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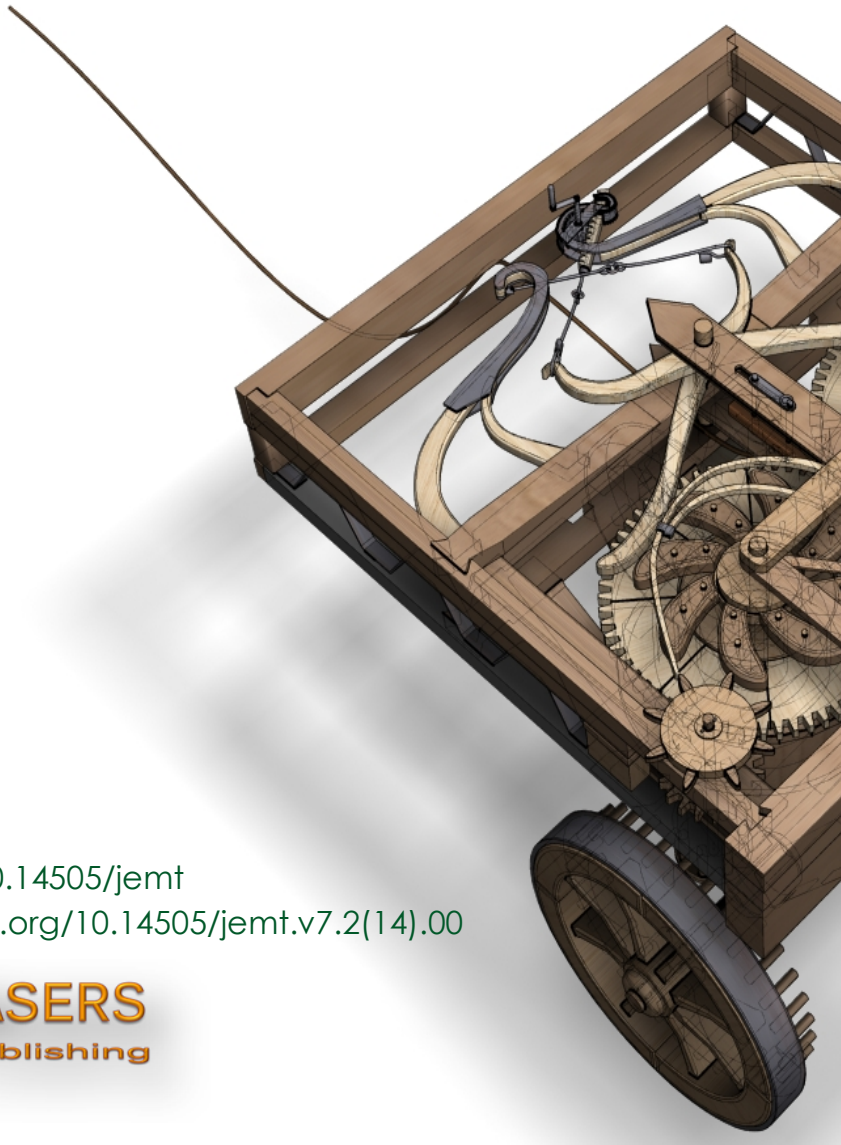

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Journal of Environmental Management and Tourism

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Monitoring the Air Pollution and Evaluation of the Impact of Aluminium Production in Talco

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Abstract

The study was conducted in the aluminium plant TALCO (Tajik Aluminium Company). The objective was to evaluate the concentration of harmful substances (in particular hydrogen fluoride, fluorine salts, and sulphur dioxide) in the air. Data were collected within 0, 1, 5, 10, and 12 km from the plant emission source. The concentration of hydrogen fluoride ranged from 0.0043 to 0.0037 mg. m-3 and fluorine salts from 0.58 to 0.002 mg. m-3. The highest concentration of fluoride was found between 7 and 8 workshops, which were under the maximum allowable concentration (MAC). Within 1 kilometre from the plant, content of the substances is at a maximum and the minimum is already within 5th kilometre from plant borders. The concentration of all substances sharply decreased within 1 km from the plant.

Keywords: environmental monitoring, air pollution, fluoride, TALCO.

1. Introduction

The atmospheric pollution by fluoride is one of the main problems in TALCO. Fluorides are released into the atmosphere from aluminium plants. The most common gaseous form is hydrogen fluoride; one of the most phytotoxic of all air pollutants which, historically, has been responsible for large-scale economic and aesthetic damage. (Armienta *et al.* 2011)

The deposition of fluoride on the surface of vegetation or the uptake by plants can cause fluorosis in mammalian herbivores if there is an excess in their diet. All of this is well documented Kaur *et al.* (2016), but questions about the long-term fate and cycling of deposited fluoride still arise when the volume of aluminium production increases. There is evidence that accumulated plant fluoride is sensitive to changes in ambient concentrations Kucherov *et al.* (2016), Wang *et al.* (2015), Weinstein and Davison (2003), however, regulatory bodies and the public are often concerned about the potential for a build-up of fluoride in soils and, consequently, elevated plant fluoride even when a source ceases mission Brougham *et al.* (2013), Divan Junior *et al.* (2008). In general, the chemistry of soil fluorine and our understanding of the physiology of fluoride uptake suggest that there is a little risk of accumulation from long-term deposition of fluoride on neutral to alkaline mineral soils, but uncultivated, acidic soils may be a greater risk Jamnická *et al.* (2007), Kramer and Heath (2014). If the fluorides concentration arises in the air (more than MAC), the fluoride will uptake on leaves of plant and on soil. The problem is that very few studies of post-emission fluoride concentrations have been published and although work, such as that by Frankowski *et al.* (2010), provides useful data, there is still a need for more information from a greater range of species and situations.

2. Standards for fluorine content in the atmosphere

Currently in Tajikistan there is a uniform standard for maximum allowable concentration (MAC) of harmful pollutants to the atmosphere. Average daily MAC for fluoride hydrogen is 0.005 mg.m-3, for solid fluorides 0.03 mg. m-3 and for sulphur dioxide 0.05 mg. m-3. The European Union has established the following indicators of MAC for pollutants in the atmosphere during the growing season: 0.0003 mg/m3 for very sensitive plants, 0.0005 mg. m-3 for sensitive plants and 0,001 mg.m-3 less susceptible plants. Highly sensitive plants react to fluoride content of 50 mg. m-3, sensitive plants react to 50 – 200 mg.m-3 and relatively stable plants to above 200 mg. m-3. Natural fluoride content in plants is usually less than 20 mg. kg^{-1}.

Monitoring

Since the launch of a plant periodic monitoring of the environment organized around the plant. Monitoring of the environment is conducted by the company laboratory in accordance with the daily schedule; also such a monitoring is carried out by the Committee of the Environmental Protection under the Government of the Republic of Tajikistan. The result of monitoring is controlled by the Service of the State Sanitary and Epidemiological.

Sampling locations and mapping

Figure 1 shows the surroundings of aluminium plant (TALCO) with a marked sanitary protection zone within a radius of 12 km and sampling points of water (blue colour 7 sampling sites) and air (red colour 11 sampling sites). The area of study covered up to 12 km from the plant and ended in the border with Uzbekistan, first sample was taken, between the workshops, in particular between 7 and 8 workshops (in distance from sources 0 km) the direction of wind rose north – east. The second samples selected in the sanitary protection zone, within 1 and 5 km from the plant, the direction of wind rose was north - east. The third samples area was selected within 12 km from the plant (territory of the hotel "Shirkent") (direction of rose wind north - east). Samples were taken in this order within radius of 12 km. (Reports of TALCO 2014)

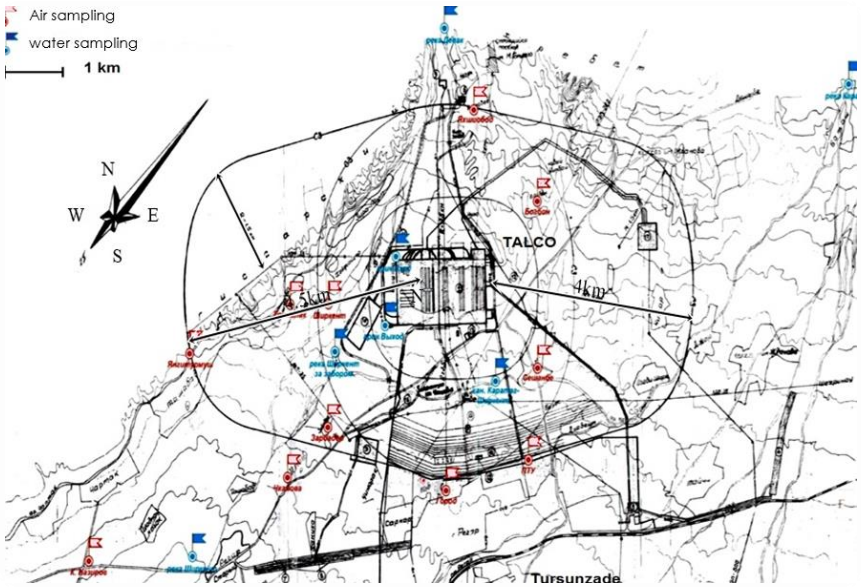

Figure 1 - Map of the protection zone sampling sites and sampling air and water around the aluminium plant TALCO.

The data used for evaluating concentration of harmful substances were analysed through the analysis of variance (ANOVA) which is a statistical method used to test differences between two or more means. It may seem odd that the technique is called "Analysis of Variance" rather than "Analysis of Means." The name is appropriate because inferences about means are made by analyzing variance Online Statistics Book by David M. Lane. This also can be confirmed by Sokal and Rohlf (1995) who described that analysis of variance which is used to test differences among sample means and differences among linear combinations of means. Its name is derived from the fact that variances are used to measure the differences among means. A simple application of the analysis of variance is to test whether two or more sample means could be obtained from the populations with the same parametric mean.

Mathematical expressions

The concentration of fluorine salt in the first sampling place, between 7 and 8 workshops (in 0 km from the emissions sources at TALCO) was 0.58 mg. m-3, which presents the highest concentration to compare with other results of samples. In the second sampling place in particular 10 kilometres from TALCO (Tajik Aluminum Company) was 0.003 mg. m-3, and 12 km from TALCO (State border with the Republic of Uzbekistan) was found 0.002 mg. m-3. To compare the result of the first sample side (0.0 km) with the second (10 km) and third (in 12 km State border with the Republic of Uzbekistan) it over a hundred times smaller. The results present that the concentration of fluorine salt sharply decreased from the first sampling site (0.0 km between 7 and 8 workshop) to second and third sampling site. Maximum allowable concentration (MAC) in Tajikistan has uniformed for fluorine salts average daily (for 24 hours) 0.03 mg.m-3, and maximum allowable concentration for work location (for 8 hours) is 1 mg/m3. Should note also that for monitoring the concentration of substances in the air, in the monitoring area, the direction of wind flow is important and it has a significant impact to transfer and spread substances to the direction of wind flow. In this monitoring the direction of wind flows was presented to north – east, *i.e.* to the direction of Dushanbe (Report of TALCO, 2013).

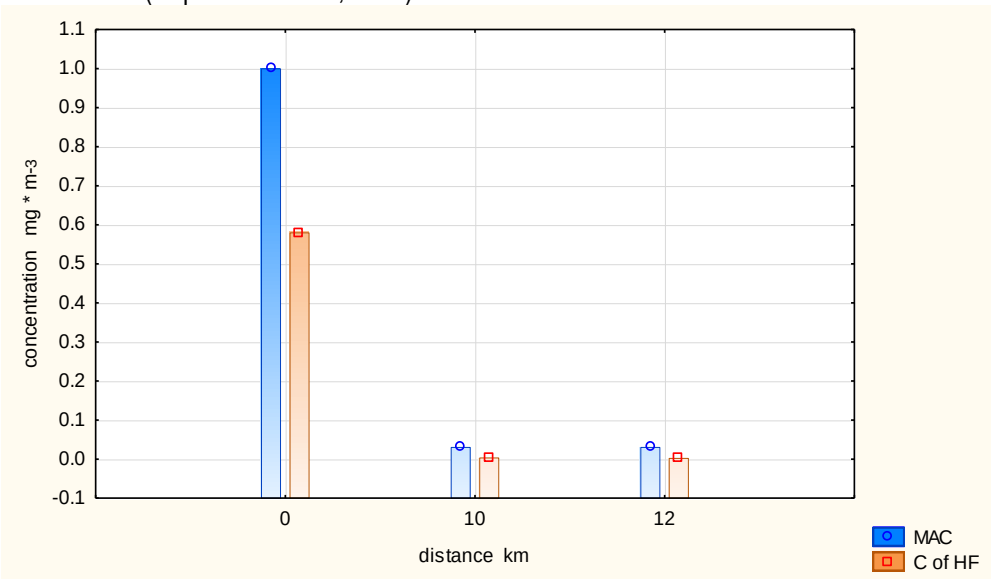

Figure 2 - Concentrations of fluorine salts comparing with MAC (maximum allowable concentrations) within 0, 5, 10 km from the source of emission at TALCO

Hydrogen fluorine is one of the most phytotoxic of all air pollutants which, historically, has been responsible for large-scale economic and aesthetic damage (NAS 1971, Weinstein and Davison 2004). The difference was between the results of fluoride salts and hydrogen fluoride was that by changing the distance (between each sampling sites) the concentration is decreased slightly. In first sampling place within 1 km from the source of the emissions, concentration of hydrogen fluoride (HF) was 0.0043 mg. m^{-3}, in the second sampling site (5 km from TALCO) 0.0040 $mg.m^{-3}$ and in the thirds sampling site was 0.0037 mg.m-3 (Figure 3). The results of concentration of sulphur dioxide are shown in Figure 4. The maximum allowable concentration for sulphur dioxide in Tajikistan is 10 $mg.m^{-3}$ (for 8 hours in work location) and 0.5 mg.m-3 (for 24 hours). The result presented that the concentration of SO2 was not exceeded the limit in any of three sampling sites, however, at 10 km from TALCO sharply decreased (Figure 4).

At all three sampling sites, the concentration of substances was under the MAC (maximum allowable concentration), at first sampling sites recorded the highest concentrations of substances and in the second and third sampling sites it is declined to minimum. In the third sampling sites (in particular at the state border with the Republic of Uzbekistan) recorded the lowest concentration. The direction of rose wind up to 50% per year is north – east, *i.e* to the direction of Tajikistan, then only less than 1% per year at the prevailing direction of flow from North to South, so the territory of Uzbekistan shall receive only the minimum amount of pollutants. Wind speed in that period in 80% ranged from 1 to 3 m. s-1. The higher wind speed was presented over 6 m.s-1.

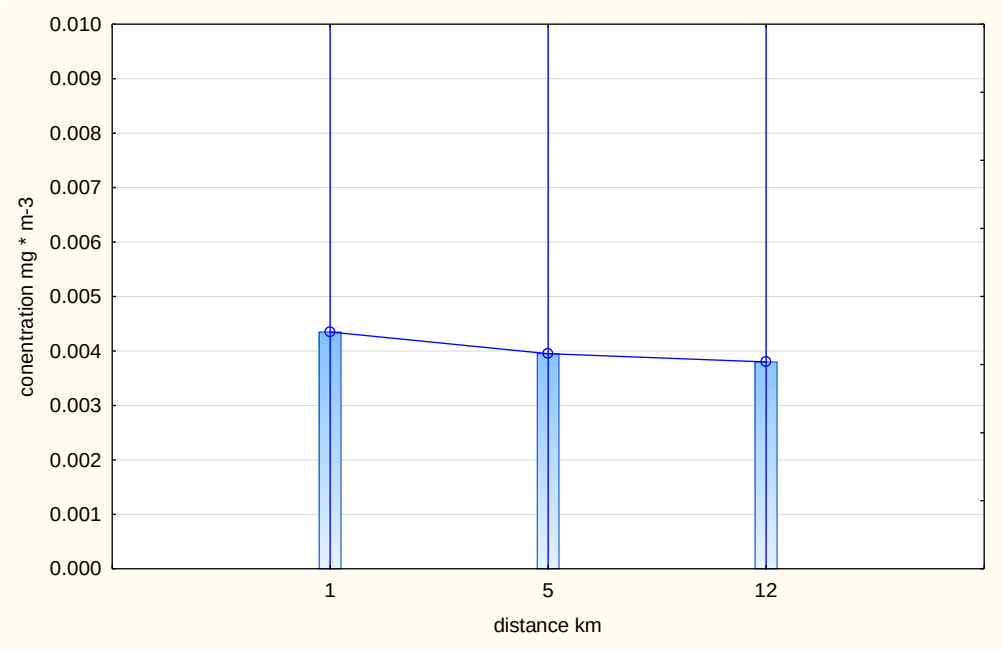

Figure 3 - Concentration of hydrogen fluoride (HF) in 1, 5, 12 km

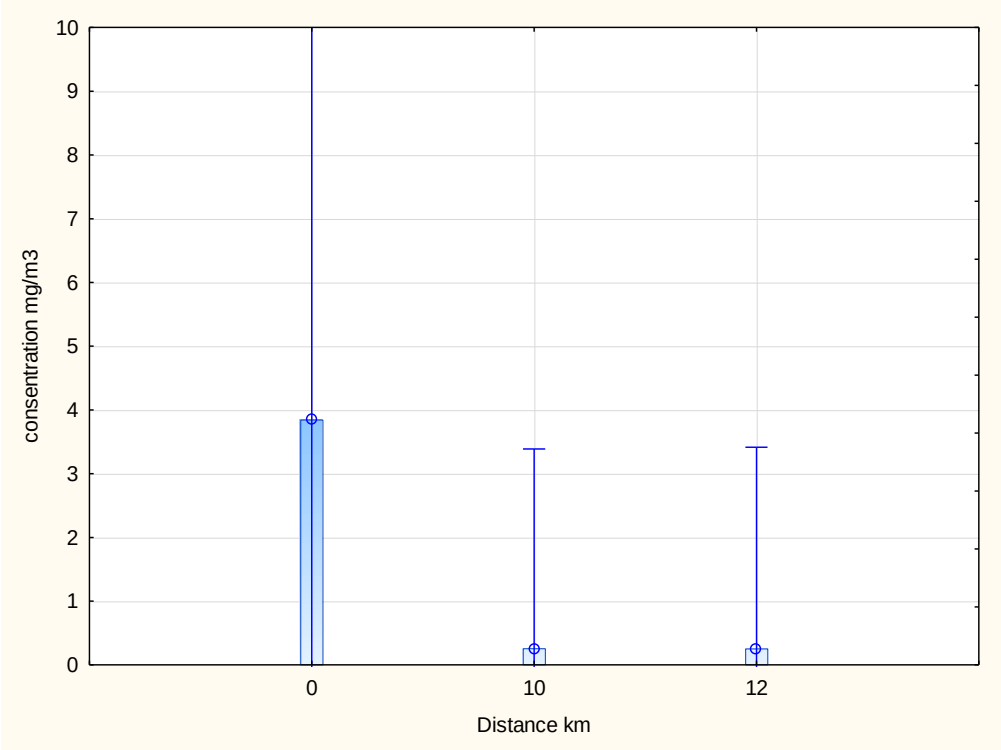

Figure 4 - Concentration of sulphur dioxide in 0, 10, 12 km

Conclusion

Thus, fluoride contents in air and its loading rates in the impact area of Tajik Aluminium Company are under MAC, which is shown in statistical data of TALCO. Besides that, the aluminium production plant is a powerful pollution source of air with fluoride. In the impact area of TALCO air emission content were identified at the distance of up to 12 km from the plant borders, which could indicate the transportation of fluoride compounds over long

distances. The data obtained show that fluoride enters to the territory of Uzbekistan with the study plants emissions with less probability degree. However the rose wind direction less than 1%/year flow to direction of Uzbekistan (north to south), taking into account that the concentration of air pollution (mostly fluorides) of studied plant significantly was related with the amount of aluminum production.

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