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The PM_{10} and $PM_{2.5}$ Dust Generation Potential of Soils/Sediments in the Southern Aral Sea Basin, Uzbekistan

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Introduction

Extensive desiccation of the Aral Sea in Central Asia has exposed large portions of the former sea bed. Enormous dust storms emanate from the area and have disastrous ecological consequences. Hundreds of thousands of tons of dust are deposited annually in areas to the S and SW of the sea (Fig. 1). The dust constitutes a major threat to the health of the population. Since the dust contains large amounts of salts, dust deposition causes severe salinization of both waterbodies and huge tracts of agricultural lands, some of the latter intensively cultivated (Rafikov, 1999). The area most afflicted by this catastrophe is the Southern Aral Sea Basin in Uzbekistan. The exposed surfaces include wetlands in the delta close to the Amu Darya River bed, with transitions to Solonchak soils, commonly with a salt crust. Takyr and Takyr-like soils exhibit a fine-grained crust and are somewhat more removed from the river bed. Shallow, stony soils occupy the elevated terrain. The desiccated and exposed Aral Sea bed includes a variety of sediments/soils, the most prominent of which are Solonchak-like soils.

The objective of this study was to assess the contribution of the major soil/sediment surfaces in the Southern Aral Sea Basin to the dust generation potential of this region.

Methods

Eight crusts and soils/sediments from 7 sites, representative of these surfaces, were sampled and their major characteristics (particle size distribution, organic carbon content, carbonate content, salt content and composition) that are related to dust generation, determined. The PM_{10} and $PM_{2.5}$ dust generation potential of the materials was postulated as a general indicator of their dust generation capability, and was determined in the laboratory using the Lubbock Dust Generation, Analysis and Sampling System (LDGASS) (Fig. 2).

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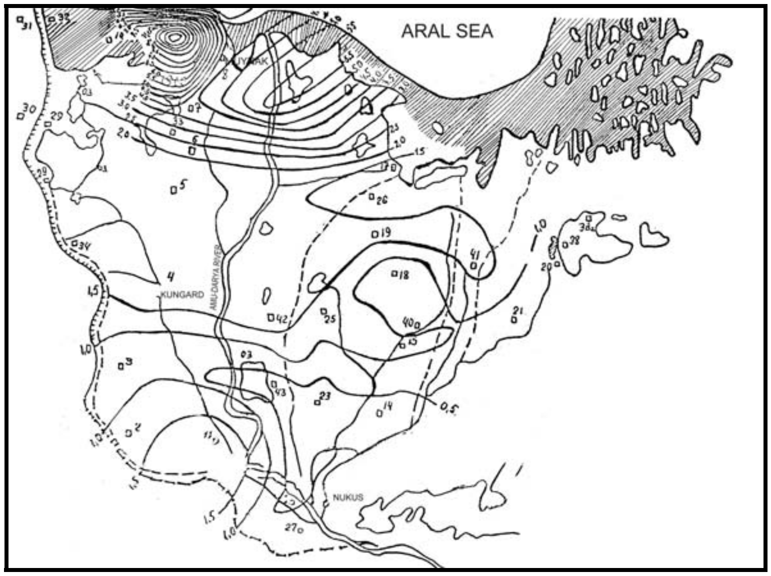

Figure 1: Distribution of dry aerosol deposits in the Southern Aral Sea Basin for 1986, in tons $ha^{-1} \cdot yr^{-1}$.

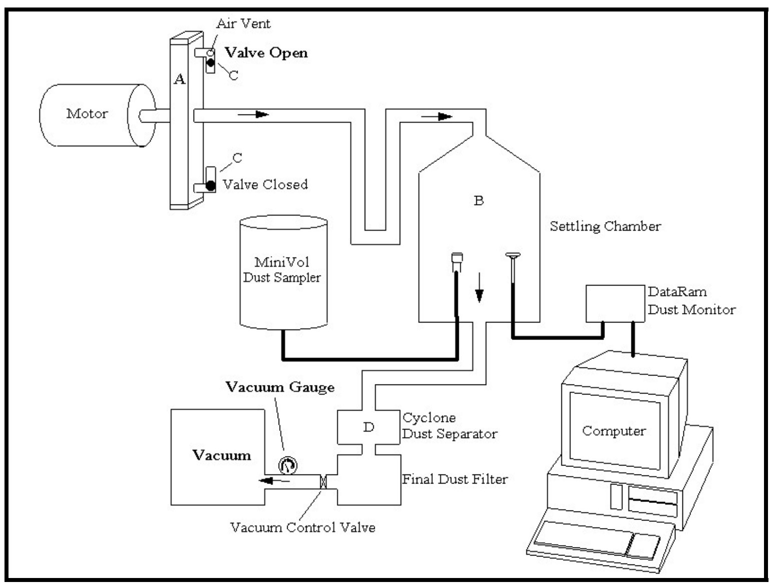

Figure 2: The Lubbock Dust Generation, Analysis and Sampling System (LDGASS).(after Zobeck&Amante-Orozco,2001)

Results

The highest amount of PM_{10} dust (579.3 mg m^{-3}) was generated from the Takyr crust material (Table 1). The lowest by one Solonchak salt crust material (39.6 mg m^{-3}). Salt crusts from the desiccated Aral Sea bottom generated intermediate amounts of dust. The distribution curve obtained for the Takyr crust PM_{10} dust is distinctly unimodal, with the maximum at 3 μm

(Fig. 3). The distribution curve obtained for the Solonchak salt crust is bimodal, with the major peak at about 1.5 µm and a secondary one at 5 µm. Apparently, high potentials for dust generation are related to high proportions of very fine aggregates (<70 µm, obtained by dry sieving), characteristic for Takyr crusts. Salt crusts seem to generate much lower amounts of PM_{10} dusts. This is due to the densely interlocking matrix of the salt crystallites forming the crust (Singer *et al.,* 2001). However, under field conditions, blowing winds charged with saltating sand grains that exert abrasive forces on the crusts, break interparticle bonds and dislodge fine particles.

PM_{10} and $PM_{2.5}$ dust generation by the Lubbock dust generator from the South Aral Sea Basin soils/sediments.

Site	Sediment source	Dust (PM_{10}) conc. $mg.m^{-3}$	Dust ($PM_{2.5}$) conc. $mg.m^{-3}$	Relative $PM_{2.5}$ conc. %
I	Salt crust	39.6	19.1	48.2
	1-15 cm	81.6	16.5	20.2
II	Takyr crust	579.3	261.1	45.1
III	Soil, 0-25 cm	379.5	135.0	34.0
IV	Solonchak (wet)	115.3	25.6	22.2
V	Solonchak (dry)	520.5	167.7	32.2
VI	Desiccated sea bottom crust	252.3	85.1	33.7
VII	Desiccated sea bottom crust	111.6	25.4	22.8

Table 1

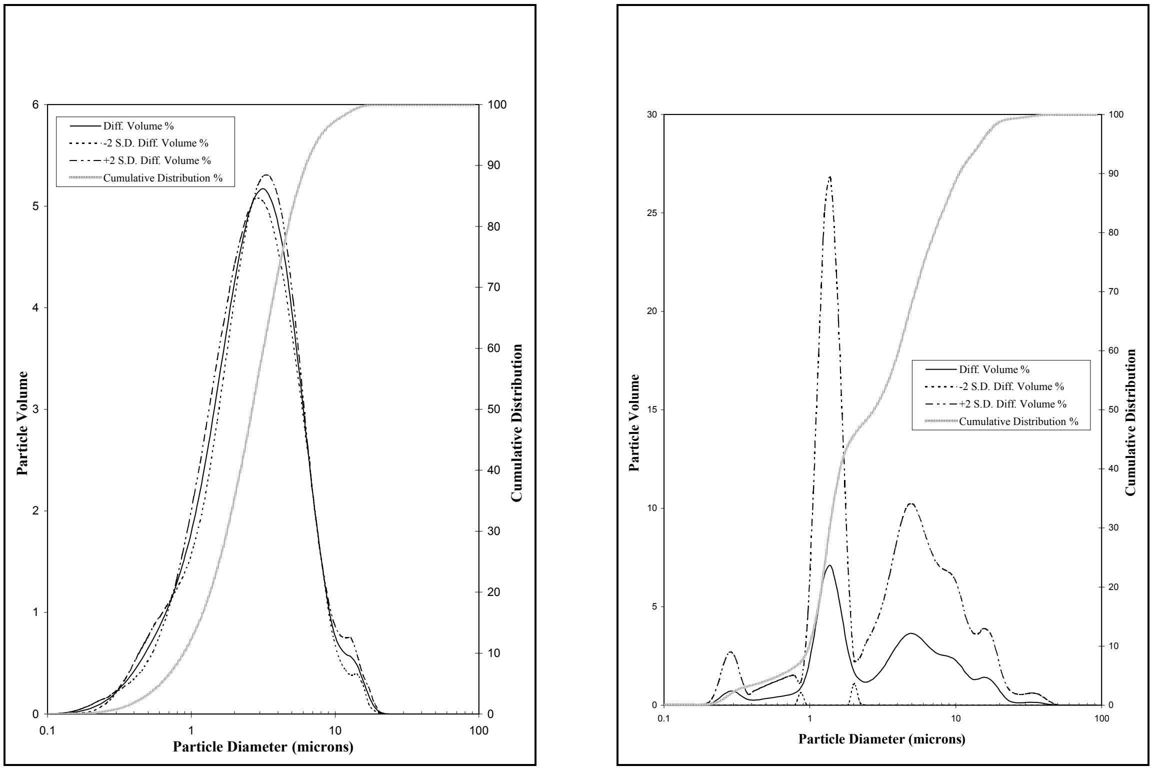

Figure 3: Particle size distribution curves of PM_{10} dust generated by the LDGASS from a Takyr (left) and Solonchak salt crust (right) from the Southern Aral Sea Basin.

Conclusions

The experimental results indicate that the Takyr and Takyr-like soils, that occupy over 1 million ha in the Southern Aral Sea Basin, constitute the surfaces with the highest potential for being the source for the severe dust storms of the area. Second to the Takyr soils, the Solonchaks and Solonchak-like soils, also with an extent of over 1 million ha, contribute highly saline dust. To these must be added a large, as yet unsurveyed, proportion of the approximately 4 million ha of exposed sea bed, that exhibit Solonchak-like characteristics.

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