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Government of the Republic of Tatarstan

Air Dispersion Study for a Waste incineration plant at Zelenodolskiy/Republic of Tatarstan/ Russian Federation

Report No. M156050/04

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Table of contents

Summary

The Government of the Republic of Tatarstan is planning to build and run a (municipal) waste incineration plant at Zelenodolskiy /Republic of Tatarstan, Russian Federation. Due to the resistance of citizens and NGOs, a second opinion on the environmental impacts on air quality, human health and treatment/possible usage of the ashes is requested by the Secretary of Environment of Tartastan.

The air dispersion study and evaluation of the results for the model scenario and the actual GLC (as measured) was done according to the German Guideline TA Luft 2002 (methodology and assessment system). This means, that it had been checked, whether (and under which conditions) the sites could get permission in Germany with regard to the Requirements for the Protection against Harmful Effects on the Environment according to No. 4. TA Luft. Additionally, the Russian environmental standards had been taken into account (however by applying the German assessment system).

With regard to the German methodology and assessment system according to the Technical Instruction on Air Quality Control, TA Luft [2], the results of the air dispersion study can be summarised as follows:

- The air dispersion study has shown that the annual German limit values according to TA Luft 2002 for the air pollutants are not exceeded at the assessment points.
- The short time values according to the Russian Environmental Quality Standards at the assessment points have also been respected (see chapter 12.2); there are no exceedances to expect.
- Furthermore, the air dispersion study has shown that the modelling approach, in comparison to the determination of immission loads through measurements, is more conservative. In the modelling approach, the emissions of the sources are estimated at 8,760 annual hours (see also chapter 7.2). This is an overestimation of the emission scenario.

With regard to the scope investigated, the results indicate – from the consultant’s point of view and the German methodology and assessment system – no evidence that the operation of the waste incineration plant at Zelenodolskiy /Republic of Tatarstan exceeds the Russian Environmental Quality Standards and could provoke harmful environmental impacts or other hazards, substantial disadvantages and considerable inconvenience for the general public and the neighbourhood.

Planegg, the 15th of June 2020

M. Sc. Eva Siebenlist	Dipl.-Ing. agr. Walter Grotz
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1 Situation and task

The Government of the Republic of Tatarstan is planning to build and run a (municipal) waste incineration plant at Zelenodolskiy /Republic of Tatarstan, Russian Federation. Due to the resistance of citizens and NGOs, a second opinion on the environmental impacts on air quality, human health and treatment/possible usage of the ashes is requested by the Secretary of Environment of Tartastan.

The following Scope of work was offered and ordered:

Air dispersion study and impact on human health with the following contents:

- Assembling the required data regarding pollutant emissions and outlet conditions based on input data provided by the client
- Assembling topographical and constructional conditions of the site in order to establish a site model
- Compilation of meteorological time series AKTerm based on site-specific, measured meteorological input data (wind direction, wind speed, cloud coverage).
- Determination of the calculation area and execution of air dispersion calculations in the form of a one year simulation in hourly resolution according to Appendix 3 of the TA Luft (using the model AUSTAL2000) taking into account the influence of the area development and the topography of the site with an upstream three-dimensional diagnostic mesoscale wind field model.
- Tabular presentation of the parameters for the additional load
- Graphic presentation of the parameters for the additional load in the assessment area.
- Consideration of the GLC baseline (ground-level-concentration) based on measured GLC-data provided by the client
- Assessment of the results based on approved assessment values (TA Luft 2002) and assessment of the impact on human health.

The air dispersion study and evaluation of the results for the model scenario and the actual GLC (as measured) shall be done according to the German Guideline TA Luft 2002 (methodology and assessment system). This means, that it shall be checked, whether (and under which conditions) the sites could get permission in Germany with regard to the Requirements for the Protection against Harmful Effects on the Environment according to No. 4. TA Luft. Additionally, the Russian environmental standards shall be taken into account (however by applying the German assessment system).

2 Regulatory Fundamentals

2.1 Federal Immission Control Act

The fundament of air dispersion study is the Federal Immission Control Act (Bundes-Immissionsschutzgesetz), released in 1974, last modified in 2017 [1].

The purpose of this law is “to protect human beings, animals and plants, the soil, water, the atmosphere as well as cultural assets and other material goods against harmful effects on the environment and, to the extent that this concerns installations subject to licensing, also from hazards, considerable disadvantages and considerable nuisance caused in any other way, and to take precautions against the emergence of any such harmful effects on the environment.”

In 2002 the Federal Ministry for Environment, Nature Conservation and Nuclear Safety, decrees the First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft), in pursuant to § 48 of the Federal Immission Control Act [1].

2.2 Technical Instructions on Air Quality Control – TA Luft 2002

The Technical Instruction on Air Quality Control [2] serves to protect the general public and the neighbourhood against harmful effects of air pollution on the environment and to provide precautions against harmful effects of air pollution in order to attain a high level of protection for the environment altogether.

The provisions of these Technical Instructions shall be observed when

a) examining applications for a permit to construct and operate a new installation (§ 6 para. 1 of the Federal Immission Control Act) as well as to alter the location, nature or operation of an existing installation (§ 16 para. 1, also in connection with para. 4 of the Federal Immission Control Act),

b) examining applications to grant a partial permit, to render a provisional decision or to grant permission of early start (§§ 8, 8a and 9 of the Federal Immission Control Act),

c) examining whether an alteration requires a permit (§ 15 para. 2 of the Federal Immission Control Act),

d) deciding about subsequent orders (§ 17 of the Federal Immission Control Act) and deciding about orders concerning the determination of the type and quantity of the emissions released from an installation and the immissions occurring within the sphere of influence of such an installation (§ 26, also in connection with § 28 of the Federal Immission Control Act).

The related assessment criteria within the framework of permit procedure also applied in the present study are presented in detail in chapter 3.**Air Dispersion Study**

In terms of plant-related pollution control, the Technical Instructions on Air Quality Control (TA Luft) provide appropriate specifications and instructions, especially in Appendix no. 3 [2].

In the following chapters, the relevant requirements for this case[1], according to TA Luft Appendix no. 3, are listed.

2.3.1 TA Luft Appendix no. 3

2.3.1.1 General

The dispersion calculation for gases and particulate matter shall be carried out as a time series calculation over a period of one year respectively or on the basis of a frequency distribution of dispersion situations over a period of several years according to the procedure described herein using the particle model of the VDI Guideline 3945 Part 3 (September 2000 version) and under consideration of other Guidelines quoted further below.

When using a time series calculation the dispersion model yields the concentration of a substance (as mass/volume) and the deposition (as mass/(surface x time)) for each hour of the year at the specified grid points. When using a frequency distribution according to Chapter 12 in this Annex, the dispersion model yields the corresponding annual mean values.

The results of a calculation for a raster of grid points shall serve to select the assessment points.

The results at the assessment points represent the additional load and serve, together with the time series of the measured initial loads, to determine the total load [2].

2.3.1.2 Determination of Emissions

Emission sources are the points to be determined where air pollutants are released from the installation into the atmosphere. The release conditions prevailing at the discharge of the emission shall be taken into account. The emission parameters of the emission source (emission mass flow, waste gas temperature, waste gas volumetric flow) shall be specified as hourly mean values. If the emission parameters vary in time, e. g. in batch operation, they are to be indicated as time series. If such a time series is not available or cannot be used, the most unfavourable conditions with respect to clean air maintenance during normal operation shall be assumed. If the emission rate is dependent on the wind velocity (wind-induced sources), this shall be taken into account accordingly [2].

2.3.1.3 Dispersion Calculation for Gases

As to gases for which no immission values have been established for deposition, the dispersion calculation shall be carried out without taking into account the deposition.

The conversion times indicated in VDI Guideline 3782 Part 1 [9] shall be used to calculate the conversion of NO to NO_2.

[1] The listing in this report only contains the relevant requirements according TA Luft Appendix 3 for this case and is not presented in full extent.

2.3.1.3.1 Chemical Conversions

Most trace substances are subject to chemical conversion during their dispersion into the atmosphere.

Within a time range of less than about ten hours, the following trace substances especially convert chemically to a significant extent: nitrogen monoxide (NO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), propene, aldehydes and some unsaturated organic compounds[2].

In the atmosphere, NO and NO_2 undergo chemical reactions that depend on meteorological conditions and on the trace gas composition of the ambient air. The most important processes are the decomposition of NO_2 molecules through the effect of solar radiation ($h \cdot v$), with the formation of NO (Reaction (R1)) and the oxidation of NO by ozone (O_3) to NO_2 (Reaction (R3)). The consumed ozone is recycled via Reaction (R2), from an oxygen atom in the electronic ground state ($O(^3P)$) and molecular oxygen (O_2). The formation energy of Reaction (R2) is dissipated via the air molecule M.

$$NO_2 + h \cdot v \rightarrow O(^3P) + NO \qquad (R1)$$
$$O(^3P) + O_2 + M \rightarrow O_3 + M \qquad (R2)$$
$$O_3 + NO \rightarrow NO_2 + O_2 \qquad (R3)$$

This standard describes an extended reaction system which accounts for the chemistry of nitrogen oxides with sufficient accuracy, in order to allow a quantitative immission forecast as part of a chemistry and transport model. Using a lifetime concept, it offers options for simplifying the proposed reaction mechanism for particular applications [13].

The extent of the chemical conversions can be estimated via the concentrations of the trace substances and their reaction partners and physicochemical and meteorological parameters [9].

To estimate the mean decomposition of nitrogen monoxide (NO) in plumes, the mean lifetimes obtained from measurements on four power stations are used in AUSTAL2000. These lifetimes thus include not only the reactions of NO with oxygen (O_2) and ozone (O_3) and secondary reactions due to sunlight but also the intensity of mixing.

Table 1. Mean NO-lifetimes in plumes obtained from measurements on four power stations [9].

Klug/Manier dispersion category[1)]	I	II	III/1	III/2	IV	V
Mean lifetime τ (h)	2.9	2.5	1.9	1.3	0.9	0.3

[2] The calculation model AUSTAL2000 is an exemplary implementation of Appendix no. 3 TA Luft in which the conversion of NO to NO_2 according to VDI Guideline 3782 Part 1 shall be used. For other atmospheric chemically active pollutants, as listed above, the TA Luft immission values consider a tolerance range for the determination of indicators. The immission values shall also apply with several pollutants occurring simultaneously or if pollutants are subject to chemical or physical transformation [2].

1) for a more detailed description see chapter 2.3.1.7.1.

2.3.1.4 Surface Roughness

The surface roughness of the terrain is described by a mean roughness length z_0. Such surface roughness shall be determined according to Table 14 on the basis of the land use classes of the CORINE Land Cover Inventory[3] (the indicated numbers correspond to the CORINE land cover nomenclature):

Table 2. Mean Roughness Length Subject to the Land Use Classes Indicated in the CORINE Land Cover Inventory [2].

z_0 (m)	**CORINE Classes**
0.01	Beaches, dunes and sand plains (331); Water bodies (512)
0.02	Landfills and Mining Dumps(132); Pastures (231); Natural Grassland (321); Sparsely vegetated areas (333); Salt marshes (421); Intertidal flats (423); Water courses (511); Estuaries (522)
0.05	Mineral extraction sites (131); Sport and leisure facilities (142); Non irrigated arable land (211); Glaciers and perpetual snow (335); Coastal lagoons (521)
0.10	Airports (124); Inland marshes (411); Peat bogs (412); Sea and ocean (523)
0.20	Road and rail networks and associated land (122); Green urban areas (141); Vineyards (221); Complex cultivation patterns (242); Land principally occupied by agriculture with significant areas of natural vegetation (243); Moors and heathland (322); Bare rock (332)
0.50	Port areas (123); Fruit tree and berry plantations (222); Transitional woodland scrub; (324)
1.00	Discontinuous urban fabric (112); Industrial or commercial units (121); construction sites (133); coniferous forest (312)
1.50	Broad-leaved forest (311); Mixed forest (313)
2.00	Continuous urban fabric (111)

The roughness length shall be determined for an area that is located within a circle around the stack, drawn with a radius equal to 10 times the construction height of the stack. If such an area is composed of units having different surface roughnesses, a mean roughness length shall be determined by calculating the arithmetic mean weighting with respect to the proportion of the respective area unit and subsequently be rounded to the closest value in the table. It is to be examined whether the use of land has changed considerably since the inventory was drawn up, or whether a significant change with respect to the immission projection can be expected.

If the surface roughness varies strongly within the area under consideration, it shall be examined how the roughness length value affects the additional load calculated.

[3] Data on ground cover in the Federal Republic of Germany (“Daten zur Bodenbedeckung der Bundesrepublik Deutschland”) provided by the Federal Statistical Office, Wiesbaden.

2.3.1.5 Effective Source Height

The effective source height shall be determined pursuant to VDI Guideline 3782 Part 3 [10]. The emitted heat flow ***M*** in MW shall be calculated using the following equation (1):

$$M = 1.36 \cdot 10^{-3} \cdot R' \ (\mathrm{T} - 283.15\ \mathrm{K}) \qquad (1)$$

M being the heat flow in MW, *R*' the waste gas volumetric flow rate (wet) under normal conditions in m^3/s and *T* the waste gas temperature in K. If waste gases are discharged via cooling towers, VDI Guideline 3784 Part 2 (March 1990 version) shall be applied accordingly.

2.3.1.6 Calculation Area Grid Points

The calculation area applied to a single emission source is the area that is located within a circle around the center of emission drawn with a radius equal to 50 times the stack height. If several sources contribute to the additional load, the calculation area is composed of the calculation areas of the individual sources. In cases of unusual terrain it may be necessary to select a larger calculation area. The raster for calculating concentration and deposition shall be selected in such a way that it will be possible to determine the location and amount of the maximum immission values in a sufficiently reliable way. As a rule, this is the case when the horizontal mesh size does not exceed the stack height. At distances from the source higher than 10 times the stack height, it is possible to select a proportionally larger horizontal mesh size. The concentration at the grid points shall be calculated as a mean value over the vertical interval from ground level up to 3 m above ground, and thus is representative of a grid point height of 1.5 m above ground. The mean values thereby calculated for a volume or a mesh of the calculation reticule shall be considered as valid point values for the grid points contained therein [2].

2.3.1.7 Meteorological Data

Meteorological data shall be specified as hourly mean values, with the wind velocity determined as a vector average. The values used should be characteristic for the location of the installation. If no measurements are available at the location of the installation, data shall be used from a suitable station of the German Weather Service (Deutscher Wetterdienst) or from another accordingly equipped station. It shall be examined whether these data can be transferred to the location of the installation; such an examination can be carried out e.g. by comparing the data to data determined in a location study. Measurement gaps that do not exceed more than 2 hourly values may be filled in via interpolation. Data availability shall be at least 90 per cent of the hours within a year.

The meteorological boundary-layer profiles required for the particle model shall be determined pursuant to VDI Guideline 3783 Part 8. In this context, the following values are required:

Table 3. Values for Meteorological Boundary-layer Profiles [2].

r_a	Wind direction in anemometer height h_a
u_a	Wind velocity in anemometer height h_a
L_M	Monin–Obukhov Length
h_m	Mixing layer height
z_0	Roughness length
D_0	Displacement height

2.3.1.7.1 Monin-Obukhov Length

The atmospheric stability (see also the following chapter) is specified by indicating the Monin–Obukhov Length L_M.

The following table shows the relationship between Monin–Obukhov Length, the roughness length and the dispersion categories according to Klug/Manier.

Tabelle 4. Relationship between Monin–Obukhov Length, the Roughness Length z_0 and the dispersion categories according to Klug/Manier.

Klug/Manier	**Roughness Length z_0**								
	0.01	**0.02**	**0.05**	**0.10**	**0.20**	**0.50**	**1.00**	**1.5.**	**2.00**
I	7	9	19	17	24	40	65	90	118
II	25	31	44	60	83	139	223	310	406
III/1	99999	99999	99999	99999	99999	99999	99999	99999	99999
III/2	-25	-32	-45	-60	-81	130	-196	-260	-326
IV	-10	-13	-19	-25	-34	-55	-83	-110	-137
V	-4	-5	-7	-10	-14	-22	-34	-45	-56

2.3.1.7.2 Klug/Manier dispersion classes

For practical applications in dispersion calculations, a series of dispersion category schemes have been developed which make it possible to assign turbulence properties to dispersion categories. It is a simplified characterization of the turbulence state and thus of the dilution capacity of the atmosphere, for example according to the Klug/Manier classification. The Klug/Manier classification is the chosen method in the TA Luft licensing procedures.

Deriving a Klug/Manier dispersion category relies on observations of cloud cover from manned or automated ground stations, e. g. those of the German Weather Service (DWD) and the wind velocity. The dispersion category is quoted as a time series of successive hourly means or in the form of a frequency distribution in which the individual situations are interpreted as stationary situations or as hourly means.

The following table shows the Klug/Manier dispersion categories and their designations.

Table 5. Klug/Manier dispersion categories.

Category	Atmospheric stability
I	very stable
II	stable
III/1	neutral/stable
III/2	neutral/unstable
IV	unstable
V	very unstable

The dispersion categories are determined according to guideline VDI 3782 Part 1 and Part 6 respectively.

2.3.1.8 Accounting for Building Influences

Influences of built-up areas on the immission in the calculation area shall be taken into consideration. If the stack height is 1.2 times higher than the height of the buildings or if buildings, for which this requirement is not met, are located at a distance of more than 6 times of their respective height from the emission source, the following can be applied as a rule:

a) If the height of the stack is more than 1.7 times the heights of the buildings, it suffices to account for the built-up area through the roughness length and the displacement height.

b) If the height of the stack is less than 1.7 times the heights of the buildings and if a free flow off can be ensured, the influences can be taken into account by using a diagnostic wind field model for airflow around buildings. Until a suitable VDI Guideline has been introduced, such wind field models shall be used whose suitability has been proved to the competent Land authority.

All buildings that are located at a distance of less than 6 times the stack height from the emission source shall be significant for evaluating the building heights pursuant to a) or b) [2].

2.3.1.9 Accounting for Complex Terrain

As a rule, complex terrain shall only be taken into account if within the calculation area, differences in elevation relative to the emission location exceed 0.7 times the height of the stack and slope gradients are in excess of 1 : 20. In this context the gradient shall be determined on the basis of the difference in elevation over a distance that corresponds to twice the height of the stack.

Generally, complex terrain can be taken into account using a mesoscale diagnostic wind field model provided that the gradient of the terrain does not exceed the value of 1 : 5 and if significant influences of local wind systems or other meteorological peculiarities can be ruled out [2].

3 Bases for pollution assessment

3.1 Determination of Immission Indicators

In the following, according to no. 4.6 TA Luft, the criteria for the necessity and the procedure of the determination of immission indicators respectively are described (with regard to the relevant pollutants).

3.1.1 Necessity of Determination of Immission Indicators

A consideration of immission indicators is not required according to section 4.1. of the TA Luft [2].

- for minor emission mass flows (no. 4.6.1.1 TA Luft),
  (for a more detailed description see the following Chapter 3.1.2)
- in case of low initial load (no. 4.6.2.1 TA Luft)
  (for a more detailed description see the following Chapter 3.1.3)
- for irrelevant additional loads (no. 4.2.2, 4.3.2, 4.4.1, 4.4.3 and 4.5.2 TA Luft).

In these cases it can be assumed that harmful environmental impacts cannot be provoked by the plant, unless there is enough evidence for a special-case examination according to section 4.8 of the TA Luft in spite of minor mass flows as referred to in a) or in spite of low initial load as mentioned in b).

3.1.2 Minor Mass Flows – Determination within the Permit procedure

According to TA Luft [2] no. 4.6.1.1 is it unnecessary to determine the immission indicators within the permit procedure for the respective emitted pollutant if the emissions do not exceed the minor mass flows[4].

[4] This procedure does not apply in this case. It only applies to existing plants if an extension is planned.

Table 6. Minor Mass Flows according to no. 4.6.1.1 Table 7, TA Luft.

Pollutant	**Minor Mass Flow** (kg/h)
As and its compounds (to be indicated as As)	0.0025
Benzo(a)pyren (as leading component for PAK)	0.0025
Pb and its compounds (to be indicated as Pb)	0.025
Cd and its compounds (to be indicated as Cd)	0.0025
HF and gaseous inorganic fluorine compounds (to be indicated as F)	0.15
Hg and its compounds (to be indicated as Hg)	0.0025
Dust (without dust components)	1
NO_x (to be indicated as NO_2)	20
SO_x (to be indicated as SO_2)	20
Tl and its compounds (to be indicated as Tl)	0.0025

3.1.3 Criteria for the Need to Determine the Existing Load

According to TA Luft [2] no. 4.6.2.1 it is not necessary to determine the existing load by carrying out individual measurements if it is established, subsequent to analysing the results obtained at measuring stations belonging to the immission measuring networks of the Länder and subsequent to an estimation or determination of the additional load or on the grounds of any other information, that the immission values for the respective pollutant can be observed at the maximum load point after the commissioning of the installation.

Moreover, determination of existing load shall not be necessary if on the grounds of other information previously obtained, e. g. previous measurements […] it can be established that, with regard to the respective pollutant, the following values apply at the maximum initial load point:

- the annual mean value is below 85 per cent of the concentration value,
- the maximum 24-hour value is below 95 per cent of the 24-hour concentration value […],
- the maximum 1-hour value is below 95 per cent of the 1-hour concentration value.

3.1.4 Existing Load Indicators

According to no. 4.6.3 TA Luft [2], immission measurement or similar determination of immission load may be drawn upon if such measurement dates back to no longer than 5 years and if the circumstances decisive for evaluation have not significantly changed over this period

- The indicator for annual existing immission load (AEIL) shall be the annual mean value derived from all hourly mean values,

- The indicator for daily existing immission load (DEIL) shall be the excess frequency (number of days) by which the concentration value for 24-hour immission impact is exceeded,
- The indicator for hourly existing immission load (HEIL) shall be the excess frequency (number of hours) by which the concentration value for 1-hour effective immission is exceeded.

3.1.5 Additional Load Indicators

According to TA Luft [2] no. 4.6.4, the additional load indicators shall be derived from mathematical immission projections on the grounds of a mean annual frequency distribution or of a representative annual time series of wind direction, wind velocity and dispersion class. In this context, the calculating method pursuant to Annex 3 TA Luft shall be applied (see also section 2.3 of the present study.**Immission Values (Environmental standards according to TA Luft)**

The immission values respectively the irrelevance criteria of the TA Luft for the relevant pollutants are shown in the tables below.

According to no. 4.7.1 TA Luft [2], the annual immission value for a pollutant is met if the total of the existing load and the additional load measured at assessment points is less than or equal to the annual immission value.Table 7. Long-term immission values (averaging period 1 year) and irrelevant additional load values, TA Luft [2].

Immission values accord. to	Irrelevant additional values accord. to	Pollutant	Concentration		Irrelevant Additional Load	
4.2.1	4.2.2	Particulate matter (PM_{10}) SO_2 NO_2 Pb in particulate matter Cd in particulate matter	40 50 40 0.5 0.02(2)	µg/m³	≤ 3.0 ≤ 3.0 ≤ 3.0 ≤ 3.0 ≤ 3.0	% of the immission value
4.3.1	4.3.2	dust deposition (non-hazardous dust)	0.35	g/(m² × d)	≤ 10.5	mg/(m²×d)
4.4.1/4.4.2	4.4.3	NO_x (indicated as NO_2) SO_2 HF and comp. as F NH_3	30(1) 20(1) 0.4 10(3)	µg/m³	≤ 3 ≤ 2 ≤ 0.04 ≤ 3	µg/m³
4.5.1	4.5.2	Arsenic As Lead Pb Cadmium Cd Mercury Hg Thallium Tl	4 100 2 1 2	µg/(m² × d)	≤ 5 ≤ 5 ≤ 5 ≤ 5 ≤ 5	% of the immission value

(1) These immission values for the protection of ecosystems respectively of vegetation only apply for the evaluation area insofar as the evaluation points for controlling these immission values are more than 20 km away from congested urban areas or 5 km from other built-up areas, industrial plants or roads.

(2) In 39th BImSchV a target value of 0.005 mg/m³ is mentioned. However, this is not a limit value; it therefore does not replace the 0.02 mg/m³ value by TA Luft that is valid until further notice.

(3) Immission value and irrelevance criterion according to No. 4.4.2 in connection with Annex 1 of the TA Luft.

In addition to the long-term immission values, TA Luft also defined short-term Immission values for the protection of the human health, as shown in the table below.

Table 8. Short-term immission values (24 h, 1 h) and permissible annual frequency of exceeded values, TA Luft [2].

Immission values accord. to	Pollutant	Averaging Period	Concentration		Permissible Annual Frequency of exceeded values
4.2.1	NO_2	1 h	200	µg/m³	18
	SO_2	24 h	125	µg/m³	3
		1 h	350	µg/m³	24
	PM_{10}	24 h	50	µg/m³	35

According to no. 4.7.2 TA Luft, the daily immission value is met

- if the AEIL existing load indicator does not exceed 90 per cent of the annual immission value and
- if the DEIL indicator reaches, as a maximum, 80 per cent of the excess frequency of the daily immission value permissible and
- if all DAIL daily values do not exceed the equivalent of the difference between the daily immission value (concentration) and the annual immission value.

In all other respects, the daily immission value is met if the total load at the respective grid points – determined by adding the yearly additional load to the daily existing load concentration values – is less than or equal to the immission concentration value for 24 hours or if an analysis shows that the permissible excess frequency is met unless special circumstances of the individual case, e. g. rarely occurring high emission levels, require to evaluate otherwise.

According to no. 4.7.3 TA Luft, the hourly immission value is met

- if the AEIL existing load indicator does not exceed 90 per cent of the annual immission value and
- if the HEIL indicator reaches, as a maximum, 80 per cent of the excess frequency of the permissible hourly immission value and
- if no HAIL hourly values calculated for all grid points exceed the equivalent of the difference between the hourly immission value (concentration) and the annual immission value.

In all other respects, the hourly immission value is met if the total load at the respective grid points – determined by adding the yearly additional load to the hourly existing load concentration values – is less than or equal to the immission concentration value for 1 hour or if an analysis shows that the permissible excess frequency is met unless special circumstances of the individual case, e.g. rarely occurring high emission levels, require to evaluate otherwise.

3.3 Simplified Overview of the Pollution Assessment within the German Permit procedure and the decision about subsequent orders

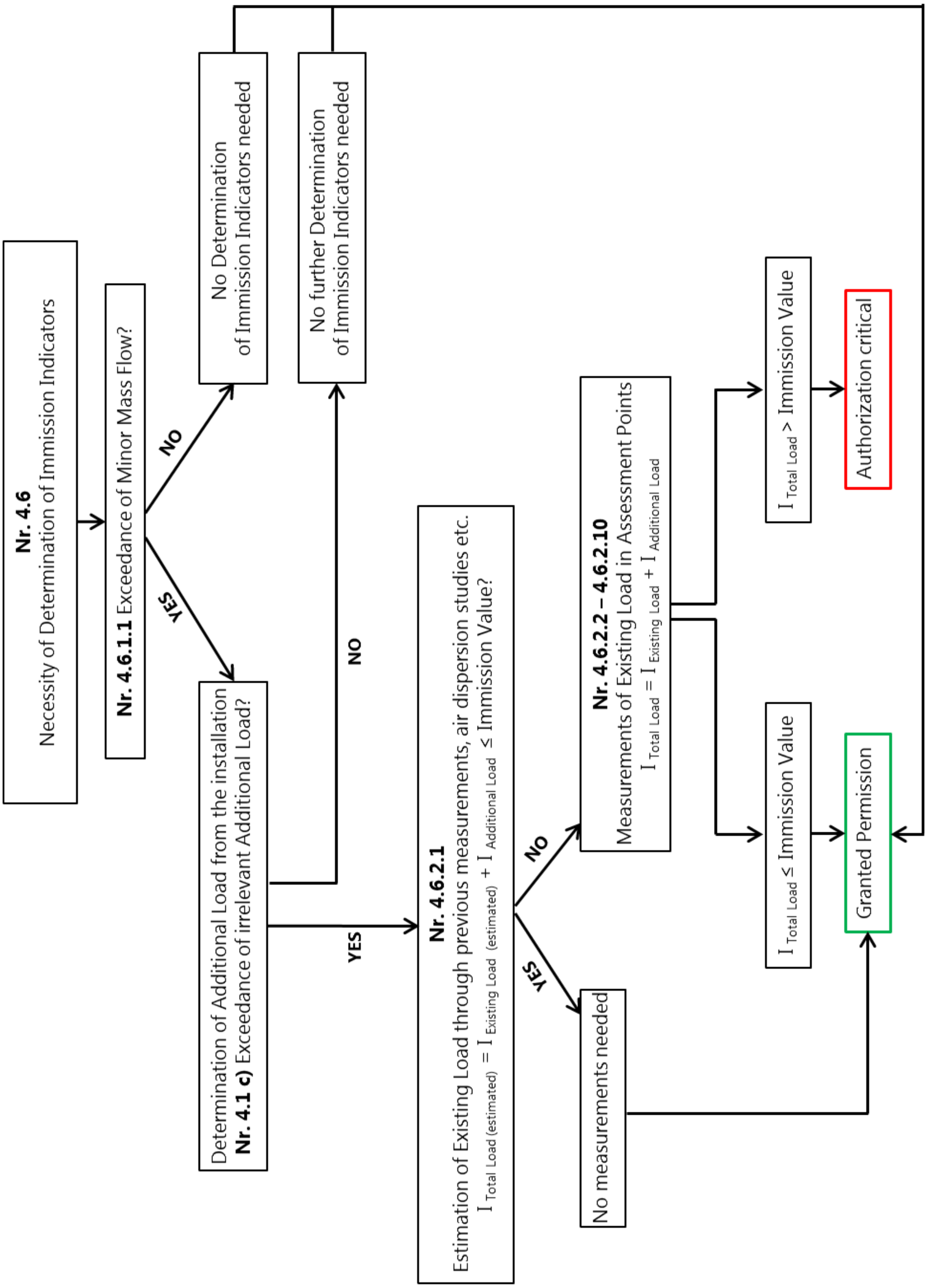

Figure 1. Simplified overview of the pollution assessment within the permit procedure.

4 Russian Environmental Standards

The assessment of the short-term immission impact of the relevant pollutants is also carried out according to the Russian Environmental Standards (EQS), given by the Russian Ministry of Environment and transmitted by the client [7].

The following table shows the average daily maximum permissible concentrations (MPC) as well as the MPC one time concentration.

Table 9. Russian environmental ambient air quality standards (daily maximum permissible concentration and one-time concentration) [7].

Pollutant	average daily maximum permissible concentration (MPC)	MPC one time concentration
	mg/m³	mg/m³
NO_2	0.04	0.2
SO_2	0.05	0.5
Pb	0.0003	0.001
NH_3	0.04	0.2
Cu	0.002	-
Cr	0.0015	-
HCl	0.1	0.2

5 Description of the local conditions

The planned waste incineration plant is located in the north-eastern part of the Zelenodolskiy municipal district, on the territory of the Osinovskiy settlement of the Republic of Tatarstan. The environment around the planned facility is characterized by forest and agricultural land.

The geodetic altitude at the location is about 120 m above sea level. Within a 5 km radius the surrounding terrain is lightly structured orographically. The terrain rises up to 145 m above sea level in a northern direction and drops to 90 m above sea level in a south-western direction.

The nearest settlements and other territories with standardized impact indicators are located:

- Krasnooktyabrskiy settlement of the city of Kazan – about 0.8 km north-eastward;
- Novonikolayevsky settlement of Osinovskiy rural settlement – about 1 km eastwards
- Osinovo settlement – about 1.9 km westward;
- SNT "Berezka" - about 1.6 km westward.

Figure 2 shows the location of the planned waste incineration plant.

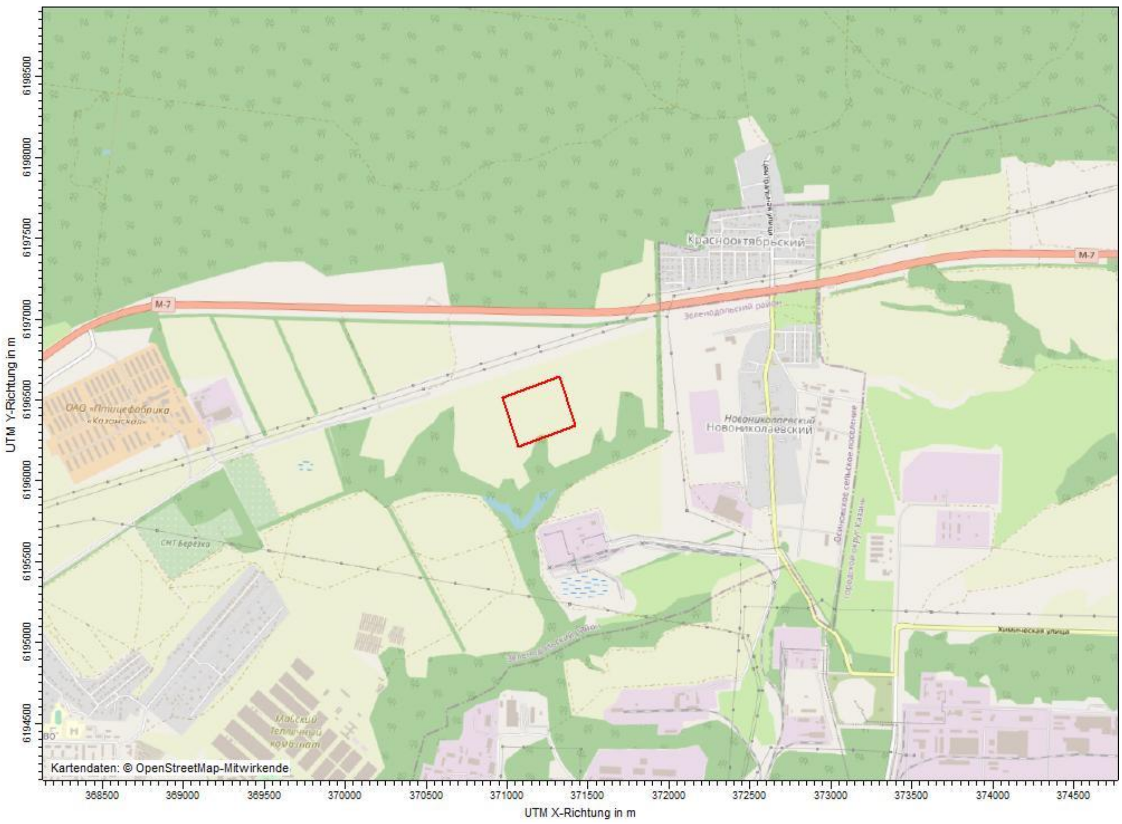

Figure 2. Location of the planned waste incineration plant (red framed) and surroundings [15].

6 Initial Level of Pollution

6.1 Assessment Points

Assessment points are points in the vicinity of an installation for which immission indicators, indicative of the total load[5], are determined. As points of interest the nearest residential developments were chosen, since people can be expected to stay there permanently.

For assessing the total load of the air pollution at the assessment points or points of interest, coordinates were given in Table 14.

Table 10. Points of interest. Kazan Monitoring Sites. Coordinates in UTM.

Points of interest	**Abbreviation**	**UTM X-Direction** (m)	**UTM Y-Direction** (m)
Krasnooktyabrskiy settlement 01	BUP 1	371949,0	6197240
Krasnooktyabrskiy settlement 02	BUP 2	372008,1	6197194
Novonikolayevskiy settlement 01	BUP 3	372486,0	6196792
Novonikolayevskiy settlement 02	BUP 4	372442,6	6196652
Novonikolayevskiy settlement 03	BUP 5	372468,2	6196469
Novonikolayevskiy settlement 04	BUP 6	372474,4	6196266
Osinovo settlement 01	BUP 7	369455,2	6195441
Osinovo settlement 02	BUP 8	369534,6	6195153

The following figure shows the position of the points of interest in the area under investigation.

[5] With respect to planned installations, the indicator for the total load shall be calculated on the basis of the initial load plus the additional load indicators.

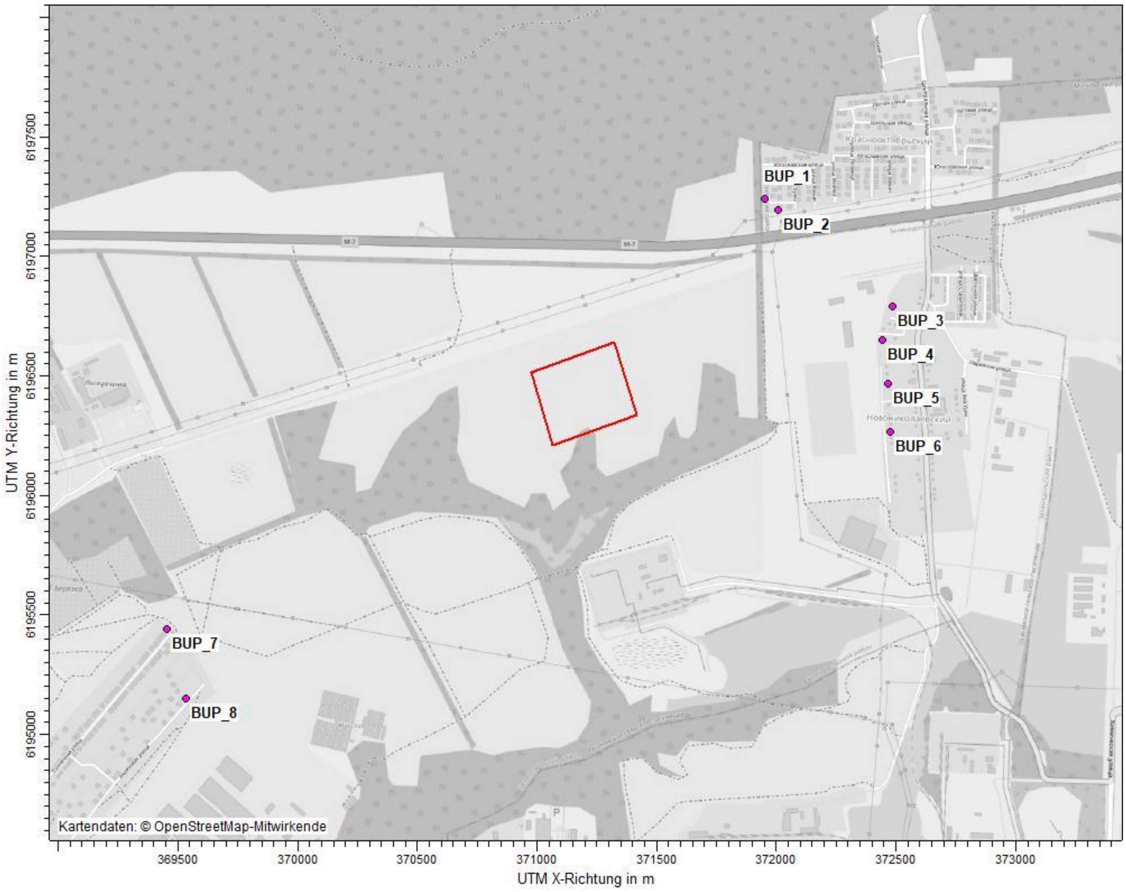

Figure 3. Position of the points of interest (nearest residential developments) marked in pink.

6.2 Existing Load

Environmental ambient air quality standards (EQS) underpin the regulation of pollution. These are expressed through maximum permissible concentration (MPC). MPCs are binding limits for all users of a given environmental medium, such as air.

Data on the background concentrations for the study area provided by FSBI “UGMS RT” and transmitted by the client [7] indicate that the content of all controlled pollutants does not exceed the established MPC (during a multi-year period, one-time NO_2 exceedances were detected).

The following tables shows the maximum daily average measurements as well as the one-time-MPC as fraction of MPC at Krasnooktyabrskiy settlement, Novonikolayevskiy settlement and Osinovo settlement.

Tabelle 11. Maximum daily average background concentrations at surrounding settlements [7].

pollutant	Krasnooktyabrskiy settlement as fraction of MPC	Novonikolayevskiy settlement as fraction of MPC	Osinovo settlement as fraction of MPC	average daily MPC mg/m³
NO_2	0.63	0.65	0.22	0.04
SO_2	0.01	0.01	0.01	0.05
NH_3	0.02	0.02	0.02	0.04
HCl	0.00	0.00	0.00	0.1
Cu	0	0	0	0.002
Cr	0	0	0	0.0015
Pb	0	0	0	0.0003

Tabelle 12. Maximum one-time MPC at surrounding settlements [7].

pollutant	Krasnooktyabrskiy settlement as fraction of MPC	Novonikolayevskiy settlement as fraction of MPC	Osinovo settlement as fraction of MPC	one-time MPC mg/m³
NO_2	0.73	0.73	0.73	0.2
SO_2	0.36	0.36	0.36	0.5
NH_3	0.1	0.1	0.1	0.2
HCl	0.1	0.1	0.1	0.2
Pb	-	-	-	0.001

The comparison of this calculated values vs. the predicted concentrations takes place in chapter 12.

7 Emission Sources

7.1 Emissions

For the purposes of the TA Luft 2002 No. 2.4, any data regarding the waste gas volume and the waste gas volumetric flow rate are referenced to standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content unless explicitly indicated otherwise.

For the purposes of the TA Luft 2002 No. 2.5, emissions shall be air pollutants originating from an installation. In this case, emissions shall be indicated as mass of substances or groups of substances emitted as related to the volume (mass concentration) of waste gas under standard conditions after subtraction of the water vapour content.

The following data are required to characterize the emission conditions:

- type of emitted trace substance,
- emission mass flux of the emitted trace substance,
- stack gas volumetric flow rate,
- stack gas exhaust temperature,
- source dimensions (length, width, height, inner diameter),
- coordinates of the source site.

The following figure shows the location of the sources on the waste incineration plant-yard as well as the rasterized buildings according to [7], visualized in the modelling program Austal View.

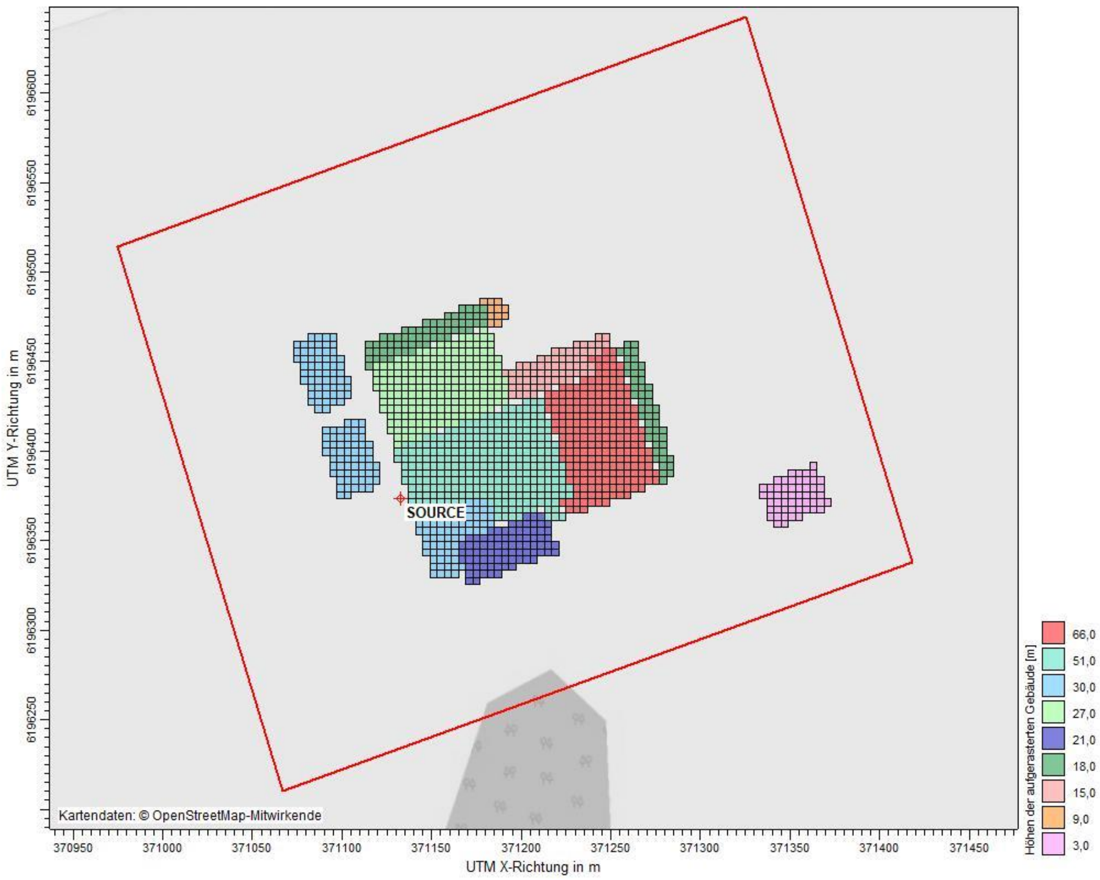

Figure 4. Location of the source on the waste incineration plant-yard and rasterized buildings [15].

7.2 Temporal characteristics of the emissions

The emissions of the sources are estimated to take place full-load at 7,725 annual hours. In the sense of a conservative approach, a year-round operating time is assumed for the dispersion study (8,760 h/a).

7.3 Plume Rise

The emissions of a stack rise into the atmosphere due to their thermal buoyancy and mechanical momentum. The height above the top of the stack which the emissions reach at a certain source distance downwind, is called plume rise. In flat terrain, plume rise is defined as the height of the plume centre line above the stack height, after the mean plume has reached its "maximum" height, or if buoyancy and momentum do not lead to a further observable rise. The sum of plume rise and stack height is the effective source height.

The plume rise as well as the progressive rising of the plume before it reaches its mean "maximum" height, may be predicted by means of plume rise equations which are dependent on emission parameters and meteorological quantities.

The effective source height taken into account was determined programmatically according to the guideline VDI 3782 Bl. 3 [10] by the dispersion model Austal2000.

7.4 Emission mass flows

To calculate the emission mass flows, the most unfavourable operating condition and the maximum emission limit values of the air pollutants shall be used.

For the consideration and differentiation of NO, NO_2 and NO_x (indicated as NO_2), the emission mass flows of these components were calculated with the most unfavourable operating condition and the maximum emission limit values as it follows:

molar mass M(NO) = 30,01 g/mol
molar mass M(NO_2) = 46,01 g/mol

For the calculation of the NO_2 fraction in the exhaust gas, the proportion of NO_2 in the exhaust gas of the respective plant type is estimated (in this case the NO_2 proportion in the exhaust gas was estimated at 10 %) and then multiplied by the volumetric flow rate at standard conditions of the exhaust gas and the emissions limit value of NO_2.

For the calculation of the NO fraction in the exhaust gas, the molar mass ratio of NO and NO_2 is set in proportion and multiplied by the volumetric flow rate at standard conditions of the exhaust gas and the emissions limit value of NO_2.

The substance NO_x is treated by the calculation program AUSTAL2000 independently of the substances NO and NO_2. That means that for AUSTAL2000, the same emissions as with NO and NO_2, according to the calculation [6].

$$NO_x = NO_2 + 1.53 \cdot NO \qquad (2)$$

must be specified. With the term 1.53 the retroactive accounting of the molar mass takes place.

The following table shows the calculated mass emission rates.

Table 13. Emissions and discharge conditions of the planned waste incineration plant.

waste incineration plan Tatarstan

		LF 1
operating mode		**Waste incineration plnat Tatarstan** Full load
Fuel		waste
max. thermal load	MW	90
Stack		
stack height	m	98
number of stack drafts		2
diameter	m	2,00
diameter stack 2	m	2,00
equivalent diameter	m	2,83
UTM-coordinates (zone 39N)		
x	m	3 71 125
y	m	61 96 373
Stack emission data		
velocity (operating cond. + operating-O_2)	m/s	18,9
velocity (operating cond. + reference-O_2)	m/s	26,0
temperature at stack	°C	114
Heat flow (based on 283 K)	MW	11,83
Operating oxygen content (dry)	Vol.-%	7,0
Reference oxygen content (dry)	Vol.-%	11,0
Water vapor content at reference oxygen content	kg/m³	0,138
Flow (damp), standard conditions, O2 content: operating value	m³/h	301.200
Flow (dry), standard conditions, O2 content: operating value	m³/h	249.200
Flow (damp), standard conditions, O2 content: reference value	m³/h	415.100
Flow (dry), standard conditions, O2 content: reference value	m³/h	354.400
Sulfur dioxide		
- max. concentration [1)]	mg/m³	50
- max. mass flow	kg/h	17,7
Nitrogen oxide		
- NO_2-proportion in the exhaust gas (empirical values / measurement data)	%	10
- max. NO_x-conzentration (as NO_2) [1)]	mg/m³	200
- maximaler NO-Massenstrom	kg/h	41,60
- max. NO_2-Mass flow	kg/h	7,09
- max. NO_2-Mass flow (with 60%-convention) [2)]	kg/h	45,36
- max. NO_x-Total mass flow (as NO_2)	kg/h	70,88
Carbon monoxide (CO)		
- max. concentration [1)]	mg/m³	50
- max. mass flow	kg/h	17,7
Dust		
- max. concentration [1)]	mg/m³	10
- max. mass flow	kg/h	3,5
Hg		
- max. concentration [1)]	mg/m³	0,03
- max. mass flow	kg/h	0,01063
Cd+Tl		
- max. concentration [1)]	mg/m³	0,05
- max. mass flow	kg/h	0,0177
Σ Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V ,Sn		
- max. concentration [1)]	mg/m³	0,50
- max. mass flow	kg/h	0,17720
Σ As, B(a)P, Cd, Co ,Cr		
- max. concentration [1)]	mg/m³	0,05
- max. mass flow	kg/h	0,0177
Dioxine and Furane		
- max. concentration [1)]	mg/m³	1,00E-04
- max. mass flow	kg/h	3,54E-05
Ammonia		
- max. concentration [1)]	mg/m³	9
- max. mass flow	kg/h	3,1896
Total C		
- max. concentration [1)]	mg/m³	10
- max. mass flow	kg/h	3,54
gas. anorg. chloride compounds as HCL		
- max. concentration [1)]	mg/m³	10
- max. mass flow	kg/h	3,544
gas. anorg. fluorine compounds as HF		
- max. concentration [1)]	mg/m³	1
- max. mass flow	kg/h	0,35

[1)] Concentration information in each case related to dry exhaust gas in the standard conditions as well as the reference oxygen content

[2)] Mass flow calculation taking into account a 10% NO2 share and a conversion rate of NO to NO2 of 60% (TA Luft No. 5.5.3)

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8 Input quantities for the air dispersion study

8.1 Calculation area and spatial resolution

The calculation area according to No. 7 in Appendix 3 to the TA Luft [2] defines itself as a circle around the emission source, whose radius is 50-fold the stack height. According to paragraph 4.6.2.5. of the TA Luft an area with a radius of at least 1 km is to be investigated for source heights < 20 m.

In the present case a calculation area was chosen, which fulfils this requirement and which is defined as a rectangular area with an edge length of 10,240 m x 10,240 m. The raster for calculating the immission concentrations was selected with a sevenfold nested grid. The mesh size in the finest grid was fixed with 4 m. According to no. 7 of Appendix 3 to the TA Luft proportionally bigger mesh sizes were chosen in greater distance with 8 m, 16 m, 32 m, 64 m, 128 m, and 256 m. Point of interest and amount of the pollution maxima can be determined with sufficient certainty with these mesh sizes. The detailed rasterizing of the calculation grid can be seen from the calculation documentation in the appendix.

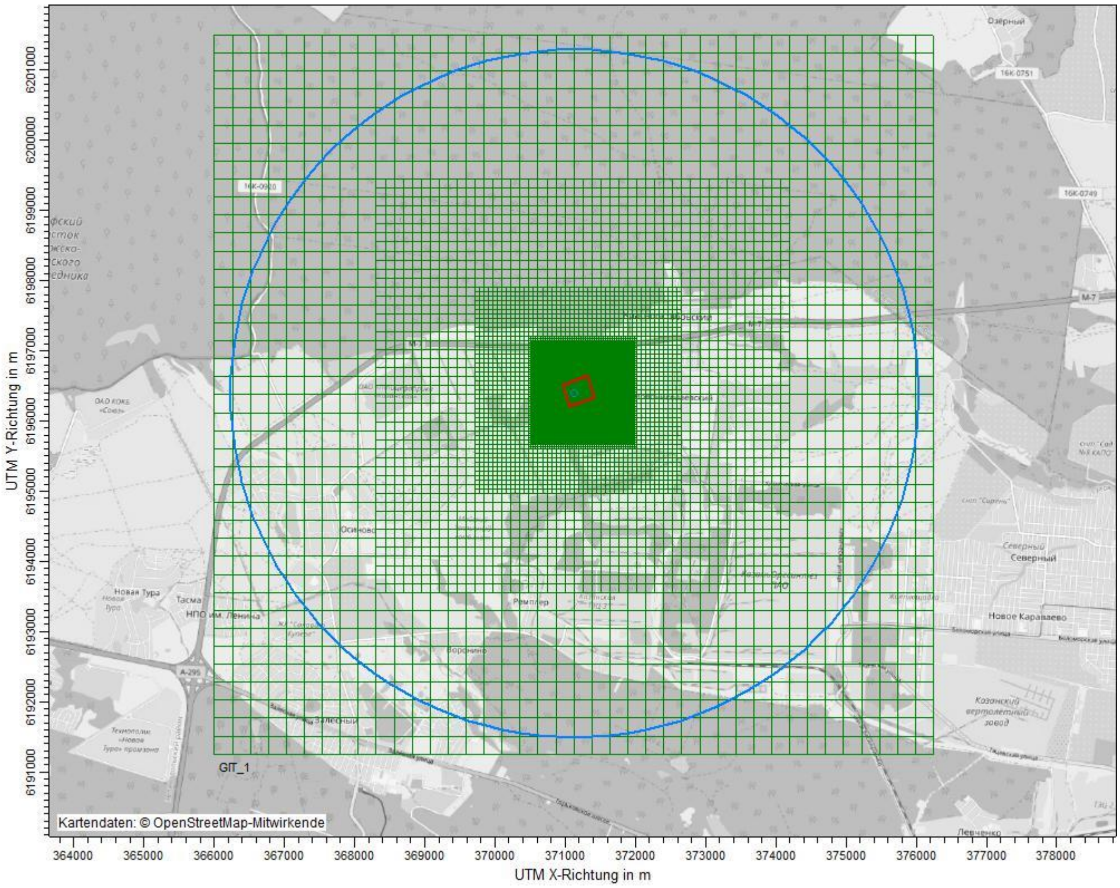

Figure 5. Location and size of the calculation grid; the blue circle shows the calculation area according to TA Luft, related to a radius of 4,900 m around the highest stack (stack height 98 m above ground).

The concentration at the emission points was calculated as an average value over a vertical interval from the ground to a height of 3 m above ground; it is therefore representative for a point of interest height of 1.5 m above floor.

8.2 Roughness length

The ground roughness of the terrain is described by a mean roughness length z_0. It has to be determined according to Table 14 in Appendix 3 of the TA Luft [2] subject to the land use classes indicated in the CORINE land cover inventory for a circular area around the stack whose radius is 10 times the height of the stack.

In this case, the highest stack is 98 m above ground. This results at least an area about 1 km² for roughness length determination. In this case, for the air dispersion calculation, the whole calculation grid was set to roughness length z_0 = 1 m. In this roughness length, the influence of buildings within study area that are not explicitly resolved in the wind field modelling is taken into account (compare chapter 9.1).

The mean roughness length of z_0 = 1 m is assigned in the CORINE land cover inventory for: not continuously urban character, industrial and commercial areas, construction sites, coniferous forests.

According to no. 8.6 in Appendix 3 of the TA Luft the displacement height d_0 results from z_0 with $d_0 = z_0*6$.

8.3 Consideration of the statistical uncertainty

By choosing a sufficient number of particles (particle rate = 8 s^{-1}, *qs* = 2 in Austal2000) in the air dispersion study, it was ensured that the model-related statistical uncertainty of the calculation method, calculated as statistical dispersion of the calculated value, has been less than 3 per cent of the annual immission value for pollution.

9 Consideration of buildings and terrain

9.1 Buildings

If the stack height is less than 1.7 times the building in a perimeter of six times the height of the stack, these shall be taken into account in the calculation model in accordance with appendix 3 No. 10 of the TA Luft.

Therefore, in this air dispersion calculation, the planned buildings of the waste incineration plant have been taken into account (see Figure 6).

9.2 Terrain

According to TA Luft, Appendix 3, No. 11, complex terrain shall be taken into account if the differences in elevation relative to the emission location exceed 0.7 times the height of the stack and slope gradients are in excess of 1:20. In this context the gradient shall be determined on the basis of the difference in elevation over a distance that corresponds to twice the height of the stack.

Generally, complex terrain can be taken into account using a meso-scale diagnostic wind field model provided that the gradient of the terrain does not exceed the value of 1 : 5 and if significant influences of local wind systems or other meteorological peculiarities can be ruled out.

In the case under consideration areas with slope gradients in excess of 1 : 20 comprise about 0.4% of the computational domain and there are no areas with slope gradients steeper than 1 : 5 (see Figure 7).

The terrain in the calculation area has been taken into account based on SRTM1[6] data in a terrain resolution of 30 m.

Taking into account the terrain and the plume rise of exhaust gas, no relevant influence of cold air or other local wind systems (not reflected in the meteorological database) on the immission situation is to be expected.

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6 Shuttle Radar Topography Mission terrain data files

Figure 8. Terrain gradient in the calculation area. Waste incineration plant yard red framed.

The subsequent figure shows the terrain iso-surfaces in the calculation area.

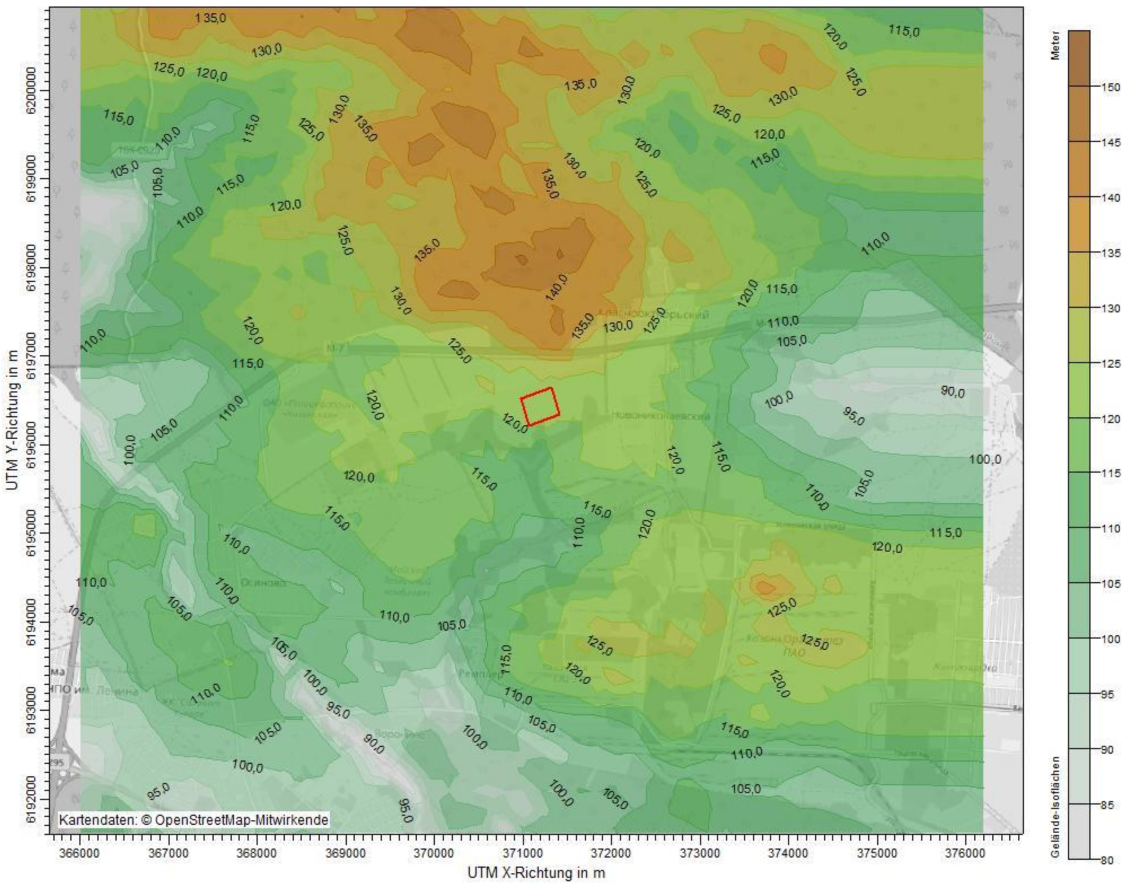

Figure 9. Terrain isosurfaces in the calculation area. Waste incineration plant yard red framed.

10 Meteorological data

The meteorological boundary conditions at the site are of essential importance for the dispersion of pollutant emissions. As required in Appendix 3 of the TA Luft for air dispersion study meteorological data should be used that are characteristic for the site.

The meteorological dataset was provided by IFU GmbH [3]. The dataset for Kazan includes time series of wind speed, wind direction and cloud coverage in hourly resolution for a period from August 2011 to March 2020. The period July 2014 to July 2015 was determined as representative year (one year out of the period from 2011 to 2020 with least deviation of the long-term medium). The determination was executed by the guideline VDI 3783, part 20 [14].

Figure 11 shows the wind direction frequency distribution and the frequency distribution for wind velocity.

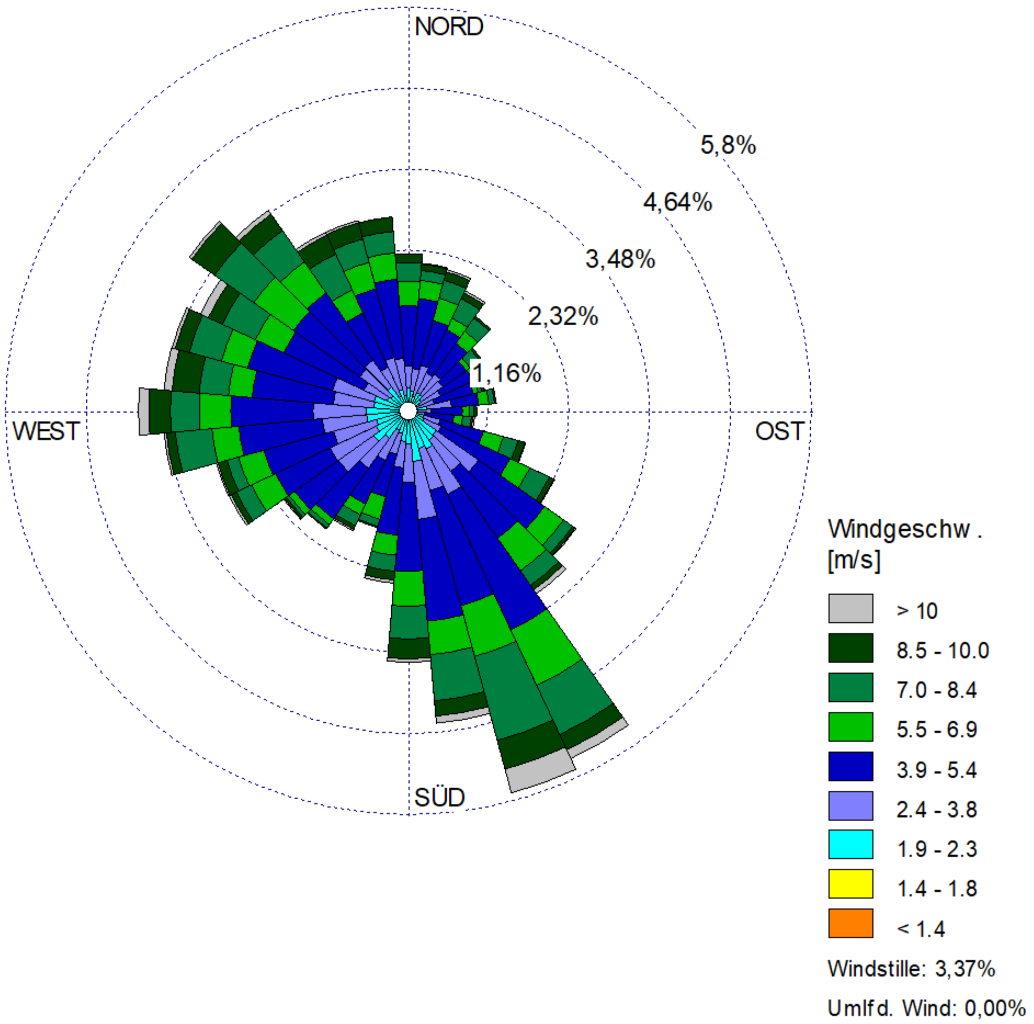

Figure 10. Wind direction frequency distribution for Kazan of the meteorological dataset for the representative year 2014/2015.

In the figures below, the frequencies of wind velocity and dispersion classes are presented according to the TA Luft. Low-wind sites with wind velocities < 1.4 m/s occur in 9.1 % of the annual hours. With a share of almost 25 % in the frequencies of all dispersion classes the stable dispersion situations of classes I and II are dominant. Neutral dispersion classes (class III/1 and III/2) are represented in about 23 % of all dispersion classes.

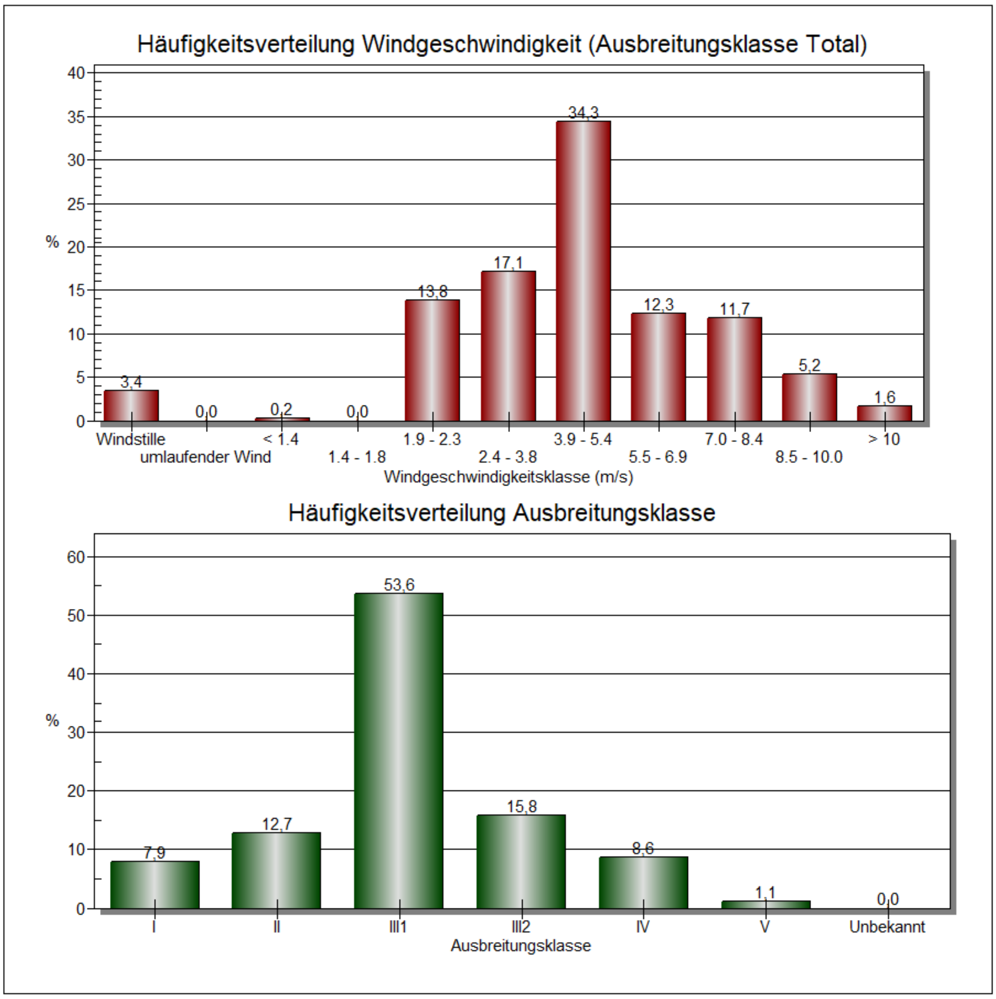

Figure 11. Frequency distribution of the wind velocity classes according to TA Luft (above) and frequency distribution of the dispersion classes according to Klug/Manier (below) of the meteorological dataset for the representative year 2014/2015.

The meteorological boundary layer profiles needed by the particle model and the parameters required

- wind direction in anemometer height,
- Monin-Obukhov-length,
- mixing layer height,
- roughness length,
- displacement height

were determined according to guideline VDI 3783, Part 8, and in compliance with the conventions as determined in Appendix 3 of the TA Luft.

11 Dispersion model

For the air dispersion study, the model AUSTAL2000 [4] is used. AUSTAL2000 calculates the dispersion of pollutants and odours in the atmosphere. It is an implementation of Appendix no. 3 of TA Luft. The underlying model, on which AUSTAL2000 is based, is described in guideline VDI 3945 Part 3 [12]. For more detailed information of the physical model and the mathematical algorithms, please refer to the guideline VDI 3945 Part 3.

12 Results of the air dispersion calculation

12.1 Annual Immission Load

The following figures show the annual average additional load/contribution and additional deposition of the waste incineration plant for the examined pollutants in the computing area.

The scaling in the figures was such that additional loads are shown in blue and green tones if they are irrelevant according to TA Luft no. 4.4.3. Additional contributions that exceed the irrelevance threshold according to TA Luft are shown in yellow, orange or red.

For very low additional loads compared to the respective irrelevance threshold no colour can be seen (e.g. particulate matter).

12.1.1 Results according to TA Luft 4.2.1 – Protection of human health

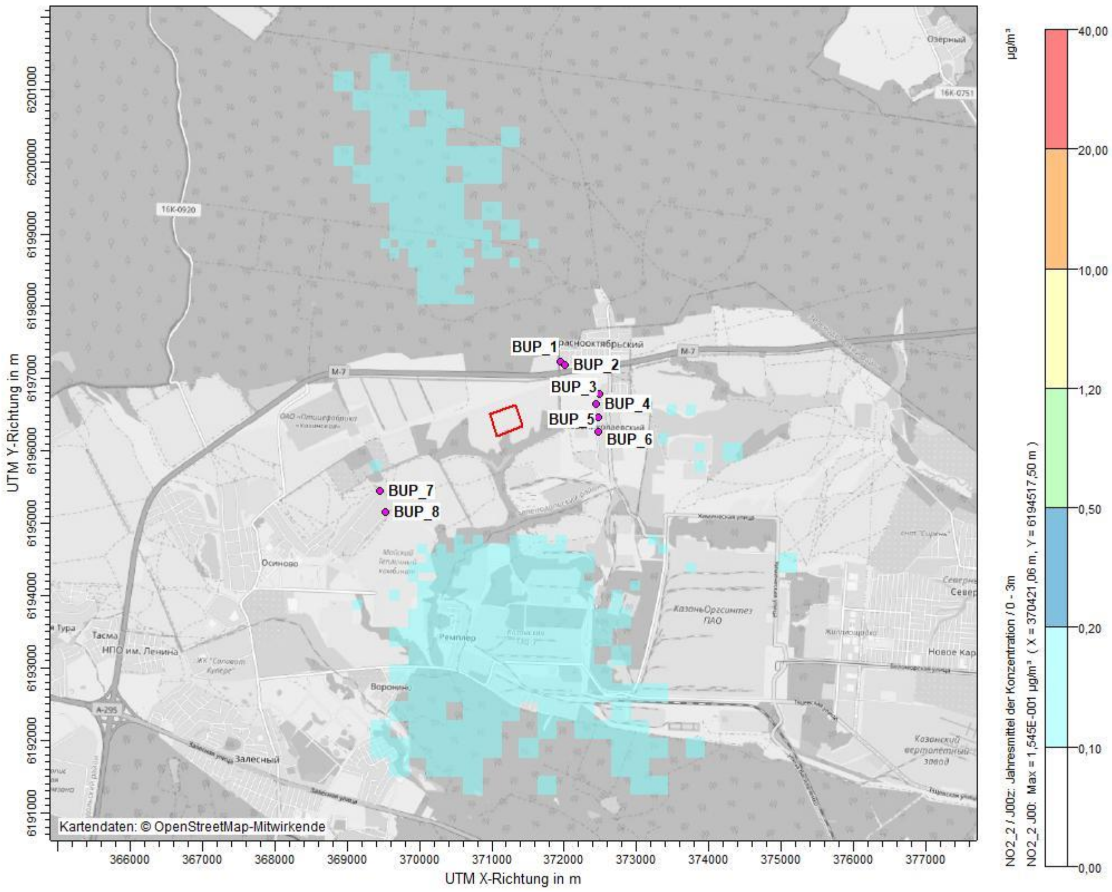

Figure 12. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for Nitrogen dioxide (Irrelevance criterion of TA Luft: 3.0 % of the annual immission value, corresponds to approx. 1.2 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

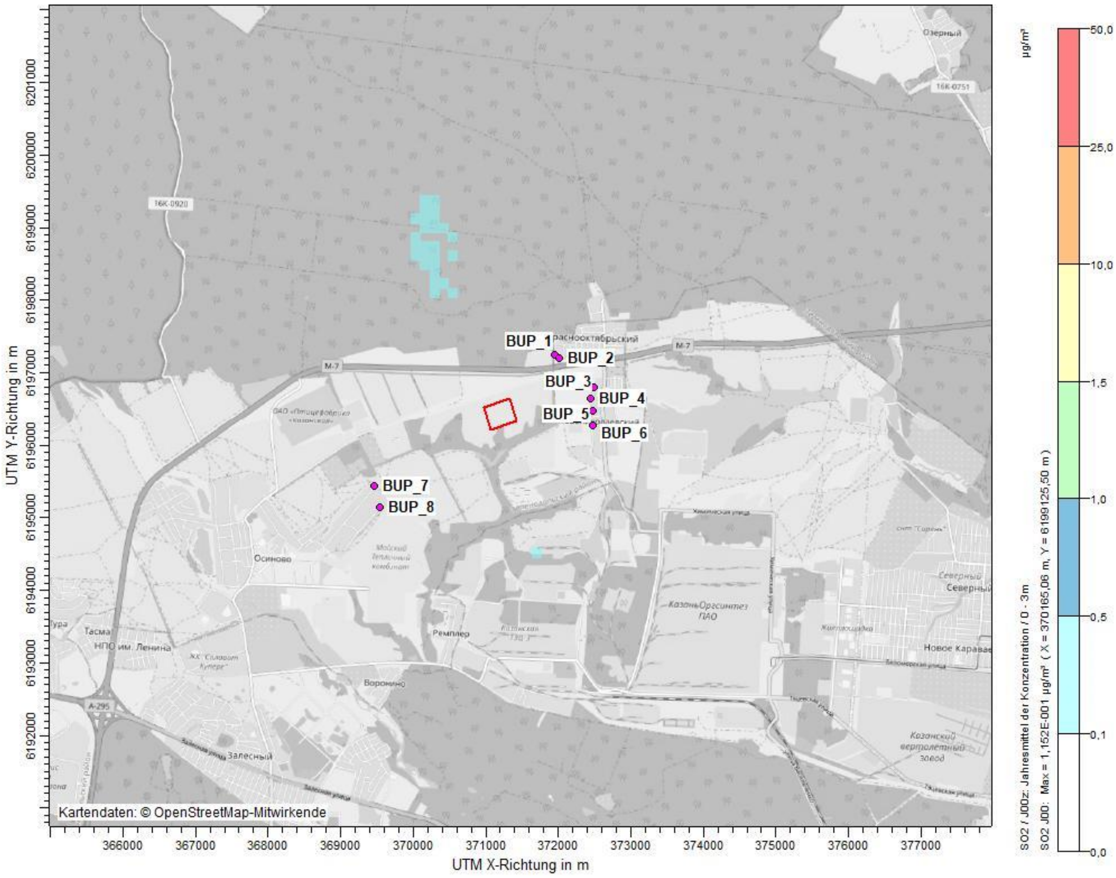

Figure 13. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for Sulfurdioxide (Irrelevance criterion of TA Luft: 3.0 % of the annual immission value, corresponds to approx. 1.5 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

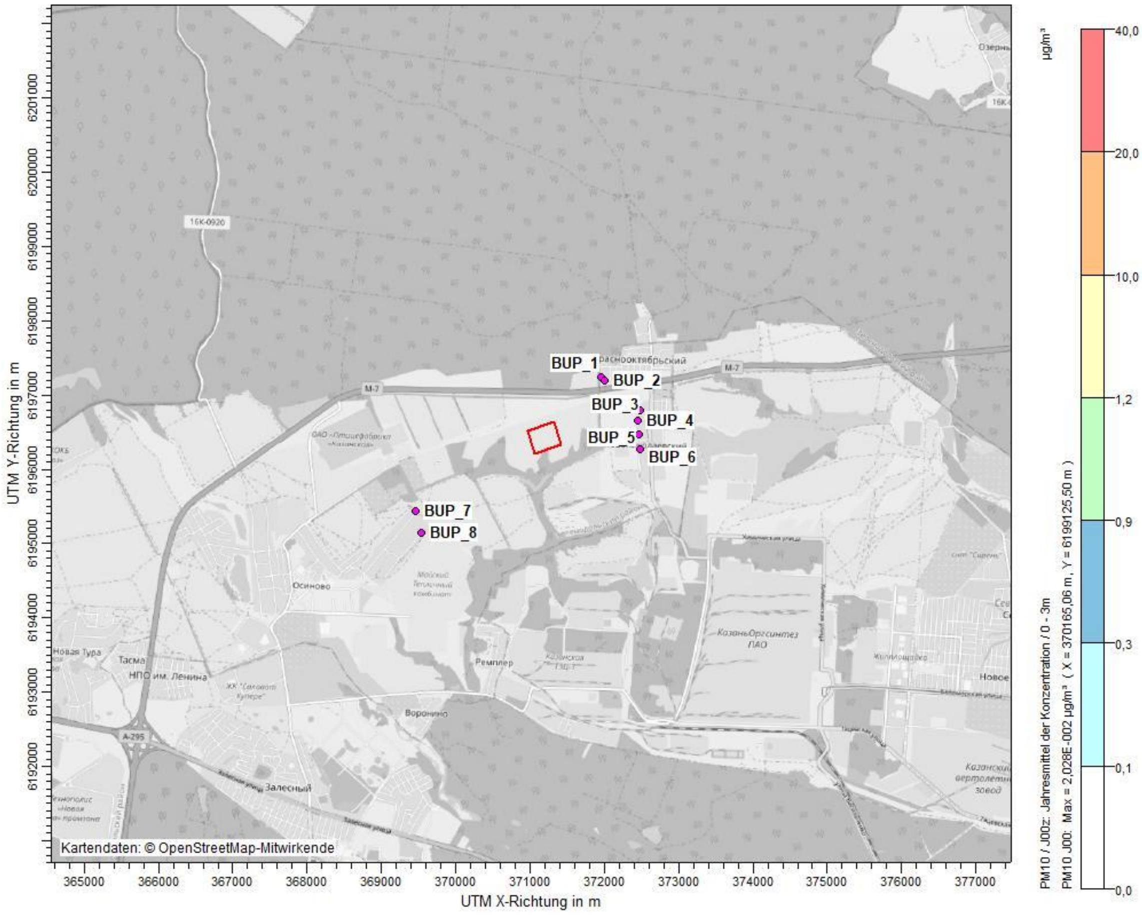

Figure 14. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for particulate matter (PM_{10}); (Irrelevance criterion of TA Luft: 3.0 % of the annual immission value, corresponds to approx. 1.2 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

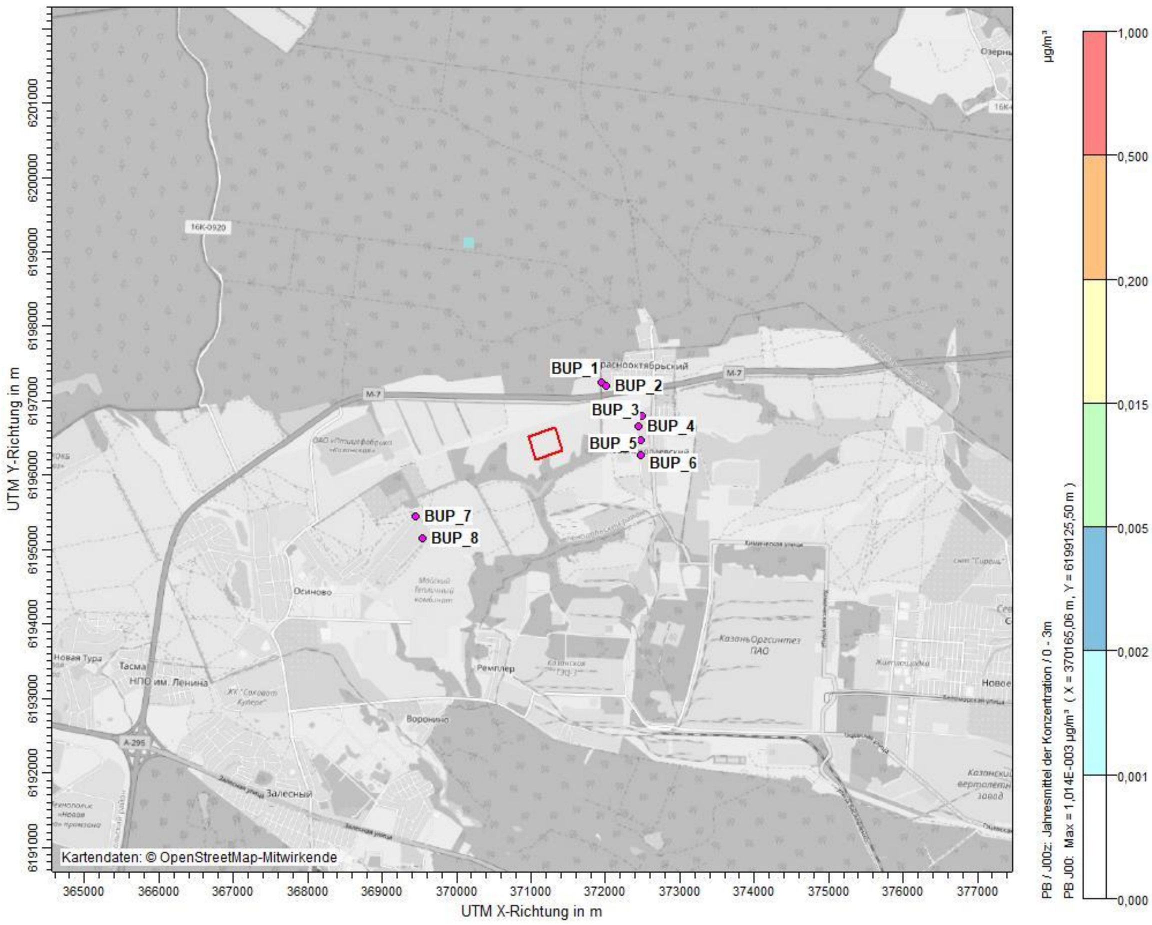

Figure 15. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for lead (Pb); (Irrelevance criterion of TA Luft: 3.0 % of the annual immission value, corresponds to approx. 0.015 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

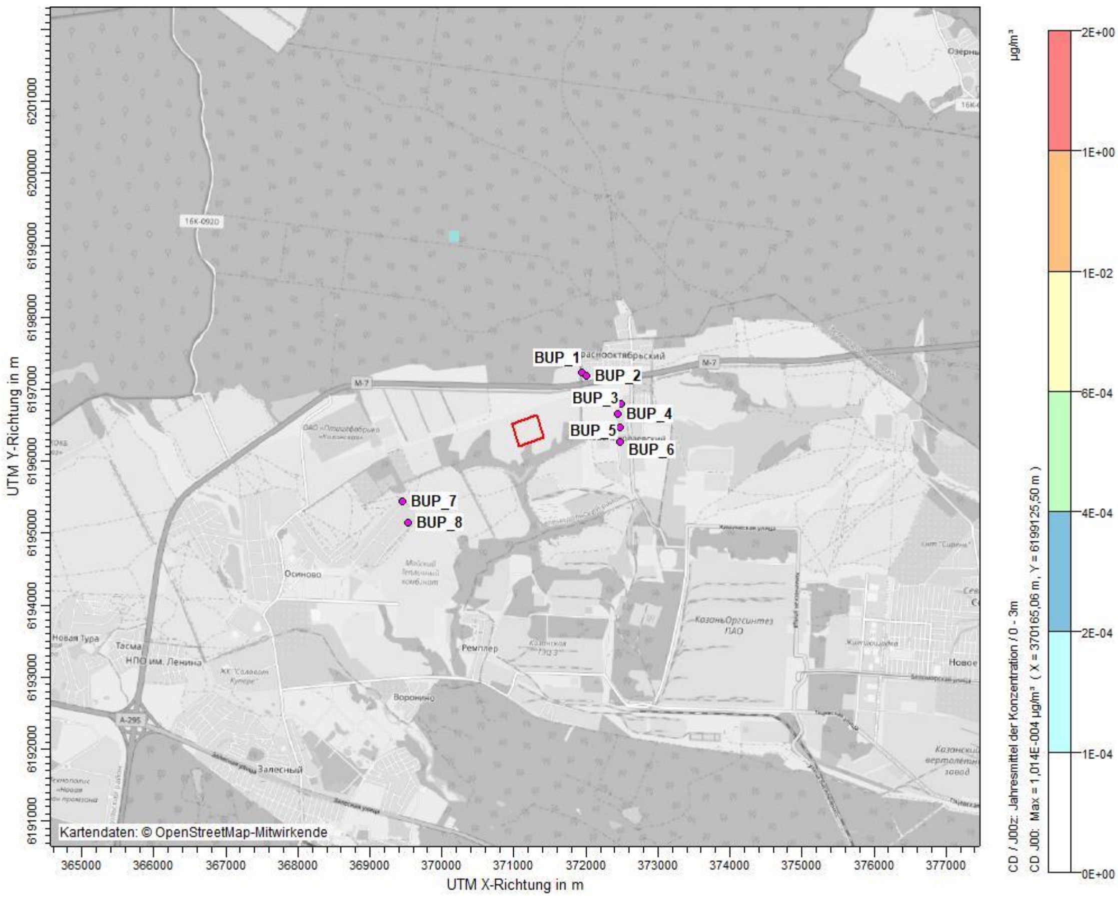

Figure 16. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for cadmium; (Irrelevance criterion of TA Luft: 3.0% of the annual immission value, corresponds to approx. 6*10-4 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

The maximum annual additional loads at each assessment point for the studied pollutants are shown in the following tables.

Table 14. Annual average additional load/contribution of the waste incineration plant for the studied pollutants in comparison to the German environmental standards according to TA Luft.

	Annual average additional load and irrelevant additional loads according to TA Luft [µg/m³]									
	BUP_1	**BUP_2**	**BUP_3**	**BUP_4**	**BUP_5**	**BUP_6**	**BUP_7**	**BUP_8**	**TA Luft irrelevant value**	**TA Luft threshold value**
NO_2	0.03	0.04	0.07	0.08	0.08	0.08	0.03	0.04	1.2	40
SO_2	0.06	0.06	0.10	0.12	0.13	0.12	0.04	0.05	1.5	50
PM_{10}	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	1.2	40
Pb	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0.015	0.5
Cd	$5*10^{-5}$	$5*10^{-5}$	$1*10^{-4}$	$1*10^{-4}$	$1*10^{-4}$	$1*10^{-4}$	$4*10^{-5}$	$5*10^{-5}$	$6*10^{-4}$	0.02

12.1.2 Results according to TA Luft 4.3.1/4.5.1– Protection against significant disadvantages and harmful environmental effects due to deposition of pollutants

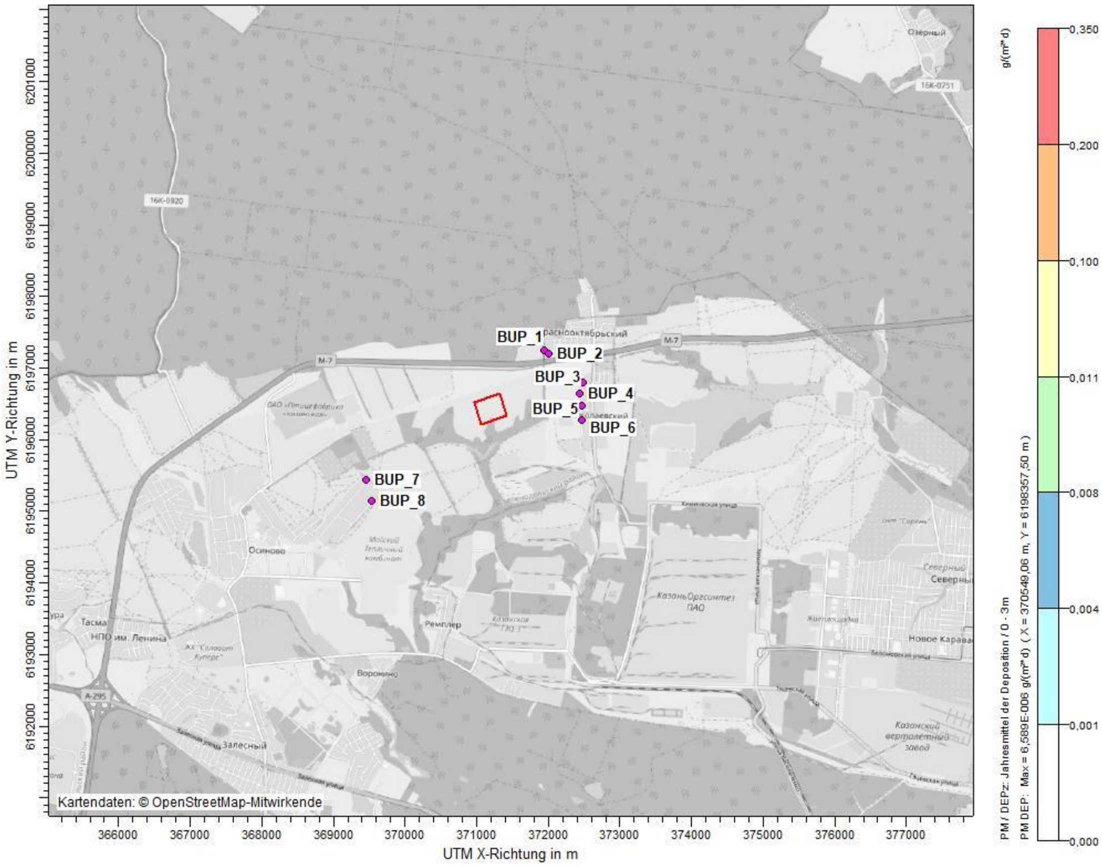

Figure 17. Annual average additional deposition of the waste incineration plant in g/(m² × d) for dust deposition; (Irrelevance criterion of TA Luft: 10.5 mg/(m² × d)); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

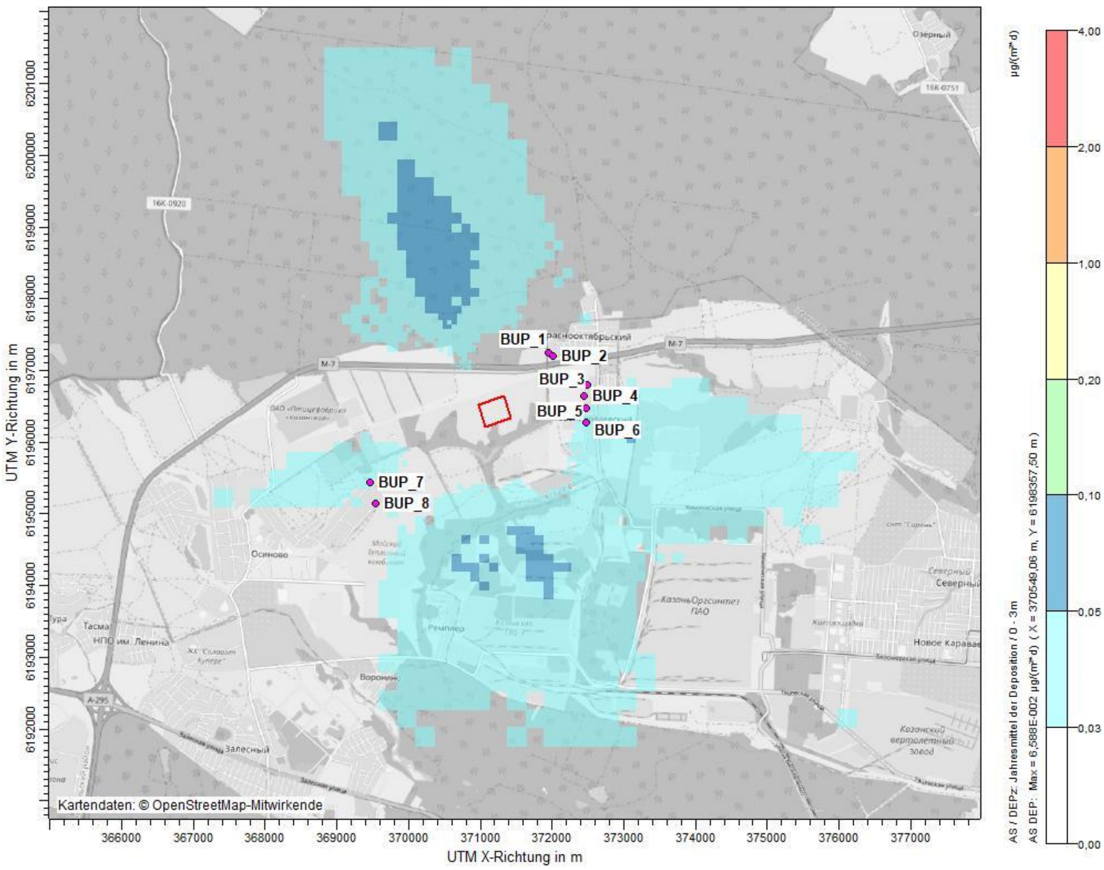

Figure 18. Annual average additional deposition of the waste incineration plant in µg/(m² × d) for As; (Irrelevance criterion of TA Luft: 0.2 µg/(m² × d)); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

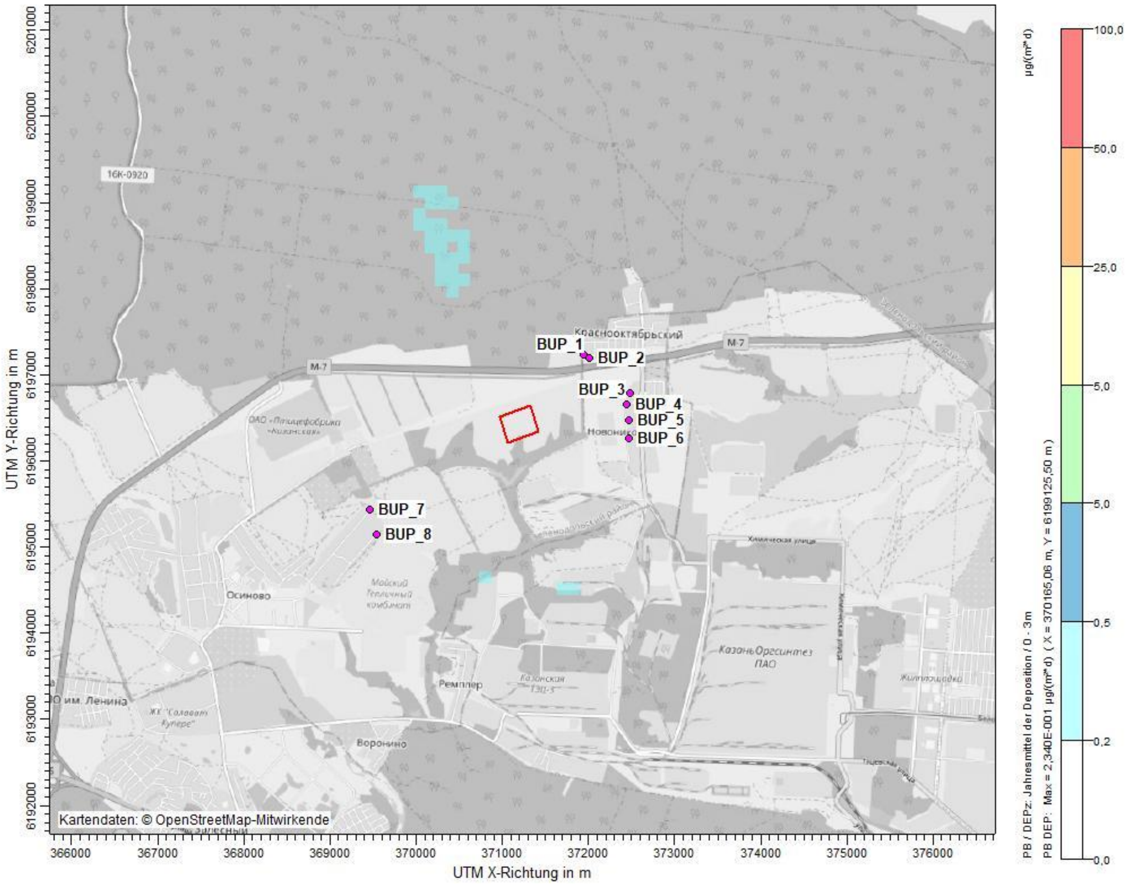

Figure 19. Annual average additional deposition of the waste incineration plant in µg/(m² × d) for Pb; (Irrelevance criterion of TA Luft: 5 µg/(m² × d)); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

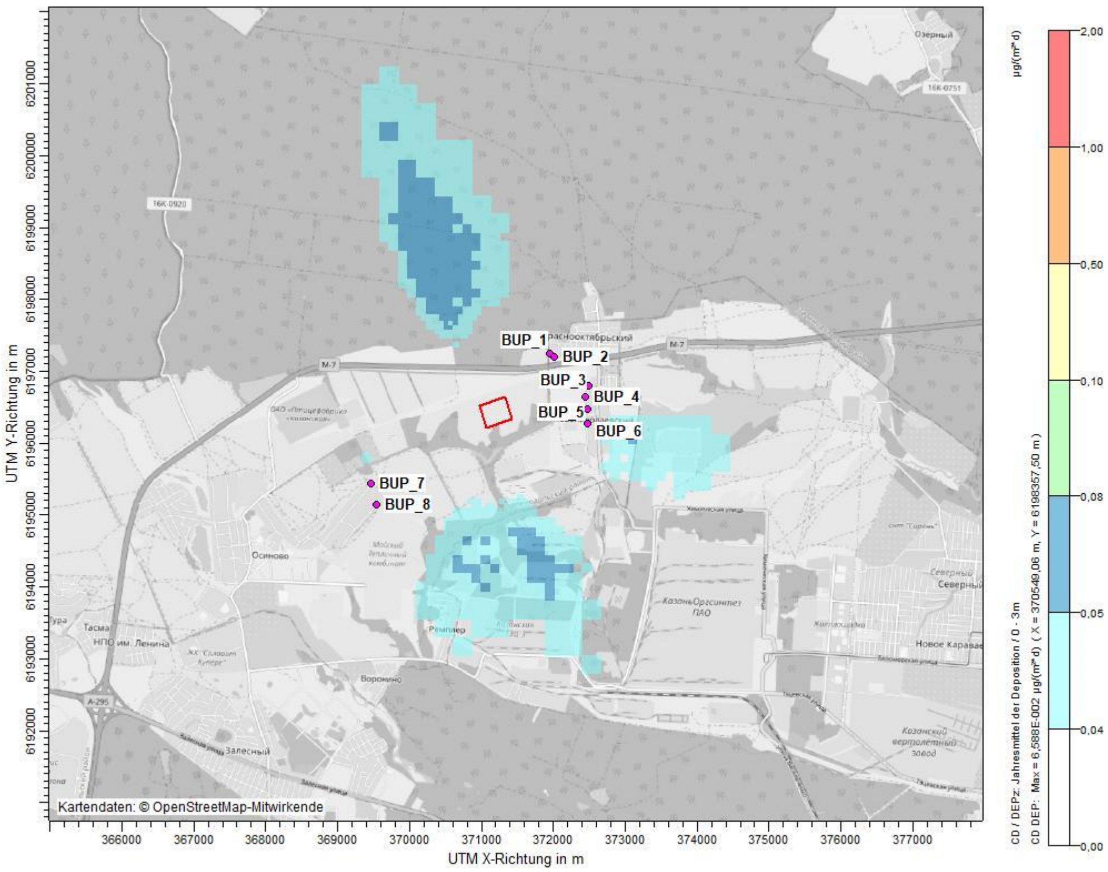

Figure 20. Annual average additional deposition of the waste incineration plant in µg/(m² × d) for Cd; (Irrelevance criterion of TA Luft: 0.1 µg/(m² × d)); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

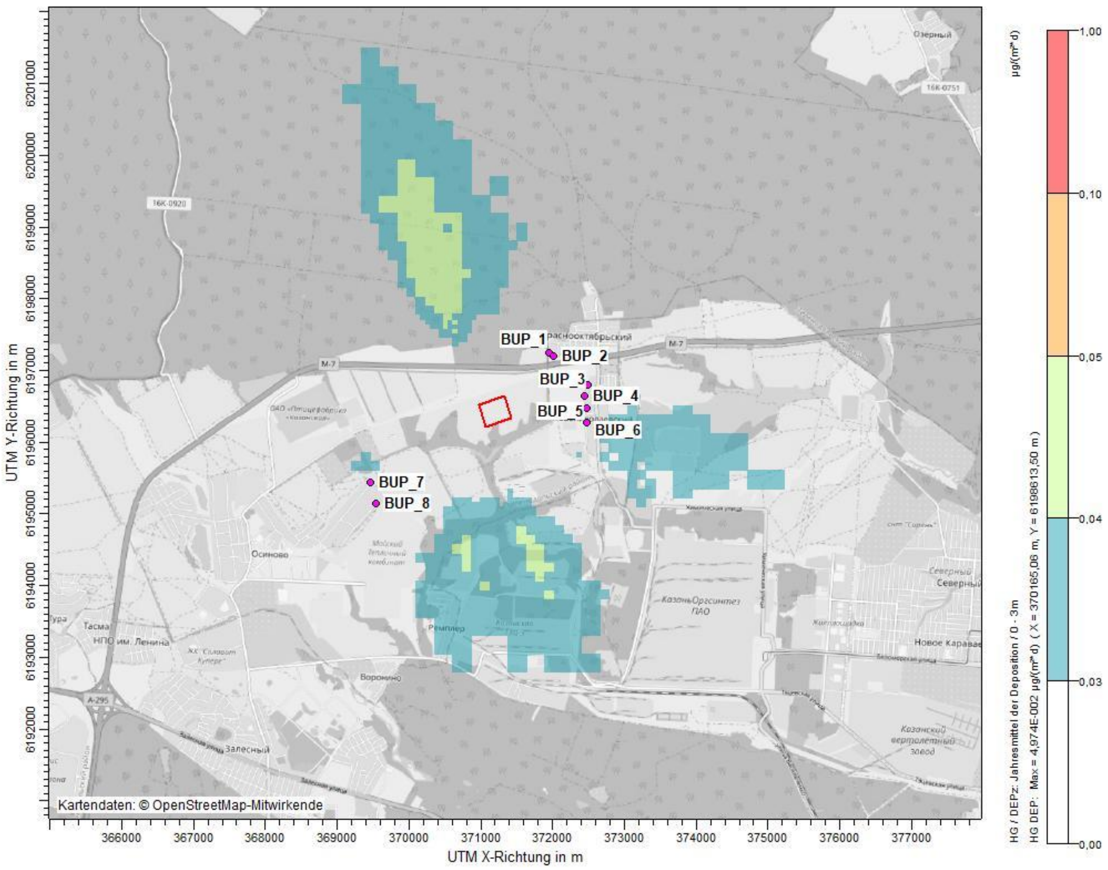

Figure 21. Annual average additional deposition of the waste incineration plant in µg/(m² × d) for Hg; (Irrelevance criterion of TA Luft: 0.05 µg/(m² × d)); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

The maximum annual additional loads and depositions at each assessment point for all studied pollutants are shown in the following tables.

Table 15. Annual average additional deposition of the waste incineration plant for the studied pollutants in comparison to the irrelevant additional depositions according to TA Luft.

	Annual average additional deposition [µg/(m² × d)] respectively [mg/(m² × d)] for PM									
	BUP_1	**BUP_2**	**BUP_3**	**BUP_4**	**BUP_5**	**BUP_6**	**BUP_7**	**BUP_8**	**TA Luft irrelevant value**	**TA Luft threshold value**
PM	0.007	0.008	0.013	0.015	0.015	0.016	0.005	0.006	10.5	350
As	0.03	0.04	0.06	0.07	0.07	0.08	0.02	0.03	0.2	4
Cd	0.03	0.04	0.06	0.07	0.07	0.08	0.02	0.03	0.1	2
Pb	0.1	0.1	0.2	0.3	0.3	0.3	0.1	0.1	5	100
Hg	0.03	0.03	0.05	0.06	0.06	0.06	0.02	0.02	0.05	1

12.1.3 Results according to TA Luft 4.4.1 – Protection of vegetation and eco systems

According to the Technical Instructions on Air Quality Control, the German regulatory fundamentals – in contrast to the Russian Environmental Standards – require a review of the air pollutants HF, NO_x and NH_3 for the protection of vegetation and ecosystems (see also chapter 3.2).

Even if the consideration of this pollutants is not required by the Russian government, the results of the calculation will be shown briefly for the sake of completeness regarding to the German fundamentals.

The following figures shows the spatial distribution of the annual mean additional load/contribution of the waste incineration plant of HF, NO_x and NH_3. The scaling in the figure was such that additional loads are shown in blue and green tones if they are irrelevant according to TA Luft no. 4.4.3. Additional contributions that exceed the irrelevance threshold according to TA Luft are shown in yellow, orange or red.

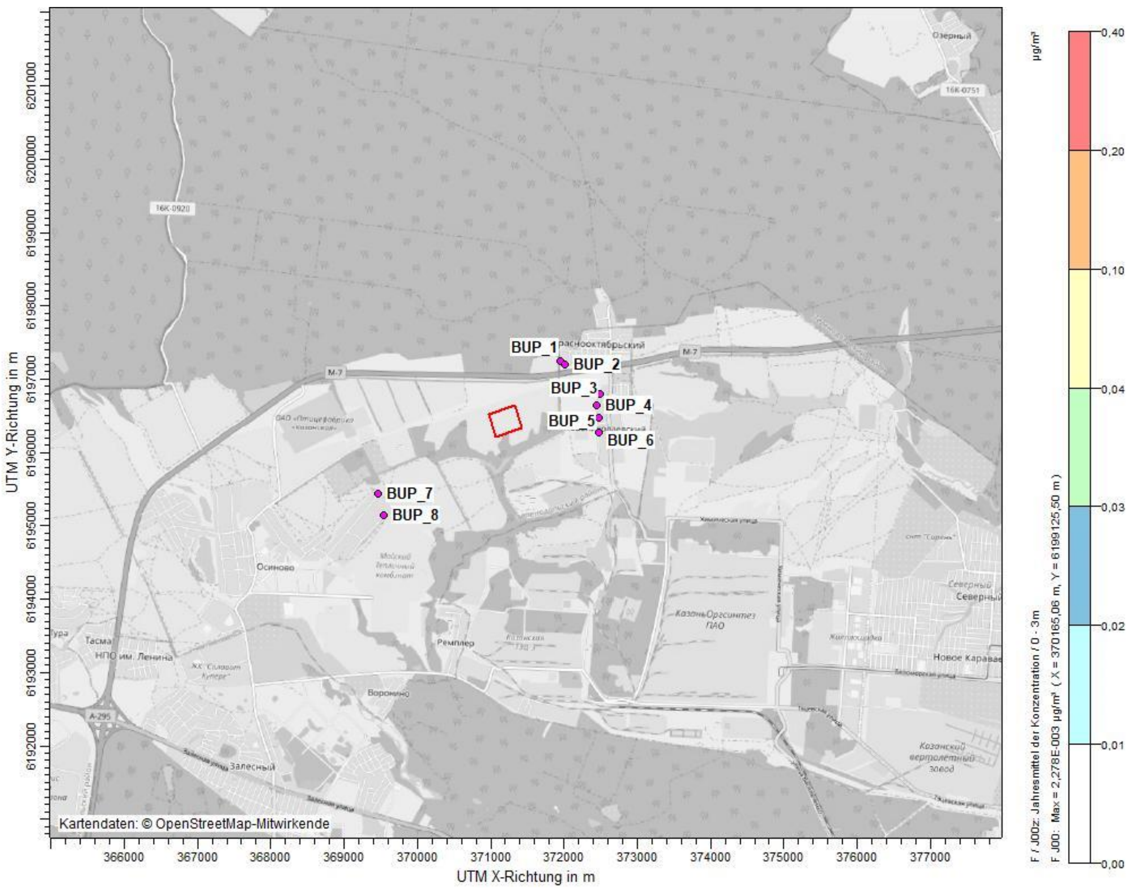

Figure 22. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for fluor; (Irrelevance criterion of TA Luft: 0.04 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

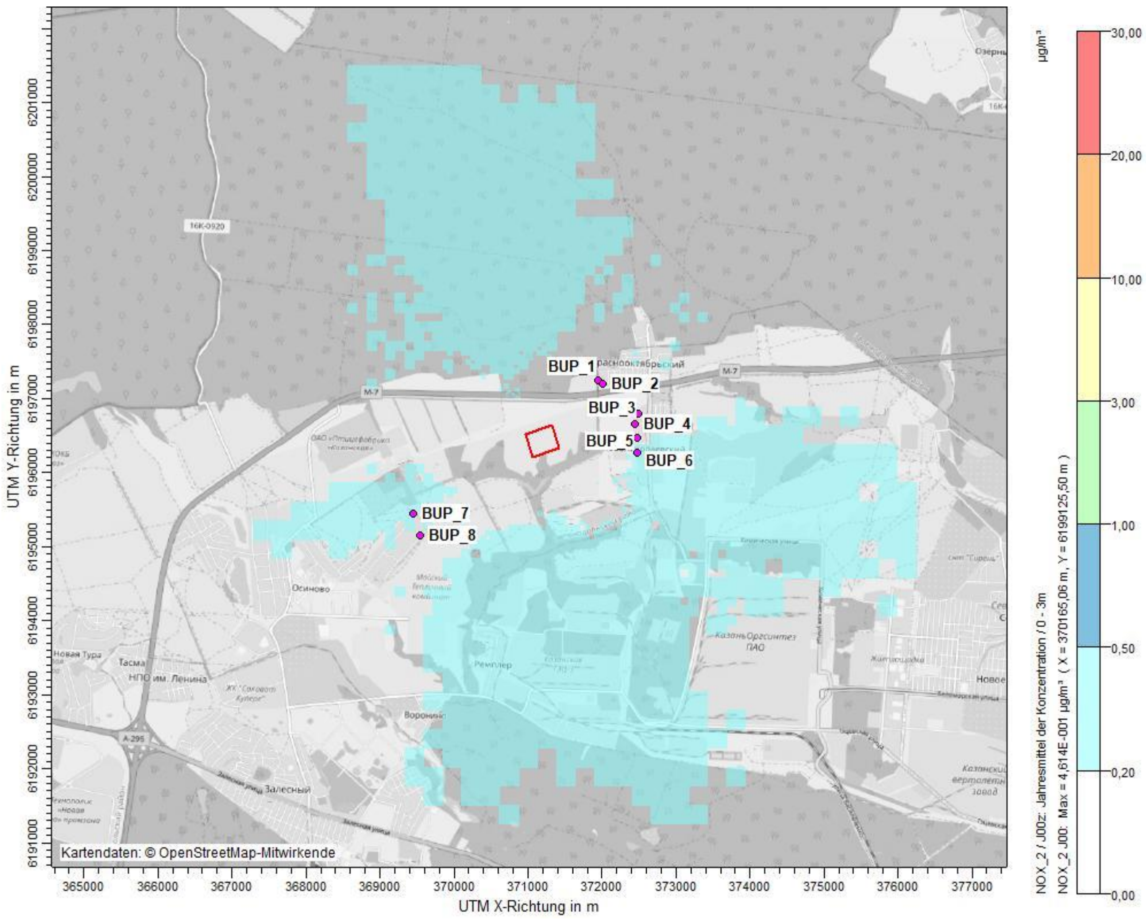

Figure 23. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for nitrogen oxides (NO_x); (Irrelevance criterion of TA Luft: 3 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

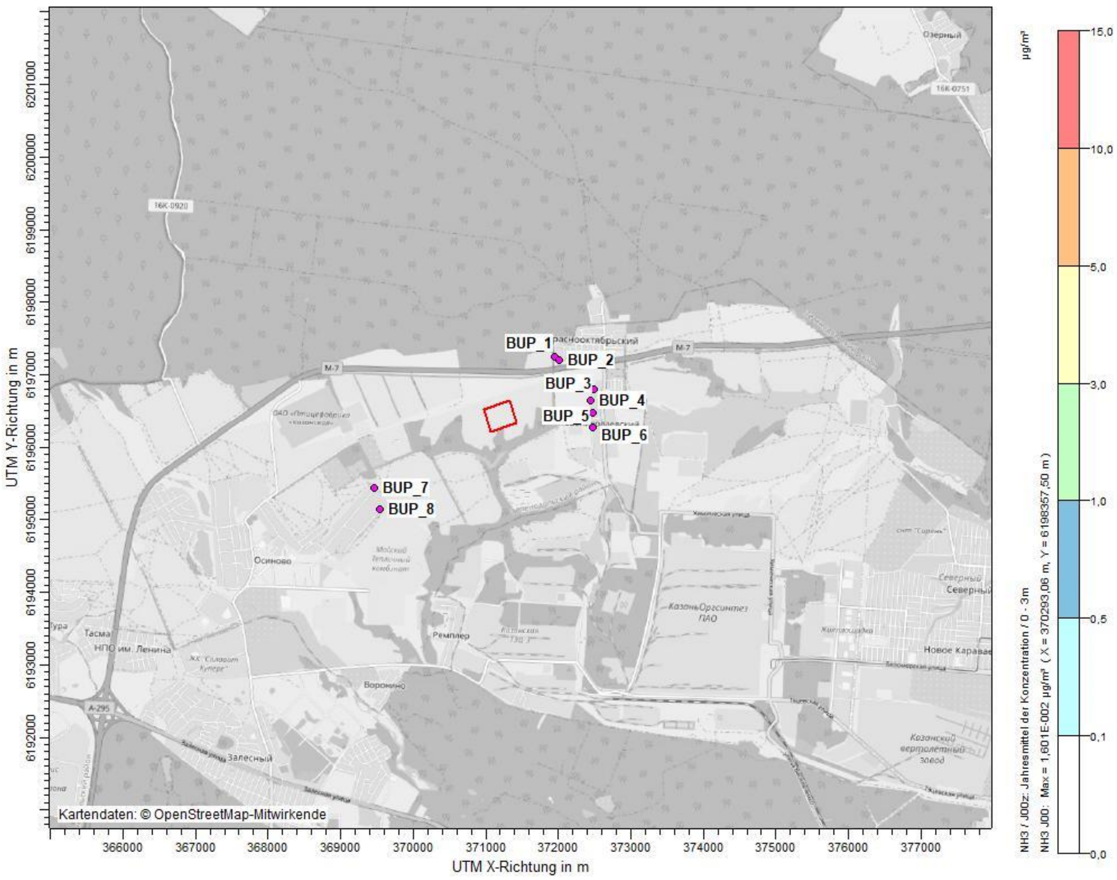

Figure 24. Annual average additional load/contribution of the waste incineration plant J00 in µg/m³ for ammonia (NH_3); (Irrelevance criterion of TA Luft: 3 µg/m³); Monitoring sites are shown as pink dots; waste incineration plant yard shown as red rectangle.

The maximum annual additional loads at each assessment point for the studied pollutants are shown in the following tables.

Table 16. Annual average additional load of the waste incineration plant for the studied pollutants in comparison to the irrelevant additional loads according to TA Luft.

	Annual average additional load and irrelevant additional loads according to TA Luft [µg/m³]									
	BUP_1	**BUP_2**	**BUP_3**	**BUP_4**	**BUP_5**	**BUP_6**	**BUP_7**	**BUP_8**	**TA Luft irrelevant value**	**TA Luft threshold value**
HF	0.001	0.001	0.002	0.002	0.003	0.002	0.001	0.001	0.04	0.4
NO_x	0.2	0.2	0.4	0.5	0.5	0.5	0.2	0.2	3	30
NH_3	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	3	10

12.2 Short-term Immission Load

12.2.1 Maximum Daily Immission Load

In the following, the maximum daily additional load/contribution of the waste incineration plant for the relevant pollutants in µg/m³ (T00) is presented in comparison with the Russian limit values (see also chapter 4).

The subsequent table shows the results of the calculation run for the points of interest for the average daily additional concentration.

Table 17. Maximum daily average additional load/contribution of the waste incineration plant for the studied pollutantsin comparison with the average daily maximum permissible concentration (MPC).

	Maximum daily average additional load and MPC [µg/m³]								
	BUP_1	**BUP_2**	**BUP_3**	**BUP_4**	**BUP_5**	**BUP_6**	**BUP_7**	**BUP_8**	**MPC**
NO_2	1,0	0,7	0,8	1,2	1,2	0,8	0,8	0,9	40
SO_2	1,6	1,4	1,4	1,6	1,8	1,4	1,4	1,2	50
Pb	0,015	0,013	0,013	0,015	0,016	0,013	0,013	0,011	0,3
Cu	0,015	0,013	0,013	0,015	0,016	0,013	0,013	0,011	2
NH_3	0,26	0,22	0,24	0,28	0,24	0,22	0,20	0,26	40
Cr (VI)	0,0015	0,0013	0,0013	0,0015	0,0016	0,0013	0,0013	0,0011	1.5
HCl	0,33	0,27	0,28	0,31	0,35	0,28	0,24	0,33	100

The total load at the assessment points results from the sum of the additional load and the background load (see chapter 6.2).

Since the daily average additional load of the waste incineration plant is below 2 % of the daily average MPC the additional load is negligible. From the expert's perspective, there are no exceedances to expect that are caused by the waste incineration plant.

12.2.2 Hourly Immission Load

In the following, the maximum hourly additional load/contribution of the waste incineration plant for the relevant pollutants in µg/m³ (S00) is presented in comparison with the Russian limit values (see also chapter 4).

The subsequent table shows the results of the calculation run for the points of interest for the maximum hourly concentration.

Table 18. Maximum hourly additional load/contribution of the waste incineration plant for the studied pollutantsin comparison with the MPC one-time concentration.

	One-time additional load and one-time MPC [µg/m³]								
	BUP_1	**BUP_2**	**BUP_3**	**BUP_4**	**BUP_5**	**BUP_6**	**BUP_7**	**BUP_8**	**MPC**
NO_2	11	12	13	28	13	12	20	13	200
SO_2	19	10	15	13	15	15	14	12	500
Pb	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1
NH_3	2.8	1.7	2.3	1.9	2.4	2.6	1.9	1.8	200
HCl	3.6	2.0	3.0	2.5	2.9	2.9	2.8	2.3	200

The one-time additional load of the waste incineration plant amounts to maximum 15 % of the one-time MPC for NO_2. The existing load is maximum 73 % of the one-time MPC in the studied region. Therefore, the total load is below the one-time MPC for NO_2.

With regard to the other pollutants, the share of the additional load in the one-time MPC even lower (max. 4 %) and is therefore negligible. From the expert's perspective, there are no exceedances to expect that are caused by the waste incineration plant.

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13 Human Toxicologic Evaluation of Air Pollutants

In this chapter the effects of air pollutants on human health is discussed in brief, based on scientific sources. We first give a short overview of the scientific field of toxicology and introduce relevant technical terms. Then, we present significant air pollutants, discuss their sources, as well as their impact on humans. Finally, we summarize the current state of research on toxicity levels of selected ambient pollutants.

13.1 Explanation of assessment values

Toxicology examines and describes the effects of chemicals or mixtures of substances on human health. The impact of any exposure is determined by two major factors: the duration of exposure (short-term, chronic, lifelong) and the type of observed symptoms (irritation, caustic, mutagenic, reproductive toxic, carcinogenic). To assess risks inflicted by ambient air pollutants the most significant indicators are the inhalative exposure level, exposure intensity and the toxicity of a substance [1]. The aim of the discipline is to determine the risk for the health of humans and animals and to prevent possible harms.

For assessment the measure „Tolerable Adsorbable Dose" (TRD) is used which is the daily dose of a toxic substance that a human can resorb without negative effects on their health. It is defined by mg/kg BW*d (BW = Bodyweight). A similar measure was established by the WHO: the „Acceptable Daily Intake" (ADI). The TRD was deduced from the multi-nationally recognized unit „Lowest Observed Adverse Effect Level" (LOAEL) and „No Observed Adverse Effect Level" (NOAEL), justified by animal or human studies and multiplied with a safety factor of 100. But TRD does not exist for carcinogen substances. Instead the measure „unit risk" is used. It is defined as estimated risk to get cancer from a permanent inhalative exposure to a hazardous substance of at least 1 µg/m³ over 70 years [2].

13.2 Presentation of different air pollutants

In this part the relevant air pollutants of human health are described.

13.2.1 PM10

Particulate Matter (PM) is the term for a complex mixture of small particles and liquid droplets in the atmosphere made up of acids, organic chemicals, metals or dust particles. Sources of PM are natural and anthropogenic. PM is classified by size according to its nominal median aerodynamic diameter [3]. PM_{10} contains coarse ($PM_{2.5\text{-}10}$), fine $PM_{0.1\text{-}2.5}$ and ultrafine ($PM_{0.1}$) fractions of dust. PM_{10} are respirable. Particles which are smaller than 4 µm are called alveolar dust and more dangerous [4]. Multiple studies showed that long-term exposure to PM increases occurrence of cardiovascular diseases, lung cancer, respiratory morbidity and mortality. Epidemiologic studies reveal correlations while long-term exposure of $PM_{2.5}$ and respiratory symptoms, asthma and lung problems in a concentration range of 5 - 15.5 µg/m³ [5].

The calculated maximum additional concentration of PM_{10} of the municipal waste incineration plant at Zelenodolskiy is 0.02 µg/m³ (annual average) at BUP_6. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentration range of 5 - 15 µg/m³ and therefore a relevant impact on human health is not to be expected, even if it is assumed that 100 % of PM_{10} is expressed as $PM_{2.5}$.

13.2.2 NO_2

Nitrogen dioxide (NO_2) is mostly produced by incineration processes. It acts as a strong irritant gas and after inhalation it attacks the mucous membrane of the respiratory tract. Short term exposure seemed to be more harmful then long-term. A study of the UBA indicates premature death due to cardiovascular diseases linked to NO2. It is also associated with diabetes mellitus, hypertension, stroke, chronic obstructive pulmonary disease (COPD) and asthma. 8 % of existing cases of diabetes mellitus are linked to NO_2 [6]. Moreover, morphological changes of cellular structures starting at 1 ppm ³, they are time and concentration reliable but not reversible [7]. The short term LOAEL is 350 µg/m³ over 30 minutes of exposure. The long time LOAEL is 60 µg/m³ on average over the period of one week [8].

The calculated maximum additional concentration of NO_2 of the municipal waste incineration plant at Zelenodolskiy is 0.08 µg/m³ (annual average) at BUP_6, 1.2 µg/m³ (maximum daily average) at BUP_5 and 28 µg/m³ (hourly) at BUP_4. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

13.2.3 SO2

Sulfur dioxide is an irritant gas and may reach the lower transpiratory system. High concentrations (> 10 000 µg/m³) can affect bronchitis, tracheitis and bronchoconstriction. Epidemiologic studies show that chronic exposure to SO2 tends to result in sinusitis, respiratory diseases and emphysema. Critical concentrations are described and located at 200 µg/m³ as daily average [7].

The calculated maximum additional concentration of SO2 of the municipal waste incineration plant at Zelenodolskiy is 0.13 µg/m³ (annual average) at BUP_5, 1.8 µg/m³ (maximum daily average) at BUP_5 and 19 µg/m³ (hourly) at BUP_1. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

13.2.4 NH3

Ammonia gas (NH3) is also an irritant gas which toxic caustic effect after inhalation occur in the upper respiratory part. Pharyngitis, laryngitis and tracheobronchitis are possible diseases by chronic influences of low concentrations. A systemic impact is not expected. The LOAEL amounts 3,6 mg/m³. The seriously injuring concentration for 30 minutes exposure is about 1750 – 4550 mg/m³ [7].

The calculated maximum additional concentration of NH3 of the municipal waste incineration plant at Zelenodolskiy is 2.8 µg/m³ (maximum hourly immission load)) at BUP_1 It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

13.2.5 HCl

Another strong irritant gas is called hydrogen chloride. After inhalation massive irritation in eyes and nasal mucous membranes as well in pharynx and larynx arise. Chronic harms are chronic bronchitis and enamel damage or dental discoloration. Voluntary human experiments showed up to concentrations of 400 µg/m³ no deviation of physiological parameter came up [7].

The calculated maximum additional concentration of HCl of the municipal waste incineration plant at Zelenodolskiy is 3.6 µg/m³ (maximum hourly immission load) at BUP_1. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

13.2.6 HF

Furthermore, hydrogen fluoride counts to strong irritant gases. Chronic symptoms from inhalation of fluorides of industrial emissions are bones or tooth fluorosis. In addition, pathological manifestations of lunge, kidney and skin were observed [7]. According to Wohlslagel (1967) the LC50 value of mice is 279 mg HF/m3 for inhaling HF for one hour (LC = lethal concentration, median). The NOAEL quantify 0.48 mg/m3 and the LOAEL 1.16 mg/m³ figured out by studies on humans [10].

The calculated maximum additional concentration of HF of the municipal waste incineration plant at Zelenodolskiy is 0.36 µg/m³ (maximum hourly immission load) at BUP_1. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

13.2.7 Metals

There is a dozen of heavy metals, which are causing air pollution, and can cause cancer: Cd, TI, Sb, As, Pb, Cr, Co, Cu, Mn, Ni, Vn, Zn. Highly relevant are Cd, Tl, As and Cr(VI) which have a strong emission limit in the 17.BImSchV. Three different groups of metals are discussed: Hg as single element, and metals with emission limits of 0,5 mg/m³ and 0,05 mg/m³. The groups are exemplary represented.

13.2.8 Pollutants with an emission limit of 0,05 mg/m³

For example, Cd accumulates in kidney and liver hence it causes damages in the kidney function. Besides causing heart and lung diseases it is cancerogenic after inhalation. Experiments with rats revealed the LOAEL for cancerogenic effects after inhalation is at 12,5 µg/m³ [18]. Cr (VI) causes strong irritations and inflammations of nasal mucosa as consequence after inhaling. As well injuries of the lungs, lung cancer and acute asthma are described.

The calculated maximum additional concentration of Cd of the municipal waste incineration plant at Zelenodolskiy is 0,0001 µg/m³ (average annual immission load)) at BUP_6. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

13.2.9 Pollutants with an emission limit of 0,5 mg/m³

In addition, arsenic As with a lower maximum is a toxic heavy metal and is cancerogenic. Characteristic is the „blackfoot disease“, an injury of the hemal system. The NOAEL of inhalation exposure for fetotoxical effects was at 43 µg/kg*d [19]. Another well-known heavy metal is lead Pb. The impact on human health for low exposition doses is described as neurotoxic, reprotoxic and effects on the haematopoietic system and blood pressure. There are also indications of it being carcinogetic. A TRD value of 1 µg/kg*d was calculated (Kalberlah, Blei und Verbindungen, 2014).

The calculated maximum additional concentration of Cd of the municipal waste incineration plant at Zelenodolskiy is 0,001 µg/m³ (average annual immission load) at BUP_6. Adults aspire 20 m3 air per day. This results in 0.02 µg intake of As per day corresponding to approx. 0.00014 at a weight of 70 kg. Adults apsire 10 m3 air per day. This results in 0.01 µg intake of As per day corresponding to approx. 0.006 at a weight of 15 kg. It can be stated, that the contribution of the plant is significantly lower than the above-mentioned concentrations limits and thus, a relevant impact on human health is not expected.

14 Conclusion

The air dispersion study has shown, that, under application of German regulations (with regard to methodology and assessment system), the German annual limit values according to TA Luft 2002 for the air studied pollutants are not exceeded.

The short time values according to the Russian Environmental Quality Standards at the assessment points have also been respected (see Chapter 12.2); there are no exceedances to expect.

Furthermore, the air dispersion study has shown, that the modelling approach, in comparison to the determination of immission loads through measurements, is more conservative. In the modelling approach, the emissions of the sources are estimated at 8,760 annual hours (see also chapter 7.2). This is an overestimation of the emission scenario.

The calculation has shown that the annual and daily additional loads caused by the planned waste incineration plant are below 2 % according to TA Luft 4.2.1 annual limit values and to the Russian average daily limit values. According to German law the plant is approvable.

Therefore, it can be assumed that harmful effects on human health as well as negative environmental effects cannot be caused by the plant.

15 Literature

The following documents have been used for the elaboration of this report:

[1] Federal Immission Control Act - Act on the Prevention of Harmful Effects on the Environment caused by Air Pollution, Noise, Vibration and Similar Phenomena (BImSchG) in the version promulgated on 26 September 2002 (BGBl. I p. 3830).

[2] First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft) of 24 July 2002m (GMBl. [Gemeinsames Ministerblatt – Joint Ministerial Gazette] p. 511.

[3] Time series AKTerm Kazan of July 2014 to July 2015; meteorological dataset provided by IFU GmbH Frankenbrg - Privates Institut für Analytik; file number: DPR.20200426.

[4] Dispersion model AUSTAL2000, version 2.6.11-WI-x.
Copyright (c) Umweltbundesamt, Dessau-Roßlau, 2002-2014,
Copyright (c) Ing.-Büro Janicke, Überlingen, 1989-2014

[5] Program AUSTALView(TG), version 9.5.21 ArguSoft company, Mechernich.

[6] AUSTAL2000, Program description for version 2.6, status 2014-06-26, available from www.austal2000.de.

[7] Data provided by the client.

[8] Guideline VDI 3782 part 1, Environmental meteorology, Atmospheric dispersion models, Gaussian plume model for the determination of ambient air characteristics, January 2016.

[9] Guideline VDI 3782 part 3, Dispersion of Air Pollutants in the Atmosphere, Determination of Plume Rise, June 1985.

[10] Guideline VDI 3782 part 6, Environmental meteorology, Atmospheric dispersion models, Determination of Klug/Manier dispersion classes, April 2017.

[11] Guideline VDI 3945 part 3, Environmental meteorology, Atmospheric dispersion models, Particle model, September 2000.

[12] Guideline VDI 3783 part 19, Environmental meteorology, Reaction mechanism for the determination of the nitrogen dioxide concentration, April 2016.

[13] Guideline VDI 3783 part 20, Environmental meteorology, Testing the transferability of meteorological data for application within the context of TA Luft, March 2017.

[14] © OpenStreetMap-Mitwirkende. Creative-Commons-Lizenz - Weitergabe unter gleichen Bedingungen 2.0 (CC BY-SA) – www.openstreetmap.org/copyright .

[15] Umweltbundesamt, "Toxikologie," UBA, 2013. [Online]. Available: https://www.umweltbundesamt.de/themen/gesundheit/belastung-des-menschen-ermitteln/toxikologie. [Accessed 18 05 2020].

[16]

[17] Kaberlah, Hassauer and Schneider, "Gefährdungsabschätzung von Umweltschadstoffen, Ergänzbares Handbuch toxikologischer Basisdaten und ihre Bewertung," in Methodische Beschreibung des F+E-Vorhabens, Basisdaten Toxikologie für umweltrelevante Stoffe zur Gefahrenbeurteilung bei Altlasten, Eikmann, Heinrich, Heinzow and Konietzka, Eds., Berlin, Band 1, Erich Schmidt Verlag, 2014.

[18] Stanek, Brown, Stanek, Gift and Costa, "Air Pollution Toxicology - A Brief Review of teh Role of the Science in Shaping the Current Understanding of the Air Pollution Health Risks," Toxicological Sciences, pp. 8-27, 2010.

[19] Anderson, Thundiyil and Stolbach, "Clearing the Air: A rewiev of the Affects of Particulate Matter Air Pollution on Human Health," Journal of Medical Toxicology, no. 8, pp. 166-175, 2012.

[20] Wichmann, "Feinstaub: Lufthygienisches Problem," Umweltmed.Forsch.Praxis, no. 10, pp. 157-162, 2005.

[21] Umweltbundesamt, "Nitrogen dioxide," 2020. [Online]. Available: umweltbundesamt.de/en/press/pressinformation/nitrogen-dioxide-has-serious-impact-on-health. [Accessed 18 05 2020].

[22] GUK, "Umweltmedizinisch - humantoxikologische Bewertung der Immissionssituation im Umgebungsbereich des geplanten Steinkohlekraftwerks Datteln - Block 4," 2013.

[23] Englert, "Richtwerte für die Innenraumluft-Stickstoffdioxid," in Gefährdungsabschätzung von Umweltschadstoffen, Ergänzbares Handbuch toxikologischer Basisdaten und ihre Bewertung, Eikmann/Heinrich/Heinzow/Konietzka, Ed., Berlin, Band 3, Erich Schmidt Verlag, 2014.

[24] Schneider and Kalberlah, "Richtwerte für die Innenraumluft - Kohlenmonoxid," in Gefährdungsabschätzung von Umweltschadstoffen - Ergänzbares Handbuch toxikologischer Basisdaten und ihre Bewertung, vol. 2, Berlin, Erich Schmidt Verlag, 2014.

[25] IHCP, "European Union Risk Assessmen Report - HF," European Chemicals Bureau, Netherlands, 2001.

[26] Schneider and Kalberlah, "Polychlorierte Dibenzodioxine und -furane (PCDD/F)," in Gefährdungsabschätzung von Umweltschadstoffen - ergänzbares Handbuch toxikologischer Baissdaten und ihre Bewertung, Eikmann/Heinrich/Heinzow/Konietzka, Ed., Berlin, Band 2, Erich Schmidt Verlag, 2014.

[27] PHE, "Polycyclic aromatic hydrocarbon," Public Health England, 2018.

[28] ARC, "Some Non-heterocyclic Polycyclic Aromatic Hydrocarbons an dsome related exposure," in Monographs on the evaluation of carcinogenic risks to humans, Lyon, 2010.

[29] Brune, Deutsch-Wenzel, Habs, Ivankovic and Schmahl, "Investigation of the tumorigenic response to benzo(a)pyrenen in aqueous caffeine solution applied orally to Sprague-Dawley rats," Journal of Cancer Research and Clinical Oncology, vol. 102, 1981.

[30] WHO, "Polynuclear Aromatic Compounds," no. 32, 1983.

[31] LAI, Bewertung von Schadstoffen, für die keine Immissionswerte festgelegt sind. Bericht des Länderausschusses für Immissionsschutz, 2004.

[32] Kalberlah, "Quecksilber und Verbindungen," in Gefährdungsabschätzg von Umweltschadstoffen; Ergänzbares Handbuch toxikologischer Basisdaten und ihre Bewertung, Eikmann, Heinrich, Heinzow and Konietzka, Eds., Berlin, Band 3, Erich Schmidt Verlag, 2014.

[33] Takenaka, Oldiges, König, Hochrainer and Oberdörster, "Carcinogenicity of camium chlorideaerosolsin wistar rats," Journal of the National Caner Institute, no. 70, pp. 367-373, 1985.

[34] Hassauer and Kalberlah, "Arsen und Verbindungen," in Gefährdungabschätzung von Umweltschadstoffen - Ergänzbares Handbuch toxikologischer Basisdaten und ihre Bewertung, Eikmann, Heinrich, Heinzow and Konietzka, Eds., Band 1, Erich Schmidt Verlag, 2014.

[35] Kalberlah, "Blei und Verbindungen," in Gefährdungsabschäzung von Umweltschadstoffen - Ergänzbares Handbuch toxikologischer Basisdaten und ihre Bewertung, Eikmann, Heinrich, Heinzow and Konietzka, Eds., Band 1, Erich Schmidt Verlag, 2014.

[36] Wohlslagel, Dipasquale and Vernot, "Toxicity of solid rocket motor exhaust: Effects of HCl, HF, aalumina on rodents," no. 3, pp. 61-70, 1976.

16 Appendix: protocol of the calculation run

```
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  End = 365.00:00:00
  Average = 24
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66.0 69.0 72.0 75.0 78.0 81.0 84.0 87.0 90.0 93.0 96.0 99.0 102.0 105.0 108.0 111.0 114.0 117.0 120.0 123.0 126.0
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  Flags = +NESTED+BODIES
-
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N 06 |  2  1  3  3  128.0  46  46  56  -2816.0  -2816.0 0.5 200 1.0e-004
N 05 |  3  1  3  3   64.0  46  46  56  -1408.0  -1408.0 0.5 200 1.0e-004
N 04 |  4  1  3  3   32.0  48  50  56   -640.0   -768.0 0.5 200 1.0e-004
N 03 |  5  1  3  3   16.0  92  92  56   -608.0   -704.0 0.5 200 1.0e-004
N 02 |  6  1  3  3    8.0 178 180  56   -592.0   -688.0 1.0 200 1.0e-004
N 01 |  7  1  3  3    4.0 188 192  44   -264.0   -344.0 1.0 200 1.0e-004
-----------------------------------------------------------------------
==================================================== bodies.def
.
  DMKp = { 6.000 1.000 0.300 0.050 0.700 1.200 15.0 0.500 0.300 }
  TrbExt = 1
-
  RFile = ~poly_raster.dmna
==================================================== sources.def
.
! Nr. |     Xq      Yq   Hq    Aq    Bq    Cq     Wq   Dq   Vq      Qq    Ts     Lw     Rh     Tt
------+------------------------------------------------------------------------------------------
Q  01 |    7.7     0.1  98.0   0.0   0.0   0.0    0.0  2.8 18.9  11.830  -1.0 0.0000    0.0    0.0
------+------------------------------------------------------------------------------------------
==================================================== substances.def
.
  Name = gas
  Unit = g
  Rate = 8.00000
  Vsed = 0.0000
-
! Substance |      Vdep       Refc       Refd       Rfak  Rexp
------------+--------------------------------------------------
K  so2      | 0.000e+000 5.000e-005 0.000e+000 0.000e+000  0.80
K  nox      | 0.000e+000 3.000e-005 0.000e+000 0.000e+000  0.80
K  no2      | 0.000e+000 4.000e-005 0.000e+000 0.000e+000  0.80
K  no       | 0.000e+000 0.000e+000 0.000e+000 0.000e+000  0.80
K  nh3      | 1.000e-002 3.000e-006 1.268e-008 0.000e+000  0.80
K  f        | 0.000e+000 4.000e-007 0.000e+000 0.000e+000  0.80
K  pm-1     | 1.000e-003 4.000e-005 4.051e-006 0.000e+000  0.80
K  pm-2     | 1.000e-002 4.000e-005 4.051e-006 0.000e+000  0.80
K  pb-1     | 1.000e-003 5.000e-007 1.157e-009 0.000e+000  0.80
K  pb-2     | 1.000e-002 5.000e-007 1.157e-009 0.000e+000  0.80
K  as-1     | 1.000e-003 0.000e+000 4.630e-011 0.000e+000  0.80
```

```
K  as-2     | 1.000e-002 0.000e+000 4.630e-011 0.000e+000  0.80
K  cd-1     | 1.000e-003 2.000e-008 2.315e-011 0.000e+000  0.80
K  cd-2     | 1.000e-002 2.000e-008 2.315e-011 0.000e+000  0.80
K  hg       | 5.000e-003 0.000e+000 1.157e-011 0.000e+000  0.80
K  xx-1     | 1.000e-003 1.000e+000 1.157e-005 0.000e+000  0.80
K  xx-2     | 1.000e-002 1.000e+000 1.157e-005 0.000e+000  0.80
------------+--------------------------------------------------
.
  Name = pm3
  Unit = g
  Rate = 8.00000
  Vsed = 0.0400
-
! Substance |       Vdep       Refc       Refd       Rfak  Rexp
------------+--------------------------------------------------
K  hg-3     | 5.000e-002 0.000e+000 1.157e-011 0.000e+000  0.80
------------+--------------------------------------------------
.
  Name = pmu
  Unit = g
  Rate = 8.00000
  Vsed = 0.0600
-
! Substance |       Vdep       Refc       Refd       Rfak  Rexp
------------+--------------------------------------------------
K  pm-u     | 7.000e-002 4.000e-005 4.051e-006 0.000e+000  0.80
K  pb-u     | 7.000e-002 5.000e-007 1.157e-009 0.000e+000  0.80
K  as-u     | 7.000e-002 0.000e+000 4.630e-011 0.000e+000  0.80
K  cd-u     | 7.000e-002 2.000e-008 2.315e-011 0.000e+000  0.80
K  xx-u     | 7.000e-002 1.000e+000 1.157e-005 0.000e+000  0.80
------------+--------------------------------------------------
=================================================== chemics.def
.
! created\from |  gas.no
---------------+--------
C  gas.no2     |       ?
C  gas.no      |       ?
---------------+--------
=================================================== emissions.def
.
! SOURCE |     gas.so2     gas.nox     gas.no2      gas.no      gas.nh3       gas.f     gas.pm-1     gas.pm-2     pmu.pm-u     gas.pb-1     gas.pb-2     pmu.pb-u     gas.as-1     gas.as-2     pmu.as-u     gas.cd-1     gas.cd-2     pmu.cd-u       gas.hg     pm3.hg-3     gas.xx-1     gas.xx-2     pmu.xx-u
---------+------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
E    01 |   4.917e+000   1.969e+001   1.969e+000   1.156e+001   8.860e-001   9.722e-002   7.876e-001   1.378e-001   5.907e-002   3.938e-002   6.891e-003   2.953e-004   3.938e-003   6.891e-004   2.953e-004   3.938e-003   6.891e-004   2.953e-004   2.658e-003   2.778e-004   7.876e-006   1.378e-006   5.907e-007
---------+------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
=================================================== monitor.def
.
! Nr. |      Xp      Yp    Hp
------+----------------------
M  01 |   824.0   866.5   1.5
M  02 |   883.0   820.0   1.5
M  03 |  1360.9   418.2   1.5
M  04 |  1317.6   278.1   1.5
M  05 |  1343.1    95.3   1.5
M  06 |  1349.3  -107.5   1.5
M  07 | -1669.9  -932.0   1.5
M  08 | -1590.4 -1220.8   1.5
------+----------------------
```

2020-05-29 08:26:38 LOPREP_1.1.10

```
Auswertung der Ergebnisse für "d:\Dauerrechnung\sieb\M156050\Rl09\austal"
==========================================================================

     DEP: Jahres-/Langzeitmittel der gesamten Deposition
     DRY: Jahres-/Langzeitmittel der trockenen Deposition
     WET: Jahres-/Langzeitmittel der nassen Deposition
     J00: Jahres-/Langzeitmittel der Konzentration/Geruchsstundenhäufigkeit
     Tnn: Höchstes Tagesmittel der Konzentration mit nn Überschreitungen
     Snn: Höchstes Stundenmittel der Konzentration mit nn Überschreitungen

Maximalwerte, Deposition
------------------------
AS  DEP  1.424e-01 ug/(m2*d) (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
AS  DRY  1.424e-01 ug/(m2*d) (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
AS  WET  0.000e+00 ug/(m2*d) (+/-  0.0%)
CD  DEP  1.424e-01 ug/(m2*d) (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
CD  DRY  1.424e-01 ug/(m2*d) (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
CD  WET  0.000e+00 ug/(m2*d) (+/-  0.0%)
HG  DEP  1.156e-01 ug/(m2*d) (+/-  1.2%) bei x= -448 m, y= 1472 m (6: 19, 34)
HG  DRY  1.156e-01 ug/(m2*d) (+/-  1.2%) bei x= -448 m, y= 1472 m (6: 19, 34)
HG  WET  0.000e+00 ug/(m2*d) (+/-  0.0%)
NH3 DEP  1.274e-01 kg/(ha*a) (+/-  3.5%) bei x= -544 m, y= 1376 m (5: 14, 44)
NH3 DRY  1.274e-01 kg/(ha*a) (+/-  3.5%) bei x= -544 m, y= 1376 m (5: 14, 44)
NH3 WET  0.000e+00 kg/(ha*a) (+/-  0.0%)
PB  DEP  5.354e-01 ug/(m2*d) (+/-  1.5%) bei x= -448 m, y= 1472 m (6: 19, 34)
PB  DRY  5.354e-01 ug/(m2*d) (+/-  1.5%) bei x= -448 m, y= 1472 m (6: 19, 34)
PB  WET  0.000e+00 ug/(m2*d) (+/-  0.0%)
PM  DEP  2.848e-05 g/(mÂ²*d) (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
PM  DRY  2.848e-05 g/(mÂ²*d) (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
PM  WET  0.000e+00 g/(mÂ²*d) (+/-  0.0%)
XX  DEP  2.848e-10 g/(m2*d)  (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
XX  DRY  2.848e-10 g/(m2*d)  (+/-  1.1%) bei x= -448 m, y= 1472 m (6: 19, 34)
XX  WET  0.000e+00 g/(m2*d)  (+/-  0.0%)
=============================================================================

Maximalwerte, Konzentration bei z=1.5 m
---------------------------------------
AS  J00  2.288e-04 ug/m3 (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
CD  J00  2.288e-04 ug/m3 (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
F   J00  4.915e-03 ug/m3 (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
HG  J00  1.280e-04 ug/m3 (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
NH3 J00  4.076e-02 ug/m3 (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
NO  J00  5.513e-01 Âµg/mÂ³ (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
NO2 J00  1.592e-01 Âµg/mÂ³ (+/-  4.6%) bei x= -832 m, y= 2240 m (6: 16, 40)
NO2 S00  4.047e+02 Âµg/mÂ³ (+/- 99.9%) bei x=  262 m, y=   90 m (1:132,109)
NO2 S18  7.630e+00 Âµg/mÂ³ (+/- 93.5%) bei x=  426 m, y= -246 m (1:173, 25)
NOX J00  9.955e-01 Âµg/mÂ³ (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
PB  J00  2.288e-03 ug/m3 (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
PM  J00  4.576e-02 Âµg/mÂ³ (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
PM  T00  2.596e+00 Âµg/mÂ³ (+/- 99.9%) bei x=  138 m, y=   54 m (1:101,100)
PM  T35  1.942e-01 Âµg/mÂ³ (+/- 26.4%) bei x= -448 m, y= 1600 m (6: 19, 35)
SO2 J00  2.486e-01 Âµg/mÂ³ (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
SO2 T00  1.418e+01 Âµg/mÂ³ (+/- 99.9%) bei x=  130 m, y=   78 m (1: 99,106)
SO2 T03  2.723e+00 Âµg/mÂ³ (+/- 15.3%) bei x= -544 m, y= 1376 m (5: 14, 44)
SO2 S00  3.404e+02 Âµg/mÂ³ (+/- 99.9%) bei x=  130 m, y=   78 m (1: 99,106)
SO2 S24  1.222e+01 Âµg/mÂ³ (+/- 99.9%) bei x= -110 m, y=  402 m (1: 39,187)
XX  J00  4.576e-13 g/m3  (+/-  3.2%) bei x= -544 m, y= 1376 m (5: 14, 44)
===========================================================================


Auswertung für die Beurteilungspunkte: Zusatzbelastung
======================================================
PUNKT            01           02           03
xp              824          883         1361
yp              867          820          418
```

```
hp              1.5             1.5             1.5
-------+-----------------+-----------------+-----------------
AS  DEP   3.493e-02  4.7%   3.845e-02  3.2%   6.382e-02  3.3%  ug/(m2*d)
AS  DRY   3.493e-02  4.7%   3.845e-02  3.2%   6.382e-02  3.3%  ug/(m2*d)
AS  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
AS  J00   5.104e-05  7.2%   5.411e-05  5.4%   9.576e-05  5.7%  ug/m3
CD  DEP   3.493e-02  4.7%   3.845e-02  3.2%   6.382e-02  3.3%  ug/(m2*d)
CD  DRY   3.493e-02  4.7%   3.845e-02  3.2%   6.382e-02  3.3%  ug/(m2*d)
CD  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
CD  J00   5.104e-05  7.2%   5.411e-05  5.4%   9.576e-05  5.7%  ug/m3
F   J00   1.097e-03  7.3%   1.167e-03  5.4%   2.062e-03  5.7%  ug/m3
HG  DEP   2.794e-02  5.1%   3.002e-02  3.5%   4.997e-02  3.8%  ug/(m2*d)
HG  DRY   2.794e-02  5.1%   3.002e-02  3.5%   4.997e-02  3.8%  ug/(m2*d)
HG  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
HG  J00   2.853e-05  7.2%   3.011e-05  5.3%   5.340e-05  5.6%  ug/m3
NH3 DEP   2.702e-02  8.3%   3.075e-02  5.7%   5.164e-02  6.1%  kg/(ha*a)
NH3 DRY   2.702e-02  8.3%   3.075e-02  5.7%   5.164e-02  6.1%  kg/(ha*a)
NH3 WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  kg/(ha*a)
NH3 J00   9.075e-03  7.1%   9.509e-03  5.3%   1.692e-02  5.6%  ug/m3
NO  J00   1.221e-01  7.3%   1.289e-01  5.3%   2.284e-01  5.6%  Âµg/mÂ³
NO2 J00   3.504e-02  7.6%   3.877e-02  6.7%   6.755e-02  6.4%  Âµg/mÂ³
NO2 S00   1.107e+01 51.2%   1.167e+01 87.0%   1.339e+01 71.6%  Âµg/mÂ³
NO2 S18   3.365e+00 81.1%   3.425e+00 56.3%   5.166e+00 99.9%  Âµg/mÂ³
NOX J00   2.222e-01  7.3%   2.364e-01  5.4%   4.177e-01  5.7%  Âµg/mÂ³
PB  DEP   1.193e-01  6.7%   1.352e-01  4.7%   2.257e-01  5.0%  ug/(m2*d)
PB  DRY   1.193e-01  6.7%   1.352e-01  4.7%   2.257e-01  5.0%  ug/(m2*d)
PB  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
PB  J00   5.104e-04  7.2%   5.411e-04  5.4%   9.576e-04  5.7%  ug/m3
PM  DEP   6.986e-06  4.7%   7.691e-06  3.2%   1.277e-05  3.3%  g/(mÂ²*d)
PM  DRY   6.986e-06  4.7%   7.691e-06  3.2%   1.277e-05  3.3%  g/(mÂ²*d)
PM  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  g/(mÂ²*d)
PM  J00   1.021e-02  7.2%   1.082e-02  5.4%   1.915e-02  5.7%  Âµg/mÂ³
PM  T00   3.007e-01 29.0%   2.504e-01 20.1%   2.652e-01 17.2%  Âµg/mÂ³
PM  T35   3.602e-02 55.6%   4.471e-02 56.2%   8.120e-02 81.0%  Âµg/mÂ³
SO2 J00   5.548e-02  7.3%   5.903e-02  5.4%   1.043e-01  5.7%  Âµg/mÂ³
SO2 T00   1.650e+00 29.4%   1.358e+00 20.3%   1.433e+00 17.2%  Âµg/mÂ³
SO2 T03   8.679e-01 28.6%   7.779e-01 31.6%   1.236e+00 33.5%  Âµg/mÂ³
SO2 S00   1.855e+01 49.8%   1.045e+01 34.3%   1.526e+01 99.9%  Âµg/mÂ³
SO2 S24   5.003e+00 93.5%   4.967e+00 37.7%   6.900e+00 72.9%  Âµg/mÂ³
XX  DEP   6.986e-11  4.7%   7.691e-11  3.2%   1.277e-10  3.3%  g/(m2*d)
XX  DRY   6.986e-11  4.7%   7.691e-11  3.2%   1.277e-10  3.3%  g/(m2*d)
XX  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  g/(m2*d)
XX  J00   1.021e-13  7.2%   1.082e-13  5.4%   1.915e-13  5.7%  g/m3
==========================================================================
PUNKT             04              05              06
xp              1318            1343            1349
yp               278              95            -108
hp               1.5             1.5             1.5
-------+-----------------+-----------------+-----------------
AS  DEP   7.266e-02  3.0%   7.251e-02  3.0%   7.819e-02  3.0%  ug/(m2*d)
AS  DRY   7.266e-02  3.0%   7.251e-02  3.0%   7.819e-02  3.0%  ug/(m2*d)
AS  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
AS  J00   1.080e-04  5.0%   1.186e-04  4.9%   1.136e-04  4.8%  ug/m3
CD  DEP   7.266e-02  3.0%   7.251e-02  3.0%   7.819e-02  3.0%  ug/(m2*d)
CD  DRY   7.266e-02  3.0%   7.251e-02  3.0%   7.819e-02  3.0%  ug/(m2*d)
CD  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
CD  J00   1.080e-04  5.0%   1.186e-04  4.9%   1.136e-04  4.8%  ug/m3
F   J00   2.333e-03  5.1%   2.556e-03  4.9%   2.439e-03  4.9%  ug/m3
HG  DEP   5.688e-02  3.5%   6.260e-02  3.3%   6.035e-02  3.3%  ug/(m2*d)
HG  DRY   5.688e-02  3.5%   6.260e-02  3.3%   6.035e-02  3.3%  ug/(m2*d)
HG  WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  ug/(m2*d)
HG  J00   5.998e-05  4.9%   6.605e-05  4.8%   6.363e-05  4.8%  ug/m3
NH3 DEP   6.064e-02  5.5%   6.605e-02  5.2%   6.183e-02  5.2%  kg/(ha*a)
NH3 DRY   6.064e-02  5.5%   6.605e-02  5.2%   6.183e-02  5.2%  kg/(ha*a)
NH3 WET   0.000e+00  0.0%   0.000e+00  0.0%   0.000e+00  0.0%  kg/(ha*a)
NH3 J00   1.889e-02  4.9%   2.089e-02  4.8%   2.029e-02  4.8%  ug/m3
```

\\S-muc-fs01\allefirmen\M\Proj\156\M156050\M156050_04_Ber_3E.DOCX:17. 06. 2020

NO J00   2.572e-01 4.9%   2.856e-01 4.9%   2.729e-01 4.8% Âµg/mÂ³
NO2 J00   7.827e-02 7.1%   7.990e-02 5.4%   7.569e-02 5.5% Âµg/mÂ³
NO2 S00   2.833e+01 99.9%   1.335e+01 83.6%   1.190e+01 99.9% Âµg/mÂ³
NO2 S18   4.997e+00 81.1%   5.204e+00 85.6%   5.047e+00 99.9% Âµg/mÂ³
NOX J00   4.725e-01 5.1%   5.178e-01 4.9%   4.940e-01 4.9% Âµg/mÂ³
PB DEP   2.634e-01 4.5%   2.797e-01 4.4%   2.711e-01 4.3% ug/(m2*d)
PB DRY   2.634e-01 4.5%   2.797e-01 4.4%   2.711e-01 4.3% ug/(m2*d)
PB WET   0.000e+00 0.0%   0.000e+00 0.0%   0.000e+00 0.0% ug/(m2*d)
PB J00   1.080e-03 5.0%   1.186e-03 4.9%   1.136e-03 4.8% ug/m3
PM DEP   1.453e-05 3.0%   1.450e-05 3.0%   1.564e-05 3.0% g/(mÂ²*d)
PM DRY   1.453e-05 3.0%   1.450e-05 3.0%   1.564e-05 3.0% g/(mÂ²*d)
PM WET   0.000e+00 0.0%   0.000e+00 0.0%   0.000e+00 0.0% g/(mÂ²*d)
PM J00   2.160e-02 5.0%   2.372e-02 4.9%   2.273e-02 4.8% Âµg/mÂ³
PM T00   2.902e-01 26.4%   3.207e-01 29.7%   2.652e-01 26.9% Âµg/mÂ³
PM T35   8.732e-02 99.9%   8.421e-02 58.1%   8.669e-02 73.5% Âµg/mÂ³
SO2 J00   1.180e-01 5.1%   1.293e-01 4.9%   1.234e-01 4.9% Âµg/mÂ³
SO2 T00   1.573e+00 26.5%   1.757e+00 29.9%   1.435e+00 27.0% Âµg/mÂ³
SO2 T03   1.199e+00 25.0%   1.415e+00 26.8%   1.225e+00 26.2% Âµg/mÂ³
SO2 S00   1.280e+01 99.9%   1.480e+01 38.3%   1.456e+01 99.9% Âµg/mÂ³
SO2 S24   6.643e+00 52.1%   7.434e+00 83.0%   6.798e+00 99.9% Âµg/mÂ³
XX DEP   1.453e-10 3.0%   1.450e-10 3.0%   1.564e-10 3.0% g/(m2*d)
XX DRY   1.453e-10 3.0%   1.450e-10 3.0%   1.564e-10 3.0% g/(m2*d)
XX WET   0.000e+00 0.0%   0.000e+00 0.0%   0.000e+00 0.0% g/(m2*d)
XX J00   2.160e-13 5.0%   2.372e-13 4.9%   2.273e-13 4.8% g/m3
==
PUNKT   07   08
xp   -1670   -1590
yp   -932   -1221
hp   1.5   1.5
-------+-----------------+-----------------
AS DEP   2.498e-02 4.3%   2.784e-02 4.1% ug/(m2*d)
AS DRY   2.498e-02 4.3%   2.784e-02 4.1% ug/(m2*d)
AS WET   0.000e+00 0.0%   0.000e+00 0.0% ug/(m2*d)
AS J00   3.844e-05 7.7%   4.493e-05 7.0% ug/m3
CD DEP   2.498e-02 4.3%   2.784e-02 4.1% ug/(m2*d)
CD DRY   2.498e-02 4.3%   2.784e-02 4.1% ug/(m2*d)
CD WET   0.000e+00 0.0%   0.000e+00 0.0% ug/(m2*d)
CD J00   3.844e-05 7.7%   4.493e-05 7.0% ug/m3
F   J00   8.363e-04 7.9%   9.755e-04 7.0% ug/m3
HG DEP   2.162e-02 4.6%   2.146e-02 4.5% ug/(m2*d)
HG DRY   2.162e-02 4.6%   2.146e-02 4.5% ug/(m2*d)
HG WET   0.000e+00 0.0%   0.000e+00 0.0% ug/(m2*d)
HG J00   2.114e-05 7.5%   2.479e-05 6.9% ug/m3
NH3 DEP   2.059e-02 7.6%   2.374e-02 7.2% kg/(ha*a)
NH3 DRY   2.059e-02 7.6%   2.374e-02 7.2% kg/(ha*a)
NH3 WET   0.000e+00 0.0%   0.000e+00 0.0% kg/(ha*a)
NH3 J00   6.575e-03 7.2%   7.772e-03 6.8% ug/m3
NO J00   8.880e-02 7.6%   1.047e-01 6.9% Âµg/mÂ³
NO2 J00   3.325e-02 10.3%   3.706e-02 8.1% Âµg/mÂ³
NO2 S00   1.996e+01 99.9%   1.327e+01 63.0% Âµg/mÂ³
NO2 S18   3.151e+00 63.5%   3.592e+00 45.9% Âµg/mÂ³
NOX J00   1.694e-01 7.9%   1.976e-01 7.0% Âµg/mÂ³
PB DEP   9.065e-02 6.4%   1.030e-01 6.0% ug/(m2*d)
PB DRY   9.065e-02 6.4%   1.030e-01 6.0% ug/(m2*d)
PB WET   0.000e+00 0.0%   0.000e+00 0.0% ug/(m2*d)
PB J00   3.844e-04 7.7%   4.493e-04 7.0% ug/m3
PM DEP   4.997e-06 4.3%   5.568e-06 4.1% g/(mÂ²*d)
PM DRY   4.997e-06 4.3%   5.568e-06 4.1% g/(mÂ²*d)
PM WET   0.000e+00 0.0%   0.000e+00 0.0% g/(mÂ²*d)
PM J00   7.687e-03 7.7%   8.985e-03 7.0% Âµg/mÂ³
PM T00   2.532e-01 18.9%   2.219e-01 23.1% Âµg/mÂ³
PM T35   2.182e-02 70.9%   2.564e-02 66.4% Âµg/mÂ³
SO2 J00   4.230e-02 7.9%   4.934e-02 7.0% Âµg/mÂ³
SO2 T00   1.377e+00 19.2%   1.204e+00 19.3% Âµg/mÂ³
SO2 T03   7.090e-01 41.6%   1.064e+00 26.2% Âµg/mÂ³
SO2 S00   1.396e+01 99.9%   1.181e+01 61.0% Âµg/mÂ³

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SO2 S24   4.242e+00 52.4%   4.143e+00 99.9%  Âµg/mÂ³
XX  DEP   4.997e-11  4.3%   5.568e-11  4.1%  g/(m2*d)
XX  DRY   4.997e-11  4.3%   5.568e-11  4.1%  g/(m2*d)
XX  WET   0.000e+00  0.0%   0.000e+00  0.0%  g/(m2*d)
XX  J00   7.687e-14  7.7%   8.985e-14  7.0%  g/m3
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