Brief report

on short-term Travel Support Grant for Collaborative Research with the Eurasian Center for Food Security, Economic and Environmental Aspects of Food Security in Central Asia and Armenia (WB program) for Dr Marina Lebedeva on studies of the chemical, mineralogical, and micromorphological properties of natural and anthropogenic soils to determine the status of marginal salt-affected lands

The field expedition mission was conducted in Karakalpakstan Karabuga Farm and on protected areas desert areas of Ecocenter |Dzheiran" , Bukhara Region, Uzbeksitan (For the period from 04 -20 September 2014). Work was done in collaboration with Dr Kristina Toderich, regional representative of the International Center for Biosaline Agriculture for Central Asia and Caucasus, Tashkent sub-office, Uzbekistan.

The working hypothesis of this travel support project was related to an indication of declining soil fertility, increasing soil erosion, loss of organic carbon, soils salinity and higher production costs in Bukhara oasis and lowest stream of Amudarya river basin. The pollution of waters and soils with toxic metals is the major environmental problem in these agroecological zones. Conventional remediation approaches usually do not ensure adequate results. The mobility of toxic pollutants can be highly facilitated by the chemical properties of soils and the aridity of the climate. The impact of these factors of land degradation induces reduction in biodiversity and yields losses of agricultural crops and wild desert plant communities.

Chemical and morphological studies, including microscopic field and laboratory analysis of soils samples collected along a salinity gradient in these two geographically different location were conducted. By our results were confirmed the impact of shifting sandy soils chemistry on environments (status of plant desert communities inclusive) . In Bukhara oasis , for example, under the crown of *Haloxylon aphyllum*-one of main edificatory of desert landscaope in this region, where the sandy soils with compacted developed crusty horizons is distinguished by higher values of pH and differently originated alkalinity. The alkalinity level of this biotope is determined by presence of sodium bicarbonate (Na_2C0_3 x $10H_20$), which is formed as results of concretion of sodium excreted from rest of died plants remains with carbonates of soils formation rocks/sands) with organic origin. The highly alkaline crusts are observed in soils developed nearby the crown/stem of *Haloxylon aphyllum.* The increased content of gypsum in the studied soils is conditioned by its hydrogenic and eolian origin. The fine-dispersed irregular-shaped gypsum crystals appear in surface horizons due to gypsum blowing from the open-pit mines from Kaisagach Mountain, located at about 50-60km south-western part of Ecocenter Dzheiran. The pattern and content of toxic salts, the distribution of salt pedofeatures within the profile of soils in different biotopes allowing us to admit existence of specific mechanism of processes of salt migration and salt transformation within soils profile under each investigated

biotope. The sandy soil under xerophytic vegetation is not saline, the soil under xero-halophytic vegetation reveals an eluvial-illuvial salt distribution with maximum accumulation at a depth of 50 cm; on the contrary, in the soil profile under halophytic vegetation the toxic salts are rapidly accumulating as appeared as results of evapotranspiration and crystallization of salts from mineralized shallow water table (usually water table level on wet solonchaks varies from 40-90cm). The most optimal biotope for *Haloxylon aphyllum* is xerohalophytic plant associations, the soils of which are characterized by a higher intensity of soil formation processes including humification of plant residues, biogenic structure formation and carbonate enrichment. Water table level in this case ranges from 10-18m in depth.

Along with evaluation of soil-water-vegetation communities' relation under Haloxylon we analyzed the soils chemistry and soil formation characteristics under Tamarix-stands, grown on different agricultural degraded desert landscapes in the lower stream of Amudarya River region (near Karabuga village), compared with similar at the Ecocenter "Dzheiran', Bukhara region. For this purpose soil chemistry, water mineralization and growth patterns of Tamarix species influencing on biomass production on marginal lands were assessed. The shrub vegetation communities consists mostly of *Tamarix* stands, which in the lower stream of Amudarya River basin and Bukhara region are frequently represented by *Tamarix ramosissima*, *T. androssowii*, *Tamarix elongata*, *Tamarix hispida* in pure stands or mixed with other annual halophytes and salt tolerant grasses. These species colonize and grow well on marginal lands within wide range of soil salinity (19.29 - 58.97% calculated for root zone (5-10 cm) soil profile and withstand a different content of toxic salts (sodic alkaline, chloride, sulfate-chloride or chloride-sulfate). *Tamarix* species belong to crinohalophytes (salt excretion ecological group of halophytes) The scanning electron microscopy (SEM) analysis of leafs of *Tamarix*, collected through field expedition in 2014 shown that predominantly ions are sodium chloride – salt mineral halite, while sodium sulfate and calcium ions are represented in small quantity (Lebedeva et. al., 2014). Salt glands, which are abundantly developed on epidermis of leaves, play a major role in salts excretion. Texture and elements of microfeatures analysis showed that the *Tamarix* grows on layered depositions. However, a prerequisite for its optimal growth and reproduction (re-growth) is growing in the lower parts of meso- or macro-slopes. This position of *Tamarix* plants on the relief was noted in all studied sites and due to desalinization of soil crust (10 cm thickness) is the main prerequisite for good seed germination or vegetative propagation of *Tamarix* species. In nature *Tamarix* "chooses" lower slopes for getting non saline (or slightly mineralized) water, which is flowing to the lower slopes or ravine in the spring after snowmelt. And it prefers to grow near the artesian water spills. The flushing of salts to the upper soil horizons with spring waters and discharge of water on the slope determine the best soil and environmental conditions for growth of *Tamarix* plantations.

Thus, our preliminarily results on evaluation of soil-water-vegetation communities' linkage under *Haloxylon aphyllum* artificial plantation and Tamarix wild stands of different species of Tamarix, grown under different agro-ecological zones in Aral Sea Basin indicate on bioremediation and soil restoration effect effects of these two species. Additionally, black saxaul plays an important pasture reclamation value as fixing shifting sands; Haloxylon shelter belts in the desert protects against soil erosion and strong winds Young stems and fruits of black saxaul are willingly eaten by for wild and domestic animals. Relevance of this research is also determined by the fact that the lither, accumulated under Haloxylon and Tamarix crowns can serve as natural seed bank conservation niche. Seeds storied here may be dispersed by wind, and thus guarantee seedling establishment on salt affected degraded surrounding lands.

Elena Shuyskaya

Report on the travel grant to Uzbekistan "Salt tolerance strategies of halophytes and its use in phytoremediation of marginal saline lands in Uzbekistan"

We performed field expedition and lab experiments with several species of halophytes with different strategy of salt tolerance (euhalophytes (succulent and nonsucculent), crinohalophytes, pseudohalophytes) in the arid and semiarid zones of Uzbekistan (Karauzyak district in lower Amudarya River Basin and Ecocentger Dzeiran, Bukgara region) to determine salt uptake characteristics and food production potential for livestock and humans. Our results showed that arid and semiarid halophytes with different strategy of salt tolerance occupy the entire niche of saline lands - from slightly saline (0.01 - 1 mg Na^+/ g soil) to strongly saline soils (5 - 6.35 mg Na^+/g soil). Crinohalophytes accumulate a relatively small amount of sodium and potassium ions (40 mg Na^+/g dry weight, and 2 mg K^+/g dry weight), and 90% of which they excrete in salts form to environment. Succulent euhalophytes accumulate a large amount of sodium ions (up to 283.7 mg Na^+/g dry weight) and demonstrate the existence of several mechanisms of salt tolerance, which probably are species-specific. Nonsucculent euhalophytes accumulate less sodium ions than other halophytes, but in 2-3 times greater than pseudohalophytes. In crinohalophyte the proline can operate as additional osmolyte in contrast to succulent euhalophytes.

During our field expedition we have identified several sites of marginal land: *A* - with shallow water table and moderate salinity (marginal old agricultural lands), *B* – around artesian freely flowing wells and along drainage channels, *C*- with relatively deep water table and high salinity (small saline depressions). Kyzylkum desert sites with natural vegetation (xerophilic, xerohalophilic and halophilic) were used as a control. The sodium content in the marginal old agricultural fields was comparable to the desert areas (1.4 - 1.5 mg Na^+/g soil). Whereas in soils around artesian wells and along drainage channels the sodium content increased about two times

and totaled 3.0 mg Na^+/g soil. The sodium content in sites with secondary saline soils (secondary solonchks) reached 6.35 mg Na^+/g soil. On the sandy desert soil in natural plant communities share of nonhalophytes and pseudohalophytes constitute about 69%. Whereas share of succulent euhalophytes reached 25% and crinohalophytes - 6%. On the marginal lands number of succulent euhalophytes increase up to 50%, and crinohalophytes - 40% (marginal old agricultural fields), up to 52% and 32% (around artesian wells and along drainage channels), and up to 60% and 40% (secondary saline soils).

According to our results, among the studied different halophytes, the annual succulent euhalophytes accumulate the highest amount of sodium (up to 20% of biomass) even growing on soil with low level of salinity. These species can be used for phytoremediation on marginal lands characterized by low salinity, but have a tendency to salinization (marginal old agricultural lands). For effective phytoremediation the annual succulent euhalophytes should be planted with high density (because of small biomass) and mix with perennial succulent euhalophytes as the habitat-forming and soil-fixed species. But at the end of the growing season the biomass of annual succulent euhalophytes should be harvested and used as additional fodder or for biogas. During the growing season crinohalophyte can excrete to environment up to 1.5 kg of salt (depend on root environment salinity), 60 - 90% of which is sodium salts. The aboveground biomass of crinohalophytes should be harvested and utilized (as fuel or for biogas) in order to avoid additional (secondary) soil salinity.

Student of Department of Soil Science, Moscow State University named after M.V. Lomonosov Aysulu Safarova had training in interdisciplinary techniques for studying halophytes and land/water interactions in marginal land and native desert plant communities.

Soils and cover vegetation analysis on salt affected desert lands (Prof. Marina Lebedeva team, Institute of Soil Research, Academy of Agricultural Research, Russia, September 2014)

Ground water sampling (more than 8-10m depth) by using (Dr Michael Lebedev, Institute of Soil Research and Mrs Aysulu Safarova , Faculty of Soils Science, Moscow State University), September 2014