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Long-Term Variability of the Composition of Near-Surface Aerosol over Desertified and Arid Zones in Southern Russia

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Abstract—We analyzed multiyear (2007–2021) complex experimental studies of microphysical parameters, mass concentration, and elemental composition of aerosol particles in the near-surface atmospheric layer of semiarid zones in the south of European Russia. Background values of the daily average mass concentration of near-surface aerosols in desertified areas of Kalmykia and the dry-steppe zone of Rostov oblast for the hot summer period are found to be 125 and 34 μg/m^3, respectively. The particle size distribution functions specific for atmospheric aerosols of the south of European Russia, are determined. An interrelation is found between the particle emission from the surface to the atmosphere and the main atmospheric processes. Long-term variations in elemental composition of near-surface aerosol are studied. Minor variations are identified in the mass concentrations of Cd, Hg, and Cu in the composition of aerosol particles in Rostov oblast. The elemental composition of Kalmykia aerosols stronger varies in terms of the contents of both natural and technogenic elements, mainly of chemical elements of salt balance and heavy metals. It is shown that most elements are weakly accumulated in aerosols, and their differentiation is heavier dependent on the mosaic character of the underlying surface. The multiyear period under study is characterized by the tendency of removing the harmful admixtures from the atmosphere of desertified territories in the south of European Russia due to reducing the climate aridization and mitigating the anthropogenic effect.

Keywords: semiarid zone, south of European Russia, near-surface aerosol, mass concentration, particle size distribution function, elemental composition, meteorological conditions, synoptic situation, long-term variations

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INTRODUCTION

Modern climate changes bring about a broad public, economical, and political resonance [1]. The processes in natural and anthropogenic landscapes and in the near-surface atmosphere intensify with the strengthening of oscillations in the climate system. This is especially true for zones with extreme natural-climatic conditions, such as arid and desertified (semiarid) regions in the south of European Russia.

Atmospheric aerosol is one of the most variable components of semiarid ecosystems and serves an indicator of their anthropogenic transformation and aridization [2]. Moreover, aerosol particles have a unique set of spatially and temporally variable physicochemical characteristics, strongly influencing the optical properties, chemical activity, and composition of the atmosphere [3, 4]. Therefore, it is of special interest to study the long-term variations in geophysical and geochemical properties of near-surface aerosols from natural zones in the south of European Russia, taking into consideration different sources of emission.

Experimental studies of the physicochemical and optical properties of near-surface aerosols from arid regions in the south of European Russia and Central Asia were first initiated few decades ago in regard to the increasingly pressing problems of desertification and drying of the Aral Sea [5–13]. Certain published works on the topic are reviewed in [14]. Much attention has been recently devoted to studying the specific features of wind-driven [15–25] and convective emission of dust aerosol to the atmosphere [26–29] and its microphysical and optical characteristics [8, 14, 30–38] in the south of European Russia, the Caspian region, and Central Asia. The chemical composition of near-surface aerosol in these regions has been studied to a lesser degree [38–42]. However, this characteristic of aerosol particles may determine their optical properties; also, it influences the specific features of different chemical and photochemical processes in the atmosphere [3, 4].

Fig. 1. Locations of key observation regions.

Long-term field observations in steppe and dry-steppe natural zones in the south of European Russia, carried out by scientists from the A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences (IAP RAS), in collaboration with specialists from the Karpov Institute of Physical Chemistry and the Institute of Geography (IGRAS), Russian Academy of Sciences, are associated with studying the elemental composition and particle size distribution of atmospheric aerosols and processes of their local emission and transboundary transport in natural and anthropogenic landscapes. However, those field experiments were fragmentarily described in several publications [14, 38, 44]. First attempts to generalize the results from those experiments are presented in [14, 43].

This work is devoted to generalizing the long-term observation time series with the purpose of studying the interannual variations in elemental composition and microphysical parameters of dust aerosol in the near-surface atmospheric layer on desertified and subarid territories in the south of European Russia.

OBJECTS, METHODS, AND OBSERVATION FACILITIES

We analyze the experimental data of long-term (2007–2021) complex field studies of the aerosol microphysical parameters, mass concentration, and elemental composition in the near-surface atmosphere of arid and desertified regions in the south of European Russia in the summer period. Key regions of the field observations were in Rostov oblast (Tsimlyansk Scientific Station (TSS) of IAP RAS) and in the Black Earth region of the Republic of Kalmykia (Fig. 1).

The study regions in the plain south of the ETR were chosen based on geographic zonal approach, taking into consideration typical landscapes [45, 46]. IAP RAS TSS is in the steppe zone of ETR at the altitude of 60 m asl (47°39′21.1″ N, 42°04′49.6″ E); this zone is surrounded by agronomic landscapes and Tsimlyansk residential zone. The climate at IAP RAS TSS is European, Atlantic-continental, with the rainfall deficit of 200–400 mm. The Black Earth region of the Republic of Kalmykia is in a dry-steppe zone, represented by typical white wormwood steppes, sand massifs of anthropogenic origin, and alkali soils on marine paleosediments in the Caspian Depression. The mosaic character of the landscape is due to micro- and mesoreliefs associated with groundwaters and processes of eolian surface processing, as well as a marked anthropogenic effect arising from agricultural uses of sand massifs on light underlying rocks and clogging of upper soil horizons. For our study, we chose sand massifs on gently undulating plain in the northwestern part of the Caspian Depression with the continental climate of the East European Plain with a rainfall deficit of 400–700 mm.

The observations were carried out using the IAP RAS aerosol complex described in detail in [20, 38]. The measuring instrumentation included: aspiration samplers for collecting aerosol samples on analytical AFA-type filters with the subsequent gravimetric and chemical analysis; six-stage impactors equipped with hydrophobic filters for determining the mass fraction and elemental compositions of aerosol particles in the wavelength channels >6.5, 4.0–6.5, 2.5–4.0, 1.5–2.5, 0.5–1.5, and <0.5 μm; an aerosol optical block consisting of LAS-P laser aerosol spectrometers and OEAS-05 optoelectronic aerosol spectrometers for recording microphysical characteristics of aerosol particles; portable instruments for measuring the number concentration of aerosol particles IGRAS; and a Davis Vantage Pro2 weather station. The synoptic situation in the periods of observations was estimated with the use of online resources and data archives on meteorological parameters from publicly available Internet sources. In particular, the trajectory analysis of air masses was carried out by calculating back trajectories of air mass transport to the observation sites using the HYSPLIT model [47, 48] at the ARL NOAA website [49].

Near-surface aerosols were studied by physicochemical methods of measurements coupled with geosystem and landscape-geochemical approach [42]. Microphysical characteristics (size distribution and number concentration) of aerosol particles were recorded by optical methods based on the properties of the optical radiation scattered and absorbed in the aerosol medium [50]. For a gravimetric analysis, samples were collected on AFA analytical filters [51] at an altitude of 1.5–2.0 m above the underlying surface using an aspiration sampler, with each sample collected for 12 h (either during day or night) or 24 h. The aerosol mass concentration was determined by the sampled data weighing method, consisting in trapping on the filter of aerodisperse admixtures in the known air volume, determining the gain in filter weight, and calculating the mass concentration (in μg/m^3). In addition to aspiration samplers, six-stage impactors and nephelometers were used in different years of observations to measure the mass concentration of aerosols. Moreover, the mass concentration of submicron and micron fractions of aerosol particles with sizes of 0.15–10 μm was calculated from the data on the particle number concentration by the well-known formula [3, p. 356].

Simultaneously with aerosol characteristics, we measured the incident and reflected radiation taking into account the actual meteorological parameters and turbulence parameters.

The elemental composition of near-ground aerosols and underlying soils as components of geochemical landscapes was studied using laboratory analytic methods of inductively coupled plasma atomic emission spectroscopy (ICP-AES), inductively coupled plasma mass spectrometry (ICP-MS), and X-ray fluorescence (XRF) analysis [52–54].

RESULTS AND DISCUSSION

Mass Concentration of Near-Surface Aerosols

The microphysical parameters (sire distribution and number concentration) and the mass concentration of aerosol particles are the most important characteristics of atmospheric aerosols, the variations in which are caused by different factors. In the near-surface atmospheric layer of semiarid regions with a small anthropogenic load, they strongly depend on the specific features of the underlying surface, meteorological conditions, and synoptic situation.

Analysis of meteorological parameters from long-term summer observations showed that the field experimental studies in Kalmykia and steppe zone of Rostov oblast were carried out mainly under the temperature-humidity conditions corresponding to the climatic norm in the second half of twentieth century—early twenty-first century for these regions [55, 56], for diverse wind parameters.

The long-term variations in the daily average mass concentration of near-surface submicron and micron aerosols are characterized in Tables 1 based on the gravimetric analysis of aerosol samples collected during the experiments (the largest values are bold) in subarid droughty zones in the south of European Russia. It can be seen that, after the wind strengthens (up to 8–12 m/s) and sandstorms occur in Kalmykia on desertified areas with movable sand massifs, the daily average mass concentration of aerosol particles may increase by a factor of 5–10 as compared to "undisturbed" conditions (for quiet and weak wind). In particular, this was the case in 2011. On the contrary, the period of the 2009 summer experimental campaign was accompanied by weak wind (with the average speed of 1–4 m/s) weather. The smallest fluctuations in the daily average mass concentration (in an range from 20 to 64 μg/m^3) were recorded at that time. These can be considered as background conditions. The meteorological conditions in the period of observations in Kalmykia in 2007–2016 were analyzed in more detail in [14].

In 2020 and 2021, the period of observations of near-surface aerosols in Kalmykia was accompanied mainly by summer-typical weather conditions, similar to those during previous observations. Air temperatures reached +31 to +35°C in daylight hours (except on July 27, 2021) and decreased to +18 to +22°C in nighttime hours. Except several days (July 23–25, 2020 and July 27, 2021), the lowest relative air humidity varied in the range 18–25% during the day and increased, on the average, to 50–65% in nighttime hours. Study of the geopotential fields showed the unstable character of the synoptic situation, with changes in air masses and their trajectories and oscillations in atmospheric pressure. Comparison of the meteorological and synoptic conditions in July of 2020 and 2021 in Kalmykia with those from previous research confirmed that they are typical for desertified regions of the republic [14, 43].

In the steppe zone of Rostov oblast (IAP RAS TSS), the temperature-humidity characteristics during the long-term summer observations, as in Kalmykia, cor-

Table 1. Long-term variations in the daily average mass concentration of near-surface aerosols in Kalmykia and at IAP RAS TSS in summer period

Year	Observation period	Min	Max	Average	SD	Median
			Kalmykia			
2007	21–31.07	24.2	203.76	73.82	55.93	46.75
2009	17–27.07	20.3	64.1	36.11	12.29	35.78
2011	20–29.07	**44.83**	**575.5**	**346.34**	**186.46**	**390.54**
2013	19–27.07	33.33	186.06	85.06	51.59	58.67
2014	22–31.07	25.34	**758.29**	197.67	**258.48**	57.54
2016	19–30.07	16.56	138.99	57.76	33.94	49.23
2020	23.07–1.08	16.68	214.2	86.31	61.88	70.06
2021	21–31.07	24.33	**631.28**	114.08	**177.42**	45.96
			IAP RAS TSS			
2012	3–14.08	18.87	63.94	42.9	14.95	44.49
2017	29.07–8.08	22.9	42.95	31.46	6.64	31.51
2018	29.07–3.08	18.39	32.16	24.9	4.84	24.15
2019	29.07–5.08	23.98	48.8	34.21	10.62	30.14
2020	4.08–13.08	13.55	32.91	21.76	6.92	20.45
2021	4.08–15.08	**26.29**	**69.54**	**46.54**	**18.02**	**43.05**

responded to the climatic norm. For instance, in 2020, the air temperature at IAP RAS TSS varied, on average, from +25 to +30°C in daytime and from +16 to +23°C in nighttime hours; in 2021, the air temperature was a little higher: +30 to +33°C, on average, during the day and +21 to +23°C at night. The relative air humidity in 2020 decreased, on average, to 30% during day and increased to 65–75% at night. In 2021, during the first half of the field campaign, the relative air humidity was, on average, a little lower; it decreased to 25% during the day and increased to 50% at night. However, in the second half of the 2021 field experiment, the relative humidity at IAP RAS TSS showed a positive trend; on August 14, 2021, it reached 45% during the day and 90% at night. The trajectory analysis indicated that this was due to an unstable synoptic situation and a change in air masses.

In 2020 and 2021, the wind speed reached 4–6 m/s in daytime hours; while at night the wind weakened to quiet and light (0.5–2 m/s) or there was calm. That is, the patterns characteristic of arid zones and droughty southern steppes are similar in wind regime.

As in Kalmykia, the synoptic situation at IAP RAS TSS stood out in instability, both during recent years and during previous periods of field studies [38].

The long-term studies showed that the mass concentrations of aerosols was minimal in a quiet atmosphere and maximal when the wind speed increased to 10 m/s and higher. The standard deviation (SD) of the mass concentrations of near-surface aerosol in Kalmykia shows a large dispersion (see Table 1) because the atmosphere is often unstable due to the mosaic character of the underlying surface types and, hence, strong gradients in surface heating. It is noteworthy that the median is close in value to the average characteristics. Therefore, the average mass concentrations of near-surface aerosols in steppe (IAP RAS TSS, 34 μg/m^3) and dry steppe (Kalmykia, 125 μg/m^3) zones can be assumed as background values for studying climate change and estimating the anthropogenic effect.

Aerosol Particle Size Distribution Function

In semiarid regions, the wind conditions have a strong effect on the size distribution of aerosol particles. In our previous work [14], we described the specific features of variations in the particle size distribution function of near-surface aerosol in Kalmykia under different wind speeds. The stronger the wind speed, the larger the concentration of the micron fraction of particles (d = 1–10 μm) and the smaller the concentration of submicron particles (d = 0.15–1 μm). For instance, in a strong wind, which was observed in daytime throughout the 2011 field campaign, the measured concentrations of micron particles were an order of magnitude higher than in other years of study, characterized by quiet, slight, or moderate wind [14]. The number concentration of submicron particles (d = 0.15–1 μm) with diameters 0.15 μm decreases with an increase in the number of micron particles (with sizes more than 1 μm). In the case of a strong wind, saltation drives the emission of micron particles from the underlying surface to the near-surface atmospheric layer. Under "quiet" wind conditions, fine and submi-

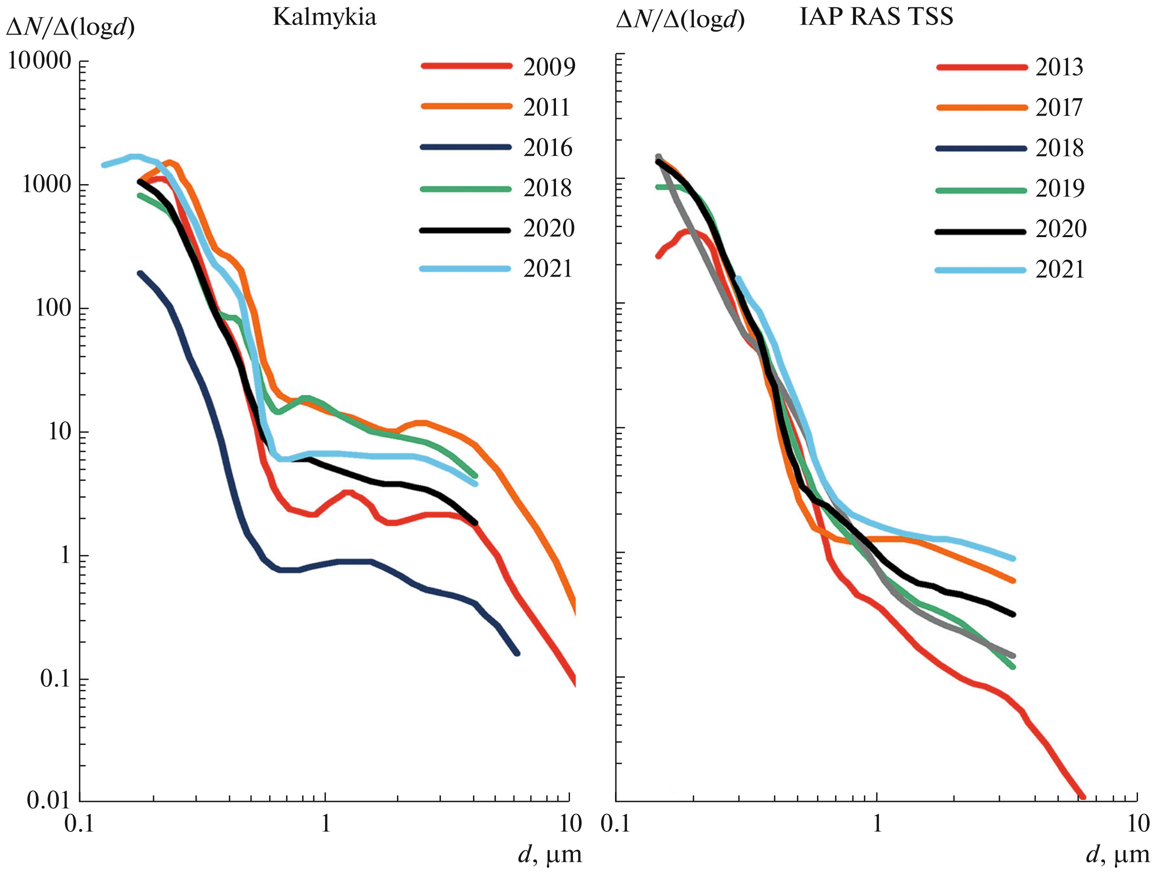

Fig. 2. Aerosol particle size distribution function according to long-term summer observations in Kalmykia and at IAP RAS TSS.

cron particles become more abundant in the atmosphere owing to their thermal convective emission [20, 26, 27, 57].

Figure 2 shows the aerosol particle size distribution function derived from long-term observations in Kalmykia and at IAP RAS TSS and averaged over the entire period of each summer campaign. The shapes of the distribution functions in the near-surface atmospheric layer were compared and found to differ in the size range 0.6–2.0 μm. A characteristic feature of the aerosol size spectrum in Kalmykia is the maximum in the region 0.9–2.0 μm, atypical for the particle size distribution function in the near-surface atmospheric layer over IAP RAS TSS. It should be noted that the distribution function with a poorly defined (blurred) maximum is characteristic for rural continental aerosol [3]. Moreover, the aerosol particle distribution function in near-surface air in surroundings of AIP RAS TSS is similar in shape to a typical urban aerosol distribution function [3], though shifted somewhat toward larger particles. Probably, this type of distribution function is due to the fact that IAP RAS TSS is located in the suburbs of the little city of Tsymlynsk and to the effect of local anthropogenic sources.

The wind conditions in Kalmykia vary during daylight hours, so that the particle distribution function stronger varies as compared to that for the near-surface atmospheric layer in the surroundings of IAP RAS TSS. This is especially marked in variations of the numbers of particles with sizes 1–10 μm, as well as in the numerical relationship between the number concentrations of submicron and micron fractions of aerosol because the underlying surface in desertified and arid areas is a strong source of salt-dust aerosol particles, the intensity of which is mainly determined by synoptic and meteorological conditions.

The number concentrations of aerosol particles in the size range 0.8–10 μm in near-surface air in Kalmykia and at IAP RAS TSS differ in absolute value, also primarily because of the specific features of wind conditions and the underlying surface on desertified areas in Kalmykia.

It should be noted, however, that the shape of the particle distribution function is well reproduced from one year to another in both Kalmykia and at IAP RAS TSS, indicating the constancy of characteristic aerosol types at the observation sites.

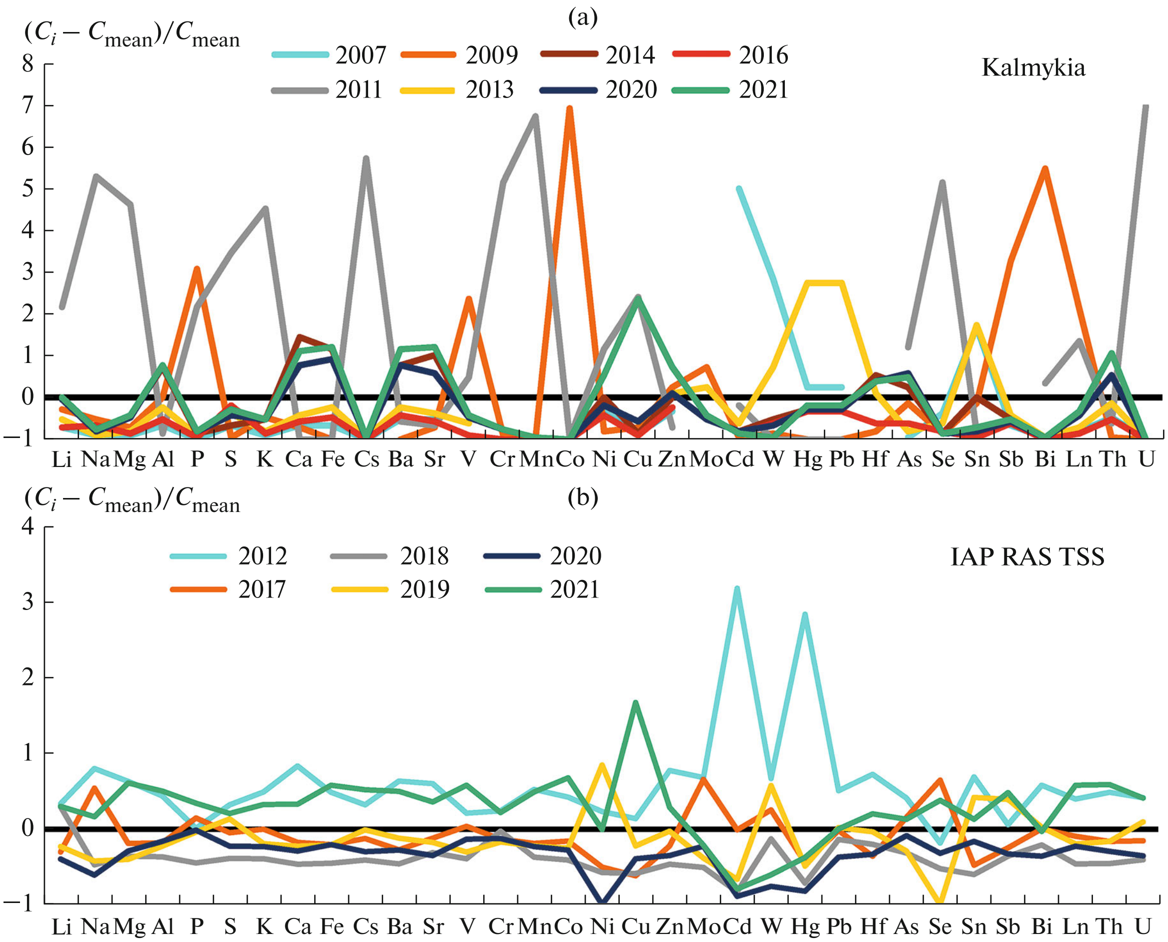

Fig. 3. Dynamics of variations in elemental composition (mass concentration of chemical elements in relative units) of near-surface aerosols according to long-term observations in Kalmykia and at IAP RAS TSS.

Elemental Composition of Near-Surface Aerosol

Analysis of elemental composition of near-surface aerosols from semiarid zones in the south of European Russia based on long-term observations in Kalmykia and at IAP RAS TSS made it possible to identify the dynamics of variations in the mass concentration of chemical elements in the composition of aerosol particles. A total of 65 elements (from Li to U) were determined. Their differentiation was considered in accordance with the well-known ecological and geochemical systematization of elements with respect to the scales of their environmental impact, taking into consideration their abundance in the Earth's crust, with respect to the elements of global, regional, and local significance.

For clarity of presentation and convenience of interpreting the results, below, we pay attention to the most significant elements as variable components of the landscapes under study. Figure 3 shows the long-term variations in the mass concentration of elements in relative units: $(C_i - C_{mean})/C_{mean}$, where C_i is the mass concentration of an element in the *i*th year; C_{mean} is the mass concentration of the element averaged over all years. It can be seen that the elemental composition of near-surface aerosol in Kalmykia experiences stronger interannual variations associated with specific features of synoptic situation and wind conditions.

Analysis of our results shows that synoptic situations in Kalmykia in 2009 and 2011 favored the emission of chemical elements into the near-surface atmosphere owing to the northwesterly wind and proximity to anthropogenic sources. These last could also contribute to the emission of heavy metals and radioactive elements in Kalmykia in 2011 during a dust storm with northeasterly and easterly air mass motions. Increased concentrations of cadmium and mercury were observed in the near-surface aerosol at IAP RAS TSS in 2012, probably due to the transboundary transport. On the whole, the variations in the mass concentration of chemicals are similar in character to the specific features of variations in the total mass concentration of near-surface aerosols.

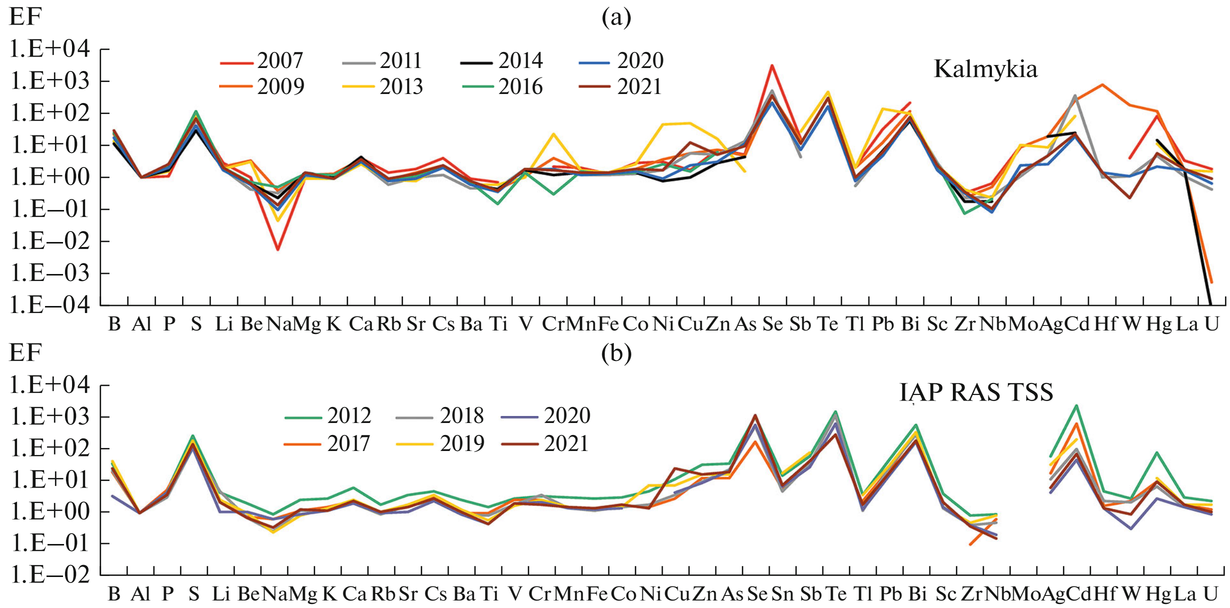

Fig. 4. Long-term variations in the enrichment factor of elements in near-surface aerosols from dry-steppe (Kalmykia) and steppe landscapes (IAP RAS TSS).

The selective accumulation of chemical elements in aerosol particles is estimated by calculating the enrichment factors [46]:

$$\mathrm{EF} = \frac{(C_{\mathrm{el}}/C_{\mathrm{Al}})\ \text{aerosol sample}}{(C_{\mathrm{el}}/C_{\mathrm{Al}})\ \text{Earth's crust}},$$

where C_{el} and C_{Al} are the concentrations of a given chemical element and of the reference element (aluminum) in the solid phase of aerosols and in the granite layer of the continental Earth's crust [59], respectively. Aluminum was chosen as a reference element because it is a typomorphous element in paleogene rocks and marine sediments for the steppe zone in the south of European Russia and, as such, can be used as a normalization factor in geochemical calculations.

The long-term variations in the average enrichment factors of chemical elements in aerosols in the near-surface atmospheric layer in Kalmykia and in the surroundings of IAP RAS TSS are shown in Fig. 4.

The elements in the composition of atmospheric aerosols of semiarid zones in the south of European Russia, presented in geochemical spectra in Fig. 4, are mainly of mixed natural-anthropogenic origin and characterized by variable mass concentration. Elements of global significance weakly vary in concentration. The strong variations are characteristic for chemical elements from salt balance and for heavy metals. On the whole, a long-term decreasing tendency is traceable in the concentrations of most elements starting from 2016–2017, which can be primarily because of decreasing anthropogenic load in this region. High sulfur content is primarily associated with natural sources (alkaline lands in Kalmykia and the Caspian region), as well as with anthropogenic sources, i.e., gas and oil production plants and motor vehicles.

Clarks of aerosol concentration (concentration of an element in aerosol sample/clark of the Earth's crust) were calculated [46], and the accumulation intensity (weak: 0–10, medium: 10–50, strong: 50–100, high: >100) of elements in near-surface aerosols was estimated to clarify the role of the atmospheric aerosols in the functioning of landscapes in the steppe zone. Table 2 presents the accumulation intensity of chemical elements in near-surface aerosols in Kalmykia and at IAP RAS TSS.

As can be seen from Table 2, the weak accumulation intensity is characteristic for most chemical elements, and their differentiation depends to a larger degree on the mosaic character of the underlying surface. The accumulation in near-surface aerosols from semiarid zones in the south of European Russia is mainly observed for heavy metals of both natural and anthropogenic regional and local origins. The high selenium and tellurium contents may be due to technogenic migration associated with regional economics and transboundary transport of pollutants.

CONCLUSIONS

We studied the variations in elemental composition and microphysical parameters of near-surface aerosol from desertified areas in Kalmykia and the arid steppe zone in Rostov oblast (IAP RAS TSS) in the summer period based on long-term observations, including the last field expeditions of 2020 and 2021.

Table 2. Accumulation intensity of chemical elements in near-surface aerosols from semiarid zones in the south of Russia (using observations in Kalmykia and at IAP RAS TSS)

Year	Clarks of concentration			
	0–10	10–50	50–100	>100
Kalmykia				
2007	Ca, Mo, Sb, Cs, W, Pb	S, Sn, Hg	Bi	Se, Cd
2009	P, Li, Be, Mg, Al, K, Ca, V, Cr, Mn, Fe, Co, Ni, Rb, Sr, Y, Cs, Ba, La, Tl, Th, U	B, Cu, Mo, Ag, Sb, Pb	Sn	S, Se, Cd, Hf, W, Re, Hg, Bi
2011	P, Li, Ca, Sc, V, Cr, Ni, Cu, Ag, Sn, Sb, Hg, Pb	S, Bi		Se, Cd
2013	B, Cr, Mo, Ag, Sb, Hg	S, Ni, Cu, Cd, Sn, Pb, Bi		Te
2014	B, S, Ca, Ag, Cd, Sn, Sb, Hg, Pb	Bi		
2016	B, Ca, Sb	S, Cd		
2020	P, Li, Ca, Sc, V, Cr, Co, Cu, Mo, Ag, Sn, Sb, Cs, La, Hg, Pb	B, S, Cd, Re, Bi	Te	Se
IAP RAS TSS				
2012	P, Li, Ca, Sc, V, Cr, Mn, Fe, Co, Ni, Cu, Ga, Sr, Mo, Sn, Cs, La, Hf, W, Tl	B, Zn, As, Ag, Sb, Hg, Pb	S	Se, Cd, Te, Bi
2017	B, P, Zn, Mo, Ag, Sn, Hg, Pb	S, As, Sb, Re	Bi	Se, Cd
2018	B, Li, Cr, Cu, Zn, As, Mo, Ag, Sn, Hg, Pb	S, Cd, Sb	Bi	Se, Te
2019	P, Ni, Cu, Zn, As, Mo, Sn, Hg, Pb	B, S, Cd, Sb	Bi	
2020	P, V, Cr, Cu, Zn, Mo, Ag, Sn, Cs, Hg, Pb	B, As, Cd, Sb	S, Bi	Se, Te
2021	B, P, Cu, Zn, As, Mo, Sb, Hg, Pb	S, Cd, Sb	Bi	Se, Te

It is confirmed that the synoptic situation and meteorological conditions strongly influence the dynamics of variations in microphysical parameters and mass concentration of near-surface aerosol from semiarid regions in the south of European Russia. Based on the analysis of long-term data, it is found that, judging from mass concentrations (20–40 μg/m^3) of submicron and micron aerosol particles in the near-surface atmospheric layer, the natural-anthropogenic landscapes of arid southern steppes in Rostov oblast can be considered as background regions with predominant agricultural land uses. Microphysical parameters (concentration and particle size distribution) of aerosol are characterized by minor variations under typical (undisturbed) conditions in the southern steppe zone (in the absence of unfavorable meteorological and hazardous natural and technogenic incidents). The first half of August 2021 had been an exception in that atypical, increased (up to 7 m/s), wind speeds were observed in the surroundings of IAP RAS TSS. As a consequence, the concentration of near-surface aerosol increased: on August 7–10, 2021, we recorded the largest (as large as 70 μg/m^3) daily average mass concentrations of submicron and micron particles in the entire period of observations.

The concentration of near-surface aerosol from desertified areas in Kalmykia shows stronger variations, mainly due to wind conditions, specific features of the underlying surface, and gradient of soil surface heating. After winds strengthen to moderate and fresh (predominantly in daytime), the mass concentration of near-surface aerosol may increase by an order of magnitude. Sandstorms quite often occur in summer in Kalmykia, leading to strong short-term fluctuations in microphysical parameters of aerosol.

Analysis of long-term variations in elemental composition of near-surface aerosol from semiarid zones in the south of European Russia revealed, in separate years, minor variations in the content of certain elements of anthropogenic origin (Cd, Hg, Cu) in aerosol particles in the near-surface air in surroundings of IAP RAS TSS.

The elemental composition of arid aerosol in Kalmykia stronger varies in terms of the content of both natural and technogenic elements. This is due to the specific features of the underlying surface, proximity to the Caspian Sea, synoptic conditions which favor transport of air masses from regions with other landscapes and with differing anthropogenic and natural aerosol sources, and the activity of local sources.

The long-term observation period under study is generally characterized by the tendency of removing harmful admixtures from the atmosphere over desertified territories in the south of European Russia owing to the decreased climate aridization and mitigated anthropogenic effect; however, it is expedient to continue the observations of ecologically hazardous technogenic chemical elements.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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