# Transboundary Atmospheric Pollution of Oil-Gas Industry Emissions from North Caspian region of Kazakhstan

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## Abstract

The study is focusing on the Atyraus region in Republic of Kazakhstan with more than 60 oil-gas fields on the Caspian Sea shelf as a source region of sulphates emissions accounting about 15 tons annually. Three locations have been chosen in the region covering adjacent Caspian Sea aquatoria, and emissions were equally distributed among these locations. From original sulphates emissions between 46-82% are subjected to atmospheric transport away from the sources. The long-term modelling of atmospheric transport, dispersion and deposition of sulphates was done employing the Lagrangian model DERMA. The generated output included air concentration, time integrated air concentration, dry and wet deposition. The results of dispersion modelling had been post-processed and integrated into GIS environment. It has been found that on an annual scale, the dominating atmospheric transport of pollution from the Atyraus region is toward east and north-east, mostly due to prevailing westerlies. Although on a hemispheric scale, the wet deposition dominates over dry (63 vs. 37%), for Kazakhstan the wet deposition contribution is slightly larger (65%). Considering total deposition during transboundary atmospheric transport, it was found that 80.3% of transported sulphates will be deposited over territories of Kazakhstan, 13.8% - Russia, about 2% each – Turkmenistan and Uzbekistan, and less than 1% over other countries.

## Sources of Atmospheric Pollution

The Atyraus region (Republic of Kazakhstan; Fig. 1a) is occupied with more than 60 oil-gas fields which are actively developing. Moreover, a new world largest field so-called Kashagan has been discovered on the Caspian Sea shelf and its exploitation is planned by the end of 2012. In our study, this region has been selected as a source region of sulphates emissions accounting about 15 tons based on 2009 estimates (*Atmosphere—Annual Report, 2009*). Three locations — A, B, C — have been chosen (Fig. 1b) in the region covering adjacent Caspian Sea aquatoria, and emissions were equally distributed among these locations (with an emission rate of $4.72 \cdot 10^{-4}$ kg/sec). From original sulphates emissions between 46% (Scenario I) and 82% (Scenario II) are subjected to atmospheric transport away from the sources (*IPCC, 2001*). Releases were considered to be continuous.

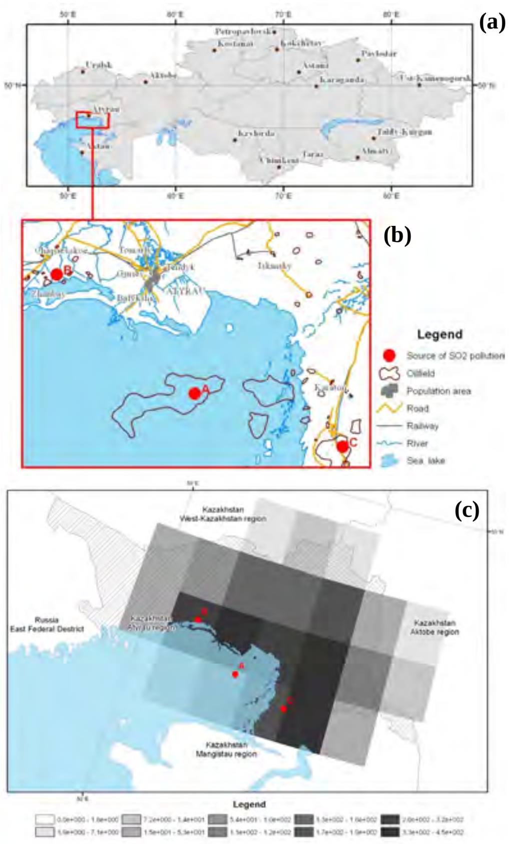


***Figure 1:*** *(a,b) Geographical placement of three emissions sources (A, B, C) of sulphates from the Atyraus region of Kazakhstan and |(c) Air concentration (kg/m³) field (represented as a sum from three sources of emissions) in the surface layer of the atmosphere on 1st Jan 2009.*

## Long-Term Modelling

To estimate potential impact due to continuous anthropogenic emissions, the Lagrangian-type Danish Emergency Response Model for Atmosphere (DERMA) in a long-term mode was employed to perform long-term simulations of air concentration (Fig. 1), time integrated air concentration, dry and wet deposition patterns as well as their detailed analysis (*Baklanov et al., 2006*; *Mahura et al., 2005*). To perform such simulations the European Center for Medium-Range Weather Forecasts (ECMWF) 3D meteorological fields for the year 2000 were used as input. After each day of release the atmospheric transport, dispersion, and deposition was estimated for the next 2 week period.

## Acknowledgements

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## References

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*Mahura A., Baklanov A., Sorensen J.H. (**2005**): Long-term dispersion modeling. Part 2: Assessment of atmospheric transport and deposition patterns from nuclear risk sites in Euro-Arctic Region. J. of Computation Technologies, Vol. 10, 112-134*

## Annual Concentration and Deposition Patterns

The results of dispersion modelling had been post-processed and integrated into GIS environment using ArcGIS (Fig. 2). These have been further used to calculate annual averaged and summary concentration and deposition fields for administrative regions, counties and cities of Kazakhstan, as well as territories of the neighboring countries.

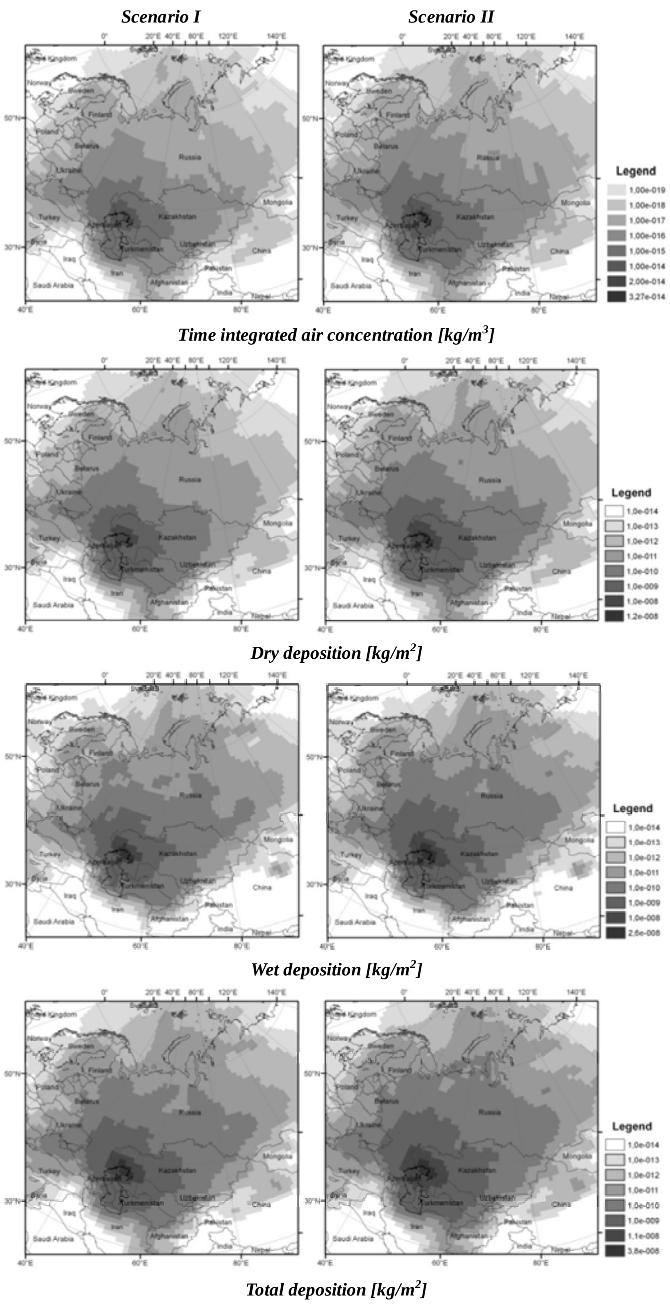


***Figure 2:*** *GIS integrated spatial distribution of concentration, and summary dry, wet and total depositions of sulphates resulted from atmospheric transport and deposition from three sources (A, B, C) of the Atyraus region of Kazakhstan.*

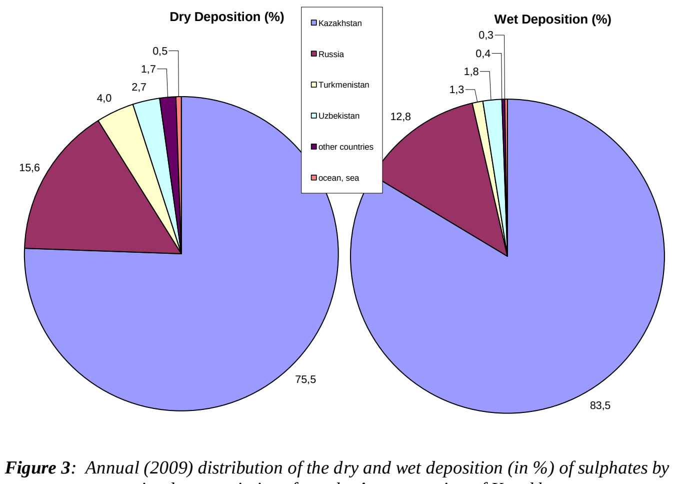


***Figure 3:*** *Annual (2009) distribution of the dry and wet deposition (in %) of sulphates by countries due to emissions from the Atyraus region of Kazakhstan.*

## Dry and Wet Deposition by Countries

On an annual scale, the dominating atmospheric transport of pollution from the Atyraus region is toward east and north-east, mostly due to prevailing westerlies. Although on a hemispheric scale, the wet deposition dominates over dry (63 vs. 37%), for Kazakhstan the wet deposition contribution is slightly larger (65%). For Turkmenistan, dry deposition is almost twice higher compared with wet (65 vs. 35%) which is due to significantly smaller precipitation in this country. Considering total deposition during transboundary atmospheric transport, it should be noted that 80.3% of transported sulphates will be deposited over territories of Kazakhstan, 13.8% - Russia, about 2% each – Turkmenistan and Uzbekistan, and less than 1% over other countries (Fig. 3).

## Annual Total Deposition by Administrative Units and Bordering Countries

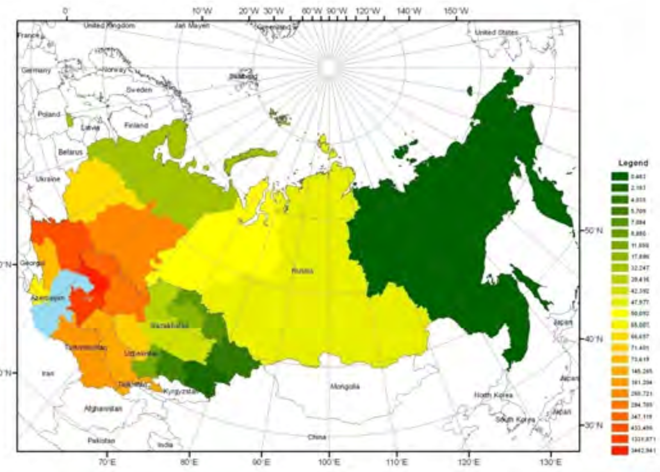


***Figure 4:*** *Spatial distribution of total deposition of sulphates (in kg) by regions of Kazakhstan and federal districts of Russia as well as by selected neighboring countries.*

Among considered 14 Regions of Kazakhstan and 8 Federal District of Russia, the highest concentrations and depositions were identified in the Atyraus and Magistaus regions of Kazakhstan as well as in the South Federal District of Russia (Fig. 4). For Kazakhstan, the lowest values were identified in the Almaty, East-Kazakhstan, Dzhambul and Pavlodar regions. Among most populated cities the city of Atyrau (Kazakhstan), Astrakhan (Russia) and Baku (Azerbaijan) showed the largest concentrations during transboundary atmospheric transport (Tab. 1).

| Country | Kazakhstan (Regions) Russia (Federal Districts) | Scenario I | | Scenario II | |
|---|---|---|---|---|---|
| | | *Annual dry deposition (kg)* | *Annual wet deposition (kg)* | *Annual dry deposition (kg)* | *Annual wet deposition (kg)* |
| **Kazakhstan** | **Atyrau** | 608 | 1323 | 1084 | 2359 |
| | **Mangistau** | 308 | 440 | 548 | 784 |
| | **West-Kazakhstan** | 74 | 121 | 132 | 215 |
| | **Aktobe** | 59 | 101 | 105 | 179 |
| | **Kzylorda** | 20 | 20 | 36 | 35 |
| | **Karaganda** | 11 | 13 | 20 | 23 |
| | **Kustanay** | 7 | 15 | 13 | 26 |
| | **Akmola** | 4 | 6 | 7 | 11 |
| | **South-Kazakhstan** | 4 | 3 | 6 | 5 |
| | **Jambyl** | 2 | 1 | 4 | 2 |
| | **North-Kazakhstan** | 2 | 3 | 3 | 6 |
| | **East-Kazakhstan** | 2 | 1 | 3 | 1 |
| | **Pavlodar** | 1 | 3 | 2 | 5 |
| | **Almaty** | 1 | <1 | 2 | <1 |
| **Russia** | **East** | 118 | 125 | 211 | 222 |
| | **Privolzhsky** | 48 | 98 | 86 | 175 |
| | **North Caucasus** | 24 | 17 | 44 | 30 |
| | **Central** | 16 | 21 | 29 | 38 |
| | **Siberian** | 7 | 20 | 13 | 35 |
| | **North-West** | 7 | 11 | 13 | 20 |
| | **Ural** | 7 | 22 | 12 | 38 |
| | **Far East** | <1 | <1 | <1 | <1 |
| **Turkmenistan** | | 59 | 32 | 105 | 56 |
| **Uzbekistan** | | 39 | 43 | 69 | 76 |
| **Azerbaijan** | | 22 | 14 | 40 | 25 |

***Table 1:*** *Annual dry and wet deposition (in kg) distribution by countries, regions (for Republic of Kazakhstan), and federal districts (for Russian Federation) for two types of scenarios.*

## Conclusion

- Transboundary atmospheric transport of industrial emissions from the Atyraus region of Kazakhstan are occurred, in general, in the eastern and north-eastern directions.
- During atmospheric transport from the sources of emissions between 26-47% of emitted sulphates were deposited on the underlying surface, and the remaining part of $SO_2$ continued to circulate within the atmosphere including chemical transformations.
- For the year of 2009, depending on selected scenarios, the total (dry and wet) deposition over territory of the Republic of Kazakhstan ranged from 3.2 to 5.6 tones, and Russian Federation — ranged from 0.5 to 1 tones., and for other countries it was less than 0.2 tones. In total, about 80% of sulphates was deposited over Kazakhstan, 14% - over Russia.