KIER DISCUSSION PAPER SERIES

KYOTO INSTITUTE
OF
ECONOMIC RESEARCH

http://www.kier.kyoto-u.ac.jp/index.html

Discussion Paper No. 638

"New Approaches for Biosaline Agriculture Development,
Management and Conservation of Central Asian Degraded Drylands "

Toderich K., Tsukatani T.

August 2007

KYOTO UNIVERSITY

KYOTO, JAPAN

Discussion Paper No.638

New Approaches for Biosaline Agriculture Development, Management and Conservation of Central Asian Degraded Drylands

Toderich K., Tsukatani T.,

August 2007

Kyoto Institute of Economic Research
Kyoto University

This paper is an attempt to contribute to a better understanding of the very difficult arid environments in Uzbekistan, and for the conservation and rational use of halophytic rangelands resources. The survey was within a framework of Joint Research Project: «*Investigation of natural resources of Central Asia and reconstruction of agriculture in Afghanistan*» supported by a Grant in Aid for Scientific Research, Japan Ministry of Education and Culture, 2003 (No. 15252002) represented by professor Dr. Tsuneo Tsukatani, Division of Economic Information Analysis, Kyoto Institute of Economic Research, Kyoto University, Japan. The field expedition was carried out from April to November 2006. The target area was Kyzylkum Desert of Central Uzbekistan.

New Approaches for Biosaline Agriculture Development, Management and Conservation of Central Asian Degraded Drylands

Introduction

This paper is an attempt to contribute to a better understanding of the very difficult arid environments in Uzbekistan, and for the conservation and rational use of halophytic rangelands resources. It is suggested to encourage the sustainable development of saline/sandy deserts soils by mobilization of phytogenetic resources, involving both native and introduced salt tolerant plants. Studies on their ecological, morphological and structural-functional properties; seed and biomass production; testing of alternative low-cost technologies to optimize the selection and domestication of halophytic arid plants are different aspects for model studies for prediction of rangelands productivity. In addition, it would have a significant goal for salinity control, remediation and economic development of arid/saline lands. One of the most promising uses of halophytes will be the production and conservation of important seeds germplasm. The demand for seeds of salt-tolerant species has increased and a number of farmers have become interested to apply biosaline agriculture techniques as a feasible option for their marginalized farms. An innovative selection programs and development of suitable modern agro-technologies are needed to multiply seeds and/or salt tolerant plant material, establish them within natural plant communities and introduce them where they are suitable in different ecosystems.

Degradation of desert rangelands, throughout the whole Central Asian region has reached an alarming degree, calling for prompt actions. Increasing human population and expanding agricultural areas have resulted in heavier grazing pressures in rangelands in spite of the increasing role of crop residues and grains in livestock production (Nordblom et al., 1997, Gus Gintzburger et al., 2003). As a result of erratic cropping in low rainfall zones, overgrazing of the good rangelands, cutting of shrubs by local population for firewood, the natural vegetation of these desert areas are under pressure from anthropogenic degradation factors. This leads to the eradication of useful, endemic or rare desert plant species and to the reduction of rangelands productivity. All the above have induced the disintegration of rural infrastructure in arid zones of Zarafshan River Basin and Kyzylkum Desert that led to the migration of local population from the native areas to neighboring cities or countries.

Salinization is one of the major ecological and production problems currently facing the agricultural sector in arid and semi-arid areas of the Central Asian countries. Continuous use by the former USSR of the major rivers of Central Asia (Amu Darya (or Oxus), Zarafshan, Syr Darya (or Jaxartes)) for production and exports of cotton, oil, and minerals, has resulted in rising water tables, waterlogging, and the saline lands around Aral Sea. Secondary, salinization (human induced) is increasing rapidly and crop production under these conditions is becoming less sustainable. Drought and salinity can have a far greater effect on food security in Central Asian than in other areas. Besides salinization, contamination by heavy metals and chemical compounds released by agriculture, uranium, oil and gas industries has been frequently reported for Kyzylkum sandy Desert (Goldshtein, 1997, 2000, Tsukatani & Yukio Katayama, 2001; Toderich et al., 2001, 2002, 2004a, b, 2006; Aparin et al., 2006). As the result, formerly high productive livestock system has deteriorated and livelihoods of the people have dramatically declined. In Uzbekistan, desert natural pastures valuable for livestock development occupy 17.5 million hectares, including 3 million hectares of shifting sands, however, only 485.1 thousand hectares are presently under irrigated agriculture. Saline pastures cover about 2 million hectares. The main vegetation distributed here are halophytes that have importance as feed, fodder, technical, medicinal plants, etc. These phyto-genetique resources might play very important role for soil desalinization, water table control, and valorization of non-conventional water resources, landscaping purpose and sand-dune fixation. Options are available for improving the livelihoods of the rural population in the Central Kyzylkums. Many of the artesian waters wells, with high temperatures, could be used not only for development of arid fodder production, but also for recreation, vegetable production, and other purposes. The creation of high productive arid livestock fodder farming systems will entail the safety of natural habitat and increase the income levels of rural communities.

The outline of the general strategies for natural rangelands regeneration and management in new changing desert/semi-desert environments are proposed and modeled.

The main objectives for implementation of such studies are:

- to select appropriate plant materials of natural halophytes with high production value (both green biomass and seeds) with high nutritional value;
- to evaluate optimal agronomic practices of different plant groups based on their reproductive biology, biochemistry, and physiology;
- study mixed cropping system of C3/C4 plants[1] in different planting ratios and their effect on seasonal biomass production under arid saline conditions from biosaline agriculture perspectives;

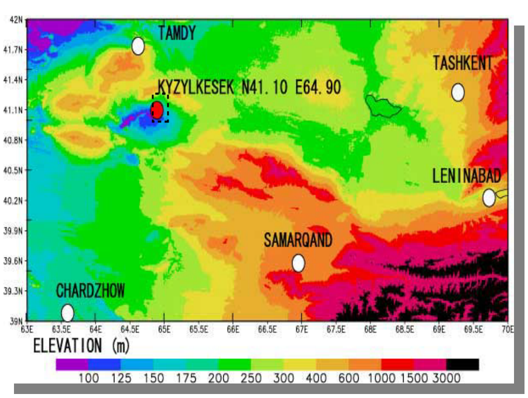
[1] Almost all plant life on Earth can be broken into two categories based on the way they assimilate carbon dioxide into their systems. C3 plants include more than 95 percent of the plant species on earth. (Trees, for example, are C3 plants.) C4 plants include such crop plants as sugar cane and corn. They are the second most prevalent photosynthetic type. During the first steps in CO_2 assimilation,

- efficient use of non-conventional water resources (hot artesian/ground mineralized water), and forage alternatives while protecting natural resources (soil and biodiversity of natural rangeland plants).

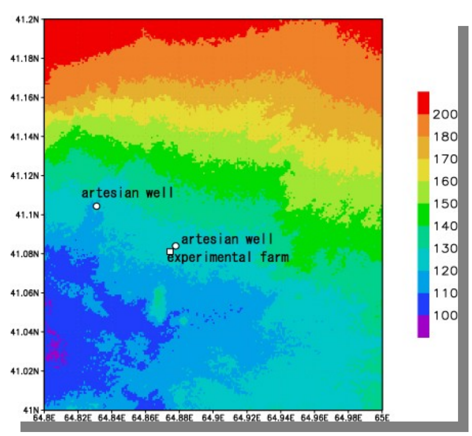
Materials and Methods

The study area covers waste marginal lands and natural rangelands affected by aridity and salinity mostly located in the lower reaches of Zarafshan River Valley and Kyzylkum Deserts, including Karakata saline depression. The target area (Figure 1) constitutes a salt depression formed by freely-flowing saline hot artesian water (vertical drainage water), which is the only water source available for cultivation under sandy Kyzylkum desert conditions. Unless the water is used in halophyte production, it would induce further salt accumulation and soil deterioration.

Soils collected from different points (0-100 cm) of surveyed area were analyzed for detailed physical and chemical analysis using atomic adsorption spectrophotometry. Total concentrations of trace elements were analyzed by ICP-MS (Hewlett Packard HP 4500 system) in the Radioisotope Research Center, Kyoto University. The electric conductivity as well as the soluble cations and anions were determined in aqueous extracts (soil/water: 1/10 w/w). All the data were statistically analyzed using "Statistics 9.0", "Surfer v.7.04" and ArcGIS 9.1.



a.



b.

Figures 1a,1b. Altitude maps in large and small scale. The dotted square in large scale map indicates the left figure area.

C3 plants form a pair of three carbon-atom molecules. C4 plants, on the other hand, initially form four carbon-atom molecules. (Smithonian Environmental Research Center)

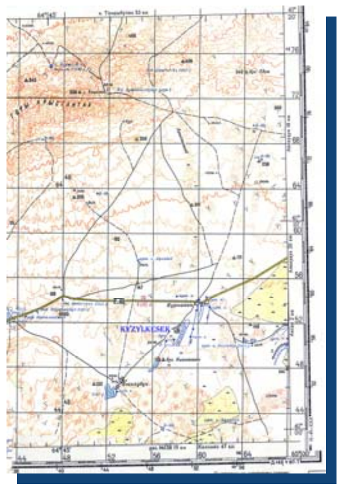


Figure 1c: Topographical map from Russian army General Staff

Trial for strip-alley livestock-farming system was established at Kyzylkesek Experimental Site (Kanimekh district Central Kyzylkum), where the average annual rainfall varies between 80-110 mm. Strips of different forage halophytes were cultivated each separated by a row of fodder shrubs. Each strip was 5-10 m wide.

I. Agro-climatic conditions and chemistry of soils and underground water.

The agro-climatic environments and availability of water sources for cultivation of crops on the desert salt-affected soils are radically different from the agricultural irrigated areas. Climatic conditions for the Kanimekh agro-ecological zone, Navoi region (Central Kyzylkum), which has been chosen as biomonitoring site of salinity trends and halophytic botanic diversity changes, is shown in Figure 2.

Spatial distribution (zonation) of natural vegetation in relation to soil salinity was studied in an area of about 10 ha, located between two artesian hot springs (Figure3.). The most important factor for the zonation was soil salinity and the salt tolerance limits of species. In general the width of each zone as is seen in the figure 3 differs according to the relief, floristic composition, and the salt concentration.

Soil type of surveyed area is silt-sandy loam, throughout the profile up to the depth of 60 cm. Representative soils samples were collected at different depths from 0-100 cm. The soil is highly saline in the top soil and in the lower layers. The predominant salinity type is sulphate-chloride. Ground water salinity varies from to 2.0-8.2 g/l. Sodium and magnesium are the dominating cations. Ground water table fluctuates from 0.8-2.5 m during May-July at the experimental agricultural plot and up to 5-8 m in the desert pasture area. Dynamics of soil moisture under different plant communities, which are distributed in the degraded pastures, is shown in Figure 4.

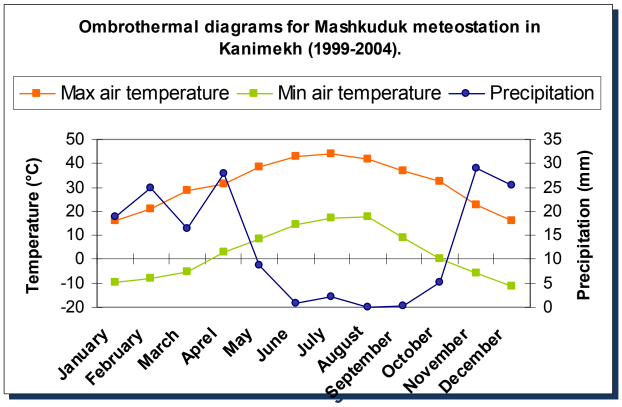


Figure 2. Climatic conditions for the Kanimekh agroecological zone (Central Kyzylkums, Uzbekistan).

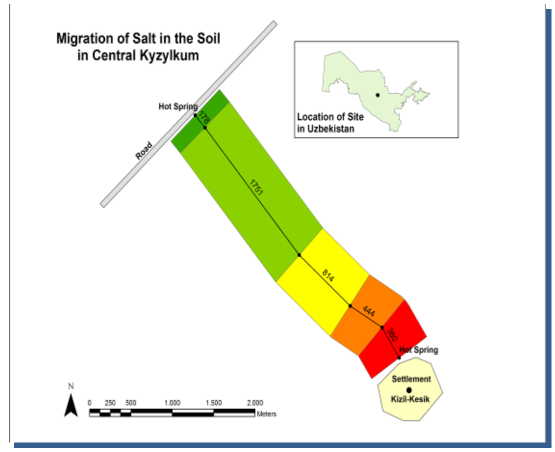


Figure 3. Spatial distribution of different desert landscapes according salinity gradient: low salinity in the virgin desert Artemisia rangelands (green color); moderate salinity under artificial Haloxylon aphyllum forest (yellow) and high salinity (salt marshes solonchaks with Tamarix, Halostachys and Aeluropus plant community (orange and red)

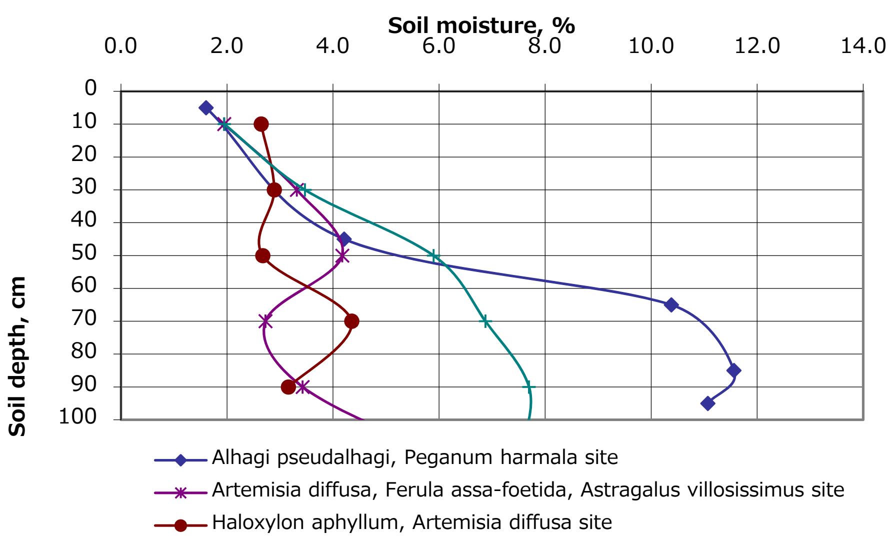


Figure 4. Dynamics of soil moisture under different desert plant communities.

Due to low transpiration capacity, *Alhagi* plant communities promote retention of soil moisture in the top soil. The same situation is also observed on saline areas near agricultural plots, where *Climacoptera* and others annual *Salsola's* species dominate. Additionally the high evaporation rates are drying the ponds in summer, making them as evaporation ponds. Poor natural drainage system of marginal cropping irrigated lands has caused an increase in the salt content at the superficial crust and groundwater that induces secondary salinization of the soils. The very intensive processes of soil salinization occur in the area located in the vicinity of the artesian wells. Therefore the introduction of salt-tolerant wild halophytes has supported studies of groundwater with reference to salinity sources and irrigation management.

Average electric conductivity of the irrigation water (artesian hot spring) varies between 8.30 to 18.1 dS/m, pH between 7.3 to 8.1 (Table 1) The dominant cation is Na^+ and the dominant anion is SO_4^{2-}.

Table 1. Chemical properties of the drainage and ground water of , Uzbekistan (Observations are for August 2006 period).

Site ID	Chemical Properties									
	pH	EC	TDS	Soluble cations *				Soluble anions *		
				Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^{2-}
		dS/m	mg/l	ppm	ppm	ppm	Ppm	ppm	ppm	ppm
Drainage water	7,93	18,1	8800	584,3	364,80	1778,40	7,00	268,5	1996,9	3695,7
Drainage water	7,85	17,8	8750	574,3	352,64	1788,94	7,00	262,4	1996,9	3607,3
Drainage water	8,10	12,5	9000	592,3	370,88	1776,98	7,00	262,4	2196,7	3697,4
Artesian irrigation water (well 1)	7,40	10,9	2654	184,1	91,20	565,11	8,00	176,9	621,2	1014,6
Well 2	7,30	9,86	2716	184,1	85,12	574,31	8,00	164,8	621,2	1018,3
Well 3	7,40	8.30	2826	190,1	93,69	585,58	8,00	176,9	621,2	1078,7

Drainage water is ≈3.5 times more saline than irrigation water. Micro element composition for the Kyzylkesek water is as follows: Sr> Ba> Ti> Mn> Cr> Ni> Cu> Mo> Pb.

II. Floristic composition of vegetation of salt affected lands and evaluation of halophytic germplasm

Studies of the region undertaken by different authors have shown presence of different ecological habitats and high plant diversity along the Zarafshan River Valley (old agricultural zone) and Kyzylkum Desert (Akjigitova, 1982; Goldstein et al., 2000, Toderich et al., 2001; Shamsutdinov et al., 2000, Gus Gintzburger et al, 2003). During the present survey more than 380 species of different groups of salt loving plants (wild halophytes representing 19 taxonomical families) were described. The study areas show a high endemism in plants (bout 3.4% from total species). Most noticeable is the relative richness of the Chenopodiaceae with nearly 33%, equivalent only with Australia chenopods. It is also quite rich in Asteraceae (20%), Poaceae (11%); Fabaceae and Brassicaceae (about 11%). Species belonging to Polygonaceae, Plumbaginaceae, Zygophyllaceae, Cyperaceae account for a smaller share (3-5%), whereas, Eleagnaceae, Plantagainaceae and Frankeniaceae make up an even smaller part (< 1.0%) of rangelands halophytic pastures. Among cited plant resources there are a number of native and exotic halophytes both C_3 and C_4 plants suitable for reclamation of arid and semi-arid, salt/affected and waterlogging areas that have been proven very useful in demonstration trials. These areas have not yet been widely used as part of the arid production system of Uzbekistan by the pastoralists and farmers.

These species grow well in association with a variety of species and often provide severe competition to perennial species, both in natural and introduced pastures on saline and disturbed mine sites. However, many of the germplasm are at the edge of disappearance due to over grazing and may become an irreversible loss of biodiversity resources. Most of populations of the desert halophytes within flora of the Uzbekistan are local and small, sometimes fragmented. They frequently have incomplete life cycles with little ability to reproduce, low indices of renewal and replacement.

Each of zones consists of different dominant species. In the first zone, where there was a high mineral content, species of genus *Salicornia, Halostahys, Halimocnemis, Climacoptera* are largely distributed. The vegetation period begins fairly late because the marshes are under water for a long part of the year. The conventional salt tolerant crops (sorghum, pearl millet, fodder beet, safflower etc.) as is seen from figure 5 occupy an intermediate place between true halophytes and xero-halophytes.

Based on soil characteristics, water table level, mineral composition of above biomass, morphological and reproductive traits, and carbon discrimination values, a new concept for classification of halophytes was developed. Based on these, different ecological groups of halophytes within the Flora of Uzbekistan could be differentiated:

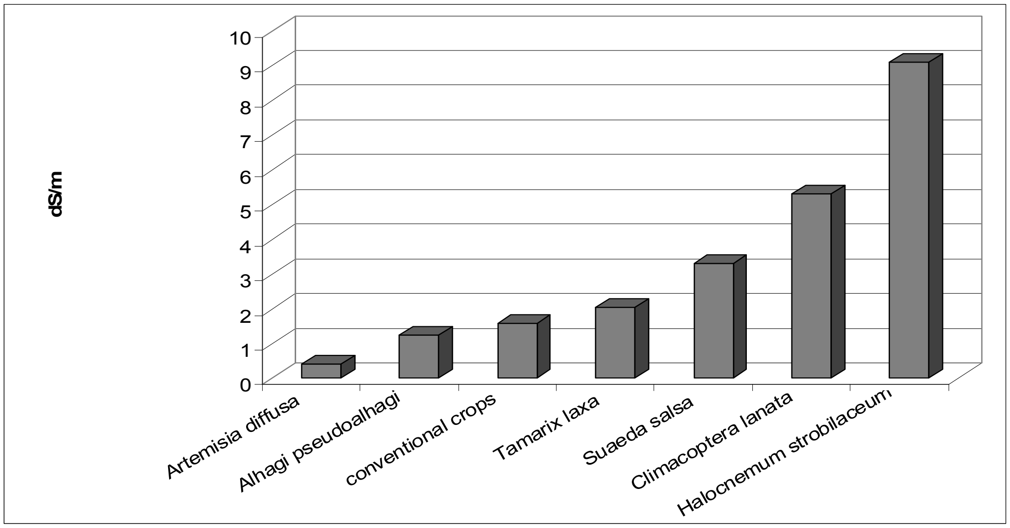


Figure 5. Ecological row of plant species distribution including conventional crops by increasing salinity in the irrigation water

Group I Hyper-halophytes

These group of plants are characterized by the presence of highly saline water (full-strength sea water; up to 100 dS/m). Water table varies from 0.5-1.5 m depth, with solonchak-alkaline and solonetz soils. Plants are succulent and have both C3 and C4 types of photosynthesis. The main species of this group includes, *C. longistylosa, C. kasakaroum, C. bucharica, C. crassa, C. subcrassa, S. transoxana, C. ferganica, C. aralensis, C. turcomanica, C. turgaica, C. itricata, C. turkestanica, Plantago coronopus L.* (C_3 photosynthesis); Salicornia species (C_3 photosynthesis); *Halostachys belangerana (Moq.) Botsch; Halocnemum strobilaceum (Pall.) M.B.* (C3 photosynthesis); *Petrosimonia crassifolia (Pall.) Bunge; Petrosimonia litwinowi Korsh; Halocnemis varia; Halogeton glomeratus.*

Group II Hydro-halophytes

Species within this group that has C3 photosynthesis occurs in wet to standing water, varying from freshwater to brackish water marshes, ditches and around seeps and springs. It can tolerate up to 10,000 ppm, and beyond that. The main species include, *Phragmites australis (Cav.) Trin; Phragmites communis* Trin; *Arundo* spp., *Typha* ssp. *Hippophae ramnoides, Populus diversifolia, Elaeagnus angustifolia.*

Group III Euhalophytes

This group of plants is a good indicator of superficial distribution (1-2m) of underground water; and mainly consist of salt-accumulator and salt-excluder plants. Occurs in wet sandy areas at the edge of salt flats, marshes and salt deserts; wet marshes salted soils on the margin of lakes, tugai, salted desert depression, takyrs. The vegetation mainly comprises of *Suaeda*, annual Salsolas; *Aeluropus repens* (Desf.) Parl.; *Aeluropus littoralis* (Gouan) Parl, *Aeluropus villosus* Hook; *Poa littoralis* Gouan; *Tamarix*; *Dactylis littoralis* (Gouan) Willd., *Kochia scoparia*, which tolerates full-strength sea water. Mostly C_4 photosynthesis.

Group IV Halo-xerophytes

Water table is at > 4 m depth having different types of soils (from sandy – clayey), grey with gypsum content, alkaline meadow salt-marshes, and sandy desert soils. *Haloxylon aphyllum,* perennial Salsolas spp.; *Ephedra strobilaceae, Halothamnus subaphylla, Campharosma lessingii, Kochia scoparia, Zygophyllum* sp., *Alhagi pseudoalhagi, Lycium turcomanicum, Lycium ruthenicum,* some *Calligonum* sp.; *Ceratoides ewersmanniana, Anabasis annua, A. salsa, Anabasis aphylla* L., *Anabasis eriopoda* (Schrenk.) Benth; *Anabasis ferganica* (Drob.) are the major contributors of this group.

Group V Halogemimezophytes

Water table varies between 1.5-2.5 m in depth, inhabits steppes, semi-desert and desert zones mostly on solonetz-alkaline soils, lake shores and river banks. *Cynadon dactylon, Limonium gmelinii, Salsola arbuscula, Karelinia caspica, Frenkenia* spp., *Zygophyllum fabago, Halimodendron halimodedron, Agropyron desertorum, Eremopyrum orientalis, Psylliostachys suvorovii, Atriplex tatarica, Bassia hyssopifolia, Glycyrrhiza glabra, Limonium otolepis* are the major dominants of the group. It includes both C_3 and C_4 plants.

Group VI Halo-gemipetrophytes

Water table varies between 1.5-4.0 m where the plant grows on stony skeletal saline substrate. It is a small group of plants mostly shrubs, semi-shrubs and semi-shrublets: *Haloxylon ammodendron, Salsola arbusculiformis,* and some species of *Atraphaxis, Nanophyton, Anabasis*.

Group VII Metallo-halophytes

Most hyper-accumulators of heavy metals and ions grow slowly and have smaller biomass, delayed flowering and low seed quality (Toderich et al, 2004, 2006b). Most distinguishable species within flora of Uzbekistan are *Artemisia diffusa* H. Krasch, *A. halophyla, Karellinia caspica, Allysum desertorum, Tamarix hispida, Frankenia* *translocate* and accumulate toxic metals from soils into the harvestable portions of roots and surface biomass (shoots, leaves, etc.).

Mineral value of halophytic edificators

The studies produced some understanding of processes involved in the accumulation of these essential elements. Still little is known about the mechanism(s) of mobilization, uptake and transport of environmentally hazardous heavy metals (Toderich et al., 2002, 2005a,b, 2006a,b). Many reports indicate that the plants containing higher concentrations of salts are toxic for livestock and responsible for different types of diseases and physiological disorders (Escarre et al. 2000).

Our investigation on chemical composition of desert plants for ions like Cl^-, SO_4^{2-}, HCO_3^-, Na^+, K^+, Ca^{2+}, Mg^{2+}, as well as phosphorus and iron, showed significant changes within different halophytic forage species. The naturally growing plants, e.g., *Halocnemum strobilaceum, Tamarix hispida, Climacoptera, Halothamnus subaphylla* contains higher Na^+ concentrations near the critical limit for livestock, while legumes (*Alhagi pseudoalhagi)* and some graminous fodder grass mostly accumulate K^+ (Figure 6).

Concentration of salt ions, phosphorus and general iron in the dry matter biomass of all species varies depending on physical and chemical properties of soils and irrigation water as is shown at Figure 7 a,b,c,d for *Alhagi pseudoalhagi*, *Tamarix laxa*, Poaceae spp. and *Climacoptera lanata,* inhabiting the bio-monitoring points along Zarafshan River and Kyzylkum Desert.

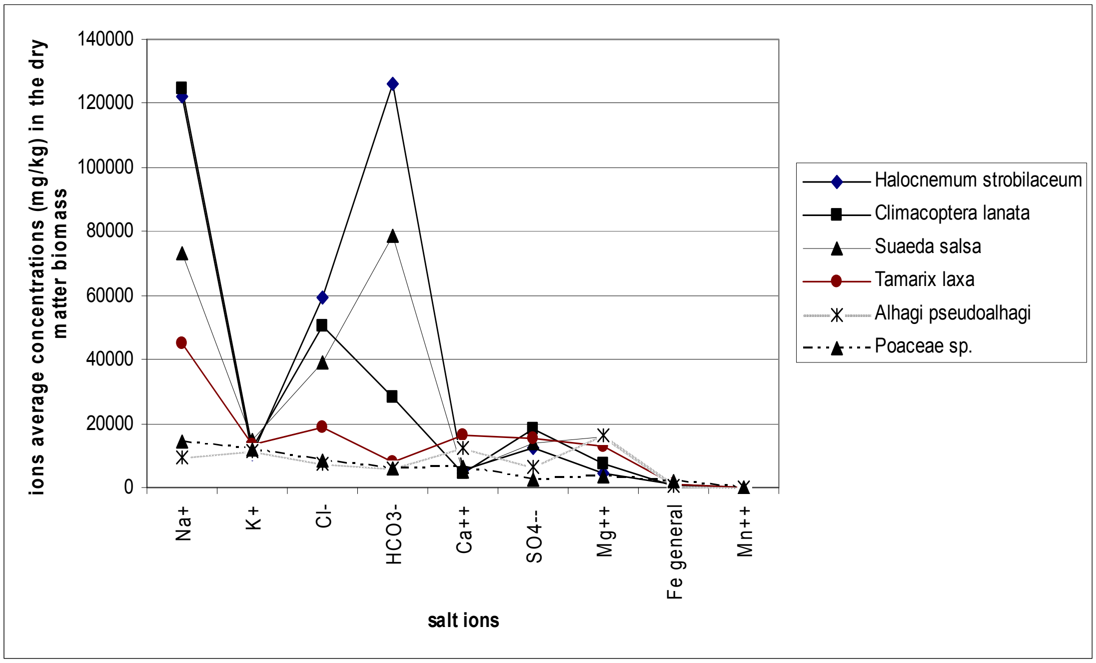
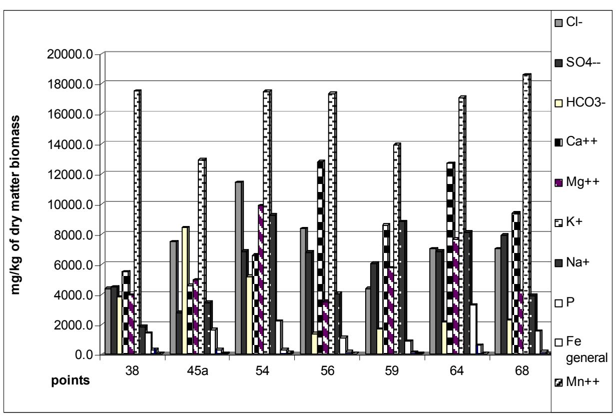
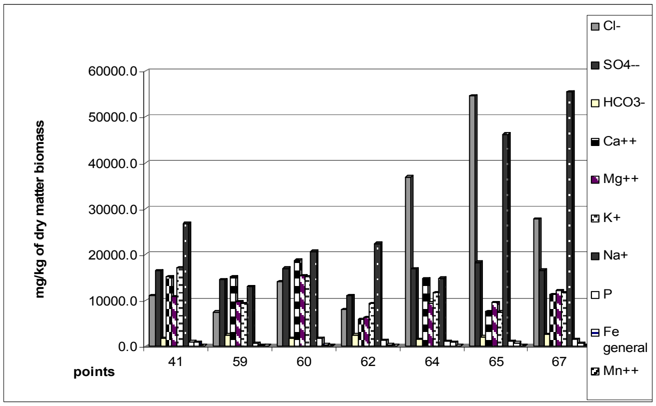


Figure 6. Changes in chemical composition of dry mater biomass of various halophytic forage species growing under sandy saline desert Environments

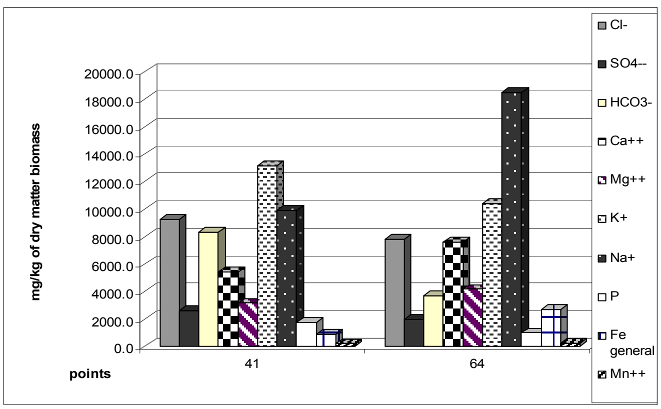


a) *Alhagi pseudoalhagi*,

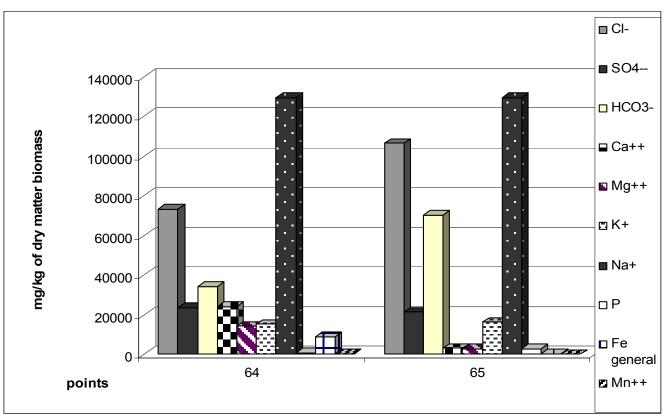
Figure 7. Concentration of salt ions, phosphorus and general iron in the dry matter biomass of (a) *Alhagi pseudoalhagi*,



b) *Tamarix laxa,*



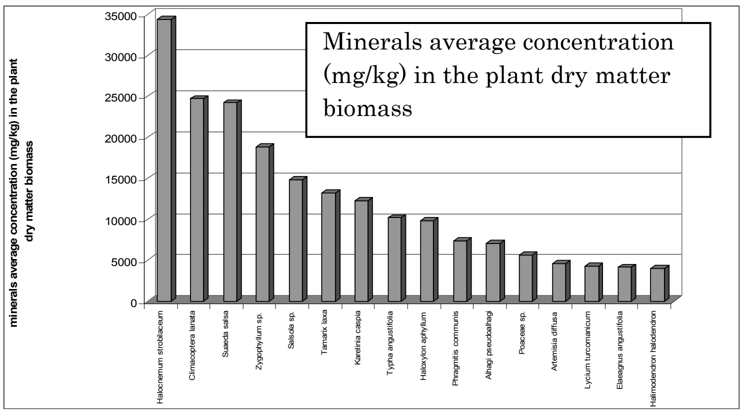
c) Poaceae spp.



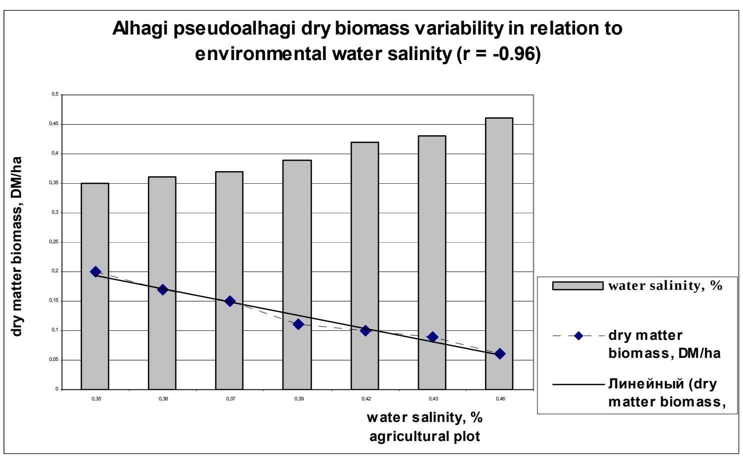
d) *Climacoptera lanata.*

Figure 7. Concentration of salt ions, phosphorus and general iron in the dry matter biomass of (a) ***Alhagi pseudoalhagi***, (b) ***Tamarix laxa,*** (c) Poaceae spp. and (d) ***Climacoptera lanata.***

Highest concentration of K^+ was found in *Kochia scoparia*, closely followed by *Atriplex nitens* and *Suaeda arcuata*. Figure 6 shows that the total mineral ions were maximum in *Halocnemum strobilaceum*, followed by *Climacoptera lanata*, S*uaeda salsa, Salsolas* spp., *Zygophyllum* spp., *Tamarix laxa, T. hispida* and *Haloxylon aphyllum*. On the base of salt concentration of main cations (Ca^{2+}, Na^{+}, K^{+}, Mg^{2+}) and anions (SO_4^{2-}, Cl^{-}, HCO_3^{-}), *Alhagi pseudoalhagi*, Poaceae spp. , *Artemisia diffusa* having a minimum concentration of mineral ions and could be categorized as relatively more palatable as forage plants. However, the fresh biomass of *Alhagi pseudoalhagi* from highly saline habitats sharply decreases with the increasing of gradient of salinity (Figure 7 a,b).



a. by mineral accumulating ability



b. changes of dry biomass of Alhagi pseudoalhagi in relation to soil salinity

Figure 7a,b . Zarafshan River Valley and Kyzylkum Desert inhabit plant species distribution row

Alhagi pseudoalhagi, Poaceae spp. and *Artemisia diffusa* are more suitable as animal fodder than other salt tolerant plants. These species can be recommended for direct grazing or feeding. Salt bushes also maintained relatively higher Ca and Mg. Potassium concentration was found higher in *Kochia scoparia Agropyron desertorum*, closely followed by *Atriplex nitens, Suaeda salsa,* while annuals Salsola and grasses like *Bromus, Aeluropus, Eremopyrum* contain low amount of mineral ions because excess salts are excluded through salt glands present abundantly on the surface of epidermis of last mentioned species.

IY. Livestock farming-cropping system under sandy saline desert Environments

Planting herbaceous fodder crops within the inter-spaces of fodder shrubs on intensive agro-forestry plantations could solve the karakul sheep feeding problem in degraded (both by overgrazing and salinity) sandy desert areas. In addition, wild halophytes species planted in widely spaced patterns (15-25 m) allows for easy mechanical cultivation and harvesting of grass and cereals. Salt tolerant trees and/or shrubs species, e.g., *Populus, Salix, Elaeagnus, Morus, Hippophae ramnoides* established on good deep soils have good potential as part of the production system. In the present case, fodder shrubs were associated with cereal farming system, including rangeland species alone, or mixed with different salt tolerant fodder crops. As part of the desert land re-vegetation, Saltbushes *Atriplex canescens, A. undulata, A. nummularia* and *A. amnicola,* were recently introduced at the saline sandy desert zones of Kyzylkum. Seedlings were produced at the nursery of the Plant Industry Institute, Uzbekistan, and were transplanted to the site under appropriate management in the fall period.

Tables 2 and 3 indicate the mean yield of native halophytes in mixture with different promising salt tolerant crops during 2005-2006. Better plant growth, accumulation of green biomass and consequently yield of both fresh and dry matter were significant for *Kochia scoparia, Climacoptera lanata, Atriplex nitens* grown in mixture with salt tolerant crops.

Table 2. Plant growth and productivity of annual halophytic pastures irrigated with artesian mineralized water at Kyzylkum site. Plantation was done in 2006.

Species/ Acc.No.	**Date of seed bedding**	**Number of plants (1000/ha)**	**Height of plants (cm)**	**Yield of fodder mass (T/ha) wet**	**Dry**	**Yield of seeds (T/ha)**	**Vegetative Period (Days)**
Kochia scoparia							
K-599	14.03.06	262.9	160.7-192.0	29.5	14.6	1.19-4.60	82- 96
	14.03.06	231.3	101.0-169.0	21.0	11.0	1.37- 2.40	80-85
K -598	14.03.06	214.6	148.0 - 188.0	28.1	9.5	2.80 - 2.92	78-80
Control/ Kyzylkum population	Self/reproduction	301.4	121.0-160.0	15.6	7.8	0.75-1.34	80-101
Atriplex nitens							
K-550	14.03.06	no data	121.0±3.9	21.0± 5.8	9.6± 3.8	2.90-3.60	125-135
K-632	Self-reproduction	no data	140.0±1.2	190 ± 4.1	9.1 ± 3.2	2.08- 4.30	136-148
K-620	Self-reproduction	no data	180.0±5.4	21.0±7.1	9.69±5.8	2..96-5.60	140-150
Climacoptera lanata							
K-621	25.02.06	173.3	47.3±0.7	58.8	17.9	0.09-0.45	180-220
K-602	25.02.06	113.3	75.3±0.9	114.6±2.3	21.1	1.43-1.56	190-232
Climacoptera + Sorghum	14.04.06.	146.0 620.0*	85.0±3.4 205.0±4.9	175±6.9 22.33±2.6	8.85±4.6 13.4±4.9	3.90-8.48 5.10-6.85	190-235 125-136
Climacoptera + Sorghum (+ Fertilizer)	10.04.04	104.5 138.0	73.3±2.2 210.0±7.8	96.8± 2.9 68.0±10.1	6.17± 3.4 23.8±9.3	1.69 - 4.2 8.30-12.47	180-210 110-125
Climacoptera + *Zea maize*	10.04.06	135.0 212.0	67.7± 0.6 250.0±3.9	61.6 ± 2.1 13.5±4.6	7.04± 3.6 25.5±7.1	1.92- 3.6 6.40-7.22	180-210 95-130
Climacoptera + *Zea maize* (+ Fertilizer)	10.04.06	153.3 234.0	89.0±6.5 280.0±6.2	45.0±6.9 42.0±8.1	22.0±5.6 19.8±4.9	4.90-13.2 5.40-10.20	195-205 85-110
Salt depression (control) *Climacoptera* pure stands	Self-reprodu-ction	51.1	46.7±1.7	62.2	11.5	0.80-1.00	210-235
Suaeda arcuata							
Salt depression	Self-reproduction	15.3	113.6	54.4	13.6	0.57-1.09	170-190

* Values mentioned for graminous crops; Sorghum or Zea mays

Table 3. Plant growth and productivity of perennial halophytic pastures irrigated with artesian mineralized water at Kyzylkum site. Plantation was done in 2006.

Name of Plant species	**Date of seed bedding**	**Number of plants**	**Height of plants**	**Yield of fodder mass**		**Yield of seeds**	**Vegetative Period**
		(1000/ha)	(cm)	Fresh (T/ha)	Dry (T/ha)	T/ha	(Days)
Salsola orientalis	Self-reproduction (II-III)	9.29-12.3	75-155	2.0-2.8	1.0-2.2	0.05-0.15	250-254
Halothamnus subaphylla	20.10.05	9.25-10.28	109-150	1.9-2.06	1.24-2.1	0.90-0.93	235-250
Kochia prostrata	Self-reproduction	17.22	94-103	2.6-3.09	2.06-2.16	0.30-0.67	250-260
Camphorosma Lesingii	Self-reproduction (II-III)	14.98	88-92	1.6-2.07	1.2-1.6	0.02-0.21	230-235
Atriplex canescens K-4773	14.03.06 (seedlings)	104	35.1-35.3	6.19±5.3	2.05-2.25		220-238
Agropyron desertorum	14.03.06	812	125-157	0.8-1.5	0.40-0.60		105-108
Alhagi pseudoalhagi	Self-reproduction (II-IY)	960/1004	58-161	0.8 5-2.40	1.24-1.60	0.10-0.19	218-225
Glychyrriza glabra*							
K-609 Karakalpakstan ecotype	25.02.06	231-345	45-110	4.10-7.90	1.27 - 3.10**	0.79-0.9	216-220
K-603-Mirzachuli steppe	25.02.06	380-416.0	60-150	8.40	3.46	0.46	190-205
Hippophae ramnoides K-656	25.02.06	280-310	68-105	-	-	-	205-220

* Expected yield of dry roots 2.5 t/ha

There were significant differences in the yield of fodder mass and seeds between annual and perennial species of halophytes. Yield of all tested species decreased with increased planting density. Use of fertilizers also affected the biomass yield.

Conclusions

Poaceae species, *Artemisia diffusa* and *Alhagi pseudoalhagi* are more suitable as animal fodder than other salt tolerant plants. Grass species can be recommended for direct grazing or feeding. For instance, *Agropyron desertorum* in mixture with *Kochia scoparia, Climacoptera lanata, A. nitens* in pure stands and in mixture with many forage perennial halophytes that were introduced under irrigation (with artesian mineralized water) can be recommended to farmer's for cultivation. This would create a livestock grazing system and also as fodder reserve on salt-affected wastelands. It was found that mixture of *Kochia scoparia* and *Agropyron desertorum* in association with wild growing *Alhagi pseudoalhagi* could produce up to 1,3 t DM/ha.

Salt bushes and perennial species of *Salsola, Halothamnus, Ceratoides, Camphorosma* that have high potential to tolerate strongly saline environments also maintained relatively higher Ca and Mg ions. The annuals and grasses like species of genus *Bromus, Aeluropus, Eremopyrum* and *Carex* contained low amount of mineral ions. This could be due to the excretion of salts through salt glands, which are absent in typical for Kyzylkum desert halophytes such as, *Atriplex canescens*, *A. nitens* and *Climacoptera lanata*, and can be utilized in the animal ration by mixing (with conventional forages) feed.

Ion contents of evaluated wild native halophytes were relatively low and hence these species could be recognized as alternative forages, both in pure halophytic pastures and/or in mixture grass stands. Most of evaluated halophytes being late flowering and seed maturating species are recommended as a fattening feed during autumn and winter seasons, when there is a deficit of forages on the pasture lands.

Crop benefits by improvement in soils and micro-climatic conditions provided by the shrubs inlcude; reduction in weed speed and potential evapo-transpiration, buffered temperatures, sand storms, increased organic matter in the soil, more stable structure, high permeability, better water budget, and quicker turnover of geobiogene.

Introduction of strips-alley cropping system represent an alternative for private farms in the livestock-based farming system, as well as a way to diversify feed resources under unfavorable environments. It also leads to the uniform distribution of good quality feed resources throughout the year and during difficult periods while preserving soils, water and phytogenetic resources. Another technique used in the salt affected sandy desert environments is to plant shrubs as windbreaks to spare the land for other crops and help protect the soils from wind erosion and sand encroachment. At present efforts are made to provide plants materials (seeds, seedlings, younger plants) to the farmers and train them on how to manage the improved rangelands.

References

Akjigitova N.I. 1982, Halophytic vegetation of Middle Asia and its indicator Properties. Tashkent "FAN" Publisher: 201p.

Aparin V., Kawabata Y., Ko S., Shiraishi K., Nagai M., Yamamoto M., Katayama Y. 2006, Evaluation of Geoecological Status and Anthropogenic Impact on the Central Kyzylkum Desert (Uzbekistan). J. Arid Land Studies: 15-4: 129-133.

Goldstein R.I. 1997, Ecological Situation of Kyzylkum in Connection with it's Industrial Development. In: Bulletin of SCST of the Republic of Uzbekistan, No3-4: 70-75.

Goldshtein R.I., Tsukatani T., Toderich K.N., Ashurmertov O.A., Aparin V.B., 2000, Ecological state and conservation of arid salt/affected lands using Asiatic Salsola species. Abstracts Book of International Seminars for Saline Agriculture. Islamabad:10-12.

Escarre J., Lefebvre C., Gruber W., Leblane M., Lepart J., Riviere Y., Delay B., 2000, Zinc and cadmium hyper accumulation by Thlaspi caerulescens from metalliferous and non metalliferous sites in the Mediterranean area: implications for phytoremediation . New Phytologists, 145: 429-437.

Gintzburger G., Toderich K.N., Mardonov B.K. and Makhmudov M.M. 2003, Rangelands of of the arid and semi-arid zones in Uzbekistan. Centre de Cooperation Internationale en Resherche Agronomique pour le Development (CIRAD) , Monpellier, France. 498 p.

Nordblom T., Shomo F., Gintzburger G. 1997, Food and feed prospects for resources in Central Asia. In Demment M. (ed.) Central Asia Regional Livestock Assessment Workshop. Tashkent , Uzbekistan . Management Entity, Small Ruminant CRSP, University of California. USA: 226p.

Shamsutdinov Z.Sh., Savchenko I,V., Shamsutdinov N.Z. 2000, Holophytes of Russia and their ecological characteristics and use. Academy of Agricultural Sciences. Russian Fodder Institute. Moscow: 399p. http://www.ilri.org/InfoServ/Webpub/Fulldocs/Cropresidues/chap%207.htm

Toderich K.N., Goldshtein R.I., Aparin V.B., Idzikowska K. and Rashidova G.Sh. 2001, Environmental state and an analysis of phytogenetic resources of halophytic plants for rehabilitation and livestock feeding in arid and sandy deserts of Uzbekistan. pp. 154-165. In: Sustainable Land Use in Deserts. Spriger Publisher, Berlin.

Toderich K.N., Tsukatani T., Black C.C., Takabe K. and Katayama Y. 2002, Adaptations of plants to metal/salt contained environments: glandlar structure and salt excretion, KIER Discussion paper, No 552, Kyoto

University, Kyoto, Japan. 18 p.
Toderich K.N., Aparin V.B., Tsukatani T. and Konkin A.B. 2003, A strategy for land rehabilitation by salt and heavy metal removal usingthe integration of Asiatic desert plant diversity. Chinese Journal of Arid Land Geography 26:10:150-159.
Toderich K.N., Tsukatani T., Petukhov O.F., Grutsinov V.A., Khujanazarov T. and Juylova E.A. 2004, Risk assessment of Environmental contaminants of Asiatic Deserts Ecosystems in relation to plant distribution and structure. Journal Arid Land Studies 14S:33-36.
Toderich K.N., Tsukatani T., Shuyskaya E.V., Khujanazarov T. and Azizov A.A. 2005a, Water quality and livestock waste management in the arid and semiarid zones of Uzbekistan. p. 574-583. In: Proceedings of the University of Obihiro, Japan.
Toderich K.N., Li V.V., Black C.C., Yunusov T.R., Shuiskaya E.V., Mardanova G.K. and Gismatullina L.G.. 2005b, Linkage studies of structure, isoenzymatic diversity and some biotechnological procedures for Salsola species under desert saline environments. p. 73-82. In: Biosaline Agriculture and Salinity Tolerance in Plants. Birkhouser Verlop AG Basel – Boston – Berlin.
Toderich K.N., Black C.C., Ashurmetov A.A., Japakova U., Gismatullina L.G. and Yunusov T. 2006a, Salsola spp. as a model for understanding plants reproductive system. p. 204-206, In: Biochemistry and Environmental Physiology in Desert Ecosystems. Baytenovskie Chteniya. Almata.
Toderich K.N., Yensen P.N., Katayama Y., Kawabata Y., Grutsinov V.A., Mardanova G.K. and Gismatullina L.G. 2006b, Phytoremediation Technologies: using plants to clean up the metal/salts contaminated desert environments. Journal Arid Land Studies 15S:183-186.
Tsukatani T. and Katayama Y. 2001, Water Quality of Zarafshan River Basins. Discussion paper No 527, Kier, Kyoto University Publisher, Japan. 28 p.