Biology
Term of solution
07/2019 – 06/2023
Budget from agency
170 000 €
Project ID
APVV-18-0104

Research Subject

Bacillus subtilis is an internationally recognized model organism, whose physiology, biochemistry and genetics have been studied for many decades. This project proposed to study the mechanisms of early stages of sporulation in *B. subtilis*, especially asymmetric septum formation and engulfment by employing a wide range of molecular biology, biochemical, genetic, structural biology and the most advanced microscopy techniques such as slimfield microscopy, FRAP, FRET and also the most advanced methods of nanocrystallography by using worldwide unique possibilities to solve the protein structures at the X-ray free electron laser (XFEL) in Hamburg.

Aim of the Research

Among the main goals of the project was the determination of the role of specific proteins in the precise localization of the asymmetric septum, discerning the order of cell division and cytoskeletal proteins in which they are arranged into the asymmetric septum, as well as the possible use of spores for biomedicine and nano-biotechnologies.

Achieved Results

Unique results of basic research as well as practical applications were obtained within the project. We present the following results as the three most significant:

1. Bacterial nanotubes were discovered ten years ago. The unique capabilities of these nanotubes have been attributed to processes such as the transfer of DNA, RNA and proteins between cells of various bacteria, as well as the "vampire-like" suck out of nutrients from a eukaryotic cell. Our results are in stark contrast to previously published findings. We have shown that nanotubes, in principle, are formed from every cell when we use various stress factors, such as pressure, or when the cells are exposed to antibiotics. The stress can cause the cytoplasmic membrane to "shoot" in the form of a nanotube through the holes created in the cell wall. An important finding was that just as the cell "fires out" the nanotube, the cell dies (Fig. 2). This means that the formation of nanotubes is not a controlled biological process but a "post-mortem" manifestation of a stressed cell.

2. The site of asymmetric septation during *B. subtilis* sporulation is linked to the membrane where FtsZ and SpoIIE initiate the formation of the Z-ring and the E-ring, respectively. These rings then serve as a scaffold for the other cell division and peptidoglycan synthesizing proteins needed to build the septum. However, despite decades of research, it is not known how the asymmetric septation site is determined. Here, we identified and characterized the interaction between SpoIIE and RefZ. We show that these two proteins transiently co-localize during the early stages of asymmetric septum formation when RefZ localizes primarily on the chromosomal DNA and from the mother cell side of the septum (Fig. 3). We discovered how these proteins and their interplay with the spatial organization of the chromosome play a key role in recognizing the site of asymmetric division.

B. subtilis spores are considered to be efficient and useful tools for surface attachment of various proteins. As part of the study, recombinant spores were prepared with the bound "spike" domain of the SARS-CoV-2 protein in fusion with the spore coat proteins CotZ and CotY. When considering whether such recombinant *B. subtilis* spores would be suitable for the development of an oral vaccine, several factors speak in their favor. First, *B. subtilis* is considered a generally safe microorganism and is also used as a probiotic. Second, spores can survive the harsh environment in the gastrointestinal tract caused by stomach acids, making them an ideal vehicle for oral vaccine delivery. The results presented in the work indicate that recombinant spores and bound proteins to the coat proteins CotY and CotZ could be widely used for the development of new oral vaccines not only against the SARS-CoV-2 virus but also against other newly emerging life-threatening viruses and bacteria (Fig. 4).

Benefits for Practise

Understanding the studied cellular events such as cell division at the molecular level has the potential to be used for the preparation of new drugs against pathogenic bacteria such as *B. anthracis, B. cereus, Clostridium difficile* and others. The studied model organism itself, B. subtilis, is already used system for the production of new easily storable and usable vaccines, and the spore coat proteins studied in the frame of this project have great potential for use in modern nano-biotechnologies.

Fig. 1 / Part of the research team. From the left, A. Vetráková, S. Žarnovičanová, D. Krajčíková, Z. Chromiková, I. Barák, N. Labajová and K. Muchová.

Fig. 2 / Scanning electron microscopy and SIM microscopy images of B. subtilis cells with nanotubes. Scale bar=2.5 µm. Published in Pospíšil et al., (2020) Nature Commun.11: 4963.

Fig. 3 / Model of sporulation septum site determination. The model shows how the precise site of the asymmetric septum at 1/6 of the cell length can be recognized by positive and negative regulators during sporulation. For simplicity, only one molecule of each studied protein and its 3D structure is shown. Published in Muchová et al. (2024) J. Biol. Chem. (accepted).

Fig. 4 / Model of the CotY-RBD fusion protein structure. A spore with different coat layers and in the center is a chromosome with cloned cotY gene in fusion with the rbd domain of SARS-CoV-2 spike protein. Published in Vetráková et al. (2023) Comp. Struct. Biotechnol. J. 18:1474-1486.

Fig. 1

Fig. 2

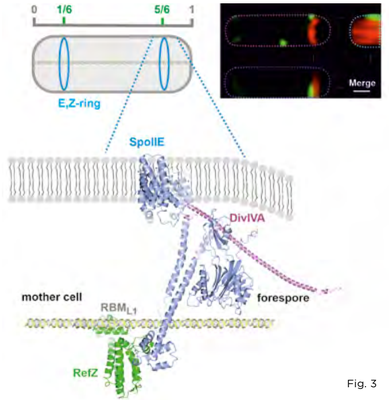

Fig. 3

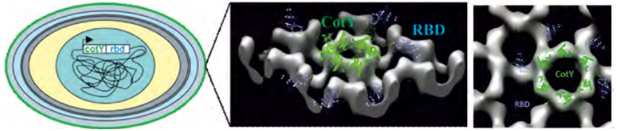

Fig. 4

Relaxation phenomena in quantum magnets

Principal investigator
doc. RNDr. Orendáčová Alžbeta, DrSc.
Applicant organisation
Pavol Jozef Safarik University in Kosice - Faculty of Science
Participating organisation
Slovak University of Technology in Bratislava - Faculty of Chemical and Food Technology
Term of solution
07/2019 – 06/2023
Budget from agency
190 000 €
Project ID
APVV-18-0197

Research Subject

The project was focused on the research of new materials and techniques usable in quantum information technologies with the aim to understand the processes mediating the interaction of spins, as a possible realization of qubits, with the environment in quantum magnets. For this purpose, quantum entanglement, negativity, etc. have been theoretically studied. Attention was also paid to the phonon system, which affects the energy flow between the set of spins and the phonon reservoir. Materials with different mechanical and magnetic properties such as crystalline/amorphous phase, concentrated/diluted phase, bulk form vs. constrained geometry were prepared in an attempt to influence the spin-lattice relaxation time scale as an upper bound for the coherence time. The design of materials as well as the experimental results were supported by theoretical simulations.

Aim of the Research

In the project, we planned to study theoretically and experimentally quantum entanglement in quantum spin systems. For spin as a carrier of quantum information, its binding to the environment is important, therefore another goal was to study the influence of the phonon and magnetic subsystems on the spin-lattice relaxation and the role of both subsystems in the formation of relaxation channels. The preparation and characterization of new magnetic materials, their modification (dilution, confined geometry, deposition etc.) and specification of optimal conditions for T1 maximization are closely related to these goals. In parallel with the development of suitable materials, the design and implementation of planar superconducting resonators was planned to achieve coupling with a set of electron spins in quantum magnets.

Achieved Results

During the implementation of the project, a large number of results related to the set goals were achieved. We theoretically predicted and experimentally proved the strengthening of quantum entanglement in the pure and mixed states of a Heisenberg dimer with mixed spins ½ and 1, in a Heisenberg diamond cluster with spin 1, a Heisenberg dimer with spin 1, and a Heisenberg spin star with spin ½. A number of compounds were prepared and characterized, while many of them also showed additional functionalities such as heat- and light-induced spin crossover, porosity and others. Direct synthesis of compounds was often supplemented or preceded by designing using various simulation and DFT techniques. The obtained structures were subsequently modified by various techniques (dilution, nanocasting, confined geometry). The study of elastic properties indicated a deviation from the Debye theory already at temperatures nominally above 15 K, which points to the presence of low-frequency optical modes. Their influence on relaxation was demonstrated by the appearance of the intrinsic "phonon bottleneck" (PB) effect. The origin of the boson peak in crystalline and amorphous systems and its impact on relaxation were also studied. By combining magneto-structural correlations and theoretical simulations, it was possible to interpret relaxation phenomena in molecular magnets formed by mononuclear and multinuclear complexes based on 3d and 4f ions, in organic materials, metallo-organic 1, 2 and 3-dimensional polymers, nanocrystals, nanoparticles and glasses. The coexistence of several relaxation channels on a different time scale (1s, 10-4 s), reciprocal behavior of relaxation, creation of a relaxation channel through induced solitons or suppression of the influence of the external PB effect by the field, sample shape, etc. was observed. A probe enabling the testing of a planar superconducting resonator was designed and constructed. A significant added value of the project was the scientific education of young workers when a total of 16 doctoral students were involved in its solution, while 7 of them have already successfully defended the topics of their dissertations.

Benefits for Practise

The achieved results brought new methods for controlled preparation of materials. In addition to the experimental and theoretical study of spin systems as carriers of quantum information, we have often found added functionality such as the possibility of using the compounds for magnetic cryocooling or as a recording medium in systems characterized by spin crossover, use in pharmacy, treatment of tumors thanks to heating in an alternating field, etc. The importance of the most significant results is also reflected in the impact factor of the journals and their inclusion mostly in the Q1 or Q2 group.

Fig. 1 / The negativity of mixed spin-(1/2,1) Heisenberg dimer as a function of the single-ion and exchange anisotropies [Phys. Rev. B 102 (2020) 184419]

Fig. 2 / Schematic plot of Fe_3O_4 nanoparticles deposited on plasma-treated polypropylene (PP) substrate.

Fig. 3 / (a) real and (b) imaginary susceptibility of Fe_3O_4-PP in zero magnetic field. (c) Relaxation time (circles) compared with Arrhenius formula (dashed) and 2D Ising spin glass (solid line) (d) Relaxation time (circles) and power law for critical slowing down [Phys. Rev. B 108 (2023) 104423]

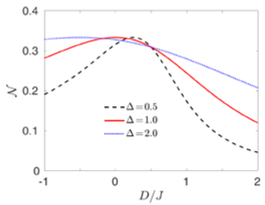

Fig. 1

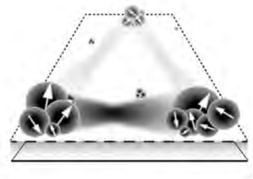

Fig. 2

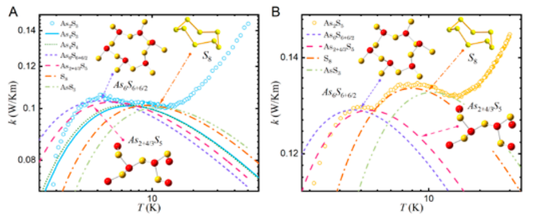

Fig. 4

Fig. 4 / Thermal conductivity of glassy samples (A) As_2S_3 (B) As_2S_5. Lines represent individual contribution from different types of nanoclusters [J.Non-Cryst. Solids 600 (2023) 122040].

Fig. 5 / Isothermal rotational entropy changes in constant magnetic fields (symbols) and predictions for the S = 1 paramagnet, E/D = 0.1, D/kB = 11.6 K and g = 2.16. Inset: Field dependence of $-\Delta S_{Rmax}$ [Magnetochemistry 8, 39 (2022). In category Editor´s Choice].

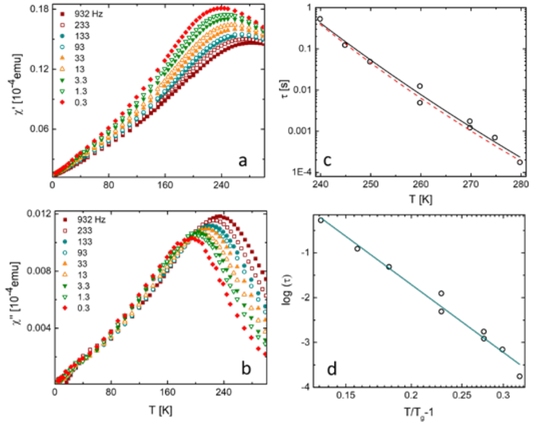

Fig. 3

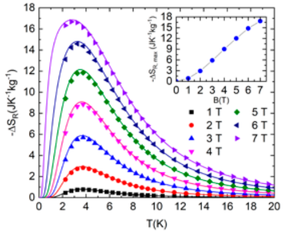

Fig. 5

Functional analysis and production of bioactive subsatnces in insects and ticks

Principal investigator
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Applicant organisation
Slovak Academy of Sciences, Institute of Zoology
Participating organisation
Slovak University of Technology in Bratislava
– Faculty of Chemical and Food Technology
Term of solution
07/2019 – 06/2023
Budget from agency
230 000€
Project ID
APVV-18-0201

Research Subject

In this project we used molecular and physiological techniques for description of expression patterns and functional characterization of ion transport peptides (ITP), eclosion hormone (EH) and membrane guanylate cyclases which probably serve as receptors for these neuropeptides of insects and ticks. Various experiments using physiological and RNAi approaches indicate that these neuropeptides are required for regulation of ecdysis of the old cuticle, metabolism and reproduction in Bombyx mori and Ixodes ricinus. We used bioluminiscent technique in expression systems with CHO and SF9 cells to identify guanylate cyclase receptor for ITPL. RNAi approaches were also used for knock down of receptors for biogenic amines. Suppression of dopamine receptor resulted in decreased production of saliva in I. ricinus. This project was extremely useful for evaluation of procedures that can be used for targeted disruption of development and reproduction of ticks and which could be used for suppression of pathogen transmission to domestic animals and humans.

Aim of the Research

In this project we used molecular, bioinformatic, biochemical and physiological methods for identification, functional and expression analysis of bioactive compounds and their receptors in insects (*Bombyx mori* and *Drosophila melanogaster*) and ticks (Ixodes ricinus a I. scapularis). As there is a lack of knowledge on signaling pathways for guanylate cyclases and their ligands, such as neuropeptides eclosion hormone (EH) and ion transport peptides (ITP and ITPL), we focused on identification and characterization of those neuropeptides. We also studied expression and function of receptors for biogenic amines dopamine (DA) and gamma aminobutyric acid (GABA), which are essential modulators of physiological processes in tick during blood feeding and potentially pathogen transmission from ticks to hosts.

Achieved Results

We described expression of ITP and ITPL in the nervous system during development, identified promoter for ITP and generated a specific transgenic line (ITP-Gal4) for funcional analysis of neurons producing this neuropeptide in the silkworm. For various physiological experiments we produced in *Escherichia coli* recombinant proteins ITP and ITPL, but also immunomodulatory protein Drp36 which is produced after infection with the tick-borne encefalitis virus (TBEV). In several high quality journals we described identification of specific hormones and their receptors, and described their roles in development and reproduction of insects and ticks. We also reviewed possible utilization of neuropeptide-receptor signalling pathways in production of specific vaccines that could suppress development, metabosim and transmission of pathogens from ticks to their hosts.

Benefits for Practise

In this project we showed that neuropeptides (ITP, ITPL and EH) are important hormaonal factors for regulation of ecdysis of the old cuticle, metabolism and reproduction of the silkworm B. mori. Our RNAi experiments indicate that ITP controls metabolism and reproduction of the tick I. ricinus. We also found that receptors for dopamine play an important role in saliva production during tick feeding and may affect pathogen transmission. Further studies focused on expression and function of receptors for neuropeptides and biogenic amines may reveal their crucial roles during development of ticks and in pathogen transmission from ticks into their hosts.

Fig. 1

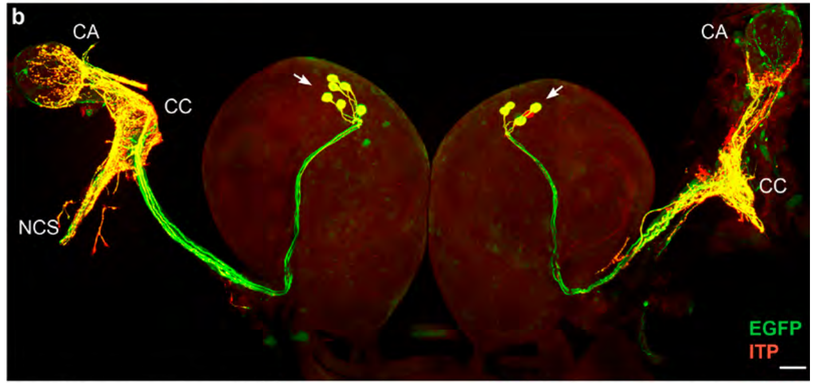


Fig. 2

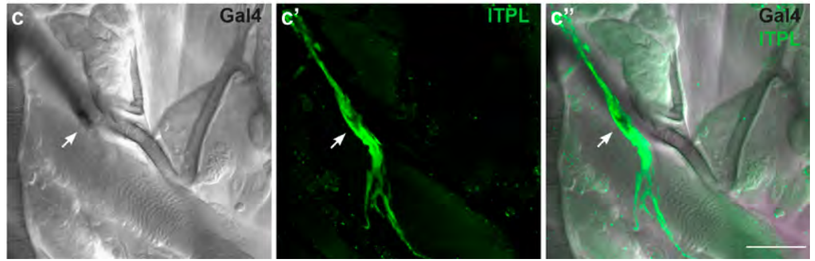


Fig. 1 / a) Schematic drawing of itp gene region. b) pITP-driven

Fig. 2 / expression of EGFP in brain neurons (arrows) with descending axons innervating peripheral secretory organs (CC, CA). c, c', c'' Colocalization of ITPL with pITP-Gal4 expression in peripheral L1 neurons. Bars 50 µm

Non-conventional applications of emerging sequencing technologies in comparative and functional genomics

Principal investigator
prof. RNDr. Nosek Jozef, DrSc.
Applicant organisation
Comenius University Bratislava
Term of solution
07/2019 - 06/2023
Budget from agency
240 000 €
Project ID
APVV-18-0239

Research Subject

Availability of high-quality genome sequences is essential for both basic research and biotechnological applications. However, the size and complexity of genomes, variable base content, repetitive and transposable elements, segmental duplications, heterozygosity or different levels of ploidy complicate the determination of genomic sequences. The project was focused on the development of experimental and bioinformatic approaches that, in combination with third-generation sequencing technologies, enable the determination of complete genome sequences of representative species from two phylogenetic lineages of ascomycetous yeasts *Magnusiomyces/Saprochaete* and *Lodderomyces/Candida*, which exhibit high genetic and phenotypic diversity and are therefore suitable for comparative and functional analyses.

Aim of the Research

The project was aimed at the development and optimization of protocols for the isolation of high-molecular-weight DNA of non-conventional yeast species, the development of new bioinformatic tools for processing data generated by a nanopore sequencer, as well as comparative and functional analysis of the obtained genomic sequences. During the COVID-19 pandemic, the project aims were further expanded to the analysis of genomic sequences of the SARS-CoV-2 virus and the monitoring of virus variants in clinical samples as well as in mixed samples isolated from wastewater.

Achieved Results

The key results of the project include (1) optimized protocols for (i) preparation and analysis of high molecular weight DNA samples by nanopore technology and (ii) biochemical enrichment of telomeric fragments and telomere length analysis of individual chromosomal ends; (2) genome sequences of 49 species of ascomycete and basidiomycete yeasts; (3) sequences of 3731 isolates of the SARS-CoV-2 virus; (4) bioinformatic software suitable for (i) processing raw data from the nanopore sequencer (basecalling and alignment to the reference genome), (ii) real-time monitoring of the sequencing process of viral genomes (e.g. SARS-CoV-2), (iii) analysis of the virus variants in wastewater samples, (iv) determination of the length of short tandem repeats (STR) in nanopore data, and (v) calculation of the statistical significance of overlaps in genomic annotations. The results of the viral sequence analysis led to the identification of a new variant of SARS-CoV-2 lineage B1.258 with a deletion in the Spike protein gene. Comparative analysis of the yeast genome sequences allowed (i) characterization of biochemical pathways in the yeasts *Lodderomyces/Candida* and corresponding metabolic gene clusters that are involved in the assimilation of hydroxyaromatic compounds, (ii) identification of novel non-canonical telomeric repeats, and (iii) evaluation of differences in the presence of expansion segments in ribosomal RNA of yeasts from the genus *Magnusiomyces/Saprochaete*. The project results were published in 26 scientific publications, as well as in the form of 14 lectures and posters at international scientific conferences.

Benefits for Practise

Developed laboratory protocols suitable for nanopore sequencing of nucleic acids, bioinformatic software, obtained genome sequences and genome browsers are applicable in biomedical research and biotechnologies. Some of the obtained results have already been applied in the analysis of variants of the SARS-CoV-2 virus in the Slovak population during the COVID-19 pandemic in 2020-2021 and are also applicable in the further monitoring of the virus in wastewater samples. Genome sequences of non-conventional yeast species and characterized biochemical pathways for the degradation of hydroxyaromatic compounds provides the basis for their use in biotechnologies or bioremediations. In the case of pathogenic species, the genome sequences have potential in molecular diagnostics or in the identification of molecular targets that are suitable for the therapeutic intervention of yeast infections. The project also contributed to the training of young scientists and students in biochemistry, genetics, and informatics.

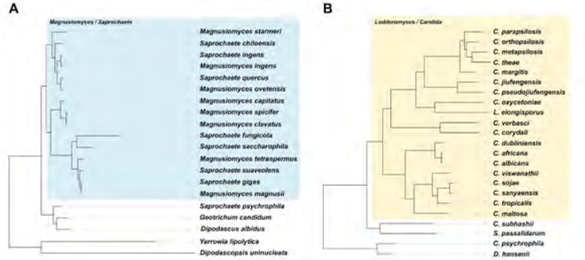
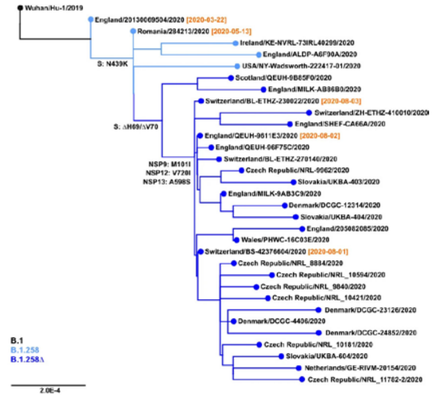


Fig. 1



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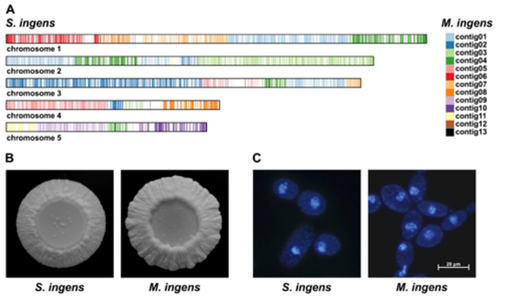


Fig. 2

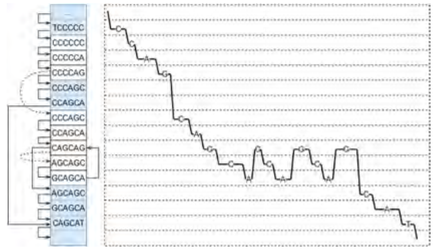


Fig. 4

Fig. 1 / Phylogenetic trees of yeasts from the clades *Magnusiomyces/Saprochaete* (A) and *Lodderomyces/Candida* (B) (Nosek et al., unpublished).

Fig. 2 / Comparison of the genome sequences (A), colony (B) and cell (C) morphology of two yeast species *Saprochaete ingens* CBS 517.90 and *Magnusiomyces ingens* CBS 521.90 (Hodorová et al., 2019).

Fig. 3 / Origins of B.1.258 ΔH69/ΔV70 variant, causing a significant wave of COVID-19 cases in the fall of 2020 in Slovakia, Czech Republic and Slovenia. The phylogenetic tree constructed from the samples in the GISAID database illustrate timing and geographical emergence of key mutations S:N439K, S:ΔH69/ΔV70, NSP9:M101I, NSP12:V720I, and NSP13:A598S (Brejová et al., 2021).

Fig. 4 / Representation of a short tandem repeat by a finite state automaton helps accurate identification of number of repeats in raw nanopore reads using a modified dynamic time warping algorithm which has been implemented in the WarpSTR software tool (Sitarčík et al., 2023).

Structure of heavy exotic nuclei

Principal investigator
doc. Mgr. Antalic Stanislav, PhD.
Applicant organisation
Comenius University Bratislava
– Faculty of Mathematics Physics and Informatics
Term of solution
07/2019 – 06/2023
Budget from agency
87 967 €
Project ID
APVV-18-0268

Research Subject

The project focused on studying the nuclear structure of heavy atomic nuclei, particularly so-called exotic nuclei far from the stability region. The general goal was to improve our understanding of nuclei, mainly close to the proton dripline above lead (Z=82) and the region of the heaviest elements 250 nucleons.

Aim of the Research

Theoretical models describing atomic nuclei are developed based on the known experimental data, often for nuclei close to the stability region. Studying isotopes at the border of existence for atomic nuclei is challenging but provides crucial data to test these models. The structure of atomic nuclei, i.e., the quantum configuration of their ground and excited states, strongly influences their stability and radioactive decay. Therefore, the project's main goal was to gain new information about the production and the nuclear structure of these exotic nuclei.

Achieved Results

The data were obtained at the top-level and prestigious international facilities providing state-of-the-art experimental infrastructure. Due to the complex nature and extensive requirements of the measurements closely cooperated with teams from several outstanding universities and laboratories. Measurements were done at the experiment SHIP at GSI Darmstadt (Germany), the ISOLDE at CERN (Switzerland), JYFL facilities at the University of Jyväskylä (Finland), the AGFA and FMA at Argonne National Laboratory (USA), and others.

In this project, we obtained outstanding and detailed decay-spectroscopy data for several isotopes. Below, we provide a few selected examples:

The unique result was obtained in the beta-delayed fission study of ^{188}Bi for which the fission data after beta decay of two separated long-lived states existing within the same nucleus were studied. This measurement represented a complex approach of combining atomic and nuclear physics, applying the atomic laser and nuclear decay spectroscopy. Another unique outcome of combined laser and decay spectroscopy was the identification of shape staggering in the neutron-deficient bismuth and gold isotopes, showing a significant periodic shape change between neighbouring isotopes.

In the region of the heaviest isotopes, we observed new K-isomeric states in ^{255}No. This type of isomer is at the aim of nuclear physics of heavy elements due to its possible stabilisation effect against the radioactive decay of nuclei. Such additional stabilisation effect could be crucial for the future production of new superheavy elements.

For 247Md, we obtained new data for the decay of nuclear isomers in this isotope which are related to the topic of production and properties of superheavy elements as well. The structure of isomers in nuclei around Fermium (Z=100) is influenced by the single-particle levels stemming from orbital defining the possible closed proton shell within the theoretical frame of the shell model. Such a closed shell, if it exists, should provide the increased stability of superheavy elements.

We performed several attempts to synthesise new isotopes. These measurements provide valuable data on the mechanism of production reactions for heavy atomic nuclei. This project contributed to the discovery of previously unknown isotopes ^{190}At at Argonne National Laboratory, ^{249}No at the JINR Dubna and ^{160}Os and ^{156}W at the University of Jyväskylä.

Benefits for Practise

The project represents cutting-edge basic research in the field of nuclear physics and its main outcomes are therefore new data and knowledge published in prestigious peer-reviewed papers. We obtained many results that contributed to the understanding of the nuclear structure of heavy elements. As an outcome of this project, almost 20 papers have been published and cited 100 times until now. Since the project was carried out at the university, the important impact was also its contribution to the education of new specialists. It helped to create a creative environment and allowed active participation in the top-level experiments for several students at Comenius University in Bratislava, who gained important experiences for their future careers.

Fig. 1 / The AGFA separator in Argonne National Laboratory (USA), where some of the measurements in the scope of this project were performed, for example, the synthesis of isotope ^{190}At, which was not known until now.

Fig. 2 / The region of neutron-deficient isotopes, whose study was one of the project's primary goals. Blue squares indicate isotopes for which the results were obtained from experimental measurements within the project.

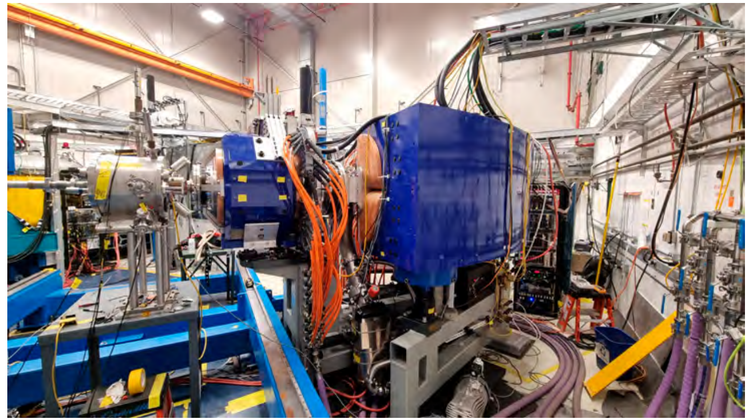


Fig. 1

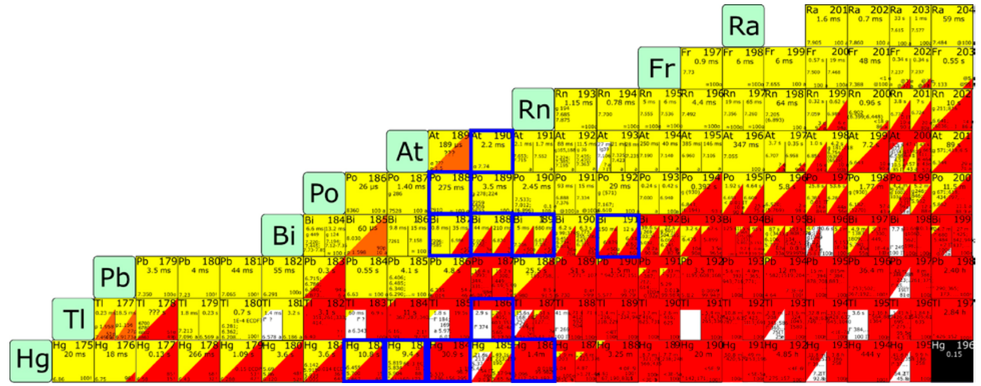


Fig. 2

Nonlinear phenomena in dynamical systems from science and technology

Principal investigator
prof. RNDr. Filo Ján, CSc.
Applicant organisation
Comenius University Bratislava - Faculty of Mathematics Physics and Informatics
Term of solution
07/2019 – 06/2023
Budget from agency
150 000 €
Project ID
APVV-18-0308

Research Subject

The project was dedicated to four thematic areas in the theory of nonlinear dynamic systems: Existence and asymptotic behavior of solutions to nonlinear parabolic and elliptic problems, Oscillatory, asymptotic, stability, bifurcation and chaotic properties of dynamical systems and their fractional versions, Mathematical modeling of dynamical processes in biology, Flow and phase transformation of incompressible fluid with free boundaries. The project was a continuation of previous successful APVV projects:
Nonlinear phenomena in evolutionary equations (2007),
Nonlinear phenomena in continuous and discrete dynamical systems (2010),
Nonlinear phenomena in evolutionary equations from natural and technical sciences (2014).
The principal investigator of this project was prof. RNDr. Marek Fila, DrSc., who died suddenly two months before its end.

Aim of the Research

The main goal was to achieve new results in fundamental research in the field of nonlinear dynamical systems, which are motivated by continuous mathematical models from natural and technical sciences.

Achieved Results

The results of the project were published in three monographs, in 117 publications in international Current Contents indexed journals and in 32 publications published in peer-reviewed international scientific journals; the results were also presented at many invited lectures at international scientific events.
Works published within the project received 333 citations in Current Contents indexed journals according to SCI by the end of 2023.
Member of the research team prof. M. Fečkan was included in the list of Highly Cited Researchers in 2019 and 2021. The list is compiled by Clarivate Analytics from the Web of Science Group. In 2020, prof. M. Fečkan was a finalist for the prize Outstanding Personality of Slovak Science.

Benefits for Practise

Given that the project belongs to the field of basic research, the application of its results into practice has two forms:
Direct form: Publication activity of the members of the research team, who published the results of their research in cooperation with mathematicians from prestigious foreign universities in leading professional journals and gave lectures at international conferences and seminars.
Indirect form: Contact pedagogical activity of the members of the research team who participated and are participating in the teaching of all three degrees of Mathematics at FMFI UK. The choice of the subject of the completed project was instrumental for the members of the research team to fulfill the reform goals aiming to foster within the study of mathematics the deep connection of mathematics with technical and natural sciences. An important result of the project was the education of graduates and PhD students. To date, 12 diploma theses have been connected with the project, of which 5 have already been defended and 7 theses are expected to be defended in June 2024. During the duration of the project, 5 PhD theses were defended and three doctoral students are still studying full-time.

Thanks to the financial support of the APVV, it was possible to further develop the international contacts of the members of the research team, which continue even after its end. Below, we detail the name and nationality of the international workplace that cooperated in the prosecution of the project:

George Mason University, USA (D. M. Anderson)
Marche Polytecnic University, Ancona - Italy (Flaviano Battelli)
Romanian Institute of Science and Technology (Marius-F. Danca)
The University of Tokyo, Japonsko (Kazuhiro Ishige)
The Academy of Sciences of the Czech Republic (J. Kyselica)
Leibniz Universität Hannover, Nemecko (Johannes Lankeit)
Martin-Luther-University Halle-Wittenberg, Nemecko (V. Pluschke)
University of Minnesota, USA (Peter Poláčik)
University of Delaware, USA (Abhyudai Singh)
Mathematics Research Institute of Université Paris 13, Francúzsko (Philippe Souplet)
Tokyo Institute of Technology, School of Science, Japonsko (Eiji Yanagida)
Guizhou University, Čína (JinRong Wang, Qixiang Li)
University of Oxford, UK (A. J. Wells)

Member of the research team doc. Richard Kollár participated in a number of activities related to the pandemic in Slovakia and was active in various advisory bodies of the government and local administration - the President of the Slovak Republic, the Government of the Slovak Republic, the Ministry of Health of the Slovak Republic, the Ministry of Education, Science, Research and Sports of the Slovak Republic, the city of Trenčín, the city of Bratislava.

Fig. 1 / Upper row, from left (assistant and associate professors): Michal Pospíšil, Richard Kollár, Pavol Bokes, Július Pačuta, Peter Guba
Bottom row, from left (professors): Pavol Quittner, Milan Medveď, Ján Filo, Michal Fečkan

Fig. 2 / Principal investigator until 20.4.2023 professor Marek Fila

Fig. 1

Fig. 2

TECHNICAL SCIENCE

Optimal design of micro/nano structures for metamaterials

Principal investigator
prof. Ing. Sládek Ján, DrSc.
Applicant organisation
Slovak Academy of Sciences, Institute of Construction and Architecture
Term of solution
08/2018 – 11/2022
Budget from agency
249 194 €
Project ID
APVV-18-0004

Research Subject

The project is devoted to the computer analysis of advanced metamaterials useful for design of a new kind of sensors for monitoring crack failure of engineering structures. Classical detectors of arising crack failure of structural elements are based on the piezoelectricity phenomenon. It is well known that piezoelectricity is attributed only to materials not exhibiting centro-symmetry. On the other hand, flexoelecricty is similar phenomenon of arising electric polarization in each dielectric material provided that there are strain gradients. Furthermore, a huge concentration of stresses, strains and strain gradients are occurring near the crack front. Therefore, the flexoelectricity can be utilized in development of new type of sensors - strain gradient sensors, which enable highly sensitive detection of strain gradient, and finally detection of crack failure without limitations of classical detectors.

Aim of the Research

The optimal design of advanced metamaterials for health monitoring of structures requires major achievements in the continuum mechanics and physics of solids, mathematical and numerical modelling, as well as development of advanced computational methods facilitating numerical simulations becoming inevitable for successful design. This determined the goals of the present project:

· Modelling of electro-elastic coupled field problems within higher-grade continuum theory with incorporation of strain gradients and gradients of electric field intensity
· Development of variational formulation for coupled electro-elastic problems within higher-grade continuum theory
· Development of computational methods for numerical treatment of boundary value problems for partial differential equations with high-order derivatives
· Derivation of the path independent J-integral for assessment of stability and/or growth of cracks in metamaterials
· Numerical verification tests of developed computational techniques and numerical simulations

Achieved Results

The new coupled-field phenomena have been modelled within the higher-grade continuum theory, since the classical continuum theory becomes inapplicable because it does not incorporate the higher-order gradients of primary field variables. Incorporation of higher-gradients into the continuum models brings also new material coefficients involving length-scale parameters. These parameters reflect the material microstructure within the employed phenomenological description which enables explanation of experimentally observable size-effects in samples whose characteristic length is comparable with the micro-length scale parameters. Obviously, such effects play role also in zones with non-negligible second order gradients of primary field variables. For assessment of crack stability and/or crack growth, the formula for the path independent J-integral has been derived. It has been revealed that the J-integral value and crack opening displacement are reduced for growing flexoelectric coefficient.

Besides the multi-physical aspects, the developed formulations include the partial differential equations with higher-order derivatives than in classical formulations, where the standard finite element method (FEM) is applicable. A successful treatment of approximation of high-order derivatives in discretization approach of numerical solutions has been achieved by development of Mixed FEM. In the mixed FEM the C0 continuous approximation is applied independently to displacement and displacement gradients. Similarly the electric potential and electric intensity vector are approximated by C0 elements. The kinematic constraints between displacements and strains are satisfied by collocation at some internal points of elements. The second constraint between the electric potential and electric intensity vector is satisfied analogically by collocation method. Also the meshless Petrov-Galerkin method has been developed for multiphysical problems described by a gradient theory.

Benefits for Practise

Structural health monitoring is especially important for high-performance structures, where failure would lead to disasters, such as nuclear waste containment structures, dams and bridge decks. It requires developing sensing method for in-situ monitoring of the onset and growth of cracks at the early stage, especially near the severe strain gradient fastener areas is of growing interest. Our research progress on flexoelectricity can initiate development of new type of strain gradient sensors.

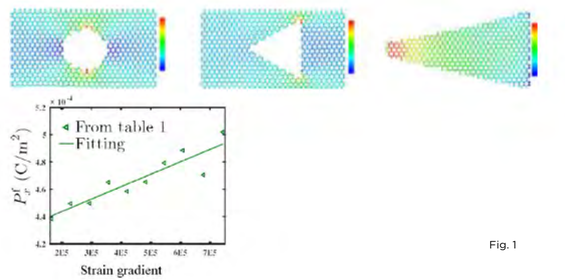
Fig. 1 / Variation of polarization vector with strain gradient on graphene

Fig. 2 / Cantilever beam with a transverse end load

Fig. 3 / Electric field of the cantilever beam with different flexoelectric coefficients

Fig. 4 / Variation of the out-of-plane displacement on the upper crack surface (θ = π) of Mode III cracks.

Fig. 5 / Variation of the out-of-plane electric polarization on the upper crack surface (θ = π) of Mode III cracks.



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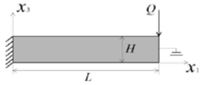
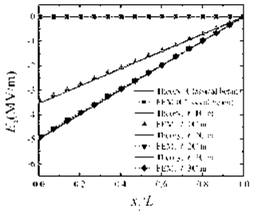


Fig. 2



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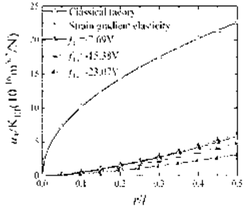


Fig. 4

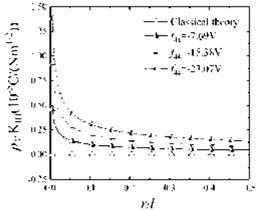


Fig. 5

Global Characterization of Skyglow

Principal investigator
Mgr. Kocifaj Miroslav, PhD.
Applicant organisation
Slovak Academy of Sciences, Institute of Construction and Architecture
Participating organisation
Comenius University Bratislava – Faculty of Mathematics Physics and Informatics
Term of solution
07/2019 – 06/2023
Budget from agency
246 429 €
Project ID
APVV-18-0014

Research Subject

Excessive night sky brightness is the most familiar manifestation of light pollution (LP) and has its origin in the interplay of ground-based artificial light and scattering processes in the Earth's atmosphere. The propagation of artificial light into the surrounding environment depends on the present optical state of the local atmosphere, and in particular on its aerosol content. It is therefore not surprising that proper air-pollution management can also help in solving the problems associated with LP. However, lighting and atmospheric conditions are both very diverse worldwide, so measured distributions of night sky brightness (NSB) often differ from model predictions. The main goal of our project was to develop the modeling methods applicable to any geographical location.

Aim of the Research

The project had ambitious goals, namely to develop a new theoretical model of light pollution propagation into nocturnal environment under arbitrary conditions and to reveal how the interaction between light emissions and the atmosphere shapes NSB. Advanced methods for identifying ground-based light emissions from cities and novel applications in both skyglow and radiative transfer modeling were among the main outcomes we expected during project implementation.

Achieved Results

We have developed novel methods and devices for the characterization of aerosol particles in the night-time atmosphere, which not only significantly advanced the possibilities of numerical modeling, but also provided new means for the management of LP with benefits in, e.g., the field of ecological studies. The experimentally and economically inexpensive methods we have designed allow experts from all over the world to study the properties of atmospheric aerosols continuously during the day and night. The huge gap in the availability of daytime and nighttime data and the lack of methods for systematic nighttime optical monitoring of local aerosols were the main reasons for why scientists have so far been unable to predict the dynamics of LP in various territories. Our models can be applied in naturally dark places as well as in locations with a high level of LP and led to a significant reduction in the calculation time of hemispheric NSB maps while maintaining high angular resolution. This paves the way to build a third World Atlas of Artificial NSB, where instead of zenith brightness, a full-sky radiance distribution will be available for every location on Earth. The project also initiated international cooperation across several scientific fields with the aim of making full use of the information content the night sky radiance data provide.

One of our main findings is that most of up-to-date models suffer from a systematic error, while the solution we proposed allows for correction of both the present and historical zenith brightness data. The model we developed appears useful also for satellite remote sensing of cities and their aerosol envelopes. The theoretical solution to the radiative transfer led to the development of ground-based methods complementary to those used in satellite imaging of the Earth's surface. The results were published in the highly respected scientific journals such as Science and Nature Astronomy and in the journals registered in the so-called "Nature-index".

Benefits for Practise

It is expected that the reduction of light pollution levels can be achieved by both technical and policy interventions made to outdoor lighting or by influencing the processes of light propagation into the environment. Traditionally, the negative impacts of LP are reduced by modernizing lighting technologies, but this type of intervention has its limits and rarely achieves a benefit of more than about 10-20%. Through systematic research, we have demonstrated that reduction of the aerosol air pollution mitigates NSB in cities and in their near surroundings by tens of percent. Cleaner urban air results in lower aerosol optical thickness, which in turn leads to a decrease of skyglow levels. We are now able to identify the air pollution sources which have a dominant contribution to NSB, and thus define the measures that should be taken in that region or city. There is no doubt that systematic control and regulation of emissions of specific types of aerosol particles is among the best means by which to reduce NSB in inhabitated areas.

Fig. 1 / Ground-based measurements of the night sky brightness distribution taken on June 19, 2018, at 1:29 a.m. local time near Illmitz, Austria (shown in the Hammer–Aitoff projection). The dominant light sources are from left to right: Bratislava, Nickelsdorf, Mosonmagyarovar, Sopron, Eisenstadt and Vienna.

Fig. 2 / The methods we developed provide a new tool for satellite remote sensing of the aerosol envelopes of cities at night. The graphic was created using images published by "earth.google.com › web" (Earth at Night - Google Earth).

Fig. 3 / Optical signal produced by urban aerosols detected by Earth-orbiting satellites. Our calculations show that satellite data are sensitive to submicron-sized particles, with the signal level depending on the scattering angle q, that is, the angle between the direction of photons escaping from the city and the direction to the satellite.

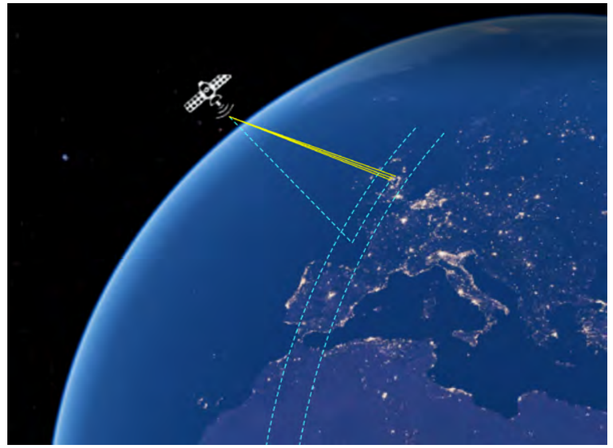
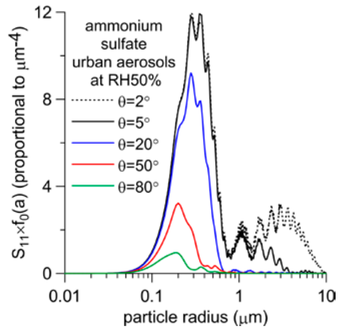


Fig. 1



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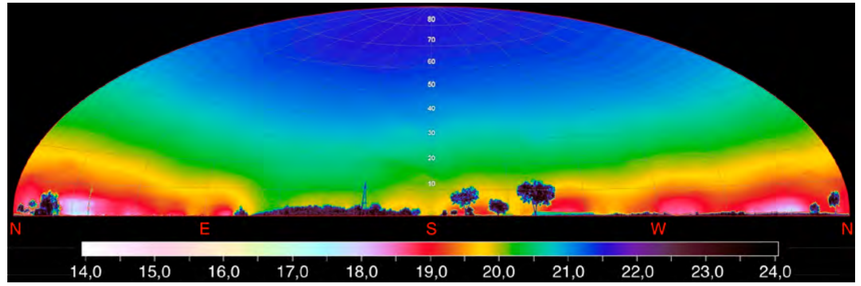


Fig. 3

New methods development for reliability analysis of complex system

Principal investigator
prof. Ing. Zaitseva Elena, PhD.
Applicant organisation
University of Zilina – Faculty of Management Science & Informatics
Term of solution
07/2019 – 06/2023
Budget from agency
227 425 €
Project ID
APVV-18-0027

Research Subject

The research subject is the reliability analysis of complex systems (objects) based on the mathematical representation of systems in the form of a Multi-State System (MSS). MSS is a mathematical model of a system that allows us to investigate and evaluate not only two system states as failure and functioning but analyze more states between failure and functioning, including system degradation.

Aim of the Research

The project's principal goal is the creation and development of theoretical conceptions for the qualitative and quantitative reliability analysis of complex systems represented by the Multi-State System (MSS) structure function. It includes the realization of theoretical research and practical application of the new results:
1. Creation of a new methodology for the description of a complex system based on MSS.
2. Development of new methods for MSS importance analysis depending on its components' state.
3. Elaboration of applications of reliability analysis based on the developed approach.

Achieved Results

The Important result of the project is the development of a new approach for the complex system reliability analysis based on its mathematical representation in the form of an MSS structure function. The use of a MSS as mathematical model allows us to implement the detail analysis of the system reliability changes from perfect functioning to the fully failure. The structure function maps the set of all possible system components' states to the system performance level. This definition of the structure function doesn't allow the use of this mathematical model for analysis of a system based on uncertain and incompletely specified data (epistemic uncertainty)/ To define this problem a new approach has been developed based on the classification method (Fig.1). Important step in this approach development is the definition of correlation of concepts in classification problem and reliability analysis problem1. A Fuzzy Decision Tree2 has been used for an MSS structure function analysis as principal classifier. Based on the approach of a MSS structure function construction the methods of a system Importance Analysis have been developed3, 4 The Importance Indices are used for the definition and evaluation of the system's critical states.

1. E.Zaitseva, V.Levashenko, J.Rabcan, A new method for analysis of Multi-State systems based on Multi-valued decision diagram under epistemic uncertainty, Reliability Engineering and System Safety, 2023
2. J.Rabcan, V.Levashenko, E.Zaitseva, M.Kvassay, EEG Signal Classification Based on Fuzzy Classifiers, IEEE Transactions on Industrial Informatics,2022
3. P.Sedlacek, E.Zaitseva, V.Levashenko, M.Kvassay, Critical state of non-coherent multi-state system, Reliability Engineering and System Safety, 2021
4. E.Zaitseva, J.Rabcan, V.Levashenko, M.Kvassay, Importance analysis of decision making factors based on fuzzy decision trees, Applied Soft Computing, 2023

Benefits for Practise

The developed methods for reliability analysis and estimation of complex systems have been used in different practical applications. Three dominant areas can be indicated, in which the proposed theoretical result has been applied:
The first of them is the reliability analysis of healthcare systems. In particular, human reliability analysis based on uncertain data in medical teams has been considered5. The influence of a new device (jaundice meter) used by a neonatology team on medical error has been evaluated (Fig.2). The second application is the reliability analysis of UAVs and their fleet/swarm6. Availability and Importance Indices have been developed and defined for several types of UAV fleets. The homogenous and heterogenous (Fig.3) fleets with hot stable (redundancy) have been investigated.
And the third application is reliability and risk analysis in climate and land degradation. The region of Slovak Eastern Carpathians (Fig.4) has been analyzed from the point of view of the risk of disturbance impact on primeval and managed forests based on Earth observation data7.

5. E.Zaitseva, V.Levashenko, J.Rabcan, E.Krsak, E. Application of the Structure Function in the Evaluation of the Human Factor in Healthcare. Symmetry, 2020.
6. E.Zaitseva, V.Levashenko, at al., Availability of UAV Fleet Evaluation Based on Multi-State System, IEEE Access, 2024
7. E.Zaitseva, S.Stankevich, at al., Assessment of the Risk of Disturbance Impact on Primeval and Managed Forests Based on Earth Observation Data Using the Example of Slovak Eastern Carpathians, IEEE Access, 2021.

Fig. 1 / The construction of the MSS structure function based on uncertain data

Fig. 2 / The proportional evaluation of the medical error in a problem of familiarization and exploitation of a new device

Fig. 3 / Heterogeneous UAV fleet reliability analysis based on MSS structure function

Fig. 4 / The map of forest disturbance risk within the study area. The forest cover is delineated using the CLC2018 dataset. The risk of forest disturbance is referred to four gradations: R_S is the high risk, R_2 is the existential risk, R_1 is the potential risk, and R_0 is no risk.

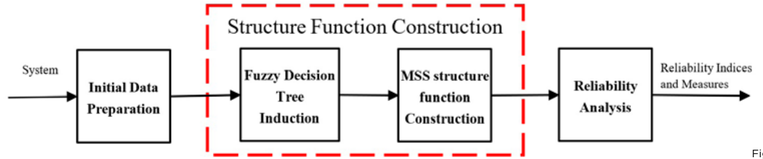
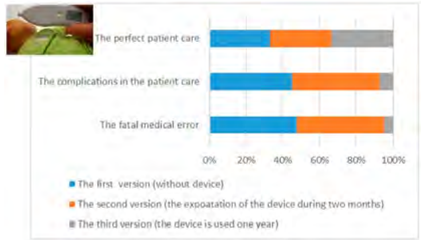


Fig. 1



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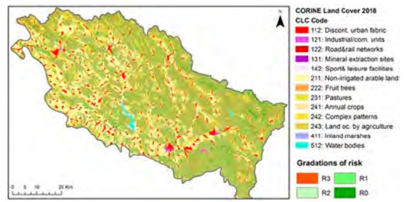

Fig. 4

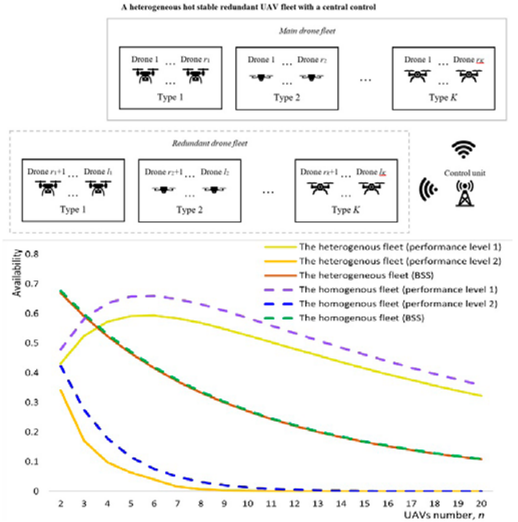

Fig. 3

Nanofluids in Electrical Engineering

Principal investigator
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Participating organisation
Technical University of Kosice
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Term of solution
07/2019 – 06/2023
Budget from agency
249 496 €
Project ID
APVV-18-0160

Research Subject

The subject of this experimental research is oriented on nanofluids based on alternative cooling and electrical insulating liquids.

Aim of the Research

The main aim of the research was to make cooling and electrical insulation of transformers more efficient using nanofluids. The partial objectives of the project were formulated as follows:

- Prepare magnetic nanofluids with nanoparticles of Fe, Co, Mn oxides and nanofluids with carbon nanostructures based on standard transformer oil, a new unique type of insulating oil from liquefied natural gas, and nanofluids based on natural and synthetic esters.
- Characterize the prepared nanofluids in terms of their composition, stability, morphology and structure.
- Experimentally investigate the magnetic, dielectric, insulating, rheological and thermal properties of prepared nanofluids depending on the concentration of nanoparticles, temperature and external electric and magnetic fields.
- Design and construct model transformers and test the cooling and insulating performance of selected nanofluids in the loaded transformer and compare the temperature rise results with standard transformer oil.

Achieved Results

Several nanofluids based on mineral transformer oils, oils from liquefied natural gas, and natural and synthetic esters were prepared and characterized as a result of this project. Among the main results it is valuable to mention the finding that the dielectric response of magnetic nanofluids can be sensitively controlled by external magnetic and electric fields, which may find application in the field of sensors or switching. It has been proven that the magnetic susceptibility of magnetic liquids can also be controlled by an external electric field. This phenomenon can be used to detect the formation of clusters of nanoparticles in an electric field.

From of electro-insulating properties point of view, it was found that the presence of stabilized nanoparticles of iron oxides can significantly suppress partial discharges in mineral oil, but not in liquefied natural gas.

A particularly interesting result is the detection of an electric field-induced layered structure of magnetic nanoparticles at the interface of a magnetic liquid and a silicon crystal with a copper layer. This knowledge contributes to the understanding of heat transport from a solid to a nanofluid. Based on this experimental result, we proposed a mechanism of heat transfer from the heat source to the nanofluid through a thermal bridge from the layered structure of magnetic nanoparticles.

As part of this project, a single-phase transformer with a nominal power of 5 kVA was produced. Prepared nanofluids were applied in this transformer as a cooling and electro-insulating medium with a volume of 12 liters. Temperature rise tests of the transformer revealed that thanks to magnetic fluids, it is possible to achieve a reduced temperature rise of the transformer. Specifically, the application of magnetic nanofluids containing Fe3O4 and MnZn ferrite nanoparticles with a concentration of up to 1% results in the reduced temperature rise and operating temperature of the transformer by 2°C in average. Testing the C60 fullerene nanofluid in the transformer yielded more surprising results. The average temperature rise with this nanofluid was 8 °C less than in the case of when pure transformer oil was used. This nanofluid flows in the transformer with the highest average speed, namely 0.07 liters per second. For the magnetic fluid containing Fe3O4 nanoparticles with a concentration of 0.01%, the flow was measured with an average value of 0.03 liters per minute.

Benefits for Practise

The main benefit for the practice is the interest of the Slovak transformer manufacturer BEZ Transformátory a.s. in the developed nanofluids. Selected nanofluids investigated in this project will be supplied to the mentioned company for testing in real distribution transformers. Based on the obtained results, the use of nanofluids in transformers will have positive economic consequences. These mainly consist in the possibility of producing smaller transformers (less material due to more efficient nanofluid cooling) and in extending the service life of transformers. It is known that reducing the working temperature of a transformer by 8°C will prolong its life by a half. With a normal lifespan of 40 years, this extension is significant. On the other hand, with emerging electromobility and expected high and fluctuating transformer loads, the nanofluid will provide more reliable transformer operation.

Fig. 1 / Photo of pure transformer oil (a), C60 fullerene - doped transformer oil (b) and magnetic nanofluid (c)

Fig. 2 / Photograph of the tested transformer model and temperature map of the transformer with nanofluid obtained by an infrared camera.

Fig. 3 / Photo of corona discharges in transformer oil (first on the left). Demonstration of the suppressive effect of magnetic nanoparticles on corona discharge in oil with increasing concentration of nanoparticles (from left to right).

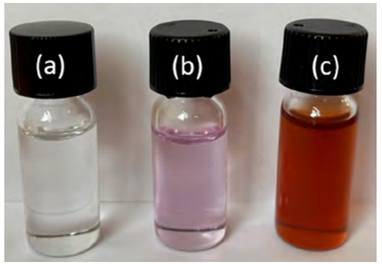

Fig. 1

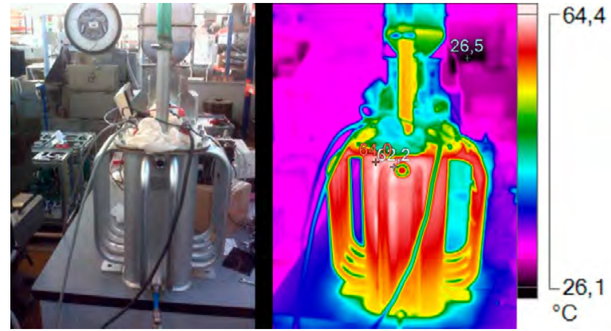

Fig. 2

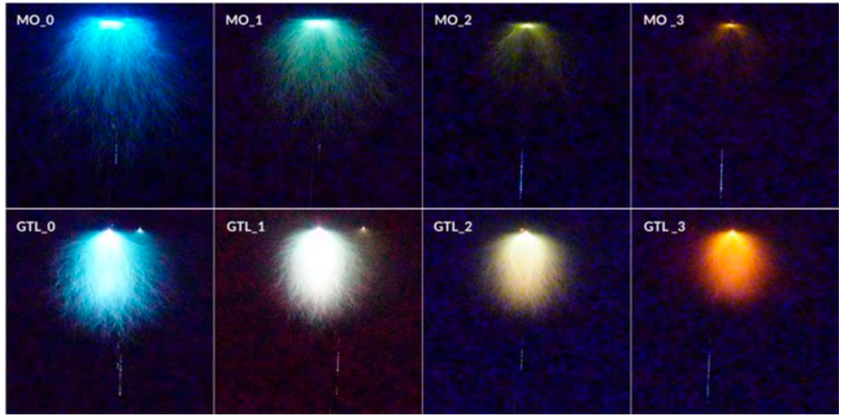

Fig. 3

Smart clothing for E-health applications

Principal investigator
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Participating organisations
VUTCH-CHEMITEX, Ltd.
Term of solution
07/2019 – 12/2021
Budget from agency
250 000 €
Project ID
APVV-18-0167

Research Subject

The project responded to the long-term forecasts of social development in Slovakia and Europe over the next 20-30 years, which show that cardiovascular diseases are among the civilization diseases of the 21st century, and the percentage of people with these diseases has been continuously increasing. The incidence of cardiovascular diseases can be reduced through early diagnosis, appropriate diseases' management, rehabilitation, and prevention. Therefore, the aim of the project was to contribute to the specific prevention and diagnosis of cardiovascular diseases by developing a multifunctional biotelemetric smart clothing. The project focused on preparing and validating the production of garments with a centrally integrated circuit and a custom mobile application designed to sense, transmit, record, and evaluate bioelectrical signals in the form of the electrocardiogram (ECG), body temperature, and real-time monitoring of human position.

Aim of the Research

Objective 1: Preparation of prototype of a multifunctional intelligent garment with built-in textile ECG electrodes, grounding electrode, temperature sensor, motion sensor, centralized integrated circuit and custom developed mobile application.
Objective 2: Preparation and verification of the production of the 1st series of prototypes of intelligent clothing including accessories under the conditions of a Slovak implementer.
Objective 3: Establishing of appropriate maintenance conditions and maintenance symbols of the intelligent clothing prototype to ensure its reliable functionality over at least 15 washing cycles.
Objective 4: Verification and evaluation the functionality of the intelligent clothing prototype in practical conditions of the medical (social or healthcare) facility and obtaining of an approval/recommendation/certificate for the use thereof in practice

Achieved Results

Following results were achieved during the project implementation:
1) 10 pcs of multifunctional intelligent bio-telemetric clothing prototypes
produced using technological procedures in the conditions of the modeling workshop of the Slovak implementer SLOVENKA - Silver s.r.o. Banská Bystrica in sizes S and M within the preparation of the 1st series of prototypes of smart clothing. The prototype of the multifunctional smart bio-telemetric garment with a centralized integrated circuit, a removable centralized control and communication unit, and its mobile application is capable of sensing, transmitting, recording, and evaluating of bioelectrical signals in the form of electrocardiogram (ECG) and body temperature in real-time.
2) Technological standard "Technology for the production of the 2nd generation bio-
telemetry clothing prototype", which includes the procedure for the production of the bio-telemetry clothing, including a description of the cut and design of the T-shirt, as well as the materials used.
3) UniversalGraph mobile application for Windows and ECG APP for Android OS.
4) Draft of utility model 177-2021 Electrically conductive magnetic coupling (status: registered utility model) and patent application 84-2021 Electrically conductive magnetic coupling (status: pending - application published).
5) Results of the project were published in scientific journals and conference proceedings at the national and international levels.

Benefits for Practise

The developed innovative smart clothing can be applied in various practical areas. Bio-telemetric clothing is designed for monitoring vital functions and the health status of individuals, with priority applications in the following areas:

1) Healthcare: monitoring patients with chronic diseases without restricting their normal activities, preventing health issues of healthy individuals, and monitoring the vital functions of elderly or isolated individuals at risk.
2) Sports: continuous sensing and monitoring of biometric data during various sports activities, tracking athletes' physical condition indicators, and monitoring their performance during training and rehabilitation.
3) Applications for protective clothing in segments with life-threatening risks, such as firefighters, police, military personnel, etc.
4) Automotive industry: monitoring the vital functions of vehicle crew members.

Fig. 1 / Final prototype of the 2nd generation of bio-telemetry garment: dress size S (A), dress size M (B)

Fig. 2 / Central Control and Communication Unit, front view (A), side view (B), rear view (C)

Fig. 3 / Example of an ECG signal captured by the bio-telemetry garment and displayed on the ECG APP for Android (A) and UniversalGraph for Windows (B)

Fig. 4 / Quality of the ECG signal and temperature sensed after each cycle of maintenance by washing and drying

Fig. 5 / Recommended symbols for the maintenance of the 2nd generation bio-telemetric clothing prototype

Fig. 1

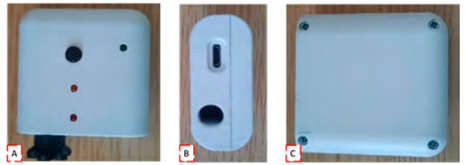

Fig. 2

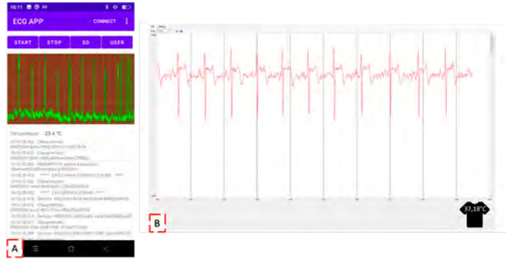

Fig. 3

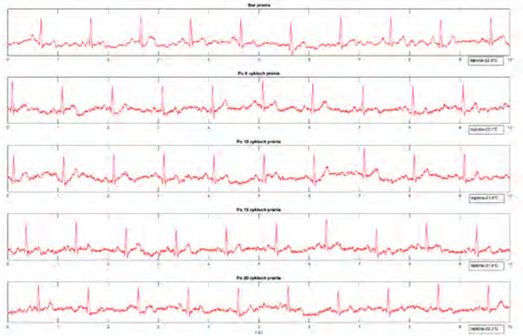

Fig. 4

Fig. 5

Originality protection of fibres, textile and clothing products

Principal investigator
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Participating organisation
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Term of solution
07/2019 – 12/2021
Budget from agency
250 000 €
Project ID
APVV-18-0187

Research Subject

The high proportion of counterfeits on the market and increasing trend of direct annual losses from infringements of the intellectual property rights of trademark owners and legitimate producers of goods belong among the long-term international problems of countries around the world. The project focused on protecting fibrous, textile and clothing products from counterfeiting, ensuring their authenticity and originality by applying photoluminescent dyes and pigments (FF/P) whose optical excitation creates on detection an individual spectral pattern allowing unambiguously demonstrable identification of the product.

Aim of the Research

The main goal of the project was to solve and introduce an innovative technology for production of polypropylene (PP), polyamide (PA) and biodegradable polylactide (PLA) fibres using progressive polymer dispersions (concentrates) containing (0,01-0,30) wt.% of a special protective photoluminescent inorganic pigment or organic dyestuff. Verification of their application in selected assortments of textile and clothing products. Preparation of innovative textile and clothing products with proven protection of their originality.

Achieved Results

The output of the project are innovative technologies from the field of progressive polymer concentrates of protective photoluminescent pigments, photoluminescent fibres, original and innovative textile and clothing products:

- progressive PP, PA and PLA concentrates of protective photoluminescent organic and inorganic pigments, which can be a basic modifying component in processes for the preparation of photoluminescent PP, PA and PLA fibres;
- progressive PP, PE and PLA concentrates of protective photoluminescent organic and inorganic pigments, which can be a basic modifying component in processes for the preparation of photoluminescent PP, PE and PLA packaging and protective sheets;
- original photoluminescent PP and PA fibres containing 0,01 wt.% and 0,30 wt.% of protective photoluminescent pigment in the fibre mass, which are safe, do not pose any health hazard, meet the required regulatory limits of the internationally recognised OEKO-TEX® system for human textile ecology and do not contain potentially harmful substances according to the REACH regulation. They can be a basic component of the system for originality protection of textile and clothing products.
- original photoluminescent PLA fibres containing 0,01 wt.% and 0,30 wt.% of protective photoluminescent pigment in the fibre mass, which can be a basic protective component of the systems for originality protection of environmentally friendly products, e.g. harmless nets intended not only for the food industry;
- original photoluminescent PP, PE and PLA packaging and protective sheets containing up to 0,50 wt. % of protective photoluminescent pigment in the fibre mass, which can be a basic component of originality protection for the buyers of packaging and protective materials;
- original textile and clothing products as well as clothing accessories with protective components from the photoluminescent PP and PA fibres incorporated into structure of the clothing directly in the process of their manufacture;
- inovative clothing products and clothing accessories for which solution of originality protection is necessary and highly desirable by additional incorporation of the identification protective components into the existing structure of the finished product;
- original protective components (labels, brand names, logotypes) containing photoluminescent PP and PA fibres incorporated into the structure of the component in the process of its manufacture.

Benefits for Practise

The project results should contribute to increasing the level of consumer protection and reducing the rate of infringement of the intellectual property rights of the manufacturers and owners of trademarks in Slovakia and abroad. Incorporation of the protective components directly into structure of the textile and clothing products will prevent the misuse of these products outside the legal owners and/or providers, thus ensuring the required level of authenticity of the protected products, belonging exclusively to ownership of e.g. relevant state department, owners of the branded goods etc. Results of the project can be widely used not only in the fibre, textile and clothing industry, but their application can also be extended into the area of sheets intended for protection of goods, which cannot be directly marked with a mark of originality.

Fig. 1 / Optical manifestation of photoexcitation of PP concentrates containing protective FF/P: a) in visible spectrum of solar radiation; b) and c) under special UV light.

Fig. 2 / Optical manifestation of photoexcitation of the protective FF/P on the laps of PP and PA fibres under special UV light.

Fig. 3 / Optical manifestation of photoexcitation of FF/P in PP and PA fibres used in woven labels: in visible spectrum of solar radiation; b) up to e) under special UV light.

Fig. 4 / Optical manifestation of photoexcitation of the protective FF/P in fibres used in the protective components – embroidered logotype and piping on a T-shirt and a face mask: a) in visible spectrum of solar radiation; b) and c) under special UV light.

Fig. 5 / Optical manifestation of photoexcitation of FF/P in the fibres used in the protective components – logotypes and socks (left sock in each pair) a) in visible spectrum of solar radiation; b) under special UV light.

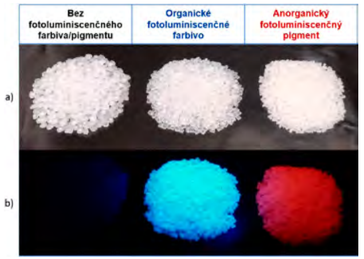

Fig. 1

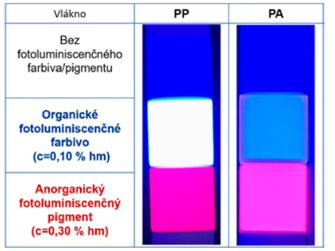

Fig. 2

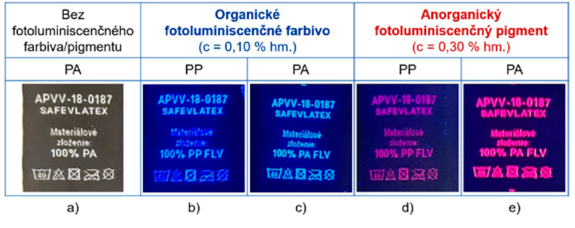

Fig. 3

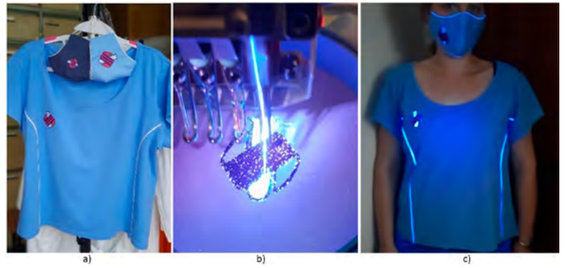

Fig. 4

Fig. 5

Chemoenzymatic synthesis of substances with pharmaceutical potential: Optimization of processes of phenylethanoid glycosides production

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Term of solution
07/2019 – 06/2023
Budget from agency
249 980 €
Project ID
APVV-18-0188

Research Subject

Tyrosol and hydroxytyrosol are natural phenylethanoid antioxidants, occurring in free or chemically bound form in olives and their products, in some medicinal plants, wastewaters from agricultural production etc. β-Glucopyranoside of tyrosol, salidroside, is characterized by antioxidant, anticancer, antiviral, anti-inflammatory, antidiabetic, neuroprotective, cardioprotective and hepatoprotective effects. Unlike the synthesis of salidroside, the preparation of other tyrosol glycosides has been studied very little. On the other side, Replacement of the sugar fragment in phenylethanoid compounds can provide new potential drugs with improved or even altered activities, since the structure of the present saccharide can significantly modulate the pharmacological and pharmacokinetic properties of natural substances at the molecular, cellular or tissue level. Testing the activity of such new glycovariants, however, requires an efficient method of their preparation in the quantities sufficient both for pharmacological studies and for further modification. The project therefore dealt with the enzyme preparation of analogs of the natural pharmacoactive compound salidroside, namely β-fructofuranosides and β-galactopyranosides of tyrosol and hydroxytyrosol.

Aim of the Research

The main goal of the project was the efficient preparation of β-fructofuranosides and β-galactopyranosides of tyrosol and hydroxytyrosol. This goal includes the selection of suitable enzymes tested for their transglycosylation activity and chemoselectivity, subsequent immobilization of the selected enzymes, characterization of the resulting biocatalysts and optimization of the reaction conditions. Another project goal was the development of procedures for product isolation and for regeneration of used aglycones, which was primarily important from the point of view of the price of hydroxytyrosol. The fulfillment of this goal included the selection of adsorbents and conditions of adsorption based on their capacity and selectivity, the selection of desorbents and desorption conditions, the determination of equilibrium single- and multi-component isotherms of products and substrates, the selection of the sequence of purification steps and the optimization of column purification with an emphasis on the purity and yield of products and a high degree of recycling of phenolic substrates. The last goal was to optimize the operational stability of biocatalysts and processes for glycoside production in laboratory bioreactors, while studying the influence of reaction conditions on the process stability of biocatalysts, the optimal yield and productivity of packed flow bioreactors with immobilized enzymes, and the long-term stability of the biocatalyst in a flow bioreactor.

Achieved Results

The reaction conditions for the preparation of the target glycosides were optimized in an effort to achieve maximum yields. The most effective among the tested glycosidases, β-galactosidase (lactase) from *Aspergillus oryzae* and β-fructofuranosidase (invertase) from *Saccharomyces cerevisiae* were immobilized on carriers with different chemical nature and immobilization principle, the Epoxy type carriers being found to be the best performing supports. The prepared biocatalysts with optimized operational stability were tested in the repeated preparation of the target glycosides. Followingly, flow reactor parameters for the continual preparation of tyrosol fructofuranoside were identified and optimized.

Chromatographic techniques for the separation and purification of glycosylation and regeneration products of tyrosol from the reaction mixture were developed. Frontal chromatography on a Macronet MN270 carrier with two-stage desorption at different concentrations of ethanol proved to be the most effective. Methods for the enzyme preparation of some tyrosol diglycosides (β-rutinoside, β-acuminoside, β-robinobioside) were also developed. All prepared glycosides were submitted for testing of their biological effects, with focus on tests of their chemoprotective properties. Hydroxytyrosol fructofuranoside was found to be a very prospective substance, with the effectiveness of protection against oxidative DNA damage at the level of hydroxytyrosol with several times lower toxicity.

Benefits for Practise

The developed procedures allow preparation of kilogram quantities of the target glycosides of tyrosol and hydroxytyrosol. By providing the obtained products for bioassays, the knowledge of biological effects of phenylethanoid glycosides. has been deepened.

Fig. 1 / Principle of synthesis of target glycosides

Fig. 2 / Production of tyrosyl β-D-fructofuranoside from sucrose and tyrosol with immobilized biocatalysts.
A – biocatalysts with oarticle size 150 – 300 µm, B – biocatalysts with oarticle size 300 – 1200 µm. Reactions conditions: 2M sucrose, 300 mM tyrosol, 55°C, 0.1 M acetate buffer pH 6, 50 mg wet biocatalyst. Carriers for immobilization: Lifetech ECR8309F (Amino C2F), Lifetech ECR8309M (Amino C2M), Lifetech ECR8209F (EpoxyF), Lifetech ECR8209M (EpoxyM), a Lifetech ECR1508 (P1508).

Fig. 3 / Selectivity of separation of tyrosol and tyrosyl β-D-fructofuranoside on hydrophobic adsorbents

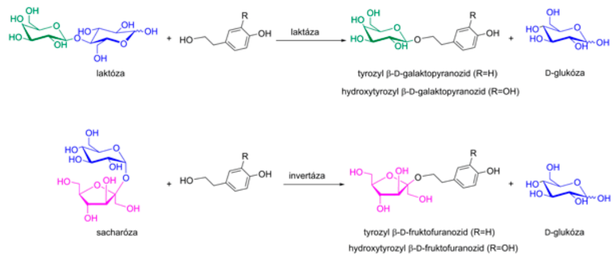

Fig. 1

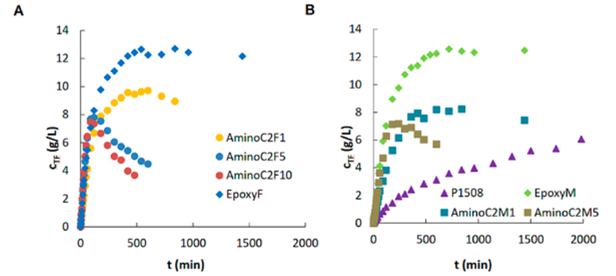

Fig. 2

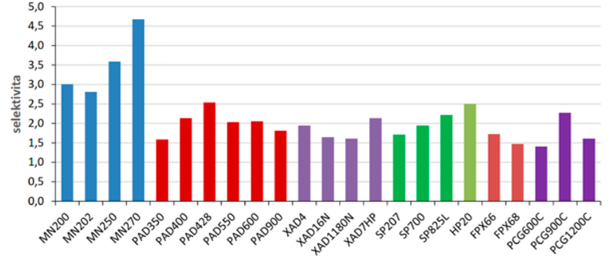

Fig. 3

Regeneration of ionic liquids used in separation processes

Principal investigator
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Applicant organisation
Slovak University of Technology in Bratislava - Faculty of Chemical and Food Technology
Term of solution
07/2019 – 06/2023
Budget from agency
62 283 €
Project ID
APVV-18-0232

Research Subject

The project is a part of a systematic study aimed at modeling of azeotropic mixtures separation by extraction or extractive distillation in the presence of a new alternative solvent - ionic liquid (IL). The use of ionic liquids in separation technologies to separate azeotropic mixtures and mixtures of components with close boiling points seems to be very promising. In case of extraction processes, e.g. in the separation of alkanes and aromatics, it is possible to use ionic liquids to separate mixtures with aromatics content below 20% due to the relatively high selectivity of ionic liquids to aromatics. Extractive distillation uses solvents (including ILs) the presence of which significantly alters relative volatility of the original mixture components, i.e., conditions of the mixture components separation are changed. Replacement of classical volatile solvents with non-volatile ionic liquids should provide benefits such as a less complicated manufacturing process and much easier solvent regeneration.
Solvent regeneration is one of the most energy-intensive steps in separation technology. The requirement for higher purity of the ionic liquid is associated with increased energy consumption in the IL regeneration process. Reducing the costs associated with the extraction solvent purification is, therefore, the focus of research aimed at the development of new regeneration procedures.

Aim of the Research

Different procedures for ILs regeneration (simple distillation, distillation and stripping with N_2, distillation and stripping with hot N_2 or with supercritical CO_2) have been proposed, but they have yet to be verified experimentally. The aim of the project was:

- to carry out the regeneration of ionic liquids in a film evaporator under laboratory conditions,
- to test the influence of experimental conditions on the efficiency of the ionic liquid regeneration process,
- to include the results in the simulation of the separation process,
- to evaluate the energetic demand of the processes employing ionic liquids and to compare them with results obtained for separation processes with traditional organic solvents.

Achieved Results

As part of the project, we focused on the selection of ionic liquids (ILs) suitable for azeotropic mixtures separation by extractive distillation and extraction. For this purpose, an extensive literature search was carried out, the aim of which was to obtain information on physical properties of ILs and their mixtures, phase equilibria of two- and three-component systems containing ILs, as well as information on separation and regeneration devices.
As it is known, information on the physical properties (necessary in separation device design calculations) is scarce for many ILs. Also, the published data (summarized in the IL Thermo database) often differ significantly. Therefore, between 2018 and 2023, we measured and presented the physical properties (density and viscosity) of a large group of imidazolium and pyridinium ILs and their two-component mixtures with water or ethanol. At the same time, we also measured and published boiling curves of these systems at atmospheric pressure in a wide concentration range for the mentioned two-component mixtures.
For the regeneration of ILs from their mixtures with water, a laboratory film evaporator MO 15 (Agrokombinát Lehnice, Slovakia) was used. The vacuum film evaporator was tested for a set of imidazolium ILs. In all cases, the resulting IL purity at the pressure of 5 kPa and temperature of around 150 °C reached 95 mole %. By reducing the pressure and increasing the temperature, the purity of some ILs improved up to 98 mole % (which corresponds to a water content of approx. 0.1 mass %).
The results of these experiments were used in simulations of separation processes, concerning the separation of azeotropic systems alcohol–water and alkane–aromatics.

Benefits for Practise

The potential of ionic liquids for the separation of azeotropic mixtures (ethanol–water, 2-propanol or tert-butanol–water, methylcyclohexane–toluene, methyl acetate–methanol, acetone–methanol,...) was investigated, while the emphasis was on the regeneration of ILs and energy demand of the entire separation process. A number of problems related to the physical properties of ILs and the phase equilibrium of systems containing ILs were solved. A regeneration device for the regeneration of ILs from their aqueous solutions was designed and tested; real working conditions of the regeneration unit at reduced pressures were examined.

Fig. 1 / Flow sheet of a unit for ethanol–water mixture separation by extractive distillation using ILs as extraction solvents: C1 – column for pre-concentration of the original binary ethanol–water mixture, C2 – extractive distillation column, C3 – vacuum film evaporator, SEP – phase separator, VALVE – throttling valve, H1-H4 – heat exchangers, MIX1-MIX2 – mixers, P1-P2 – pumps. Material flows: F1 – feed (original binary ethanol–water mixture), S0 – fresh solvent, ETHANOL – product of separation.

Fig. 2 / Variation of regenerated IL's purity (x_S) with temperature in a film evaporator at reduced pressure P.

Fig. 3 / Variation of ethanol mole fraction in distillate from column C2 ($x_{D2,ethanol}$) with solvent-to-feed mole ratio ($\dot{n}_S/\dot{n}_F$) and different purities of IL (x_S).

Fig. 4 / Dependence of heat consumption in the reboiler of extractive distillation column C2 (Q_{W2}) on the number of theoretical stages (N) at different purities of ILs (x_S).

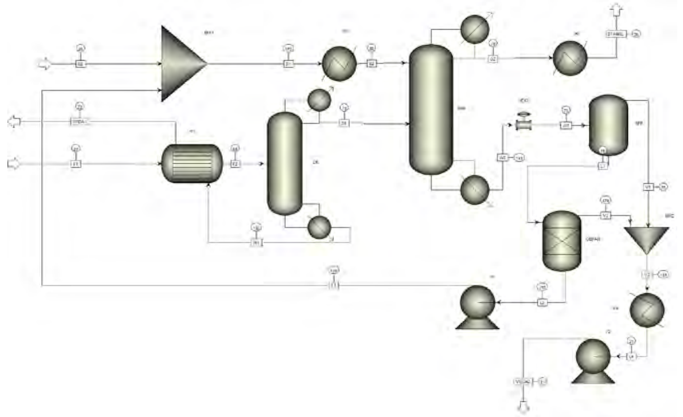
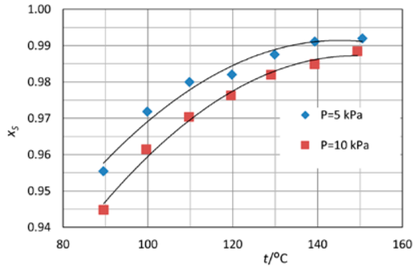


Fig. 1



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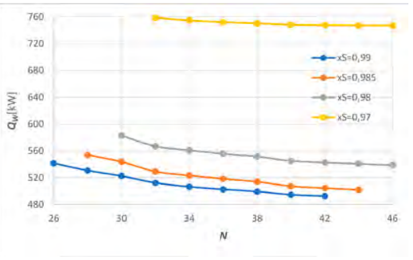

Fig. 4

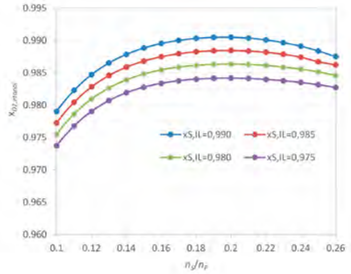

Fig. 3

Automation of Building´s Electronic Documentation Verification Using Innovative Data Collection Techniques and Virtual Models

Principal investigator
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Applicant organisation
Slovak University of Technology in Bratislava - Faculty of Civil Engineering
Term of solution
07/2019 – 06/2023
Budget from agency
248 761 €
Project ID
APVV-18-0247

Research Subject

The information technology input for the building life cycle is more and more intensive, starting with design, through realization and including the maintenance and the operation of the assets. Building information modelling (BIM) enables the utilization of the virtual models and brings the possibility of its automated verification and effective verification of the construction works. Currently, BIM enables the interactive verification of construction works by the investor and all other stakeholders. This kind of application is very time and labour consuming, therefore the automation of the process of verification is needed. The automation of the process of verification (the result is information about the completeness, as-built position and shape of the constructed elements or its parts and the information about the quality of the construction works executed) requires spatial data collection with high precision. For this purpose, various innovative techniques of data collecting are applicable, e.g. terrestrial laser scanning (TLS) or photogrammetry (360°spherical imagery), which enable effective spatial data collecting and partial automation of creation and verification of virtual models. Automating the modelling with appropriate mathematical algorithms significantly reduces time, errors and the need for human resources, and it also contributes to the efficient use of financial resources not only for the creation of documentation but also for geometric verification of construction works as-built.

Aim of the Research

The goal of the presented project was to develop a methodology for checking the as-built execution of buildings in a BIM environment. Expand BIM functionalities with tools for automated quality verification of the executed work, based on the automated creation of 3D models from data obtained by TLS (or by convergent imaging using close-range photogrammetry).

Achieved Results

During the solution of the project, requirements were formulated, and tools were created for automated data collection (measurement) using TLS, reflecting the structural arrangement and the required quality of the construction works. Algorithms have been developed for the segmentation of point clouds, which represent the as-built structures of the rough building and enable the creation of 3D models of the structural elements of the building. Also, a technological scheme was proposed for the automated comparison of the designed BIM model with the model obtained by TLS and the creation of differential models expressing the quality of the executed works (absolute and relative accuracy of structural elements).
To verify the procedures proposed in the project, a case study was carried out during the project solution, which applied all the knowledge and current results of the project solution.

Benefits for Practise

During the implementation of the project, a technological scheme of the procedure for verifying the construction of the rough structure of buildings was developed and verified in case studies. The basis for verification of the design is a point cloud created by TLS or photogrammetry. Regression 3D models are created from the point clouds, which are compared with the BIM model. Deviations are expressed, in addition to tables of deviations, also in the form of deviation maps using hypsometry. The deviation maps express the relative accuracy of the geometry of structural elements (e.g. flatness of the wall, roundness and straightness of the column, etc.) as well as its absolute accuracy (position and orientation with respect to the BIM model, position and size of the structural opening, etc.). The proposed technological procedure will significantly shorten the time needed to check the geometric parameters of building structures, as well as make the whole process more efficient, because the checked parts are not selected randomly, but the entire surface of the selected structure is checked.

The solution results together with the results of the case studies were published in journals as well as at conferences. During the implementation of the project, a total of 53 publications were published, of which 5 were published in current content journals (level Q1 or Q2). The results of the project implementation can be used by the public, professionals, at the same time they serve as an educational and expertise base for students, doctoral students and young scientists on the study programs Geodesy and Cartography, Building Technology and Management and Mathematical and Computational Modeling.

Fig. 1 / Flowchart of the proposed approach for verification of building structures

Fig. 2 / Result of laser scanning, point cloud

Fig. 3 / Comparison of the segmented as-built point cloud with the BIM model

Fig. 4 / Comparison of the regression model and the segmented point cloud – flatness verification

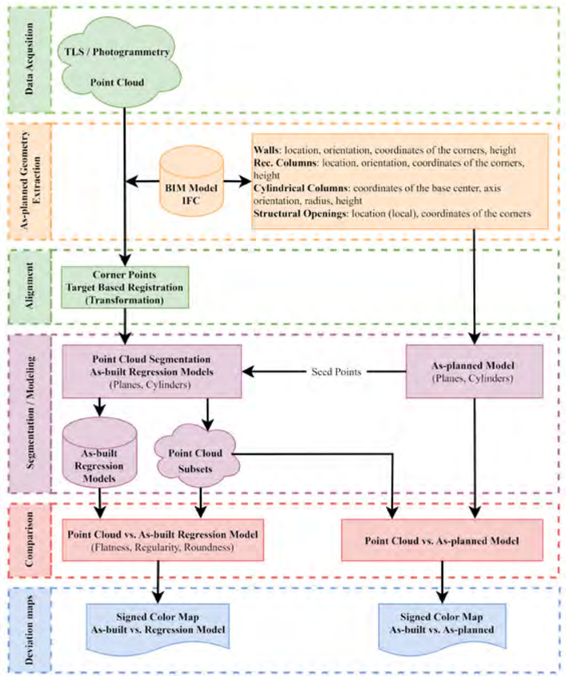


Fig. 1

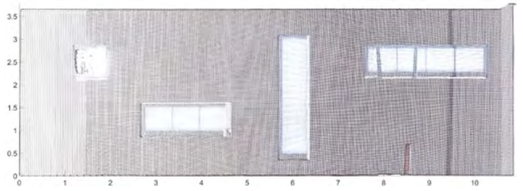
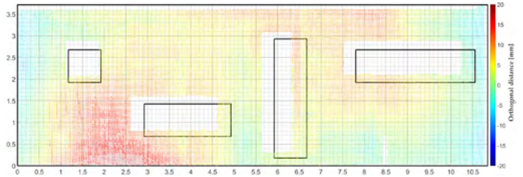


Fig. 2



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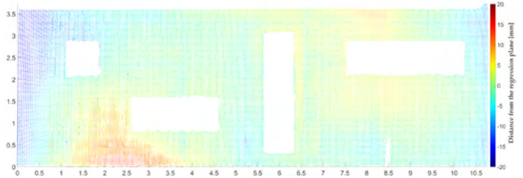

Fig. 4

Smart Belt Conevyors

Principal investigator
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Applicant organisation
Technical University of Kosice - Faculty of Aeronautics
Participating organisations
Technical University of Kosice - Faculty of Mining, Ecology, Process Control and Geotechnology
Technical University of Kosice - Faculty of Mechanical Engineering
Term of solution
07/2019 – 06/2023
Budget from agency
249 832 €
Project ID
APVV-18-0248

Research Subject

The project was focused on the transformation and strengthening of the SR industry using the innovative transport and sensor technologies within the Industry 4.0 platform. The main project vision was the creation of a new workstation for complex diagnostics of belt conveyors with an experimental intelligent belt conveyor equipped with monitoring system based on the embedded magnetic markers consisting of the magnetic microwires implemented in the conveyor belts in order of their optimization and increasing of the operational life of this high-performance continuous transport technology.
The interconnection of the sensor and information technologies with the user, together with the implementation of the Smart Industry concept leads to the enhancement of the performance and safety.
The subject of the research was also the improvement of the quality of the closed pipe belt conveyor in terms of its physical-mechanical and special properties and the influence of the impact bars application as an innovative support system for the elimination of deformations and damages of the conveyor belt.
The added value of the project was, in addition to the analysis of the possibilities of improving the quality of the working and environmental conditions, also the analysis of the impact of pandemic measures on the conveyor belts.

Aim of the Research

The main project goal was to obtain knowledge in diagnostics of pipe belt conveyors, especially in connection with the built-in magnetic markers and sensors. A partial goal of the project was the creation of a modernized version of the electronics for the complex diagnostics system of belt conveyors. Other partial goal was to obtain original results related to the impact stress of non-traditional pipe hyperelastic conveyor belts in interaction with new non-traditional support systems, taking into account the quality of the joints, as well as to the testing their physical-mechanical and special properties. Based on the results obtained from the testing, the other partial goal was to create a database for the information system for the assessing the quality of pipe belt conveyors.

Achieved Results

A modernized version of the electronics for the complex diagnostics system of belt conveyors was created, supplemented by the detection of mechanical damage to the conveyor belt using magnetic microwires.
Original outputs from the impact stress of conveyor belts in interaction with new non-traditional support systems were also obtained. At the same time, the physical-mechanical properties of the particular components were tested and analyzed, whereas the results were compared with the calculation and simulation models and subsequently implemented into the database for the knowledge information system for the assessment of the belt conveyors quality.

Benefits for Practise

The results obtained by the conveyor belt diagnostics system can be used to make maintenance planning more efficient. In addition to mechanical damage, thanks to the magnetic markers, it is also possible to sense the speed of the belt and subsequently to evaluate potential problems with the drive or control systems of the belt conveyor. Other advantage is the possibility of marking of particular segments, thanks to which it is possible to identify a damaged segment or to stop the conveyor belt exactly in the maintenance area. Furthermore, applying the predictive maintenance procedures, it is possible to reduce the operational and maintenance costs significantly.

Thanks to the laboratory model of the experimental belt conveyor with the closed belt, which is characterized by a high degree of modularity and modifiability, it is possible to test not only various maintenance or diagnostic systems, but also various types of structural elements of belt conveyor for the laboratory testing of their mechanical properties to obtain input data for the creation and verification of mathematical models of stress-strain states, even with the implemented microwires it the role of magnetic markers, which serve as sensitive elements of magnetic sensors.
The outputs of the created information knowledge system on the Visual Basic platform with the support of Windows, provide data relevant for decision-making of production, sales and maintenance managers of intelligent pipe blet conveyors in various industrial sectors.
The transfer of developed technologies into practice is performed in cooperation with the Edis vvd, company, which is the contractual customer of the research and development results of this project.

Fig. 1 / Experimental belt conveyor and its model

Fig. 2 / Numerical-experimental analysis of magnetic microwire

Fig. 3 / Analysis of stress-strain states of impact bars under impact stress

Fig. 4 / Block diagram of the measuring chain in the VEMA magnetometer used in the complex diagnostics system of the belt conveyor

Fig. 5 / Illustration of the knowledge system of the belt conveyor maintenance quality

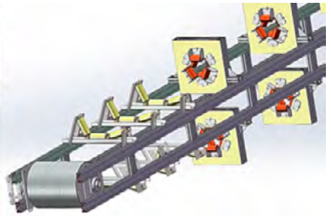

Fig. 1

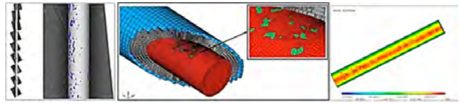

Fig. 2

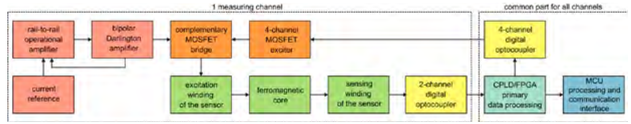

Fig. 4

Fig. 3

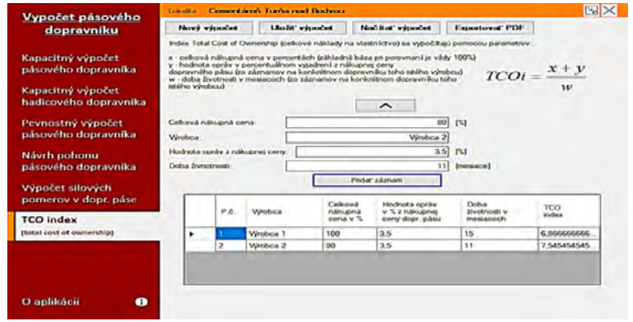

Fig. 5

Chalcogenides as emerging eco-friendly and low-cost nanomaterials for energy- and medicine- related sectors

Principal investigator
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Applicant organisation
Slovak Academy of Sciences, Institute of Geotechnics
Term of solution
07/2019 – 06/2023
Budget from agency
250 000 €
Project ID
APVV-18-0357

Research Subject

Project will be aimed at the synthesis, characterization and utilization of advanced chalcogenide materials for application in energy and medicine sector. Binary, ternary and quaternary compounds of copper with a variable composition will be treated. Efficiency of thermoelectric and photovoltaic materials will be tested. Bio-imaging as well as potential drug effectivity with antibacterial and anticancer effects will be studied. Mechanochemical methodology with the ability for scaling of the materials under study will be applied.

Aim of the Research

· Binary systems Cu-X (X=S, Se), their synthesis, characterization and potential utilization as absorbers for solar cells, parts of thermoelectric cells and medicine materials for antibacterial and anticancer treatment. New systems are expected to be synthesized via mechanochemistry as well enhanced bioavailability

· Ternary systems Cu-Y-X (Y=Sb, Bi, Fe, Sn; X=S, Se), their synthesis, characterization and potential utilization as absorbers for solar cells, parts of thermoelectric cells and medicine materials for antibacterial and anticancer treatment. New systems are expected to be synthesized via mechanochemistry as well enhanced bioavailability. The study of thermoelectric properties and an antibacterial activity will be focused in this aim

· Quaternary systems Cu-Z-Sn-S (Z=Zn, Fe), their synthesis, characterization and potential utilization as absorbers for solar cells, parts of thermoelectric cells and medicine materials for antibacterial and anticancer treatment. New systems are expected to be synthesized via mechanochemistry as well enhanced bioavailability

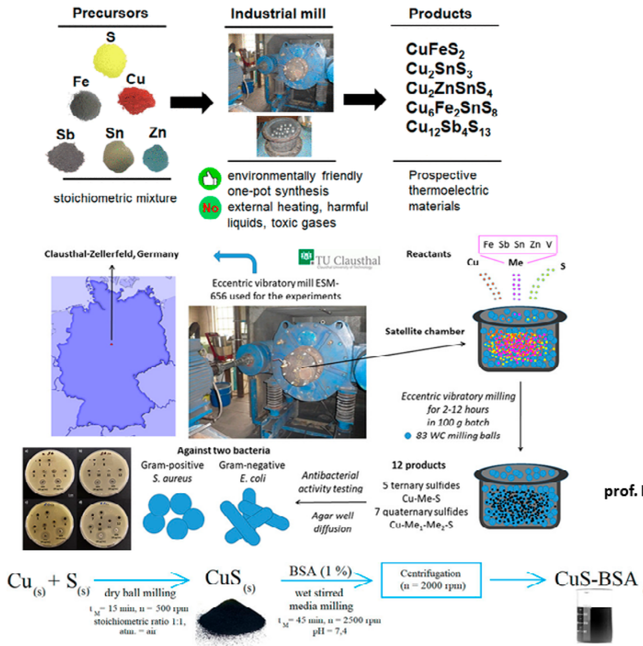
Achieved Results

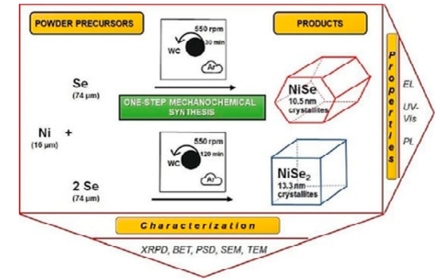
Synthesis of chalcogenides, their properties and applications were studied in this project. For preparation of binary, ternary and quaternary compounds apparatus of mechanochemistry has been applied, namely mechanical activation, mechanochemical oxidation, mechanochemical reduction and mechanochemical synthesis. These procedures were applied for preparation of advanced materials for possible application in phovoltaics, photocatalysis, energy sector and medicine. The results of researches were published in top scientific journals. During the project realization the results were published in more than 50 publications in foreign current journals and found a response in more than 170 citations in current journals accorging to SCI. Aims of project was fulfilled. Several examples were selected from a plethora of original results :

· mechanochemical synthesis of coper selenide CuSe by fast one step procedure (5 min) in a laboratory and industrial mill
· utilization of magnetometry for research of kinetics in synthesis and reduction of compounds containing iron e.g. chalcopyrite CuFeS2, stannite Cu2FeSnS4 and rhodostannite Cu6Fe2SnS8
· mechanochemical synthesis and doping of tetrahedrite Cu12Sb4S13 performed in an industrial mill for the first time
· preparation of nanocomposites e.g. CuFeS2/TiO2 applying mechanochemistry for intensification pf photocatalytic decomposition of pollutants in liquid media
preparation of kesterite Cu2ZnSnS4 by solid state synthesis verified in an industrial mill as an original alternative to current liquid procedures of synthesis

Benefits for Practise

Synthesized chalcogenides can be used in the future as absorbers in photovoltaic cells, thermoelectrics in the energy industry, in photocatalysis in ecological applications and as antibacterial agents in medicine. This application can be predicted on the basis of the original results achieved in solving the project and verified on an industrial scale.





Research team

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Principal investigator

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Mgr. Mária Kováčová

Mgr. Martin Stahorský

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RNDr. Erika Dutková, PhD.

Mgr. Zdenka Lukáčová Bujňáková, PhD.

Research and development of energy saving hybrid bearing reducer with lowered wear rate for robotic equipment (for Industry 4.0)

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Applicant organisation
Slovak Academy of Sciences, Institute of Materials Research
Term of solution
07/2019 – 11/2022
Budget from agency
248 582 €
Project ID
APVV-18-0438

Research Subject

The main objective of the project was the research and development of the new hybrid bearing reducer by improving mechanical properties (hardness, strength, fracture toughness, wear resistance, friction coefficient) and physical (thermal conductivity) properties of steel materials and ceramic nanocomposites with a ceramic matrix with the addition of carbon nanomaterials to ensure better resistance to abrasion as in the case of a allsteel reducer. Experimental materials were tool steels and ceramic nanocomposites with varying proportions of CNT, CNF and graphene platelets. The relationship between laser modification, friction properties of experimental materials, and their microstructural parameters was examined to optimize their interconnectivity and use the lessons learned to develop the optimal material for use in the hybrid bearing reducer prototype.

Aim of the Research

Creation of microstructureal design with laser what is concerning morphology, microstructure, hardness, and wear resistance for the application as friction bearing in hybrid bearing reducer.
By powder metallurgy prepare of nanocomposite ceramic friction material with optimized microstructure, hardness, and wear resistance for roller elements in hybrid bearing reducer.
Study of mutual relationships between microstructure and mechanical properties and analysis of evolution of microstructural parameters of experimental materials after application of laser modification and pulsed sintering of powders.
Analysis of mechanical and wear characteristics of materials in the relationship to morphology and their microstructural changes caused by laser modification, in the case of ceramics by the addition of toughening phases.
Testing and comparison of friction coefficient and wear resistance of mutual combinations of friction couples steel – ceramioc nanocomposite with different lubricants.
Creation of technological procedure of preparation of such materials with the focus on application in bearing reducer.
Characterization of morphology, microstructure, mechanical and friction properties.

Analysis of proces parameters effects on mechanical properties.
Preparation and testing of experimental prototype of hybrid reducer with implemented modified components with improved functional properties.
Implementation and application of experimental outputs in praxis in partner organization Spinea.

Achieved Results

Gear bearing reducers contain elements of power transmission systems that should have a high level of wear resistance. The proposed laser modification served to harden the surface layer of the functional transfer surface. This solution did not affect the core of the functional segment, which preserved its toughness. Therefore, the sliding surfaces of the reducer were modified by the proposed experimental procedure by gently hardening the surface using laser beams, which prevented damage to the functional surfaces. The material composition was corrected in order to achieve optimal functional properties - low wear and low coefficient of friction, required mechanical properties and microstructure. The manufactured prototype of the reducer was tested on a test bench in two different modes to verify the functional operating characteristics. The sliding surfaces were laser modified and the roller segments were coated with a sliding material based on MoS2.

Benefits for Practise

Based on functional tests on the test stand at Spinea, s.r.o. it turned out that both conventional steel reducers with grease and reducers with coated rollers worked adequately under the test load conditions. Although only tests of starting and quasi-static friction moments were carried out, the result of the tests shows that the coating of reducer rollers has great potential. The test result suggests that the coated roller reducer could outperform the conventional steel greased reducer and reduce energy costs, potentially increase the life of the reducer, or reduce maintenance costs by later degradation of the lubricant (lower friction → lower operating temperature → longer lubricant life). The reducer modified in this way can find application in high-precision, high-load robotic arms working with high accelerations. The ambition of the research team was to achieve the repeatability and applicability of the achieved results of the research project in practice and to develop a prototype of a new bearing reducer made of metal-ceramic components, the so-called hybrid bearing reducer, which was partly successful.

Fig. 1 / Testing stand

Fig. 2 / Viscous friction curve depending on input speed and torque, bearing reducer with rollers without MoS_2 coating

Fig. 3 / Viscous friction curve depending on input speed and torque, bearing reducer with MoS_2 coated rollers

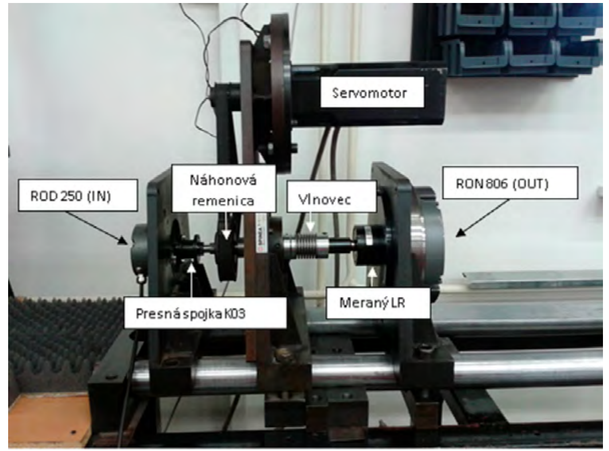
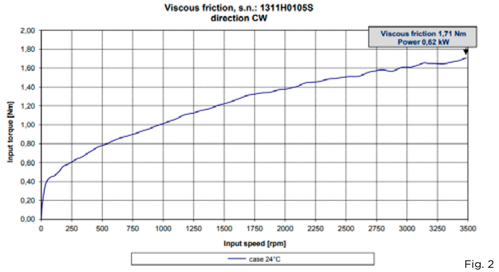


Fig. 1



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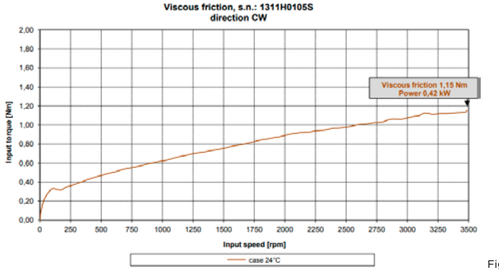

Fig. 3

Special Light Electric Vehicle from Unconventional Materials to Heavy Conditions and Terrain – LEV

Principal investigator
prof. Ing. Medvecký Štefan, PhD.
Applicant organisation
University of Zilina
Term of solution
07/2019 – 12/2022
Budget from agency
248 344 €
Project ID
APVV-18-0457

Research Subject

Current off-road ATVs (ATV) are overweighed, noisy and non-ecological. All of them have a similar structural basis, which does not allow modular customization according to customer requirements. Moreover, current set up does not allow ATVs to be control by seniors or the handicapped people.
The main idea of the project is to develop and build an unconventional ATV for high risk or out of the way terrains. The body of ATV was built from glass/carbon components driven by an electric engine.
The ATV have unconventional construction with an easy modifiable platform. The platform set up depends on the way of use. The plan was to build applications for mountain rescue services, firefighters, military purposes, biologists, hunters or farmers.
The process of solving the project was oriented to three basic areas:
• electromobility and unconventional drive design
• modular architecture of the vehicle system
• bodywork, space for the crew and cargo
• independent vehicle direction control

Aim of the Research

The main goal of the project was to develop and build the prototype of a small all-terrain vehicle with using of unconventional materials and components, driven by electric drives, design for high risk or out of the way terrains.

For successful project solution were done partial goals:
1. Development of the modular ATV structure
2. Development of ATV body with mechanical chassis, driven parts with electric drives and power source
3. Development of crew and cargo platforms
4. Development of a prototype of a mechanically independent vehicle direction control system

Achieved Results

The modular architecture of the ATV allows variety of modules, different arrangements of drives and customized platforms for the crew and cargo. The designed vehicle control system consists of a central control unit, including the drive control system, vehicle direction, vehicle braking, and remote control system. The development of the chassis module with the electric and mechanical part of the drive including the power source and space for the crew and cargo was carried out with the maximum effort to simplify the operation of the vehicle. The seat for the crew is designed as a light and strong shell of composite material. It enables easy boarding and safe sitting.
The experimental measurements of the properties of composite materials and computer simulations were continuously carried out in the laboratory for development of individual modules (chassis module, crew module, cargo module). Innovative principles of bionic construction, such as optimization of the whole, multifunctionality, compatibility with the environment, energy saving, use of renewable energy sources, recyclability, and modularity network connection, were applied in the design process.

Three utility model applications were submitted:
1. Electromechanical steering joint with tilting in two planes;
2. Electric off-road vehicle axle module;
3. Electric vehicle chassis modular axle system.

The project results are intended for university student education, and for research and development in centers for electromobility, unconventional drives, and their components.

Benefits for Practise

The designed prototype of a small ATV Modulo is an innovative alternative to many current ATVs. The custom-built modular lightweight construction with a quiet electric drive and simple set up and control was prepared for potential user. The light construction and the clean electric drive of ATV enable professionals to access ecologically sensitive areas. This unconventional ATV is possible to use for high risk or out of the way terrains. The modular architecture of the ATV allows variety of modules, different arrangements of drives and customized platforms for the crew and cargo. The simple set up and design of ATV allow to control by seniors or the handicapped people.
The class of light off-road modular electric vehicles is missing on the market. In the professional commercial sphere, ATV designed in this way will provide a universal work tool, which an off-road motorcycle and a heavy off-road ATV cannot provide.

Fig. 1 / Electromechanical control joint

Fig. 2 / Laboratory tests of the prototype at the MAHA roller dynamometer

Fig. 3 / Road tests of the Modulo vehicle, the supporting part of the module consists of Al profiles

Fig. 4 / Modulo vehicle, the supporting part of the module consists of a carbon monocoque

Fig. 5 / Modulo vehicle

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Development of an original construction for a compacting machine with inverted kinematics

Principal investigator
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Applicant organisation
Slovak University of Technology in Bratislava
– Faculty of mechanical Engineering
Term of solution
07/2019 – 12/2022
Budget from agency
250 000 €
Project ID
APVV-18-0505

Research Subject

The global trend of replacing fossil fuels with renewable energy sources also influences the direction of research of production machinery in the area of agglomeration of materials. High-grade biofuel production is a suitable direction for the recovery of biomass and other energy wastes. One of the technologies that turns biomass into biofuels possessing the required properties is briquetting. There are three basic briquetting technologies – mechanical, hydraulic and screw pressing.
Briquetting screw presses demonstrably create briquettes of the highest quality. An advantage of this type of briquetting is the fact that, unlike with other technologies, the briquette is formed in a continuous process. However, the current design of briquetting screw presses has several critical disadvantages. This concerns, for example, the material or geometrical optimization of the screw, modular structure of the screw with a replaceable end piece, elimination of excessive load on the axial bearing by back alignment of two screws.

Aim of the Research

The goal of the solved project was the development, production and testing of a functional model of the original, patent-protected principle of screw briquetting press kinematics. The basis of the proposed design of the compaction machine with "inverse kinematics", (SK 288712) lies in the fact that the rotary part of the machine is a body with a firmly installed screw and an immovable mandrel attached in the middle of the rotary drum. The rotary movement is carried out by the compression chamber which includes the screw as its essential part. And on the other side, the compacting instrument, which is in this case called "a mandrel", is firmly fixed in the frame of the machine and does not perform any movement.
The compaction machine with inverse kinematics consists of three main structural parts – compression chamber, rotary screw firmly attached to the rotary compression chamber and the fixed instrument – mandrel. Each of the three main structural components may be in two different versions.

Achieved Results

Compaction machine with inverse kinematics brings many advantages.
- low energy consumption thanks to the rotating drum. When rotating a larger diameter, a smaller torque is sufficient for the necessary pressing force than in the case of a conventional device,
- a simpler design solution for heating and cooling the pressing mandrel, because it does not rotate.
- there is no excessive wear at the end of the press screw. - the bearings on which the rotary compression chamber is mounted are not axially loaded, because the force acts in a critically small diameter.

Benefits for Practise

As part of the project, a functional model of the screw briquetting press was designed (Fig. 1), manufactured (Fig. 2) and tested. The tests confirmed that the proposed principle of the press is correct. The material was fed into the compression chamber and was formed into the final briquette shape (Fig. 3) . This has been demonstrated by the continuous output of compacted raw material from the compression chamber. This fulfilled the goals of the project and created the necessary prerequisite for the production of a real prototype of a screw briquetting press with inverted kinematics.

Fig. 1 / Structural design of the functional model

Fig. 2 / Open pressing chamber of a real functional model

Fig. 3 / View of the briquette coming out of the pressing chamber

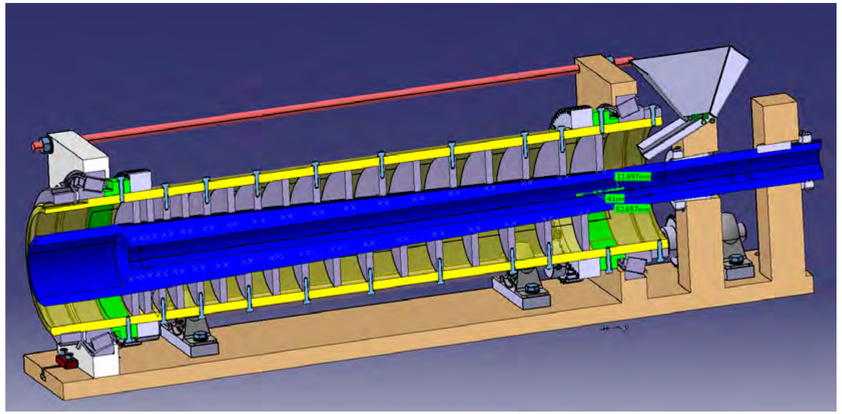

Fig. 1

Fig. 2

Fig. 3

MEDICAL SCIENCE

Resistance to antituberculotics – new possibilities of its detection and therapeutic management

Principal investigator
prof. MUDr. Mokrý Juraj, PhD.
Applicant organisation
Comenius University Bratislava
– Jessenius Faculty of Medicine in Martin
Term of solution
07/2019 – 06/2023
Budget from agency
249 880 €
Project ID
APVV-18-0084

Research Subject

Application of whole-genome sequencing in the diagnosis of resistant forms of tuberculosis (TB), identification of new mechanisms of resistance and biomarkers of ongoing disease.

Aim of the Research

1. To find out the current representation of patients with different types of resistance in the Slovak Republic (SR) in order to modernize, refine and speed up the diagnosis of resistance to antituberculosis drugs (ADs).
2. To introduce the method of whole genome sequencing (WGS) in the Slovak Republic and to verify with it the individual types of resistance of *M. tuberculosis* detected in the years 2010-2018 as well as newly diagnosed cases during the implementation of the project.
3. To compare phenotypic and genotypic resistance by different methods (cultivation, PCR, WGS) and the results of the comparison transfer to recommendations for routine diagnosis of resistant forms of TB.
4. To create and implement analytical methods for detecting the levels of laboratory markers and ADs and monitor the relationship of plasma concentrations of ADs used to the response to treatment and the occurrence of side effects in patients with different types of resistance (correlation with the patient's clinical condition, individualization of pharmacotherapy) with a subsequent recommendation for pharmacological management of patients with TB and its resistant forms.
5. To carry out a metabolomic analysis of patients with TB and look for possible changes caused by resistant forms of TB.

Achieved Results

As part of the project, we performed the first ever molecular-epidemiological analysis of multiresistant strains of M. tuberculosis in Slovakia and the Czech Republic (10.1038/s41598-022-11287-5, 10.1016/j.jctube.2021.100292). Through the obtained data, we characterized several outbreaks of infection and transmission chains. The classification of strains into phylogenetic lines/sublines showed a high occurrence of the so-called Beijing Line. This lineage represents a major threat due to its increased mutational capacity, virulence and transmissibility compared to other lineages. In addition, it is most widespread in the territory of Ukraine and the countries of the former Soviet Union; therefore, due to increased migration, we consider it important to monitor it in the coming years. The results of genotyping susceptibility revealed the first patients infected with a strain resistant to the new generation AD delamanid. Patients have not yet had this drug included in their treatment regimen, which indicates the transmission of such resistant strains within the population. Delamanid resistant strains showed a rare mutation in the ddn gene, the evolutionary origin of which is currently being studied in a pan-European study. In addition, we characterized new mutations encoding resistance to streptomycin (in the gidB gene) and pyrazinamide (in the kefB gene) (10.1093/jacamr/dlad108).
In connection with the therapeutic measurement of plasma levels of selected ADs, we developed and validated a new method for the therapeutic measurement of isoniazid, pyrazinamide and ethambutol (10.1002/rcm.9425). The results of immunological analyzes demonstrated the clinical potential of determining the concentration of selected cytokines (IFN-α2, IL-1, IL-1α, IL-1ra, IL-6, IL-10, IL-12 p40, IL-17, LIF and TNF-α) in the short-term monitoring of the effectiveness of the treatment regimen.

Benefits for Practise

The characterization of transmission chains and outbreaks of resistant TB led to the adoption of appropriate measures to stop their spread, including a complete examination of contacts.
The confirmation of genotypic resistance to delamanid was the decisive factor leading to the routine determination of susceptibility to this drug at the National Reference Laboratory for Mycobacteria in Prague.

New mutations encoding resistance to streptomycin and pyrazinamide have been included in the latest version of the mutation catalog published by the WHO (https://www.who.int/publications/i/item/9789240082410), which provides clinicians with a simple tool to interpret data obtained by WGS. In an effort to improve the management of TB treatment, we developed and validated a method (based on liquid chromatography/tandem mass spectrometry) for the simultaneous determination of plasma levels of isoniazid, ethambutol and pyrazinamide. Based on the measured levels, it is possible to adjust the dosage of selected ADs and thereby contribute to the personalization of TB treatment.

Fig. 1 / Phylogenetic tree including all multidrug-resistant strains (MDR) of *M. tuberculosis* diagnosed in the Czech Republic during the years 2005-2020 (A) and mono- and polyresistant strains diagnosed during the years 2018 and 2020 in Slovakia and the Czech Republic (B). In addition to the phylogenetic relationship of the studied strains, the figure shows genotypic resistance to selected first- and second-line antituberculosis drugs. INH - isoniazid, STM - streptomycin, EMB - ethambutol, PZA - pyrazinamide, CS - cycloserine

Fig. 2 / Classification of MDR and extensively-drug resistant (XDR) *M. tuberculosis* isolates into the respective phylogenetic lineages (A) and identification of transmission chains of MDR and XDR strains in Slovakia (B) and the Czech Republic (C) based on the number of different single nucleotide polymorphisms (SNPs).

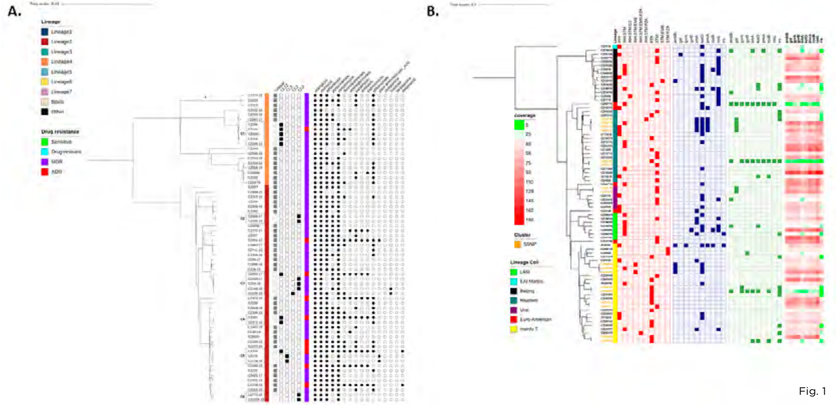

Fig. 1

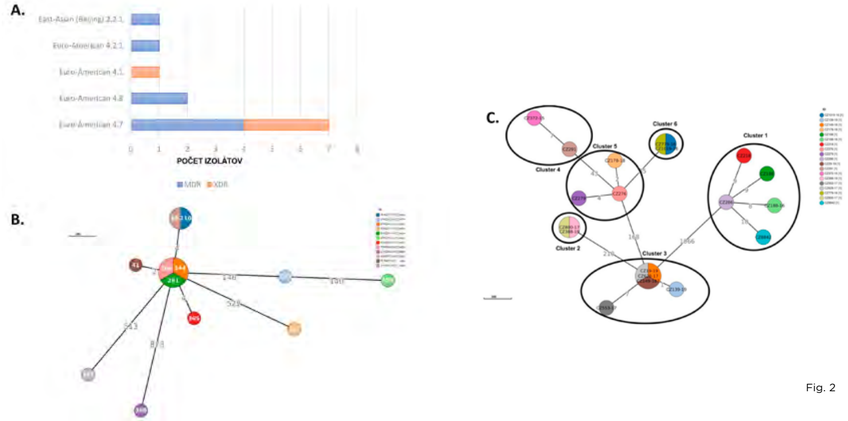

Fig. 2

Development of strategic therapeutics against selected vector-borne neuroinfections

Principal investigator
doc. MVDr. Bhide Mangesh, PhD.
Applicant organisation
University of veterinary medicine and Pharmacy in Kosice
Term of solution
07/2019 – 06/2023
Budget from agency
278 662 €
Project ID
APVV-18-0259

Research Subject

Host-pathogen interactions play a central role in the pathogenesis. Historically, small-scale biochemical, biophysical and genetic experiments were used to identify interactions among pathogen and the host cells. Small-scale studies usually reveal small pieces of tangled host-pathogen interactions. Although each piece of information is valuable, like in a jigsaw puzzle the assembly of pieces is difficult and a comprehensive picture of interactions among the host and a pathogen (ligand-receptor interactome) is still missing. Especially, in case of CNS invasions, the overall knowledge of ligand-receptor interactions is very fuzzy, because of the unique physiology of neurovascular unit (NVU) that forms the blood-brain barrier (BBB) and lack of reliable *in vitro* model. This project proposal emphasized on four areas: i) mapping the complete picture of the host (cells of NVU: brain microvascular endothelial cells-BMECs, astrocytes and neurons) – pathogen (neuroinvasive West Nile Virus and Dengue virus) interactions employing whole transcriptome analysis (RNA-seq); ii) identification of a set of ligands and their binding sites (domains) with advanced proteomics tools (LC-SWATH-MS, limited proteolysis, protein array, advanced bioinformatic tools, etc.) to reveal ligand interactome; iii) blocking the adhesion of pathogen ligands to BMECs using single domain antibodies - sdAbs (also called as nanobodies) engineered by state of the art *in vitro* immunization of B-cells and phage display technology (to abate the translocation of pathogens across BBB); iv) development of the antiviral peptides (from combinatorial phage library) that may fight against pathogens in CNS.

Aim of the Research

1. Mapping of complete picture of the host-pathogen interaction at NVU level
2. Blocking of the adhesion of pathogen to the BMECs using sdAbs (and thus blocking
3. Synthesis of AMPs that may fight against pathogens in CNS

Achieved Results

We hypothesized that neuroinvasive Borrelia adhere to the brain microvascular endothelial cells (BMEC, major component of neurovascular unit) with the help of multiple surface proteins. Using LC-SWATH-MS and advanced bioinformatic tools we identified nearly 20 proteins that can interact with BMECs. With the help of technique 'limited proteolysis', we identified the receptor binding domain (RBD) of borrelial antigens. RBDs of the protein E of TBEV and WNV were discovered during this project. Using RNA-seq we further revealed signaling events (transcriptome) evoked by pathogens or their major antigens in BMEC. Neuroinvasive Borrelia modulate BMEC cell response, which causes loosening of the cell-cell tight junctions that allow Borrelia to cross the blood-brain barrier. In the case of WNV and TBEV, domain III of protein E disrupts normal BMEC function, resulting in virus translocation in the brain parenchyma. In the second part of the project, we developed single domain antibodies (nanobodies) and cyclic peptides against RBDs, which can specifically bind to the pathogens. Some of the developed nanobodies and cyclic peptides showed potent virus neutralization ability. Cyclic peptides developed against Borrelia showed potent borreliacidal activity. Anti-TBEV, Anti-WNV and anti-Borrelia cyclic peptides and nanobodies developed in this project are currently being used in synthesis of *non-carrier* based drug that can cross the human blood-brain barrier and treat the infections. We delivered: 15 papers, 15 abstracts in conferences, 3 patents (submitted), 1 application submitted for trademark, 5 invited speeches, 2 EU projects, 6 national projects, 2 brain gain (2 post-docs) and several PhD students finished/ing their PhD.

Benefits for Practise

In this project, we identified the functional domains of antigens used to develop specific nanoantibodies and C7C cyclic peptides against *Borrelia*, TBEV and WNV using the phage display technique. We successfully developed anti-WNV nanoantibodies that demonstrated neutralization ability against WNV pseudoviral particles in a virus neutralization assay. We have also developed anti-TBEV nanoantibodies that neutralize the live virus, which was confirmed by the plaque reduction neutralization test. The developed nanoantibodies have a high potential for therapeutic application.

Fig. 1 / Membrane of *Borrelia* and membrane binding phages selected in phage display (left). *Borreliaexpressing* GFP (right).

Fig. 2 / Tight junction between two endothelial cells (up). Different molecules and their sizes (down). Red line indicates a size that can pass through the tight junction (crossing from blood to brain)

Fig. 3 / A cartoon of development of the antiviral peptide. The tick-borne encephalitis virus – TBEV (right, ball like structure). Zoom in cartoon of envelop protein (between blue lines), and receptor binding site (RBS) at its end. The peptide – GGGCXXXXXC displayed on M13 phage (left), capable of blocking binding of virus on the cell.

Fig. 4 / IgG antibody in human. Heavy chain only antibody found in *Camelidae* animals. Only VHH (nanobody), produced in recombinant form still possess full antigen binding ability.

Fig. 5 / Structure of the nanobody produced against envelop glycoprotein (green) of TBEV. Binding domain of nanobody (CDR3) is shown in cyan.

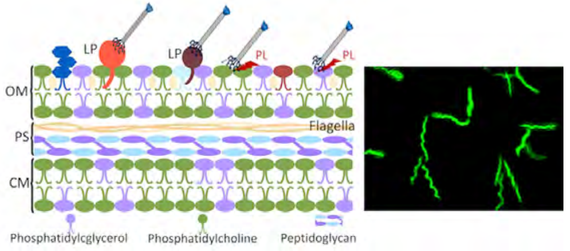

Fig. 1

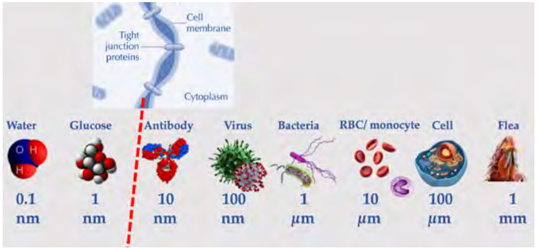

Fig. 2

Fig. 3

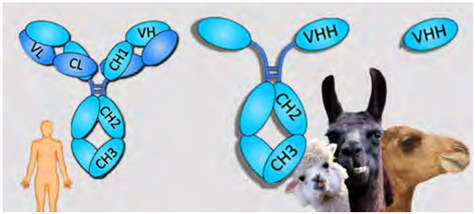

Fig. 4

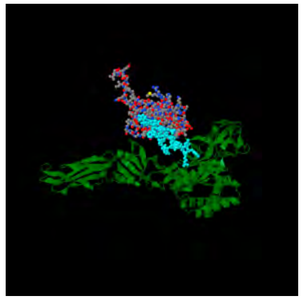

Fig. 5

Bridge between the mental state and neuroendocrine function of mother and her child: the mechanisms involved

Principal investigator
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Applicant organisation
Biomedical Research Center - Institute of Experimental Endocrinology
Participating organisations
Comenius University Bratislava - Faculty of Medicine in Bratislava
Term of solution
07/2019 – 06/2023
Budget from agency
279 533 €
Project ID
APVV-18-0283

Research Subject

The main research focus was the unraveling of the mechanisms responsible for the bridging between the mental state of the mother and her child under stressful conditions.

Aim of the Research

The main hypothesis of the project has been that neuroendocrine, immune, and metabolic signals underlie the bridging, which mediates the impact of the mental state of the mother on her child.
The main aim of the extended part of the project was to investigate the selected components of the renin-angiotensin-aldosterone system, which are associated with the effects of the coronavirus SARS-CoV-2 in the cells. The goal was to obtain knowledge leading to new targets of novel pharmacological treatments to improve the therapy of COVID-19.

Achieved Results

In line with the fulfillment of the main goal, we have published the design of an ongoing study in mother/child dyads 3-4 days following the birth and 7-9 months thereafter. The feasibility of the methodological approaches, as well as the possibility of saliva sampling and analysis of neuroendocrine markers, was confirmed. We found the first relationships between mothers and their babies. Because this clinical study had to be interrupted during the COVID-19 pandemic, the final analyses and the evaluation of "bridging" between the mental state of mothers and their babies are still ongoing. In another study directly related to the main goal in mothers and their children aged 7-11 years, cumulative concentrations of stress hormones in hair were evaluated. The stressor used was real-life stress during a pandemic. We have discovered the existence of a positive correlation between hair testosterone in mothers and their children. Testosterone may participate in the "bridging" between the mental state of mothers and their children under difficult real-life stress conditions. We brought evidence of the positive effects of glucocorticoid treatment during pregnancy in a retrospective study on 427 mothers and their neonates. In the animal part of the project, we revealed that blockade of aldosterone synthesis in rats early after birth resulted in changes in anxiety behavior and neuroendocrine responses to stressors later in life. In the COVID-19 extended part of the project, we brought evidence of the antiviral potential of glycyrrhizin, the active substance of the plant Glycyrrhiza glabra. We have revealed that food supplementation by an extract of Glycyrrhiza glabra (licorice roots) leads to a decrease in gene and protein expression of angiotensin-converting enzyme 2 (ACE2), which represents the entry point of SARS-CoV-2 into the cells (Fig. 2). Such decrease has been observed only in tissues, which express ACE2 together with 11-beta-hydroxysteroid dehydrogenase type 2 (11ß-HSD2) and mineralocorticoid receptors. Such tissues are the small intestine and lungs. The obtained results are motivating for further research to find new preventive and therapeutic possibilities during viral infections. The results of the project were published in 14 papers with a high impact factor.

Benefits for Practise

New findings obtained by searching the mechanisms of bridging between the mental state of the mother and her child contribute to the optimization of preventive steps needed to reduce negative consequences of severe stress situations (pandemics, climatic changes, social isolation) on the healthy development of the young generation. The results obtained in fields related to the COVID-19 pandemic are likely to contribute to the development of new preventive and therapeutic approaches related to virus infections and other negative features of everyday life.

Fig. 1 / The main hypothesis of the project.

Fig. 2 / Food supplementation by an extract of licorice roots leads to decreased expression of an enzyme involved in the entry of the coronavirus SARS-CoV-2 into the cells.

Fig. 1

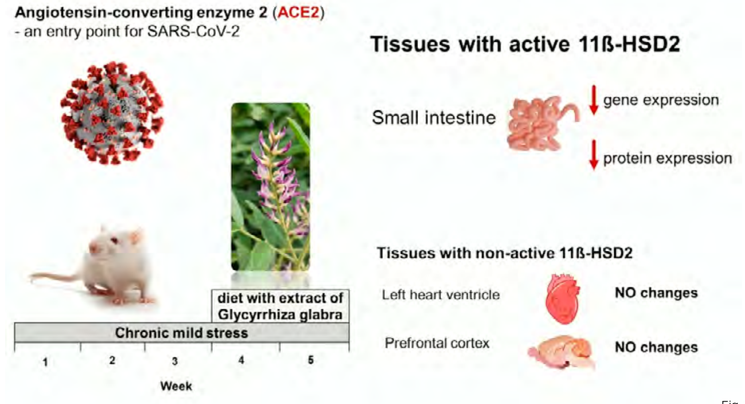

Fig. 2

Novel biomarkers of prodromal Parkinson's disease

Principal investigator
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Applicant organisation
Pavol Jozef Safarik University in Kosice
– Faculty of Medicine
Term of solution
07/2019 - 06/2023
Budget from agency
249 995€
Project ID
APVV-18-0547

Research Subject

Identification of early diagnostic and prognostic biomarkers of prodromal Parkinson's disease (PD) and other extrapyramidal diseases.

Aim of the Research

- Validate the MDS research criteria for prodromal PD within the longitudinal follow-up of 2 cohorts of patients with prodromal PD, identify potential new prodromal and risk markers
- Validate a new methodology for determining peripheral α-synuclein using 5G4 antibodies in skin biopsies
- Genetic analyzes using advanced NGS methods in patients with movement disorders, determine the population-specific genetic background of patients in Slovakia
- Biobanking of samples for subsequent projects – biobanking of blood (including isolated DNA, miRNA), cerebrospinal fluid, urine, stool (at the same time DNA isolation of the intestinal microbiome), skin biopsies (from proximal and distal areas of the body) and large intestine (colon ascendens and sigma)

Achieved Results

A total of 420 patients with manifest PD, 64 patients with prodromal PD and over 200 healthy controls are included in this study within PARCAS, PDBIOM and CEGEMOD cohorts. As part of the project, we built an extensive biobank of samples from enrolled patients, which currently serves as the basis for several multilateral collaborations and projects focused on proteomic analyzes (UCL London), analysis of a-synuclein seeding assay neuron-derived pathological alpha-synuclein in extracellular vesicles from blood as and genomic analyzes within the International RBD Genomics Consortium, skin fibroblasts are used in cooperation with the SAS Institute of Neuroimmunology for the purpose of analyzing markers of neurodegeneration and senescence in fibroblast-derived exosomes. We determined the diagnostic accuracy of the implemented multistage RBD screening, which in our cohort reaches 49% of patients classified as "probable idiopathic RBD", we also determined the prevalence of known as well as new risk and prodromal markers of PD in a cohort of patients with idiopathic RBD and validated new research criteria MDS for prodromal PD in our cohorts, which will be followed prospectively. As part of the project, we validated a new methodology for the determination of peripheral α-synuclein using 5G4 antibodies on a significantly larger cohort of patients with prodromal PD and also in skin biopsies, in order to assess the optimal tissue and methodology for the diagnosis of peripheral α-synuclein. In our population, we found a relatively high prevalence of carriers of pathogenic variants in the GBA gene at the level of 5%, and we were also the first to analyze the presence of genetic variants in the GLA gene associated with Fabry disease in a larger cohort of patients with PCH. Moreover, we identified a new cause of juvenile parkinsonism caused by biallelic variants in the WARS2 gene (Škorvánek et al. PRD 2022). We also published a genetic analysis using whole-exome sequencing in the world's largest cohort of patients with dystonia to date (Zech et al. Lancet Neurol 2020), and we also designed and subsequently validated a simple clinical predictive algorithm for genetic testing positivity using whole-exome sequencing in patients with dystonia. In addition, we described 2 new genetic diseases caused by mutations in the genes IMPDH2 (Zech et al. Lancet Neurol 2020) and VPS16 (Steel et al. Ann Neurol 2020). We also published several new phenotypes of TCF20 (Svoreňová et al. PRD 2022), TOR1A (Paveleková et al. PRD 2021), CD40LG (Škorvánek et al. Ann Clin Trans Neurol 2022) and ERCC4 (Škorvánek et al. Mov Disord 2022) genes. We also consider the discovery and description of a highly specific methylation biomarker of the pathogenicity of variants in the KMT2B gene to be significant (Mirza-Schreiber et al. Brain 2022).

Benefits for Practise

In summary, our results contributed to improved knowledge on diagnosis and screening of prodromal PD, the genetic background of parkinsonism as well as other movement disorders, especially dystonias. We identified 2 new genetic human diseases and expanded the phenotypic spectrum of several already known genetic diseases. We have published several predictive clinical algorithms for genetic testing of patients with movement disorders.

Fig. 1 / Pedigrees of families with bialelic pathogenic variants in *WARS2* gene

Fig. 2 / Genetik heterogeneity of patients with dystonic syndromes evaluated by whole exome sequencing

Fig. 3 / Comparison of prodromal Parkinsons disease probabilities evaluated by the original versus update MDS research criteria

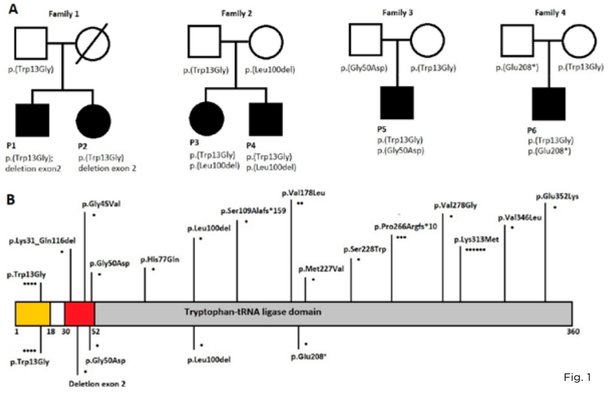


Fig. 1

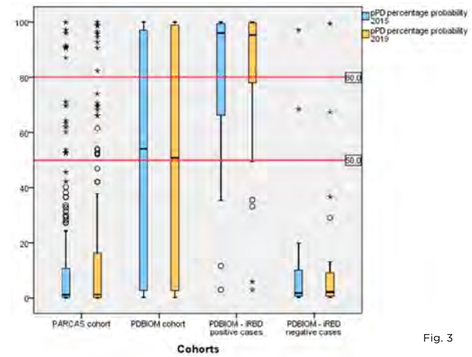


Fig. 3

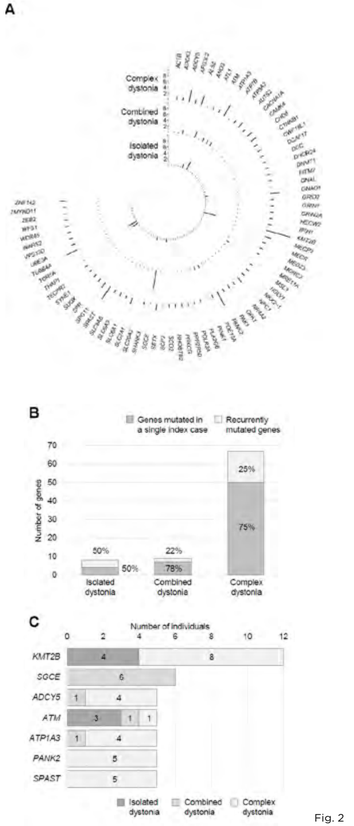
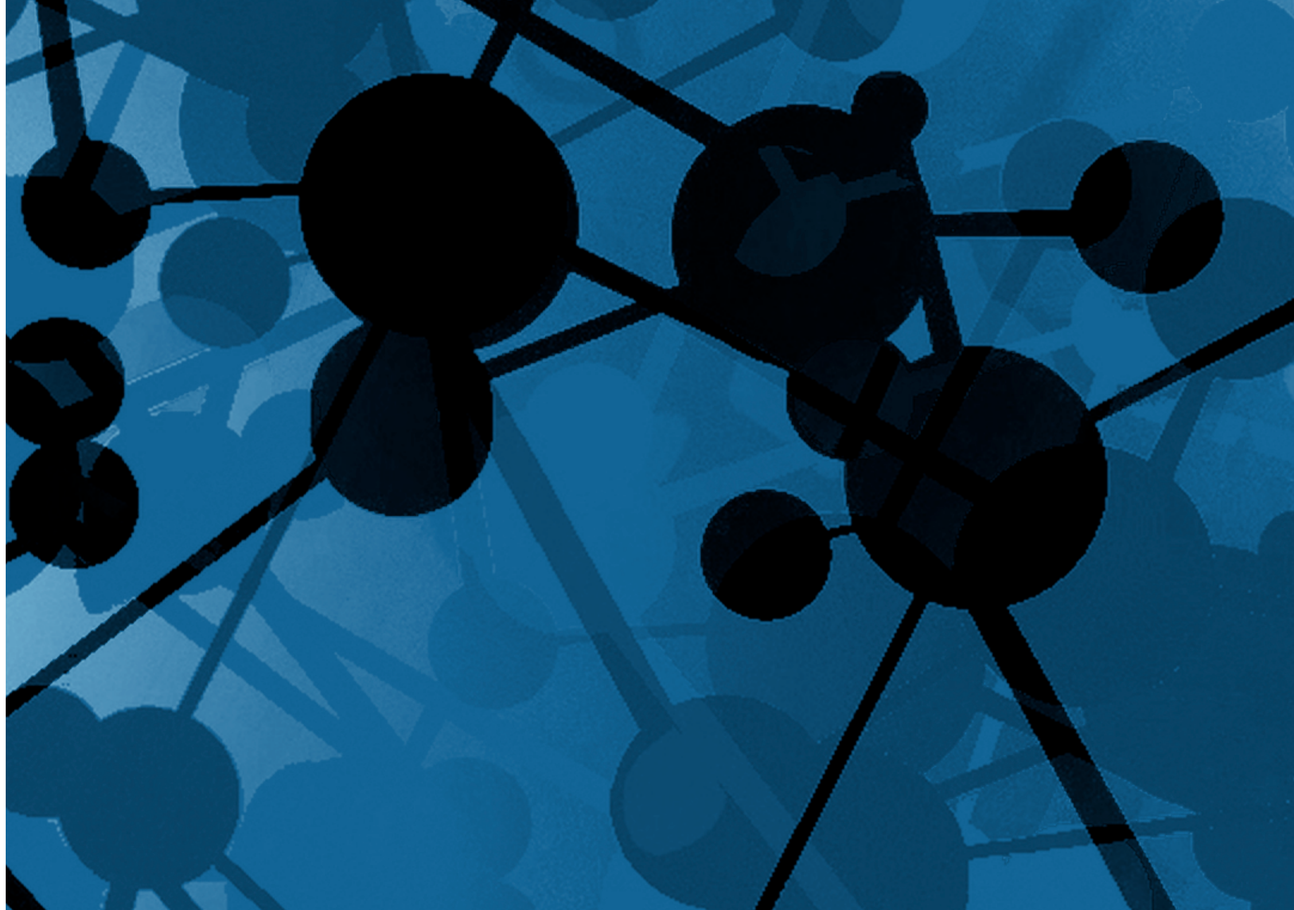


Fig. 2

AGRICULTURAL SCIENCE



Interactive impacts of tree competition, harmful agents, climate, and management on post-disturbance forest development

Principal investigator
doc. Ing. Konôpka Bohdan, PhD.
Applicant organisation
National Forest Centre - National Forest Centre
Term of solution
07/2019 – 06/2023
Budget from agency
249 998 €
Project ID
APVV-18-0086

Research Subject

Among the most significant topics in the field of the environment are issues concerning: a) the impacts of climate change and its inherent phenomena, and b) the preservation of biodiversity in various natural communities. Both areas are relevantly related to forests. The sustainable preservation of biodiversity, or ecosystem services in forest ecosystems, are disrupted by harmful agents. Thus, we focused on the post-calamity development of forest stands and possibilities for its regulation. We primarily monitored production-ecological processes, including limiting factors (Fig. 1).

Aim of the Research

The main objectives of the project were:

- to determine the stock, production, and species diversity of post-calamity vegetation, or to quantify the contribution of individual species to carbon stock,
- to quantify the effects of intra-stand tree competition (Fig. 2) on forest production and species composition in initial growth stages,
- to estimate the relationship between the quantity of forest trees and ground vegetation, and the development of this interaction over time,
- to monitor interactions between forest trees, ground vegetation, and wild ruminating ungulates,
- to quantify the impact of harmful insects on the survival of young trees,
- to compare the impact of forest management (unprocessed vs. processed calamity wood, natural regeneration vs. artificial regeneration, etc.) on the development of forest trees and ground vegetation,
- to provide recommendations for forestry and hunting management in areas following large-scale disturbances.

Achieved Results

Significant progress has been made in understanding interactions between browsing wild ungulates and young forest stands (Fig. 3). New models have been developed to estimate biomass quantities for selected species of broadleaved trees in terms of food attractiveness to wild ungulates. We propose that softwood trees should not be removed all at once during clearing operations, but rather over several repeated interventions. Among these tree species, it is advisable to keep rowan trees for the longest period (Fig. 4).
Analysis in the post-calamity areas has shown that the presence of unprocessed wood debris (Fig. 5) reduced the intensity of damage to young forest stands by wild ungulates. However, leaving fallen wood during the first 10–15 years does not create a suitable medium for forest regeneration. The best approach should involve a combined post-calamity management strategy, meaning localized processing of the fallen wood debris. This method would differentiate forest complexes and enhance resilience against harmful factors. New insights regarding the potential of various methods to insect pests (such as bark beetles or weevils) have indicated that the use of the fungus Beauveria bassiana is promising. This fungus can be introduced into the forest environment on simple carriers.
Edge-breaking findings have emerged for production-ecological processes in young forest stands. For instance, significant differences in biomass allocation between European beech and Norway spruce in young stages have been identified. The largest interspecific difference in biomass stock structure was observed in the contribution of assimilatory organs. This contribution was greater in spruce than in beech, due to the inter-annual retention of needles as well as the lower growth efficiency of spruce. Beech demonstrated high intra-stand ecological plasticity.
In terms of interspecific competitive relationships, rapid biomass expansion of trees and a decline in ground vegetation were confirmed in the initial stages of development. Succession, in the form of an increasing share of trees at the expense of ground vegetation, leads to the stabilization of carbon sequestered in biomass. A negative trend was observed in the decline of species diversity in ground vegetation.

Benefits for Practise

As part of the project's objectives, which fell within the category of basic research, a wealth of theoretical knowledge was acquired. These findings should translate into practical applications. We have proposed principles for post-calamity management, forest regeneration systems, protection of trees against harmful agents, and methods for adjusting species composition through selective clearing. In game management, we suggest a significant reduction in the population density of wild ruminating ungulates, particularly red deer. Moreover, there is a need to improve their age and sexual structures.

Fig. 1 / The schema of researched components of forest ecosystems, including limiting factors and interactions. We focused on young stages after large-scale disturbances.

Fig. 2 / Four levels of intraspecific competition in the canopy of silver birch (target tree is marked in dark green) in the young stage: A) competitively free crown, B) under mild pressure, C) under moderate intensity pressure, D) under strong pressure.

Fig. 3 / The high population of wild browsing ungulates restricts, and in some cases even prevents, forest regeneration. An example is a young stand of sycamore repeatedly damaged by the browsing.

Fig. 4 / The rowan tree doesn't have economic significance, but it is forage attractive to browsing wild ungulates. Therefore, we quantified its forage potential (above-ground biomass divided into stem, bark, branches, and leaves).

Fig. 5 / An example of field work performance under a declined spruce stand in the conditions of unprocessed calamity wood (High Tatra 2022).

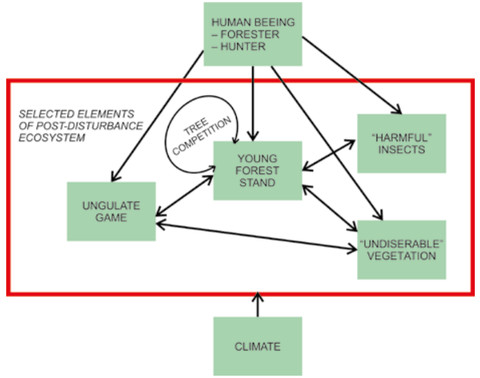


Fig. 1

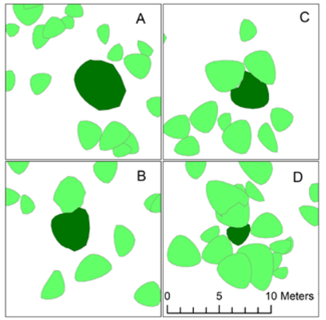


Fig. 2

Fig. 3

Fig. 4

Fig. 5

Toxic and essential elements in milk and dairy products: sources, concentrations and importance for human health

Principal investigator
prof. Ing. Toman Róbert, PhD.
Applicant organisation
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Term of solution
07/2019 – 06/2023
Budget from agency
215 476 €
Project ID
APVV-18-0227

Research Subject

The project deals with the occurrence of toxic and essential elements in milk and dairy products of ruminants from different regions of Slovakia according to the environmental load. Identification of the main sources of environmental and primary production contamination in direction: environment-animal-product-human is a main problem of quality assurance and health safety of dairy-based products. Considering the health consequences of lower iodine intake, the possibility of milk iodine fortification is a natural solution to this problem. The mammary gland and the mechanisms of elements transfer into milk can significantly influence the final concentration of elements in milk and milk products. The ultimate indicator of the appropriateness of consumption of dairy products is the risk assessment of toxic elements intake from products, especially from a burdened environment, as well as the expression of the coverage of the daily intake requirement of essential elements, especially by population groups at risk, such as preschool children and pregnant and lactating women.

Aim of the Research

The aims of the project reflect the need to monitor the actual status of toxic and essential elements in milk and dairy products produced in Slovakia from farms and the commercial network in relation to the quality of ruminant animal products from the point of view of human nutrition, their occurrence in milk and dairy products of cows, sheep and goats, as well as the contribution of the mammary gland to their transfer to milk and dairy products. An important objective of the project is to determine the status of iodine in milk and milk products, the effect of its addition to feed and the subsequent consumption of these iodine-enriched milk and milk products in a selected group of people on their iodine status and other health indicators in clinical studies. An integral part of the project is the intention to objectively quantify the risk of milk and milk product consumption on human health and also the contribution to the total intake of essential elements for different age groups of humans.

Achieved Results

Analyses of milk and dairy products from cows, sheep and goats in 19 regions of Slovakia determine the positives and risks of the presence of elements in these products from farms. Overall, the quality of products from farms and supermarkets is good, with the absence of highly toxic elements (Cd, Cr and possibly Pb). Dairy products do not contribute an alarming proportion to the toxicological intake reference values (TDI, PTWI, p-RfD). Among the essential elements, in some regions there are excellent concentrations of essential elements (Ca, Mg, K, Zn, Se), which cover a significant proportion of the recommended dietary dose for children and the most categories with the highest need (lactating women, etc.). However, higher concentrations of Cd, Al, Ba were found in the organs and mammary gland of sheep. Higher levels of As, Cr, Ni, Pb were found in commercial products, which may pose a potential risk to the consumer. Iodine supplementation in feed has also significantly affected its content in milk. Clinical studies in humans have shown that consumption of milk and milk products has contributed to iodine intake. The mammary gland, mainly the alveolar epithelium and lumen, are involved in the transport of elements into the milk. Several interactions between elements in milk and the mammary gland were identified which, in the case of mutagenic elements, may increase the risk of cancer.

Benefits for Practise

Essential and toxic elements in milk and dairy products has been analyzed in 19 regions of Slovakia, which provides the farmer with information in which areas of nutrition and production of dairy products are positives and deficiencies in a particular place, region and farm in Slovakia. The results will be used to identify possible sources of contamination, but also to verify the correct nutrition of the animals, also with regard to the farming system (organic, conventional). The results of the clinical studies are of benefit directly in clinical practice and in the nutrition of population groups at risk of thyroid and cardiovascular diseases. The application of the results is also in the development of nutritional models for primary and secondary prevention of these diseases, especially in the young population, as well as in nutritional counseling. The results are also useful for the development of scientific opinions within the EFSA Scientific Panel on Contaminants in the Food Chain.

Fig. 1 / Concentration of Ca, Na and K in milk and dairy products from farms in Slovakia.
1. sheep milk, 2. sheep whey, 3. sheep žinčica, 4. sheep soft cheese, 5. sheep milk, 6. sheep milk, 7. sheep whey, 8. sheep soft cheese, 9. cow milk, 10. cow milk, 11. cow milk, 12. cow whey, 13. cow soft cheese, 14. cow ripened cheese, 15. cow cheese threads, 16. butter, 17. goat milk, 18. goat whey, 19. goat yoghurt, 20. goat milk, 21. goat whey, 22. goat soft cheese, 23. goat ripened cheese, 24. goat soft cheese.

Fig. 2 / Concentration of Mg, Fe and Zn in milk and milk products from farms in Slovakia.

Fig. 3 / Concentration of Al, Ba, Sr and As in milk and milk products from farms in Slovakia.

Fig. 4 / Application output - Occurrence of toxic and essential elements in milk and dairy products.

Fig. 5 / Application output - Impact of the consumption of iodine-enriched products through animal feed.

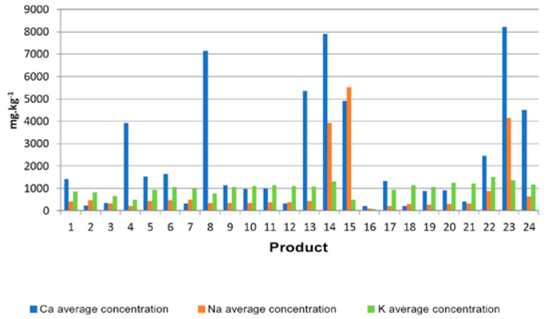
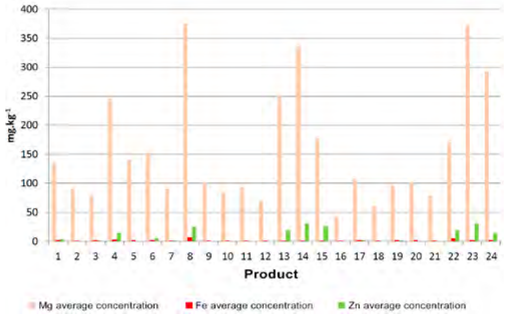


Fig. 1



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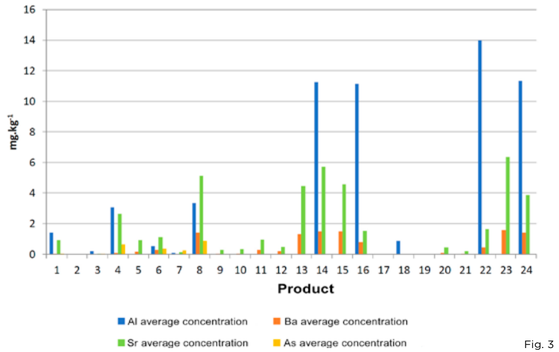

Fig. 3

Fig. 4

Fig. 5

Etiology of early preimplantation development disorders

Principal investigator
MVDr. Fabian Dušan, DrSc.
Applicant organisation
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Term of solution
07/2019 – 06/2023
Budget from agency
224 672 €
Project ID
APVV-18-0389

Research Subject

Fertilization rates in farm animals are relatively high. However, not all fertilizations result in a live birth. Early embryo mortality is a difficult problem for farmers to deal with. It is also a frequent cause of infertility in humans. Various endogenous and exogenous factors are involved in the etiology of disorders of early (preimplantation) development. In our previous studies, we have documented the negative effects of maternal overweight and different types of pesticides, especially insecticides. The main goal of the project was to study the molecular mechanisms of disorders caused by these factors in a mouse model.

Aim of the Research

We investigated the mechanisms by which specific bioactive molecules originating from the maternal organism (insulin and adiponectin as potential mediators of the influence of maternal obesity on the early embryo) or from the external environment (a worldwide-used neurotoxic insecticide fironil, targeting and blocking GABA A receptors) influence preimplantation development. In parallel, the effectivity of two basic reparatory mechanisms in preimplantation embryos, the elimination of apoptotic cells by phagocytosis and the repair of damaged DNA by activation of reparatory proteins, were studied.

Achieved Results

The results of study performed on overweight mice developed in an intergenerational model of obesity showed that when negative effects of superovulation, aging, and high-fat consumption are eliminated, obesity-induced alterations in qualitative parameters of matured oocytes do not necessarily have to be linked to fertilization disorder. Still, blastocysts derived from such oocytes showed an elevated incidence of apoptotic cell death, altered gene expression (a significant increase in the amount of insulin receptor transcripts), and, as shown by in vitro tests, development of insulin resistance. Such changes can have a negative impact on the health of the offspring. Moreover, we have shown that in mouse embryos adiponectin acts as a hormonal regulator of glucose uptake, which becomes especially important in phases with reduced levels of circulating insulin (e.g. in obese mothers suffering from type 1 diabetes mellitus). In the next study, we have detected 14 GABA receptor transcripts in ovulated oocytes and 9 GABA receptor transcripts in mouse blastocysts. The results of in vitro tests showed that GABA and synthetic GABA receptor ligands can negatively affect preimplantation embryos via GABA-A and GABA-B receptors. Our results have also contributed to the expansion of knowledge about the fundamental physiological processes in early embryos. We have shown that intact embryonic cells can act as non-professional phagocytes and possess all the mechanisms necessary for the recognition, engulfment and digestion of damaged blastomeres. In mouse blastocysts, the majority of incidentally occurring apoptotic cells is eliminated by neighboring embryonic cells. As shown by in vitro tests, the non-professional embryonic phagocytes were also able to respond to increased incidence of apoptosis induced by specific inducers. Finally, we have shown that mouse zygote can tolerate a certain degree of induced DNA damage before entry to the S-phase of cell cycle and continue embryogenesis. However, the phenomenon creates a predisposition to a segregation disorder of condensed chromatin that results in the formation of micronuclei.

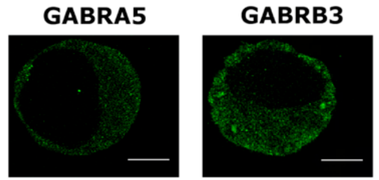
Benefits for Practise

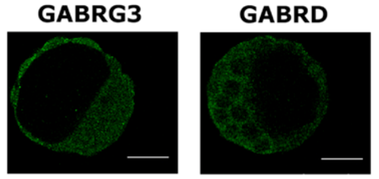
Based on the obtained results, it is possible to define specific health risks at the time of preimplantation development, i.e. in the postpartum insemination period in farm animals, in the mating period of domestic, pet and hunting animals and in the period of the first week of pregnancy after in vitro fertilization in women. Information on the mechanisms and impacts of the influence of maternal overweight (high body condition score) and maternal intoxication with insecticides (either in the form of high single doses in the veterinary prevention and therapy of parasitic diseases or in the form of long-term intake of low doses in grain, vegetables and fruit contaminated with residues) will help in the introduction of preventive measures in the management of animal production, with the aim of reducing the constantly increasing incidence of post-fertilization infertility. Economic losses resulting from this phenomenon can be reduced by proper management of animal nutrition and health in the peri-conception period.

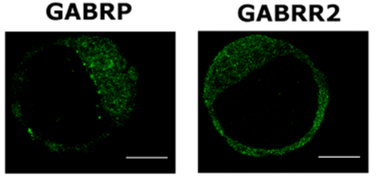
Fig. 1 / Expression of selected gamma-aminobutyric acid (GABA) receptor proteins in mouse blastocysts. GABA receptor subunits were detected by immunofluorescence staining (green signal).

Fig. 2 / Effects of GABA on cell number and proportion of dead cells in embryos. Mouse preimplantation embryos treated with GABA showed slightly decreased cell number and significantly increased proportion of dead cells.

Fig. 3 / Phagocytosis of dying (apoptotic) cell by non-professional phagocyte in mouse blastocyst. To visualise cell internalisation, fluorescence staining of in plasma membranes (F-actin, red) and nuclei (DNA staining, blue) was combined with TUNEL labelling (showing apoptotic nucleus with fragmented DNA, green).







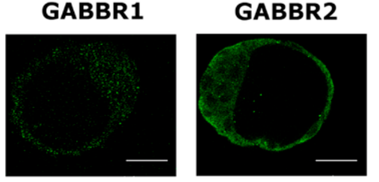
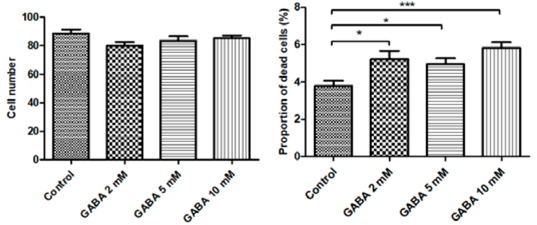


Fig. 1



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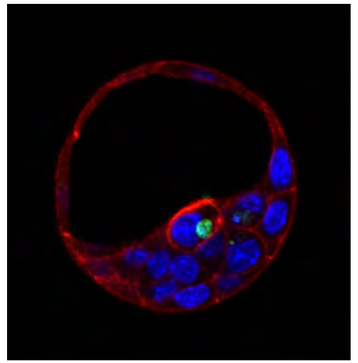

Fig. 3

Use of Advanced Phenomic Approaches to Exploit Variation in Photosynthetic Efficiency to Increase Yield Under Fluctuating and Stress Environment

Principal investigator
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Applicant organisation
Slovak University of Agriculture in Nitra
- Faculty of Agrobiology and Food Resources
Term of solution
07/2019 – 06/2023
Budget from agency
249 450 €
Project ID
APVV-18-0465

Research Subject

Elucidating the mechanisms of crop tolerance to environmental stresses related to climate change is a significant challenge limiting the targeted development of biological material in breeding, which impacts the productivity and quality of plant production. The research project was focused on applying modern phenomic approaches and evaluating physiological and biochemical traits in analysing regulatory mechanisms to reveal the variability of the photosynthetic efficiency of wheat under stress conditions. The project concept was based on a close methodological connection between modern technologically advanced phenotyping approaches and conventional ecophysiological methods to study interactions between genotype and environment.

Aim of the Research

The general aim of the project was to study the mechanisms of tolerance of wheat to drought and high temperatures to maintain photosynthetic activity and its efficiency. The project was proposed to provide effective criteria for the evaluation and screening of genetic resources of cereals tolerant to drought and high temperature in extreme climatic conditions concerning their production and quality. Specific objectives were aimed at the experimental study of regulatory and acclimation processes in the photosynthetic apparatus of phenotypically contrasting wheat genotypes in response to dynamically changing environmental conditions, with an emphasis on photochemical efficiency, as well as the role of regulatory and protective mechanisms of excess energy dissipation in photosystems. In addition, the project aimed to quantify the phenotype of wheat genetic resources using non-destructive ecophysiological approaches and advanced imaging techniques and to study the protective role of osmo- and photo-protectants for maintaining the functionality of the plant photosynthesis mechanism in dynamically changing environmental conditions.

Achieved Results

The project experiments were carried out on collections of genotypes, which enabled building datasets of phenotypic, physiological and biochemical indicators reflecting responses of genotypes to stress. Detailed mechanistic analyses showed that the nonstomatal limitation of photosynthesis was associated with alterations in the photochemical processes of photosynthesis. Our results illustrate the importance of alternative electron flows to eliminate excitation pressure in the electron transport chain. At the same time, associated criteria identifying the sensitivity and tolerance of genotypes (including photosynthetic mutants and genotypes differing in ploidy) to subsequent photooxidative damage to photosynthetic structures in leaves were identified. In field and pot vegetation experiments on larger collections of genotypes, the results of testing non-invasive methods in conditions of drought and high temperature were obtained. The applicability of rapid screening techniques was compared, and effective parameters based mainly on spectral reflectance and chlorophyll fluorescence methods were identified. The results of separate experiments also confirmed the applicability of the methods for evaluating parameters related to the water regime, such as analyses of cuticular transpiration and accumulation of osmoprotectants. In addition to the conventional methods, we applied modern high-performance methods of automated plant phenotyping using RGB, hyperspectral and fluorescent imaging sensors, with subsequent image analysis and automated trait quantification. This approach allowed us to evaluate many structural and functional traits of whole plants and their quantitative comparison with the data analysed conventionally.

Benefits for Practise

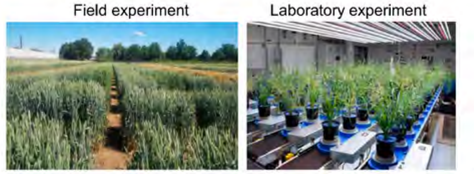
The realisation of the project enabled us to obtain original results by using phenomic approaches to reveal the causes of the variability of photosynthetic efficiency for the increase of wheat yield. Effective and targeted utilisation of parameters derived from non-invasive measurements, including automated phenotyping, can significantly contribute to the knowledge of the properties of genetic resources included in breeding or research on tolerance to environmental stresses. The proposed approaches offer a better understanding of plant functioning. They will generate new applications that can be used in breeding for higher resistance to environmental conditions, which is especially significant in the context of deepening climate changes. The results will also be applicable to the functional description of crop genetic resources in gene bank collections.

Fig. 1 / Scheme of the project implementation concept and its major elements.

Fig. 2 / Trends of plant and canopy physiological status indicators measured by fluorescence (Pitot parameter) and spectral reflectance (WBI parameter) techniques in field experiments during the spring growing season of wheat. DOI: 10.3390/agronomy10091275

Fig. 3 / Results of ECS signal analysis (parameter gH+ and ECSt) recorded in two groups of wheat genotypes (hexaploid and tetraploid) comparing non-stressed plants and plants immediately after the end of temperature stress (R1) and after several days of regeneration (R2). DOI: 10.1007/s11120-020-00812-0

Fig. 4 / Comparison of the responses of wheat genotypes acclimated (A) and non-acclimated (NA) to high temperature (H) compared to the control (C) expressed by the amplitude of the signal of photosystem I active units (Pm). On the right are RGB phenotype images of the genotypes captured by an automated phenotyping system. DOI: 10.3390/plants11050616



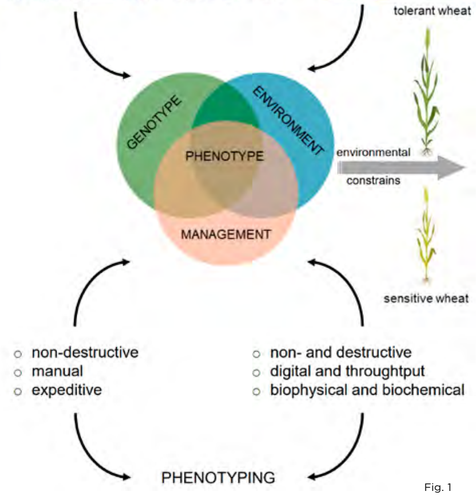
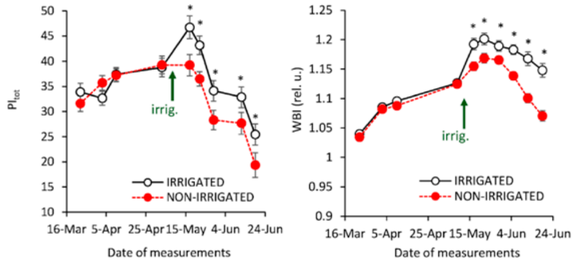


Fig. 1



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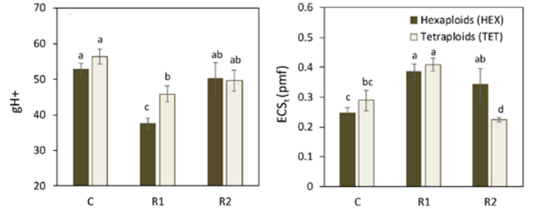


Fig. 3

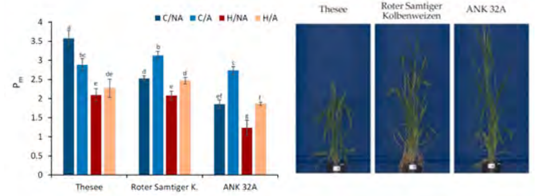


Fig. 4

Integrated monitoring and environmental risk assessment of PCBs and mercury contaminants in the Zemplín Region (Slovakia), one of the most ecologically threatened territories in Europe

Principal investigator
RNDr. Oros Mikuláš, PhD.
Applicant organisation
Slovak Academy of Sciences, Parasitological Institute
Term of solution
07/2019 – 06/2023
Budget from agency
249 454 €
Project ID
APVV-18-0467

Research Subject

Environmental pollution is one of the biggest problems threatening the survival and future development of human civilization. Among the pollutants, polychlorinated biphenyls (PCBs) and highly toxic heavy metals play a key role as they accumulate in the aquatic ecosystem, including plants, invertebrates and animals, and persist for a long time. The aim of the project was to clarify the important issues of environmental pollution of the PCB-contaminated Zemplínska Šírava reservoir, one of the worst man-made pollutions in Europe, and its surroundings, including the adjacent protected landscape area of the Bodrog river basin. Several components of the polluted reservoir and its surroundings were analyzed for PCB and Hg concentrations. A new interdisciplinary approach was chosen, combining standard methods for pollutant detection with the use of bioindicators and molecular cytogenetics.

Aim of the Research

The project deals with the important issue of environmental pollution of the Zemplínska Šírava reservoir, one of the most anthropogenically polluted places in Slovakia. The aim was to carry out the first integrated monitoring of pollution by polychlorinated biphenyls and mercury, using both standard direct physical and chemical methods and indirect methods with parasitic organisms as bioindicators. Particular attention was also paid to the detection of PCB transfer lines in the adjacent landscape of the Bodrog river basin.

Achieved Results

Economically important fish species (carp, bream, and catfish) from the Zemplínska Šírava reservoir and the adjacent areas of the Bodrog river basin (Laborec, Latorica and Bodrog rivers) were used for the analysis of polychlorinated biphenyls (PCBs). Within the model system intestinal parasite - fish, high levels of PCBs were measured in various organs of the fish, which indicates that the consumption of fish from this area is still inappropriate. It was also found for the first time that tapeworms can accumulate significantly higher (200-times) PCB concentrations compared to fish organs. Since tapeworms were more sensitive to the presence of pollutants in the aquatic environment compared to fish organs, they could be used as sensitive bioindicators even at lower pollution levels.
It is important to note that although the production of PCBs was banned almost 40 years ago, high levels of these compounds are still present in soils and aquatic sediments, from where they spread further into the environment via the waterways. This is also proven by our study, in which we detected PCB substances in fish caught up to 60 km away from the source of contamination. The current results indicate that the Latorica Protected Landscape Area, which consists of unique original floodplain forests and meanders inhabited by rare representatives of aquatic plant and animal species, is also significantly threatened by toxic PCB contamination.
For the analysis of heavy metals, 16 sediment samples, 3 samples of freshwater mussels and 102 fish individuals from seven species were taken from the reservoir. The highest mercury concentrations were found in the sediments, fish muscles and livers. The maximum permissible levels for mercury in fish meat were exceeded in two cases.
An increased incidence of morphological malformations, chromosomal aberrations and the occurrence of extra B chromosomes were also observed in the parasites. These results suggest that malformations in individual parasite species can serve as indicators of environmental stress.
During an ichthyoparasitological survey, the presence of a non-native Asian parasite species *Khawia japonensis* was detected for the first time in the wild population of common carp in eastern Slovakia.

Benefits for Practise

Given the enormous accumulation capacity of PCB compounds by fish intestinal parasites, the research results will have applications in pollution monitoring, ecotoxicological research and ecological parasitology. From a veterinary and medical point of view, the results of the high PCB compound levels in the muscle tissue of two economically important fish species, carp and catfish, are important. As the long-term consumption of contaminated fish meat poses a significant health risk to humans, the timely detection of contaminants in the environment is crucial. Therefore, our results are clearly helpful to prevent negative effects on human health as well.

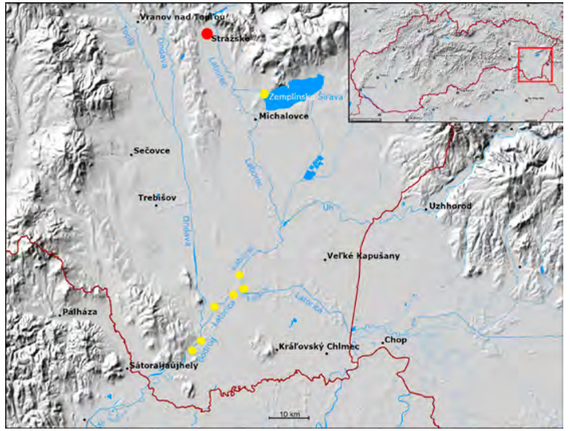
Fig. 1 / Place of PCB production (red circle) and localities (yellow circles) of biological material collection within the project

Fig. 2 / Sampling of catfish muscle for the analysis of PCB substances

Fig. 3 / Tapeworms in physiological solution isolated from catfish intestine

Fig. 4 / Sum of PCBs detected in the dorsal and abdominal muscle in ng.g^{-1} w.w in relation to age of fish. Red line shows the maximum permissible value of sum of PCB in fish meat in wet weight (limit is 125 ng.g^{-1} w.w.).

Fig. 5 / Chromosomes of Acanthocephala. A) karyotype with B chromosome, B) diplotene nucleus showing GC-rich heterochromatin (yellow), C) diplotene nucleus with B chromosome, D) FISH with 18S rDNA probe (red) on sex chromosome



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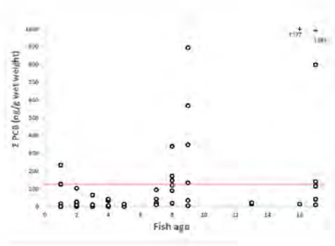

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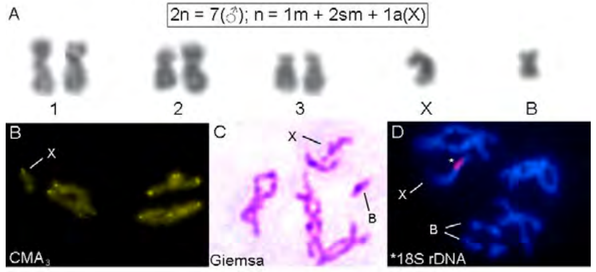
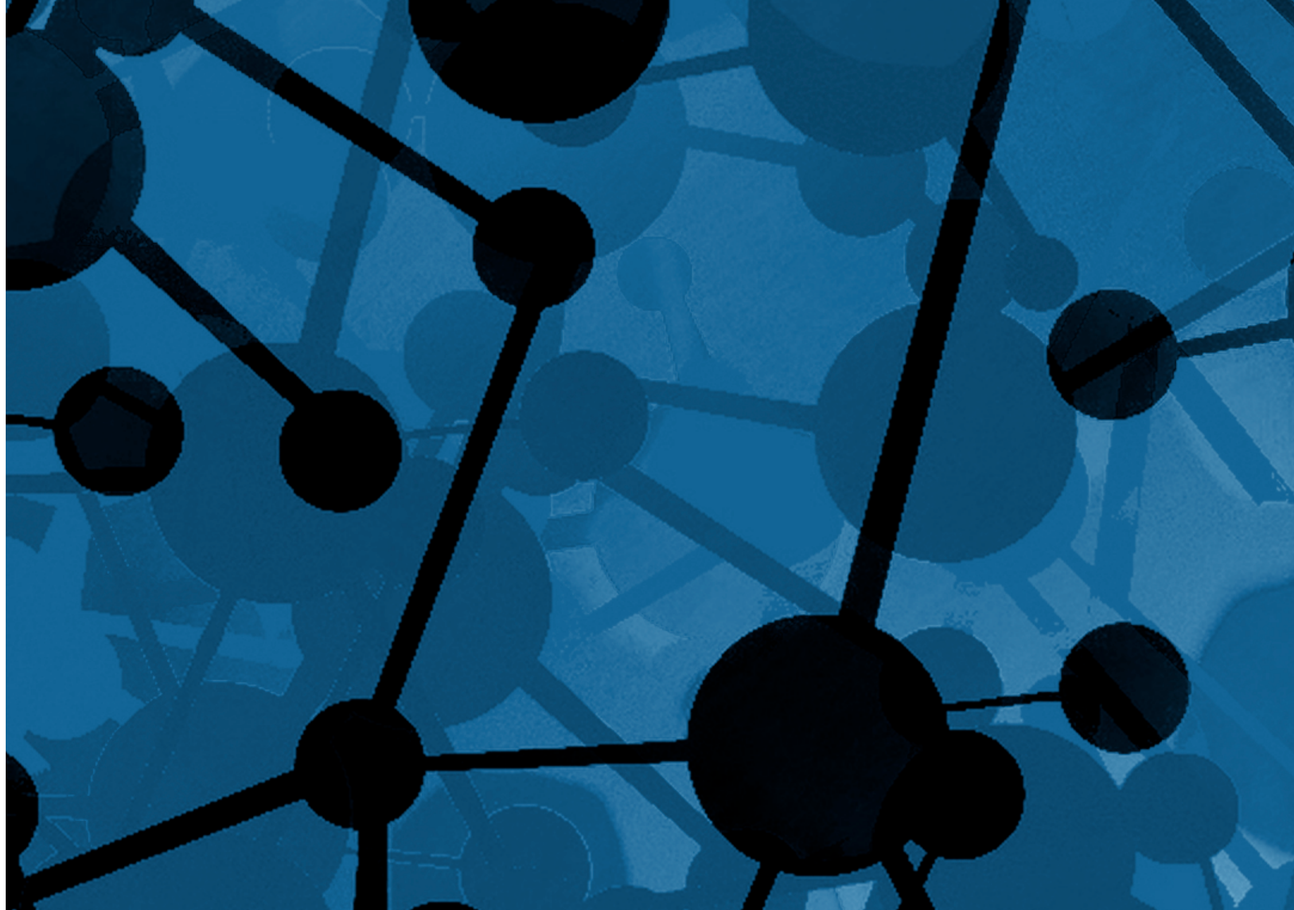


Fig. 5

SOCIAL SCIENCE



Teaching at second chance schools from the perspective of a teacher and adult learner

Principal investigator
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Applicant organisation
University of Presov in Presov - Faculty of Humanities and Natural Sciences
Participating organisations
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Term of solution
07/2019 – 06/2023
Budget from agency
230 659 €
Project ID
APVV-18-0018

Research Subject

The key aspects of teaching in second chance education of adults with and without primary education. The project reflected on the paucity of empirical findings on the forms and quality of learning for low-educated and non-educated adults in primary and secondary education.

Aim of the Research

The main aim was to identify the key aspects of teaching adults in second chance education in primary and secondary vocational schools from the perspectives of the teacher and the adult learner. The aim was to identify the current state of knowledge and practice in the field under investigation, to analyse the competency requirements of teachers in second chance education, to identify the key aspects of teaching from the perspective of teachers and learners, and to develop a theoretical model of competencies for teachers of adults with and without a primary education.

Achieved Results

The monograph Second chance education in the context of lifelong learning and regional development policies (Pirohová, Lukáč, Lukáčová, 2020) systematizes the knowledge on second chance education in current legislation and public policy documents. Findings from interviews with teachers are summarised in the publications Poverty does not favour education. Teaching in second chance education from the teacher's perspective (Šut'áková, Pirohová, Ištvan, 2022) and in two publications from the prison environment: Education in prisons. Teachers' perspective on formal education of imprisoned (Lukáčová, Lukáč, 2022) and Education in prisons II. Completing primary school through the eyes of teachers (Lukáčová, Lukáč, 2023). In addition, dozens of studies have been published in national and international journals and in the proceedings of several national and international conferences. During the project, cooperation with several domestic public institutions was established. Members of the research team were invited to collaborate with Holy Cross College (USA) in the preparation of a chapter on education in prisons in Slovakia for the international publication Unlocking learning. International perpsectives on education in prison (McDevitt, M. Gellman, eds., 2024).

The most important findings of the project can be grouped into the following main points:
- Lack of a system of second chance education. There is no concept adopted, there are no dedicated support schemes, there is no network of second chance schools. Some schools apply selected second chance principles, but rather intuitively, not on the basis of scientifically documented and applied practices as applied abroad. The availability of information on the offer of second chance education is problematic. The information is not offered in a uniform and clear form, it is not available to the actors who come into contact with the low-skilled.
- Lack of teacher training in the professional education of teaching staff. Teachers in Slovakia are not trained specifically for adult education, even though they consider such education to be demanding and carried out at the expense of their own free time. An important finding is that they do not feel sufficiently prepared to teach adults, but at the same time they do not actively seek opportunities to develop these competences.
- Lack of methodological support. The lack of methodological guidance and the absence of teacher training is expressed by an adaptation strategy of mainly selection and reduction of the curriculum, with the risk of reducing the quality of teaching.
- Lack of support for learners. There is no coherent and well-thought-out system of support for low-skilled learners and its intensity depends on their characteristics and the sensitivity of school administrators and teachers.

Benefits for Practise

The results drawn attention to the need for systematic training of teachers for education of adults, especially those with little or no education. The recommendations can serve for the practice of public policies in the field of education and employment services as a starting point for the development of a systemic approach to the education of the most vulnerable groups of adults with an overlap to the labour market. The recommendations are directed towards the practice of educational institutions and state and local government bodies with the intention of systemic and professional strengthening of adult education also in the light of the predicted changes in the composition of secondary school students in connection with the increasing drop-out rate and the ageing of the population.

Fig. 1 / BCN conference - project researchers at an international conference in Barcelona.

Fig. 2 / Conference on second chance education at the University of Prešov.

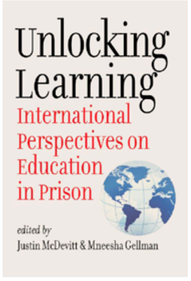
Fig. 3 / Cover of a international collaborative monograph with a chapter by the project researchers.

Fig. 4 / Cover of monograph on second chance education in Slovakia.

Fig. 5 / Cover of a monograph on teachers' perspectives on second chance education.

Fig. 1

Fig. 2



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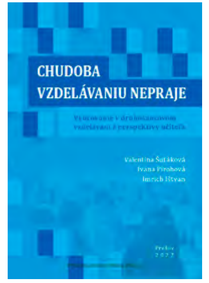

Fig. 5

Generation Z – new challenges in youth development

Principal investigator
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Applicant organisation
Pavol Jozef Safarik University in Kosice
- Faculty of Medicine
Participating organisation
Comenius University Bratislava - Faculty of Medicine in Bratislava
Pavol Jozef Safarik University in Kosice
Term of solution
07/2019 – 06/2023
Budget from agency
249 253 €
Project ID
APVV-18-0070

Research Subject

The project identifies formative influences on the psycho-social and behavioural characteristics of Generation Z in the past decade, especially the influence of new technologies and changes in social context of adolescents. Understanding these formative influences will contribute to the development of effective preventive programmes focused on strengthening health of adolescents and preventing various undesirable phenomena.

Aim of the Research

The aim of the project is to investigate the specifics of the adolescence in Generation Z using Health Behavior in School-Aged Children (HBSC) study, but also by consulting adolescent and adult stakeholders.

Achieved Results

Implementation of the project enable to explore the the specifics of the adolescence in Generation Z through a combination of quantitative and qualitative methods with application of a participatory approach and multidisciplinary international cooperation. Qualitative data (data collection 2020, 107 respondents, 11 consultations, three themes) allowed us to gain a deeper understanding of adolescents' experiences related to the transfer of cultural capital, the adoption of a healthy lifestyle and the use of digital technologies. We used consultations with adolescents and adults (2021, approx. 100 experts, 25 online consultations) to identify key formative influences and key research questions, which we took into account in the development of new tools and in the preparation of the HBSC 2022 study protocol (data collection 2022, nationally representative sample of school-aged children, 11-15 years, 94 schools, 10142 respondents). Prevalences, gender and age differences in more than 160 indicators of mental health, physical health, health-related behavior and social context, but also changes in indicators over the last 12 years (2014/ 2018/ 2022), and statements of adolescents illustrating the given topics were processed in the monograph. The analysis of quantitative data allowed us to better understand how digital technologies, the school environment, sleep, physical activity or adverse circumstances are related to the indicators of healthy adolescent development.
Analysed data were used in 36 scientific papers published in current content journals with almost 200 citations already.

Benefits for Practise

Based on a studies conducted on nationally representative samples of adolescents aged 11, 13 and 15 years, the prevalence, gender and age differences in more than 160 indicators of mental health, physical health, health-related behavior and social context, but also changes in indicators for the last 12 years (2014/ 2018/ 2022), or statements of adolescents illustrating the given topics and these findings are processed in a monograph that is publicly available.
Using the knowledge gained and based on the statements of teenagers, we prepared a short film documentary of the statements of teenagers, including English subtitles, which was also processed as a trailer.
Based on research findings output in terms of 8 educational activities (seminars, webinars, podcasts, video clips), 5 dissertations, 30 diploma theses and 11 bachelor's theses was proceed.
As part of the popularization activities, the findings of the solved project were presented in 8 contributions at foreign scientific conferences, through 16 active participations in domestic professional conferences and discussions, in 15 contributions in audiovisual media and regular contributions (approx. 130) on web platforms spread through social networks .
The research findings were presented as part of a series of lectures organized by the Youth Council of the Košice Region and in cooperation with the local government and local organizations active in the field of youth, but we also realized a series of lectures on the topic of "Cyberbullying" for primary school students in connection with the National Project Supporting the Protection of Children from Violence under the auspices of UPSVaR. The representatives of the research team were invited to a meeting to prepare the SR youth strategy for the years 2021-2028. A memorandum on cooperation with the FENIX Children's Organization, o.z. was signed.
The HBSC research team received an FeDoR award in the Feather of help category for their cooperation on the project "Health is not a cliché", thanks to which the HBSC National Report was enriched with the statements of children, and was also awarded the Pavel Jozef Šafárik University rector's prize for media coverage.

Fig. 1 / Measuring cardiovascular fitness

Fig. 2 / PhD defence in Groningen, the Netherlands

Fig. 3 / Meeting of the international HBSC network in Kaunas, Lithuania

Fig. 4 / HBSC National Report release, a press-conference, Bratislava

Fig. 5 / Writing week of the research team in Košice

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Fig. 4

Fig. 5

Internet Gaming Disorder – IGD: risk factors, symptoms and their measurement

Principal investigator
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Applicant organisation
University of Presov in Presov
Term of solution
07/2019 – 06/2023
Budget from agency
200 000 €
Project ID
APVV-18-0140

Research Subject

A new psychiatric diagnosis proposed by the World Health Organization in 2019 for the International Classification of Diseases: gaming disorder.

Aim of the Research

The primary objectives of the project were:

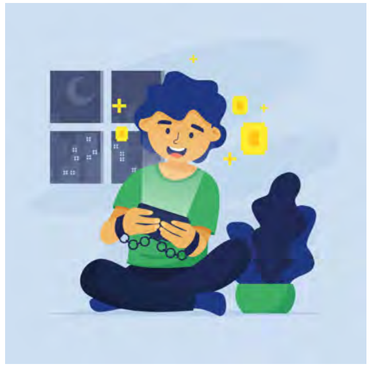
1. To evaluate the appropriateness of the proposed symptoms for diagnosing this disorder and to identify the central symptoms - those that should be pivotal in the diagnosis.
2. To identify risk factors contributing to the development of this disorder.

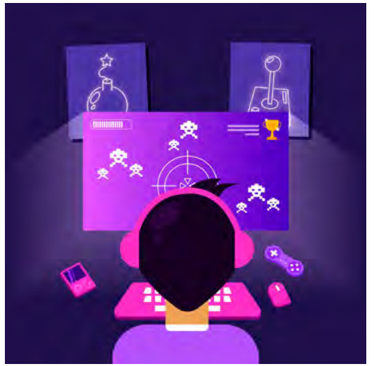
Achieved Results

The Slovak translation of the 11th edition of the International Classification of Diseases, which should include the new diagnosis of gaming disorder, has not yet been published. From the perspective of the 10th edition of this classification, neither psychiatrists nor clinical psychologists can diagnose pathological gaming as it is not included in the classification. A variety of tools exist to estimate the prevalence of gaming disorder in the Slovak population, but they significantly vary in the problems they identify and their severity. Therefore, the identification of appropriate measurement tools is crucial.
In several studies, we have confirmed the centrality of two symptom-criteria used in questionnaires - Loss of Control (the individual struggles to control the gaming, its onset, duration, intensity) and Continued Use Despite Problems (the individual continues to play despite being aware of significant problems caused by their gaming).
Through a meta-analysis, a large-scale study where we statistically summarized the findings from 1234 previously published studies on the topic of gaming disorder, we identified several risk and protective factors. These may be beneficial for the design of prevention and intervention programs. The strongest protective factors were self-esteem and intelligence, while the risk factors included depression, gaming to escape from real-world problems, stress, anxiety, time spent gaming, impulsivity, and aggression.
By conducting a longitudinal study - repeated questioning of gamers over a 6-month period - we found that from the initial state - understanding the level of problematic use of the Internet and social networking sites, gaming to escape from real-world problems, and anxiety - it was possible to predict the course of the development of the disorder 6 months later.

Benefits for Practise

Epidemiological Perspective: By verifying validity of various instruments and symptoms, we identified a questionnaire - the Gaming Disorder Test, which is available also in the Slovak language and is suitable for conducting studies focused on the prevalence of gaming disorder.
Prevention: We identified self-esteem as a suitable variable for prevention, as it can be enhanced through various interventions. Similarly, for risk factors, it is beneficial to focus on individuals who excessively play games to escape from real-world problems, exhibit impulsivity, and experience stress, anxiety, or negative emotions.
Diagnosis and Treatment: Clinicians may find it useful to know that specific motivations for gaming (such as gaming to escape from real-world problems) or concurrent excessive use of the Internet and social networking sites can increase the likelihood of the disorder's symptoms worsening and developing more rapidly.





Innovative methods for analyzing the performance of wood and forestry complex using the principles of green growth

Principal investigator
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Applicant organisation
Technical University in Zvolen
Term of solution
07/2019 – 12/2022
Budget from agency
165 959 €
Project ID
APVV-18-0520

Research Subject

The subject of the research was the analysis of the impact of global climate change, which has a significant impact on forest ecosystems and causes changes in the structure of tree species representation, the stability of forest ecosystems, which brings an increase in demand for the provision of ecosystem services. This has an impact on forestry performance and the availability of wood raw material for the wood and energy industries. A number of documents have been produced by international organisations and the scientific community which predict the consequences of global changes (economic, climate) on the emergence of new social issues and issues of economic growth. World organisations are drawing attention to the need to adapt national economies and to identify the impact on social stability. Among the global trends likely to affect the use and production of wood for the wood industry is the emerging market for ecosystem services in response to global climate change. This is a competitive alternative to the use of forests for wood production and processing.

Aim of the Research

The project aimed to propose innovative methods and procedures for the analysis and quantification of the impacts of climate change on the economic development of the forestry sector, risk factors threatening the sustainability of its performance, the efficiency of the wood industry, and the social stability of the regions following the principles of green growth.

Achieved Results

The results provided an analysis of the forestry production volume type, quality, and price level of harvested assortments and have been applied in developing models to increase the transparency and efficiency of the timber market, especially in modelling timber prices and forecasting future incidental harvesting. Rising electricity prices put pressure on biomass as a renewable energy source. The use of dendro-mass from forestry and wood processing industry (WPI) between 2015 and 2021 was analysed and the potential of biomass use for energy purposes from logging residues, plantations of fast-growing tree species (FGT), as well as the potential for energy use of dead wood was quantified. In Slovakia, 3 million tonnes of biomass are utilized annually for energy, with 1 million tonnes from WPI residues and by-products. From forestry 0.85 million tonnes are firewood, 1.16 million tonnes post-harvest biomass, and a minimal 0.01 million tonnes from FGT energy plantations. The resulting total biomass potential was quantified at 4.82 million tonnes. Compared to current use, this is an increase of almost 40%. The highest reserves were identified in the use of fresh and hard dead wood and in plantations and energy plantations of FGT. Significant reserves, particularly in logging residues, are estimated at 30% above current levels. The performance of Slovakia's WPI from 2009 to 2020 was analyzed using specific indicators across SK NACE categories. At the same time, using selected methods of inductive statistics and time series, dynamics and trends of selected performance indicators of wood-processing enterprises development were modelled with the presentation of their possible statistical dependence.

Benefits for Practise

The project has provided evidence to inform decision-making at both macroeconomic and enterprise levels. It includes an analysis of the global, economic, and societal impacts on the forest-wood-energy industrial complex, and an analysis of the logistics chain in the WPI in the context of sustainability. The study surveys consumer perceptions of WPI's eco-friendly products, gauges interest in wood types and colour shades, and identifies opportunities for forestry, timber, and furniture companies to meet this demand. The project underscores the potential of wooden houses as renewable resource option and supporting the fulfilment of the bioeconomy principles. The project assessed the current state of implementation of green entrepreneurship principles in the Slovak wood and forestry micro, small and medium-sized enterprises and subsequently identified the possibilities and potential for their sustainable development. The impact of green growth on forestry and WPI was analysed from economic, environmental, and social perspectives, leading to green growth indicators proposal for these enterprises and a marketing strategy for family-owned wood-processing and furniture businesses.

Fig. 1 / Rate of increase in the WP sector for the indicators "Average registered number of employees" and "Labour productivity per person employed"

Fig. 2 / Real and model calculated price for coniferous sawlogs during 2001 to 2017 (€.m^{-3})

Fig. 3 / Research team of TUZVO

Fig. 4 / Book outputs of the project

Fig. 1

Fig. 3

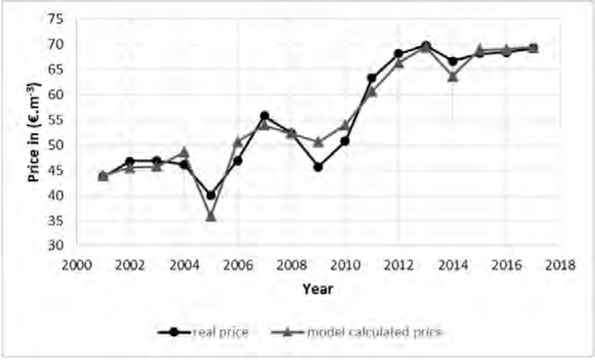

Fig. 2

Fig. 4

HUMANITIES
SCIENCE

Social inclusion through the cultivation of language use

Principal investigator
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Applicant organisation
Comenius University Bratislava - Faculty of Philosophy
Term of solution
07/2019 – 06/2023
Budget from agency
199 000 €
Project ID
APVV-18-0176

Research Subject

The project is involved in the research stream of social sciences and humanities with a focus on social inclusion with regard to the role of language, and therefore also the possible contribution of linguistics to the understanding of this process. The research was oriented to the description and reflection of communication practice with the aim of theoretical modeling of social inclusion and communication cultivation of society. The basic support point of the conducted research was the idea that the communication cultivation of society is an important means of social inclusion and the creation of an inclusive society.

Aim of the Research

The aim of the project was to develop an empirically supported and theoretically justified model of communication cultivation of society, in which the strategy of social inclusion, integration and strengthening of cohesion is promoted. The basic research goal included the following (complex) structural components: 1) communication culture as an inclusive, integrative and cohesive factor of society, 2) communication cultivation of society as a support means of social inclusion, 3) communication emancipation of society members, 4) optimally transparent language as a means of adaptation in social inclusion, 5) foreignness in social relations, 6) language discourse as a tool for enforcing the strategy of communication cultivation of society. The target structure of the project was gradually enriched with analyzes and interpretations related to inclusive and civic linguistics, inclusive rhetoric and mediatization.

Achieved Results

The results of the project are presented by theoretical modeling of social inclusion and communication cultivation of society, enriched by interpretations of inclusion in the context of civic science, contemporary rhetoric and the impact of mediatization on society. The results reflect the answers to four fundamental questions: What is the origin of the ideology of social inclusion and inclusive society? How is an inclusive society formed? What kind of communication is inclusive? What is the communicative cultivation of society based on? Four theses correspond to those questions: 1. The ideology of social inclusion arose from factors stored in the genesis of the subject. 2. An inclusive society is formed by creating inclusive social systems. Such systems are created by systematic inclusive communication, initiated by the inclusive will of actors with inclusive communication competence. 3. Communication is inclusive when referential, pragmatic-ethical, or self-regulatory self-realization does not disrupt conformity with egalitarian homogenization. 4. The communication cultivation of society is based on the cultivation and democratization of inclusive communication competence. This competence consists of the ability to (a) operate communicatively in accordance with inclusive communication rules, (b) adapt to the variability of inclusive communication situations, (c) apply the inclusive potential of language and communication.

Benefits for Practise

The results of the project are applicable in the social science discourse focused on the problems of forming an inclusive society, in the implementation of the ideology of social inclusion in political practice, in practical spiritual activity oriented on the forms and methods of cultivating inclusive communication, and in formal and informal communication and culture education. Socially inclusive activities in these spheres aim to support an inclusive culture such as an open complex of inclusive thinking, communication, behavior and action, which its bearers perceive as the normality of an inclusive society. In the social science discourse, in political, spiritual and educational practice, the results of the project can be used to approximate this normality, and therefore also to the communication normality, represented by the standardization of inclusive communication, which benefits from the possibilities of inclusive use of language means. A special contribution of the project results is the described and explained concept of inclusive communication, which applies to all possible communication events with the justification that in every communication someone may be disadvantaged and thereby deprived of the possibility of equal participation in a certain aspect of it. This means that the developed concept of inclusive communication has a universal application potential.

Fig. 1 / Associate Professor PhDr. Juraj Dolník, DrSc. – principal investigator

Fig. 2 / Associate Professor PhDr. Olga Orgoňová, CSc. during the duration of the Dictionary of Police Professionalisms at the international symposium "The 15th Forensic International Symposium" of the Institute of Forensic Science of Police Force

Fig. 3 / Publications produced as part of the project

Fig. 1

Fig. 2

Fig. 3

Database of historical terminology to the history of Central Europe

Principal investigator
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Applicant organisation
Comenius University Bratislava - Faculty of Philosophy
Term of solution
07/2019 – 06/2023
Budget from agency
150 000 €
Project ID
APVV-18-0333

Research Subject

The main objective of the research project was to systematically process, summarize, and present scientific knowledge from key areas of the social history of Central Europe from ancient times to the 20th century. These areas include: 1) Defining the concept of Central Europe and its transformations 2) The state and its various forms in the history of Central Europe 3) Central European diplomacy 4) The concept of nation and ethnic categories 5) Migration patterns 6) Wars and conflicts 7) Religions and religious affiliations 8) Urbanization and urban planning 9) Health and hygiene practices 10) Food and culinary traditions.
The implementation of the project aimed to address gaps in Slovak historiography, particularly the lack of comprehensive lexicographic works covering these topics.

Aim of the Research

The primary objective of the project was to develop and provide free access to the "Database of Historical Terminology for the History of Central Europe." This research objective aligns with the prevailing trend in the dissemination of research findings, which increasingly favors online publications over traditional print media, particularly in the social sciences and humanities.
The secondary goal of the project was to present the findings of research conducted on selected aspects of the social history of Central Europe through analytical and synthetic studies.

Achieved Results

During the five years of the project, the researchers successfully developed and made accessible the Database of Historical Terminology of Central European History. This database, grounded in multidisciplinary approaches, elucidates the significant phenomena shaping the development of Central Europe, including Slovakia, from late antiquity to the conclusion of the 20th century.

Another significant output of the project comprises two collective monographs titled "Central Europe in the Transformations of Time. I. – II." These comprehensive publications offer numerous fresh and innovative insights gleaned from the social history of Central Europe. Their publication by the esteemed domestic publishing house VEDA further underscores the significance of this unique scientific accomplishment in Slovakia.
Thanks to the project's support, members of the research team also contributed to the academic literature by publishing 5 scientific monographs, with two released by VEDA, one foreign monograph published by the globally respected SPRINGER publishing house, 15 scientific studies appearing in publications from prestigious foreign publishing houses such as BRILL and ROUTLEDGE, 7 scientific studies featured in domestic journals registered in CCs, 2 university textbooks on the history of the Middle Ages (the first of their kind in Slovakia), and 48 scientific studies published in journals and anthologies in Slovakia. The project not only met but also exceeded the goals set at its outset.

Benefits for Practise

The freely accessible online database of historical terminology on the history of Central Europe, along with two collective monographs on the history of the region, offers a broad spectrum of users—from academia to educators at various levels of schooling, as well as individuals in the public sector and mass media—convenient access to well-founded information regarding the fundamental characteristics of our region's historical development.
The project's promotion was further facilitated by 45 media appearances by project participants on television (RTVS) and radio (RTVS), including participation in discussion programs, interviews on specific topics, and contributions to various podcasts for Slovak dailies and monthlies such as SME, Denník N, Hospodárske noviny, Pravda, Historical Revue, and others. Additionally, events such as the Comenius Children's University and the mini Erasmus program for secondary schools aided in promoting the project's objectives.

Project members also served as supervisors for numerous bachelor's and diploma theses related to the project's themes and are currently supervising two doctoral students whose work aligns with the project's topics. Furthermore, researchers actively participated in a multitude of domestic and international conferences. With direct support from the project, they organized an international scientific conference focusing on identity issues in the Central European region, as well as the 5th edition of the esteemed international conference Medieval Central Europe Research Network (MECERN): Continuity and Change in Medieval Central Europe.

Fig. 1 / HURBANIČ, Martin - IVANČÍK, Matej - ZUPKA, Dušan (eds). Central Europe in the Past. Studies in Social History. Bratislava: Veda, 2023.

Fig. 2 / MÚCSKA, Vincent - RYBÁR, Lukáš - ROŠKOVÁ, Daniela (eds.). Central Europe in the Past. Studies in Social History II. Bratislava: Veda, 2023.

Fig. 3 /HURBANIČ, Martin. The Avar Siege of Constantinople in 626. History and Legend. Cham: Springer, 2019.

Fig. 4 / ZUPKA, Dušan. Sword and Cross: War and Religion in Medieval Central Europe (10th - 12th Century). Bratislava: Veda 2021.

Fig. 5 / ŠKORVANKOVÁ, Eva. Guardians of Family Hearths? Women in the Ideology and Politics of the Slovak State. Bratislava: Veda 2021.

Fig. 1

Fig. 2

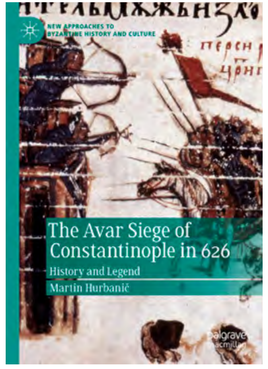

Fig. 3

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