The use of natural zeolite (clinoptilolite) for the treatment of farm slurry and as a fertilizer carrier

University of Belgrade
(Faculty of Agriculture and Faculty of Technology and Metallurgy)

University of Sarajevo
(Faculty of Agriculture and food sciences)

Norwegian University of Life Science
(Department of Plant and Environmental Sciences)
University of Belgrade (BU)

- founded in 1838
- a state-owned university
- main activities: higher education and scientific research
- BU has educated more than 300,000 students
- 31 faculties and 13 institutes are separate legal institutions with their own management bodies, whose responsibilities are regulated by the Law on Universities.
- since 2004 the higher education system has been adjusted in accord with the Bologna process; UB obtained accreditation in 2009.
Popularization of science among nursery school pupils
Faculty of Agriculture

- Opened in 1919
- To date 16,650 students have graduated, 950 completed their Master studies and 750 Doctorates.
- Offers 8 courses: Agricultural Production, Fruit and Vineyards, Livestock, Land Melioration, Protection of Herbs and Agricultural products, Agricultural Plant, machinery and tools, Agroeconomy and food technology.
University of Sarajevo - Faculty of agricultural and food sciences

- The first university in Bosnia and Herzegovina, originally established in 1531. US expanded in a modern university in 1949.
- 122,000 students received BcD, 3,891 MD, and 2,284 PhD in 43 different fields studying within 23 faculties.
- Opened in 1940
- To date 5000 students have graduated, 250 completed their Master studies and 200 Doctorates. The FAFS is organized through 4 departments and 8 institutes.
Norwegian University of Life Sciences

- Established in 1859 as the Norwegian agricultural post-graduate college
- University status in 2005
- 3800 students (2010)
  - 1160 Bachelor
  - 1960 Master
  - 180 Other
- 460 PhD and post-graduate students
- 1120 staff
  - of which 640 scientific
- Offers 2-, 3- and 5-year academic studies
  - (Bachelor’s, Master’s and PhD)

- The Norwegian University of Life Sciences will be an internationally renowned and innovative university for life sciences, environment and sustainable development.
Grasslands in Serbia and Bosnia and Herzegovina

- Natural grasslands are in both B&H and SRB a very important source of voluminous livestock feed.
- Also, they are important component of environment since they enable:
  - protection of soil from erosion
  - preservation of biodiversity
  - taking part in tourist economy.
Grasslands is basis for livestock development

- In Serbia, distribution of grasslands is unequal but with increase of altitude the grasslands increase especially their share in the structure of soil used in agriculture.

- Total area under grasslands which can be used for the production of livestock feed is approx. 1,260,000 ha. In a half of municipalities the natural grasslands are the prevailing source for plant production.
Generally, the grassland areas have been mainly degraded because of poor management and careless utilization.

This is confirmed by the data that show their share in agricultural land:
- Bosnia and Herzegovina: 54%
- Serbia: 38% (17% meadows and 21% pastures)

Grasslands in Serbia and Bosnia and Herzegovina

- B&H and central part of SRB are mainly hilly-mountainous and for both the natural grasslands are of great importance for livestock production.
Statistical data state that the average yield on natural grasslands is low: \textbf{approx. 1.9 t ha}^{-1} \text{ of DM on meadows and 0.4 t ha}^{-1} \text{ of DM on pastures!}

- Improvement of natural grasslands is achieved by the use of mineral fertilizers;
- N fertilizers are an important factor in intensive grass-based dairy farming, as nitrogen affects the DM yield and the crude protein content of herbage.
- Tests performed in Serbia show a favorable effect of N fertilizers on the yield and on the protein, ash and fat content. Also, the DM yield was increased by 150 % during two years utilization of 160 kg ha\(^{-1}\) of N fertilizer. Increase in the DM yield depends on the amount of precipitation.
N fertilizers usually contain nitrates which show low retention on the soil surface.
An elevated dose of fertilizers has to be applied to enable plant growth.
Excessive use of nitrate-rich manures in agriculture leads to leaching of a large quantities of nitrates from the soil to the groundwater. **Nitrate pollution is one of the main problems for the water supply companies!**
The aims of the present project are to investigate the feasibility of using a zeolite based fertilizer (ZEOF) on natural meadows-pastures. ZEOF has several advantages:

- Non-toxic natural material
- ZEOF can be easily applied at the beginning of the vegetation period
- ZEOF provides the fertilizing effect throughout the whole period.
- It is ecologically advantageous since the active compounds and nutrients are leached out into the soil slowly and gradually
- ZEOF is expected to provide an increase of the share of grasses and legumes of a good quality.
What are zeolites?

- hydrated calcium aluminium silicate
- upon rapid heating, the mineral Stilbite produces large amounts of steam, that arises from water adsorbed by the material

• A.F. Crönstedt (A.F. Crönstedt, Akad. Handl. Stockholm, 18 (1756) 120) named the mineral

ZEOLITE $\rightarrow$ (zeo – boiling; lithos – stone)
What and why clinoptilolite?

- The most abundant naturally occurring zeolite;
- Cheap, available, and environmentally friendly.
- Thermally stable up to 800 °C
- Exhibits an excellent adsorption capacity towards ammonium and metal ions.
- Capable of sorbing different molecules such as odourous compounds.
Clinoptilolite mines in Serbia

Zlatokop mine
Zlatokop mine (Vranjska Banja)

$\text{Ca}_{1.6}\text{Mg}_{0.7}\text{K}_{0.7}\text{Na}_{0.3}\text{Al}_{5.5}\text{Si}_{26}\text{O}_{72}\cdot23\text{H}_2\text{O}$
Zeolite data

Mineral composition, wt.%
Clinoptilolite 73
Quartz 14.6
Feldspar 12.8

Chemical composition, wt.%
SiO$_2$ – 65.63, Al$_2$O$_3$ – 12.97, Fe$_2$O$_3$ – 1.48, Na$_2$O – 0.95, K$_2$O – 1.33, CaO and MgO – 1.41, loss of ignition - 12.96.

Physical and mechanical properties
Melting temperature 1260 °C
Specific weight 2200-2400 kg m$^{-3}$
Appearance and smell grey-green, without smell
Effective pore diameter 0.4 nm
pH 6.8-7.2
Project realization

SRB

B&H

NORWAY
Serbian team

- Treatment by clinoptilolite of the slurry (manure) produced in an animal farm (zeolite will be directly spread over the farm floor)
- Effect of zeolite on the counts of different physiological groups of bacteria will be investigated (as an example, pig slurry naturally contains $10^{10}$ bacteria per ml, some of them are pathogenic).
- Previously performed studies showed that addition of zeolite results in a reduced count of different physiological groups of bacteria.
Team from Bosnia and Herzegovina

- ZEOF will be tested in the course of two years
- Effect of the ZEOF on the meadow-pasture vegetation will be studied
- Influence of the ZEOF on the botanical composition of the plants, the forage quality and the DM yield will also be examined.
Norwegian team

- This team will study ZEOF from the aspect of the dynamics of nutrient release.
- The team will also study the influence of zeolite on the soil properties.
Dissemination of results

- Workshops
- Study visits
- Seminars
- Stuff exchanges
- Preparation of monograph
Expected results

- Reduction of the offensive odour emission during storage of manure
- Disinfecting effects
- Improvements in the homogeneity and flow characteristics of manure
- Better nutrient utilization and performance
- Favorable effect on the DM yield
Beyond the project …

A novel strain of E. coli caused a serious outbreak of foodborne illness in May and June 2011 in northern Germany. An organic farm was identified as responsible and has been shut down.

SEM photo of E. coli and S. aureus immobilized on the natural clinoptilolite from Zlatokop mine (N. Rajic et al. submitted for publication)
Assessment of the project’s vulnerability

- A substantial part of the project participants are women as well as the master and doctoral students, all of which is a guarantee that the project will be successful!
Thank you for your attention