Chapter 19
The Aralkum, a Man-Made Desert on the Desiccated Floor of the Aral Sea (Central Asia): Final Conclusions and Comments

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The Aral Sea no longer exists. Within about 50 years a huge new desert has developed: the Aralkum. Public awareness of this area has grown considerably in the last few years.

Two research projects of the Department of Ecology at the University of Bielefeld, financed by BMBF (German Federal Ministry of Education, Research and Technology), were only two of several attempts to reveal the dynamic situation. The first was to study "Succession processes on the desiccated sea floor of the Aral Sea and perspectives of land-use" (1998–2001), the second was to study "Combating desertification and rehabilitation of salt deserts in the Aralkum" (2002–2005). Some of the open scientific questions are answered in chapters in this book. Both projects revealed interesting and new scientific data and results. They were also able to contribute to better socioeconomic conditions in some villages, and to increase the participatory involvement of stakeholders by capacity building. The cooperation with scientific institutions in Kazakhstan and Uzbekistan, and with the relevant political administrations, gave good opportunities for information exchange and increased mutual understanding in future applications of phytomelioration measures and nature conservation topics. For both, knowledge of the general situation is a precondition.

The abiotic dynamics in the area was demonstrated by Chaps. 2–4. On 13 June 2009, the analytical laboratory of Johnson Cosmic Center (NASA 2009) fixed for the first time the complete drying of the shallow eastern part of the Aral Sea (see also Fig. 2.6b). Today, the Aral Sea consists of several remnant water bodies – the Small Aral Sea (North Aral Sea) in the territory of Kazakhstan and the Large Aral Sea (West Aral Sea or Southwest Aral Sea) as a deepwater part of the former sea in Uzbekistan and Kazakhstan. A small remnant basin is the Tschebas basin in the northwest. Within about 50 years a huge new desert has developed. This desert is caused by human activities; thus, it is an artificial desert, but all the ongoing processes follow natural laws and are most interesting for science. The area of the dry seafloor of the Aral Sea, called the Aralkum (Agachanjanz and Breckle 1993; Breckle and Agachanjanz 1994; Breckle et al. 2001; Breckle and Wucherer 2011), is still increasing and is currently about 60,000 km. The present huge salt desert area

S.-W. Breckle et al. (eds.), *Aralkum - a Man-Made Desert: The Desiccated Floor of the Aral Sea (Central Asia)*, Ecological Studies 218,
DOI 10.1007/978-3-642-21117-1_19,

of the desiccated seafloor is now comparable with the Iranian salt desert or the Great Basin salt desert in Utah (USA). But the fundamental difference is the timescale. The latter deserts were formed by a geological process, whereas the Aralkum has been formed within a few decades, meaning a much faster speed of development.

The dry seafloor of the Aral Sea is a new terrestrial surface. It has developed to form a new geographical object, a new desert, that has a strong environmental impact on the surroundings of the Aral basin. The Aralkum is located within the Asiatic desert belt. In the Aralkum area, two climatic subdistricts can be distinguished – the Aralsk subdistrict in the north and the Muinak subdistrict in the south. The limit between these two districts is defined. The northern part of the Aralkum is part of the Kazakh-Dzungarian or northern Turanian deserts, and the southern part is part of the southern Turanian deserts (see Chap. 4). The climatic conditions of the area are governed by global trends. The global trend of rising temperatures is also to be seen in the area of the Aralkum. The annual mean temperatures as well as most of the monthly mean temperatures of almost all stations around the Aral Sea have risen since 1960 by about 1–2K. The warming trend was also indicated by Kuzmina (2007), who gave smoothed functions for the seasons for the Aralsk meteorological station, which indicate a rise in temperature of about 2–3 K between 1937 and 2002. The same is true for the hinterland stations (Kazalinsk, Kyzyl-Orda, Chilik-Rabat, Kuruk). The annual precipitation seems to be rising too, but is very dynamic and thus not yet statistically significant.

In the Aralkum, about 20% (about 12,000 km^2) is sand and sandy-loamy deserts, mainly the first parts of the seafloor which became dry in the 1960s and 1970s. The majority is salt desert (70%, about 42,000 km^2), and this situation is rather different from that in other deserts, where sometimes no salt desert may exist (e.g., in the Negev, the Sonoran Desert or the Chihuahua; Table 1.1). The remaining area (10%) is wetlands and remnants of tugai scrub, as well as transformed landscapes that are under the influence of the Amu Darya and the Syr Darya (see Chap. 1). The Aralkum is a new continental area that is governed by geohalomorphic as well as by aeolian processes. The vast-plain open-sea bottom is not totally plain; it exhibits old submarine channels, hills, ridges, sands splits and tombolos, which, are now overformed. The desiccated soil sediments along the coast and the forms of the primary relief play an important role in the formation and development of the present landscape structure in the Aralkum. The north and the west of the Aralkum are limited by the high structural denudation plateaus of Turgay and Ustyurt, in the east by the sand deserts Priaralski Karakum and Kyzylkum and in the south by the Amu Darya delta. The elevation amplitude of the Aralkum is now between 25 m above sea level (asl) and 58 m asl, including the old and new Aral terraces (see Chap. 3).

The biotic dynamics, the flora and vegetation cover, and the already rich fauna of the Aralkum were discussed in Chaps. 8–11. The rapidly changing conditions and the fast successional processes are fascinating and give a new picture of the not at all constant species pattern (Chaps. 10, 12 and 13). The flora of the Aralkum consists of about 370 species, belonging to 44 families and 178 genera (Chap. 8). The flora of the Aralkum is rather young and has formed since 1960 as a typical immigration and desert flora. Formation of the Aralkum flora in ancient and modern

times occurred and is occurring simultaneously with the development of landscapes, vegetation and soils. It is certainly a flora where species have to be adapted to the rather severe ecological conditions of drought and heat in summer, to frost in winter and to moving sand conditions and to varying salinity, as well as to inundation and anaerobic conditions of solonchak soils.

The Aralkum region is a biodiversity centre of halophytes in Middle Asia and Central Asia (Wucherer et al. 2001). Plants have developed various mechanisms to cope with salinity (Chap. 12). Often morphological structures are typical for distinct adaptation strategies. Especially halosucculence of stems or leaves, or both, is very common in halophytes strongly adapted to salinity (Breckle 2002). The halophytic species, nevertheless, are on the other hand indicators of the degree of salinity on their site, and thus can be used to monitor salinity. A novel list of indicator values for salinity is presented. All species of the Aralkum flora are listed in Table 12.9 with their ecological salinity indicator value (*S* value), their halophytic strategy type and their life form. This list may serve as an easy way to check the degree of salinity at adjacent agricultural plots.

The Aral Sea depression is part of the temperate continental desert and semidesert belt. Accordingly, the vegetation of the Aralkum is a desert vegetation (Chap. 9). It is in various stages of development. The main vegetation types of the Aralkum are halophytic, psammophytic, tugai and salt-meadow communities. The salt and sand deserts and accordingly the halophytic and psammophytic vegetation types dominate. The typical pattern of landscapes, vegetation and soils is striated. The southern and southeastern coasts of the former Aral Sea including the dry seafloor belong to the southern Turanian phytogeographical area, and the western, northern and northeastern coasts belong to the northern Turanian area. The dry seafloor of the Aral Sea is a new surface, where terrestrial plants (including seed banks) and animals have not existed before. It is now actively populated by organisms. The formation of plant communities, soils, a new groundwater level, aquifers and all components and processes of ecosystems is occurring more or less simultaneously (Wucherer and Breckle 2001). It is a typical primary succession (Chap. 10). The succession on the dry seafloor has continued for the last 50 years. The distribution and dynamics of the vegetation and ecosystems were surveyed along transects. On average, the succession on loamy stands can be described by two to four stages, and that on sandy soils can be described by three to five stages. The existence of a distinct stage is a consequence of the ecological conditions and stability, and thus might range between 2 and 30 years. The geological, geomorphological, climatic, edaphic and aeolian factors controlled the vegetation development in the Aralkum in the first few years after the desiccation. But in the late phase, mechanisms of facilitation and tolerance have played a crucial role, especially by the psammophyte succession.

The fauna of the Aralkum (Chap. 11) has been studied only partly. Although many faunistic data have been collected in the Aral Sea basin over the past decades, there is no systematic monitoring of the faunal settlement of the Aralkum. But lists of mammals of the Kazakhstan part of Aral Sea region, the migratory breeding bird species and rare winter visitors, the resident breeding bird species, passage visitors (birds), vagrant birds, reptiles collected around the Aral Sea in the 2002–2004 and the

taxonomical diversity of insect orders and other groups have been produced. The shoreline of the Aral Sea in Kazakhstan belongs mainly to two zoogeographical zones (in relation to mammals) – northern Aralo-Caspian deserts and the Kyzylkum. The southern border of the first zone runs along the state border between Kazakhstan and Uzbekistan (Karakalpakstan) and along the Syr Darya. The Kyzylkum zone comprises the Kyzylkum from the Syr Darya to the state border with Uzbekistan, and the Uzbekistan coast. This conclusion confirms the climatic (Chap. 4) and botanical-geographical (Chap. 9) border between the northern and southern Aralkum.

The desiccated sea bottom was completely transformed into an area covered by sands and solonchaks. There are many plans for tackling and combating the disastrous situation caused, for example, by the dangerous salt-dust storms. The salt-dust storms are particularly endangering human health as well as productivity of agricultural areas by enhancing salinization in adjacent agricultural regions. This is a prominent problem in the Aralkum area as a whole. Semenov has developed a physical model to evaluate the amount of aerosols transported from the desiccated seafloor of the Aral Sea (Chap. 5). This is a regional problem. Monitoring of land cover condition and analysing land cover change in the Aralkum is of great importance, since the ecological situation is still very dynamic and a large part of the landscape in the Aralkum is unstable (Chap. 6). The results demonstrate that MODIS time series classification is a valuable tool to produce accurate landscape classification, landscape change maps and statistics for large areas. For the southern Aralkum, the results of the postclassification change detection revealed that (a) between 2000 and 2008, no significant vegetation cover emerged on the former seabed in the study area; (b) the shrubland and reed classes show high interdependence; and (c) the potential source area for dust and salt storms in the study area has increased. The results of analysis of satellite data for the period 2005–2008 (Chap. 7) show significant differences in the frequency and magnitude of dust storms from year to year. A monotonic increase in the annual activity of the transport processes is observed. It is obvious that the process of removal of salt-dust aerosol particles from the dry bottom of Aral Sea is the result of progressive drying of the former seabed and the formation of a growing area with an unstable surface not fixed by vegetation.

This problem could be solved by huge plantings of heat- and frost-resistant as well as drought- and salt-resistant woody plant species to minimize wind speed and deflation processes on the soil surface of the dry seafloor. Huge experimental plantings (Chaps. 15–17) with plots up to 250 ha have shown that only very few species are suitable for this purpose: *Haloxylon aphyllum* and *Halocnemum strobilaceum*. Some other species still need to be tested accordingly (*Halostachys caspica* and *Tamarix*, *Ammodendron*, *Suaeda* and *Salsola* species). Furthermore, recent evaluation of various experimental sets revealed that special techniques to plant saplings have to be applied and have to be adjusted to the relevant soil situation.

The problems of the local sandstorms (Chaps. 5 and 15), threatening villages and infrastructure, must be solved by local wind shelter programmes and rational grazing management, involving activities of all inhabitants.

The problems of nature conservation in the Aralkum region are described in Chap. 14. The territory of the nature reserve in the north was expanded in 2006 by almost 10 times (160,826 ha), including territories of the dry seafloor. The area now consists of two cluster areas: (1) the former island of Barsa-Kelmes with the surrounding dry seafloor; (2) the former islands of Kaskakulan and Uzun-Kair with the surrounding dry seafloor. These are the main habitats of onager (*kulan*; *Equus hemionus onager*) and Persian gazelle (*jairan*; *Gazella subgutturosa*), to where they migrated after the area became dry. The flora and vegetation represent typical combinations of plants and vegetation types for the region as well as unique trends of the successional development on the desiccated seafloor of the Aral Sea.

Chapter 18 presents a synthesis on the complexity of the social and economic situation in the post-Soviet states as well as an approach to the applications of scientific results to combat desertification also regarding the issue of the sensitivity of the area to climate change. An important issue will certainly be the rebuilding of efficient agriculture with water-saving techniques and plant crops for advanced irrigation (Breckle and Küppers 2007; Breckle and Wucherer 2007).

To conclude, the Aralkum is characterized by a very high percentage of salt desert plains (Table 1.1). Those sites only can be invaded by halophytes (Chap. 12) from the adjacent deserts (Kyzylkum and Karakum), which themselves are centres of biodiversity in Chenopodiaceae and other halophytic and also psammophytic plant families. Both play an important role in ecosystem development. The dry seafloor is the largest area worldwide where a primary succession is taking place. Knowledge of vegetation dynamics in the Aralkum, which is a mosaic of sand and salt desert ecosystems, is important for understanding of the ecosystem dynamics in the whole Central Asian area. The desiccation of the Aral Sea and the formation of the Aralkum are without doubt important milestones in the formation and evolution of new Turanian geoecosystems and bioecosystems and for the Middle Asian region as a whole. Future studies may reveal if there is a steady state of a dynamic equilibrium of water balance as well as of ecosystems has been reached. Most probably, the development of species patterns adapted to the harsh environmental conditions will be very dynamic.

The importance of this huge new desert with the remnant water bodies for the Central Asian states may be seen as an area for gas and oil mining, but also as an area where nature may have a chance to develop rich semidesert and desert ecosystems as basic parts of a protected nature reserve or a national park (Chap. 14).

Within this volume some important data and basic scientific knowledge are brought together in an interdisciplinary and international approach by not only scientists from the fields of ecology and geography, but also social scientists and economists. To improve the regional situation, cooperation of nature conservation organizations, developmental and health agencies and other main stakeholders in the area with administrations, decision makers and regional and national politicians is an urgent need (Chap. 18).

The Central Asian states involved are strongly advised to fulfil their mutual treaties (Chap. 18) as well as to use international help and funds for joint development of adapted water and energy supplies for the people living adjacent to the

Aralkum. The Aralkum is a focal point for combating desertification on many levels. Joint programmes for social and economic development of the area with promotion of education and capacity building of the people provide a great chance for a better future by minimizing the negative effects of the irreversible desiccation of the Aral Sea and by accepting the new desert Aralkum as an opportunity for the next generations.

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