Analysis of a sand and dust storm event in Termez, Surkhandarya Region, Uzbekistan: impacts and insights

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Abstract. Sand and dust storms (SDS) are classified as global natural disasters and cause significant environmental and social problems. The article presents a study of a sand and dust storm that occurred on June 9, 2023, in Termez, Surkhandarya region, Uzbekistan. The research employed a multi-faceted approach, utilizing Landsat satellite imagery, and ground truth data collected through EKOLAB equipment. Additionally, a survey was conducted among the residents of the affected area to gather insights into the social impacts of the SDS event, and recommendations were developed by the authors to mitigate its consequences. The study aims to provide a holistic understanding of SDS occurrence in the region and its effects on the local population.

1. Introduction

Sand and dust storms (SDS) are recurrent environmental phenomena that can occur not only in dry lands but also in humid climates during extended periods of drought, resulting in direct and indirect consequences of enormous significance. However, despite numerous publications on the topic, causes, processes, patterns, and historical occurrences of sand and dust storms are not always well understood, particularly when it comes to events from the past [1]. SDS are common hazards, especially in semi-arid and arid regions, where factors such as thunderstorms or strong air pressure gradients can lead to increased wind speeds over a wide area [2]. The United Nations Convention to Combat Desertification (UNCCD) identified 151 countries, accounting for 77 percent of all nations, as being affected by SDS, with 45 countries, or 23 percent, classified as SDS source areas [3].

A hot, dry southwest wind, known locally as the Afghan wind in southern regions of Uzbekistan (Surkhandarya and Kashkadarya), carries a substantial amount of dust. The wind, originating from the southwest and blowing in the southwest direction from Afghanistan, is called a black storm in Afghanistan, and it affects the upper part of the Amudarya basin. The Afghan wind is the result of the aerodynamic acceleration of a warm air mass from the southwest, which becomes compressed between the Hisar mountain range, along with the influence of a cold air front originating from the

northwest, and it occurs for approximately 30-70 days each year [4]. The natural factor has been the most adverse climatic influence on the southern regions of the Surkhandarya region for many years, leading to the occurrence of SDS cases in the region.

The objectives of the study were to (i) monitor changes in the city's visibility using satellite imagery and quantify contamination through air contaminants sampling with specialized equipment both during and outside of the SDS event, and (ii) assess the impact of SDS on the local population through a small survey and formulating recommendations for mitigating its effects.

2. Materials and methods

The study was conducted in Termez, specifically focusing on the SDS event that transpired on June 9, 2023, and lasted approximately 8-9 hours. Termez is the capital of the Surkhandarya Region in southern Uzbekistan (latitude: 37° 13' 27.01" N, longitude: 67° 16' 41.99" E), situated along the border with Afghanistan (Figure 1). In terms of administrative divisions, it holds the status of a city at the district level with a 36 km^2 area. Termez experiences a cool arid climate transitioning to a hot arid climate, characterized by lengthy, scorching summers and brief, cool winters.

The study employed a combination of research methods, including spatial analysis, in-situ measurements, and descriptive research.

Spatial analysis was conducted to obtain information about the conditions of Termez before (June 1), during (June 9), and after (June 17) the SDS event through Landsat 8 and Landsat 9 satellites, jointly operated by NASA and the US Geological Survey for Earth observation.

In situ measurements were carried out at four specific locations within the city: Dekhlaviy Street (37° 12' 20.48" N, 67° 16' 13.74" E), Porloq Yul Street (37° 14' 50.14" N, 67° 19' 27.81" E), Fidokor Street (37° 15' 40.06" N, 67° 18' 31.54" E), and around the international airport (37° 16' 51.23" N, 67° 19' 8.39" E) from June 7 to June 11, 2023. The measurements involved the use of EKOLAB equipment, which was listed in the official state registry, to assess levels of various atmospheric pollutants, including sulfur monoxide (SO), hydrogen sulfide (H_2S), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen fluoride (HF), ammonia (NH_3), formaldehyde (CH_2O), and inorganic dust.

Finally, to gauge the impact of environmental pollution on the local population, a small survey was conducted among 200 respondents from the four aforementioned locations within the city.

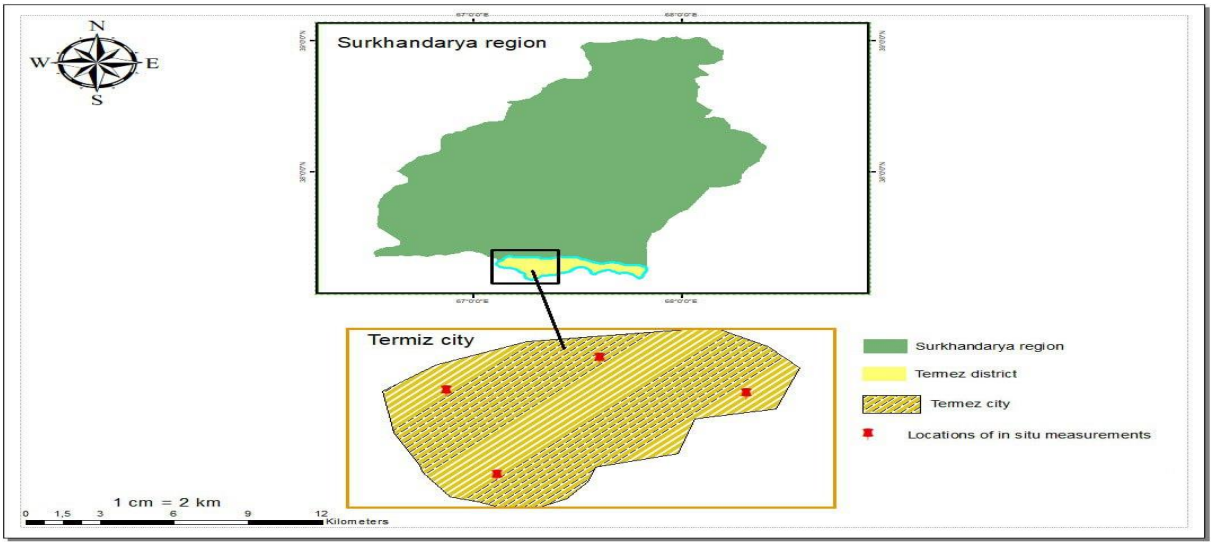

Figure 1. Map of the study area

3. Results and discussion

The outcomes of the spatial analysis revealed substantial distinctions among the images captured on June 9, during the SDS event, and those from June 1 and June 17, when there was no SDS event in the study area (Figure 2). The June 9 satellite image depicted the SDS event enveloping the entire city, diminishing the city's visibility from space, unlike the images from June 1 and June 17. Additionally, it's worth noting that particles of sand and dust can lead to the weakening of radio waves as they scatter and absorb the waves [5]. The findings not only highlight the visual impact of SDS events but also underscore their potential to disrupt communication systems and affect radio wave propagation due to the scattering and absorption of particles.

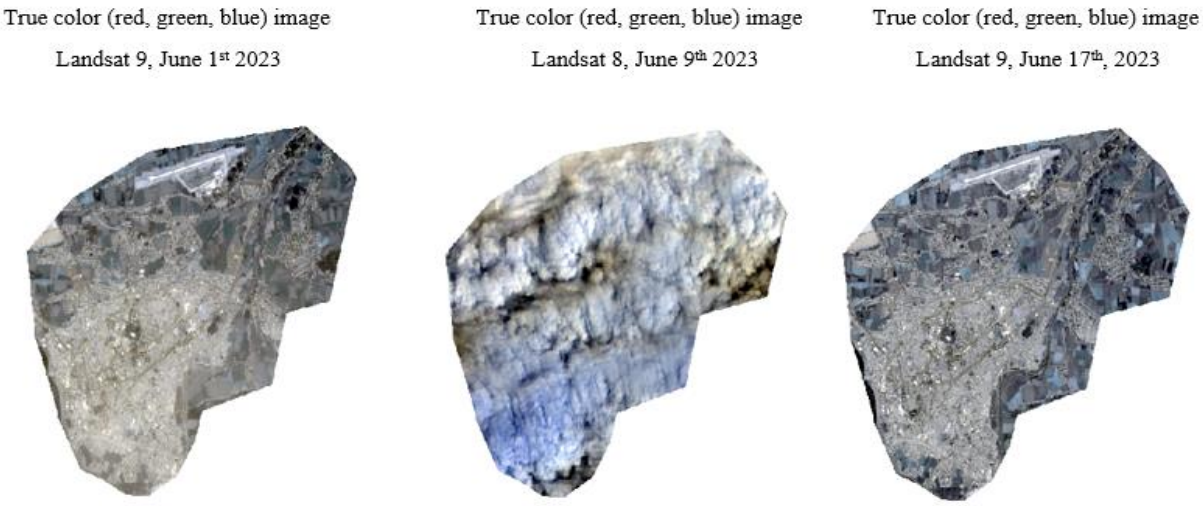

Figure 2. Satellite views of Termez on June 1, 9, and 17, 2023

The impact of SDS events on the study area is evident not only in the visual changes observed in satellite images but also in the environmental and health aspects. Based on the analysis carried out at four specific city locations between June 7 and June 11, 2023, to gather ground truth data, the results on June 9, during the SDS event, differed from values on the other days. In situ measurements taken during the SDS event on June 9 showed a substantial rise in inorganic dust concentrations, especially in the southern city area, in contrast to typical conditions. However, there were no notable alterations in other substances such as sulfur monoxide (SO), hydrogen sulfide (H_2S), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen fluoride (HF), ammonia (NH_3), formaldehyde (CH_2O).

The analysis results indicated that on June 9, the concentration of inorganic dust in the air exceeded the SanPiN Ruz 0293-11 standard by 2.32 times on Dekhlavi Street, 1.92 times on Porloq Yul Street, 1.87 times on Fidokor Street, and 1.81 times around the international airport (Table 1). However, on the remaining days, the levels of inorganic dust and other components in the air did not surpass the specified standards and therefore are not included in the table.

Table 1. Results of in situ measurements on June 9, 2023, for Termez

Dekhlavi Street

Name of ingredients	SanPiN Ruz 0293-11[a], Mg/m^3	Analysis results, Mg/m^3	Responding to requirement
Sulfur monoxide (SO)	5.0	1.458	Norm
Hydrogen sulfide (H_2S)	0.008	0.000	Norm
Sulfur dioxide (SO_2)	0.5	0.210	Norm
Nitrogen dioxide (NO_2)	0.085	0.000	Norm

Hydrogen fluoride (HF)	0.012	0.000	Norm
Ammonia (NH_3)	0.2	0.000	Norm
Formaldehyde (CH_2O)	0.035	0.000	Norm
Inorganic dust	0.15	0.348	2.32 times more than the norm
Porloq Yul Street			
Sulfur monoxide (SO)	5.0	1.89	Norm
Hydrogen sulfide (H_2S)	0.008	0.000	Norm
Sulfur dioxide (SO_2)	0.5	0.112	Norm
Nitrogen dioxide (NO_2)	0.085	0.000	Norm
Hydrogen fluoride (HF)	0.012	0.000	Norm
Ammonia (NH_3)	0.2	0.000	Norm
Formaldehyde (CH_2O)	0.035	0.000	Norm
Inorganic dust	0.15	0.288	1.92 times more than the norm
Fidokor Street			
Sulfur monoxide (SO)	5.0	1.326	Norm
Hydrogen sulfide (H_2S)	0.008	0.000	Norm
Sulfur dioxide (SO_2)	0.5	0.187	Norm
Nitrogen dioxide (NO_2)	0.085	0.000	Norm
Hydrogen fluoride (HF)	0.012	0.000	Norm
Ammonia (NH_3)	0.2	0.000	Norm
Formaldehyde (CH_2O)	0.035	0.000	Norm
Inorganic dust	0.15	0.28	1.87 times more than the norm
Around the international airport			
Sulfur monoxide (SO)	5.0	1.421	Norm
Hydrogen sulfide (H_2S)	0.008	0.000	Norm
Sulfur dioxide (SO_2)	0.5	0.248	Norm
Nitrogen dioxide (NO_2)	0.085	0.000	Norm
Hydrogen fluoride (HF)	0.012	0.000	Norm
Ammonia (NH_3)	0.2	0.000	Norm
Formaldehyde (CH_2O)	0.035	0.000	Norm
Inorganic dust	0.15	0.271	1.87 times more than the norm

[a] Sanitary Maximum Permissible Concentrations (MPCs) and Tentative Permissible Concentrations (TPLCs) of Exogenous Hazardous Substances in Air. SanPiN RUz - 0293-11

A descriptive method is commonly employed to identify acute and chronic diseases associated with improvements in air quality [6]. 101 of the participants in the survey conducted among the local population about the June 9 event and SDS events in general were women, the remaining 99 were men, and more than 50% of them were highly educated. The survey was conducted mainly among 18-60-year-olds.

A total of 83% of the respondents perceived the atmospheric air quality around their place of residence or workplace as unsatisfactory on the day of the SDS event (Figure 3). Furthermore, although 64% of the participants reported feeling unwell that day, with 15% experiencing exacerbations of chronic illnesses (Figure 4), only 22% sought medical consultation, while 50% administered self-first aid (Figure 5).

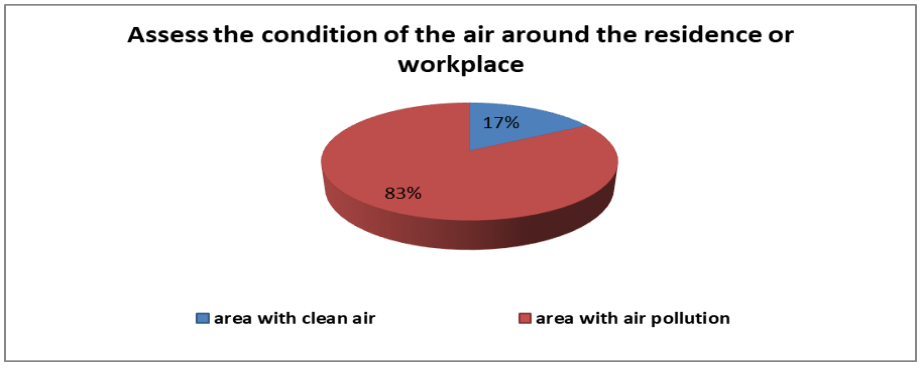

Figure 3. The result of assessing the condition of the air around the residence or workplace on June 9, 2023, for Termez

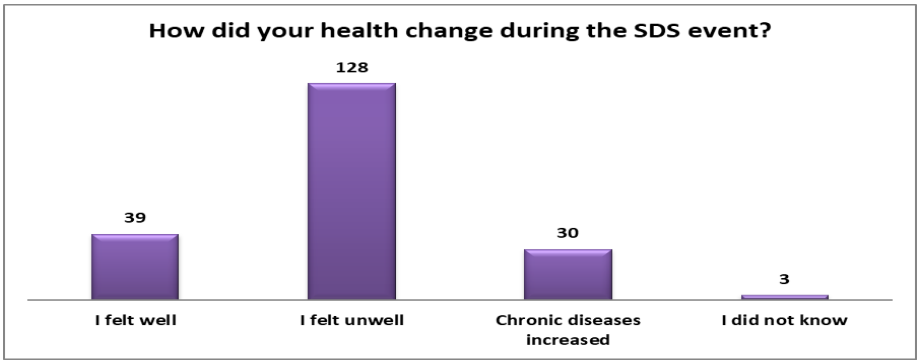

Figure 4. The result of assessing health change among the local population on June 9, 2023, for Termez

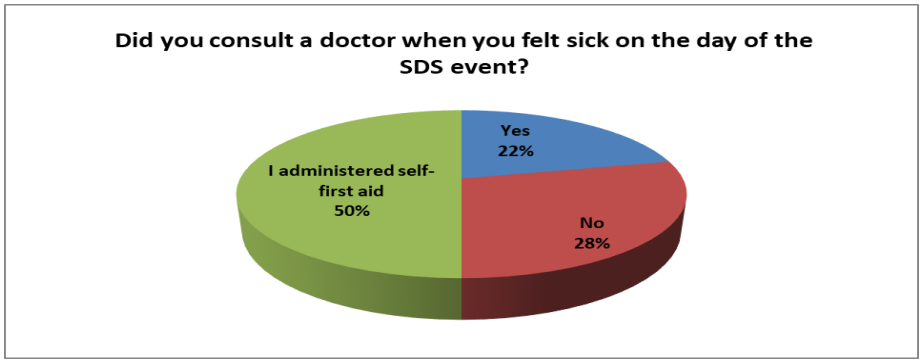

Figure 5. The result of the evaluation of the appeal to a doctor among the local population, June 9, 2023, for Termez

In response to questions about the frequency of SDS events in their residential area, participants reported that 3-4 years ago, such events occurred once or twice a month. However, they noted that at present, SDS events are observed weekly. Respondents emphasized that the increased frequency of SDS events has had a detrimental impact on the population's health, with those suffering from chronic illnesses experiencing health deterioration lasting from 2-3 days to 1-2 weeks during such events.

4. Conclusion

The study focused on assessing the impact of the June 9, 2023, sand and dust storm (SDS) event on the environment and residents of Termez. The research utilized Landsat satellite images to monitor changes in the city's visibility from space during and outside the SDS event.

The scientific findings revealed that during the approximately 8–9-hour SDS event on June 9, the levels of inorganic dust were 2.32 times higher than the norm in the southern part of the city and 1.81 times higher than the norm in the northern part. However, other substances, such as sulfur monoxide (SO), hydrogen sulfide (H_2S), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen fluoride (HF), ammonia (NH_3), formaldehyde (CH_2O), remained within acceptable limits.

The survey results indicated that residents observed a significant increase in the frequency of SDS events compared to 3-4 years ago, with occurrences now happening weekly. On the day of the SDS event, 79% of respondents reported health issues and the development of chronic diseases. Additionally, 72% of respondents mentioned giving first aid to themselves and resorting to medical assistance when their health deteriorates.

Based on the aforementioned findings, and with the aim of mitigating the adverse effects of SDS events and enhancing the ecological environment, the authors propose the following recommendations:

1. Development of enhanced collaboration among relevant stakeholders and international organizations to comprehensively assess the impact of SDS events on human health, socio-economic aspects, and the environment in the research area.
2. Reinforcement of scientific research endeavors focused on efficient monitoring, impact assessment, forecasting, early warning systems, disaster prevention, preparedness, and effective response strategies to SDS events in the city.
3. Establishment of a green belt comprising diverse tree species in the direction of sand and dust storms in the area, drawing from global experiences in dealing with SDS events, as observed in regions like the Arabian Peninsula, the African continent, and China [7].
4. Creation of microclimatic conditions within the city's bordering areas with Afghanistan by implementing artificial water bodies.
5. Formation of mini wind farms in regions adjacent to the research area to effectively harness the potential of the Afghan wind, offering the local population a sustainable source of electricity.

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