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Dust storms, dust transfer and depositions in the southern Aral Sea region

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Introduction, problem situation

Aeolian processes as manifested by dust and sand storms (DSS) are natural events that occur world-wide in arid regions [1]. The vast distribution and existence of desert landscapes indicates that these regions are important source areas of dust storms among others [2]. In recent times human activity has created another source on the desert margins in semi-arid areas that previously were stable [3]).

The genesis of dust storms is controlled by strong winds, surface material susceptible to wind erosion and transport, and unstable atmospheric conditions. At a wind speed of 0.6 m/sec particle mobilization starts. After becoming entrained, wind speeds of 16-24 km/h are necessary to sustain particle movement [2].

Land surfaces poor in vegetation coverage and dried out soils are accelerating factors of sand and dust transport. Dust transport also has considerable impact on the human society if highly populated regions are on the transport pathway or sink areas as dust transport can bring pollutants into residence areas [4]. The quantitative prediction of dust storms is impossible unless the entire dust cycle, consisting of dust emission, transport and deposition, can be correctly assessed. In recent years, dust emission schemes have been developed that account reasonably well for the impacts of atmospheric forcing and land-surface properties on dust emission [5].

The Aral Sea disaster has been caused by the overexploitation of the water and land resources and is related to problems of polluted surface and ground water bodies, the loss of agricultural productivity and biodiversity, the regional climate change and also the human health, especially within the disaster zone [6]. Major consequences of the Aral Sea shrinkage, apart from the decrease of its water volume and area, an increase of the water salinity and a modification of the salinity pattern is the formation of a vast saline desert with the area of almost 3.6 mln ha on the exposed seabed [7] (Fig.1). The main factors of dust storm occurrences are the frequency of strong winds and availability of source material in dust emission sites. During the last decades the total area of dust emission sites in the Aral Sea region increased significantly because of the shrinking of the Aral Sea and consequent drying of its exposed bottom and deltaic areas of Amudarya and Syrdarya Rivers [2].

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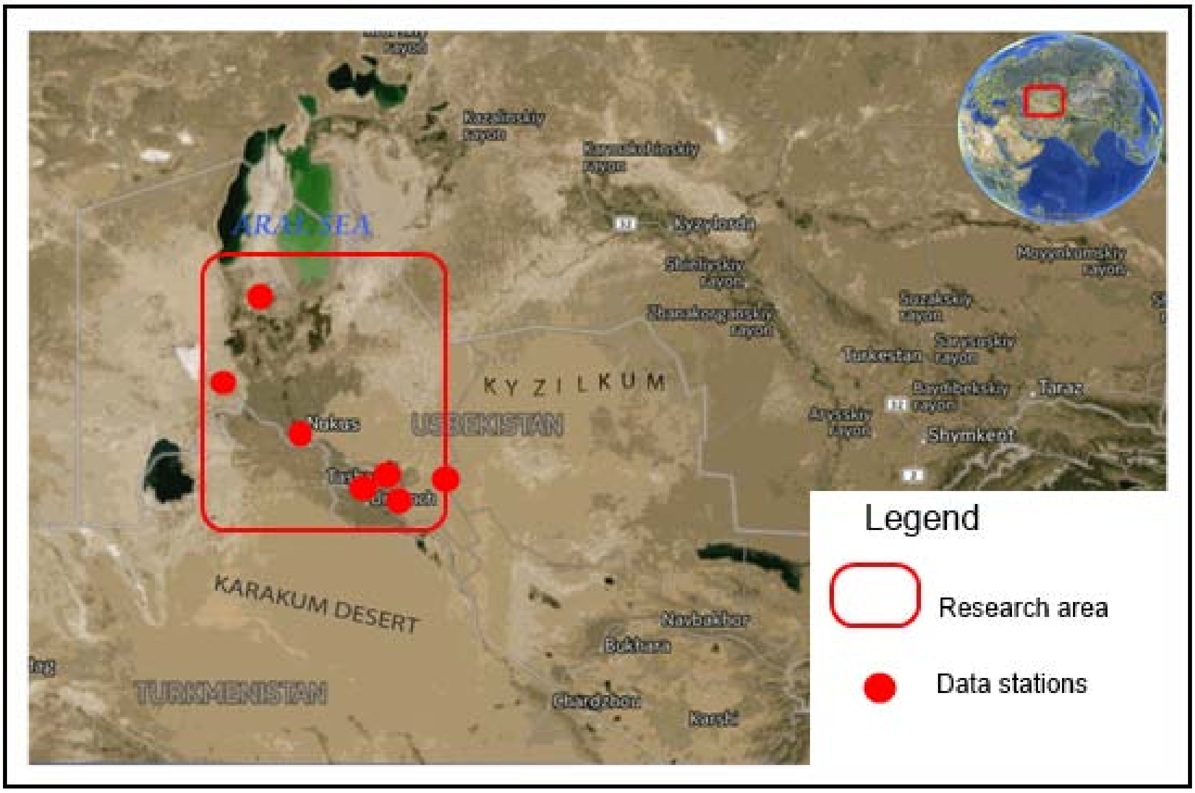

Fig. 1 Research area and study sites, southern Aral Sea region

Problem settings and Objectives

The Aral Sea disaster is a complex problem formed by the anthropogenic influence of land use activities within the lake's catchment and the special conditions of a terminal lake in an arid area. Under conditions of the Aral Sea ecological crisis, natural ecosystems within a 400 km radius of the seashore have undergone drastic transformations. In region of Aral Sea crisis cause many problems depends and affects each other (Fig. 2).

In the present research we are pointing out only the problem of dust storms and dust deposition. The aim of this research approach is to analyze the spatial and temporal distribution of dust depositions in the southern Aral Sea region. Dust occurrence and its effects lead to the modification of the mineral structures of the arable land. Productive soils are degraded and salinized, the agricultural productivity is decreasing.

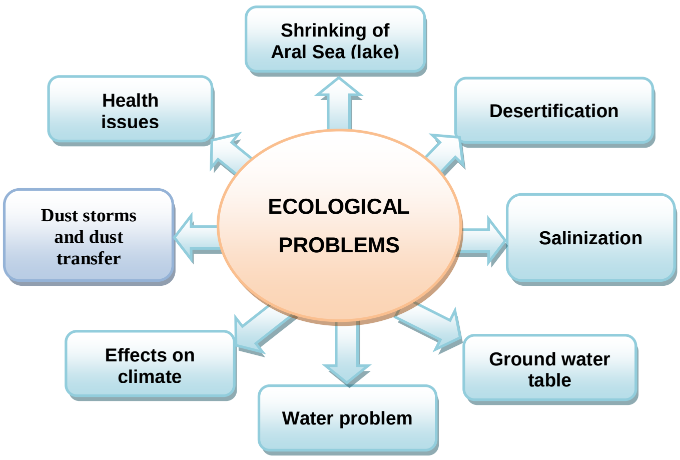

Fig. 2 Aral Sea disaster and Research focus

Materials and methods

The spatial and temporal distribution of the dust deposition was analyzed using passive deposition sampler installed in seven stations in the southern Aral Sea region: Muynak, Jaslyk, Takhiatash, Yangibazar, Beruniy and Buzubay. The sampler design was kept simple to ensure the longevity required for this long-term measurement program. Each sampler consists of a plastic tray (diameter 23cm) as a dust and sand sink, filled with artificial grass. Both monthly dust samples and dust samples of dust storm events have been collected. Soil samples were collected in 2011, at six measuring stations, with exception of Buzubay. Samples were taken from three soil depths (Fig.3). Meteorological data was collected from the same seven stations including temperature, precipitation, wind direction, wind speed and dust storm visibility, frequency and duration. The dust samples were weighed using a precision scale with an accuracy of 0.0001 g. The grain size distribution was analyzed by means of microscopic grain size counts (analyzing of four representative subsamples per dust sample using 0.2 g of sample material). The mineralogical composition was determined by X-Ray-diffraction and the chemical composition was determined by X-Ray-fluorescence and AAS.

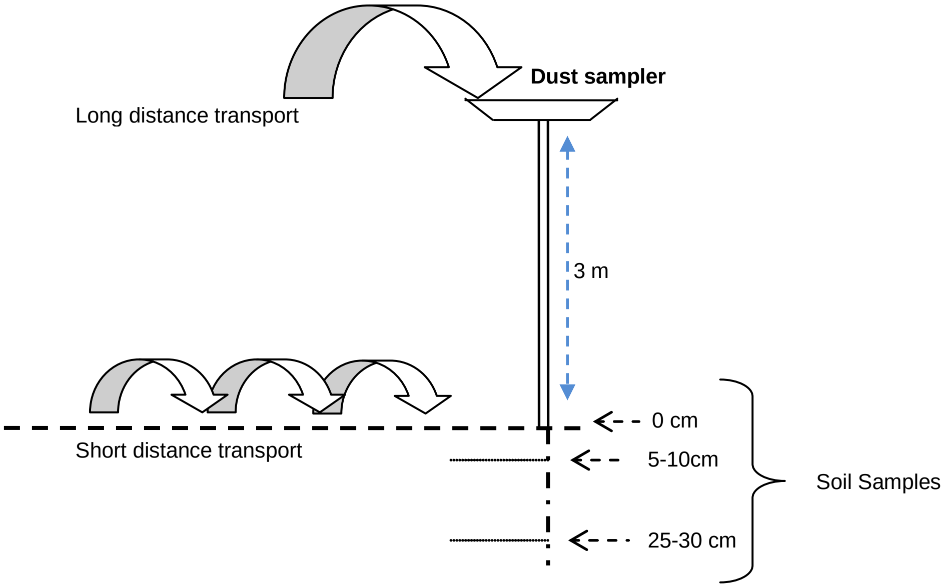

Fig. 3 Dust deposition and soil sampling design at the meteorological stations

Results and conclusion

One outcome of the meteorological data analyses is the dominance of north-eastern winds in six of the seven stations. This corresponds with increased dust deposition rates at stations located in the South and Southwest of the Aral Sea, which is the main source of this dust. Furthermore an increase of the deposition rates during the last decades was detected in this region. The average dust deposition rate from the years 2007-2010 was 5-6 times higher than during the period 1982-1995. The desiccation of the Aral Sea and the formation of the Aral Kum is the main reason for this increase in the dust deposition. Furthermore the analysis showed that the impact of the Aral Kum is smaller than the impact of the natural deserts like the Kyzyl Kum as the average deposition rate near the Aral Kum was much lower than near the Kyzyl Kum (450 kg/ha and month in Muynak and 1,200 kg/ha and month in Buzubay). The seasonal distribution of dust shows a clear maximum of the deposition activity during the summer months (Fig. 4). The grain size distribution of the collected dust samples is different from station to station. For example, Buzubay station dust (originating in the Kyzyl Kum which means Red Sand) is dominated by 75 % medium silt (0.002 – 0.00063 mm). Other stations have higher sand content: Jaslyk 55 % coarse - fine sand (2 – 0.063 mm), Muynak 50 % coarse & medium sand (2.0 – 0.2 mm) and Takhiatash 68 % coarse - fine sand. The results from the chemical analyses of the dust samples revealed four major components: HCO_3, SO_4, Cl and Ca. There are no big differences between the stations. However, dust from the Buzubay station (Kyzyl Kum) is dominated by HCO_3. While the Aral Kum stations are characterized by higher salt concentrations (Cl and SO_4). The results of dust monitoring have confirmed the aeolian dust transport from northern and north-eastern directions, which means that the the regions Karakalpakstan and Khorezm, which are located to the South of the Aral Kum are especially impacted by the salty dust from that manmade desert.

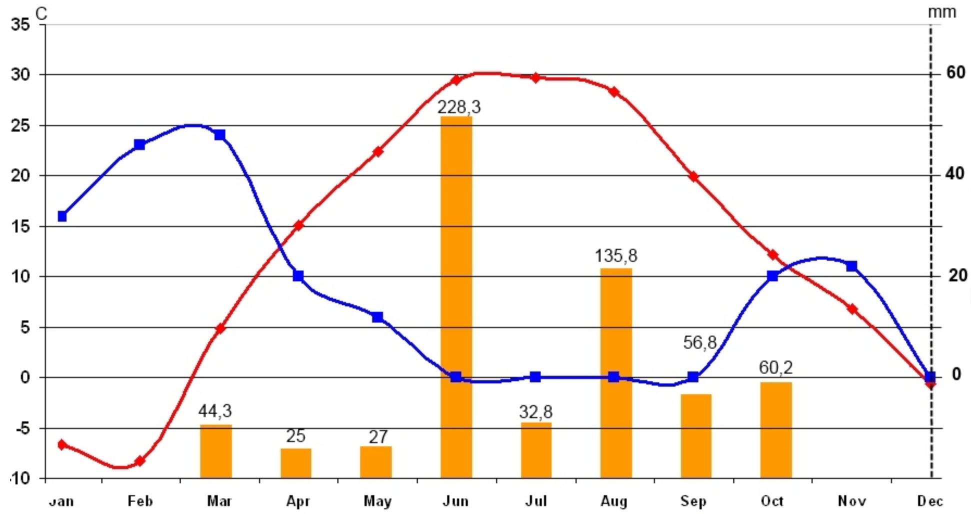

Fig. 4 Average air temperature (red), precipitation (blue) and dust deposition (in kg/ha/month) at Muynak

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