



## International Course and Field Seminar Characterization and Engineering of Karst Aquifers

Trebinje, Bosnia & Herzegovina



International  
Hydrological  
Programme



The Hydro-Energy  
System of Trebišnjica  
HET, Trebinje

### REPORT

of the Fourth International Course and Field seminar  
“*Characterization and Engineering of Karst Aquifers*”  
Trebinje, Bosnia & Herzegovina, 01 – 08. June, 2017.



The fourth international course and field seminar *Characterization and Engineering of Karst Aquifers* was held in Trebinje, Bosnia & Herzegovina, between 01 – 08 June, 2017. Traditionally, the course was organized by the Centre for Karst Hydrogeology of the Department of Hydrogeology, University of Belgrade - Faculty of Mining & Geology (hereafter FMG) and the Geological Survey of the Republic of Srpska, Zvornik, with sponsorship of UNESCO who sponsored 10 selected participants. Support to this year Course had been provided by the Northern Arizona University (NAU), Flagstaff, AZ, USA, and our hosts - Hydro-electric power plant system of Trebišnjica River (hereafter HET) and Municipality of Trebinje. This year, the Course was attended by 21 participants, while lectures provided by 7 professors.

Experts who delivered their lectures during this year course were: Prof. Dr Zoran Stevanović, University of Belgrade, Serbia; Dr Petar Milanović, Ret. Assoc. Prof. University of Mostar, Bosnia & Hercegovina; Dr Ognjen Bonacci, Prof. Emer. University of Split, Croatia; Abraham Springer, Ph.D. Professor School of Earth Sciences and Environmental Sustainability Northern Arizona University, USA; Prof Dr Dragan Milovanović, University of Belgrade, Serbia; Dr Vesna Ristić Vakanjac, University of Belgrade, Serbia and Dr Saša



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

Milanović, University of Belgrade, Serbia. This year for the first time three junior experts from University of Belgrade Ljiljana Vasić, Branislav Petrović and Veljko Marinović had opportunity to give their lectures about specific topics and research work in karst for their doctoral theses. Also, this year a two participants from USA, namely Charles (Chuck) Graf from Arizona Department of Environmental Quality and Jeff Bennett from Big Bend National Park as well as one from India, Ramanathan Baskar from Department of Environmental Sciences and Engineering Guru Jambheshwar University of Science and Technology, India provided lectures about their work and experiences obtained.

First meeting of the participants was held on June, 1 when after common dinner and a welcome note all participants together with prof. Stevanović and organising team took a walking tour in the city of Trebinje. Followed welcome cocktail was opportunity for Prof. Stevanović to introduce some of the lecturers, sponsors from HET and Geological Survey of the Republic of Srpska and also the organising team from FMG.



Walking tour of the Trebinje city



Welcome cocktail



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

The registration of participants took place on 2<sup>nd</sup> June, at the hall of the HET in Trebinje. All participants received printed lecture notes and other course materials (bag, notebook, pencil, T-shirt, hat with the course logo as well as DVD with PowerPoint presentations of all lectures and various movies including one of the Trebišnjica River regulation).



Entrance to the HET and the conference hall



Registration desk

Opening ceremony started at 9<sup>00</sup> AM with the welcome speech of Mr Radovan Grđinić, Head of Department for Development and Survey of the HET, Dragoslav Banjak, President of the Assembly of Trebinje and Boban Jolović, Geological Survey of the Republic of Srpska, Zvornik, who wished a productive work and pleasant stay in Trebinje and at HET to the participants. Also, prof. Zoran Stevanović once again wish welcome to all participants as well as to all lecturers and officially open the Course.



Opening ceremony



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
 Trebinje, Bosnia & Herzegovina

After the welcome address, Prof. Stevanović provided an introductory lecture "*Introductory note about course; Historical development of karstology and karst hydrogeology; Importance of karst and karst distribution worldwide; Geo-heritage sites; Dinaric karst*". He described the system of education at the Faculty of Mining & Geology to the participants and presented all course topics, a table of content and the course schedule. Also, he explained characteristics of Dinaric karst and its importance.



First lecture of Professor Zoran Stevanović

After the first lecture, the students introduced themselves and presented their interests and the reasons for attending the course. 21 participants from 11 countries, namely: USA, Bosnia & Herzegovina, Honduras, Germany, India, Italy, Republic of Macedonia, Mexico, Montenegro, Slovenia and Serbia.

List of participants

Name and Surname	City and State	Institution/Company/School	
Timm KABUS	Potsdam, Germany	Technical University Cottbus, Germany	



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina

Leni OZIS	Ljubljana, Slovenia	Department of Geography, Faculty of Arts, University of Ljubljana, Slovenia	
Kristina MILICEVIĆ	Belgrade, Serbia	Faculty of Mining and Geology, Department of Hydrogeology	
Marjan TEMOVSKI	Prilep, Rep. of Macedonia	Institute for Nuclear Research Hungarian Academy of Sciences, Debrecen, Hungary	
Ian TSO	Flagstaff, Arizona, US	Northern Arizona University	



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina

Milorad KLIČKOVIĆ	Belgrade, Serbia	Institute for nature conservation of Serbia	
Bojana MIJANOVIĆ	Nikšić, Montenegro	Faculty of Mining and Geology, Department of Hydrogeology	
Miguel MORENO	Merida, Mexico	Technische Universität Dresden, Saxony, Germany	
Aleksandra DEDIJER	Trebinje, Bosnia and Herzegovina	Faculty of Mining and Geology, Department of Hydrogeology	



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

Cameron RHODES	Flagstaff, Arizona, USA	Northern Arizona University	 A photograph of Cameron Rhodes, a young man in a grey blazer, standing at a desk in a seminar room. He is looking towards the right. A woman is seated at the desk next to him, and a white printer is visible on the desk. A banner in the background reads "International Course and Field Seminar: Characterization and Engineering of Karst Aquifers, Trebinje, Bosnia & Herzegovina".
Miloš MILOVANOVIĆ	Starčevo, Serbia	Faculty of Mining and Geology, Department of Hydrogeology	 A photograph of Miloš Milovanović, a man in a blue t-shirt, standing and presenting to a group of people seated at a table. He is holding a document. The setting appears to be a seminar or meeting room.
Tirza C. Contreras GALEANO	Puerto Cortes, Cortes, Honduras CA	Empresa Nacional de Energia Electrica (ENEE)	 A photograph of Tirza C. Contreras Galeano, a woman in a patterned top, standing and presenting to an audience seated in a room with red walls. She is holding a document. Several people are visible in the audience, some looking towards her.
Don MANTHE	Phoenix, Arizona, USA	Retired engineer	 A photograph of Don Manthe, a man in a light-colored t-shirt, standing and presenting to an audience seated in a room with red walls. He is holding a document. Several people are visible in the audience, some looking towards him.



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina

Ines WIEHLE	Potsdam, Germany	Stiftung Naturschutzfonds Brandenburg (Conservation Fund)	
Robert Hoppe	Flagstaff, Arizona, USA	Northern Arizona University	
Uroš MILIĆ	Kuršumljija, Serbia	Faculty of Mining and Geology, Department of Hydrogeology	
Michael BANGS	Flagstaff, Arizona, USA	Northern Arizona University	



**International Course and Field Seminar**  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina

Alessandro PARISI	Gravina in Puglia (BA), Italy	Politecnico di Bari - Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh)	
Ramanathan BASKAR	Hisar, Haryana, India	Department of Environmental Sciences and Engineering Guru Jambheshwar University of Science and Technology Hisar, Haryana, India	
Jeff BENNETT	Alpine, Texas, USA	Big Bend National Park	
Charles (Chuck) GRAF	Tucson, Arizona, USA	Arizona Department of Environmental Quality	

The next lecture was delivered by Prof. Dragan Milovanović: *Carbonate and non-carbonate rocks: mineralogy, depositional environments and classifications.*

Three more lectures were also held on June, 2. Prof. Milovanović lectured on *Chemical factors of karstification and Role of tectonics*, and after him Prof. Stevanović continued with



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

two lectures: *Porosity and permeability of karstic rocks; Karstification process and its features: Surface and subsurface karst landforms*, while the last lecture for that day was *Groundwater circulation in karst: recharge, flow types and directions, discharge*.



Professor Dragan Milovanović

The next day (June 3<sup>th</sup>), in the morning session, presentations were carried out by Prof. Stevanović Prof. Vesna Ristić Vakanjac and Dr Saša Milanović, who spoke about Methods in karst hydrogeology. The first lecture was presented by prof. Stevanović: *Methods in karst hydrogeology – an overview; Geology, field reconnaissance and mapping, water occurrences inventory, remote sensing, geophysics and tracing tests, water occurrences inventory, GIS and database*. Prof. Vesna Ristić Vakanjac continued after him with her first lecture: *Methods in karst hydrogeology – climate, hydrology, water chemistry, statistics*. After coffee break Dr Saša Milanović finished morning session with lectures *Methods in karst hydrogeology – geomorphology, speleology, speleo diving, hydrogeology maps, GIS and database*.



Lectures of Prof. V. Ristić Vakanjac and dr Saša Milanović

In the afternoon session, Prof. Stevanović continued with presentations about methods in karst hydrogeology: *Methods in karst hydrogeology – exploratory drilling, groundwater tapping, hydrogeological properties and field tests*. After presentations about Methods in karst hydrogeology, Charles (Chuck) Graf presented his lecture *Kartchner Caverns, Arizona*,



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

*USA Discovery, Development, Management – A snow peace for preservation, public engagement, education and science.*



Lecture of Chuck Graf

On the next morning, participants had an opportunity to learn practical aspects of karst hydrogeology, engineering concepts, and solutions. The first part was reserved for lectures, and the afternoon for a half-day excursion. Morning lecture was presented by Prof. Petar Milanović, topics are *Problems related to construction of dams, reservoirs and other structures and buildings in karst; Investigation, design, corrective measures, case studies.*



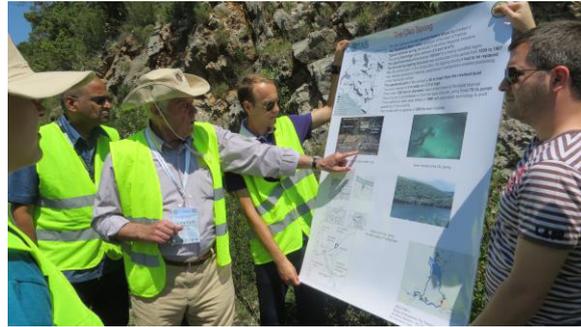
Introduction of Petar Milanović and his morning presentation

During the half-day field trip, the students, together with the lecturers, visited intake for water supply of Trebinje (spring “Oko”) and Grančarevo and Gorica dams. First stop was at the Oko spring, situated several meters above the riverbed of the Trebišnjica River, upstream of the town of Trebinje, where prof. Petar Milanović gave a presentation about this spring used for city water supply, his removal and new tapping structure built after initial site was submerged by new reservoir (Gorica).



# International Course and Field Seminar Characterization and Engineering of Karst Aquifers

Trebinje, Bosnia & Herzegovina



First stop at spring “Oko” tapping structure

Next stop was Grančarevo dam, where Prof. Milanović delivered a presentation about hydrogeology and geophysical survey, dam design, constructive and monitoring elements as well as remedial works for leakage prevention. After visiting Grančarevo dam, students were transferred to another smaller dam – Gorica dam, situated 3 km upstream from Trebinje on Trebišnjica River. The tunnel for water transport to HE Plat near Dubrovnik (Croatia) as well as remedial works to reduce leakage from reservoir estimated in average amount of 5 m<sup>3</sup>/s were explained at the dam site.



Visit to Grančarevo dam





International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina



Visit to Gorica dam

Participants had also an opportunity to visit the Main Hydrochemical Laboratory of HET, where Mr. Zdravko Mrkonja, chief of the Laboratory, showed all instruments, equipment and explained what kind of analyses can be performed and how frequently Laboratory staff sampling and testing the water.

After half-day field trip, students had opportunity to watch *DVD movie "Trebišnjica"*.



Visit to HET Hydrochemical laboratory

Fourth day of course was reserved for all-day field trip. The field trip was guided by Prof. Petar Milanović, who provided explanations at every observation point. The trip started in Popovo Polje, one of the world's largest karst poljes. The first stop was at the Trebišnjica River in Popovo Polje, the largest sinking stream in entire Europe which is today completely regulated. The students had an opportunity to see riverbed which nowadays is covered with concrete blanket, and ponors that were previously utilized by local villagers as water mills. After, the excursion continued to the Vjetrenica cave, known for its extreme windiness in the entrance area, as well as for the presence of protected endemic specie *Proteus anguinus* ("human fish") in its deep channels. After cave, participants visited nearby located Bio-speleological museum.



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina



Popovo polje and Trebišnjica River



Vjetrenica cave and Bio-speleological museum

Further on, the students were able to see Bregava River, Dabarsko and Fatničko polje with spring Vrijeka and estavelle Obod. This year, for the first time, participants had chance to see excavation of the hydrotechnical tunnel that will connect Nevesinjsko polje reservoir with Dabar polje and Bileća Lake. After visiting this construction site, on the way to Trebinje stops were at Trebišnjica River spring (Dejanova cave), which is submerged and flooded by the Bilećko Lake (Reservoir) and at the exit of another tunnel that connecting Fatnica polje and the Bilećko Lake.



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina



Bregava river



Visit of tunnel



Stands at Dabarsko, Fatničko polje and Bilečko lake

The next day (6<sup>th</sup> June) the lectures continued and in the morning were performed by Prof. Zoran Stevanović and Prof. Vesna Ristić Vakanjac. First presented lecture is related to



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

*Characterization of karst aquifers; Groundwater budget; Specific regime of karstic groundwater (quantity, quality); Safe yield; Aquifer control and sustainability, while Prof. Ristić Vakanjac continued with Modeling of karst aquifer – Springs hydrograph analysis and stochastic models.*

Afternoon session was reserved for junior expert classes. Firstly Branislav Petrović presented lecture *Karst aquifer vulnerability; Anthropogenic impact and hazards; Karst Disturbance Index*, after him Ljiljana Vasić presented her lecture *Quality dynamics at karst springs. A challenge for drinking water supplies. Isotopic methods in karst, GW ageing with case study Kučaj-Beljanica*. Last of this three presentations titled *Groundwater management and transboundary aquifers in karst: problems and solutions* provided by Veljko Marinović.



Lectures of young experts

After their lectures, Jeff Benet presented *Important to the Conservation and Protection of the Rio Grande in Big Bend National Park* and after him Ramanathan Baskar continued with lecture *Mineral-microbe interactions in caves – an overview*. This day was closed with movie made by S. Milanović about protecting the nature: “Forgotten species”.



Lectures of Jeff Benet and Ramanathan Baskar

On the last lecturing day (7<sup>th</sup> June), lectures were performed by Prof. emeritus Ognjen Bonacci, who spoke about *Water resources cycle in karst; Surface-groundwater interaction; Feasibility studies and engineering design; Environmental impact assessment; Case studies*, and after him, during morning session, Dr Saša Milanović also gave the two lectures: *Leakage from reservoirs, specific research methods and remedial measures* and *Modeling of karst aquifers – conceptualization for numeric models, software, GIS Modeling*.



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina



Lecture of Prof. emeritus Ognjen Bonacci

In the afternoon session Prof. Stevanović talked about *Transboundary aquifers in karst: problems, solutions and experiences*. After him Prof. Abraham Springer presented a lecture: *Spring hydrology: catchment delineation, inventory, assess, manage springs ecosystems*.



Lectures of Prof. A. Springer

After his presentation, students together with professors, had field work on Lušac spring, located in Trebinje city, where Prof. Springer showed directly on the spring how to make an inventory of the spring and how to properly measuring the springflow.





International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**

Trebinje, Bosnia & Herzegovina



Field work on the Lušac spring – guided by Prof. A. Springer

The final exam was conducted on the last day (8<sup>th</sup> June). It consisted of written test with 37 questions and verbal discussions. Eleven students attended the exam. Members of the examination panel were professors from the University of Belgrade Zoran Stevanović, Vesna Ristić Vakanjac and Saša Milanović and Abraham Springer from NAU.



Written part of exam

After the written test, the panel called students for verbal discussion. All of students that entered the written test passed the exam with grades in range from 8-10 (obtained points were from 75 to 96, out of maximum 100).



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina



Verbal discussion

The closing ceremony was held in the afternoon on June the 8<sup>th</sup>. All attendants who completed the course received a Certificate of Attendance, and an additional Certificate which included final grade and credits (6 ESTC) issued by the University of Belgrade – FMG. All lecturers received Certificate of Appreciation for participation in the course. Finally, Prof. Stevanović noted that the results of questionnaire indicated high overall evaluation of the course (see at the end of this Report).





## International Course and Field Seminar Characterization and Engineering of Karst Aquifers

Trebinje, Bosnia & Herzegovina



Closing ceremony

The awards for the best score on the final exam were given to the next students:

First Prize: Uroš Milić – Serbia (grade 10, excellent)

Second Prize: Michael Bangs – USA (grade 10, excellent)

Third Prize: Miloš Milovanović – Serbia (grade 10, excellent)

Fourth Prize: Robert Hoppe – USA (grade 9, very good)



First Prize: Uroš Milić



Second Prize: Michael Bangs



Third Prize: Miloš Milovanović



Fourth Prize: Robert Hoppe

After the closing ceremony, good atmosphere has transferred to a local ethnic restaurant “Studenac” on farewell party, where the participants and lecturers were enjoyed local food and wines. They also enjoyed music and dance, which continued till late hours.



# International Course and Field Seminar Characterization and Engineering of Karst Aquifers

Trebinje, Bosnia & Herzegovina



Farewell party

As during the previous three years of course in Trebinje, social life of participants, lecturers and the organising team was very active and all of them spending a lot of time together,. There were many parties in the Trebinje's local pubs and clubs, talks, exchanged life and scientific experiences. But, the next morning all of them regularly attended the lectures and participated actively.





International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina



Reported by  
Ljiljana Vasić, PhD student



CEKA Team of the year 2017 !



International Course and Field Seminar  
**Characterization and Engineering of Karst Aquifers**  
Trebinje, Bosnia & Herzegovina

**Questionnaire – Results of respond**

**1. The quality of content for the workshop**

Poor	
Fair	
Good	25%
Excellent	75%

**2. The quality of presentation**

Poor	
Fair	
Good	45%
Excellent	55%

**3. The level of technical material presented in the workshop**

Poor	
Fair	
Good	30%
Excellent	70%

**4. In terms of benefitting my professional/academic practice, the workshop was**

Not useful	
Somewhat useful	25%
Very useful	75%

**5. Will you use some of the knowledge that you have learnt on the course?**

No, unlikely	
Maybe, possible	10%
Yes, likely	90%

**6. The length of the workshop**

Too long	
Too short	15%
Just right	85%

**7. How do you like field trips, and were they too long for you?**

They were good, but lasted too long	5%
The time we spent on stops was too long	5%
Everything was fine	45%



I would like to have more excursions than lectures 45%

**8. I would recommend this workshop to others interested in karst**

No, unlikely

Maybe, possible

15%

Yes, likely

85%

**9. How much you are satisfied with accommodation and transfer to hotel:**

Poor

Fair

5%

Good

25%

Excellent

65%

**10. How do you like Trebinje city and the time you spent in the evening:**

Poor

Fair

Good

15%

Excellent

85%

**11 What is your overall evaluation of the course (1- worst; 5-best)?**

1

2

3

4

25%

5

75%