SLOVENSKA AKADEMIJA ZNANOSTI IN UMETNOSTI

7th DANUBE ACADEMIES CONFERENCE

LJUBLJANA
2017

7th DANUBE ACADEMIES CONFERENCE (DAC)
12–13 May, 2016, Ljubljana

Conference proceedings

Organized by:

European Academy of Sciences and Arts
Slovenian Academy of Sciences and Arts

Under the auspices of the President of the Republic of Slovenia,
Mr. Borut Pahor
and under the high patronage of the European Parliament

SPREJETO NA 80. SEJI IZVRŠILNEGA ODBORA,
16. MAJA 2016.

Glavni urednik / Chief editor: Andrej Kranjc
Uredniški odbor / Editorial board: Tadej Bajd, Uroš Skalerič, Jože Krašovec
Priprava / Preparation: Darja Rogelj
Tisk in oblikovanje / Printing and design: Designpro, d. o. o.
Število izvodov / Copies: 300
Izdala / Published: Slovenian Academy of Sciences and Arts

CIP - Katatožni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

556(4)(082)
502.131.1(4)(082)

DANUBE Academies Conference (7 ; 2016 ; Ljubljana)
Conference proceedings / 7th Danube Academies Conference - DAC, May 12th -13th, 2016 Ljubljana ; organized by European Academy of Sciences and Arts [and] Slovenian Academy of Sciences and Arts ; [glavni urednik Andrej Kranjc]. - Ljubljana : Slovenska akademija znanosti in umetnosti, 2017

ISBN 978-961-268-050-3
1. Kranjc, Andrej, 1943- 2. European Academy of Sciences 3. Arts Slovenian Academy of Sciences and Arts
290219776

DANUBE
ACADEMIES
CONFERENCE

7th DANUBE ACADEMIES CONFERENCE (DAC)
Ljubljana
12–13 May, 2016

Conference proceedings

Ljubljana, 2017

CONTENTS

OPENING ADDRESS OF THE CONFERENCE

Prof. Dr. Tadej Bajd, President of the Slovenian Academy of Sciences and Arts

Dear President of the European Academy Professor Felix Unger,
dear President of ALLEA Professor Günter Stock,
dear Presidents and representatives of Danube Academies,
dear participants of the conference, dear colleagues,

I wish to start this opening address with a few words describing our Academy. Academia Operosorum was the first Academy on the Slovenian territory. It was founded in Ljubljana over 300 years ago, already in 1693. This first Academy only had 23 members. They were lawyers, theologians and physicians. The present Slovenian Academy is relatively young, it was founded in 1938. It is the supreme national institution uniting up to 100 scientists and artists. The Academy also has up to 90 foreign corresponding members. The Academy promotes sciences and arts through activities organized in six sections.

The Slovenian Academy organizes various scientific symposia discussing different topical subjects. Through the conclusions of these symposia, the Academy gives advice to politics in the area of culture, science, education, and environment protection. Academy members share conference conclusions with the general public via the Academy website and national media. The Slovenian Academy of Sciences and Arts particularly focuses on actual topics such as perspectives of higher education, evaluation of research results, science ethics, various aspects of teaching in primary and secondary schools. Climate changes, wood and forest are frequently discussed subjects. The public is also interested in attending conferences on the present-day state of humanism, human rights, hate speech and aging. The Academy frequently hosts younger audiences, particularly when organizing events related to subjects such as internet, artificial intelligence or robotics.

Another important activity of the Slovenian Academy of Sciences and Arts is frequent issuing of various publications. Several recent books are treating the history of Academy, describing work of living members and commemorating the opera of individual deceased members. The Academy regularly publishes periodicals edited by individual sections. Particularly worth mentioning are *Acta Carsologica* which is a magazine distinguished for its 60 years long history and the international impact. Slovenian national identity has for centuries been based on Slovenian language. It is therefore not difficult to understand that important achievements of the project Natural and Cultural Heritage of the Slovenian Nation are related to the dictionaries of standard and specialized Slovenian language. The project is conducted jointly with the Research Centre of the Slovenian Academy of Sciences and Arts. Particularly prominent is the activity of the Janez Vajkard Valvasor Foundation, devoted to issuing the reprints of works of this 17th century Slovenian polymath. Among them excels the *Iconotheca Valvasoriana*, composed of 17 volumes with 7.700 graphical prints of European masters. It has been presented to reputable institutions, including the Royal Society of London, the European Union in Brussels, Albertina in Vienna, the Beijing University Library, the Vatican Library and the Uppsala Library.

The Slovenian Academy actively cooperates with other academies and inter-academy associations throughout the world. So far, the Academy has signed agreements on international cooperation with 40 foreign academies. We also organize or sponsor different international events such as today's 7th Danube Academies Conference. The Danube Academies Conferences were established through the initiative of the European Academy of Sciences and Arts. The importance of the Ljubljana meeting is emphasized by the patronage of the Slovenian President Borut Pahor and the European Parliament.

The Danube region boasts many individual highly established scientists, experts, and researchers. To further promote the science in the Danube region, it is necessary to bring together these individuals into a more unified and interconnected research sphere. This can be achieved either through bilateral projects between individual countries or through participation in European research programs. In this respect, bilateral national projects must become more directed and efficient, while research groups from the Danube region must strive for being included more frequently into the European research projects. Another problem common to all countries in the region, is the emigration of young researchers who often do not find new opportunities for themselves in Europe. All these problems will be discussed also during this conference together with the main topics, i.e. small and medium sized enterprises, water, energy, and nutrition safety.

I would like to use this opportunity to thank the Vice-president Professor Andrej Kranjc for his organizational efforts in preparation of this meeting.

Finally, I have one final pleasant obligation to fulfil, namely to wish you all a pleasant stay in Ljubljana.

LIMITED RESOURCES AT UNLIMITED CAPABILITIES – NEW IDEAS, PROCESSES & MATERIALS WILL ALLOW A GOOD AND CAN PROVIDE A BRILLIANT FUTURE

Prof. Dr. Henning Zoz[1,2,3], info@zoz.de
[1]Zoz GmbH, Maltoz®-Strasse, D-57482 Wenden, Germany
[2]CIITEC-IPN, Instituto Politecnico Nacional, Mexico City, C.P. 02250 México, D.F.
[3]Ritsumeikan University, Kusatsu, Shiga 525-8577, Japan

Abstract: Any modern society considers sustainability, saving resources and increasing performance every day and our all future will be ruled by materials as never before. Based on general materials limitation, goal (a) is "making more with less" and since materials consumption contradicts with such limited resources, goal (b) is recycling. Along with the clear understanding, that there is no waste on this planet but material, both induce to advanced materials processing with the utilization of larger surface and finer structures leading to nanostructures.

High kinetic processing has been proven as a major route for reducing materials' grain size in large volume at economic manufacturing and cost capability as well as the "nanostructure-making-equipment", the Simoloyer® is well-known including technology and key advantages.

Zentallium®, the super-light-weight material at half titanium cost approaching pressing and sintering after hot extruded semi-finished material is on the market. Zentallium® represents grain size stabilized aluminum utilizing carbon nanotubes.

The globally first public bridge by Zoz/Dyckerhoff high performance cement at high strength, virtually endless durability and enormous CO_2-emission savings has been set up in Germany in November 2012. Second demonstrator has followed in June 2013 (heritage balustrade at ZCS Siegen - 12 tons) and the first product from the shelf came up early 2015.

Other materials manufacturing results are Nanostructured Ferritic Alloys (next gen. ODS, Zoz/GE), Hydrolium®/H2Tank2Go® including vehicles (Zoz ZEV-fleet & H2-OnAir+ - Zoz/HZG/Airbus *et al.*), advanced Zn-flake coatings (anti-corrosive material, Zoz, RFS) and even battery cathodes (phosphate systems Mn and Fe, ZoLiBat®) as well as a novel processing route of generating high quality rubber from the roots of dandelion plant (Zoz, Fraunhofer & Continental).

Keywords: Simoloyer®, High Kinetic Processing, Zentallium®, FuturZement, Hydrogen-storage

---

Omejeni viri pri neomejenih sposobnostih – nove ideje, procesi in materiali bodo omogočili dobro in svetlo bodočnost

Povzetek: Vsaka moderna družba sledi trajnostnemu razvoju, omejevanju porabe naravnih virov in povečevanju učinkovitosti njihove porabe, ker bo naša bodočnost odvisna od materialov bolj kot kadarkoli prej. Zaradi omejenih materialnih virov je cilj (a) "narediti več z manj" in, ker je poraba materialov omejena z razpoložljivimi viri, je cilj (b) recikliranje. Zavedanje, da v naravi ni odpadkov ampak so to zgolj druge oblike materialnih virov, vodi do novih prednih tehnoloških procesov in materialov s fino granulirano strukturo z velikimi mejnimi površinami, ki vodijo do nanokonstrukcij.

Visoko kinetični procesi so se uveljavili kot glavni pristop za zmanjševanje velikosti gradnikov materialov v masovni ekonomsko učinkoviti in cenovno ugodni proizvodnji, prav tako je dobro znana tudi "nanostrukturna-proizvodna-oprema" Simoloyer® , ki izkazuje ključne prednosti.

Zentallium®, "super-lahek" material, za polovico cenejši od titana, je na trgu v obliki ekstrudiranih pol-proizvodov, bodoče alternativne tehnologije za njegovo proizvodnjo so tudi stiskanje in sintranje. Zen-

tallium® predstavlja material na osnovi aluminija s fino granulirano strukturo, stabilizirano z ogljikovimi nanocevkami.

Globalno prva javna mostna konstrukcija, izdelana iz Zoz/Dyckerhoff visoko-zmogljivega cementa z visoko trdnostjo, praktično neomejeno trajnostjo in enormnim zmanjšanjem emisij CO_2, je bila izvedena v Nemčiji v novembru 2012. Naslednji demonstrativni primer je sledil v juniju 2013 (rustikalni ograjni stebri v ZCS Siegen- 12 ton), prva serijska proizvodnja pa leta 2015.

Drugi primeri proizvodnje materialov so nanostrukturirane feritne zlitine (nova gen. ODS, Zos/GE), Hydrolium®/H2Tank2Go®, vključno z vozili (Zoz ZEV-fleet & H2-OnAir+ - Zoz/HZG/Airbus *et al.*), napredni Zn-flake premazi (proti-korozivni materiali, Zoz, RFS) in celo katode baterij (fosfatni sistemi Mn in Fe, ZoLiBat®), kakor tudi nov procesni postopek za izdelovanje visko kvalitetne gume iz korenin regrata (Zoz, Fraunhofer & Continental).

Ključne besede: Simoloyer®, visoko kinetični procesi, Zentallium®, FuturZement, shranjevanje vodika

Introduction

Today and for the future, mankind is obliged to think about what will happen if there is not enough material and if there are not enough resources anymore. Therefore the importance of ultimate and utmost complete recycling and recovery does also include wastes of the past as well as the corresponding suitability of any new product before launched in the market.

The only other possibility of generating more (resources) is increasing performance of all processing, application and materials.

Recycling & Performance are the key issues for achieving sustainability.

Looking at materials, advanced performance can be achieved by increasing the materials function that describes the relation of invested material vs. achievable utilization over volume and time. Since the materials function is mostly depending on materials surface, increasing effective surface is the goal to be achieved by decreasing the unit-size/scale.

Nanomaterials are materials which are produced and applied on a small scale and show enhanced and unique properties compared to comparable materials which are not nanosized (European Chemical Agency 2016). They offer lots of opportunities. Nanostructured materials are modified on the atomic scale. This results in a change of the material's surface-near solid state properties (Spektrum der Wissenschaft 1998).

Nanostructured materials provide a grain size <100nm resulting in a large surface of grain boundaries, virtually a large inner surface. Nanostructures can also represent e. g. a micron-scale matrix with nanoscale phases for generating enhanced properties or other combinations.

Nanostructures can be manufactured in large volume at economic level and insofar contribute significantly to the overall goal of "making more with less".

One of the most practicable and insofar economic routes to obtain useful nanostructures is the High Kinetic Processing technique (HKP) performed by Simoloyer®.

High Kinetic Processing in the Simoloyer®

HKP is a synonym for well known processes Mechanical Alloying (MA), High Energy Milling (HEM) and Reactive Milling (RM) at higher energetic level.

MA has been described by repeated deformation, fracture and cold welding of powder particles by highly energetic collisions of grinding media (Zoz 1998, Zoz 2008). Such process can allow the synthesis of novel materials with enhanced or even new properties that cannot be synthesized by conventional techniques due to chemical, physical or thermodynamic barriers.

HEM and RM follow the same principle with a focus on creating reactive surfaces and enabling chemical and physical reactions (Zoz 1998, Zoz 2008). They differ in the target of processing and in energy that is transferred into the material.

Compared to the well-known/conventional "milling" devices, HKP in the Simoloyer® provides a significantly higher kinetic energy impact and energy impact efficiency (Zoz 1998, Zoz 2008).

Simoloyer® is basically representing a high energy horizontal rotary ball mill where the definition "mill" does not perfectly but nearest meets the proper definition (Zoz 1996).

Milling/grinding is understood as a process to reduce the particle size of solids such as granules or powders. HKP is understood as a process to primarily reduce the grain size of solids e. g. granules or powders. Reduction of particle size at HKP can be a primary goal e. g. for materials with a very high hardness. On the contrary, also a growth in particle size can be the target e. g. manufacturing ductile metal flakes (DMF) from fine powder dust.

Table 1: Devices in use for MA, HEM and RM (Zoz 1998, Zoz 2008)

Device	Simoloyer®	Shaker Mill	Planetary Ball Mill	Attritor®	Drum(ball)-mill
max. diameter [m]	0.9	0.08	0.2	1	3
max. total volume [l]	900	0,2	8	1.000	20.000
maximum relative velocity [m/s]	16	4-5 (4.2)	5	4.5-5.1	< 5
specific energy [kW/l]	1.1(-3)	-	-	0.1-(0.75)	0.01-0.03
scaling up	yes	no	no	yes	yes

(Simoloyer® is a brand of Zoz GmbH, Germany, Attritor® is a brand of Union Process, USA)

The kinetic impact can be described by the maximum relative velocity (MRV) of (grinding)media. HKP in the Simoloyer® today can reach 18 m/s compared to <6m/s in conventional (milling) processes at high (energetic) efficiency >50% compared to <5% (Zoz 1999a) at conventional ball- rod- or shaker-milling insofar confirming the simple understanding of kinetic energy equation (Eq. 1).

$$E_{kin}=\frac{1}{2}mv^2 \qquad \textit{Equation 1}$$

Since HKP describes a process based on collision rather than of shear and friction interaction of (grinding)media, consequently HKP also allows a process at a low level of contamination caused by the processing (milling) tools. This is also favored by shorter processing times resulting the higher energetic impact level.

Table 1 compares the Simoloyer with other devices in use for MA, HEM and RM with respect to capacity, impact and provided energy.

The Simoloyer®

The Simoloyer® is the HKP device, patent-protected and responsible for numerous inventions in materials and processing (Zoz 2014).

Advanced process control is provided by the Maltoz®-control software allowing patented Cycle Operation particularly for ductile materials composites exhibiting critical milling behavior (CMB) countering agglomeration tendency.

Advanced processing is provided by patented air-lock systems including dead-zone free processing, charging and discharging under vacuum/inert gas at elevated as well as undercooled temperature. The Simoloyer® is technically scalable from lab-scale to industrial in batch, semi-continuous and auto-batch operation mode (carrier gas). Processing tools are available in stainless steel/Stellite®, WC-Co and Si_3N_4.

The Simoloyer® is the commercial device for synthesizing advanced/new materials e.g. far away from thermal equilibrium or at conventional immiscibility of components. By structural design, important mate-

Fig. 1: *a) Simoloyer® CM01-2lm laboratory scale with air-lock, b) Simoloyer® CM08lm (back) and CM20lm in front, c) Simoloyer® CM20-20lm-s1 semi continuous operation mode and d) Simoloyer® CM100-s2, auto-batch operation mode*

rials' properties can be influenced, grain size tremendously reduced and also chemical reactions can be performed under solvent-free clean condition by solid state synthesis and at 100% yield. Up to 900 tonnes p. a. and per unit can be manufactured.

Applications in Highlights

Super-light-weight: Zentallium®

Zentallium® is the Al-CNT composite which is lighter than aluminum and as strong as steel. At a tensile strength of 700 MPa, the specific strength is exceeding that from Ti-6-4 at about half of the materials cost and significantly higher than that of stainless steel (Fig. 5).

Basically, the Al 5083 is grain-refined to nanoscale utilizing the Simoloyer® at strictly closed condition and ultimate cycle operation processing. *In situ* and air-locked, the carbon nanotube (CNT) sponges are dissoluted and alloyed into the Al-matrix on nanoscale.

Fig. 2a-b: *Passivation of Zentallium® powder after Simoloyer® – processing and hot extrusion at ZTC*

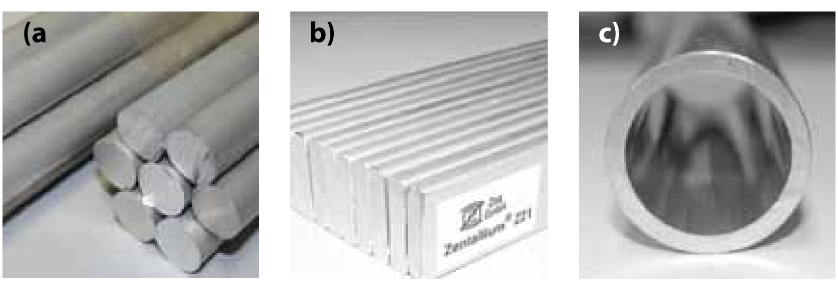


Fig. 3a-c: *Hot-extruded bars D15mm, rods 20/5mm, tube 30x3mm (semi-finished)*

After a passivation step (Fig. 2a) of the highly reactive composite powder, Zentallium® is consolidated by hot extrusion (Fig. 2b) into different semi finished products (Fig. 3a-c). The CNTs during this manufacturing step are hindering the structural re-growth after severe grain-refinement. Zentallium®-powder can also be pressed and sintered, however, so far only hot-extruded semi-finished products bars D15, rods 20/5 (Fig. 3a-b) are available at Zoz from which finished products (Fig. 4b-c) are processed by common machining at weight-saving rates >60% compared to steel.

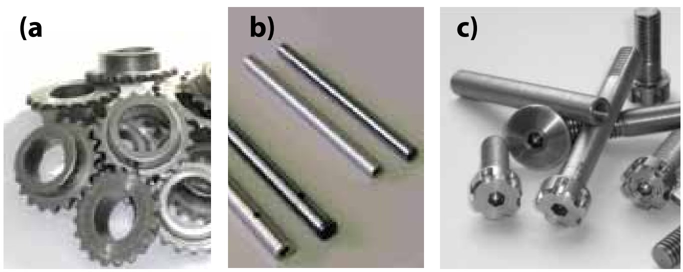


Fig. 4a-c: *Zentallium® finished gear parts (pressed & sintered), helicopter shafts & bicycle screws (made from Zentallium® bars)*

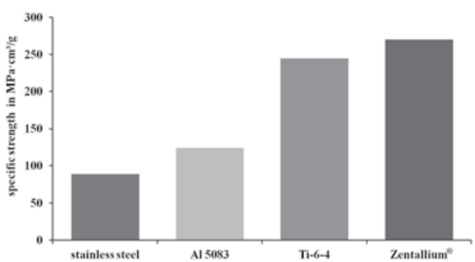


Fig. 5: *specific strength of stainless steel, Al- and Ti- alloys and Zentallium®*

Zentallium® obtains its high strength according to nano-scale crystallites following the Hall-Petch-relation (Smith 2006, Hall 1951, Petch 1953).

Zoz received the Materialica Award 2010/Germany for some structural parts by Zentallium®.

High Performance Cement/Concrete: FuturZement | FuturBeton

FuturZement and the resulting FuturBeton represent nanostructured cement res. concrete at outstanding performance, economics and environmental friendly impact. FuturBeton is 3-4 times stronger (~140 MPa) than ordinary concrete (OPCC) exhibiting very high early

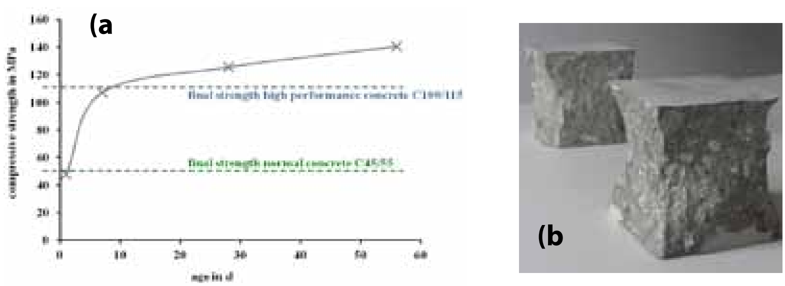


Fig. 6a-b: *Compressive strength of FuturBeton vs. ordinary concrete (OPCC) and high performance concrete (HPC) and »used« ASTM test-cubes (b)*

Fig. 7: *The bridge Rosenthal at Olpe/Germany*

strength (~45 MPa after 1 day) at superior durability and substantial CO_2-emission saving (20%). The total absorption costs (TAC, Germany 2012) based on a single Simoloyer® CM900, leading to about 43,000 tons FuturBeton p. a. is resulting into additional cost of 10 USD per ton of super-concrete.

The Simoloyer® is utilized in a semi-continuous processing mode (Fig. 01c) to super-activate ground granulated blast furnace slag (GGBS). HKP does increase the basically very low hydraulicity of GGBS to a level, where HKP-GGBS can react without any further activators and is replacing 30% of Ordinary Portland Cement (OPC). Due to the continuous processing, the super-activation on nanoscale takes a few seconds at a significantly increased processing kinetic level (Zoz 2001a, Zoz 2001b, Zoz 2001c, Zoz 2002).

HKP-GGBS is then mixed with 70% OPC at high intensity resulting into FuturZement that is further processed to FuturBeton at practically conventional conditions. The resulting advanced construction material provides a significantly denser packing and fined porosity which means that water / moisture virtually cannot penetrate any longer or at least far less resulting in a significant improvement of durability against diffusion of aggressive media that can destroy concrete.

The CO_2 emission saving of 20 % is achieved by substitution of clinker/OPC. Additional CO_2-savings can be claimed due to the high durability and high strength because of less materials consumption and less maintenance or replacing of corroded parts. Thus FuturZement and FuturBeton are highly economic and ecologic.

With FuturBeton, construction-industry can build more faster, sleeker, higher, cost-effective, durable and more environmentally friendly with better surface and less steel.

Energy Storage: H2 solid state absorber, H2Tank2Go®, IronBird, P2G2F®, B4S-SM

H2Tank2Go® represents the "click'n-go" Hydrogen-tank cartridge system containing rechargeable nanostructured RT-MH Hydrolium® powder (Fig. 8a) that is developed for a clean, reliable, fast, mass-capable and cost-effective solid state hydrogen storage future utilizing given infrastructures such as vending machines (Fig. 8b), home-depot and home delivery. The H_2-capacity of 2-4 wt-% of the <1l tanks is >50g operating at <10bar at a lifetime >20years.

Fig. 8: *a) H2Tank2Go® loaded with Hydrolium® (dark powder), b) H2Tank2Go® at a tank vending machine, c) IronBird/Stromkoffer in the trunk of a Zoz-ZEV vehicle, and d) solar-aircraft Icare II (IFB) shall learn to fly on* H_2

The **IronBird/Stromkoffer** (IronBird is the Airbus definition of the Zoz-Stromkoffer to be translated as power-box) represents the lightweight, cost-effective on-board energy platform carrying 6 H2Tank-2Go® and 2 small PEMFC (fuel cells) focusing on both, H_2-repowering of battery ZEVs in ground transportation (Fig. 8c) as well as range extending the Icare II solar glider (IFB, H2-OnAir) in aviation (Fig. 8d).

Fig. 9: *a)* H_2*-tank system B4S-SM complex metal hydrides and b) HZG@ZTC*

The systematic of **Power-to-Gas-to Fuel** (P2G2F®) was nominated for the German Environmental Award 2013 and describes Hydrogen generation from renewable energies, solid state storage, vending-like distribution and consumption in transportation - rethinking mobility for tomorrow's world.

B4S-SM is the world-wide first semi-commercial borohydride solid-state storage tank based on complex metal hydride ($LiBH_4$ & MgH_2) and has just been introduced in June 2016 by Zoz and Helmholtz-Centre Geesthacht (HZG) in Germany (Fig. 9). Resulting from the EU-project BOR4STORE (BOR4STORE 2016), the reactive hydride composite material (RHC) is synthesized under extremely closed & clean condition in a Simoloyer® CM100 in auto-batch processing at the HZG-Hydrogen Technology Centre at ZTC in Olpe.

B4S achieves a gravimetric H_2-density of almost 10 wt-% !! fully reversible in the H_2-storage powder where the theoretical value is even higher at 18.3 wt-%.

In this respect, novel and advanced in-tank-storage and absorber materials are the objective of the ongoing HySCORE-project (HySCORE 2016). The availability of low cost PEM electrodes is the goal of the ongoing project LOCOPEM (LOCOPEM 2016) and in case of success will be essential for the economics of the IronBird.

Anti-corrosion: Ductile Metal Flakes & ZFP Coating

HKP/Simoloyer® can be utilized for the rapid manufacturing of all kind of ductile metal flakes powder (Zoz 2000, Zoz 1999). Virtually by means of the “HEM-effect” at high kinetic energy impact, processing can be up to 1.000 times faster (Zoz 1999) than in the conventional route (classic ball milling or stamping). By the “MA-effect”, a whole range of alloys can be in situ synthesized e. g. a zinc flake becomes brighter if a small fraction of Al-powder is added into the process.

Zoz in this field is focusing on ZFP coatings (ZFP = zinc-flake pigments) where the advanced flake manufacturing leads to both, outstanding

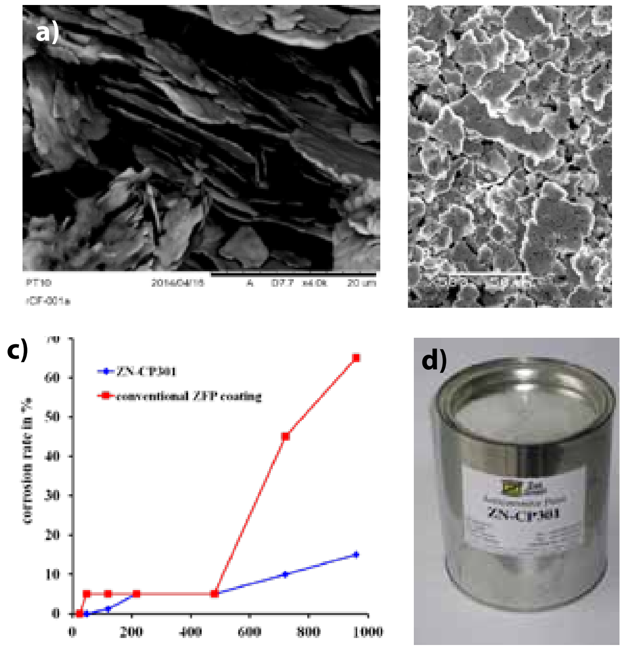


Fig. 10a-d: *HKP-ZFP (Zinc-Flake by Simoloyer®), a) SEM), b) corresponding Zn-lamellar layer, c) corrosion rate of ZN-CP301 vs. conventional ZFP coating at salt spray test and d) a product can of anticorrosive paint ZN-CP301*

cost-efficiency and far higher corrosion protection than conventional flake-based products. Since by HKP the flake is processed not in solvents but under dry condition with small fractions of polymer process controlling and dispersing agents, the result is highly flexible and highly economic and also environmentally friendly at a remarkable saving of volatile organic compounds (VOC). Processing times are ranging in minutes rather in hours and days (Zoz 1997) resulting in a high manufacturing capability of up to 1.000 tons p. a. ZFP in a single Simoloyer® CM900 unit.

In order to bringing this HKP-ZFP to the market, appropriate binder systems have been developed for manufacturing ZFP-lacquer systems resulting in the resin based ZN-CP301 anticorrosive coating (Fig. 10d). Figure 10a shows the Zn-flake after rapid manufacturing by HKP/Simoloyer®, Figure 10b a corresponding Zn-lamellar layer and Figure 10c the corrosion rate of ZN-CP301 in comparison to a conventional ZFP coating at outstanding and far superior performance with respect to long term stability in salt spray according to ISO 7253. E. g. after 950h, the corrosion rate of the ZN-CP301 product is >4 times lower!

After this technical-economic success, the ongoing development of HKP-ZFP to stable water-dispersible pigments is expected to lead to an innovation at highest economical and ecological importance. Previous results are promising and shall break a path to a future with water-based efficient high performance stir-in ZFP-lacquers for industrial, trade and Do-It-Yourself utilization.

ODS/NFA-manufacturing

One of the most exclusive application fields of the Simoloyer® is represented by Oxide Dispersion Strengthened alloys (ODS) and lately also by Nanostructured Ferritic Alloys (NFA) that may be described as a next gen. ODS at further advanced dispersoids by quality, scale, density and by their location in the matrix.

Common ODS alloys (e. g. Plansee PM2000 (Klueh 2005, Metallwerk 1993) provide advanced mechanical and/or structural properties such as high tensile and creep strength at elevated temperatures mainly in Al-, Fe- and Ni-based materials in power generation, aerospace and automotive. NFAs, exhibiting a dense dispersion of finer oxides (NFs sub 10nm) are developed for particular demands in nuclear fission and fusion technology such as advanced irradiation damage- and/or corrosion-resistance and high accident tolerance (Kimura 2016).

The most determining parameters, dispersion and refining are achieved by HKP. The virtually forced solubility of the dispersoid in the metal matrix requires an ultimate high energy transfer into the powder material leading to full dissolution of the starting oxide material creating a homogenous network dispersion after consolidation. Same ultimate is a consequent clean handling particularly a clean atmosphere and low contamination during loading, processing and unloading at a full materials yield.

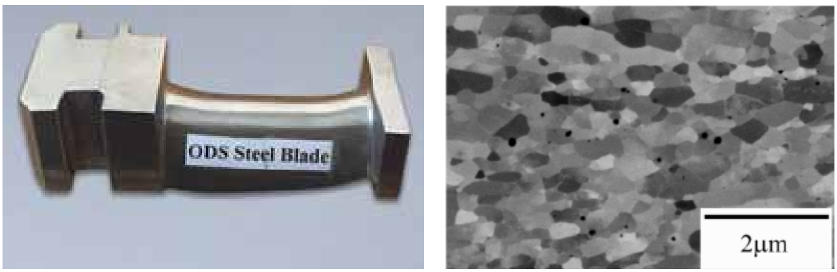


***Fig. 11:** turbine blade from ODS steel (picture taken from Zoz-ARCI Center, India) and BSE SEM image of 14 YWT (DiDomizio 2014)*

As of the above, the Simoloyer® is practically the globally exclusively applied device / technique. When it comes to semi-industrial or industrial manufacturing, the Simoloyer® represents the only known processing solution where the manufacturing of hundreds of kilos under such conditions has been proven since 2014 (DiDomizio 2014). This also included 50 kg of a 14YWT Nanostructured Ferritic Alloy FCRD NFA-1 (Odette 2015) with an oxide scale of 1-4 nm at defined crystal lattice position with a high dislocation density, a superior irradiation damage resistance and a remarkable thermal stability of the dispersed oxides even after 19.000 hours (792 days) at 1.000 °C ending with the summary question/proposal: “do NFA`s represent the “omega” nuclear structural material ?!” (Odette 2015).

Extending limited resources: Taraxagum™

Taraxagum™ is a brand of the Continental Tires Germany GmbH representing auto-tires made with natural rubber from dandelion (Fig. 12) (Continental 2016). To date the conventional cultivation of natural rubber is utilizing the rubber tree (Hevea brasiliensis) mainly in the so-called "rubber belt" up to 30 degrees north and south of the equator. The continuously increasing demand of rubber processing industries as well as the fact, that newly planted rubber trees only after 7-10 years are bringing up a first return along with a global environmental understanding is challenging to finding alternative sources preferably to grow outside the "rubber belt".

Fig. 12: *Continental-Expo with Taraxagum auto-tire at the OZ-16 Nanostructure Symposium at Wenden/Germany (left) and ZTC at Olpe/Germany, location of the rubber extraction facility, plant-photo not allowed*

For Zoz and Zoz- processing technology expertise, the dandelion-rubber as a promising alternative became a goal several years back. Starting with a top-secret cooperation with the Fraunhofer Institute for Molecular Biology and Applied Ecology - IME at Münster/Germany this resulted in the Fraunhofer-IME Dandelion Rubber Extraction Facility under the roof of ZTC at Olpe. The semi-industrial manufacturing unit started processing container-loads in 2016. These Fraunhofer-activities are practically funded by Continental, technical details are confidential.

Energy Storage: Li-Ion-3rd. generation cathodes and battery ZoLiBat®

ZoLiBat® is representing advanced cathode material for 3rd gen. Li-

Fig. 13: *pouch-cell ZoLiBat® (LMP)*

Fig. 14: *ZoLiBat®-battery pack (14 cells)*

Fig. 15: *isigo®1.0-ZLB with 1 and longo®1.0-ZLB for 4 ZoLiBat®-battery packs*

Fig. 16: *LMP-cathode material made with Zoz-Simoloyer®, HPL>DOW-Kokam*

Ion batteries and a battery series itself. In this field Zoz is a) equipment supplier (LithiumFerroPhosphate = LFP) and materials co-developer and equipment supplier (LithiumManganesePhosphate = LMP) for the phosphate systems that are doped by HKP on nanoscale. On the anode side so far only preliminary work on a nanostructured Si-matrix is done. The ZoLiBat® as a battery answers the political demand of availability of a domestic high performance state of the art electrochemical energy storage system.

The ZoLiBat® cathode material/technology provides a high efficient nanostructured LFP- and LMP-electrode material offering a high structural stability due to the strong P-O-bonding. High C-rates allow fast charging and the nano-phosphates result at a low inner resistance Ri staying low over the entire lifetime, high currents can be achieved. Low toxicity and good thermal and electrical cycle-stability are very important benefits. The absence of cobalt offers a significant cost-advantage at high scaling effects. Scaling is not intended to be done at Zoz, likewise all advanced materials manufactured are basically/originally demonstrators for the advanced HKP technology.

References

BOR4STORE: Fast, reliable and cost effective boron hydride based high capacity solid state hydrogen storage materials, EU-Project, FCH-JU Grant No 303428. - [Online] Available from: http://bor4store.hzg.de/index.html.en [Accessed 28th October 2016]

Continental Reifen Deutschland GmbH, C. Hesse, 2016**:** Kautschuk aus Löwenzahn - Continental entwickelt Nachhaltigkeit. – [Online] Available from: http://www.taraxagum.de [Accessed 7th September 2016].

DiDomizio, R., Huang, S., Dial, L., Ilavsky, J. & M. Larsen, 2014: An Assessment of Milling Time on the Structure and Properties of a Nanostructured Ferritic Alloy (NFA).- Metall and Mat Trans A, 45, 5409-5418

European Chemicals Agency, n.d.: Nanomaterials. - [Online] Available from: https://echa.europa.eu/regulations/nanomaterials [Accessed 1st September 2016].

Hall, E.O., 1951*:* The Deformation and Ageing of Mild Steel: III Discussion of Results.- Proc. Phys. Soc. London, 64, 747–753.

HySCORE: Efficient H_2-storage by novel hierarchically porous core-shell structures with embedded light metal hydrides, project funded by the Federal Ministry of Education and Research (BMBF) of Germany, proj.-no. 03SF0532D. - [Online] Available from: https://www.enargus.de/pub/bscw.cgi/26?op=enargus.eps2&q=EB6010&s=14&v=10&id=2728502 [Accessed November 3rd 2016]

Kimura, A., Han, W., Je, H., Ha, Y., Kasada, R., Yabuuchi, K., Möslang, A., Lindau, R. & J. Hoffmann, 2016: Development of nano-scaled ODS Steels at Kyoto University and KIT.- In: *Proceedings OZ-16, 9th International| 9th German-Japanese Symposium on Nanostructures*, 6th-8th March 2016, Olpe-Wenden, Germany

Klueh, R. L., Shingledecker, J., Swindemann, R. W., Hoelzer, D. T., 2005: Oxide dispersion-strengthened steels: A comparison of experimental and commercial steels.- J. Nucl. Mater., 341(2–3), 103-114

LOCOPEM: Development of low cost gas diffusion electrodes based on CNTs/CNFs for application in PEM fuel cell systems, project funded by the EU within the operational programme "*Investing in our Futur*e" from the European Regional Development Fund and the Ministry of Economic Affairs, Energy, Industry, Small and Medium-Sized Enterprises and Craft of North Rhine-Westphalia, proj.-no. NW-1w1w006a / EFRE-0800147. - [Online] Available from: https://www.w-hs.de/kooperieren/forschungsinstitute/westfaelisches-energieinstitut/homepage/forschung-wei/wasserstoffenergiesysteme/locopem [Accessed November 3rd 2016]

Metallwerk Plansee GmbH, 1993: Material Data Sheet ODS-Superalloy PM 2000

Odette, G. R.; - In: Proceedings 2nd OZ-Workshop at the University of California at Berkeley (UCB), 15th May 2015, Berkeley, CA, USA

Petch, N.J., 1953: The Cleavage Strength of Polycrystals.- J. Iron Steel Inst. London, 173, 25–28.

Smith, W. F. & J. Hashemi, 2006: *Foundations of Materials Science and Engineering* (4th ed.), McGraw-Hill, ISBN 0-07-295358-6.

Spektrum der Wissenschaft, Spektrum Akademischer Verlag, Heidelberg, 1998: Lexikon der Physik, Nanostrukturierung. – [Online] Available from: http://www.spektrum.de/lexikon/physik/nanostrukturierung/10118 [Accessed 1st September 2016].

Zoz, H., Ernst, D., Weiss, H., Magini, M., Powell, C., Suryanarayana, C., Froes, F.H., 1996: Mechanical Alloying of Ti-24Al-11Nb (at%) using the Simoloyer.- Mater. Sci. Forum, 235-238(10), 59-66

Zoz, H., Ernst, D., Mizutani, T., Okouchi, H., 1997: Simoloyer® CM100s, semi-continuously Mechanical Alloying in a production scale using Cycle Operation - Part I.- Metall, 51(10), pp. 568-572

Zoz, H. *et al.*, 1998: High Energy Milling / Mechanical Alloying / Reactive Milling - Devices in use.- In: *Proceedings of the 3rd International Symposium of the School of Chemical Engineering*, May 27th- 29th 1998, University of Mexico City, Mexico City.

Zoz, H., Reichardt, R., Ren, H., 1999: Energy Balance during Mechanical Alloying, Measurement and Calculation Method supported by the Maltoz®-software.- In: *Proceedings of the 6th annual international conference on Composites engineering (ICCE/6)*; International Community for Composites Engineering and College of Engineering, University of New Orleans, Orlando, Florida, USA, (27th June-3rd July), 697

Zoz, H., Ernst D., Reichardt, R., Mizutani, T., Nishida, M., Okouchi, H.: Simoloyer® CM100s, semi-continuously Mechanical Alloying in a production scale using Cycle Operation – Part II.- Mater. Manuf. Process, 14(6), 1999, 861-874

Zoz, H., Ren, H., Reichardt, R., Benz, H. U., Nadkarni, A., 1999: Ductile Metal Flakes based on [Au],[Ag],[Al],[Cu],[Ti],[Zn] and [Fe] Materials by High Energy Milling(HEM). Part I.- Adv. Powder Metall. Part. Mater., 1, 93-107

Zoz, H. et al., 2000: Production of ductile metal flakes by high energy milling.- Metal powder report, 55(10), 47-48

Zoz, H., Benz, H. U., Schäfer, G., Dannehl, M., Krüll, J., Kaup, F., Ren, Reichardt, R.: High Kinetic Processing of Enamel, part I. - In: *Proceedings International Symposium on Metastable, Mechanically Alloyed and Nanocrystalline Materials*, 24th-29th June 2001, Ann Arbor, MI, USA

Zoz, H., Benz, H. U., Schäfer, G., Dannehl, M., Krüll, J., Kaup, F., Ren, H., Jaramillo V., D., 2001: High Kinetic Processing of Enamel, part I-a.- InterCeram: International Ceramic Review, 50, 388-395

Zoz, H., Benz, H. U., Schäfer, G., Dannehl, M., Krüll, J., Kaup, F., Ren, H., Jaramillo V., D., 2001: High Kinetic Processing of Enamel, part I-b.- InterCeram: International Ceramic Review, 50, 470-477

Zoz, H., Benz, H. U., Schäfer, G., Dannehl, M., Krüll, J., Kaup, F., Ren, H., Jaramillo V., D.: High Kinetic Processing of Enamel, part II. - In: *Proceedings PM²TEC 2002, 2002 World Congress on Powder Metallurgy & Particulate Materials*, 16th-21st June 2002, Orlando, FL, USA

Zoz, H. 2008: *Development of High Kinetic Processing as a Manufacturing Technique at Industrial Importance*. PhD thesis. Instituto Politécnico Nacional, Centro de Investigación e Innovación Tecnológica, Mexico City, pp. 130

Zoz Group (©2014), Simoloyer®. - [Online] Available from: http://www.zoz.de [Accessed 6th October 2016].

HIGHER EDUCATION INSTITUTIONS AND SME: TRANSLATION OF KNOWLEDGE TO THE MARKET

Prof. Dr. Dejan B. Popović, dbp@etf.rs
Serbian Academy of Sciences and Arts, Belgrade,
RS and Aalborg University, DK

Abstract: Current educational policies favor that Higher Education Institutions (HEI) support the productive thinking of their students and educate them to develop links with the business community efficiently. This led to specific funding schemes and research incubators which host spin-offs. However, in many cases, the new company (SME) is facing a problem: how to improve skills for differentiating between an idea and innovation. In parallel, the link between the HEI and SME is not well anticipated by the young entrepreneurs.

Universities promote small business development through the establishment of Business Innovation Centers (BIC). A BIC aims to develop clusters of connected businesses. The clusters should provide benefits to the universities, SMEs and the economy in general. The BUI are formed based on evidence from the success of industrial clusters. However, the industrial clusters have an organic structure, and the BICs are artificially created without the marketing analysis. The BIC are typically state-funded centers offering various services (space, ICT infrastructure, financial and IP related consulting). The form that is likely to serve much better is to concentrate on Independent Private Incubators (often called “accelerators”) founded by other private partners to support SME at the growth stage.

This presentation reviews how relationships between SME and HEI foster the innovative potential of SMEs.

Keywords: Higher education, innovation, SME, incubators, death valley

Visokošolske znanstvene ustanove in majhna ter srednje velika podjetja: prenos znanja na trg

Povzetek: Sedanja izobraževalna politika zagovarja, da visokošolske ustanove (VU) podpirajo produktivno razmišljanje svojih študentov in jih izobražujejo za povezovanje z učinkovito poslovno skupnostjo. To je privedlo do posebnih shem financiranja in raziskovalnih inkubatorjev za *spin-off* podjetja. V mnogih primerih pa se veliko novih majhnih ali srednje velikih podjetij (MSP) srečuje s težavo, kako razlikovati med idejo in inovacijo. Tako je povezava med VU in MSP za mlade podjetnike zelo kompleksna.

Univerze pospešujejo razvoj majhnih podjetij z oblikovanjem poslovnih inovacijskih centrov (PIC). Njihov cilj je razvoj grozdov povezanih podjetij. Grozdi morajo zagotoviti koristi za univerze, majhna in srednje velika podjetja in gospodarstvo na splošno. PIC so oblikovani na podlagi uspeha industrijskih grozdov. Vendar pa imajo industrijski grozdi organsko strukturo in PICi so umetno ustvarjeni brez tržnih analiz. PICe običajno financira država, ki ponuja različne storitve (prostor, IKT infrastrukturo, finančno in IP svetovanje). Oblika, ki bi verjetno služila veliko bolje, je osredotočenje na samostojne inkubatorje (pogosto imenovane ”pospeševalci”), ki jih ustanavljajo zasebni partnerji. Poudarek tega članka je na razvoju inovacij in na njihovem prenosu na trg.

Ključne besede. visokošolsko izobraževanje, inovacije, majhna in srednje velika podjetja, inkubatorji, dolina smrti

THE CHALLENGE

Current policies that merely promote further investment in supply-side interventions in higher education institutions (HEI) do not address the issue of translating research and knowledge into innovation and growth adequately. To achieve partnerships, regions and their HEI will have to design and implement increasingly sophisticated and transformational programs. In this way the two-direction road will be built: reach out (i.e. supply side) as well as 'reach in' (i.e. demand side). The HEI need to be adaptive to the environmental changes. The type of involvement will definitely depend on the local economic system and values. The HEI needs to define: 1) processes and practical mechanisms to build capacity and incentives for universities and regions to work together, 2) understanding where the region is 'at', 3) creating the regional partnership, 4) designing and implementing interventions, 5) anticipating changes, 6) capacity building and leadership development.

Today, public policies are often based on the following: 1) looking backward, 2) benchmarking and 3) applying fashion concepts. The necessary change has to incorporate the following elements: 1) creating new ideas, 2) re-using existing ideas in a new form, 3) giving old ideas a new life, 4) absorbing/ imitating innovative ideas, 5) following new consumers' demands.

Introduction

The problems that traditional education is facing is related to the massive export of brains. The environment is changing fast based on the explosive development of the information and communication technologies (e.g., Aliexpres, Wiki). Global market (an increased need for internationalization) *vs.* local system (government, business, civil society) needs to be addressed to secure the competitiveness. The educational system must consider that the risk-free environment is being replaced by the market environment for which the traditional ways of governance are not adequate. The traditional open education is not appropriate for the current trend that is oriented towards the knowledge protection. This protection is a fundamental element in the knowledge transfer. The current mobility and other aspects of the European education system could be a bottleneck for the efficient knowledge protection. The quality of teaching is often judged on the quantitative effect expressed in the number of publications and public presentations. Students are required to present their results to qualify for higher degrees and positions that would allow them to compete for good jobs. The competition is fostered by the fast development of private HEI in which quality is sometimes jeopardized by the need for enrollment high enough to produce investment. The motivation to preserve leadership needs to be nurtured at HEI for the appropriate growth of innovations.

Poor growth performance of many new technology-based firms is fund starvation. For building a strong foundation, it would be neces-

ROLE OF HIGHER EDUCATION INSTITUTIONS

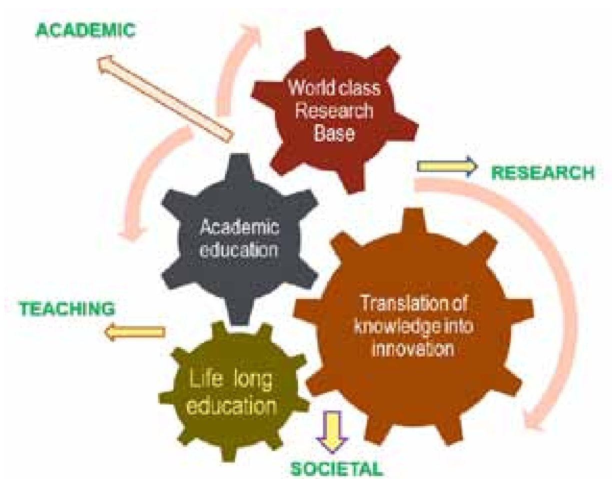


Fig. 1: *A comprehensive model of the productive link beteen HEI and SME. HEI are an element linking high edge science results through the academic and life long education with the SME that are the basis for the translation of knowledge into innovations.*

sary to support the SMEs financially in a different manner compared to the traditional solutions. In many cases, governments spends too little on business innovation. It is necessary to integrate all parties for improving the innovative performance of the firm, as suggested in Fig. 1.

The role of SME and HEI in fostering the economy

The economy is no longer in an era of massive centralized programs. Leading sciences and technologies start to favor the emergence and development of decentralized "poles" and "science districts". The research and development are accepting the bottom-up nature of the process of progressive aggregation of capabilities (human, technical, financial and organizational). The European scene is having more and more the role of the joint national and European policies, being no longer in a "shaping" position but rather in an "accompanying" one (Ahlback, 2005; Becher & Khulmann (Eds) 1994; Casper & Whitley, 2004; Feldman & Link (Eds) 2001; Jan & Chen, 2006). This "territorial" relevance links with massive transformation, the radical shift, observed in all policies addressing industrial research from "national champions" towards SMEs. Numerous studies have demonstrated that SMEs are the leading local providers of employment, and in most developed countries, the dynamic part of job creation.

The HEI are faced with the same movement as companies saying that they have to define their core competencies, concentrate their efforts on those skills, and enter into lasting partnerships with others to provide complementary competencies. To be relevant for its proximity to regional or sectoral actors, an HEI does not have to turn into a world specialist. It is to be expected that nearly all regions will have HEI with "sectorial" and "problem-driven" pockets of relevance (Larédo, 2003; Niosi, 2009). Thus, in 20 years from now, the core of public HEI may be located somewhere between the teaching only type (in a way more prone to private initiative) and the specialized research universities.

Most likely the present balance in employment (between large and small firms) will determine the HEI training requirements, making the locally rooted needs the dominant feature of more than 50% of current HEI. This brings the conclusion that HEI and public-sector research (i.e. SMEs) are a critical element of any future Science and technology policy.

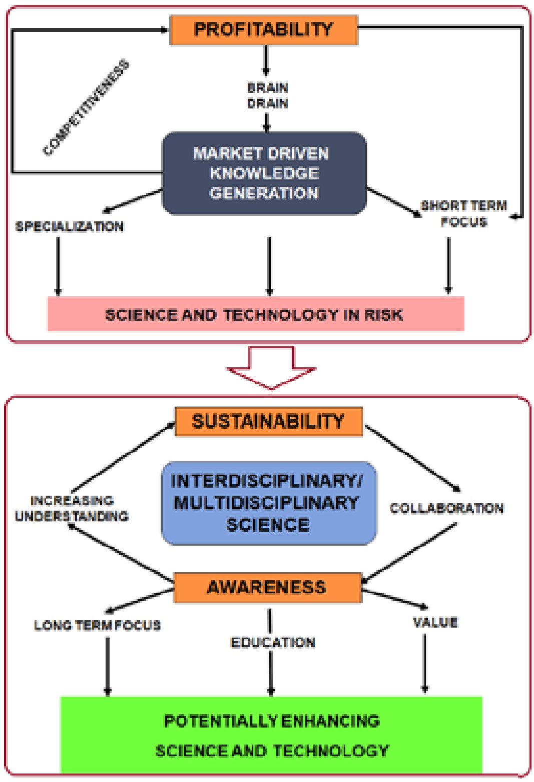


Fig. 2: *The market driven model of the knowledge generation (top panel) and the sustainabiliby/awarenes model for potetial enhancement of the economy thorugh optimal use of sceince results (bottom panel).*

The instrumental part is to change the pure thinking often used when starting an SME. This traditional approach comes from the simplistic belief that an excellent research result that has been accepted in the research community can be translated into innovation. The key element that will make SME a valuable partner in the development of the economy is the competitiveness. In a knowledge-based economy, competitiveness of SMEs is based on ability to provide excellent products at a competitive price. Globalization has made it crucial for most enterprises, including SMEs, to become internationally competitive even when operating wholly in the domestic market. SMEs need a coherent business strategy to improve their efficiency continuously, reduce production costs and enhance the reputation of their products. The keyword is the business model which in many cases does not consider the impact of the innovation on the market. The elements that must be the core of the SME operation are: 1) acquiring new technology, 2) improving management practices, 3) developing creative and appealing designs, and 4) effective marketing policy.

Fig. 2 shows the model of the SME operation that can make the difference. In past, the cycle of exploitation was linked almost exclusively to market-driven knowledge generation (Fig. 2, top panel). This ultimately leads to brain drain, short-term focus, and high specialization. The profitability is the driving element in this cycle. The organization of the productive link between HEI and SME needs to focus on the potentials to enhance the science and technology by considering the role of science in the sustainability and awareness. The collaboration and increased understanding of the impact of the work are an essential element, especially in the increasing role of information and communication technologies as the base of the current almost only active interdisciplinary and multidisciplinary science. This model combines the long term focus, education, and the added value to the society (Fig. 2, bottom panel).

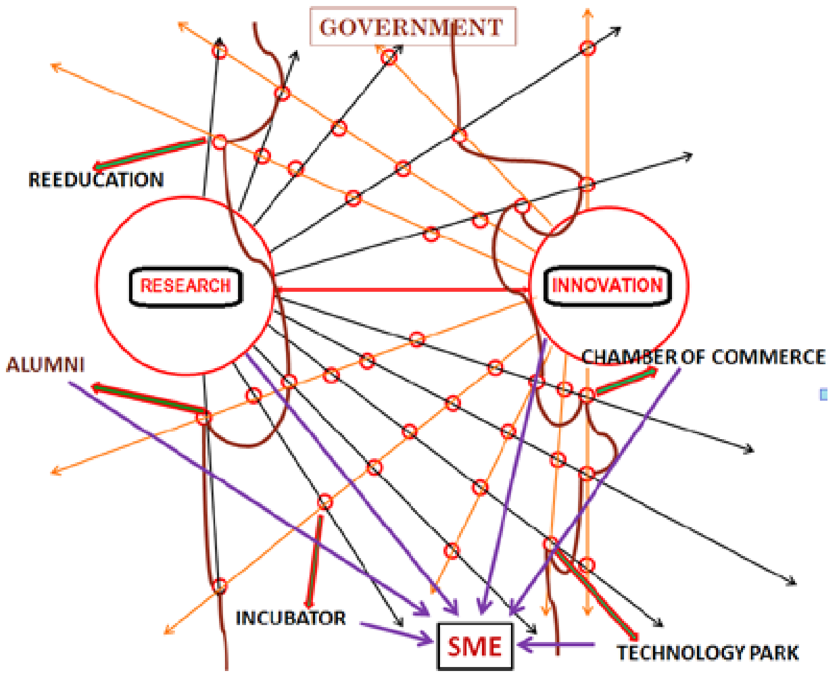


Fig. 3: *The sketch of the stakeholders for the translation of ideas into innovations.*

To comprehend the complexity that needs to be optimized it is necessary to look into the research and innovation model (Fig. 3). The research and development at HEI (i.e. generating ideas) spread results within a broad spectrum (black arrows starting from the circle RESEARCH). The innovation can be created in several ways as suggested by orange lines entering the circle INNOVATION. There are many crossing of the black and orange lines each potentially deserving some attention. This plurality of crossing points is linked with stakeholder of the novelty: alumni, HEI re-education programs, chamber of commerce, incubator and technology parks that in some way host the SME. The government agencies are regulators of all stakeholders, but not the process as a whole. The question which of the pathways is optimal cannot be decided at this level since the schema does not include two major players: users and investors. The actual decision which will make the translation of an idea to the innovation is made based on the business plan made by investors (public or private), users based on the applicability of the innovation and regulatory bodies which guaranty the safety, ethics, and confirmation to standards.

Conclusion or how to reach creative industries

Policies have to be conceived in a unique and rapidly evolving environment of multiple public players. This has implications: 1) the need for clearer consideration of regional actors as fully fledged players and 2) the need for a less normative approach than subsidiarity able to take into account competition and duplication as a typical feature of public intervention (Larédo, 2003).

It has to take account of the changing techno-economic dynamics where new technologies no longer require central coordination but rather public incentives to a local emergency. This goes along with a revised view of what constitutes a favorable knowledge infrastructure. A complete reappraisal is needed of patenting policies that are too often taken for granted (Larédo, 2003).

The challenge is also to change the public intervention to face seriously the extent, composition, organization and dynamics of public-sector research to include HEI, government, investors and the manufacturing institutions.

It is necessary to support the SMEs financially in a different manner compared to the traditional solutions. The solution may be the renewed engagement of federal and provincial governments in the backing of new technology-based firms. One possible policy is to develop stronger interactions between HEI and SME by co-founding Ph.D. and post-doc fellowships (in high-tech fields) by sharing the costs of continued education.

To optimize the process of generating innovations (i.e. the performance of the business) by a sustainable link between the stakeholders: HEI, SMI, investors, and users of the output from the science-based activities, the government needs to provide an umbrella that minimizes the administrative and maximizes the productive links between the stakeholders.

References

Ahlback, J., 2005: *The Finnish National Innovation System*, (Helsinki, Helsinki University Press)

Becher, G. & S. Khulmann (Eds) 1994: *Evaluation of Technology Policies in Germany* (Boston: Kluwer).

Casper, S. & R. Whitley, 2004: Managing Competencies in Entrepreneurial Technology Firms: A Comparative Institutional Analysis of Germany, Sweden and the UK, Research Policy Vol. 33, pp. 89-106.

Feldman, M. & A. Link (Eds) 2001: *Innovation Policy in the Knowledge-Based Economy*, (Boston: Kluwer)

Jan, T.-S. & Y. Chen, 2006: The R&D system for industrial development in Taiwan, Technological Forecasting and Social Change, Vol. 73, pp. 559-574.

Larédo, P., 2003: Six major challenges facing public intervention in higher education, science, technology and innovation, Science and Public Policy, 30(1), pp.4-12.

Niosi, J., 2009: Bridging Canadian technology SMEs over the valley of death. International Productivity Monitor, Apr 1(18):80.

INTEGRATED ENVIRONMENTAL RESEARCHES ON THE ROMANIAN DANUBE VALLEY. A GEOGRAPHICAL PERSPECTIVE

Prof. Dr. Dan Balteanu[1], Diana Dogaru[1], Mihaela Sima[1],
[1]Institute of Geography, Romanian Academy, igar@geoinst.ro

Abstract

Geographical research on global environmental change issues integrates into new research paradigms and views of the International Programme *Future Earth – Research for Global Sustainability*. The present paper highlights several spatial integrative assessments on environmental and socio-economic components in the Romanian Danube Valley, within the context of global environmental change and global sustainability research domains. The scope is to illustrate the use of spatial scientific services referring to pressing social and environmental problems in the area for policy, stakeholders at different levels of governance, and the public. The projects of the Institute of Geography tackled aspects such as: land use land cover changes and agricultural issues, as well as natural hazards and local communities' resilience. The analyses considered the challenges imposed by climate change, the complexity of the topics in the Danube basin requiring better integrated and cross-disciplinary researches within the context of global environmental change domain.

Keywords: Lower Danube basin, global environmental change, transdisciplinary research, 'Future Earth' Programme

Celostne okoljske raziskave v romunski dolini Donave. Geografski pogled v prihodnost

Povzetek

Geografske raziskave svetovnih sprememb v okolju se vključujejo v nove vzorce in poglede mednarodnega programa *Zemlja prihodnosti – Raziskave za svetovni zdržni razvoj.* V tem prispevku je poudarek na celostnih prostorskih ocenah okoljskih in družbeno-ekonomskih sestavnih delov v romunski dolini Donave, kot delom svetovnih okoljskih sprememb in raziskav svetovnega vzdržnega razvoja. Namen prispevke je ponazoriti uporabo prostorskih znanstvenih metod za pereče družbene in okoljske težave politike, odločujočih na raznih vladnih ravneh in javnosti. Projekti Geografskega inštituta vključujejo raziskave uporabe tal, sprememb rastlinskega pokrova in vprašanj kmetijstva kot tudi tveganj in odporov lokalnih skupnosti. Razčlenjevanja upoštevajo izzive podnebnih sprememb in prepletenost vsebin donavskega porečja in zahtevajo prizadevanje za celostnost ter vključevanje raziskav različnih strok v sklopu svetovnih okoljskih sprememb.

Ključne besede: Spodnje donavsko porečje, svetovne okoljske spremembe, meddisciplinarne raziskave, program »Future Earth«

Introduction

Global environmental change research aims to increase the knowledge in terms of better understanding the human-environment interaction at various spatial and temporal scales, involving integrated and interdisciplinary researches that address various topics: e.g. biodiversity and ecosystem services, climate, coasts, food systems, land use and land cover, natural hazards, oceans, urban areas, and water resources.

Land use is one of the core research themes of environmental change, expressing direct consequences of anthropic pressure on agroecosystems, constructing particular human-environmental relations in rural areas and arranging specific cropping distribution patterns. In terms of resource management, land use is tightly connected with water use considering that agriculture is the largest consumer of freshwater water resources through irrigation (Foley et al., 2011). Furthermore, climate change is already augmenting water scarcity in drought affected areas, while increasing the variability of hydrological parameters in regions benefiting from water surplus, inducing chain effects in the functionality of the ecosystems as well as in the trends and development of human activities (Mauser et al., 2008, World Bank, 2016).

Likewise, natural hazards represent a widely-discussed phenomena nowadays both in the scientific and non-scientific communities, with a stronger focus in the last years in connection to climate change. At the Danube basin level, the EU Strategy for the Danube Region acknowledges that the management of hazards represents a common challenge in the region, mainly in terms of flood hazard through the priority area 5 on environmental risks. The Strategy mentions other potential hazard and risk phenomena in the Danube Region, importance being given to droughts, industrial accidents and associated pollution.

Spatial analyses evaluate the regional differences of the mentioned aspects, supporting decision-making processes to assess resources management alternatives available for each region according to its environmental particularities and socioeconomic context. Such aspect is as much a methodological matter as it is a conceptual research question. On the one hand, it relates to regional particularities and problem priorities, to impacts and feedbacks and development pathways, and, on the other hand, to ways of problem quantification and analysis, including use of specific indicators and indices, application of process-based models that provide estimates of environmental functions and productivity and ultimately to scenarios of sustainable development.

Moreover, environmental change research topics – land use, agricultural water management and climate change, natural hazards, among others – are part of the action plans of national and macroregional strategies, such as EU Strategy for the Danube Region (2010), EC

White Paper on Adaptation to Climate Change (2009), EU Roadmap for a Resource Efficient Europe (2011), Territorial Development Strategy of Romania (2015), etc. Therefore, it is of particular interest to approach the associated research questions through the lenses of knowledge co-design and co-production concepts which have a strong cross-disciplinary focus and tightly connect the decision making-factor with the research milieu through enhanced collaboration and increased application of participatory methods (Future Earth Programme, Lang et al., 2012). The two concepts emphasize the idea that the scientific efforts should be channeled towards producing knowledge and proofs that explain the current challenges and projected impacts faced by society due to global change, thus constructing solution-oriented studies and transdisciplinary research in which the role of stakeholders' participation is essential (Mauser et al., 2013). Both the stakeholders' views and the experts' analytical results are integrated into outcomes which form sound scientific based alternatives that support decision-making processes and sustainable development pathways.

The paper provides an overview on geographical issues connected to global environmental change in the lower Danube Valley and neighboring plain areas in view of three main aspects, namely, land use / land cover issues, agricultural development and natural hazards threats.

Researches on land use land cover change

Romanian Danube Valley and the adjacent plain areas form a distinct space in the country's landscape covering about 49 000 sq. km (Fig.1). The socioeconomic profile of the region is strongly marked by the presence of the Danube River and the associated geomorphology (i.e. floodplain, wetlands, river's terraces and plain areas), being particularly agricultural and rural, with the exception of the cities (i.e. Bucharest, Braila, Galati) and their polarizing hinterlands.

The changes in land use / land cover in the lower Danube valley in Romania are a clear expression of the human pressure on the environment over time, on one hand, and of the region's natural capital, given its ecosystems goods and services, on the other. The main types of floodplain transformations consisted in massive damming, draining and irrigation works during 1960s until 1980s which had strong consequences on the floodplain lakes and wetlands, soil quality, local climate, hydrological regime of the Danube and of the groundwaters, and had modified the landscape to a great extent, with the cropland area increasing by 54.5 % (Kucsicsa et al., 2015). As a consequence, the infrastructures in the Danube floodplain cover 75% of its total area, i.e. 1 158 km dams, 418 000 ha drainage areas and 225 000 ha of irrigation systems (Visinescu and Bularda, 2008). Worth mentioning that the entire irrigation infrastructure, further extended in the plain fields, serves an area of 1 875 058 ha (Grumeza and Kleps, 2005). Along with the benefits of these measures which were reflected in increased agricultural productions and development of rural areas, the disadvantages resulted from oversizing irrigation system, particularly by extending it in the higher parts of the region (e.g. upper river terraces), fact that led to important demands of consumption of energy and water resources as well as to significant economic and technical drawbacks over time.

Fig. 1: Romanian Danube Valley and the adjacent plain areas

Since the early 90s, the region has undergone sharp dynamics in terms of land use patterns, water resources exploitation and socio-economic transformations, specifically during the transition and post-transition periods towards market economy. They resulted in highly spatially diverse situations, e.g. fragmented lands alternating with large parcels belonging to big commercial-oriented agricultural holdings, improper farming practices, considerable destruction of the irrigation systems which were crucial for drought combat, little social returns for the locals from the well performing agricultural activities, etc. In fact, two distinct temporal intervals could be distinguished in the evolution of crop structures, land tenures and type of farms in Romania since early 90s (Balteanu and Popovici, 2010; Popescu, 2013). Specifically, in the first 10 years since the fall of the totalitarian regime, the excessive fragmentation of farm land, emergence of numerous individual farms of subsistence agriculture, poor agricultural infrastructure and services (degraded irrigation systems, inappropriate farming practices, etc.) contributed to significant changes in the quality of agricultural productivity and crop production. Conversely, over the last decade, the agricultural sector has been turning from individual / family-oriented farms and highly fragmented lands towards agricultural holdings with a strong commercial focus. However, this situation is spatially different, as in many parts, the agricultural resources are still unexploited and/ or impacted by drought and desertification, land degradation, water stress, confusion about property rights, etc. (Balteanu and Popovici, 2010; ECLISE, 2014).

Within the context of global environmental change research, land use / land cover change aspects and land use management are important to consider, especially in view of future developments of Common Agricultural Policy expectations which are oriented to agricultural practices that support green economy, including adoption of water saving technologies (EC Blueprint to Safeguard Europe's Water Resources, 2012). Under these circumstances, integrative management of water and land resources plays an undeniable role within the Danube River basin, particularly from an upstream – downstream perspective, while improved water use efficiency practices are key strategies in obtaining economic viable cropping systems.

Researches on agricultural issues

The agriculture in the lower Danube valley and the adjacent plain areas was profoundly affected by the disruptive changes of the transition and post-transition periods, particularly in terms of sectoral economic added value, institutional (re)arrangements, resource management and socioeconomic profile of the rural areas. Correlated with the projected impacts of climate change scenarios, these aspects are of high relevance for the agricultural production which depends on the environmental conditions as well as on the farming practices and resource management strategies. The agricultural potentials of this region are remarkable, given the croplands which cover about 85% of the area and the soil types which are represented by cambic and calcaric chernozems extended over large areas in the central and southern areas of the Romanian Plain with lower amounts of precipitation of (i.e. below 500 mm), luvisols, vertisols and cambisols in the rainier plain areas towards the contact with the hilly Subcarpathians (i.e. around 700 mm), while the alluvial soils belt the region's floodplain areas (Geografia Romaniei V, 2005). Most of them are heavy or medium textured soils, of high fertility, with a good water capacity and aeration porosity, and with a low or medium draught resistance to ploughing (Canarache, 2006). However, the climatic conditions highly influence the agricultural productivity in the region. Characterized by a temperate climate of strong continentalism in the south-eastern part and Mediterranean influences in the western areas, the Romanian Plain together with the Danube floodplain is a region impacted by drought phenomena and rather low amounts of precipitations.

Despite the acute need of irrigation application in the lower Dan-

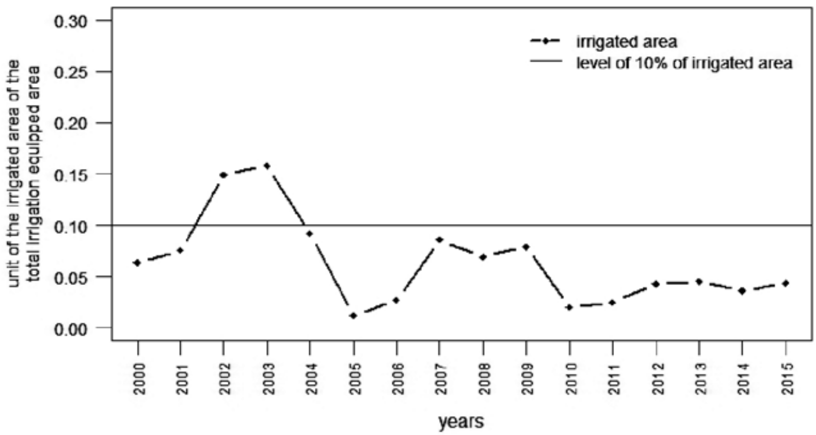


Fig. 2: *Irrigated areas in the Romanian Plain over 2000 – 2015 period, as percentage of the total area equipped with irrigation infrastructure.*

ube, the current coverage of the irrigated areas is below 10% of the total area equipped with supply systems (Fig. 2). Regionally, the situation is slightly different as in the south-eastern part of the lower Danube valley and its neighboring plain areas the irrigated area is about 20% of the total area equipped with irrigation, while in the south-western part and the northern part of the region it drops to an insignificant value (Fig. 3). This situation reflects the territorial disparities of the cropland management. The presence of large agricultural holdings of strong commercial profile in the eastern part is associated with the existence of or premises for intensive agriculture using modern infrastructures and farming practices for higher yields and farms' economic viability. Contrary, the agriculture in the western part is still related to the existence of small farm properties and land fragmentation which constrain the growth of agriculture and development of rural areas. Nevertheless, the use of irrigation in the analyzed region is a prerequisite for drought mitigation and productive agriculture, particularly considering that yields are lower than many EU member states for many crops, in spite of the remarkable productivity potential (e.g. in this region, the yield for maize is between 4 - 6 t / ha, while in France is of 9.1 t / ha and in Germany of 9.5 t / ha (www.ec.europa.eu/eurostat/)). The reasons are multiple, being mainly due to the advanced degree of deteriora-

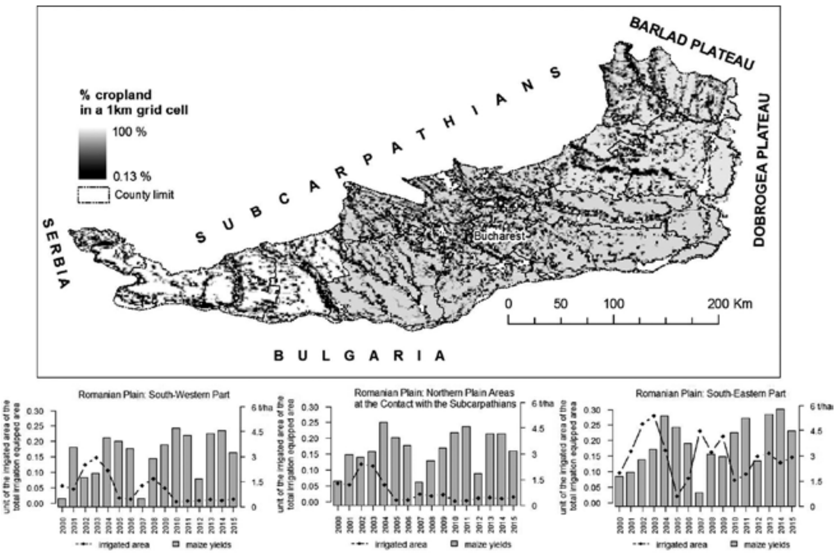


Fig. 3: *The Romanian Plain: cropland cover as percentage in a 1km grid cell (Dogaru and Kucsicsa, 2015). The interrupted line graphs represent the area irrigated at least one time during the growing season over the 2000 – 2015 period, being expressed as percentage of the total area equipped with irrigation systems, while the bar graphs represent the maize yield over the same period. The graphs characterize three general areas of the Romanian Plain, specifically the south-eastern, south-western and northern plain areas, arbitrarily separated by county limits.*

tion of the old infrastructures, drop of the irrigation water demand particularly in highly fragmented farmlands, water costs, and frequent reorganizations of the administration of the water users.

Moreover, the IPCC-projections show considerable increases in precipitation variability and intensification of dryness in central and south-eastern Europe, affecting the agricultural productions as well as the hydrological regime with consequences on the region's water availability (IMPACT2C, 2013; ECLISE, 2014). In this case, the adaptation measures refer to both agro-technical (e.g. drought resistant cultivars, farming practices based on preserving/increasing soil water retention capacity, efficient application of irrigation in order to optimize crop water productivity, etc.) (Sandu and Mateescu, 2014) and land use and water resources management measures at regional scale (e.g. equitable allocation of water among sectors, cropland structure and use of irrigation supply systems according to the environmental conditions and availability of water resources). In this respect it is worth mentioning a previous research performed at the Institute of Geography within the FP7 ECLISE project referring to providing climate information services to users aimed to provide climate change information to farmers in southern part of the Romanian Plain along the Danube. It was interesting to observe that, even farmers perceive that investments in irrigation system to be an essential adaptation measure in the area, they have already taken some "no regret" measures, which deal with choice of crop varieties or change in management practices (Sima et al., 2015). Policy support to farmers would encourage them to invest more in this direction, especially for small farms with low income which are the most vulnerable category.

Researches on natural hazards issues

Being a large river basin, with a transboundary management of the resources, natural hazard management in the region needs to be ensured through transnational cooperation between countries for better preparedness, response and adaptive capacity. In this respect, researches on natural hazards performed on a bilateral or multi-countries approach, using common databases and methodologies are necessary in the management process, but also to increase the communities level of understanding, awareness and preparedness in case of emergency situations.

One of the projects that Institute of Geography implemented in the last years was focused on these aspects of joint natural and technological hazard assessment, as a first-step towards better management, education and adaptation. It was a cross-border project between Romania and Bulgaria on *"Romanian – Bulgarian Cross-Border Joint Natural and Technological Hazards Assessment in The Danube Floodplain. The Calafat-Vidin - Turnu Măgurele-Nikopole Sector"* (ROBUHAZ-DUN, www.robuhaz-dun.eu), implemented by academia partners from both countries. There were analyzed floods, the main hydrological hazards of the Danube alluvial plain, climatic, geomorphological and technological hazards, and there were established the corresponding vulnerability indicators. Besides the joint assessment and mapping of the hazards, using a commonly designed methodology, ROBUHAZ also aimed in providing science to different stakeholders in terms of information on natural and technological hazard and water quality (Fig. 4). In this respect, attention has been given to how to communicate environmental quality data to users (local communities), considering the common problem the agricultural rural communities share in Romania: problems related to water quality and aquifer vulnerability to pollution with nutrients and pesticides. What has been noticed and reported in terms of environmental quality data in ROBUHAZ-DUN project, was the low access to environmental quality and hazard data (Sima et al., 2013; Balteanu and Sima, eds., 2013; Senila et al., 2014), awareness, education and information being a pre-requisite step in better coping to hazardous phenomena.

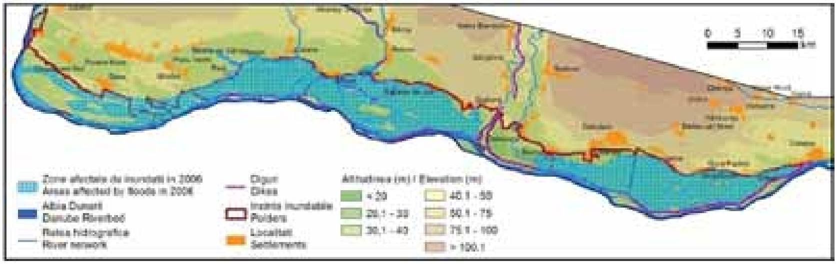


Fig. 4: *Areas affected by floods in March-April 2006 (Chendes, 2013)*

Conclusions

The complexity of the problems in the lower Danube valley and the adjacent plain areas call for better integrated and cross-disciplinary researches within the context of global environmental change domain. Analyses regarding land use, agriculture and water management, while taking into account the effects of climate change and the trade-offs among sectors for resources use and equitable allocation of resources at regional level are of particular relevance for the lower Danube having in view its potentials and development pathways.

For instance, specific researches such as: agriculture water availability, demand and supply, climate change impacts on agricultural production, environmental and economic impacts of irrigation, increased water productivity which further reflects adaptation policies to climate change effects, institutional improvements with respect to integrated management of resources, and last but not least, to environmental function preservation are regional topics that require solution-oriented approaches in order to provide sound scientific knowledge and alternatives for viable and sustainable agricultural management under climate change and future development pathways in the area. Moreover, there are evidences that climate change will further increase the frequency and magnitude of natural hazards, thus a combined approach of these aspects are very important to be included in research plans of countries sharing the Danube Basin. As well, evaluations of the socioeconomic particularities represent a major component of region's resilience to climate change in the lower Danube.

Furthermore, efficient and interconnected operation of the institutions from different administrative levels, adopting a bottom – up approach in which the local needs are primarily accounted for, represent important elements of achieving regional sustainability.

Acknowledgements. This work is part of the project 8 of the *National Strategy of Research and Innovation for the Romanian Danube Region*, coordinated by the Romanian Academy and of the priority project "*The Geographic Study of the Romanian Danube Valley*", planned within the yearly research framework of the Institute of Geography.

References

Bălteanu, D. & M. Sima (ed.) 2013: Hazard assessment and mitigation in the Danube Floodplain (Calafat-Vidin – Turnu Măgurele-Nikopol sector). Technical Guide, Romanian and English version, Universitaria Publishing House, pp. 247, Bucharest.

Balteanu D., Dumitrascu, M., Sima, M. & D. Dogaru, 2015: Geographical researches undertaken in European projects on current agricultural aspects.- In: Hera, C. (ed.) Global climate changes: focus on natural resources, Romanian Academy Publishing House, 359-371, Bucharest (in Romanian).

Balteanu, D. & AE. Popovici, 2010: Land use changes and land degradation in post-socialist Romania.- Revue Roumaine de Géographie, 54, 2, 95 – 105.

Canarache, A., 2006: Soil physical properties and regimes as components of soil fertility.- In: Hera, C. & C. Kleps (eds), Soil Fertility and the Future of Agriculture in Europe, Proceedings of the international workshop associated to the 4th UEAA General Assembly, Bucharest, Romanian Academy Publishing House, Bucharest.

Dogaru, D.& Gh. Kucsicsa, 2015: Using multiple linear regressions to derive cropland and pasture proportion maps in Romania, Revue Roumaine de Géographie, 59, 2, 101 – 109.

ECLISE, 2014: Climate change effects for Baragan Plain, Romania, Institute of Geography, Romania, Report no. D 5.1., Available from: http://www.eclise-project.eu/content/mm_files/do_855/D5.1_Baragan_Plain_IGAR.pdf

European Commission, 2009: White Paper – Adapting to climate change: Towards a European framework for action, Brussels. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009DC0147&from=EN.

European Commission, 2011: Roadmap for a Resource Efficient Europe, Brussels. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0571&from=EN.

European Commission, 2012: Blueprint to Safeguard Europe's Water Resources, Brussels. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0673&from=EN.

European Commission, Brussels. 2010: Action Plan – European Union Strategy for the Danube Region. Available from: (http://ec.europa.eu/regional_policy/sources/docoffic/official/communic/danube/action_plan_danube.pdf*).*

Foley, JA., Ramankutty, N., Brauman, KA., Cassidy, ES., Gerber, JS., Johnston, M., Mueller, ND., O'Connell, C., Ray, DK., West, PC., Balzer, C., Bennett, E., Carpenter, SR, Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D.& DPM. Zaks, 2011: Solutions for a cultivated planet.- Nature, 478, 337-342.

Chendes, V., 2013: Hydrological hazards. In: Balteanu D., Sima M. (eds.), Hazard assessment and mitigation in the Danube Floodplain (Calafat-Vidin – Turnu Măgurele-Nikopol sector). Technical Guide, Romanian and English version, Edit. Universitaria, Bucharest.

Grumeza, N. & C. Kleps, 2005: Irrigation systems in Romania.- CERES Publishing House, pp. 424, Bucharest, (in Romanian).

Impact 2C, 2013: Quantifying projected impacts under 2^0C warming, Quantifying projected impacts under 2°C of warming, Policy Brief, pp. 22.

Kucsicsa, Gh., Balteanu, D., Popovici, AE.& N. Damian, 2015: Land Use / cover changes along the Romanian Danube Valley. In: Bicik, I., Himiyama, Y., Feranec, J.& L. Kupkova, (eds.) IGU-LUCC Research Reports: Land Use/Cover Changes in Selected Regions in the World, Vol. XI, 7-18, Prague

Lang, D., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M. & C. Thomas, 2012: Transdisciplinary research in sustainability science: practice, principles, and challenges.- Sustainability Science, DOI 10.1007/s11625-011-0149-x

Mauser, W., Klepper, G., Rice, M., Schmalzbauer, B., Hackmann, H., Leemans, R. & H. Moore, 2013: Transdisciplinary global change research: the co-creation of knowledge for sustainability.- COSUST, doi.org/10.1016/j.cosust.2013.07.001

Mauser, W., Marke, T. & S. Stoeber, 2008: Climate change and water resources: scenarios of low-flow conditions in the Upper Danube River Basin.- IOP Conference Series: Earth and Environmental Science, 4 (012027), 1–11.

Ministry of Regional Development and Public Administration, 2015: Territorial development Strategy of Romania. Available from: http://www.fonduri-structurale.ro/Document_Files/Stiri/00017493/7hctm_Anexe.pdf.

Popescu, G. 2013: Old problems, new relationships in agriculture.- Romanian Academy Publishing House, Bucharest, pp.258, (in Romanian).

Sandu, I. & E. Mateescu, 2014: Current and predicted climate changes in Romania.- In: Saulescu, N (ed.) Climate Changes: a grand challenge for agricultural research, Romanian Academy Publishing House, Bucharest, pp.17-36, (in Romanian).

Sima, M., Enciu, P., Kucsicsa, Gh. & A. Bela, 2013: Water quality in the rural communities of the Romanian Danube Floodplain (Calafat-Turnu Magurele sector).- In: ***Water Resources. Forest, marine and ocean ecosystems, Proceedings*** of the 13th ***International Multidisciplinary Scientific GeoConference SGEM*****, 16-22 June, 2013, Albena, Bulgaria, 455-462,** DOI:10.5593/SGEM2013/BC3/S12.058**.**

Sima M, Popovici E-A, Balteanu D, Micu D, Kucsicsa G, Dragotă C, Grigorescu I (2015). A farmer-based analysis of climate change adaptation options of agriculture in the Baragan Plain, Romania. Earth Perspectives, 2:5, SpringerOpen Journal, DOI 10.1186/s40322-015-0031-6.

Senila, M., Sima M., Roman M., Levei E., Roman C. & D. Balteanu, 2014: Chemical parameters of well waters in an area affected bz flood events: Case study of Timiş-Bega Area, Romania-, In: Water resources. Forest, Marine and Ocean Ecosystems, Proceedings of the 14th SGEM GeoConference

SGEM2014, June 19-25, 2014, **Albena, Bulgaria,** 119-126, DOI: 10.5593/SGEM2014/B31/S12.016
Visinescu, I. & M. Bularda, 2008: Important changes of the Danube hydrological regime and its impact on agriculture in the dammed areas. Annals of NIRDA Fundulea, 76, 101-112, (in Romanian).
World Bank, 2016: High and dry: climate change, water and economy, World Bank, Washington, CD.
www.ec.europa.eu/eurostat/
http://www.futureearth.org/.
Geografia Romaniei vol. V, (2005), Romanian Academy Publishing House, Bucharest.

ON CONTRACTING SPECIALIZED GEOTECHNICAL WORKS

Prof. Dr. Gert Stadler[1] **and Dr. Michael Werkl** [2]
[1] em. o. Univ. Prof. Dipl.-Ing. Dr.mont., Graz University of Technology, Austria, stadler@tugraz.at
[2] Dipl.-Ing. Dr.techn, Graz University of Technology; profacto GmbH, Austria, michael.werkl@profacto.at

Abstract

Specialized geotechnical works for building foundations, for tunneling, or in a mine like: diaphragm walling, piling, geotechnical and mineral exploration, high pressure grouting (against water ingress or gas), installation of prestressed anchors, stope support or hydraulic backfilling, are frequently (sub-) contracted to specialist contractors. More than 200.000 workmen are estimated to be engaged worldwide in this type of works, generating a production value of around 20 BioUS$.

In essence our case here turns around a sort of "legal impossibility" in identifying and allocating the "*risk of the ground*" and *"circumstances of execution"* as far as workability of ground is concerned and, around how particular types of contractual agreements may help avoiding conflicts arising from "*parties not fully knowing of the terms of the agreement*".

The client is (contractually and legally) "supplying" the ground (rock or soil) in which the relevant works are to be carried out. If not expressly agreed otherwise, the quality of the ground is the clients "responsibility". Ground quality however, may vary within short distances. Unconfined compressive strength, equivalent quartz content, brokenness, frequency and orientation of fissures, seepage of water, heterogeneous sediments, cobbles and boulders - all of these would influence contractors productivity compared to explored, predicted or reasonably assumed values - and as such, influence calculability of costs and prices at all. Furthermore, the client may supply to the contractor services like, shaft- and underground transport, ventilation, water and compressed air, plus skilled/unskilled labour.

If, for one reason or another, some of these facilities are not available, or ground-quality continues to deviate from the one assumed or agreed, prices would have to be adapted to new circumstances of execution.

Established standards for these procedures are manifold but ambiguous and cumbersome.

If however - like introduced in some of South African mines as well as Austrian dam sites and tunnels - instead of only unit prices per production item, the compensation is split in time-related (invoiced well below cost) and production-oriented items (carrying the difference to full costs), a satisfactory situation (the so called **StilfOs-System)** for both partners is installed inasmuch as, the client pays less time-related cost if production increases, and also, the contractor earns over-proportionately more, if production passes anticipated levels.

The paper presents the principle and relates its performance to other comparable models, used for contracting works of "*imperfect description or carried out under unpredictable circumstances of execution*" (Werkl M., 2004).

Keywords: contracting, geotechnical, civil-engineering/mining, Graz University of Technology

---

Sklepanje pogodb pri specialnih geotehničnih delih

Povzetek

Specialna geotehnična dela, ki se pojavljajo pri gradnji temeljev, tunelov in rudnikov, velikokrat zahtevajo stranske pogodbe s specialnimi podjetniki. Takšna dela so na primer: gradnja preponskih sten, podpi-

ranje z oporniki, geotehnične in mineralne raziskave, zaščita pred vstopanjem vode ali plina z uporabo malte pod visokim tlakom, instalacija prednapetih sider, podpore v rudniku ali hidravlično zasipavanje. Ocenjuje se, da takšna dela v svetu opravlja več kot 200 000 delavcev in da je vrednost teh del okrog 20 milijard dolarjev.

V bistvu gre v tem primeru za vrsto »legalne neizvedljivosti« pri identifikaciji in umestitvi »rizika tal« in »okoliščin izvedbe«, ko gre za uporabnost tal. Različni pogodbeni dogovori lahko pomagajo pri izogibanju konfliktov, ki nastajajo zato, ker »stranki ne poznata povsem pogojev dogovora«.

Klient (dogovorno in legalno) »dobavlja« tla (kamenino in zemljo), v katerih se bodo odvijala relevantna dela. Kolikor ni posebej drugače dogovorjeno, je za kvaliteto tal »odgovoren« klient. Kvaliteta tal pa se lahko spreminja že pri kratkih razdaljah. Nekonfinirana kompresivna odpornost, ekvivalentna vsebnost kremenjaka, lomljivost, pogostost in orientacija razpok, pronicanje vode, heterogeni sedimenti, prodnik in pečine vplivajo v primerjavi z raziskanimi, napovedanimi in privzetimi vrednostmi na produktivnost podjetnika. Na ta način vplivajo na zanesljivost izračuna stroškov in na ceno del. Klient lahko podjetniku omogoči usluge, kot so podzemni prevoz oziroma prevoz v jaških, prezračevanje, dobavo vode in stisnjenega zraka ter kvalificirano ali nekvalificirano delovno silo. Kolikor iz takšnega ali drugačnega razloga nekatere od teh uslug niso na voljo ali pa se kvaliteta tal še nadalje razlikuje od predpostavljene ob dogovoru, potem je potrebno ceno prilagoditi novim okoliščinam in izvedbi.

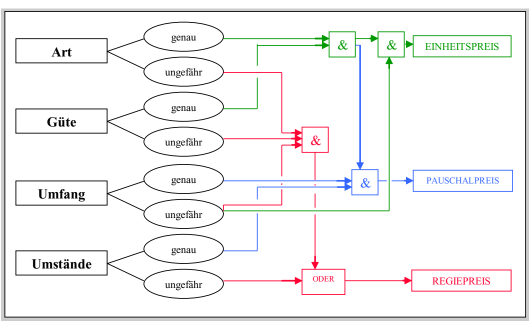
Uveljavljeni standardi za takšne procedure so mnogovrstni, vendar nejasni in nerodni. V primeru nekaterih rudnikov v Južni Afriki in pri gradnji avstrijskih jezov in tunelov, je namesto cene za posamezno produkcijsko postavko, kompenzacija porazdeljena v časovno odvisne (fakturirane precej pod ceno) in produkcijsko orientirane postavke (všteta je razlika do polne cene). Takšna situacija je sprejemljiva za oba partnerja, saj klient plača manj časovno odvisnih stroškov, kadar produkcija naraste, podjetnik pa zasluži proporcionalno več, kadar produkcija preseže predviden obseg.

Članek opisuje principe in primerja njihovo izvedbo z drugimi primerljivimi modeli, ki se uporabljajo pri pogodbenih delih z »nepopolnim opisom« ali z deli »ki potekajo v nepredvidljivih izvedbenih okoliščinah«.

Ključne besede: sklepanje pogodb, geotehnika, civilno inženirstvo/rudarstvo, Tehnična univerza v Gradcu

Introduction and discourse

The problem of contracting works of inherently "*imperfect*" description and specification is an ongoing theme in Civil Engineering and Construction - mainly, for works of ground engineering. But Mining also suffers from such "*imperfect"* contracts resulting from either mutual interference or change in circumstances of execution. How to deal then, with these situations of potential dispute?



Art	Type
Güte	Quality
Umfang	Quantity
Umstände	Circumstances
genau	exact
ungefähr	approximate
Einheitspreis	unit price contract
Pauschalpreis	lump sum price
Regiepreis	direct labour contract

Fig. 1: *»Recommendation in Austrian Standard ON A 2050 on how to relate type of compensation/contract to quality of description of the works.«*

BLECKEN was one of the first to investigate the problem *au fond*; GANSTER then, differentiated the problem with respect to **Austrian**

Standard ON A 2050 for Public Procurement, where defined procedures for the choice of contractual models are specified. (Fig.1). "*Imperfect*" knowledge by the client on *type, quality, quantity or circumstances* of execution (be it *exact* or *approximate*) of the works, do - according to ON A 2050 - lead to different types of schedules of rates: *unit price, lump sum price* or *direct labour contract compensation.* - This constitutes a fine schedule for how to contracting elements of *"uncertainty"* (at the stage of calling for tenders) however, few clients effectively do make use of it - albeit - few state-authorities also, do freely point the finger to matters of *uncertainty* in their respective project designs …

A particular version of this approach to *uncertainty* and changing conditions has been formulated in **Austrian Standard ON B 2203**, the Standard Condition of Contract for Tunneling. The basic concept of this Norm consists of introducing special items for compensating time related costs - linked to agreed production values stated in the tender (!), on the basis of which e.g. extended time of construction leads to an automatic adjustment of the value of the works.

In the United Kingdom the use of the **New Engineering Contract** (NEC) is *en vogue*; and practiced in a certain number of sub-versions; all of which being characterized u.o. by the installation of an independent Contract-& technical Expert who is acting as an on-the-job-Arbiter - agreed and accepted by both parties. All changes and deviation from the original contract are as such brought to a solution of some kind, and - experience seems to confirm the concept.

At the time of building the high speed railway line Cologne-Rhine/ Main (180 km between Frankfurt/Main and Cologne, Germany) **functional tenders** had been invited, specifying only a framework of technical and commercial parameters, leaving the detailed design of the (mainly tunnelling-)works however, to the contractor. Intention being, that a gain in design-time by the client and possibly innovative solutions and production oriented resourcing by the Contractors might outweigh additional costs caused by risks of the ground, have an overall gain in time of construction and as such - in overall economy of project costs. In the end - not only because of environmental extras - the disappointing result however was, having to accept additional costs of 52% (as per 2002). And quite a number of surveys into the reasons for this overrun showed, that the rigid hierarchy of clients approval of contractors design proved to lead to thousands of additional claims and, that the system therefore only rewards the efforts, if the contractor becomes an early partner - in principle - already before contract award.

TIWAG and PURRER somewhat alike, focussed on an *"optimal final product"* avoiding distractions by claim management and negotiations around changes, accepting that, "*change & disruption of conditions & program are <u>normal</u> on a project*", and would better be attended **proactively**.

On the one hand Purrer found, that adjudication processes for large infrastructure projects (Brenner Tunnel between Austria and Italy or, Hydro Power Kaunertal II) had theoretically and in practice proven to be of superior quality if handled on the basis of negotiation instead of cheapest (best) price. Realizing that "construction" is - above all - a type of "techno-social" process, defined avenues of cooperation and elements of cybernetics had been introduced into the procedure (VIP) of awarding the contracts, which made it possible to

- judge on anticipated quality of cooperation,
- stability of appropriate pricing and
- likelihood to stay within budgeted limits.

On top of this, Mitteregger/Deisl of TIWAG recently did introduce a **predefined automatism of adjusting prices under changed conditions of execution** (e.g. change of rock properties). The adjustments are based on variation of key geotechnical parameters and their respective influence on costing/pricing, as documented in calculation sheets.

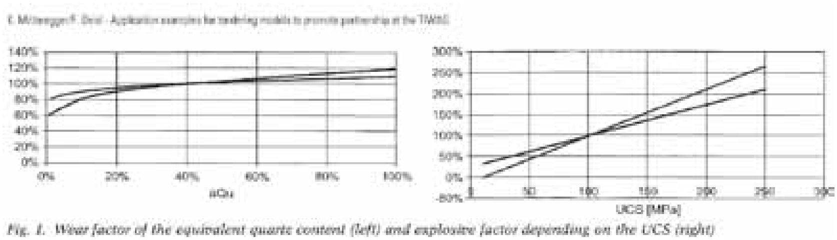


Fig. 2: *»Relating changes in quartz content and uniaxial strength of rock to agreed adjustments of respective rates/unit prices.«*

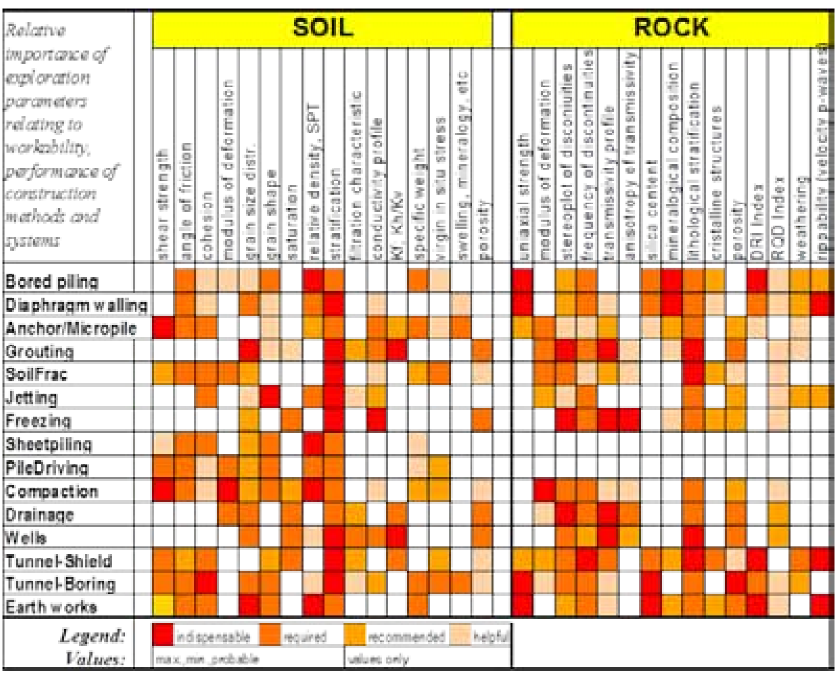


Fig. 3: *»Qualitative significance of geotechnical parameters to be explored for different specialized foundation works«.*

Parameters and percentage of adjustment (if changes to the values used for pricing occur) are proposed by the tenderer, and are agreed at the time of finalizing the contract. Example is given here (Fig.2) on the correction factors for UCS (unconfined compressive strength) versus explosives, and equivalent quartz content versus coefficient of wear and tear (CAI). The latter documents, that equivalent quartz (silica) content of 40% had been used in the calculation of costs, and a UCS of 100 MPa. Documented changes would ease adjusting the respective cost factors by agreed, predefined percentages. One curve in the respective graphs represents the result of a survey, the other one - the one agreed in the contract (Mitteregger, Deisl, 2014).

But, which parameters of the ground would matter? And, would these differ for different construction methods? Which geotechnical properties of the ground would - in contrast to parameters influencing **the design** of the foundation for a structure - govern its workability, and for which tools and what methods (augured piles, HP-jetting, sheet piling, etc.?) Very few publications do exist on this aspect, because of being "classified experience & expertise" of Contractors. On this point, an independent research would improve the situation substantially, and results could then form basis and input in the TIWAG-model on a larger scale, and foremost, for foundation engineering works in general. My personal perspective (admittedly somewhat un-researched but backed by decades of contractual experience) on how the outcome of such investigations might be of the kind of (Fig.3).

If for each and every "indispensably" labelled geotechnical parameter-value (Fig.3), for any different construction method, a function for productivity change would be able to be given - then, in consequence - cost/price-adjustment would be already part of the contract agreement (see TIWAG-model).

The Contract models of **FIDIC** do comparably make use of a complex set of rules, laid out in accordance with generalised project characteristics and requirements. These are widely accepted in the civil en-

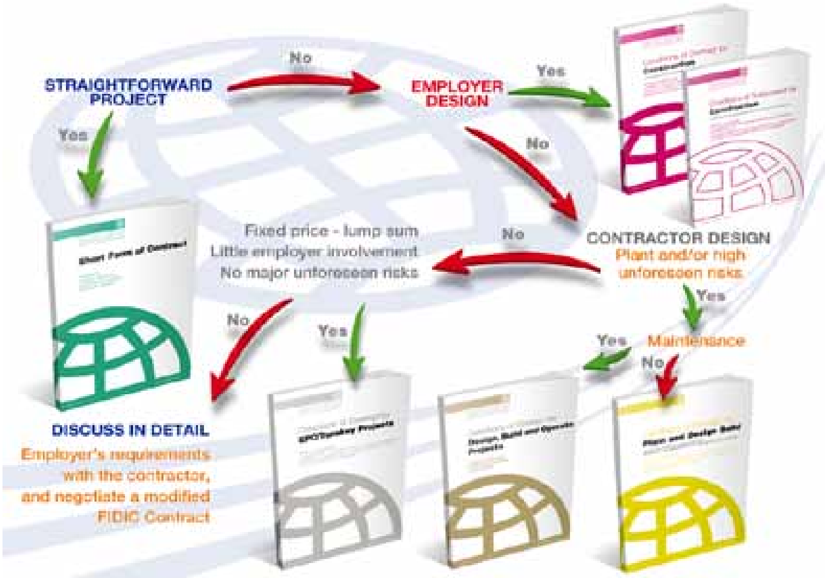


***Fig. 4:** „Which FIDIC Contract to use?" (International Federation of Consulting Engineers, URL, n.d.)*

gineering industry and, enforced on projects with international funding. Adjustments according to changes however, are cumbersome and leading to unnecessary dispute, if compared to…

…yet another way of "coping with incompleteness" (in design and tender documents) leading to "An Approach using Time and Production Related Compensation" (Werkl, Heck, 2011).

The authors postulate that, present confrontational contract forms in mainland Europe - using established unit prices, lump sums and reimbursable mechanisms - should be queried against the background of a transparent and fair risk allocation. Therefore, the scope of their research was to find a new approach in construction contracting using specific partnering principles which evolve from, and are intimately

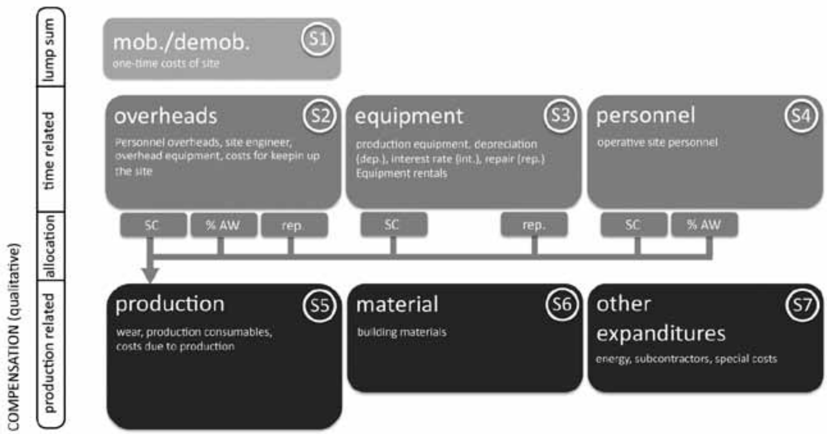


***Fig. 5:** »Categories of costs for the StilfOs-compensation model«.*

linked to, compensational regulations (Stadler, Reinisch, 1998). With a focus on (by nature of the works inevitably) imperfectly described works the referred paper not only points out the reasons for such confrontation but also introduces a solution in form of the "time- and production related compensation-model named "**StilfOs**". StilfOs originates from Canadian Oil well contracting and experience gathered in South-African mining business (Stadler, 2009), and is to be classified as "a production-oriented mode of compensation with effort-based principles" (Werkl, Heck, 2011).

The system is based on a quite **simple re-allocation of costs, where part of the time-related costs is shifted into production compensation**. The level of time-related costs (for personnel and rent of equipment) intentionally is held well below covering of true costs, the missing amount taken over into production items. Therefore full costs are only covered when performance assumptions are reached, see Fig 5.

If the productivity rises, the costs per unit produced are decreasing for the Client - at the same time the return for the Contractor increases.

Both partners benefit from the productive increase - for both partners the situation will become obviously less favourable, when productivity decreases. As a consequence, both parties will try to keep productivity at as high levels as possible.

As it is common practice in contracting civil engineering works, one starts with a detailed calculation of items, whereby a breakdown of costs into seven groups (S1 to S7) is required.

“One-time” Site Costs such as Mobilization and Demobilization (S1) are established as lump sums. Site Management (S2), Equipment (S3) and Personnel (S5) are compensated (albeit, between 50 and 70% of actual costs only) in accordance with actual construction time. The allocation of the “short-fall” comprises of:

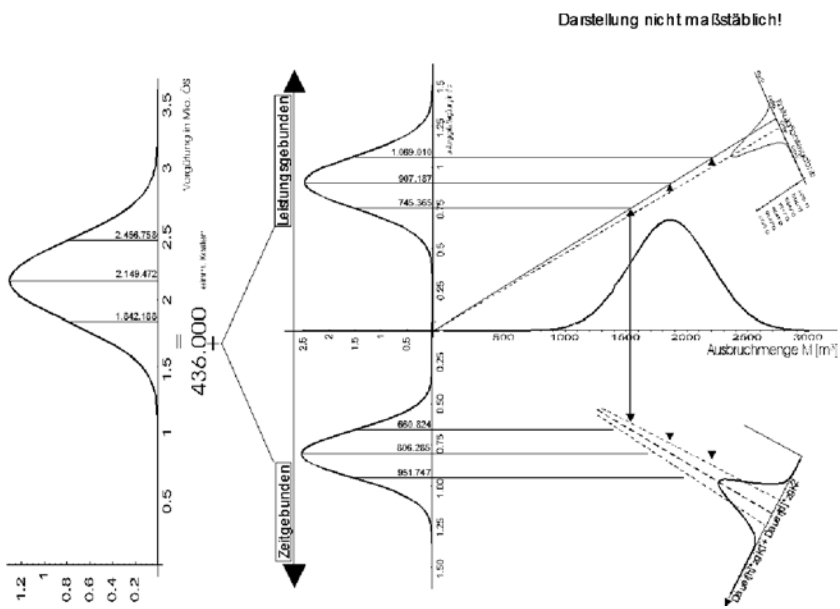


***Fig. 6:** »Probabilistic analysis of the influence of changes of various cost-categories on the total/overall costs of the works«.*

- all surcharges (SC)
- a calculative discount on average Wages (%AW)
- all repair costs for Equipment (rep.)

Allocating these short-fall-costs to production compensation does in fact generate this **incentive mechanism** already mentioned above! In consequence, the Client will try to ensure optimal working conditions supplying design and instructions completely and in time (only risks of the ground remain quasi-shared) and, the Contractor will employ best resources and techniques to reap maximum marginal profits. That at least is what theory suggests, and practical experience confirms!

The 7-group-cost-structure (Fig. 5) increases the transparency of the tender. Basic requirement when using the StilfOs method however is a mutually agreed choice of resources. Therefore on both sides technical and economical competence is of crucial importance to ensure true partnering.

Research work by Ganster (2001) investigated probability functions applied to cost-relevant parameters (Fig. 6) and did proof, that the "stability" of anticipated overall project costs is quite remarkable, if compared to unit price contracts not using this system (Ganster, 2001).

Conclusion

Analysis shows that there do exist commercially favourable models of contracting ground engineering works of inherently imperfect description and high risks of productivity-relevant changes of ground and conditions of execution; in particular are to mention: the **TIWAG-model** and **StilfOs**. These models create stability in costing, reduce speculative pricing and provide time - free to attend to project matters instead of bickering about claims and court cases.

References

Ganster. M. (2001), Vertrags- und Vergütungsmodelle für unvollkommen beschriebene Leistungen, Graz University of Technology, Library Catalogue, 2001

Mitteregger K., Deisl F. (2014), Application examples for tendering models to promote partnership at TIWAG, Geomechanics and Tunneling, (2014), No 6, p698 ff

Werkl, M. (2004), Analysis of contract and compensation schemes for special underground works with focus on time and production related compensation (StilfOs) exemplified at grouting works, master thesis Graz University of Technology, 2004.

Stadler, G., Reinisch, A. (1998), StilfOs, kalkulatorische Verknüpfung von zeit- und leistungsbezogenen Vergütungselementen für Bauleistungen, Wirtschaftsingenieur, 41.12, 1998

International Federation of Consulting Engineers, URL, no date, *http://fidic.org/bookshop/about-bookshop/which-fidic-contract-should-i-use*

M. Werkl and D. Heck, (June 2011), Institute of Construction Management and Economics, doi:10.3850/978-981-08-7920-4_S1-CP06-cd, Zurich, Switzerland

Stadler, G. (2009), Ansatz für eine flexible Leistungsvergütung bei Verträgen zur Herstellung unvollkommen beschriebener Leistung, Festschrift Prof. Diederichs, RWTH Aachen, Germany.

THE PHILOSOPHY OF SUSTAINABLE DEVELOPMENT AND SUSTAINABLE FUTURE OF HUMANKIND – SURVIVAL OF HUMANITY

Prof. Dr. Timi Ećimović, timi.ecimovic@bocosoft.com
World Philosophical Forum

At the request of Professor Timi Ećimović, his presentation is not a part of this publication. It is, however, available in entirety in the digital library at www.institut-climatechange.si. Thank you.

Filozofija trajnostnega razvoja in trajnostne prihodnosti človeške vrste - preživetje človeštva

»Na željo prof. dr. Timi Ećimovića prezentacija ni vključena v to izdajo, ampak navajamo samo naslov domače strani www.institut-climatechange.si, kjer v digitalni knjižnici najdete celoten članek. Zahvaljujemo se zainteresiranim«.

FUTURE PERSPECTIVES AND ENVIRONMENTAL CHALLENGES FOR OUR RIVERS – RESEARCH AND COOPERATION IN THE DANUBE RIVER BASIN

Prof. Dr. Thomas Hein[1,2,3], **Eva Feldbacher**[2], thomas.hein@boku.ac.at
[1]International Association for Danube Research (IAD), Wilhering, Austria
[2]WasserCluster Lunz, Inter-university research institute, Lunz, Austria
[3]University of Natural Resources and Life Sciences, Vienna (BOKU), Vienna

Abstract

At global scales river systems and their basins have been progressively impacted by human activity, as part of the wider modification of the global hydrological cycle intensified in the Anthropocene. In many cases these impacts have been cumulative; associated with marked changes in river flow, sediment and nutrient flux and changes in the land use of the basins. Linked to these developments is an intense use of these ecosystems and the services they provide, ranging from the use of water for consumption, transportation, energy production, nutrient retention to services more recently related to appreciation of the landscape and risk reduction applying for example more integrated flood water retention approaches. These uses also highlight the linkages between various societal sectors, their temporal dynamics and the need for an integrated view.

The Danube River basin as the Danube itself shows also multiple pressures affecting the ecosystem functioning but also impacting the ecosystem service provisioning. Based on new legal instruments such as the European Water Framework Directive (EU WFD), utilising basin wide cooperation major improvements in water quality have been achieved in parts of the catchment and for some sources of pollution.

On the other hand, especially the severe reduction in connectivity due to continuity disruption along the river course and laterally by decoupling floodplain areas (have) lead to major limitations in ecological conditions and pose risks for future changes in environmental conditions related for example to climate change effects.

Strengthened, long term scientific cooperation as well as recent initiatives aiming to address these pressures, e.g. improving connectivity conditions and considering future challenges, are active in the Danube River Basin and provide new opportunities for adequate solutions and thus, constitute a key contribution to sustainable development.

Keywords: connectivity, river basin management, floodplain, cooperation, river floodplain restoration

---

Ključni vidiki in bodoče možnosti rečne ekologije in upravljanje podonavskih ekoloških sistemov

Povzetek

V svetovnem merilu je človek vedno močneje vplival na porečja kot dela svetovnega hidrološkega cikla, še posebej se je ta vpliv povečeval v anthropocenu. V številnih primerih se je ta vpliv sešteval, tako pri pomembnih sprememb rečnih tokov, pretoka sedimentov in hranil ter rabe tal v porečjih. S tem razvojem je povezano vedno močnejše izrabljanje teh ekoloških sistemov in njihovih virov, kot so poraba vode, transport, proizvodnja energije in zadrževanje hranil, ali sodobnejši vidiki, kot je upoštevanje poikrajinskih značilnosti in zmanjševanje tveganj, kakršen je primer celokupnega pristopa k zadrževanju poplavne vode. Taka uporaba poudarja povezanost različnih družbenih dejavnikov, njihovo časovno dinamiko in celosten pogled. Tako v porečju Donave kot tudi na sami Donavi so opazni številni pritiski na delovanje ekosistema kot je opazen tudi povratni vpliv ekosistema samega. Na

podlagi novih zakonskih določil, kot je Evropska okvirna direktiva za vode (EU WFD), in na podlagi širokega sodelovanja je bilo doseženo vidno izboljšanje kakovosti voda v delu porečja in izboljšanjev zvezi z nekaterimi viri onesnaževanja. Po drugi strani pa se večajo ovire ekološkemu upravljanju in tveganje sprememb ekoloških pogojev v prihodnosti, npr. zaradi vpliva klimatskih sprememb, ki jih povzročata vedno slabša povezanost in vrzeli v povezanosti tako vzdolž same reke kot tudi širše zaradi večanja poplavnega sveta. Nove možnosti za ustrezne rešitve v porečju Donave je tako okrepljeno dolgoročno znanstveno sodelovanje kot tudi sedanje pobude o izboljšanju medsebojnega sodelovanja, kar je ključnega pomena za zdržni razvoj.

Ključne besede: povezanost, upravljanje porečja, poplavni svet, sodelovanje, obnova poplavnih področij

Background

On global scale, rivers and their basins have been severely impacted by human activities, as part of the wider modification of the global hydrological cycle especially in the last two centuries (Vörösmarty et al., 2013). In many cases these impacts have been cumulative; associated with marked changes in landscape structures and regulation, river flow (Poff & Matthews, 2013), sediment (Syvitski et al., 2009), and nutrient flux (Seitzinger et al., 2006), and changes in the relationship between rivers and their adjacent environments (Habersack et al. 2016). The latter include the reduction of lateral connectivity (i.e. between river and floodplain, which negatively influences the exchange processes between differently connected floodplain areas and the main channel (Allan, 2004, Wiens, 2002), disruption of longitudinal continuity (from the basin headwaters downstream) as well as altering the vertical connectivity (between channel and contiguous groundwater; Ward, 1989) through a combination of land use change and river and floodplain engineering works over past decades (time, as temporal scale; Ward, 1989). These changes have wider implications for basin hydrology, fluvial geomorphology and the conservation and management of freshwater biodiversity to the extent that it is now difficult to identify 'pristine' systems (seen as reference systems in the EU Water Framework Directive) against which the effects of anthropogenic change can be measured (Buise et al., 2003). While conflicting aims such as ensuring water security, providing flood protection, and enabling the development of hydropower whilst conserving associated ecosystem services, and minimizing the loss and alteration of biodiversity are widely recognised (Vörösmarty et al., 2010) frequently the approaches to river and basin management do not consider the full range of issues leading to limitations in achieving the more holistic goal of sustainable river basin management (Arthington et al., 2010, Habersack et al., 2016).

Current Status of Environmental Conditions in the Danube River Basin

The Danube is the most international river basin connecting 10 countries (Sommerwerk et al., 2009) and drains a catchment of 808,000 km^2 from 19 countries, and from more than 60 navigable tributaries. The Danube flows in an easterly direction from the Black Forest Mountains to the Black Sea where its mean annual discharge is 6,486 m^3/s (~ 205 km^3/a) (Tockner et al., 2009). It transverses diverse landscapes and cultures that have shaped the history of the region. As with most transboundary rivers, basin management was historically driven by the economic relevance of trade and shipping routes (Irvine et al. 2016).

The **Upper Danube** with the length of 624 km is characterised as a gravel bed river, downstream the Danube is a sand bed river. The **Middle Danube** (mean slope of about 0.1 ‰) is ~929 km long and surrounded by the Hungarian plain and ends in the incised Iron Gate Gorge which has a higher slope. The **Lower Danube** has a length of ~863 km and is characterised by a lower slope (0.05 to 0.01 ‰) with a substrate characterized by dominant fine grain sizes. Finally the **Danube Delta, Europe's largest deltaic wetland,** constitutes a separate river section; it is significantly influenced by changing sea levels, and is characterised by estuarine conditions (Habersack et al. 2016). Severe reduction of lateral connectivity can be found in all river sections, the highest extent of floodplain loss up to 90% is found in the Upper Danube (Hein et al. 2016).

The Danube River Basin Management Plan

The significant water management issues identified in the recent river basin management plan of the Danube River basin are related to water pollution, namely organic, nutrient and pollution and effects of hazardous substances (ICPDR 2015). Apart from water quality, alteration of Danube *hydromorphology* (*sensu* WFD) causes significant environmental concerns. The canalisation of sections of the river have increased water velocity, peak volumes and thus flood risk to downstream areas (Van Assche, Duineveld, et al., 2015). Land reclamations have affected ecological connectivity, and dams provide barriers to fish movements within the river. The loss of floodplain area and severe alteration of existing floodplains has caused massive changes in nutrient dynamics, fine sediment dynamics, limits flood water retention and has strong negative impacts on riverine biodiversity (Hein et al. 2016). In the program of measures a plan to improve the environmental conditions is elaborated. Clearly, addressing these issues requires considerable collaboration and coordination between different sectors and concerted research activities, as well as clear identification of feasibility and socio-economic consequences.

Cooperation in the Danube River Basin

An early initiative to cooperate within the Danube River Basin started in 1956, as a network of scientists named IAD (International Association for Danube Research) aiming to foster knowledge exchange between scientists in all Danube countries to improve the environmental conditions of the Danube River system. Almost 30 years later environmental basin cooperation was defined in 1985 with the Bucharest

Declaration of eight riparian countries calling for collaborative pollution prevention, followed in 1992 by the Environmental Programme for the Danube Basin and the 1994 Danube River Protection Convention (DRPC) (Kliot, 2001). In 1998, the International Commission for the Protection of the Danube River (ICPDR) was established as the implementing body of the DRPC to ensure that "*surface waters and groundwater within the Danube River Basin are managed and used sustainably and equitably"*. The ICPDR, a distinct albeit collaborating body within the Danube Commission, comprises 14 states and the European Union, and is the formal organization responsible for trans-boundary management of the catchment. In 2007, a Joint Statement of these organizations recommended sustainable and environmentally friendly improvement of navigation, which requires new inter- and multi-disciplinary technical skills of water managers and of societal capacities for a sound involvement (ICPDR et al., 2007).

European policy increasingly shapes ICPDR activities, in particular the EU Water Framework Directive (WFD) and recently, the EU Flood Directive. Although six of the contracting countries are not EU members, they have committed to "make all efforts" to implementing the WFD (ICPDR, 2009). The ICPDR, supported by seven standing expert groups (see www.ICPDR.org), facilitates coordinated national implementation. Extensive joint surveys of the river and many tributaries provided important baseline information for chemical and biological elements necessary to build harmonized national monitoring programmes (ICPDR, 2008, ICPDR 2015). The assessment also revealed significant gaps, including insufficient monitoring data and lack of WFD compliant methodologies, missing inter-calibration of biological methods, incompatibility of biological, physical and chemical elements, and not fully harmonized classification schemes for ecological status assessment (ICPDR, 2009). At the catchment scale, water abstraction and groundwater monitoring was highlighted as a gap by ICPDR (2009), requiring more extensive sampling networks and improved bi- and multilateral cooperation.

Programmes of Measures (POMs) determine the planning and management agenda for improving water quality under the WFD. Current POMs in the Danube basin prioritize solving point source pollution by starting with upgrading waste water treatment plants and reducing industrial emissions. EU experience suggests implementation will take many years. Local authorities have to work with industries to gradually upgrade facilities, create buy-in by senior management and awareness within the workplace, supported by trained environmental managers to implement effective Environmental Management Systems. Non-EU Member states agreed to apply the requirements of EU Directives and Standards to realise one common ecological status of the Danube and other water bodies, but neither technical nor administrative changes are cost-neutral.

Future Perspectives

In the near future the environmental situation of the Danube River Basin will be impacted by new drivers of change e.g. intensified effects of climate change and the introduction of invasive species (ICPDR 2013, Habersack et al. 2016, Hein et al. 2016). This will lead to a new combination of multiple pressures affecting aquatic ecosystems. As the rate of change is already very high and might get accelerated in future, current plans of economic development involving a massive development of hydropower and navigation in the Danube River basin in concert with projected changes will require new approaches and tools as well a further alignment of policies and more integrative approaches viewing riverine systems as socio-ecological systems (Haberl et al. 2006). A prerequisite will be to adapt the educational system to have skilled experts in the field of integrated water management of these socio-ecological systems and foster the research cooperation within the Danube River basin to provide a sound knowledge basis, by more interdisciplinary approaches, but also more integrated research approaches linking for example freshwater, coastal and marine systems. Concrete actions can be to have science orientated Joint Danube surveys, which are also extended to the coastal region and include emerging issues and furthermore, facilitate the knowledge transfer from science into policy including also more adaptive approaches in management (Pahl-Wostl et al. 2008). A key driver for this development can be the European Strategy for the Danube Region (EUSDR, http://www.danube-region.eu/), if adequate tools for the identified priority areas are available and an overall key target will be to increase the capacities within the region to achieve a more sustainable future development.

References

Allan, J.D., 2004: Landscapes and riverscapes: The influence of land use on stream ecosystems. Annu. Rev. Ecol. Evol. Syst. 35, 257-284.

Arthington, A.H., Naiman, R.J., McClain, M.E. & C. Nilsson, 2010: Preserving the biodiversity and ecological services of rivers: new challenges and research opportunities. Freshwater Biology 55 (1), 1–16.

Buise A.D., Klijn, F., Leuven, R.S.E.W., Middelkoop, H., Schiemer, F., Thorp, J.H. & H.P. Wolfert, 2003: Rehabilitation of large rivers: references, achievements and integration into river management. Large Rivers 15 (1–4), 715–38.

Chapman, D., Trásy, B., Várbíró, G., Bradley, C., Gettel, G., Hatvani, I.G., Hein, T., Kovács, J., Liska, I., Oliver, D.& P. Tanos, 2016: Developments in water quality monitoring and management in large river catchments using the Danube River as an example. Environmental Science and Policy, ISSN 1462-9011, 64, 141 – 154.

Haberl, H., Winiwarter, V., Andersson, K., Ayres, et al. (2006): From LTER to LTSER: Conceptualizing the socio-economic dimension of long-term socio-ecological research. Ecology and Society, 11 (2), 13.

Habersack, H., Hein, T., Stanica, A., Liska, I., Mair, R., Jäger, E., Hauer, C.& C. Bradley, 2016: Challenges of river basin management: current status of, and prospects for, the River Danube from a river engineering perspective. Science of the Total Environment, ISSN 0048-9697, 543 (A), 828 – 845.

Hein, T., Schwarz, U., Habersack, H., Nichersu, I., Preiner, S., Willby, N. & G. Weigelhofer, 2016: Current status and restoration options for floodplains along the Danube River. Science of the Total Environment, ISSN 0048-9697, 543 (A), 778 – 790.

ICPDR, DC, SDRC, 2007. Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin. Vienna.

ICPDR, 2008: Joint Danube Survey 2 – Final Scientific Report. INTERNATIONAL COMMISSION FOR THE PROTECTION OF THE DANUBE RIVER (Pub.), pp. 242, Vienna.

ICPDR. 2009: Danube River Basin District Management Plan. International Commission For The Protection Of The Danube River (Pub.), pp. 109, Vienna.

ICPDR, 2013: Climate adaption strategy for the Danube River Basin. International Commission For The Protection Of The Danube River (Pub.), pp. 44, Vienna.

ICPDR. 2015: The Danube River Basin District Management Plan – Update 2015. International Commission For The Protection Of The Danube River (Pub.), pp. 124, Vienna.

Irvine, K., Hein, T., Habersack, H., Weigelhofer, G., Popescu, I., Pfeiffer, E., Păun, A., Drobot, R., Gettel, G., Staska, B. & A. Stanica, 2016: Educating for action: Aligning skills with policies for sustainable development in the Danube river basin. Science of the Total Environment, ISSN 0048-9697, 543 (A), 765 – 777.

Kliot, N. & D. Shmueli, 2001: Development of institutional frameworks for the management of transboundary water resources. International Journal of Global Environmental Issues, ISSN 1466-6650, 306 – 328.

Mauser, W., Prasch, M., Koch, F. & R. Weidinger, 2012: DANUBE STUDY – CLIMATE CHANGE ADAPTATION: Study to provide a common and basin-wide understanding towards the development of a Climate

Change adaptation strategy in the Danube River Basin. Final report. Ludwig-Maximilians-Universität Munich, Germany. 174 p.

Pahl-Wostl, Claudia, Jan Sendzimir, Paul Jeffrey, JCJH Aerts, Ger Berkamp, & Katharine Cross, 2008: Managing change toward adaptive water management through social learning. Ecology and Society 12, art. 30.

Poff, N.L. & J.H .Matthews, 2013: Environmental flows in the Anthropocene: past progress and future prospects. Current Opinion in Environmental Sustainability 5 (6), 667-675.

Seitzinger, S., Harrison, J.A., Böhkle, J.K., Bouwman, A.F., Lowrance, R., Peterson, B., Tobias, C. & G. van Drecht, 2006: Denitrification across landscapes and watescapes: a synthesis. Ecological Applications 16 (6), 2064-2090.

Sommerwerk, N., Baumgartner, C., Bloesch, J., Hein, T., Ostojic, A., Paunovic, M., Schneider-Jacoby, M., Siber R. & K. Tockner, 2009: The Danube River Basin. In: Tockner, K., Robinson, C.T.& U. Uehliner (eds) *Rivers of Europe*, Chapter 3, 59-112, Academic Press, Oxford.

Syvitski, J.P.M., Kettner, A.J., Overeem, I., Hutton, E.W.H., Hannon, M.T., Brakenridge, G.R., Day, J., Vörösmarty, C., Saito, Y., Giosan, L. & R..J Nicholls, 2009: Sinking deltas due to human activities. Nature Geoscience 2, 681-686.

Tockner, K., Uehlinger, U. & C.T. Robinson, 2009: Rivers of Europe. Academic Press, ISBN: 9780123694492

Van Assche, K., Beunen, R. & M. Duineveld, 2015: An overview of EGT's main concepts. In: *Evolutional Governance Theory: Theory and Applications*. Springer International Publishing, pp.19-33, Heidelberg.

Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P. & S. Glidden, 2010: Global threats to human water security and river biodiversity. Nature 467 (7315), 555–61.

Vörösmarty, C.J., Pahl-Wostl, C., Bunn, S.E. & R. Lawford, 2013: Global water, the anthropocene and the transformation of science. Current Opinion in Environmental Sustainability, 5 (6), 539-550.

Ward, J.V., 1989: The four-dimensional nature of lotic ecosystems. Journal of the North American Benthological Society 8, 2-8.
Wiens, J.A., 2002: Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47, 501-515.

WATER POLICY AND HYDROLOGY IN THE COUNTRIES IN TRANSITION

Prof. Dr. Mitja Brilly, Mitja.Brilly@fgg.uni-lj.si
Faculty of Civil and Geodetic Engineering, University of Ljubljana

Abstract

The International Hydrological Programme (IHP) is an intergovernmental programme of the UNESCO devoted to water research, water resources management, and education and capacity building. The Intergovernmental Council and the IHP Bureau take governance over the programme. The Eastern European IHP UNESCO region, Electoral Group II, covers a large area of Eastern Europe and North Asia and interregional cooperation is extremely important. UNESCO's Electoral Group II comprises former socialist countries that underwent transition in the 1990s that caused both positive and negative changes in water policy. Due to Election Group II's large territory expanding on two continents, interregional cooperation is extremely important. The cooperation of IHP National Committees in the Danube River Basin started already with the start of the International Hydrological Decade 1965–1975. Cooperation inside the Group is not strong enough and not well organized. There are not enough UNESCO centres and UNESCO chairs that would support UNESCO IHP activities. Representatives of IHP committees of Electoral Group II met in March 2016 in Škocjan, Slovenia, and adopted a common position regarding the problems in water management. Since ancient times, and more intensively from the mid-19th century, the space belonging to water has been reduced. Riverbeds have been shortened and narrowed, and levees have been built for flood protection; this resulted in the serious reduction of floodplains and wetlands primarily for agriculture and urban development. Now is time to return part of the space back to water and the Slovenian Committee of the UNESCO IHP have proclamations campaign ‘More Room for Water’.

Keywords: International hydrological programme, UNESCO, water, transition, Danube River Basin

---

Politika do voda in hidrologija v državah v tranziciji

Povzetek

Mednarodni hidrološki program (IHP) je medvladni program UNESCO namenjen raziskavam voda, upravljanju z vodnimi viri, izobraževanju za podporo institucijam, ki se ukvarjajo z vodo. Medvladni Svet IHP in IHP Biro sta zadolžena za vodenje programa. Vzhodna Evropska Regija IHP UNESCO, pokriva veliko območje vzhodne Evrope in Severne Azije in je zanjo medregionalno sodelovanje izredno pomembno. Volilna skupina Vzhodnoevropske regije UNESCO obsega nekdanje socialistične države, ki so v tranziciji od leta 1990, kar pa povzroča pozitivne in negativne spremembe na področju politike do voda. Zaradi velikega območja volilne skupine, ki se širi po dveh celinah, je medregionalno sodelovanje izjemno pomembno. Tako se je sodelovanje IHP nacionalnih odborov v porečju reke Donave začelo že z začetkom Mednarodnega hidrološkega desetletja v obdobju 1965-1975. Sodelovanje znotraj Regije II ni dovolj dobro organizirano. Ni dovolj UNESCO središč in UNESCO kateder, ki bi podpirale projekte IHP UNESCO. Predstavniki nacionalnih odborov Vzhodno Evropske Regije IHP so na sestanku odborov marca 2016 v Škocjanu, v Sloveniji, sprejeli skupna stališča glede težav na področju upravljanja z vodami. Od davnih časov, in bolj intenzivno od sredine 19. stoletja, se je zmanjšala prostor, ki pripada vodi: struge so se krajšale in ožile, z nasipi za zaščito pred poplavami so bila vodi odvzeta poplavna območja in mokrišča, vodni prostor pa koriščenj predvsem za potrebe kmetijstva in razvoj mest. Zdaj je čas, da se pri

iskanju rešitev, ki omogočajo trajnostni razvoj, del odvzetega prostora vrne nazaj vodi. Slovenski nacionalni odbor IHP UNESCO je zato razglasil akcijo "Več prostora za vode".

Ključne besede: Mednarodni hidrološki program, UNESCO, vode, tranzicija, porečje reke Donave

The International Hydrological Programme (IHP) is the intergovernmental programme of the UNESCO devoted to water research, water resources management, and education and capacity building. Since its inception in 1975, IHP facilitates an interdisciplinary and integrated approach to watershed and aquifer management, which incorporates the social dimension of water resources, and promotes and develops international research in hydrological and freshwater sciences. The Intergovernmental Council is responsible for planning, definition of priorities, and supervision of the execution of International Hydrology Programme (IHP). The Council is composed of 36 UNESCO Member States elected by the General Conference of UNESCO at its ordinary sessions held every two years. Equitable geographical distribution and appropriate rotation of the representatives of the Member States are ensured in the composition of the Council. Each of UNESCO's six electoral regions elects Member States for membership in the Council. Between the Council sesions, the IHP Bureau is responsible for governance over programme. The composition of the Bureau so formed reflects an equitable geographical distribution and each member representing one of the UNESCO's six electoral regions (UNESCO IHP, 2016).

The Eastern European IHP UNESCO electoral region, Region II, covers a large area of Eastern Europe and North Asia, extending from the Mediterranean Sea to the Pacific Ocean and from the Caspian Sea to the Arctic region. Countries of the region are: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Latvia, Lithuania, Former Yugoslav Republic of Macedonia, Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia and Ukraine, Figure 1. The climate is very diverse, from humid to arid, and mainly cold. Due to Election Group II's large territory expanding on two continents, inter-regional cooperation, particularly with Regions I and IV, is extremely important.

Fig. 1: *Map of the region*

The Russian Federation, as a member of IHP-UNESCO Regional group II, maintains an actively international cooperation in the field of transboundary waters with neighbouring countries within the IHP-UNESCO Region I, Region II and Region IV. Cross-border cooperation is implemented in the use and protection of surface water and marine areas. Importance should be attached to intra-regional cooperation, but also to well organised cooperation with the neighbouring Region I – Europe and North America, in IHP Danube cooperation, and cooperation of Nordic countries. In the future should be establish better cooperation in the Black Sea area with Region I and in Central Asia with Region IV – Asia and the Pacific.

UNESCO's Electoral Region II comprises former socialist countries that underwent transition in the 1990s. The transition caused both positive and negative changes in water policy. In some countries that gained independence during the transition process, IHP National Committees are not yet established. Over the last 15–20 years, the common strategy of Region II countries in the fields of hydrology an water resources has been mostly based on the development specificities of these countries under the circumstances of radical changes occurring in their social and economic areas. For most countries, these changes have had common negative effects, such as reduction of hydrological networks and their technical backwardness, decreased quality of observations, sharp reduction in budgets of scientific and technical institutions, the reduction in the extent of scientific research and funding of international cooperation, and practical cancellation of experimental research and of free data, information and publication exchange. The policy in transition lost the sense of long-term directions in developing water management. Water regime processes typically take a long time and leave a permanent mark on spatial morphology. Therefore, long-term plans and guidelines are necessary for successful management. Politicians change in power relatively quickly, so they have no need for long-term directions, as they are not able to carry out long-term plans. Due to the reduced budgetary funds, in most countries the funds for hydrological observations and research were cut. In Hungary, VITUKI, the world-renowned water research institute, stopped its operations. Slovenia is an exception in developing hydrological observations, where EU funds have been used to update the hydrological observation network and produce a state-of-the-art system of flood forecasting. East European countries have mainly joined the EU and tried to implement EU water directives supported by EU funding.

Due to Region II's large territory expanding on two continents, interregional cooperation, particularly with Regions I and IV, is extremely important. The cooperation of IHP National Committees in the Danube River Basin started already with the start of the International Hydrological Decade 1965–1975, Figure 2.. 26 conferences of the Danube countries have been held so far. The monograph on the river basin, based on measurement data in the period 1930–1970, was published in 1988. Major research achievements until 2008 were published in a monograph »Hydrological Processes of the Danube River Basin« (Brilly at all. 2010). Please find more on the Danube cooperation at UNESCO OFFICE IN VENICE 2016.

__Fig. 2:__ The Danube River Basin IHP cooperation

In recent decades, the IHP UNESCO activities have focused on cooperation between UNESCO Centers and UNESCO Chairs. As a Category 1 Center, IHP UNESCO-IHE comprises 37 water-related UNESCO category

2 centres and 38 Water Chairs. The lack of funds in countries of Region II has been a problem of the National IHP Committees for carrying out IHP programme research for the operation. This is why the region has relatively few UNESCO Chairs and Category 2 Centers to take care of development and research under the IHP Programme. UNESCO centres of 2 category in Region II are (UNESCO IHP, 2016):

- International Research and Training Centre on Urban Drainage (IRTCUD), established in 1987 (Serbia). IRTCUD aims to foster advanced research development in urban water management, having expanded its field of work originally concerned with the aspect of urban drainage.
- European Regional Centre for Ecohydrology (ERCE) established in 2006. The Centre promotes integrative multidisciplinary ecohydrological research at a catchment scale for sustainable management, protection and restoration of aquatic resources. Basic research includes: hydrology, hydrobiology, environmental chemistry, landscape processes, soil ecology, phytotechnology, environmental toxicology and genetics, population studies and mathematical modelling (Poland).
- Centre for Water for Sustainable Development and Adaptation to Climate Change established in 2013, the center acts as a regional center in Southeast Europe focusing on cooperation in the areas of applied research, water administration, development and promotion of adaptation strategies, capacity development, and research for application, education, and training in the area of climate change impact on water resources management and the adaptation to such impacts (Serbia).

UNESCO Chairs in the Region II are:

- UNESCO Chair in Water Resources, established in 2001 at Irkutsk State University, Russian Federation
- UNESCO Chair in Hydrogeology established in 2003 at the Eötvös Loránd University, Budapest, Hungary

- UNITWIN Network on Water Resources established in 2009 at Irkutsk State University, Russian Federation
- UNESCO Chair on Water Resources Management and Ecohydrology, established in 2010 at the Water Problem Institute of the Russian Academy of Sciences, Russian Federation
- UNESCO Chair on Water for Ecologically Sustainable Development established in 2012 at the University of Belgrade, Serbia
- UNESCO Chair on Water related Disaster Risk Reduction established in 2016 at the University of Ljubljana, Slovenia

A few of the countries in the region are economically underdeveloped and require special attention and support in developing water management, particularly hydrology.

In 2015, UNESCO celebrated its 70th anniversary, and UNESCO's International Hydrological Programme (IHP) its 50th anniversary. Region II representatives met in September 2015 in Moscow and adopted a common position on the problems in hydrology in the countries in transition. Representatives of IHP committees met again in March 2016 in Škocjan, Slovenia, and adopted a common position regarding the problems in water management (Slovene NC IHP, 2016). Most important conlusions are:

- Due to the geographical location of countries of the IHP UNESCO Group II, an initiative for trans-regional cooperation with neighboring regions was expressed. Examples of good practice of such cooperation are in the Danube basin, in the Nordic region, and in Central Asia. Furthermore, setting up new relationships is recommended in Central Asia region.
- The cooperation and support of IHP UNESCO in the field of hydrology in the less developed countries of region II in Europe and Asia should be improved (e.g. through the UNESCO Secretariat, permanent delegations or national commissions for UNESCO). Some effort should be made to establish IHP Committees in newly developed countries. Also the information about the changes re-

garding the contact persons of IHP Committees should be updated promptly.
- Water policy and hydrology need long-term planning for their proper development. We would like to ask countries to produce such strategy documents and increase funding for long-term hydrological observations. The collected hydrological data should be used free of charge.
- Better cooperation among the Danube Commission, the International Commission for the Protection of the Danube River (ICPDR) and IHP Danube region is necessary.

With the growing population, industrialization and urbanization, the inundated areas and wetlands have been consumed and, through river engineering, watercourses have been regulated so that the space belonging to water has been reduced. Since ancient times, and more intensively from the mid-19th century, riverbeds have been shortened and narrowed, and levees have been built for flood protection; this resulted in the serious reduction of floodplains and wetlands. The surfaces 'taken' from rivers were intended primarily for agriculture and urban development. The situation was similar in Slovenia. Twenty years ago the maintenance of embankments of regulated natural watercourses was brought to a halt, and the new practice was seen as eco-friendly maintenance of watercourses. Many river banks were overgrown with bushes and the space for water was only further reduced. In some places, the vegetation in the narrow channels completely obscured the surface of the water. The serious damages due to the recent floods and, last but not least, fatalities, are the price that we pay today. This situation will be further aggravated by the expected impact of climate change. Since 2013, the Slovenian Committee of UNESCO IHP has taken part in the activities focusing on the campaign 'More Room for Water'. The activities of 'More Room for Water' satisfy the requirements of both the EU Flood Directive and the Water Framework Directive (Slovene NC IHP, 2016).

References

Brilly M., 2010, Hydrological processes of the Danube river basin : perspectives from the Danubian countries. Dordrecht [etc.]: Springer, cop. 2010. XIV, 436 pp.

Slovene NC IHP, 2016, Minutes of the meeting of representatives of National Committees – members of IHP UNESCO's Group II – Central and Eastern Europe, 16-18 March 2016, Škocjan Caves, Slovenia, Available from:
http://www.ksh.fgg.uni-lj.si/IHP/Data/Minutes%20of%20the%20meeting%20%20–%20members%20of%20IHP%20UNESCO's%20Group%20II%20.pdf, [Accessed 26 September 2016]

UNESCO IHP, 2016, UNESCO's Intergovernmental Scientific Cooperative Programme in Hydrology and Water Resources, Available from:
http://www.unesco.org/new/en/natural-sciences/environment/water/ihp, [Accessed 26 September 2016]

UNESCO OFFICE IN VENICE 2016, Danube Cooperation, Available from http://www.unesco.org/new/en/venice/natural-sciences/water/danube-cooperation/ , [Accessed 26 September 2016]

SEDIMENTS IN THE SAVA RIVER BASIN

Prof. Dr. Matjaž Mikoš, matjaz.mikos@fgg.uni-lj.si
Faculty of Civil and Geodetic Engineering, University of Ljubljana

Abstract

River sediments are an essential, integral and dynamic part of any fluvial system and form a variety of habitats. Having this fact in mind and recognizing the need for an efficient cooperation among the countries and promotion of sustainable sediment management solutions in the Sava River Basin, the Parties to the Framework Agreement on the Sava River Basin (FASRB) have in 2015 signed the Protocol on Sediment Management to the FASRB.

A number of activities foreseen by the Protocol have already been performed by the International Sava River Basin Commission (ISRBC) supported by a group of selected experts from the Parties to the FASRB through the project "Towards Practical Guidance for Sustainable Sediment Management using Sava River as a Showcase" (2012-2015) implemented in cooperation with, and with the financial support of, the UNESCO Venice Office (UVO), the European Sediment Network (SedNet) and the UNESCO-IHP International Sediment Initiative (ISI).

The paper reports on the selected main project outcomes: a drafting guidance on sustainable sediment management in the Sava River Basin, an estimation of Sava River sediment balance, and a proposition for establishing of a sediment monitoring system for the Sava River.

The topic of sediments in fluvial environments had to be given more attention and is definitely relevant also for the Danube River Basin and all of its main tributaries' basins.

Key words: fluvial sediments, hydrology, monitoring, Sava River, water management

Sedimenti v porečju reke Save

Povzetek

Rečni sedimenti so bistveni sestavni in dinamični del katerega koli fluvialnega sistema; v njem oblikujejo različna življenjska okolja. Izhajajoč iz tega dejstva, zaradi potrebe po učinkovitem sodelovanju med državami in zaradi želje po spodbujanju trajnostnih rešitev za upravljanje s sedimenti v porečju Save, so države pogodbenice Okvirnega sporazuma o Savskem bazenu (FASRB) v letu 2015 podpisale Protokol o upravljanju s sedimenti kot delu okvirnega sporazuma.

Številne dejavnosti, ki jih predvideva protokol, že danes opravlja Mednarodna komisija za Savski bazen (ISRBC), ki jo je podprla skupina izbranih strokovnjakov iz držav pogodbenic okvirnega sporazuma s svojim delovanjem v okviru projekta "Razvoj praktičnih smernic za trajnostno gospodarjenje s sedimenti s prikazom uporabe na primeru reke Save" (2012-2015). Projekt se je izvedel v sodelovanju in s finančno podporo Unesca, Evropske mreže za sedimente (SedNet) in Unescove Mednarodne pobude za sedimente (ISI).

Prispevek prikaže izbrane glavne rezultate projekta: osnutek smernic za trajnostno gospodarjenje s sedimenti v Savskem bazenu, oceno bilance sedimentov reke Save in predlog vzpostavitve sistema za monitoring sedimentov v reki Savi.

Obravnavi rečnih sedimentov v fluvialnih okoljih moramo nameniti več pozornosti in ta problematika je vsekakor pomembna tudi za povodje reke Donave in vseh njenih podporečij.

Ključne besede: hidrologija, monitoring, rečni sedimenti, Sava, vodno gospodarstvo

INTRODUCTION

The Sava River Basin (hereafter SRB) as a part of the Danube River Basin (Fig. 1, right) is shared by five countries: Slovenia, Croatia, Bosnia and Herzegovina, Montenegro and Serbia, while a negligible part of the basin area also extends to Albania.

Fig. 1: *The location of the SRB in the Danube River Basin, and the SRB topographic map.*

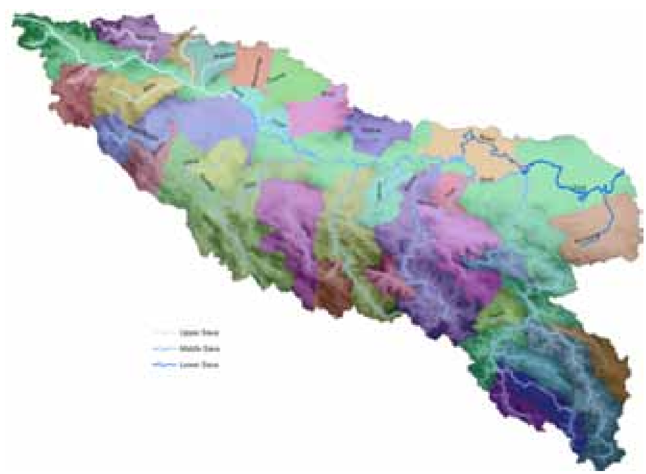


Fig. 2: *The sub-basins in the SRB (Fig. 3 from ISRBC, 2013; p. 3).*

Total area of the SRB is 97,713 km^2. High mountains dominate in the upper part of the basin (Fig. 1, left). The southern middle part is hilly and mountainous, while the SRB northern middle and lower part are characterized by low mountains and flat plains. The SRB river network is well developed (Fig. 2), but the basin is very asymmetric (Fig. 3). The Sava River is a typical gravel-bed river upstream of the station Rugvica with a sharp transition to a sand-bed river type downstream of it (Fig. 4).

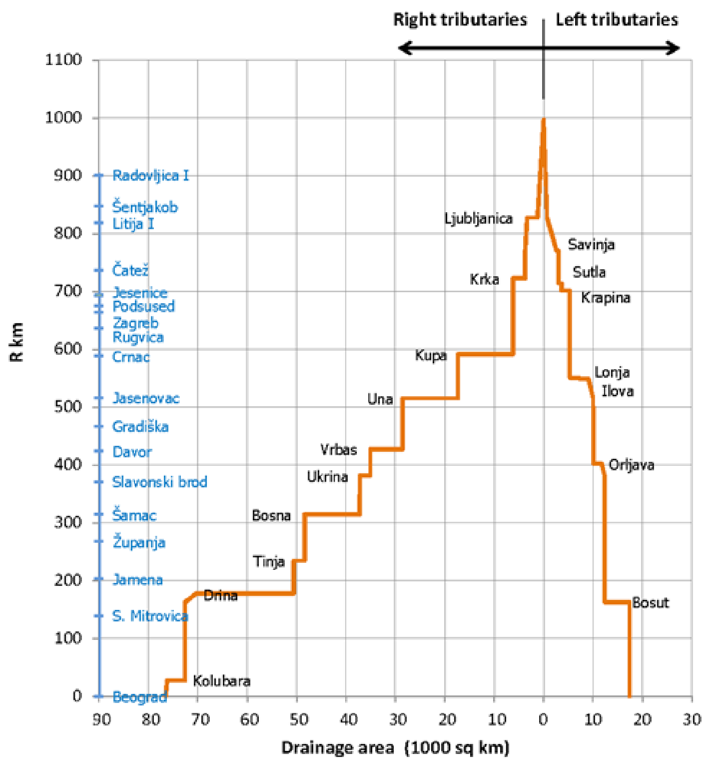


***Fig. 3:** The tributaries in the SRB (ISRBC, 2013; Fig. 4, p. 4).*

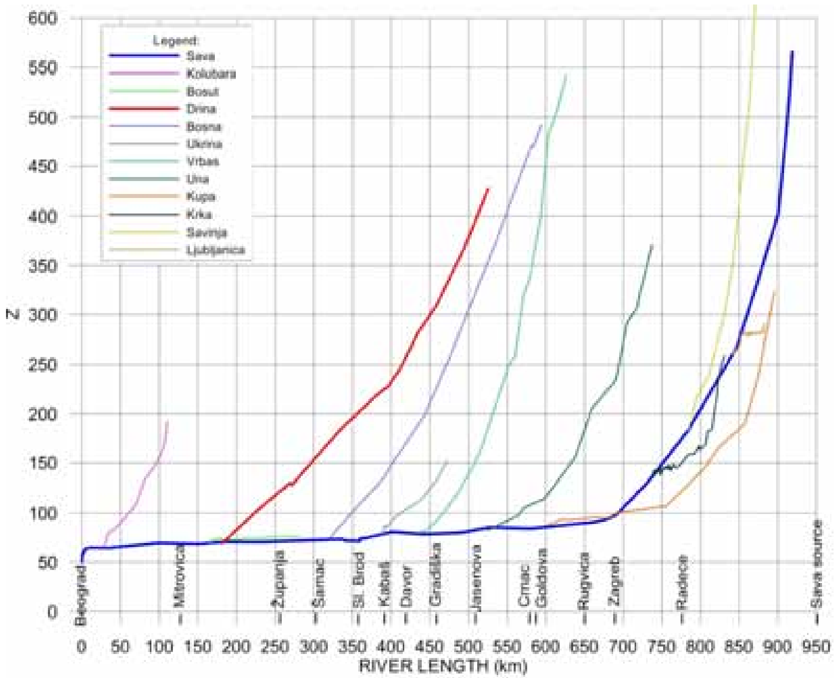


Fig. 4: *The schematic longitudinal profiles of the Sava River and its main tributaries (ISRBC, 2013; Fig. 12, p. 11).*

SOME RECENT PROJECTS ON SEDIMENT MANAGEMENT IN THE SAVA RIVER BASIN

Slovenia, Croatia, Bosnia and Herzegovina, and Serbia are Parties of the *Framework Agreement on the Sava River Basin* (FASRB) (ISRBC, 2002). The implementation body of the FASRB is the International Sava River Basin Commission (ISRBC; www.savacommission.org), stationed in Zagreb, Croatia, which is responsible for development of joint plans and programs regarding the sustainable water management among other tasks. ISRBC has developed the *Protocol on Sediment Manage-*

ment to the FASRB (ISRB, 2015a), which affirms the need for efficient cooperation among the Parties and for promotion of sustainable sediment management (SSM) solutions.

To respond to the above mentioned needs, a project *Towards Practical Guidance for Sustainable Sediment Management using the Sava River Basin as a Showcase* has been launched upon the initiative of UNESCO Venice Office, together with the UNESCO International Sediment Initiative (ISI; www.irtces.org/isi/), European Sediment Network (SedNet; http://sednet.org/), and the International Sava River Basin Commission (ISRBC; www.savacommission.org) aiming to develop and validate a practical guidance on how to achieve a SSM Plan on the river-basin scale, using the SRB as a showcase.

In 2012, a four-day *Practical training course on sustainable sediment management with the Sava River Basin as a showcase* was organised in Zagreb, Croatia. The invited sediment experts from Europe, USA as well as national experts from Bosnia and Herzegovina, Croatia, Serbia and Slovenia exchanged the information on a) sediment balance throughout the river system; b) sediment monitoring; and c) evaluation of sediment quality and quantity. The workshop materials are freely available on the internet (http://www.savacommission.org/event_detail/8/22/273/5).

In 2015, a two-day *Workshop on sediment monitoring in the Sava River Basin* was held in Zagreb, Croatia. Among others, the following topics were discussed: a) proposal on establishment of strategic goals and specific objectives of the sediment monitoring and data exchange system; b) review of technical international standards and techniques of monitoring; c) review of existing sediment monitoring data, standards and techniques in the Sava River Basin and discussion on proposed future monitoring network; d) sediment modelling; e) presentation on sediment monitoring techniques and equipment. The workshop materials are freely available on the internet (http://www.savacommission.org/event_detail/0/0/344/6).

The project *Estimation of Sediment Balance for the Sava River* (project BALSES; www.savacommission.org/project_detail/16/1) has been implemented in the period 2012-2013 by the core expert group which has analysed the sediment balance for the main Sava River course, considering the input from the main tributaries, and thus to form a basis for sustainable transboundary sediment and water management. A full project report is available on the internet (ISRBC, 2013); a synthesis report was also published in a journal (Babić Mladenović et al., 2014).

The project *Proposal of the Establishment of the Sediment Monitoring System for the Sava River Basin* (http://www.savacommission.org/project_detail/20/1) has been implemented as the next step in the period 2014-2015 by the basically same core expert group. The main objectives of this project were:

i. Establishment of strategic goals and specific objectives of the sediment monitoring and data exchange system.
ii. Review of existing sediment monitoring data.
iii. Review of technical international standards and technics of monitoring and assessment of their application in the SRB.
iv. Establishment of on-line free database on sediment taking into account the initial functionalities of Sava Geoportal implemented by ISRBC.

A full project report is available on the internet (ISRBC, 2015b); a synthesis report was also published in journals (Kupusović, 2016; Babić Mladenović et al., 2015).

SELECTED RESULTS ON SEDIMENT BALANCE AND SEDIMENT MONITORING SYSTEM IN THE SRB

The starting point for the BALSES project with the aim of the estimation of the Sava River sediment balance (though in a way excluding a more detailed analysis of major Sava River tributaries, which of course has a major impact) were collecting and analysing officially (publically) available monitoring data from the network of existing (and past) monitoring stations in the SRB (see Fig. 5 for overview). Already the first impression is quite clear that there are rather many gaps in the hydrological sense – the geographical coverage is far from optimal, e.g. there are no actual monitoring stations on the Sava River in Bosnia and Hercegovina. They are occasionally monitoring some of the Sava River tributaries, such as the Drina or the Bosna River.

Fig. 5: *The SRB sediment monitoring stations (ISRBC, 2013; p. 87).*

A detailed overview was prepared for the 4 countries (Tab. 1), including Sava River tributaries. There is an obvious disparity between countries in the number of parameters measured and in monitoring frequency (daily measurements are to be seeking for). Also river sediment granulometry is poorly monitored, even though it is of paramount importance for any sediment modelling purposes.

Table 1. *The SRB sediment monitoring stations (Tab. 6 from ISRBC, 2013; p. 24)* – H (water level, cm), Q (discharge, m^3/s), SSC (suspended sediment concentration, g/m^3), LT (load transport rate, t/day, t/month, t/year), Prof. SSC (integrated SSC measurement in the river cross section), SL & BL (suspended & bed load particle size distribution)

Country	STREAM	Code	Monitoring site	G - K Position	Monitoring variable	Op. period	Institution	Daily		Occas.	Granulometry	
								SSC	LT	Prof. SSC	SL	BL
SLOVENIA	SAVA - main channel	3420	Radovljica I	Y 5436120; X 5133220	H,Q,SSC,LT,	1953-	ARSO	x	x			
		3570	Šentjakob	Y 5468075; X 5104515	H,Q,SSC,LT,	1955-1994	ARSO	x				
		3725	Hrastnik	Y 5507381; X 5108630	H,Q,SSC,LT,	1993-	ARSO	x	x			
		3740	Radeče	Y 5514390; X 5103055	H,Q,SSC,LT,	1955-1993	ARSO	x				
	SORA	4200	Suha I	Y 5448320; X 5113319	H,Q,SSC,LT,	1953-	ARSO	x	x			
	SAVINJA	6200	Laško I	Y 5518410; X 5112230	H,Q,SSC,LT,	1953-	ARSO					
	SAVINJA	6210	Veliko Širje I	Y 5515244; X 5105337	H,Q,SSC,LT,	1955-	ARSO	x	x			
	SOTLA	4740	Rakovec I	Y 5555070; X 5086540	H,Q,SSC,LT,	1965-	ARSO			x		
CROATIA	SAVA - main channel	3087	Podsused	Y 5565652; X 5074098	H,Q,SSC,LT,	1979-	DHMZ	x	x	x	x	x
		3096	Rugvica	Y 5595979; X 5067325	H,Q,SSC,LT,	1978-	DHMZ	x	x	x	x	x
		3219	Jasenovac	Y 4614661; X 5014177	H,Q,SSC,LT	1978-	DHMZ	x	x	x	x	x
		3098	Slavonski Brod	Y 6500781; X 5000950	H,Q,SSC,LT	1960-	DHMZ	x	x			
	KRAPINA	3054	Kupljenovo	Y 5563758; X 5088155	H,Q,SSC,LT	1980-	DHMZ	x	x			
	KUPA	4016	Hrvatsko	Y 5477111; X 5043087	H,Q,SSC,LT	1963-	DHMZ	x	x			
	ILOVA	3185	Munije	Y 6445034; X 5058159	H,Q,SSC,LT	1979-	DHMZ	x	x			
	BIJELA	3171	Badljevina	Y 6437061; X 5040307	H,Q,SSC,LT	1984-	DHMZ	x	x			
	BJELOVARSKA R.	3188	Bjelovar	Y 6411531; X 5083507	H,Q,SSC,LT	1979-	DHMZ	x	x			
	Reserv. NOVSKA	3151	Novska g. step.	Y 6424413; X 5023989	H,Q,SSC,LT	1980-	DHMZ	x	x			
B&H	SAVA - main channel	No actual monitoring site*										
	Tributaries	No actual monitoring site*										
SERBIA	SAVA - main channel		Sremska Mitrovica	Y 7388292; X 4981825	H,Q,SSC,LT,	1974-	IJC	x	x	x	x	x
			Beograd	Y 7453377; X 4961362	H,Q,SSC,LT,	1986-	IJC	x	x	x	x	x
			Sremska Mitrovica	Y 7390175; X 4981125	H,Q,SSC,LT,	1958-1980	RHMZ					
			Sabac	Y 7397450; X 4959150	H	1958-2002	RHMZ					
			Beograd	Y 7456875; X 4963650	H	1958-1998	RHMZ	x	x	x	x	x
	DRINA		Mihaljevici	Y 7369129; X 4896888	H,Q,SSC,LT,	1991-2002	RHMZ	x	x			
	DRINA		Radalj	Y 7352975; X 4921075	H,Q,SSC,LT,	1984-2002	RHMZ	x	x			
	DRINA		Badovinci	Y 7369845; X 4961554	H,Q,SSC,LT,	1990-2001	RHMZ	x	x			
	KOLUBARA		Slovac	Y 7427150; X 4910975	H,Q,SSC,LT,	1958-1992	RHMZ	x	x			
	KOLUBARA		Beli Brod	Y 7436750; X 4914330	H,Q,SSC,LT,	1986-2001	RHMZ	x	x			
	KOLUBARA		Drazevac	Y 7438150; X 4939050	H,Q,SSC,LT,	1958-2002	RHMZ	x	x			

* B&H only occasionally measurements of SSC, BL (Drina, upstream of Višegrad, period 1989/1990) in order to define reference conditions before HEPP Višegrad has been buildt, and very rare measurements on the River Bosna and some tributaries of the Sava River in B&H.

Furthermore, the available sediment monitoring data from the stations were compared and some correlations could be drawn. The correlation between the annual Sava River flows and the annual suspended loads (Fig. 6, left) show different patterns for the upstream gravel-bed river section (Hrastnik, Radeče, Podsused, and Rugvica stations) and for the downstream sand-bed river section (Jasenovac, Slavonski

Brod, Sremska Mitrovica, and Beograd stations). The comparison given for separately for the winter and summer season at the Sremska Mitrovica station between the average monthly suspended loads and the average monthly discharge shows good correlation and no seasonal effects (Fig. 6, right).

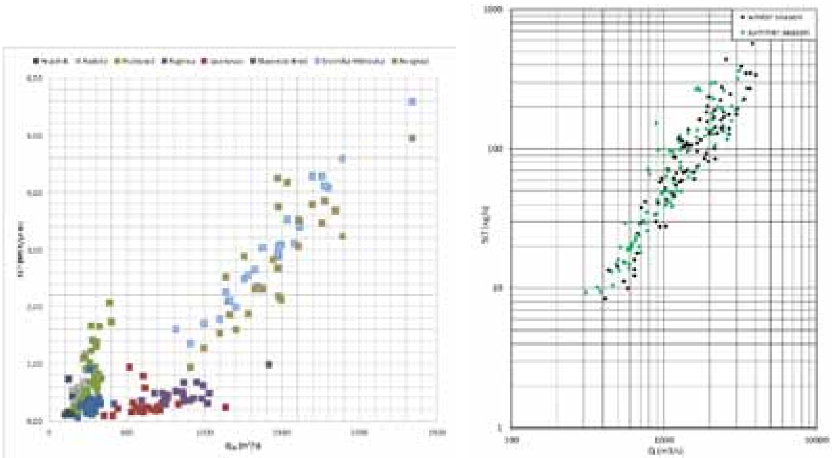


Fig. 6: *The correlation between the annual river flows and the annual suspended loads along the Sava River (left), and the average monthly suspended loads and the average monthly discharges at the Sremska Mitrovica station (SRBC, 2013; Fig. 53 & 55, p. 58 & 61).*

Apart from analysing correlations between selected hydrologic parameters important for the Sava River sediment balance estimation, the variability of the sediment transport process was studied to some extent. In Figure 7, we present a longitudinal variability of the annual suspended sediment loads along the Sava River for 4 selected years (1990, 2003, 2010 & 2011).

Firstly, the average values show the influence of the transition in the Sava River from gravel-bed to sand-bed type of a river at the Rug-

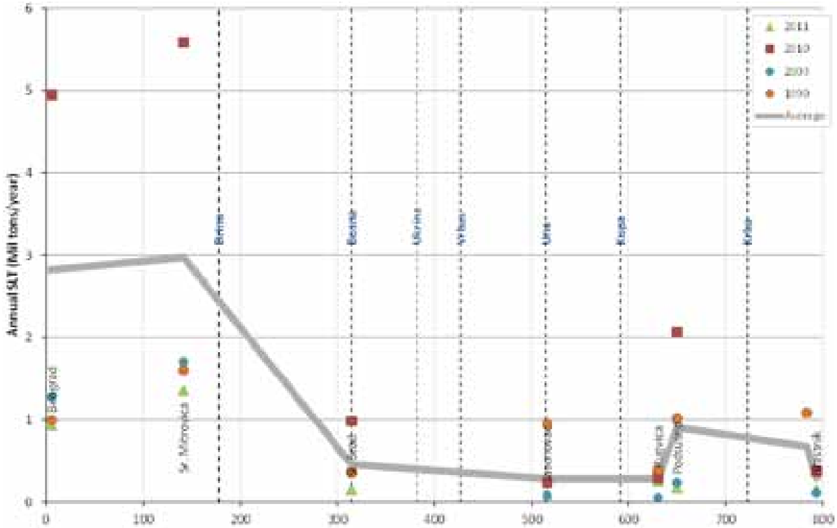


***Fig. 7:** The longitudinal presentation of the annual suspended sediment loads along the Sava River in selected years (ISRBC, 2013; Fig. 56, p. 62).*

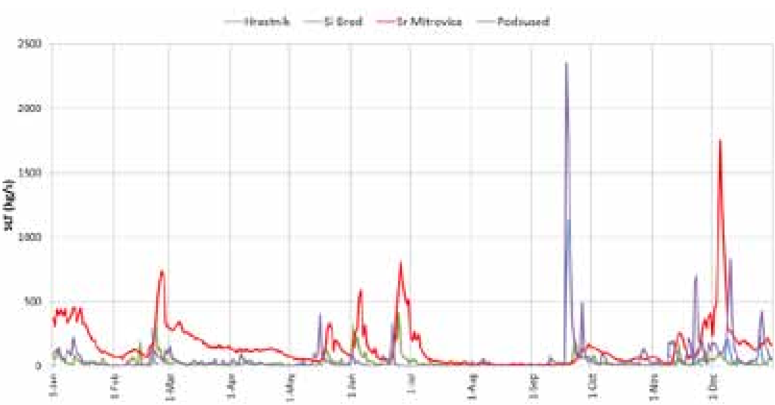


***Fig. 8:** Daily suspended sediment loads along the Sava River in 2010 (ISRBC, 2013; Fig. 60, p. 65).*

Table 2. *An overview of gaps in suspended sediment measurements in the hydrological stations in the SRB (ISRBC, 2013; Tab. 9, p. 69).*

Country	River	Hydrological station	L [rkm]	Monitoring period of SS	H,Q gaps	SSC gaps	LT gaps	Institution	Active
SLOVENIA	SAVA	Radovljica	900.95	1953-2012		1953-2004 2007-2012	1953-2004 2007-2012	*ARSO*	Active
		Hrastnik	793.5	1993-2012		1993-1996 2007-2012	1993-1996 2007-2012	*ARSO*	
	SORA	Suha I		1953-2012	H,Q 1991	1953-2008 2011	1953-2008 2011	*ARSO*	
	SAVINJA	Laško I		1953-2012		1953-1989 1994-2012	1953-1989 1994-2012	*ARSO*	
	SAVINJA	Veliko Širje I		1967-2012	H,Q 1991-1993	1974, 1977 1990-1993	1974, 1977 1990-1993	*ARSO*	
	SOTLA	Rakovec I		1965-2012		1965-1977 2007-2012	1965-1977 2007-2012	*ARSO*	
	SAVA	Šentjakob	847.1	(1955-1994)		1974-1977 1995-2012	1974-1977 1995-2012	*ARSO*	*Inactive*
	SAVA	Radeče	783.62	(1955-1993)		1974 1994-2012	1974 1994-2012	*ARSO*	
CROATIA	SAVA	Podsused žičara	675.4	1979 -	no gaps	no gaps	no gaps	DHMZ	Active
	SAVA	Rugvica	636.3	1978 -	Q 1996-1999 2004-2006	only daily gaps*	1996-1999 2004-2006	DHMZ	
	SAVA	Jasenovac	500.5	1978 -	Q 1992-1996	1992-1996	1992-1996	DHMZ	
	SAVA	Slavonski Brod	360	1960 -	Q 1994-2003	only daily gaps*	1994-2003	DHMZ	
	SAVA	*Stara Gradiška*	453.4	*(1963-1991)*	*H 1992-1997* *Q 1992-2004*	*1965* *1991-2013*	*1965* *1991-2013*	*DHMZ*	*Inactive*
	UNA	*Kostajnica*	42.1	*(1967-1991)*	*H1992-1996,* *Q1992-2001*	*1991-2013*	*1991-2013*	*DHMZ*	
	ORLJAVA	*Mijači*		*(1975-1991)*	*no gaps*	*1991-2013*	*1991-2013*	*DHMZ*	
	PAKRA	*Manastir*		*(1984-1991)*	*H1992-1994,* *Q1992-1998*	*1987* *1991-2013*	*1991-2013*	*DHMZ*	
SERBIA	SAVA	Sremska Mitrovica	141.5	1974-	**	1984-1988 1990-1991 1993-2008	1984-1988 1990-1991 1993-2008	IJC	Active
	SAVA	Beograd	5.6	1986-	**	1990-1991 1999	1990-1991, 1999	IJC	
	SAVA	*Sremska Mitrovica*	*139.24*	*1958-1980*	*no gaps*	*1981-2012*	*1981-2012*	*RHMZ Srbije*	*Inactive*
	SAVA	*Sabac*	*106.38*	*1958-2002*	*only H*	*2003-2012*	*2003-2012*	*RHMZ Srbije*	
	SAVA	*Beograd*	*2.0*	*1958-1998*	*only H*	*1999-2012*	*1999-2012*	*RHMZ Srbije*	
	DRINA	*Mihaljevici*	*132*	*1991-2002*	*not operational, 2004-2012*	*2003-2012*	*2003-2012*	*RHMZ Srbije*	
	DRINA	*Radalj*	*85.5*	*1984-2002*	*no gaps*	*2003-2012*	*2003-2012*	*RHMZ Srbije*	
	DRINA	*Badovinci*	*16.5*	*1990-2001*	*not operational, 2002-2012*	*2002-2012*	*2002-2012*	*RHMZ Srbije*	
	KOLUBARA	*Slovac*	*88*	*1958-1992*	*no gaps*	*1993-2012*	*1993-2012*	*RHMZ Srbije*	
	KOLUBARA	*Beli Brod*	*72*	*1986-2001*	*no gaps*	*2002-2012*	*2002-2012*	*RHMZ Srbije*	
	KOLUBARA	*Drazevac*	*12*	*1958-2002*	*no gaps*	*2003-2012*	*2003-2012*	*RHMZ Srbije*	

* Daily gaps due to ice or flood events

* H-Q monitoring on nearby station of RHMZ Srbije

vica station, where an increasing trend in annual suspended loads with an increasing watershed area abruptly has a drop (discontinuity), to then increase again towards the confluence with the Donava River.

Secondly, the variability in the annual suspended loads between years is rather large (up to factor of 5 in the lower parts, and up to factor of 10 in the upper parts), stressing the importance of wet hydrological years (such as e.g. 2010) for sediment transport.

It is also well known that the majority of suspended sediments (valid also for bed load) is annually transported during a few high flows (floods), as nicely presented for 2010 and for four measuring stations in Figure 8.

Table 2 shows the monitoring period for each of the hydrological station in the SRB together with the gaps in the measurements of water levels H [cm], discharges Q [m^3/s], suspended sediment concentration SSC [g/m^3], [mg/l] and suspended load transport rate LT [t/day]. The existing suspended sediment monitoring for the Sava River main channel is clearly seen on Fig. 9.

Having insight into the state-of-the-art situation with regard to the sediment data availability and their data quality, and having in mind existing gaps, there inevitably exist uncertainties that are derived from the different reasons. The suspended sediment and bed load measurements are hard to compare/unite due to different sampling techniques and changing techniques during time, different frequency of measurements, different duration of time series in the long-term measurements, complete lack of measurements in some parts of the SRB, changing of the gauging station location during time (e.g. upstream/downstream of tributary). Monitoring of sediment quality exists, but countries monitor different parameters with different frequency of monitoring, in some cases we face a complete lack of such monitoring. Last but not least, some major impacts in the SRB (large structures such as HPP) are not adequately covered by the existing monitoring system.

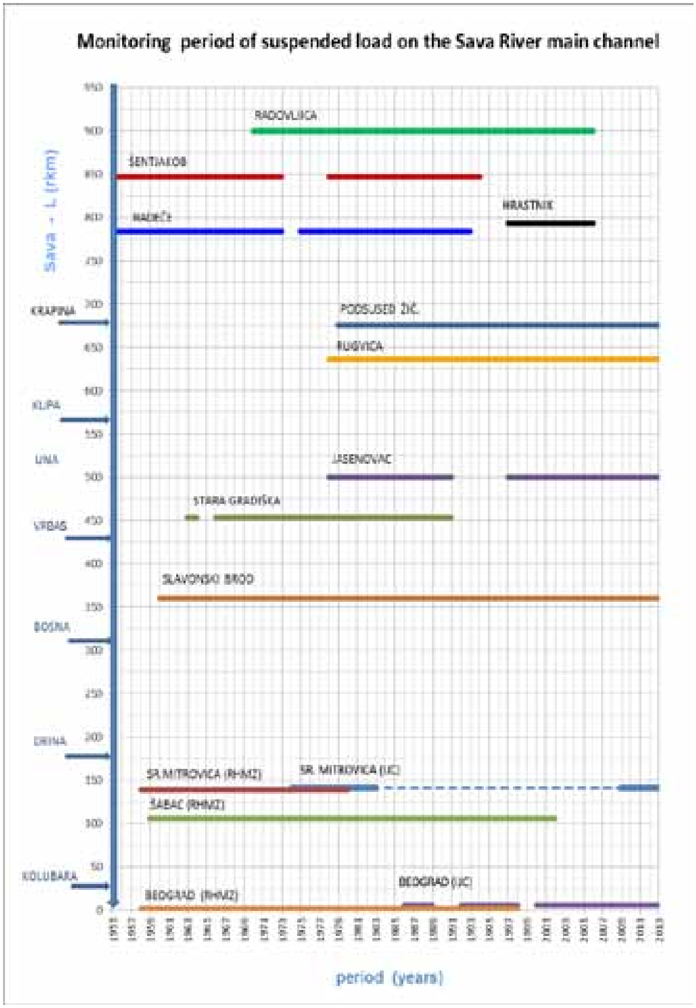


Fig. 9: *An overview of suspended sediment measurements done in the Sava river main channel in the period 1955–2013 (ISRBC, 2013; Fig. 64, p. 70).*

With regard to the estimation of the Sava River sediment balance the following conclusions have been drawn:

1. The size and highly heterogeneous natural characteristics of the SRB significantly affect the inflow of water and sediment.
2. Significant tributaries bring large sediment load and have a major influence on the hydrologic, hydraulic and sediment regimes of the recipient.
3. The heterogeneity of geomorphological and morphological conditions along the course of the Sava River also effects sediment transport and deposition processes.
4. The controlled regime of the Iron Gate 1 reservoirs' backwater levels is the most important artificial influence on the sediment transport and deposition processes in the Lower Sava.
5. Excavation of material from the Sava riverbed is a relatively important component of these processes, even though the effects of dredging are generally local and depend on the location of the excavation field.
6. River training structures and HPP play a significant role in riverbed formation along some stretches of the Sava.

The BALSES project also suggested in its conclusions the following further activities:

1. The currently monitored sediment-balance related parameters in all hydrologic stations along the Sava River main channel and in its major tributaries should be connected to a joint Sediment Database, available online for free.
2. The effort towards the harmonisation of monitored sediment data by applying the same technical international standards should be made.
3. The monitoring network should be made denser with additional new hydrologic stations to be taken into operation in the years to come.

4. The sediment monitoring should integrate regular cross-section measurements in selected cross sections along the Sava River main channel and the main tributaries.
5. A numerical modelling of sediment transport in the Sava River main channel based on reliable sediment data to validate the model should be performed.

The project on establishment of the Sediment Monitoring System for the SRB, based on the strategic goals and specific objectives of the sediment monitoring and data exchange system in the SRB, and based on an overview of sediment transport processes, prepared a review of technical international standards and techniques for sediment monitoring. Next, a review of existing sediment monitoring data, standards and techniques in the SRB was prepared, structured separately for Slovenia, Croatia, Bosnia and Hercegovina, and Serbia. On this basis, a proposal of a future sediment monitoring system in the SRB was developed - for locations of the existing and the proposed future sediment monitoring stations see Figure 10. Furthermore, an establishment of an on-line free database on sediment was suggested, to be implemented in the existing Hydrological Information System of the ISRBC (Sava HIS, http://savahis.org), where the datasets upload and validation will be performed.

Late in 2015, the ISRBC established the Sava Water Council (SWC) as its advisor body for the general purpose of public participation and stakeholder involvement in the work of the ISRBC. Through the SWC the ISRBC would be adequately and appropriately informed with knowledge, tools and innovations regarding water resources, river basin management, navigation and other water users (e.g. nautical and eco-tourism) and about the concerns and needs of the stakeholders.

The research and other activities of the ISRBC in the last few years are the right steps towards the preparation of a modern Sustainable

Fig. 10: *The sediment monitoring in the SRB (ISRBC, 2015; p. 49) – showing the existing and the proposed future sediment monitoring stations on the Sava River and its tributaries.*

Sediment Management Plan as a part of the SRB Management Plan in order to give river sediments its place in water management activities that it should deserve. What is essentially missing in the steps undertaken so far, is the fully integration of the sediment quality issues into the Sustainable Sediment Management Plan. Despite the results of the international project SARIB (Sava River Basin, 2004-2007) that the pollution of the Sava River sediments is low and generally lower than the pollution of the Danube River sediments (Globevnik et al., 2010), the Sava River sediment quality should be further investigated. The results of the SARIB projects are summarized in the SARIB GIS data base, and freely available on the internet (http://www.ksh.fgg.uni-lj.si/sarib/).

Acknowledgements

The activities of the author as a member of the core group of experts working on the projects presented in this paper were financially supported by the ISRBC. The data used in the projects were partially open access data from the Slovenian Environmental Agency (ARSO) of the Ministry of the Environment and Spatial Planning, and partially a results of research activities of the author working in the National Research Programme P2-1080 "Water Science and Technology, and Geotechnics", financed by the Slovenian Research Agency (2004-2008, 2009-2013, 2014-2016).

LIST OF REFERENCES

Babić Mladenović, M., Bekić, D., Grošelj, S., Mikoš, M., Kupusović, T., Oskoruš, D. & S. Petković, 2014: Towards sediment management in the Sava river basin.- Water Research and Management, 4(1), 3-13.

Babić Mladenović, M., Bekić, D., Grošelj, S., Mikoš, M., Kupusović, T. & D. Oskoruš, 2015: Establishment of the Sediment Monitoring System for the Sava River Basin.- Water Research and Management, 5(4), 3-14.

Globevnik, L., Mikoš, M., Padežnik, M., Petan, S., Petkovšek, A., Vidmar, A., Milačič, R., Ščančar, J., Heath, E., Ogrinc, N. & M. Brilly, 2010: SARIB.-In: Brilly, M. (ed.) Hydrological Processes of the Danube River Basin – Perspectives from the Danubian Countries. Springer Netherlands, pp. 389-428, Dordrecht. http://link.springer.com/chapter/10.1007/978-90-481-3423-6_13 [Accessed 1st May 2016].

ISRBC, 2002: *Framework Agreement on the Sava River Basin*.- International Sava River Basin Commission, Zagreb, pp. 21. Available from: http://www.savacommission.org/dms/docs/dokumenti/documents_publications/basic_documents/fasrb.pdf [Accessed 1st May 2016].

ISRBC, 2013: *Towards practical guidance for sustainable sediment management using the Sava river basin as a showcase: estimation of sediment balance for the Sava river*.- International Sava River Basin Commission, Zagreb, pp. 87. Available from: http://www.savacommission.org/dms/docs/dokumenti/documents_publications/publications/other_publications/balses_final.pdf [Accessed 1st May 2016].

ISRBC, 2015a: *Protocol on Sediment Management to the Framework Agreement on the Sava River Basin*.- International Sava River Basin Commission, Zagreb, pp. 10. Available from: http://www.savacommission.org/dms/docs/dokumenti/documents_publications/basic_documents/protocols/protokol_nanos.pdf [Accessed 1st May 2016].

ISRBC, 2015b: *Towards practical guidance for sustainable sediment management using the Sava river basin as a showcase: Establishment of the Sediment Monitoring System for the Sava River Basin*.- International Sava River Basin Commission, Zagreb, pp. 49. Available from: http://www.savacommission.org/dms/docs/dokumenti/public/projects/establishment_of_sediment_monitoring_in_srb__final.pdf [Accessed 1st May 2016].

Kupusović, T. 2016: Uspostava monitoringa nanosa za riječni bazen Save.- Voda i mi, 91, 14-17. http://www.voda.ba/casopis/Vodaimi91.pdf [Accessed 1st May 2016].

IMPORTANCE AND PROTECTION OF KARST AQUIFERS IN THE DANUBE BASIN

Dr. Nataša Viršek Ravbar, natasa.ravbar@zrc-sazu.si
Research Centre of the Slovenian Academy of Sciences and Arts,
Karst Research Institute

Abstract

The karst phenomena that are formed by specific lithology, tectonics and natural processes play an important role in the environmental and anthropogenic settings of the Danube basin. In addition, karst terrains offer a great range of economic assets, provide unique habitats and valuable ecosystem services. Among these groundwater resources are certainly of the highest importance that influence hydrological regimes and offer exploitable reserves such as a vital water supply source. The focus of the present contribution is presentation of the main karst areas in the Danube basin and the basic geomorphological and hydrological characteristics of karst regions. Owing to its particular nature, karst environment is highly susceptible to destruction and must therefore be holistically managed in an appropriate and careful manner.

Key words: Alpine karst, Dinaric karst, Classical karst, karst aquifer, drinking water resource, protection

---

Pomen kraških vodonosnikov v porečju Donave in njihovo varovanje

Povzetek

Kraški pojavi, ki nastanejo v posebnih kamninah in tektonskih pogojih, in s posebnimi naravnimi procesi, igrajo pomembno vlogo pri

okoljskih in antropogenih značilnosti porečja Donave. Poleg tega kraška območja ponujajo velik spekter ekonomskih dobrin, pogojujejo edinstvene habitate in dragocene ekosistemske storitve. Med njimi je kraška podzemna voda prav gotovo zelo pomemben dejavnik, ki vpliva na hidrološke režime in ponuja naravne vire, med katerimi je ključna pitna voda. Poudarek pričujočega prispevka je na predstavitvii poglavitnih kraških območij v porečju Donave ter osnovnih geomorfoloških in hidroloških značilnosti krasa. Zaradi teh posebnosti je kraško okolje zelo dovzetno za uničenje. Zato je treba na teh območjih skrbno izvajati ustrezno in celostno upravljanje.

Ključne besede: alpski kras, dinarski kras, Klasični kras, kraški vodonosnik, vodni vir, varovanje

Introduction

Karst terrains are one of the landscape types that provide humans with numerous and multiple benefits, which are derived from ecological services (e.g. drinking water) and aesthetic attractiveness. On the other hand, they are subject to increasing pressure and serious pollution from agriculture, industry and settlements.

Globally, karst areas account for about a fifth of the surface at all latitudes and at all elevations. In Europe karst areas cover about a third of the continent, while south-western China hosts the largest contiguous karst areas in the world, occupying about 500,000 km^2 (Ford & Williams, 2007).

The present contribution aims at highlighting the importance of karst in the Danube basin especially as fresh water resource. A special focus is laid to karst of Slovenia that is considered the cradle of karst and karstology. The paper also provides general explanation on what karst is and how karst aquifers function. Considering special characteristics of karst environment is essential for understanding, proper protection and conservation of karst.

Karst in the Danube Basin

Karst normally occurs on permeable carbonate rock, such as limestone and dolomite which account for a significant portion of the Danube basin (Fig. 1). The karst is noteworthy relief for the part of the Alpine, Moravian, Carpathian and Balkan region, including most of the Dinaride Mountains. Parts of the North Hungarian and Transdanubian Mountains contain some of the well-developed karst areas as well (Gunn, 2004).

Karst is the most widespread in the Dinaride Mountains and ranks among largest contiguous karst areas in the world (Gams, 2003). The so-called Dinaric karst extends from the Friuli Plain (Northeastern Italy) along the coast of the Adriatic as far south as Zapadna Morava River and Albania. It hosts unique landscapes where predominant relief forms are mountain ranges and plateaus, stretching in a northwestern – southeastern direction (the so-called Dinaric direction) and are intersected by karst poljes or deep gorges (Fig. 2). Intense surface- groundwater interaction and large-scale hydraulic connection is significant for Dinaric karst that is also considered the *locus typicus* for karst landscapes around the world.

In the Danube Basin significant is also the so-called Alpine karst. Alpine karst is characterised by high mountain ridges and plateaux cut by deep valleys. It is typical for the Alps, Carpathians and Dinarides. Owing to colder climate the areas are often bare or covered with dense vegetation, seasonal snow and past and present glaciers. Exceptionally steep hydraulic gradients develop between upland recharge areas and adjacent valleys. Karst waters come out as the sources in the Quaternary deposits at the bottoms of the valleys or directly from the steep rocky slopes in the form of abundant waterfalls (Fig. 3). The fundamental characteristics of Alpine karst underground are considerably great vertical development and longer preservation of ancient passages.

In Slovenia, karst landscape accounts about a half of the country. Karst areas that drain into the Danube Basin are mostly present in the

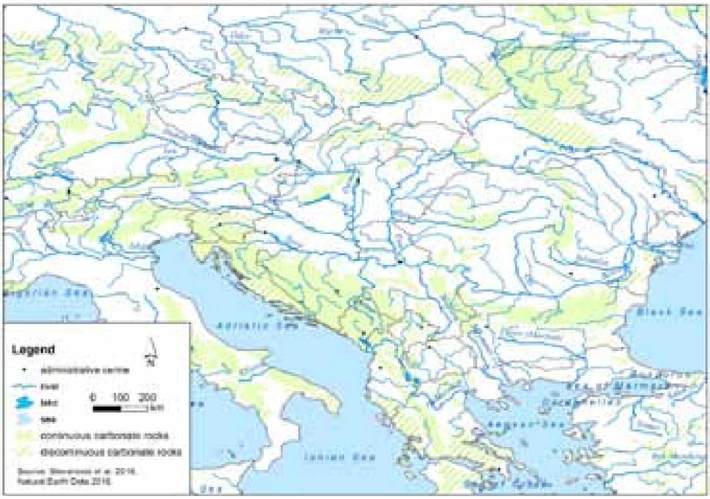


Fig. 1: *Distribution of karst terrains in Southeastern Europe and in the Danube Basin.*

Fig. 2: *Planinsko Polje is one of the best global examples of a karst polje, i.e. a large, flat-floored depression with steep surrounding slopes. Poljes usually have perennial or temporary sinking streams with springs on one side and ponors on the other side. For location of Planinsko Polje see Fig. 8.*

Sava River Basin. Dinaric and Alpine karst types prevail that are developed predominantly in carbonate bedrocks of Mesozoic and Cenozoic age. The Slovene Dinaric karst was specifically important for the history of research of the karst and karst phenomena. The distinct karst features are located in the area between Ljubljana and Trieste, the area also depicted as the Classical Karst (for location see Fig. 8).The area that occupies nearly a third of the country, comprises several karst poljes, sinking rivers and more than 6,000 registered caves.

Fig. 3: *The Savica waterfall is a Sava spring in the Slovene Julian Alps that measures 78 m in height. The discharges range between 1 and 13* m^3/s*. The water originates from the 550 m long karst cave just above the waterfall.*

Importance of Karst

Karst terrains provide wide range of economic assets, unique habitats and valuable ecosystem services. These territories have created unique settings with values related to natural, historical and cultural heritage and relevant natural and environmental significance.

Among the wide range of numerous benefits groundwater resources are certainly of the highest importance. In many regions karst aquifers often afford the only exploitable reserves, which therefore present invaluable sources for human health, food security, and the economic sector. Due to the exceptional quality and quantity of the water in karst springs that can achieve discharge values of some tens to some hundreds of m^3/s, these water sources have played an extremely important role in water supply, irrigation, and power generation for millennia.

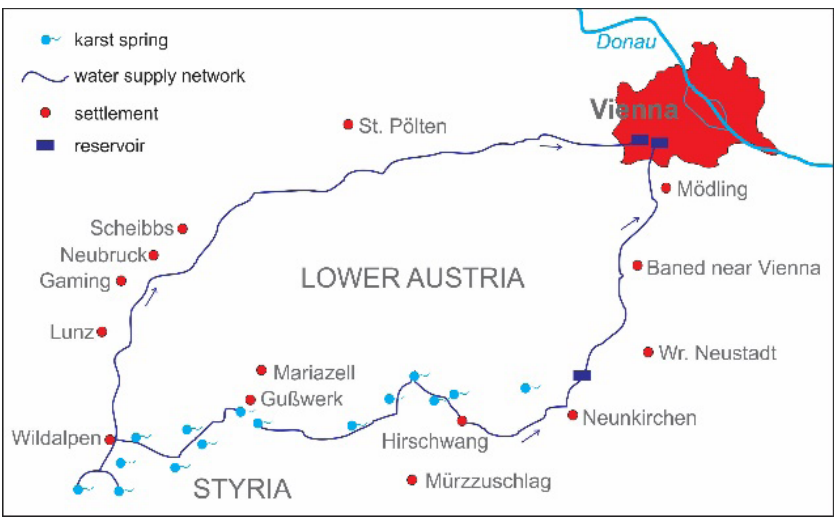


Fig. 4: *Vienna is supplied with drinking water from karst springs nearly 200 km away via two long-distance mains (Source: Vienna's Water Supply, 2016).*

In some countries, such as Slovenia, Austria and Croatia karst water sources cover around half of the needs after drinking water. Many major Alpine cities, such as Vienna with a population over 1.5 million are supplied by high-quality karst water derived from the Lower Austrian-Styrian Alps nearly 200 km away (Fig. 4). The city is supplied with 400,000 m^3 of fresh spring water daily that on its way to Vienna flows through hydroelectric power stations, which generates 65 million kilowatt hours (Plan, 2009).

Moreover, many karst springs contribute to surface waters and play a major role in maintaining numerous aquatic ecosystems and wetlands. Additional economic benefits provided by karst landscapes are minerals and rock, forest and agriculture. With technological and economic development, karst areas have grown to be among the most important providers of oil and gas, and sources of geothermal energy. At the same time karst areas are a valuable ecosystem, providing special habitats and containing high levels of biodiversity. The Dinaric karst region is among the richest areas in Europe in terms of flora and fauna and one of the global "hotspots" of biodiversity. Dinaric karst was where the first troglobitic and stygobiont cave-dwelling animal species were discovered and scientifically described (Fig. 5).

Particular karst landforms, such as caves, poljes, springs and other geomorphologically remarkable phenomena contribute significantly to geodiversity and are fundamental to the retention of biodiversity. These landforms are also historically venerated as sites of religious, spiritual and cultural importance or a focus of human attention for recreation and well-being (Fig. 6). Many have become tourist attractions and prompted the development of tourism (e.g. Postojnska jama, Plitvice).

In addition to the above resources, karst systems provide a number of other ecosystem services, for example carbon sequestration (White, 2013). They also offer opportunities for scientific study and education by providing an insight into past geomorphological, ecological and anthropogenic conditions.

***Fig. 5:** The remarkable cave amphibian, Proteus anguinus, was the first stygobiont to be mentioned in scientific writing, described by J. N. Laurenti in 1768 (Photo: Jurij Hajna).*

***Fig. 6:** The cave of Postojnska jama is the top Slovene tourist destination hosting more than 600,000 visitors per year. The Postojna cave system (25 km passages) has many entrances and is hydrologically connected to the Planina cave system (> 6 km passages). Both are of exceptional geomorphological, hydrogeological and speleobiological significance (Photo: Jurij Hajna).*

Specifics of Karst Terrain

Karst is a terrain with distinctive landforms and hydrology arising from high rock solubility of carbonate rocks, such as limestone and dolomite, or evaporites, and consequently well-developed solution-channel (secondary) porosity (Ford, 2004). Karst landscape is characterized by rounded peaks, closed dells, dolines, collapse dolines, karrenfields, and karst poljes with sinking rivers on the surface. However, distinctive surface features may be completely absent where the soluble rock is mantled, such as by glacial debris, or confined by a superimposed non-soluble rock strata. Beneath the surface, karst landscapes are characterized by complex and extensive subterranean caves and shafts (Fig. 7).

The key landform process is aqueous dissolution and, in contrast to processes in other relief forms, in karst chemical weathering dominates over mechanical transport (Jones & White, 2012). Rainwater becomes

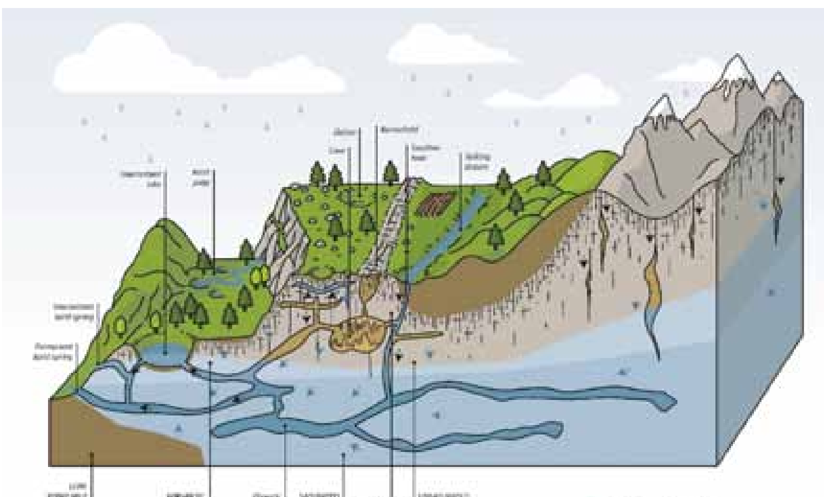


Fig. 7: *Schematic illustration of a typical karst landscape and its hydrological characteristics (Ravbar & Šebela 2015).*

acidic as it comes into contact with carbon dioxide in the atmosphere and in the soil. As it drains into fractures in the rock, the water begins to dissolve away the rock, enlarging the joints and bedding planes and creating a network of underground conduits. These conduits can vary in size from slightly enlarged cracks to tunnels many metres in diameter and many kilometres in length.

Karst is also characterized by distinct hydrology. Due to secondary porosity, the fissuring and crushing of the rock that enables immediate percolation of rainwater into the underground the surface is very permeable. In a dispersed manner, precipitation water percolates down the fissures and channels in the bedrock. Consolidated streams

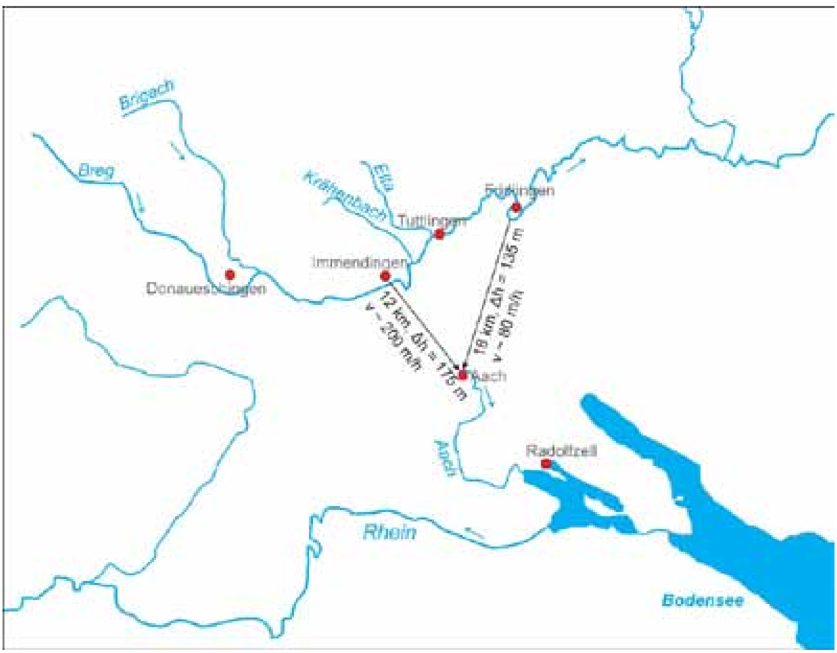


Fig. 8: *The Danube River is associated with the Danube – Aach karst system of sinking and reappearing of water.*

that gather water on non-karst surfaces also sink into the karst underground. Underground waters then flow together to form larger streams that continue toward springs through karst channels. The catchments of the springs are not always easily defined, but their boundaries are typically independent of surface relief and topographic divides.

The origin of the Danube is at the confluence of the two streams Brigach and Breg outflowing as karst springs. Near Immendingen and Fridingen, the water of the Danube sinks into the riverbed in various places. Danube loses about 6 m^3/s of its flow into riverbed sinks, and this water rises from the Aach Spring, 12 to 18 km away and 135 to 175 m lower, at the head of a major tributary to the Rhine causing bifurcation at the North Sea – Black Sea watershed (Käß et al., 1996; Fig. 8).

Similar flow bifurcations can be observed in many places of the Classical Karst area in Slovenia, located on the Adriatic-Black Sea watershed. The drainage of the Javorniki-Snežnik karst massive that is recharged by rainwater and snowmelt is in addition influenced by great variability in flow characteristics depending on specific hydrological conditions. During low-water conditions, groundwater from the Javorniki mountains and the western lying Pivka Valley drain directly towards the Planinsko Polje in the northeast. In high-water conditions water level rises and a groundwater divide forms below the Javorniki mountains so that a part of the area drains towards the Pivka Valley in the southwest (Fig. 9). Oscillations of groundwater may comprise several tens of meters. Due to groundwater fluctuations and weak connections between different karst conduits, several intermittent rivers and lakes of different size, temporal duration and frequency may occur in karst poljes or in shallow karst areas (Fig. 10). Great variability in flow characteristics depending on hydrological conditions may also result in differences of flow velocities that comprise several orders of magnitude, changes of flow directions and shifting of catchment boundaries. Considerable hydrologic variability is particularly pronounced in many locations of the Dinaric karst.

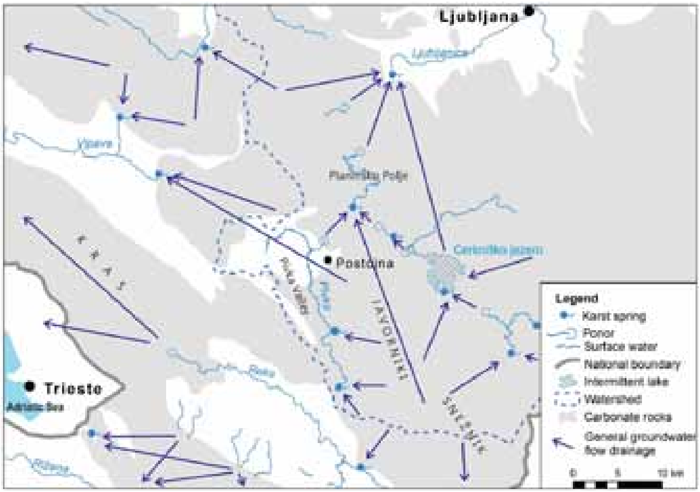


Fig. 9: *Map of the Classical Karst in Slovenia with Adriatic-Black Sea watershed and the general underground flow connections proved by tracer tests.*

Fig. 10: *Slovenia's largest intermittent karst lake Cerkniško jezero, which can extend over 25 km^2 and contain more than 28 million m^3 of water, but it can also be completely dry. Its occurrence and extent depend on the current hydrological conditions. For location see Fig. 8.*

Instead of Conclusion - Protection of Karst

Owing to its particular nature, karst terrains are highly susceptible to climatic pressures, human impacts and contamination. In the past few decades karst landscapes have faced a growing demand for their wide range of economic assets that have in some karst regions already caused landscape and ecosystem deterioration (Ravbar & Šebela, 2015). Once damaged, karst surface and underground environments take a long time to recover, and the process is a difficult one. For this reason, karst must be holistically managed in an appropriate and careful manner.

Because of their significant natural values some of the karst areas and caves are protected with the regional or national parks or designated as UNESCO World Heritage Sites. However, despite the high percentage of carbonate rock and the economic importance of karst areas in the Danube basin countries still lack a comprehensive land-use planning and management approaches for development in karst areas that would consider the specific characteristics of karst environments.

Literature

Ford, D., 2004: Karst.- In: Gunn J. (Ed.) *Encyclopedia of Caves and Karst Science*. Fitzroy Dearborn, New York, London, pp. 473-475.

Ford, D.C. & P.W. Williams, 2007: *Karst Geomorphology and Hydrology*.- Academic Division of Unwin Hyman Ltd, pp. 601, London.

Gams, I., 2004: *Kras v Sloveniji v prostoru in času*.- Založba ZRC, pp. 516, Ljubljana.

Gunn, J. (Ed.), 2004: *Encyclopedia of caves and karst science*.- Taylor & Francis, pp. 1940, London.

Jones, W.K. & W.B. White, 2012: Karst.- In: White, W.B. & D.C. Culver (Eds.) *Encyclopedia of Caves*. Elsevier, Academic Press, Amsterdam, pp. 430-438.

Käß, W., Löhnert, E. P. & A. Werner, 1996: Der jüngste Markierungsversuch im Karst von Paderborn (Nordrhein-Westfalen).- Grundwasser, 1(2), 83-89.

Natural Earth Data, 2016.- [Online] Available from: http://www.naturalearthdata.com/ [Accessed 25th April 2016].

Plan, L., 2009: Kläffer Spring - The major spring of the Vienna Water Supply (Austria).- In: Kresic, N. & Z. Stevanovic (Eds.). *Groundwater hydrology of springs: Engineering, theory, management and sustainability*. Butterworth-Heinemann, pp.411-427.

Ravbar, N., & S. Šebela, 2015: The effectiveness of protection policies and legislative framework with special regard to karst landscapes: insights from Slovenia.- Environmental Science & Policy, 51, 106-116.

Stevanovic, Z., Goldscheider, N. & Z. Chen, 2016: WOKAM–The world karst aquifer mapping project, examples from South East Europe, Near and Middle East and Eastern Africa.- In: Stevanović, Z., Krešić, N. & N. Kukurić (Eds.). *Karst without Boundaries*. CRC Press, 23, 39.

Vienna's Water Supply, 2016.- [Online] Available from: https://www.wien.gv.at/ [Accessed 3rd May 2016].

White, W. B., 2013: Carbon fluxes in karst aquifers: sources, sinks, and the effect of storm flow.- Acta Carsologica, 42(2/3), 177.

WATER ECOSYSTEM MONITORING AND RUNNING WATER STATUS IN SLOVENIA FROM THE ECOLOGICAL POINT OF VIEW

Prof. Dr. Mihael J. Toman, mihael.toman@bf.uni-lj.si
Biotechnical Faculty, University of Ljubljana

Abstract

Water is often considered only a necessity for humanity and not as a habitat for aquatic organisms and the entire aquatic ecosystem. Slovenia is a country with abundant water but many of the 28.000 km watercourses are no longer natural. Large amounts of water do not necessarily relate to good water quality or optimal ecological status.

A large part of Slovenian watercourses are torrential with changing water levels, which may consequently result in flooding. Discharges of waste water from the industry and settlements and diffuse pollution from urban and agricultural land pollute the water environment. Water treatment is implemented on less than 50% of waste waters. Slovenian rivers are characterized by high self-purification ability, so the situation in regard to the degree of pollution is relatively good.

The situation is much different in lakes, reservoirs, accumulations and river reservoirs, in which the water is retained. Increased content of organic matter leads to a lack of oxygen and kills the organisms. High nutrient content causes blooming (eutrophication), particularly of dangerous cyanobacteria, which secrete microcystin - a carcinogen matter which can be transmitted into drinking water. The results of the monitoring have revealed a 75% increased load of standing water bodies in NE Slovenia. To reduce the risk and load a proper use of synthetic fertilizers and unprocessed manure should be promoted. Sediments in water accumulations are also a dangerous source of toxins. Therefore, it is imminent to detect which rivers (if any) are safe for dam construction.

In addition to organic and chemical contamination the changes of the aquatic environment, which include inappropriate construction of water objects, channeling and riverbed regulation, energy recovery and dam construction, water flow diversions, non-native species inclusion etc. are even more alarming. Almost all impacts are Slovenian reality. Therefore, the evaluation of the aquatic environment is becoming more challenging. We are no longer only striving to achieve satisfactory water quality, but a good ecological status of most water bodies with the exception of those, which have been heavily modified in the past. These are large regulated rivers in major cities, channeled water for the purposes of flood protection, etc. In Europe, up to 40% of all rivers are heavily hydro-morphologically modified.

We are also faced with low levels of different synthetic chemical compounds. These are accumulated in the organisms (including humans) and the dose results in hazardous effects. Such slightly contaminated water kills slowly but surely. These compounds include endocrine disruptors and studies have shown extremely complex environmental and health problems in our country. They are transmitted from the plastic bottle, which represents a new source of these compounds in landfills, which may enter the aquatic environment.

Non-native species also represent a major problem and many have become invasive. Rainbow trout was introduced into Slovenian waters and the population of brown trout drastically decreased. Asian cyprinids are also frequent in our waters as they are economically interesting. A few years ago the zebra mussel (*Dreissena polymorpha*) was “discovered” in Lake Bled and the publicity was very active, but nothing was really done about its population.

I often question Slovenian mentality in terms of environmental and water protection. Surveys show that 90% of people are concerned about the fate of the planet and drinking water in the future. The reality is quite different. How can we otherwise understand illegal dumps,

pouring the slurry, excessive use of fertilizers and protective agents, unnecessary use of drinking water, the introduction of non-native species and needless purchases of water in plastic bottles, where good-quality tap water is ensured?

We need a good water management and evolve a respect for aquatic environments. The generally assumed mantra of sustainable development is characterized by hypocrisy, which states that we only want good for the planet. However, we are mainly interested in our personal survival and stand to wonder whether enough good quality water can be ensured for posterity and floods and droughts can be avoided. But if there is no natural water and no aquatic organisms we too cannot endure.

Key words: Water Ecosystem, Monitoring, Running Waters, Ecological Status, Slovenia

---

Monitoring vodnih ekosistemov in stanje tekočih voda v Sloveniji z ekološkega vidika

Povzetek

Vodo pogosto razumemo le kot dobrino za človeštvo in ne tudi kot življenjski prostor vodnim organizmom, torej vodni ekosistem. Slovenija je vodnata država, kar 28.000 km vodotokov imamo, mnogi pa niso več naravni. Veliike količine vode ne pomenijo tudi dobre kakovosti še manj dobrega ekološkega stanja.

Velik del slovenskih vodotokov ima hudourniški značaj s spreminjajočim vodostajem, zato so pogosto poplave. Vodna okolja onesnažujejo izpusti odpadnih vod iz industrije in naselij ter razpršeno onesnaženje z urbanih in predvsem kmetijskih površin. Čistimo manj kot 50% vseh odpadnih voda. Slovenske reke imajo visoko samočistilno sposobnost, zato je stanje glede na stopnjo onesnaževanja relativno dobro.

Drugače je pri jezerih, akumulacijah in rečnih zajezitvah, v katerih se voda zadržuje. Prevelika vsebnost organskih snovi povzroča pomanjkanje kisika in pogine organizmov, velika vsebnost hranil pa cvetenje (evtrofikacijo). Nevarna so cvetenja cianobakterij, ki izločajo mikrocistine, kancerogene snovi, ki lahko zaidejo tudi v pitno vodo. Na osnovi monitoring vemo, da je pri nas tako obremenjenih kar 75 % stoječih vodnih teles v severo vzhodni Sloveniji. Zmanjšanje nevarnosti je v ustrezni rabi umetnih hranil in nepredelane gnojevke. Vir strupov so tudi usedline v rečnih akumulacijah, zato je zelo pomembno, katere reke in če sploh lahko zajezimo.

Danes je poleg organskega in kemijskega onesnaženja še bolj zaskrbljujoče obremenjevanje vodnega okolja, ki vključuje neprimerne gradnje vodnih objektov, kanaliziranje in reguliranje strug, energetsko izrabo in gradnjo jezov, preusmerjanje vodnih tokov, vnašanje tujerodnih vrst ipd. Skoraj vse našteto je tudi slovenska realnost. Zato je danes vrednotenje vodnega okolja bolj zahtevno. Ne govorimo več le o kakovosti vode, ampak o ekološkem stanju vodnih teles. Cilj je, da v vseh vodotokih dosežemo dobro ekološko stanje, razen v tistih, ko so bili močno preoblikovani. Takšne so velike regulirane reke v večjih mestih, kanalizirane struge za namene varstva pred poplavami ipd. V Evropi je hidro morfološko močno spremenjenih kar 40% rek.

Soočamo pa se tudi z različnimi sintetskimi kemijskimi snovmi v zelo nizkih koncentracijah. Pojavlja se problem doze v telesih organizmov, tudi človeka in posledičnih nevarnih učinkov. Takšna, malo onesnažena voda ubija počasi, vendar zanesljivo. Med te snovi sodijo motilci endokrinega sistema. Raziskave so potrdile, da so te snovi izjemno kompleksen okoljski in zdravstveni problem tudi pri nas. Spijemo jih s kozarcem vode iz plastenke, plastenka na odlagališču pa je nov vir teh snovi za vodna okolja.

Nič manjša nevarnost so tujerodne vrste, marsikje že invazivne. Ameriške postrvi smo naselili v slovenske vodotoke in zdesetkali populacijo potočne postrvi, azijske krapovce vlagamo, ker prinašajo dober posel. Ko smo pred leti »odkrili« školjko trikotničarko v Blejskem jezeru, so o tem govorili in pisali vsi mediji zgodilo pa se ni nič.

Pogosto si zastavljam vprašanje, kakšna je okoljska miselnost in varovanje voda v Sloveniji. Ankete kažejo, da je 90% prebivalcev zaskrbljenih z usodo planeta in pitno vodo v prihodnje. Realnost je precej drugačna. Kako sicer razumeti črne deponije, razlivanje gnojevke, pretirano rabo umetnih gnojil in zaščitnih sredstev, prekomerno rabo pitne vode, vnašanje tujerodnih vrst in nepotrebne nakupe vode v plastenkah, ko nam iz pipe teče kakovostna pitna voda.

Potrebujemo dobro gospodarjenje z vodo in spoštovanje vodnih okolij. Splošno prevzeta mantra o trajnostnem razvoju je značilno sprenevedanje, da želimo dobro planetu. Zanima nas predvsem naše preživetje, sprašujemo se ali bo dovolj kakovostne vode za zanamce in ne bo poplav in suš. Toda če ne bo naravnih voda, ne bo vodnih organizmov, če ne bo kakovostnih vodnih virov, tudi nas ne bo.

Ključne besede: vodni ekosistemi, monitoring, tekoče vode, ekološko stanje, Slovenija

Introduction

Water should be understood as a medium with specific physical and chemical properties and therefore unique liquid. Chemical compounds define chemical status of water and enable metabolic activities. Life in the planet Earth depends on water feature.

Water creates water bodies, water ecosystems (Toman, 2007). Organic and nutrient cycling maintains water ecosystem and diversity of organisms which represent different and for each water body specific community. Running and standing waters are special in their physical, chemical and biological properties therefore, the effects of pollution are different. High nutrient level, e.g. nitrogen and phosphorous cause eutrophication mainly in standing waters, high contents of organic compounds causes oxygen depletion or even anoxia in running waters. Running waters, e.g. brooks, streams, rivers characterized by water flow, water velocity, type of substrate, habitats and biocoenosis and influence of catchment area. The results of such characteristics are different self-purification efficiency.

Running water is dynamic, four dimensional system. Biological, chemical and physical properties are influenced by lateral impacts (land – water interaction), longitudinal changes, vertical connection define the quality of groundwater and temporal scale. River regulations, dam's construction or channelization strongly effect and change the running water system. Flooding zone might be the most important for lateral impacts and for flood protection.

Organisms in lakes, reservoirs, ponds are mainly influenced by light and temperature changing. Light define photic and aphotic zone, temperature determine thermal stratification pattern in temperate climate. Biocoenosis is different; the most important is plankton community in open water environment.

Water ecosystems are recipients getting matter and energy from terrestrial ecosystems and from the atmosphere. Forest stream depends on organic matters from forest and ions from the land. Farm land providing nutrients, chemicals and different toxicants which could be lethal for stream biocoenosis. 80% of pollution is terrestrial origin; the most uncontrolled impacts include dispersed chemical pollution from agriculture. Significant influence has household wastes, deforestation, industry, livestock and transports. We must not forget so called loading which include different physical changes in water courses (regulations, dams, channelization, river reservoirs and water abstraction) and also alien species which could become invasive (Toman et al., 2015). Different invertebrate species and mainly fish are the most common invasive species.

Ecological Status in Slovenian Rivers

After adoption of Water Framework Directive 2000/60/ES biological elements for assessment became the main part of ecological status of rivers. It includes species composition and number of individuals of aquatic vegetation (phytobenthos and macrophytes), benthic invertebrates and fish (species and age structure of individuals) (Toman, 2007). In the past we used so called saprobic system, rivers were separate in four quality classes, chemical, microbiological and biological assessment have equal weight. Up to date methodology together with biological elements used assistant elements such as hydro-morphological characteristics, chemical and physical data and specific pollutants. Each EU member state develops its own system of assessment of ecological status of running waters. Slovenian methodology is prepared, except fish as monitoring element.

As mentioned before pressures on river ecosystems are different and include hydro-morphological alterations, organic pollution, eutrophication and toxic substances. 65% of hydro-morphological pressure is moderate, 22% negligible and 13% significant. It is worrying that for more than 50% of organic pollution, eutrophication and toxic substances we do not have any data; therefore water system management is not good enough. Nutrients, heavy metals, phyto-pharmaceutical matters, endocrine disruptors causing chronical effects. I believe that we are not ready for such pressures. The only way is change of agriculture practices and our way of life.

Lowland rivers and standing waters in SE Slovenia are mainly influenced by nutrients which cause eutrophication and by substances for plant protection which chronically effect aquatic life. Example is cyanobacteria toxic blooms which is source of neurotoxins in eutrophic waters and presents a serious risk for ground water quality and consequently for our health.

Many of toxic substances, mainly low concentrations of heavy metals (Horvat et al., 2005, Žižek et al, 2011), endocrine disrupting contaminants (Plahuta et al., 2015) and finally alien species (Toman, 2014) do not affect the current ecological status of rivers or water environment as a whole. They killed slowly and have chronical effects not only for the aquatic life but also for the human beings. We are still lack of suitable monitoring system for "modern" pollutants such as endocrine disrupting compounds bisphenol A but it is our reality now. Such compounds are release into aquatic environment also from sewage treatment plants, so classical water treatment is not enough. They affect development, growth and reproduction rate of wildlife populations. Chronical toxicity tests confirm growth rate inhibition, changes in feeding behavior, pigmentation of animals, molting rate in crustatians and in some animals changes in reproduction rate and sex change. I understand such threats as a key stone for our new water resources management.

Last final report (March 2016) of ecological status of rivers and lakes in Slovenia from biological (macroinvertebrates and macrophytes), hydro-morphological and chemical point of view, summarizes monitoring data of selected Slovenian running waters (Germ, 2016). Comprehensive review is not possible. We have ecological status from bad to very good; conclusion about necessary measures is not part of the report. We only could conclude that about 60% of Slovenian water courses are in good water status. Is this true?

References

Germ, M. et al, 2016: Izvajanje monitoring ekološkega stanja rek in jezer v letu 2015 z bentoškimi nevretenčarji in makrofiti. Končno poročilo, UL, Biotehniška fakulteta, pp. 114, Ljubljana.

Brilly, M., Toman, M. J & Rusjan, S., 2005: Monitoring the impacts of urbanization on the ecological state of river water bodies in the Gradaščica catchment. - In: Maraga, F. & Arattano, M. (eds.) *Progress in surface and subsurface water studies at the plot and small basin scale : 10th Conference of the Euromediterranean network of experimental and representative basin (ERB),* 13 - 17 October 2004, Turin, Italy. *pp.* 41 - 52.

Horvat, M., Naglič, M., Stergaršek, J., Kotnik, J., Fajon, V., Gibičar, D., Žižek, S. & Toman, M. J., 2005: Mercury, methylmercury and selenium in muscle, liver and gills of the fish from the river polluted due to past mercury mining. – In: *Abstracts book*, ICH Net, XIII International Conference on Heavy Metals in the Environment, June 05 - 09, 2005, Rio de Janeiro, Brazil. pp. 444 - 448.

Toman, M. J., 2007. Vrednotenje vodnih ekosistemov. -In: Bukovec, N. (eds.) *Med-predmetno povezovanje v naravoslovju: monografija za učitelje naravoslovnih predmetov*, (Projekt Partnerstvo fakultet in šol). Ljubljana, Fakulteta za kemijo in kemijsko tehnologijo, 2007, pp. 20 - 25.

Toman, M. J., 2008: Vodni ekosistemi - struktura in funkcija (Freshwater ecosystems - structure and function). -In: Strgulc-Krajšek, S. & Vičar, M. (eds.) *Ekosistemi - povezanost živih sistemov, Proceedings Ecosystems - interdependence of living systems,* Zavod RS za šolstvo, 2008, Ljubljana, pp. 50 - 56.

Plahuta, M., Tišler, T., Pintar, A. & Toman, M. J., 2015: Adverse effects of bisphenol A on water louse (*Asellus aquaticus*). - Ecotoxicology and environmental safety. 117, 81 -88.

Toman, M. J., Plotnikov, I., Aladin, N. V., Micklin, P. & Ermakhanov, Z., 2015: Biodiversity, the present ecological state of the Aral Sea and its impact on future development. -*Acta Biologica Slovenica*, 58, 1, 45 - 56.

Toman, M.J., 2014 : *Prisotnost in številčnost ter stopnja invazivnosti školjke Dreissena polymorpha v Blejskem jezeru.* - Project report, Biotechnical Faculty UL, Ljubljana, pp.30.

Žižek, S., Milačič, R., Kovač, N., Jaćimović, R., Toman, M. J. & Horvat, M., 2011: Periphyton as a bioindicator of mercury pollution in a temperate torrential river ecosystem. -*Chemosphere*, 85, 5, 883 - 891.

QUO VADIS PHOTOVOLTAICS – CONTRIBUTION TO SUSTAINABILITY AND REPOWERING OF EUROPE

Prof. Dr. Marko Topič, marko.topic@fe.uni-lj.si
Chairman of the European Technology and Innovation Platform Photovoltaics, Faculty of Electrical Engineering, University of Ljubljana

Abstract

Energy has become one of the grand challenges that Europe is currently facing. The way energy is produced and used has a major impact on our economy, environment and society as a whole. All major future energy scenarios forecast a key role for photovoltaic solar energy (PV). PV has a huge European and global potential, making it an important building block for a secure and sustainable energy system. Further, the COP21's overarching goal from Paris last year to reduce greenhouse gas emissions and to limit the global temperature increase clearly showed that expectations for PV are high. Photovoltaics already proves that through intensive R&D PV deployment could be accelerated by further enhancing light-to-power conversion efficiency, and reducing PV module and system prices as well as grid-integration bottlenecks.

Keywords: Photovoltaics, Sustainability, Energy.

Quo vadis fotovoltaika – prispevek k trajnostnem razvoju in energetiki Evrope

Povzetek

Energija, predvsem prevelika energijska odvisnost, je postala ena izmed velikih izzivov za Evropo. Energetika ima ogromen vpliv na našo ekonomijo, okolje in družbo kot celoto. Vsi scenariji o prihodnosti energetike napovedujejo ključno vlogo izkoriščanja sončne energije s fotovoltaiko na čelu. Fotovoltaika ima ogromen potencial tako v Evropi kot v svetu in bo sestavni del varne in trajnostne oskrbe z električno energijo. V luči zastavljenih ciljev 21. konference pogodbenic okvirne Konvencije OZN o spremembi podnebja (COP21) so pričakovanja za fotovoltaiko velika. Skozi intenzivne raziskave in razvoj fotovoltaika že dokazuje, še bolj pa obeta, da bo z nadaljnjim povečevanjem učinkovitosti pretvorbe, zmanjševanjem stroškov gradnikov fotonapetostnih sistemov in zmanjševanjem omejitev pri integraciji v omrežje uresničila pričakovanja.

Ključne besede: fotovoltaika, trajnostni razvoj, energija.

Introduction

Energy has become one of the grand challenges that Europe is currently facing. The way energy is produced and used has a major impact on our economy, environment and society as a whole. Europe imports more than half of energy from abroad. In 2004 the share was below half (47,4 %), but energy import and energy dependency has increased in the last ten years (53,8 % in 2011). EU-28 spent 548 bn EUR (4,2 % of GDP) for the energy import. Although the current low prices of oil and natural gas are drivers for recovery of our economy, it is a risk that needs to be resolved. According to the European Environment Agency and their technical report on Cost of air pollution from European Industrial facilities the cost of damage to health and the environment in monetary terms from air pollution released in the years 2008 to 2012 by industrial facilities is huge and calls for action (European Energy Agency, 2014). The major pollutants are power-generating facilities, mainly fueled by coal/lignite and located predominantly in Germany and Eastern Europe. Damage costs 2008-2012 normalized to gross domestic product are the highest in Bulgaria, Romania, Estonia, Poland and Czech Republic. Therefore, a transition to sustainable future is a must. The transition to sustainable energy sources is not only a viable option, but socially desirable economic opportunities can be harvested by integrating the sustainable energy issue with other important enablers of our society such as ICT, the urban agenda, living and transport.

All major future energy scenarios forecast a key role for photovoltaic solar energy (PV)(IEA PVPS, 2016). PV has a huge European and global potential, making it an important building block for a secure and sustainable energy system. Further, the COP21's overarching goal from Paris last year to reduce greenhouse gas emissions and to limit the global temperature increase clearly showed that expectations for PV are high.

Current Status of Photovoltaics

The PV sector has gone through decades of growth and development. Economy of scale has decreased the prices enormously (Fig. 1 – pay attention to the log-log plot) and is now ready to serve as one of the major building blocks of a sustainable energy system. However, PV has just reached 1% of global electricity supply and has harnessed only a small fraction of its vast potential.

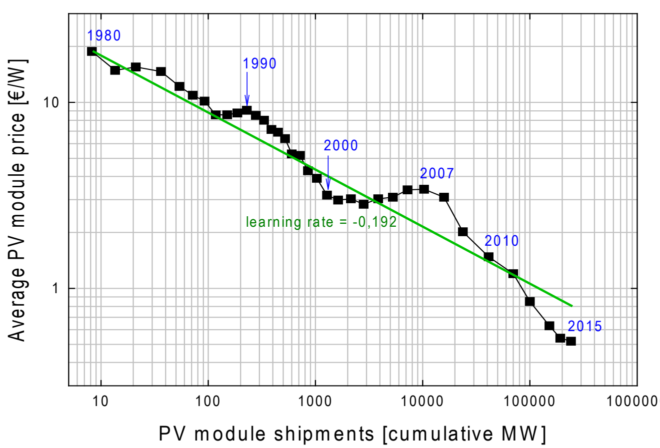


Fig. 1: *Learning curve of photovoltaic module price.*

The global photovoltaic industry faces three trends moving in parallel. Firstly, production costs and market prices are decreasing, secondly, the average efficiency of PV modules is continuously increasing and finally, reliability of PV components is further improving, with lifetimes of PV modules to be extended from 25 years towards 40 years and more.

The average PV module price worldwide dropped dramatically over the last decade (Fig. 1). On one hand due to economy of scale, excess capacity, oversupply and lower demand caused by less favorable feed-in tariffs and, on the other hand, due to fierce competition. According to GreenTechMedia (Kinsey, 2016), the average price in last two years slipped from 0.63 €/W in December 2013 to 0.52 €/W in December 2015, which equates to a 17% drop driven by reducing production costs in China, where about 70% of global production is made. This reduction affects all aspects across the PV value chain, from raw silicon to PV modules. Similar trends are observed in prices of thin-film PV modules.

At the same time, the average efficiency of PV modules is increasing across all technologies, starting with multicrystalline PV modules whose average efficiency is about 16%. It is the most widespread technology in use with a 55% share of the PV market in 2015, followed by monocrystalline (36%) and thin-film technology (9%). In 2015, SunPower (USA) announced that it was ready to sell PV modules with 22% efficiency (made of interdigitated back contact monocrystalline silicon solar cells), while Panasonic (Japan) announced that it had achieved record efficiency of 23.8% for a monocrystalline silicon PV module using its HIT(R) cell technology (modules' average efficiency of 19%). First Solar (USA) made a new champion thin-film CdTe PV module (18.6% efficiency whereas the average efficiency in production is 16%).

Table 1. *Progress of installed PV power plants (in MW) connected to the grid in EU-28 member states.*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Germany	1.910	3.063	3.846	6.019	9.959	17.370	24.875	32.698	36.402	38.408	39.763
Italy	46	58	120	458	1.157	3.478	12.764	16.361	18.065	18.622	18.924
United Kingdom	11	14	19	23	30	75	1.014	1.657	2.782	5.380	8.918
France	26	33	47	104	335	1.054	2.831	4.027	4.625	5.699	6.578
Spain	58	118	733	3.421	3.438	3.808	4.214	4.516	4.766	4.872	4.921
Belgium	2	4	22	71	574	787	1.812	2.649	3.040	3.140	3.228
Greece	5	7	9	19	55	205	631	1.543	2.585	2.603	2.613
Czech	0	1	4	55	463	1.953	1.959	2.022	2.064	2.067	2.083
Netherlands	51	51	53	57	68	97	118	321	739	1.048	1.405
Romania	0	0,2	0,3	0,5	0,6	2	2,9	49	1.022	1.293	1.325
Bulgaria	0	0	0,8	1	6	17	132	933	1.019	1.020	1.021
Austria	24	29	27	32	53	103	173	421	631	785,2	935,3
Denmark	3	3	3	3	5	7	16	391	572	602	782,5
Slovakia	0	0	0	<0,1	0,2	144	488	517	588	590	591,1
Portugal	3	4	18	68	102	131	143	228	303	423	460
Slovenia	0,2	0,4	1	2	9	36	90	217	248	256	257,4
Hungary	0,2	0,2	0,4	0,5	0,7	2	4,1	3,7	35	77,7	137,7
Sweden	4	5	6	8	9	10	18	23	43	79	130
Luxembourg	24	24	24	25	26	27	30	76	95	110	125
Poland	0,3	0,4	0,6	1	1	2	1,8	3,4	4,2	29,9	86,9
Malta	0,1	0,1	0,1	0,2	2	2	11	18	28	54	73,2
Lithuania	0	0	0	<0,1	<0,1	0,1	0,1	6,1	68	68	73,1
Cyprus	0,5	1	1	2	3	6	10	17	35	65	69,5
Croatia	0,5	1,2	3,2	5,6	12	16	16	20	20	34,2	44,8
Finland	4	4	5	6	8	10	11	11	11	11,2	14,7
Estonia	0	0	0	<0,1	<0,1	<0,1	0,2	0,2	0,2	0,2	4,1
Ireland	0,3	0,3	0,4	0,4	0,6	0,6	0,7	0,7	1	1,1	2,1
Latvia	0	0	0	<0,1	<0,1	<0,1	1,5	1,5	1,5	1,5	1,5
EU-28 Cummulative	**2.170**	**3.420**	**4.940**	**10.380**	**15.860**	**29.330**	**51.360**	**68.640**	**79.790**	**87.340**	**94.570**
EU-28 Annual		**1.250**	**1.520**	**5.440**	**5.480**	**13.470**	**22.030**	**17.280**	**11.150**	**7.550**	**7.230**

Table 1 shows the progress of installed PV power plants connected to the grid in European Union (EU) (Eurobserv΄er, april 2016). In EU, the largest amount (22 GW) of photovoltaics systems were installed and connected to the grid in 2011 and the turnover of the European PV market amounted to approximately €36 billion. Since then the market calms down with approximately 7 GW installed PV systems annually. Germany reached the far largest deployment (40 GW) followed by Italy

(19 GW), UK (9 GW), France, Spain etc. Germany and Italy also lead in the PV power installed per inhabitant (490 and 311 W/inhabitant, respectively) and at the very end of the PV deployment by the end of 2015 are Poland, Latvia and Ireland (Fig. 2). The average of installed PV power in EU is 186 W/inhabitant.

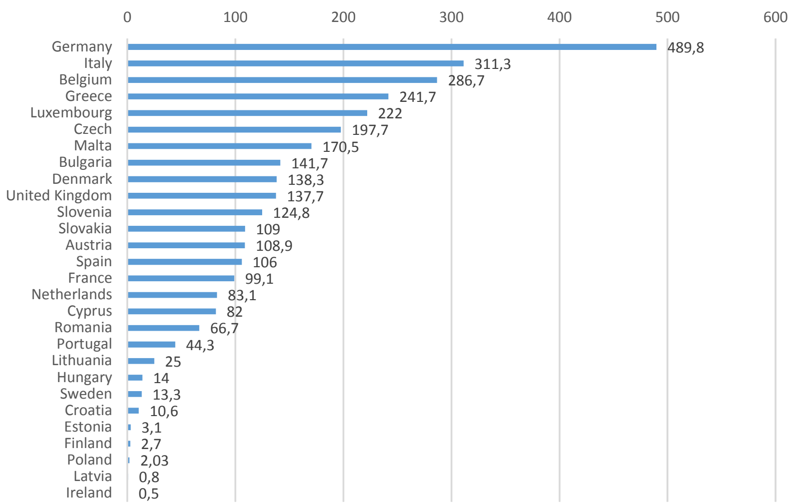


***Fig. 2:** Photovoltaic capacity per inhabitant for each EU member state in 2015 (Eurobserv΄er, april 2016).*

We can conclude that in several European countries PV already provides more than 5% of the annual electricity demand, a level originally anticipated to occur only after 2020. On the other hand, PV has not taken off in few member states yet.

Globally, 2015 has seen an impressive growth and acceleration of the global market deployment with about 50,7 GW of additional installed capacity, 26,5% above 2014. In total, cumulative amount of installed PV power by the end of 2015 reached 242 GW, which is only a small fraction of its vast potential.

Outlook

Based on current market trends, Solar Power Europe (2016) estimates that PV has the potential to meet 8% of the EU electricity demand in 2020 and 15% in 2030. If achieved, this would result in a considerable contribution to the reduction of CO2 emissions, since the carbon footprint of PV systems is at least 10 times lower than that of fossil fuel-based electricity, with no CO2 emissions during operation.

For a fair comparisons with electricity prices and the cost of other power generation technologies, the concept of Levelised Cost of Electricity (LCOE) is widely used. Although it does not cover hidden external costs (such as decommissioning of power plants), it is a valuable key performance indicator for power generation technologies. With significant decrease in prices of PV power plants, the cost of photovoltaic (PV) electricity has decreased dramatically over the past years. Parity with retail electricity and oil-based fuels has been reached in many countries and market segments and wholesale parity is approaching in several markets.

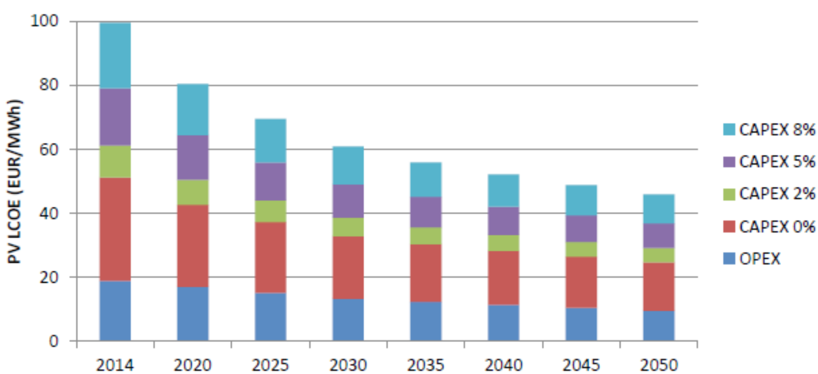


Fig. 3: *PV LCOE evolution for a ground-mounted system in Munich, Germany for three different weighted average cost of capital (WACC) rates.*

According to the study of the European Photovoltaic Technology Platform (Vartiainen, Masson, Breyer, 2015) we can anticipate that the PV module price will most likely to be halved again and balance of system (BoS) price will decrease by more than 35% by 2030, leading to an overall PV system CAPEX reduction of about 45%. The anticipated development does not require any major technology breakthroughs but is a natural cause from continuing efforts in reducing materials use, mastering manufacturing processes and improving PV device efficiency. At the same time, PV system OPEX is expected to decrease by 30%. PV LCOE will decrease by 30-50% from 2014 to 2030, depending on the volume growth and learning rate.

Research, development and innovation are key enablers for successful continuation of the EU being at the forefront of the PV global sector and hence, to be able to seize the great economic opportunities associated with its growth in European and global markets. PV deployment could be accelerated by further enhancing light-to-power conversion efficiency, and reducing module and system prices as well as grid-integration bottlenecks. After a difficult period in the PV industry over the past few years, we may expect a strong revival in the coming period. The sense of urgency for innovation is felt more than ever and global market conditions are improving. This also implies a huge challenge for the photovoltaic community.

References

Costs of air pollution from European industrial facilities 2008–2012 — an updated assessment, European Energy Agency, 2014 (ISBN 978-92-9213-495-2).

IEA PVPS TRENDS 2016 IN PHOTOVOLTAIC APPLICATIONS, 2016 (ISBN 978-3-906042-45-9), http://iea-pvps.org/index.php?id=256, last access 6 Nov 2016.

http://www.greentechmedia.com; e.g. Geoffrey Kinsey, The Perils of PV Price Prediction, https://www.greentechmedia.com/articles/read/the-perils-of-pv-price-prediction, last access 6 Nov 2016.

PHOTOVOLTAIC BAROMETER – **EUROBSERV'ER** – APRIL 2016, http://www.eurobserv-er.org/pdf/photovoltaic-barometer-2016-en/, last access 6 Nov 2016.

Solar Power Europe web page: http://www.solarpowereurope.org/insights/new-global-market-outlook-2016/, last access 6 Nov 2016.

Eero Vartiainen, Gaëtan Masson, Christian Breyer: "PV LCOE in Europe 2014-2030, Final Report", European Photovoltaic Technology Platform, 2015. http://www.etip-pv.eu/index.php?eID=tx_nawsecuredl&u=0&g=0&t=1478697810&hash=20a35f250a2ab205699205bba3ec8e828809c09f&file=fileadmin/Documents/FactSheets/English2015/PV_LCOE_Report_July_2015.pdf, last access 6 Nov 2016.

EFFICIENT ENERGY SUPPLY FOR HEATING AND COOLING

Prof. Dr. Alojz Poredoš, alojz.poredos@fs.uni-lj.si
Faculty of Mechanical Engineering, University of Ljubljana

Abstract

Forecasts of achieving energy- climate targets 3x20 in the European Union show the effectiveness of policy implementation in this field. Some problems occur only in the reduction of primary energy consumption. For heating and cooling of buildings we use nearly half of all primary energy. On the other hand more than 70% of the electrical energy is produced from fossil fuels, whereby only one third of the primary energy is used, but two thirds of it is wasted in form of heat. There are enormous opportunities to use this excess heat for heating and cooling, thereby reducing primary energy use and emissions. This could easily be achieved or exceeded set targets of energy efficiency.

In this paper a comparison of the energy efficiency of different energy supply systems for heating and cooling is presented. Highlighted are the possibilities of increasing the efficiency of existing energy systems. Recommendations for the development of energy systems in new urban environments are given. Indicated are the advantages of district energy systems, as district heating and cooling in comparison with local, inefficient devices. Represented is a new concept of decentralized energy supply in urban areas in sense of Smart and Low carbon cities.

Keywords: Energy supply, heating, cooling

Učinkovita energetska oskrba za ogrevanje in hlajenje

Povzetek

Prognoze doseganja energetsko podnebnih ciljev 3x20 v Evropski uniji kažejo na uspešnost izvajanja politike na tem področju. Nekaj težav se pojavlja pri zmanjševanju rabe primarne energije. Za potrebe ogrevanja in hlajenja stavb porabimo skoraj polovico vse primarne energije. Po drugi strani pridobivamo več kot 70% električne energije iz fosilnih goriv, pri tem pa izkoristimo samo eno tretjino primarne energije, dve tretjini pa je zavržemo v obliki toplote. Tukaj so ogromne priložnosti, da izrabimo to odvečno toploto za ogrevanje in hlajenje in s tem zmanjšamo rabo primarne energije ter tudi emisije. S tem bi zlahka dosegli oziroma presegli zastavljene cilje energetske učinkovitosti.

V prispevku je prikazana primerjava energetske učinkovitosti različnih sistemov oskrbe z energijo za ogrevanje in hlajenje. Izpostavljene so možnosti za dvig učinkovitosti obstoječih energetskih sistemov. Podana so tudi priporočila za razvoj energetskih sistemov v novih urbanih okoljih. Pokazane so prednosti daljinskih energetskih sistemov, kot je to daljinsko ogrevanje in daljinsko hlajenje v primerjavi z lokalnimi, neučinkovitimi napravami. Prikazan je nov koncept decentralizirane energetske oskrbe v urbanih področjih za pametna in nizko ogljična mesta.

Ključne besede: Energetska oskrba, ogrevanje, hlajenje

Introduction

Energy supply to consumers for heating and cooling is essential to ensure basic living comfort for citizens and to enable undisturbed production in the industry. Thermal energy can be supplied to end users from different energy sources, using different technologies for heat and cold production. A variety of systems exist, ranging from small decentralized applications, micro and small cogeneration units, heat pumps and individual solar thermal collectors. In urban areas, large-scale industrial boilers and furnaces, and large centralized generation (CHP) units provide heat for district heating networks.

District energy systems provide a comprehensive supply of energy to consumers with different types of energy. District heating systems have been used world-wide for a long period of time. On the other hand district cooling systems are not yet well established in Europe. A number of such systems exist in North America. Some examples of district cooling can also be found in the Scandinavian countries, in France and Germany. An increase in the standard of working and living conditions is inevitably connected with cooling as the part of air-conditioning systems. Cooling is frequently provided with partial solutions, for example by installing small electrically driven air-conditioning units on windows. In most of the cases, such devices are air cooled and over-dimensioned for the rooms they are cooling. Moreover they often use environmentally unfriendly refrigerants. This results in a higher and uncontrolled consumption of electric energy, especially during the period of the peak cooling demand. In contrast, during the summer, co-generation systems are experiencing problems with low heat and electricity production as a consequence of low district heat consumption. Since the systems are designed for heating of buildings in the winter, the very low heat demand in the summer period decreases the cogeneration's efficiency. A possible solution to both of these problems is the introduction of a trigeneration system for the simultaneous production of electricity, heat and the cooling energy. The latter is in this case produced by absorption chillers and serves a district cooling system (Spur, 1996; Kitanovski, 2000).

3x20 EU Energy Package

The package consists of three targets:

1. 20% reduction of primary energy consumption
   (energy efficiency) 8% -2013

2. 20% renewables (RES) in energy supply
   (SLO goal 25%) 15% -2013
3. 20% reduction of greenhouse gas emissions 17% -2013

Analyses of the short term targets show that we are on good track to reach 20% of RES and to decrease gas emissions for 20%. However we face some problems regarding the decrease of the primary energy use and related decrease of its consumption for 20% compared to projections. The main reason for this problem can be shown in the Figure 1. As can be seen from the Figure 1, European Union did not consider these obligations seriously until the 2008. As the consequence, the consumption even increased in the period from 2000-2008. There were many different measures to change this trend. Among those, the most important was the Energy Efficiency Directive in 2012, based on the National Energy Efficiency action plans.

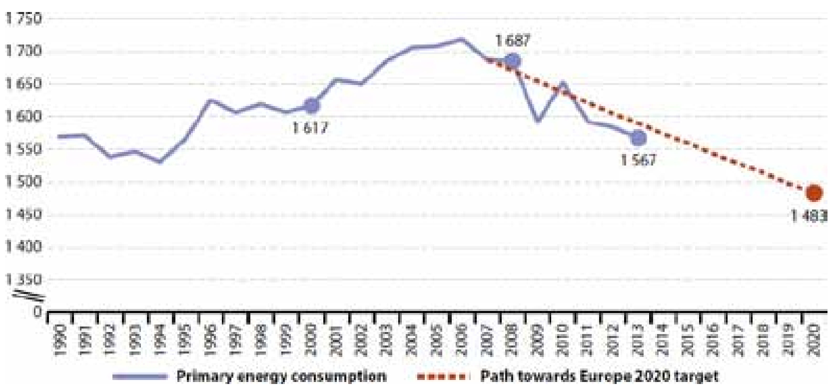


Fig. 1: *EU energy efficiency trends (Communication from the Commission to the European Parliamanet and the Council, 2014)*

Energy for Heating and Cooling

Energy consumption for heating and cooling in buildings and industry comprises close to half of the energy produced and used in the

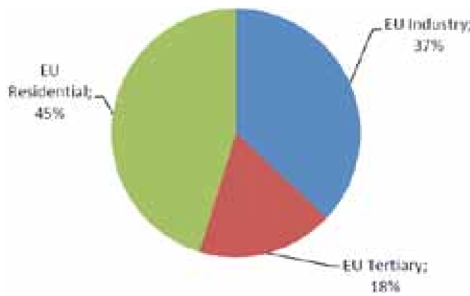


Fig. 2: *Final energy consumption for heating and cooling- share per sector (Commission staff working document, 2016)*

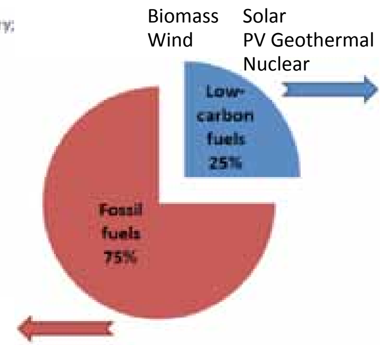


Fig. 3: *Energy sources for heating and cooling (Commission staff working document, 2016)*

European Union (Figure 2). This sector represents a large potential for increase of the energy efficiency in the EU and to accomplish the objectives of saving 20 % of the primary energy consumption by 2020. Moreover the development of a strategy for efficient and sustainable heating and cooling is a priority in order to reach climate and energy goals by 2050.

Figure 3 shows that we still use 75% of the energy for heating and cooling from fossil fuels. Therefore it is very important to look for efficient energy conversion, transmission (distribution) and end use of energy for heating and cooling.

On the other hand we can see how inefficient the global electricity production (Figure 4) is. According to IEA, 2/3 of primary energy from fossil fuels is wasted in conversion. This surplus energy is actually heat, which can be used for heating and also for cooling. We must find the way how to avoid loosing of so much primary energy. Also for heating and cooling we must use available energy at first. A small part of such energy is already used. There is still a big potential. District energy systems, i.e. district heating and district cooling, enable use of surplus heat. Such kinds of systems transfer heat energy from combined heat and power (CHP) systems to end users. There is still a significant potential for reduction of the primary energy consumption for heating and cooling.

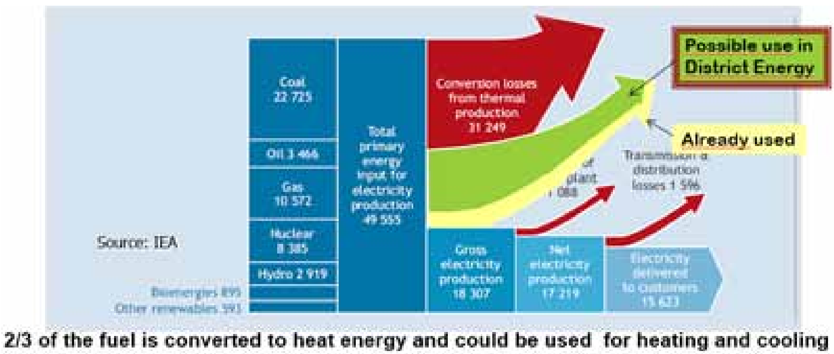


Fig. 4: *Energy Flows in the Global Electricity System –TWh.*

District Energy Supply for Heating and Cooling

One of the most efficient ways of the energy supply for heating and cooling is trough district energy systems. These systems provide a reliable supply to consumers with heat and cold (Figure 5). In district energy systems, we can use heat directly for heating. However there are also cooling technologies which enable the use of heat for the cold production. Not only residential and commercial buildings can use this heat for cooling. Surplus heat can be efficiently used also for heating and cooling in industry. In such a way we can save a lot of additional primary energy.

District heating systems have been broadly applied in the world. On the other hand the district cooling systems are not yet well established. However, one may observe an intensive development in recent years. District heating can utilize also renewable sources like biomass, geothermal and solar thermal energy, waste heat and the municipal waste. Highly efficient combined heat and power systems can operate successfully only in a combination with district heating systems.

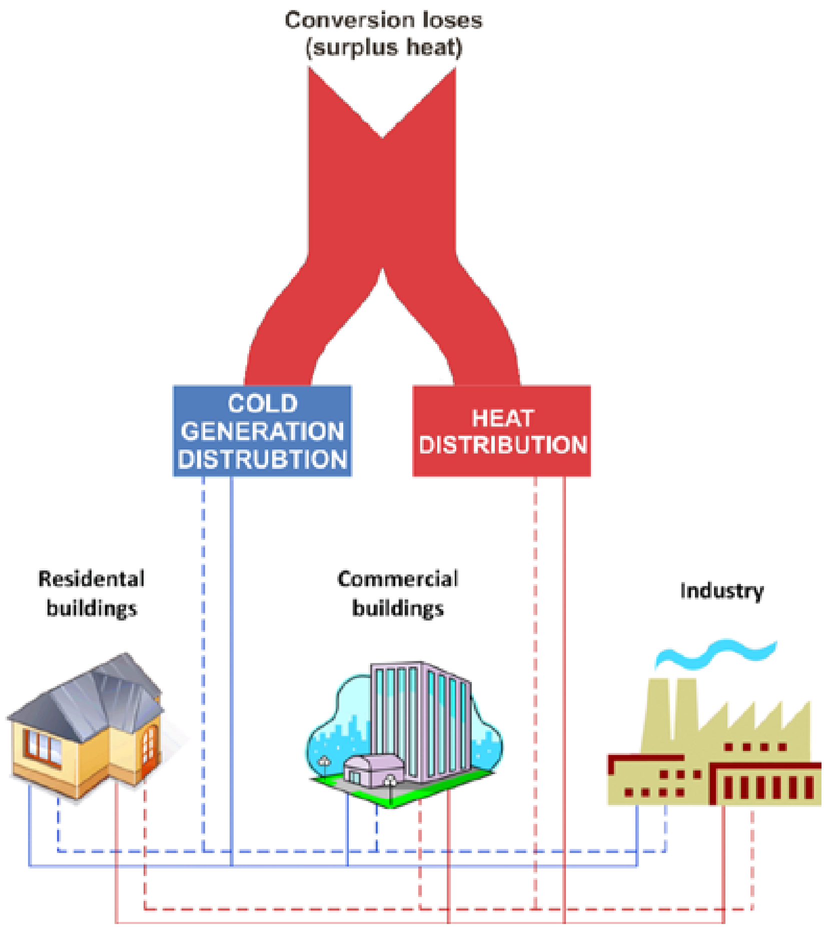


Fig. 5: *District energy system*

While energy use for heating decreased significantly in the last decade due to a number of energy efficiency related measures, energy use for cooling is increasing by significantly. More cooling energy is demanded in order to ensure the standard of working and living conditions. In summer, heat from the cogeneration plants (CHP) is mostly used for heating of the sanitary hot water or for some industrial processes and the production load is much lower than in winter. The solution to increase both energy and economic efficiency is by the introduction of a trigeneration system, which refers to a simultaneous production of electricity, heat and cold. The cooling energy in this case is provided by the application of the heat driven absorption chillers but also in their combination with electrically driven chillers.

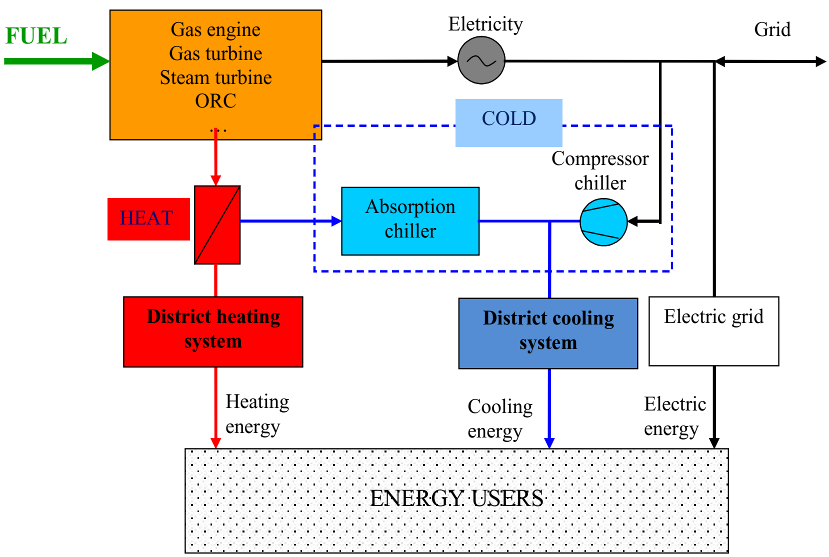


Fig. 6: *Trigeneration system*

From trigeneration system we can supply consumers with all 3 energy products: electricity, heating and cooling energy. In more advanced trigeneration systems, both heat driven and electricity driven chillers are applied. This combination affects the optimization of the operation of the system.

District Cooling (Poredoš, Kitanovski, 2011)

In comparison to conventional cooling or air conditioning systems, district cooling systems have numerous advantages, such as:

- reduced burden on the environment
- greater possibility of using ozone-friendly cooling technologies
- reduction of investment and operating costs per unit of cooling power
- higher energy efficiency
- higher degree of reliability in the generation of cold
- reduction of peak electrical energy consumption due to different possibilities of the cooling energy production.

District cooling systems have been proven to be more environmentally friendly than individual smaller cooling units. They reduce the emissions of hazardous substances and, with the use of a sorption cooling technique, ozone-unfriendly refrigerants can be eliminated completely. When cooling devices are driven by heat from CHP, thermal burden on the environment is reduced directly.

With the development of district cooling to a similar extent and in the manner as used in district heating, district cooling will become accessible and will improve the working and living conditions of a broader group of customers due to a reduction of the cooling energy price per unit of cooling power. The supply of cooling energy will be reliable and no longer dependent on the operating unreliability of cheap and poorly maintained equipment, which is currently dispersed among consumers. This solution is especially important when waste heat from other processes is used, what prevents its loss into the surroundings.

Central District Cooling Systems

Centralized district cooling systems produce cold and transport a cold medium via pipelines to business and residential buildings and industrial facilities for cooling and for other needs of industrial processes (Figure 7). District cooling systems are intended for the supply of densely populated areas.

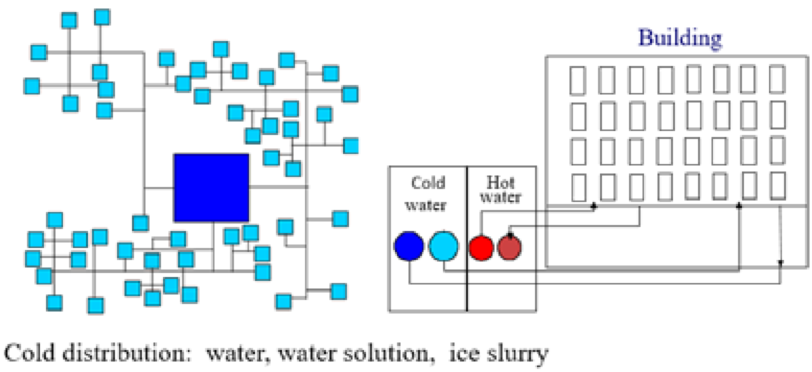


***Fig. 7:** District cooling system with central cold production*

Pipelines in these systems can be installed above ground or underground. The majority of them are installed underground and are made from preinsulated or even noninsulated pipes, which are justified by low investment costs.

Local District Cooling Systems

Heat from district heating systems can be used as the energy source to drive systems with local generation of cold. These systems are used almost in all cases in which district cooling is introduced into existing urban area. Cooling devices which are usually of the absorption type are installed in a thermal station and a cold water distribution system is needed only inside the building. This solution saves the costs of pipeline networks and avoids problems related to their (usually underground) installation in urban areas (Figure 8).

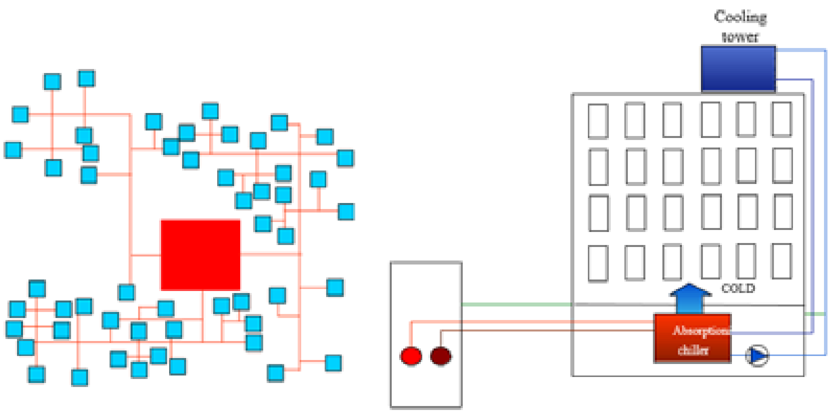


Fig. 8: *District cooling system with local cold production*

Conclusions

Energy efficiency must have the first priority in our energy future. It must take part in the whole energy supply chain: conversion (production), transmission and distribution, and in end use. We must use available energy at first and should not waste any kind of energy on one side and use other energy in the same time and at the same location. There is still very big potential to use surplus heat, which can double the utilization of primary energy. New and also existing CHP systems must be upgraded with cooling, i.e. transformed into trigeneration. To decrease energy use for cooling, we must replace local individual cooling with district cooling. To use heat from CHP successfully, we must use absorption chillers. This solution ensures also higher economic efficiency of CHP. Operational optimal trigeneration system includes compressor and the absorption chiller. Long distance energy transport should be avoided in order to decrease energy losses. Therefore we must focus on distributed energy supply.

Radical changes towards better energy and environmental future are possible only with changes of our life style.

Literature

Spur M.: District Energy/Cogeneration Systems in U.S. Climate Change Strategy. Climate Change Analysis Workshop, Sprinfield, Virginia, June 6-7, (1996), p. 2-19.

KITANOVSKI, Andrej. Sistemi daljinskega hlajenja: magistrsko delo, (Fakulteta za Strojništvo, Ljubljana, Magistrska dela,]1112). Ljubljana: A. Kitanovski], 2000. 88 f., graf. prikazi, tabele. [COBISS.SI-ID 3606811

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL: Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy, Brussels, 23.7.2014

COMMISSION STAFF WORKING DOCUMENT: Review of available information accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU Strategy for Heating and Cooling Brussels, 16.2.2016

POREDOŠ, Alojz, KITANOVSKI, Andrej. District heating and cooling for efficient energy supply. In: *Proceedings*, International Conference on Electrical and Control Engineering, Sep. 16-18, 2011, Yichang, China, (IEEE catalog number, CFP1173J-PRT). [S. l]: Institut of Electrical and Electronics Engineers, 2011, str. 5238-5241. [COBISS.SI- ID 12003099

The Danube Academies Conference is a new project of the European Academy of Sciences and Arts, bringing together all national Academies of the Danube region and focusing on the development in the Danube area. This idea is supported by the European Commission and Commissioner Johannes Hahn, who wants to see an additional drive for a fostering act in the whole Danube area.

The firts Danube Academies Conference took place in Vienna in 2011. In May 2016 seventh meeting was held in Ljubljana.

ISBN 978-961-268-050-3