Air pollution in Ugljevik, Bosnia and Herzegovina

Photo: Igor Isanovic

Introduction

The municipality of Ugljevik, located in Republika Srpska, an entity of Bosnia and Herzegovina, is one of the oldest coal mining regions in the Balkans. What started as a small dig in 1899 on Mount Majevica on the south side of the municipality, developed by local inhabitants, is today a large open-cast lignite mine that produces 1.8 million tonnes of lignite every year. The constant expansion of the mining area swallowed up most of the original settlements on the mountain which led to the construction of today's town of Ugljevik in 1980, often referred as new Ugljevik, where most of the population moved to.

Four years before that, in 1976, the construction of the 300 MW Ugljevik lignite-fired power plant started as well. The power plant is now around two kilometres from the nearest houses in new Ugljevik. It dominates the landscape of the entire municipality with its 310-metre-tall flue gas stack, which is the tallest structure in Bosnia and Herzegovina.

Most of the lignite produced by the mine, around 95 per cent, is used to supply the power plant, but some of it is also sold on the open market and is used by buildings and houses in the area for heating during the winter.

For more information

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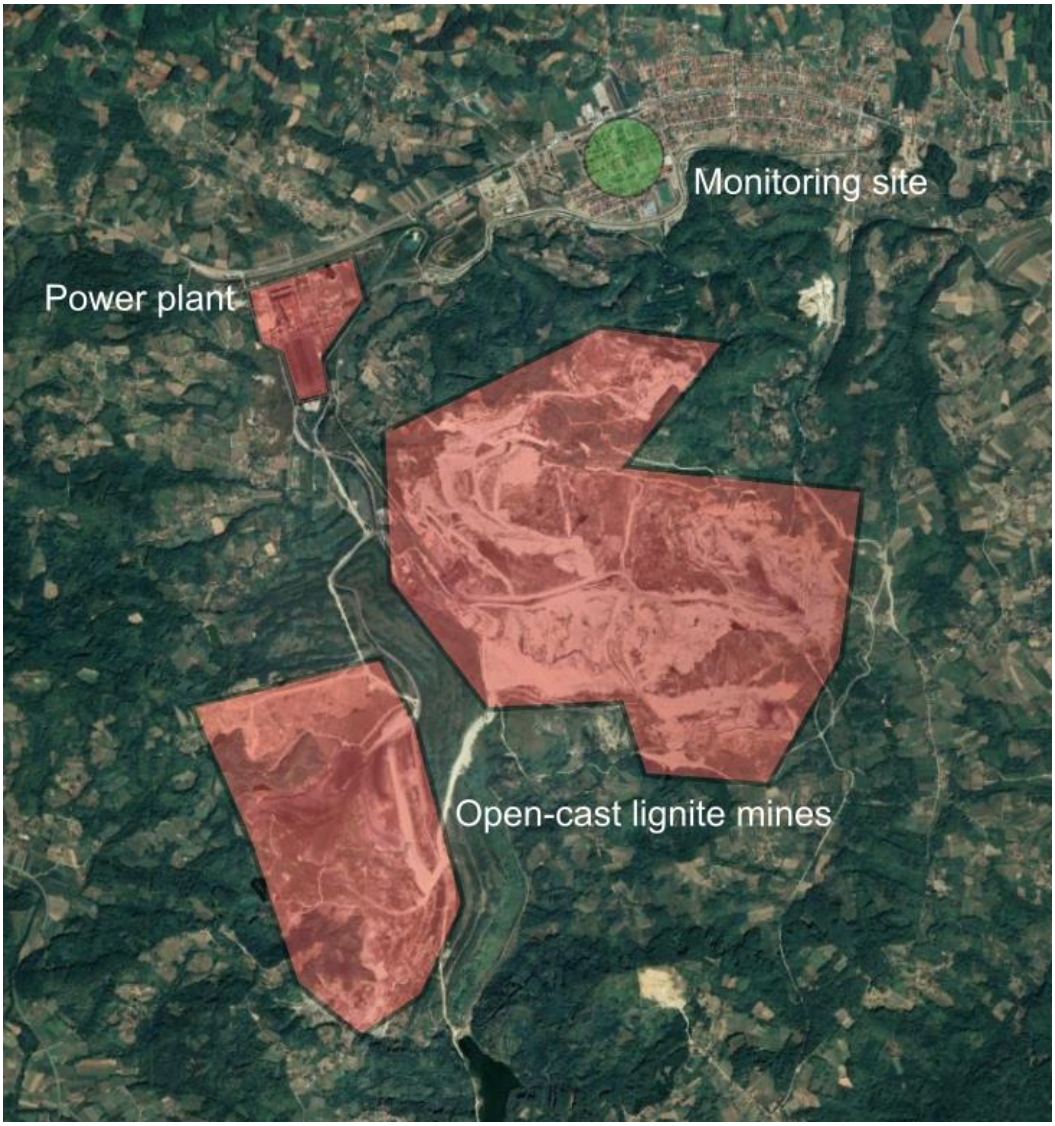

Image 1: *Distribution of coal facilities (red areas) in relation to the independent air quality monitoring location (green circle). Map source: Google Earth 2023*

The power plant is notorious Europe-wide for its extremely high emissions of sulphur dioxide (SO_2) into the air. With an average of around 85,000 tonnes of SO_2 emissions during the last five years, most of the time it is in the top five polluters in Europe in this category.[1] Despite the exceptionally high stack of the power plant, the town of Ugljevik is still suffering from serious air pollution.

In the last two decades, the entity-owned electricity production company that is managing the power plant, Elektroprivreda Republike Srpske, has gradually taken steps to reduce this pollution with the installation of desulphurisation equipment.

Back in 2009 a EUR 85 million financing contract was signed with the Japan International Cooperation Agency (JICA), but construction started only in 2017. The equipment officially started test operations in 2019, but then in early 2020 it was reported that there were technical problems with the plant's dust filters, whose proper functioning is a precondition for the desulphurisation equipment to be operational. A year later, in

[1] Continental Europe without the European part of Russia.

February 2021, the power plant sought technical assistance to resolve the problems and obtain an operating permit for the desulphurisation equipment. However, based on the official emissions inventory of the power plant,[2] the equipment was still not operational at the end of 2023, four years after the test operations started.

The BiH / EU air quality legal framework and World Health Organisation (WHO) standards

Air quality monitoring and management in Republika Srpska is regulated by the *Law on air protection.*[3] This law also regulates air quality monitoring.

The *Regulation on the establishment of the Republika Srpska network of measuring stations and measuring points,*[4] determines the number and arrangement of measuring stations and measuring points in a certain zone and agglomeration, as well as the scope, type and frequency of measurements. The national network, according to the Law on air protection, needs to be established to measure local, regional and cross-border atmospheric transfer of pollutants in the air, as well as air quality in protected natural and cultural heritage sites.

The monitoring of air quality, via the national network, is carried out by the Republika Srpska Hydrometeorological Institute for the purpose of establishing, organising and managing the air quality monitoring system in the Republic of Srpska and establishing an information system for monitoring air quality values, for the purpose of reporting on monitoring results according to prescribed formats.

The limit values against which the measurements are assessed are prescribed in the *Decree on air quality values.*[5] Compared to the EU's Ambient Air Quality Directive (AAQD),[6] the limit values are generally the same, other than the hourly limit for NO_2 which is stricter in Republika Srpska (150 µg/m^3 compared to the EU's 200 µg/m^3). The Decree also contains limit values that are not part of the AAQD, like an annual limit for SO_2, a daily limit for NO_2, and a daily and annual limit for CO.

Pollutant	Averaging period	Limit value
SO_2	1-hour	350 µg/m^3, not to be exceeded more than 24 times per calendar year
	24-hour	125 µg/m^3, not to be exceeded more than 3 times per calendar year

[2] European Environment Agency, EIONET, Central Data Repository, *EIONET*, reported 28 March 2024.

[3] Закон о заштити ваздуха („Службени гласник Републике Српске", број 124/11, 46/17)

[4] Уредба о успостављању Републичке мреже мјерних станица и мјерних мјеста („Службени гласник Републике Српске", број 124/12)

[5] Уредба о вриједностима квалитета ваздуха („Службени гласник Републике Српске", број 124/12)

[6] European Parliament and the Council, Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, *EUR-lex*, 21 May 2008.

	1 year	**50 µg/m³**
NO_2	1-hour	**150 µg/m³**, not to be exceeded more than 18 times per calendar year
	24-hour	**85 µg/m³**
	1 year	40 µg/m³
PM10	24-hour	50 µg/m³, not to be exceeded more than 35 times per calendar year
	1 year	40 µg/m³
PM2.5	1 year	25 µg/m³
CO	Daily 8-hour mean	10 mg/m³
	24-hour	**5 mg/m³**
	1 year	**3 mg/m³**
O3	Daily 8-hour mean	120 µg/m³, not to be exceeded on more than 25 days/year, averaged over 3 years

In addition, the WHO recommends different, more stringent limit values to protect the health of the population. These are the limit values used to calculate the health burden caused by air pollution. Although they are not legally binding, countries should aspire to reach these values to provide a healthy environment that will not cause severe respiratory and cardiovascular illnesses.

Pollutant	**Averaging period**	**Limit value**
SO_2	24-hour	40 µg/m³, 99th percentile (i.e. 3-4 exceedances per year)
NO_2	24-hour	25 µg/m³, 99th percentile (i.e. 3-4 exceedances per year)
	1 year	10 µg/m³
PM10	24-hour	45 µg/m³, 99th percentile (i.e. 3-4 exceedances per year)
	1 year	15 µg/m³
PM2.5	24-hour	15 µg/m³, 99th percentile (i.e. 3-4 exceedances per year)
	1 year	5 µg/m³

CO	24-hour	4 µg/m^3, 99th percentile (i.e. 3-4 exceedances per year)
O3	Daily 8-hour mean	100 µg/m^3, 99th percentile (i.e. 3-4 exceedances per year)
	Peak season	60 µg/m^3

Air quality in Ugljevik and possible sources of pollution

As part of the national air quality monitoring network, one monitoring station is placed in Ugljevik. It monitors ambient air concentrations of PM10, SO_2, NOx, NO_2 and NO. The monitoring station is placed within the grounds of the power plant, less than 300 metres from the stack. As such, it cannot properly monitor ambient air quality in the town of Ugljevik itself, so it is impossible to evaluate the air pollution affecting the town's population.

Real-time air quality measurements from Ugljevik, as well as for all of Republika Srpska, are available on the website of the Hydrometeorological Institute.[7] The website also has daily reports for the current month, monthly reports for the past six months and annual reports.

The latest published annual report from 2022. According to the report, the measurements collected for PM10 and NO_2 can be considered valid for aggregating the data, but not the ones for PM2.5 and SO_2 since they do not cover the required percentage of the year.[8]

The annual PM10 concentration was 19 µg/m^3, within the legal limit, but exceeding the WHO recommended limit value of 15 µg/m^3. The legal 24-hour limit value was exceeded on 7 days, with highest recorded daily average of 96 µg/m^3.

Measured NO_2 concentrations were within all legal limits and the annual average of 9 µg/m^3 was even within the WHO recommended limit. The highest recorded 24-hour value was 50 µg/m^3, which is significantly higher than the WHO recommended limit value of 25 µg/m^3, but from the annual report it is impossible to see how many times this limit was breached.

The coal fired power plant in Ugljevik is obviously the biggest single source of SO_2 emissions into the air. In 2023 these amounted to 97,188.71 tonnes,[9] in spite of the power plant having desulphurisation equipment. The equipment clearly did not work on a regular basis, despite testing having reportedly finished successfully in August 2022.

[7] Hydrometeorological Institute of Republika Srpska, Real-time air quality measurements, *Hydrometeorological Institute of Republika Srpska*, accessed March 2024.

[8] According to the Air Quality Directive and the national legislation of Western Balkan countries, a minimum required proportion of valid data needs to be collected for checking validity when aggregating data and calculating statistical parameters. The requirements are: 75 per cent (i.e. 45 minutes) for assessment of one-hour values; 75 per cent (i.e. six hours) for eight-hour values; 75 per cent of the hourly averages (i.e. at least 18-hour values) for 24-hour values; and 90 per cent of the one-hour values or (if not available) 24-hour values over the year for annual mean. If less than the required data is available during the analysed period, the average value for that period is not considered valid.

[9] European Environment Agency, EIONET, Central Data Repository.

Analysis of the measurements compared to BiH/EU/WHO standards

For the purposes of this analysis, the air quality in Ugljevik was monitored for a little over seven months in one calendar year, from 22 May 2022 until 31 December 2022. The monitored pollutant was SO_2, as well as basic meteorological data like temperature, humidity, pressure, wind speed and wind direction. The monitoring device was installed somewhat higher than the official guidelines, but that allowed for the site to be completely open on all sides and provide a better overview of the main SO_2 polluters. Ambient air concentrations of SO_2 remained high throughout the entire monitoring period, regardless of the season.

The SO_2 concentration in ambient air is regulated with an hourly limit value of 350 µg/m^3 that must not be exceeded more than 24 times per year, a daily limit value of 125 µg/m^3 that must not be exceeded on more than three days in one calendar year and an annual limit value of 50 µg/m^3. The daily limit value recommended by the WHO is a lot stricter – 40 µg/m^3.

In the monitored period, the hourly limit value was never exceeded and remained within the legal standards. The highest hourly value that was recorded was 347 µg/m^3 on 23 July.

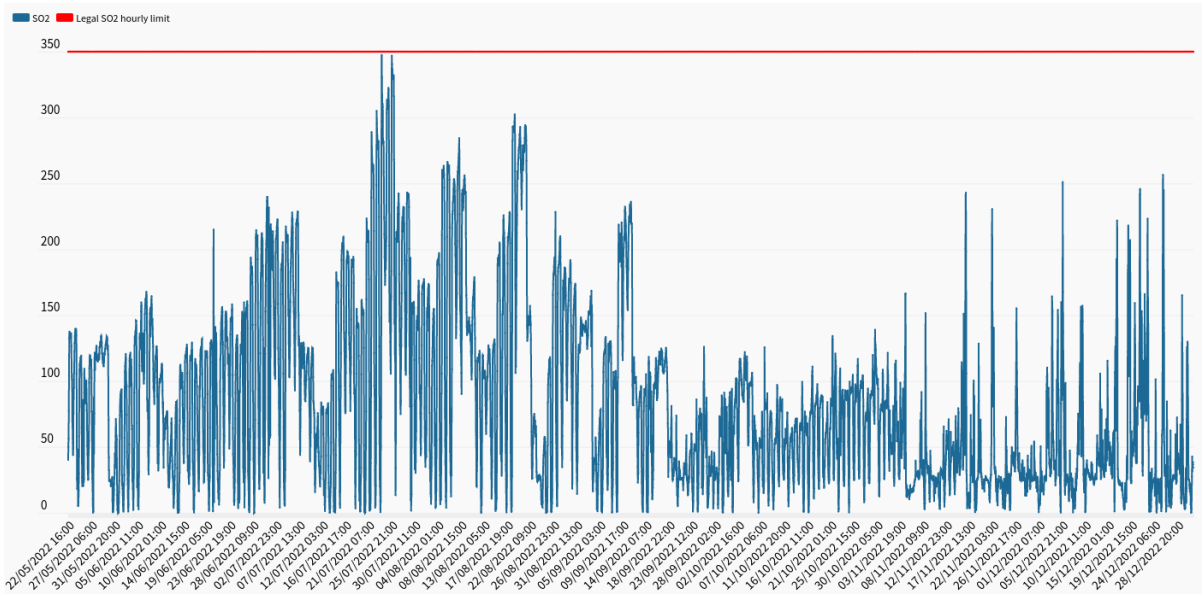

Image 2: *Average hourly SO_2 concentrations (blue line) during Ugljevik independent monitoring in 2022, compared to legal SO_2 hourly limit (red line).*

However, because SO_2 concentrations were continuously high, the legal daily limit value was exceeded 43 times. The highest concentration was 269 µg/m^3 on 20 August, more than double what is legally allowed. The recommended WHO limit value was exceeded on 180 of the 224 total days monitored, which means that on 80 per cent of the days, the air was more polluted than the health protective recommended limit.

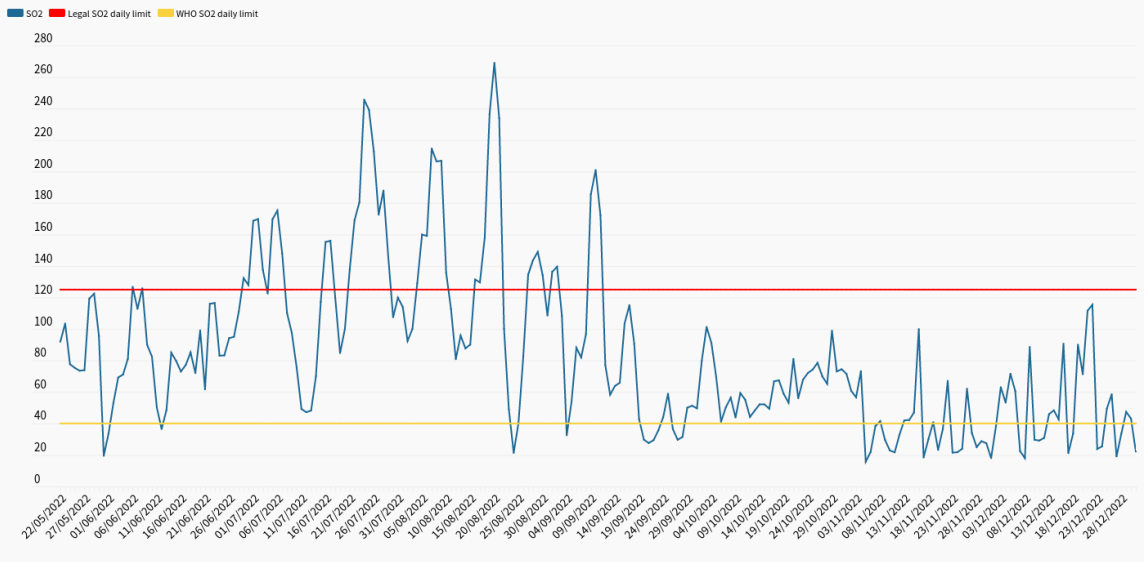

Image 3: *Average daily SO_2 concentrations during Ugljevik independent monitoring in 2022, compared to legal SO_2 daily limit (red line) and WHO recommended SO_2 daily limit (yellow line).*

Identification of sources of pollution

In order to identify the possible sources of the high SO_2 pollution, the 30-minute mean values were used to determine the peaks in pollution. The following images display several of the highest peaks of SO_2 pollution in Ugljevik during the monitoring period.

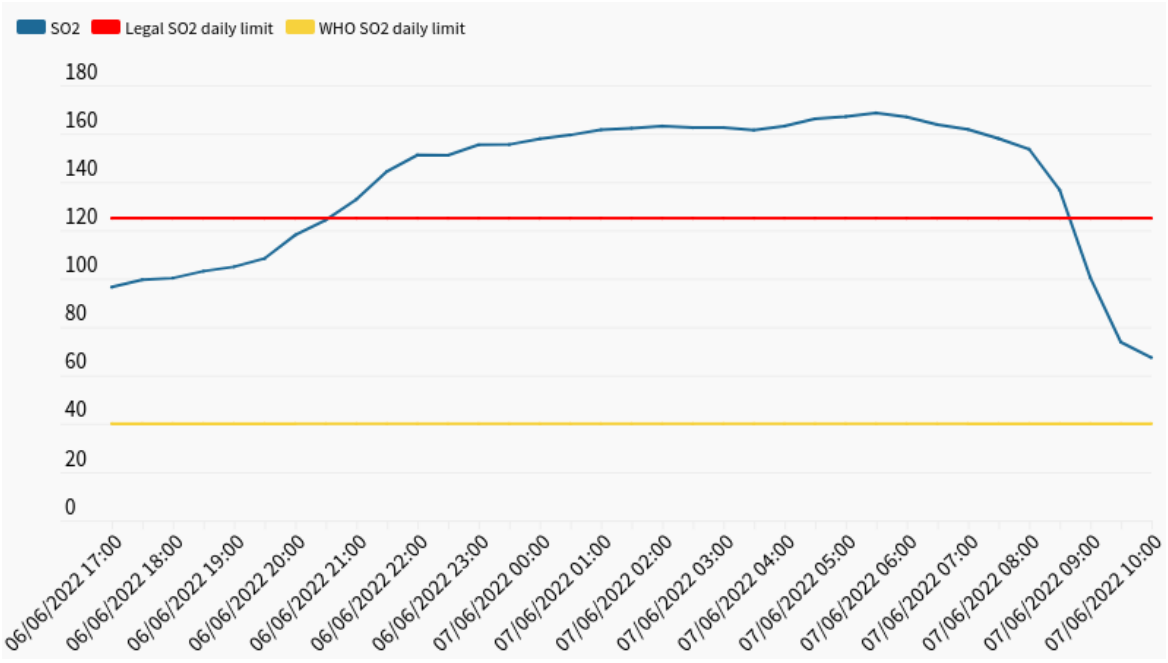

Image 4: *30-minute SO_2 concentrations (blue line) in Ugljevik between 6 June 2022 17:00 and 7 June 2022 10:00. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

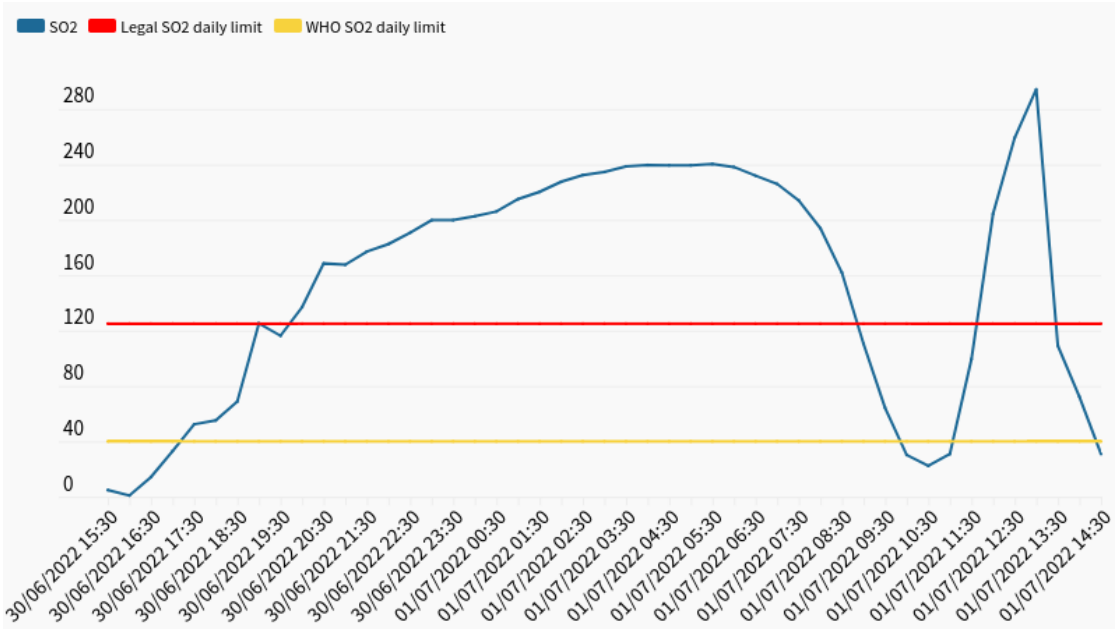

Image 5: *30-minute SO_2 concentrations (blue line) in Ugljevik between 30 June 2022 15:30 and 1 July 2022 14:30. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

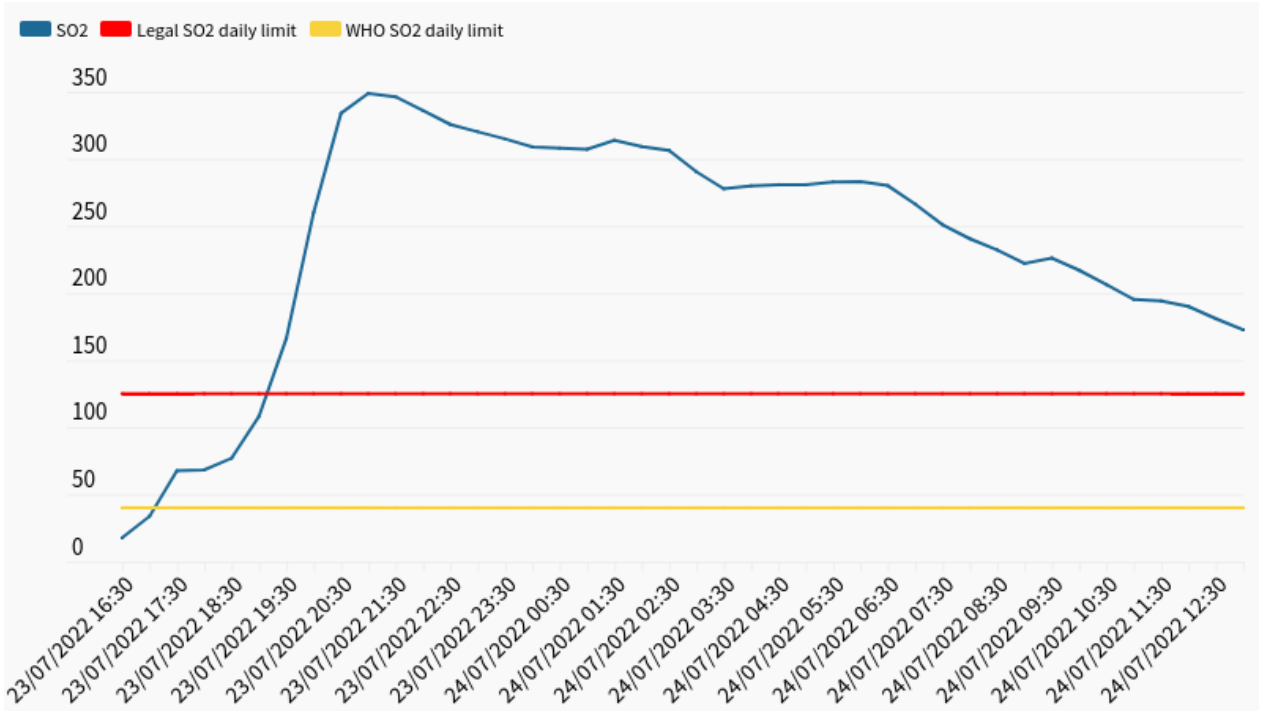

Image 6: *30-minute SO_2 concentrations (blue line) in Ugljevik between 23 July 2022 16:30 and 24 July 2022 12:30. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

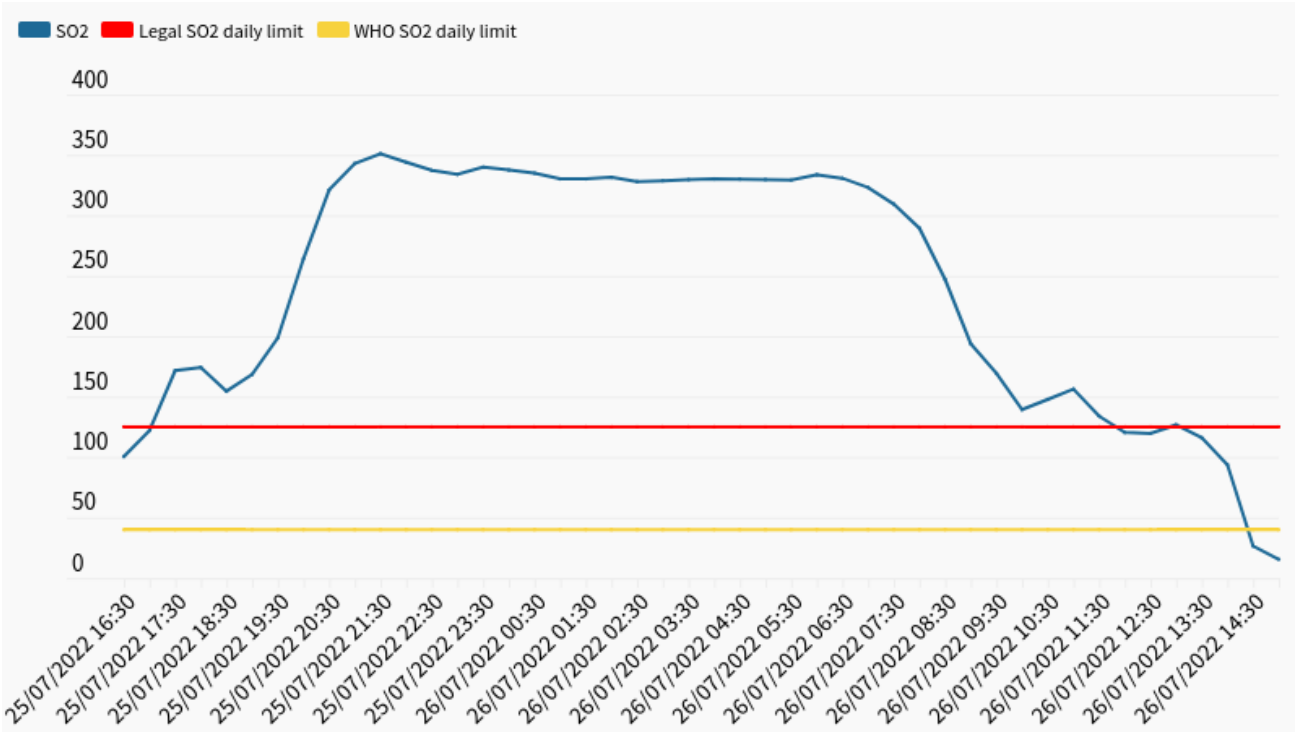

Image 7: *30-minute SO_2 concentrations (blue line) in Ugljevik between 25 July 2022 16:30 and 26 July 2022 14:30. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

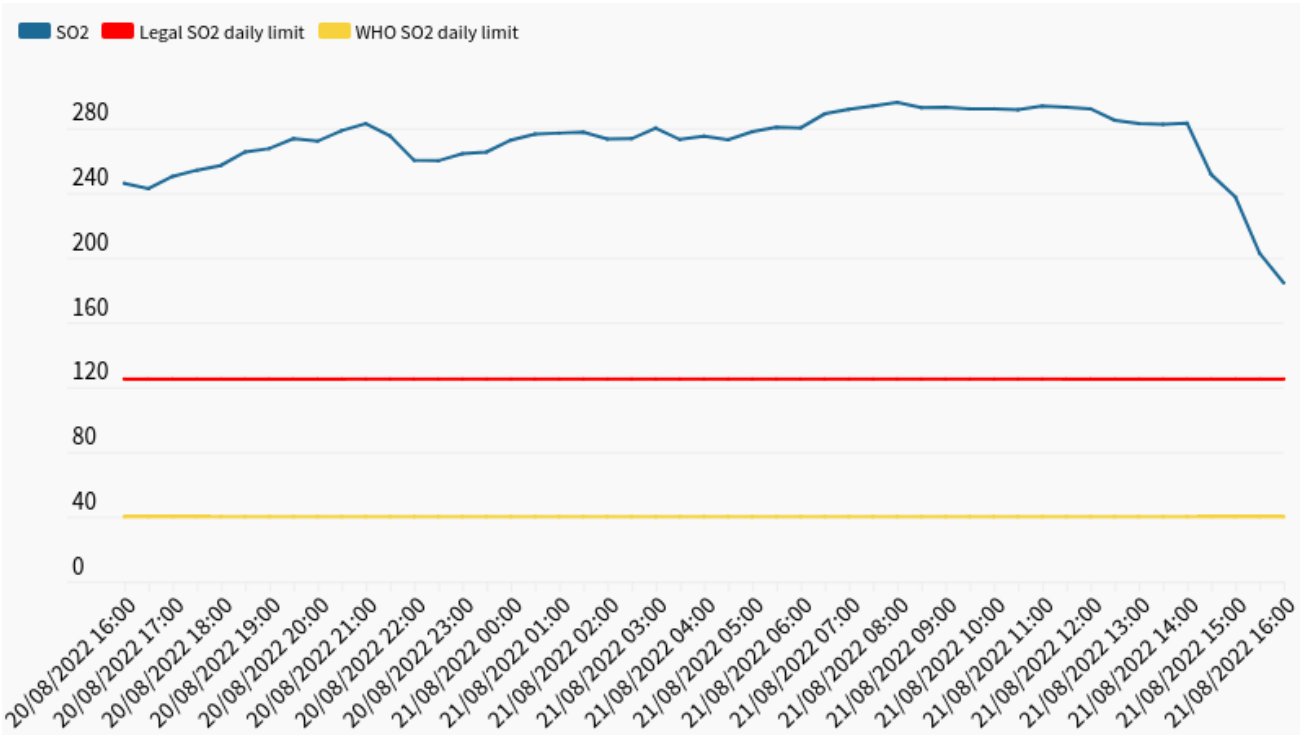

Image 8: *30-minute SO_2 concentrations (blue line) in Ugljevik between 20 August 2022 16:00 and 21 August 2022 16:00. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

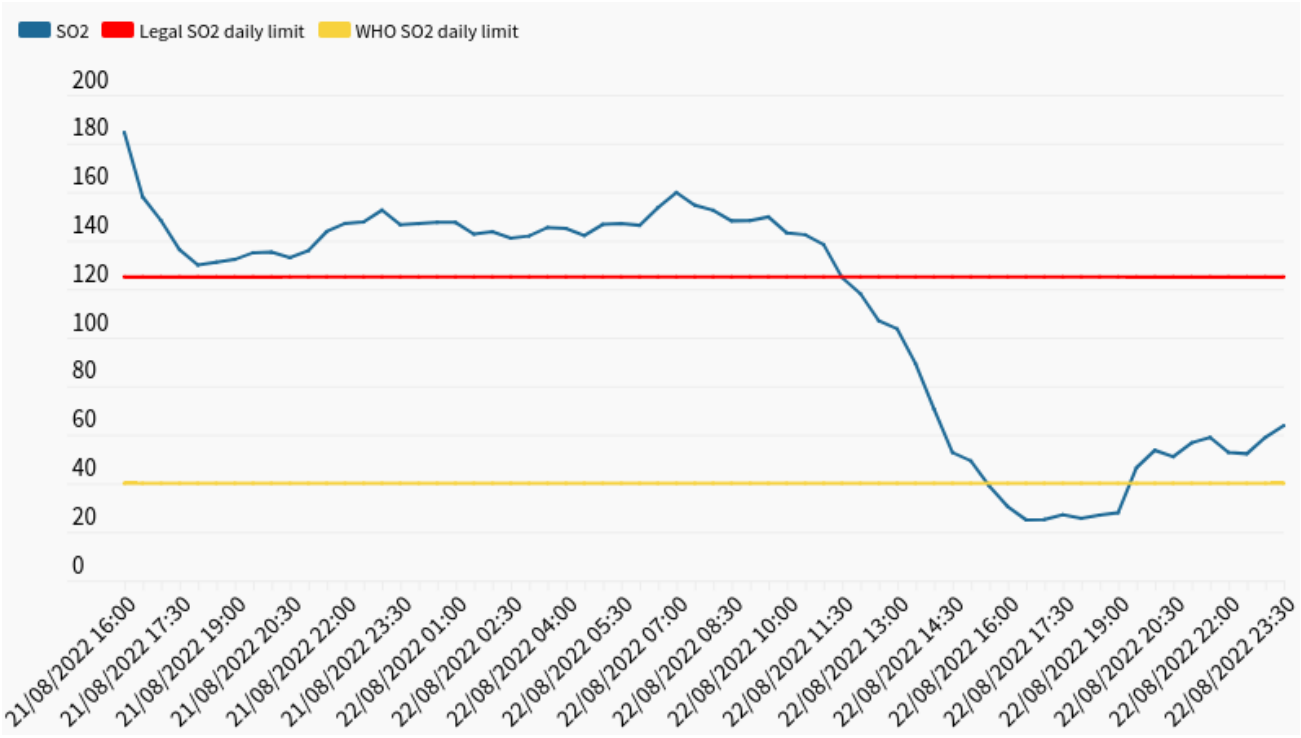

Image 9: *30-minute SO_2 concentrations (blue line) in Ugljevik between 21 August 2022 16:00 and 22 August 2022 23:30. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

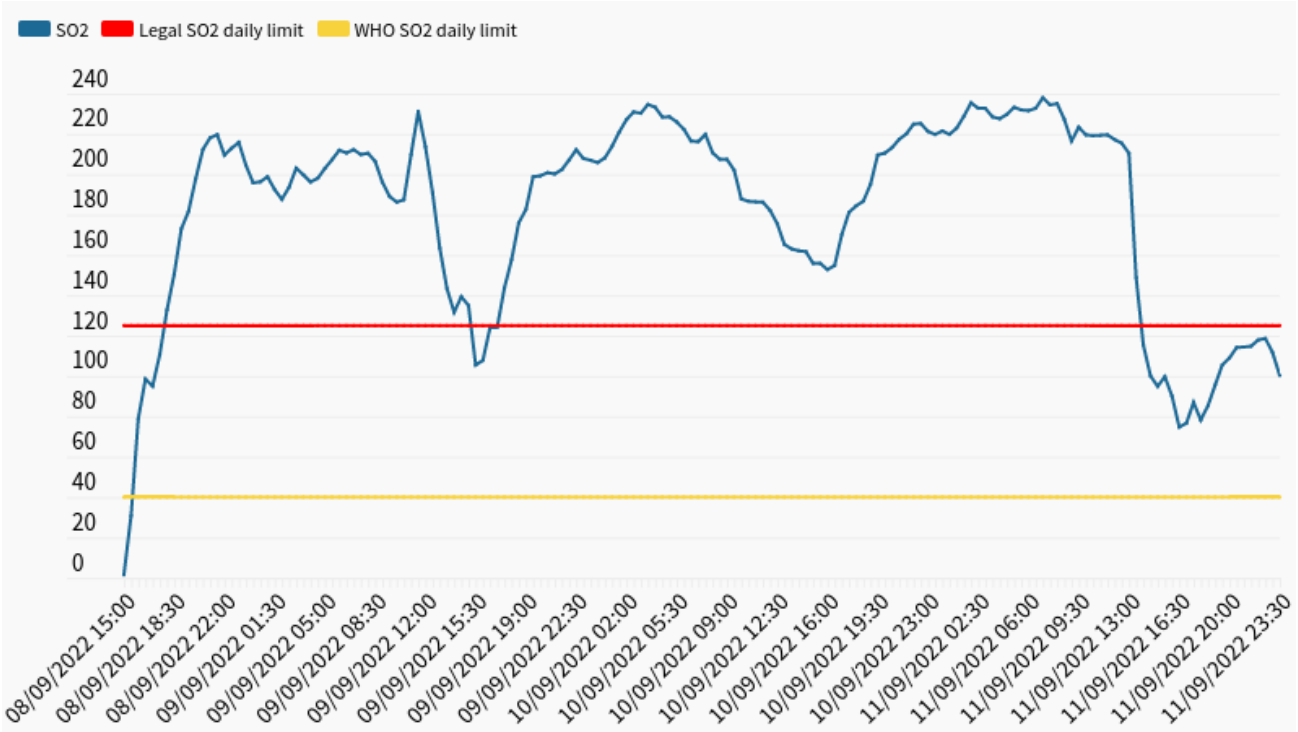

Image 10: *30-minute SO_2 concentrations (blue line) in Ugljevik between 08 September 2022 15:00 and 11 September 2022 23:30. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

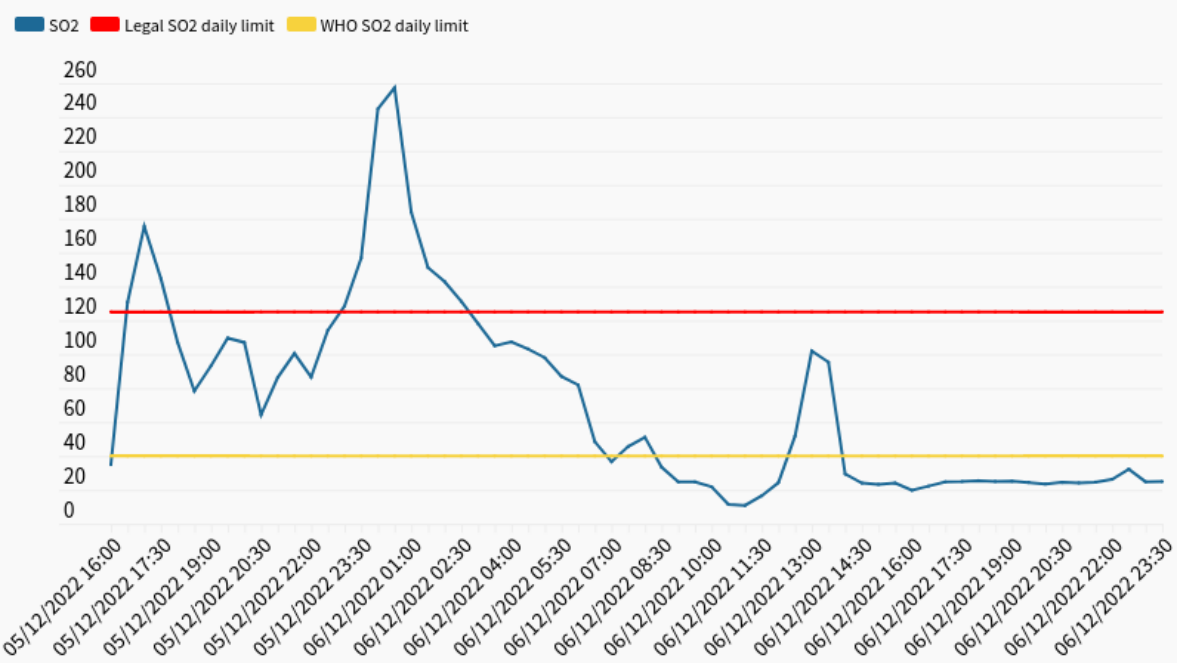

Image 11: *30-minute SO_2 concentrations (blue line) in Ugljevik between 5 December 2022 16:00 and 6 December 2022 23:30. The legal SO_2 daily limit value (red line) and WHO recommended SO_2 daily limit (yellow line) do not apply for short-term measurements and are for reference only.*

For those peaks, the wind direction data is then taken into consideration so that the general direction where the main pollution is coming from can be determined. The combination of pollution and wind direction data is displayed as a pollution rose.

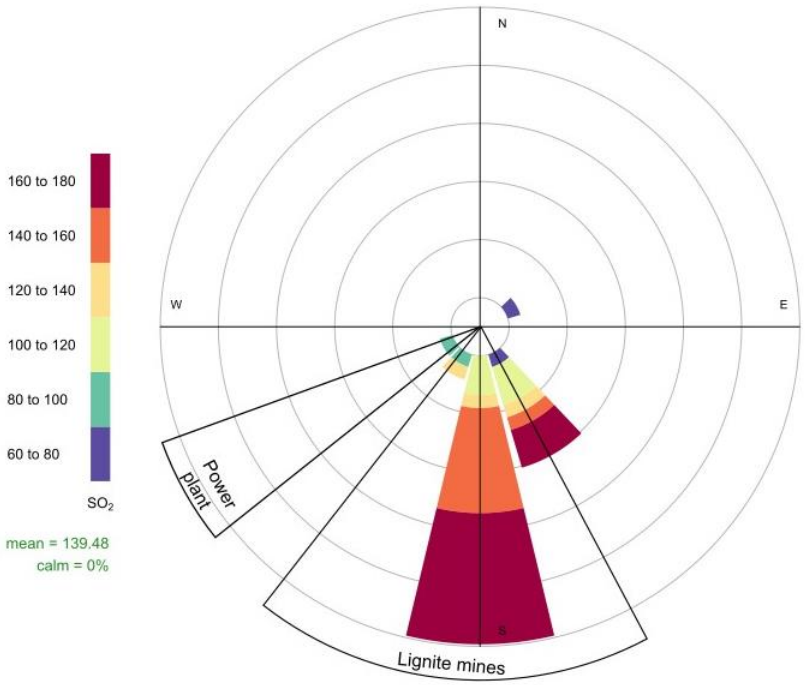

Image 12: *SO_2 exposure of the monitoring location in Ugljevik on 6-7 June 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

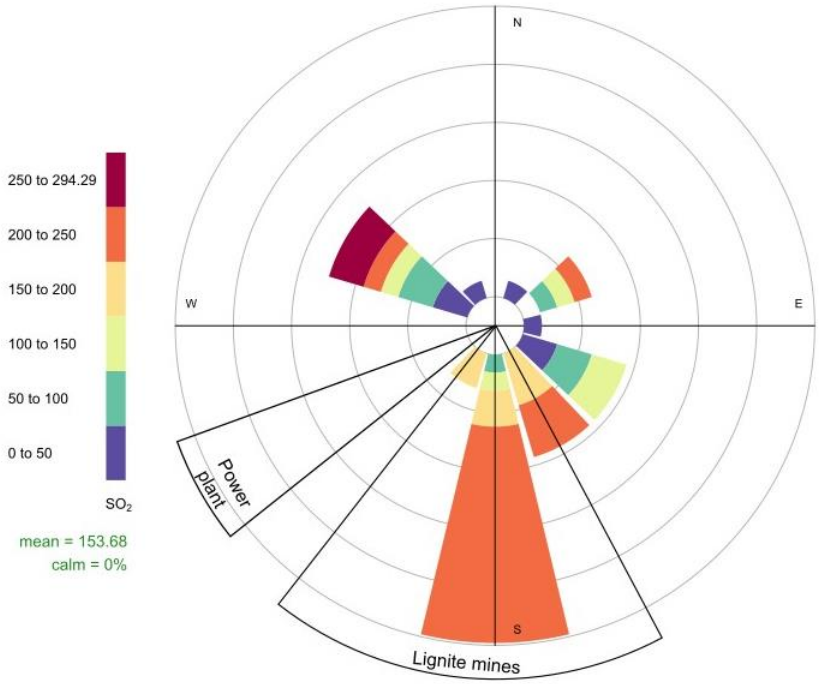

Image 13: *SO_2 exposure of the monitoring location in Ugljevik on 30 June-1 July 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

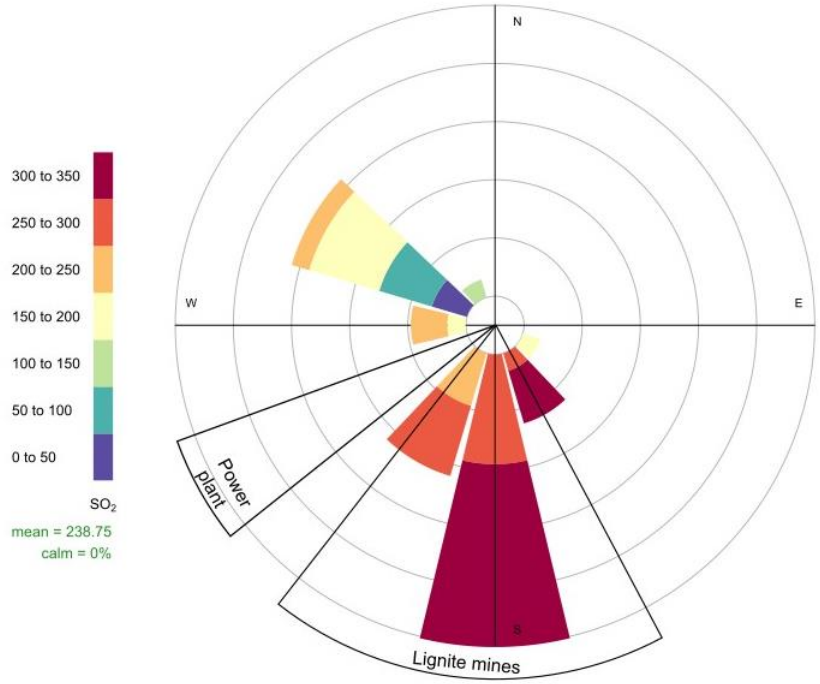

Image 14: *SO_2 exposure of the monitoring location in Ugljevik on 23-24 July 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

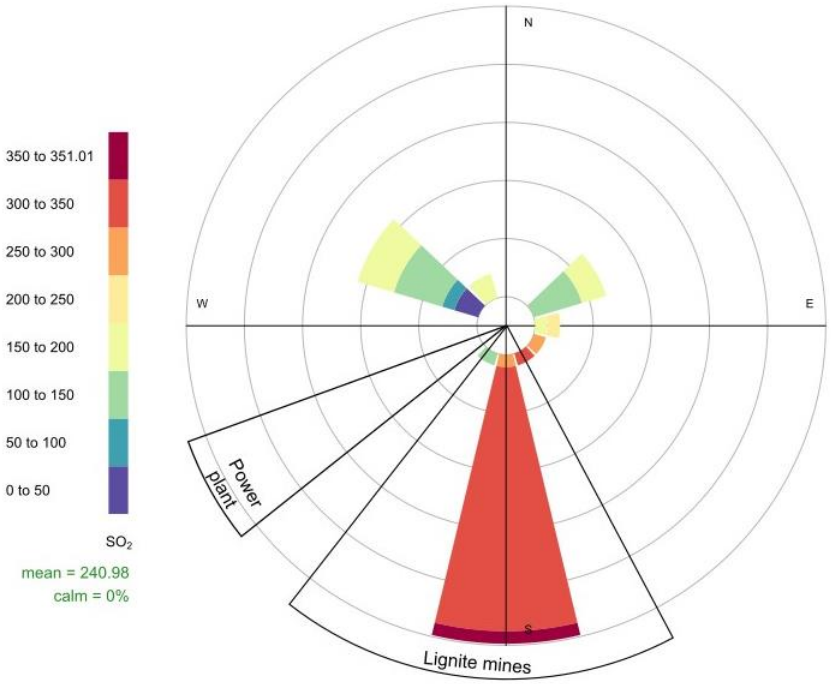

Image 15: *SO_2 exposure of the monitoring location in Ugljevik on 25-26 July 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

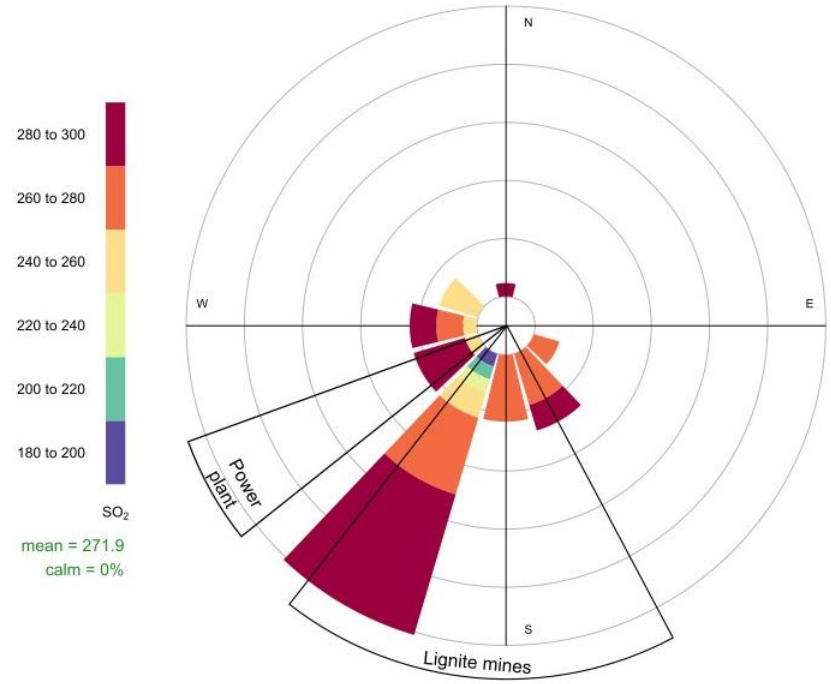

Image 16: *SO_2 exposure of the monitoring location in Ugljevik on 20-21 August 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

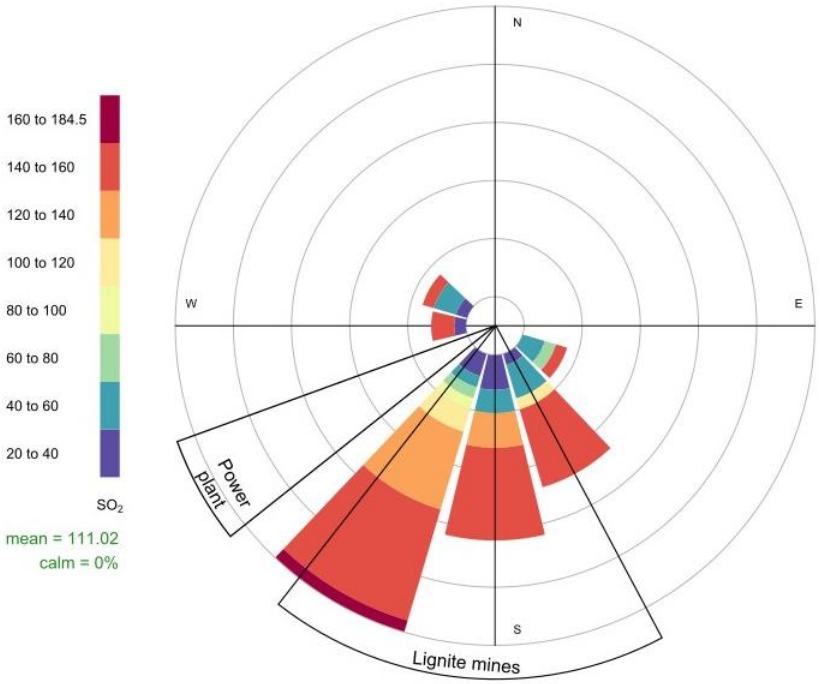

Image 17: *SO_2 exposure of the monitoring location in Ugljevik on 21-22 August 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

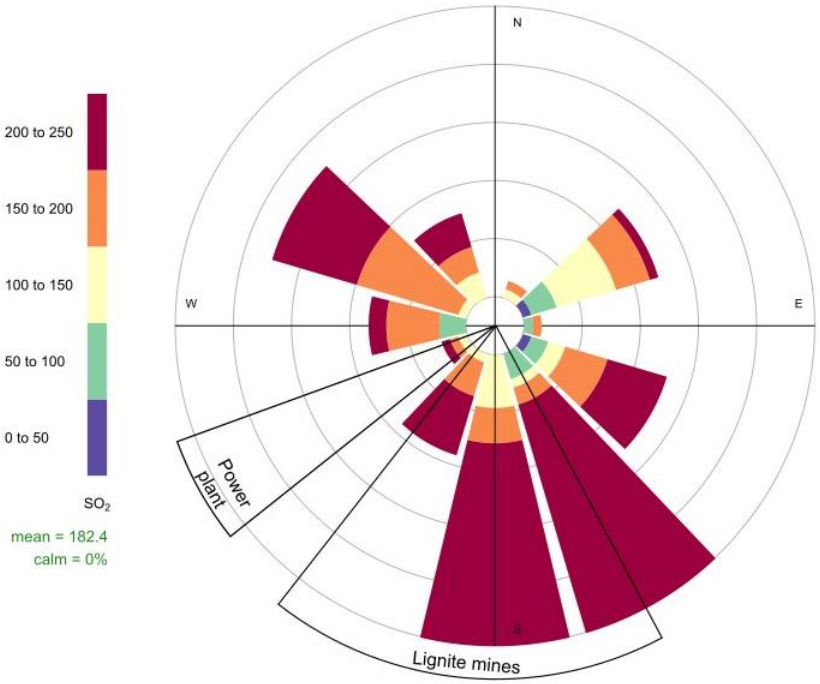

Image 18: *SO_2 exposure of the monitoring location in Ugljevik on 8-11 September 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

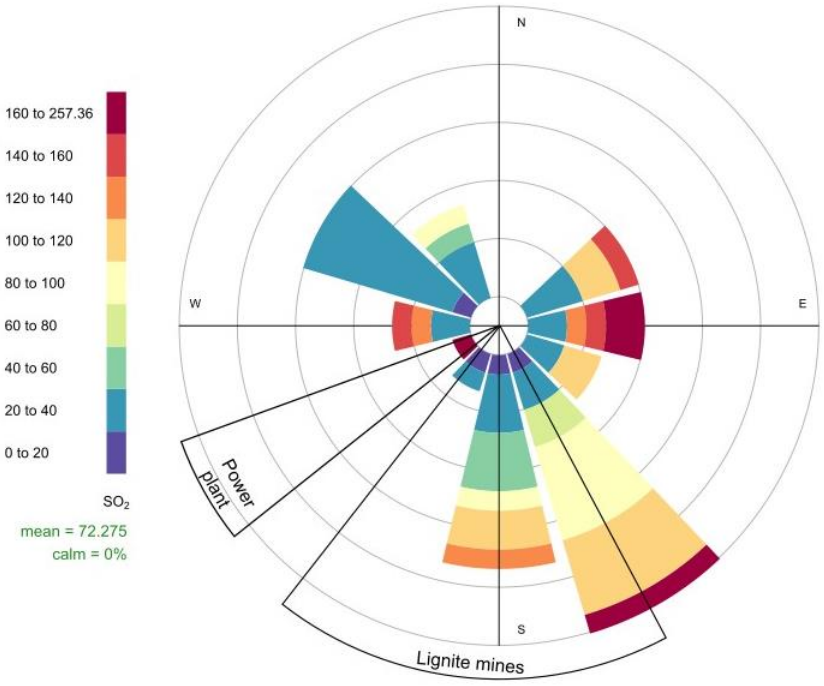

Image 19: *SO_2 exposure of the monitoring location in Ugljevik on 5-6 December 2022, compared to the direction of the major sources of pollution, exceedances per wind direction.*

From these roses, it is hard to conclude what is the main source of pollution with SO_2 that causes such high peaks. On most occasions, the simulation points to the lignite mines south of Ugljevik, but those are unlikely to produce such high levels of fugitive SO_2 emissions, unless there is spontaneous combustion of lignite in the mines that releases SO_2. One possible explanation is that the hills south of Ugljevik where the mines are located create a certain temperature inversion which is taking the flue gas that is coming out of the stack from the power plant and then is bringing it down into Ugljevik from the south. However, other than the obvious South to North wind direction that is present most of the time, the collected data is not sufficient to support this claim. Another possibility is that the stack of the power plant is tall enough to not have direct influence on ambient air quality in Ugljevik, but without any other sources of SO_2 emissions in the area that can produce such high levels of pollution it is difficult to dismiss the power plant entirely.

Contribution of the main sources of air pollution

By including the variations in wind speed in the analysis and presenting the results in a polar plot for a one-month period, the general impact of different sources can be observed, not just from the pollution peaks. To get a better understanding of the sources of pollution over a longer period, the wind direction must be complemented with wind speed. Wind can have different effects depending on its speed. Higher speeds can cause plumes from tall stacks to be brought down to ground-level or can increase particle suspension from facilities such as ash landfills and open-cast mines, but they can also dilute the concentrations of gaseous pollutants. Lower speeds can keep pollution suspended in a relatively small area over a longer period of time, or sometimes cause anomalous results for the pollution roses, especially when the monitoring area is situated in a valley with nearby mountains.

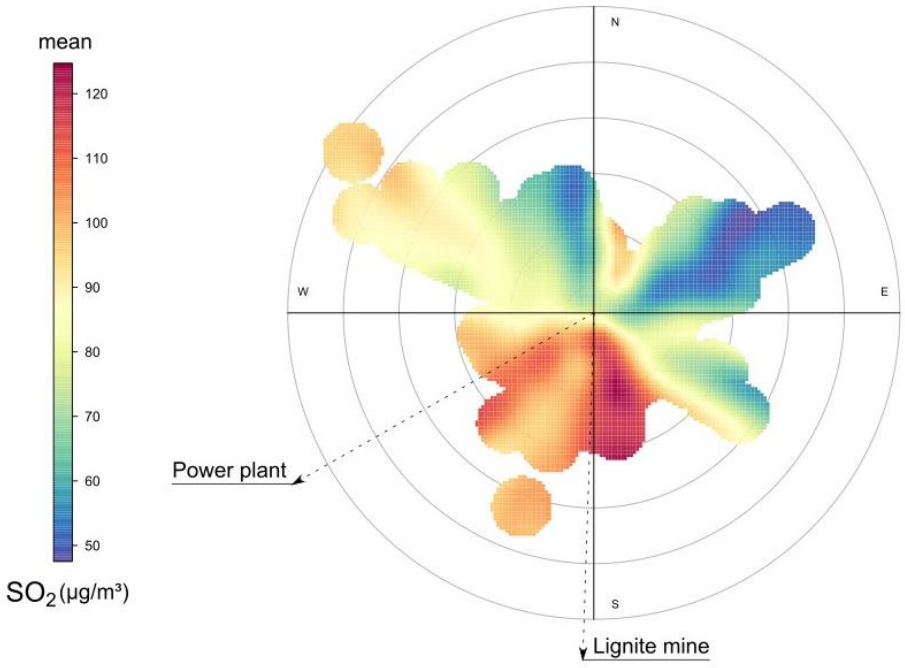

Image 20: *Modelled mean SO_2 exposure of Ugljevik during May 2022.*

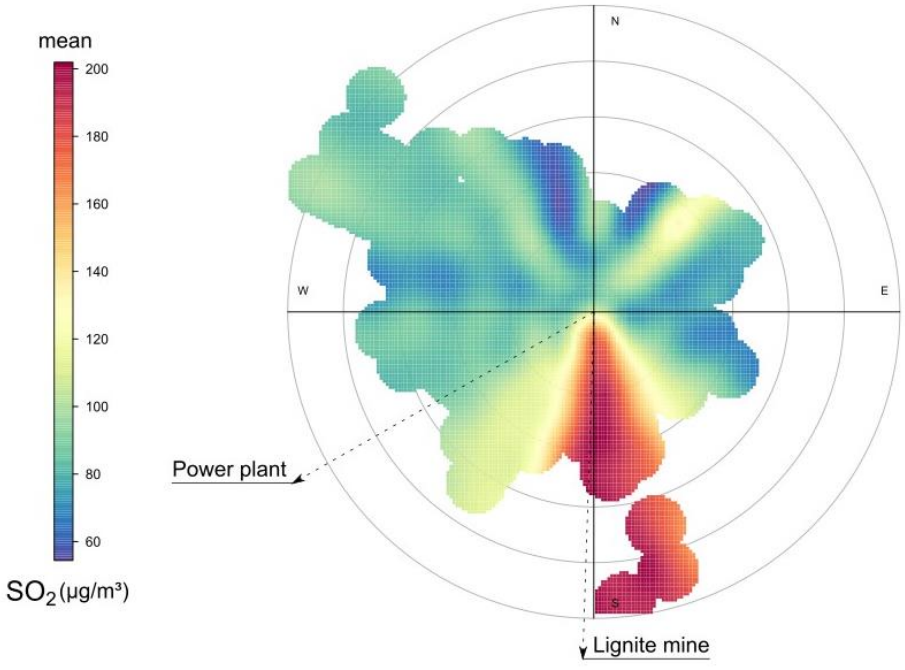

Image 21: *Modelled mean SO_2 exposure of Ugljevik during July 2022.*

When just the highest values of SO_2 concentrations, which can potentially contribute to breaches of the hourly limit value, are considered, the modelling shows similar results.

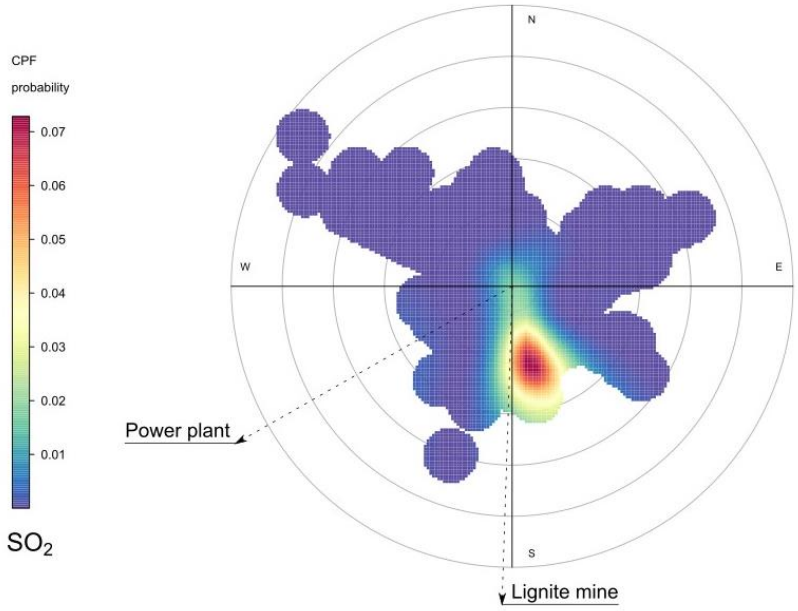

Image 22: *Polar plot of the probability of sources for the highest five per cent of the SO_2 values (95-100 percentile) in May 2022.*

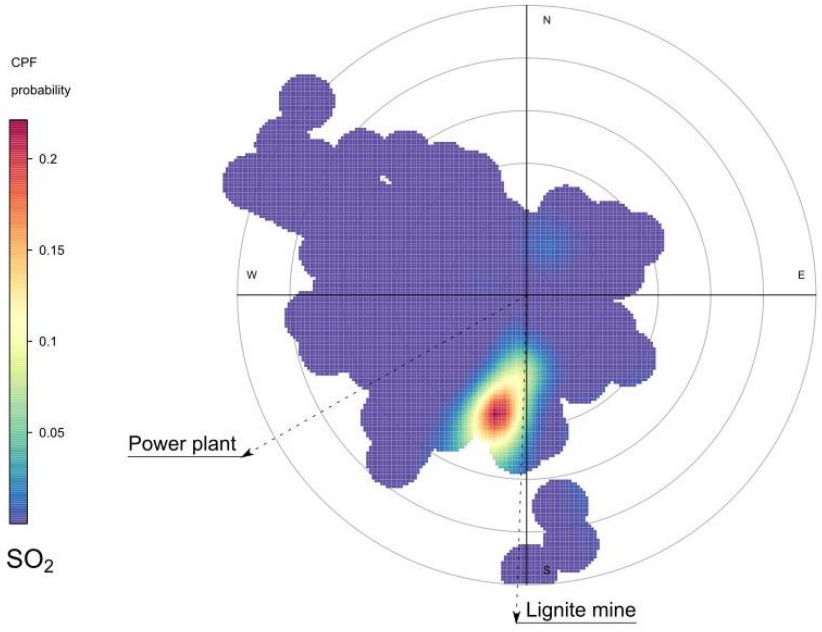

Image 23: *Polar plot of the probability of sources for the highest five per cent of the SO_2 values (95-100 percentile) in July 2022.*

The only conclusion that can be drawn from the overall analysis is that there is either some large unidentified source of SO_2 pollution south of Ugljevik, or that the gases from the stack are not brought down to street level directly but are rather significantly influenced by air movement.

Conclusions

During the long-term independent monitoring conducted in 2022, significant breaches of the legal limit values for SO_2 were recorded. Compared to the stricter WHO health protective standards, SO_2 concentrations were higher than the recommended limit on 80 per cent of the days, which can cause significant health risks.

Even by using different tools for determining the major sources of pollution, it is hard to pinpoint only one source. Most of the SO_2 pollution reached the monitoring station from the south of Ugljevik where there are not obvious sources, while the power plant is to the south-west. There are possible explanations that can compensate for this anomaly, but this kind of independent monitoring cannot provide sufficient data for any stronger claims.

Recommendations

The Republika Srpska Hydrometeorological Institute must move the air quality monitoring station to a location that is not so close to the power plant so that the actual impacts on ambient air quality in Ugljevik are measured.

The power plant operator must use the installed desulphurisation equipment or keep operating hours as low as possible to comply with ceilings under Bosnia and Herzegovina's National Emissions Reduction Plan.[10]

The lignite mine operator must monitor fugitive emissions and spontaneous combustion happening during extraction, and take appropriate measures to limit emissions from the mine.

The local authorities need to prepare a local air quality plan that foresees short-term measures to be taken by the power plant operator when air pollution is continuously above the legal limit values.

The Entity and local authorities must accelerate the work towards the energy transition and stop any plans for new coal-fired power plants in Ugljevik.

In addition, they need to begin the just transition planning process, and join the new EU initiative for support of coal affected regions that will be a continuation of the Coal Regions in Transition in the Western Balkans For this purpose, they need to start working on a bottom-up needs assessment process involving large shares of the local population and the business sector to determine the way forward in a coal-free and low-pollution region.

The health and medical community also need to be more active in informing the public about health risks due to exposure to high levels of SO_2 pollution, but also to participate in decision making processes where they can highlight the true costs of coal power generation in economic and public health deliberations, consultations and health impact assessments.

[10] USAID, National Emission Reduction Plan for Bosnia and Herzegovina, *Energy Community*, November 2015.