

INDEPENDENT DOCUMENTARY STUDY

Ambient Air in Kiselyovsk

Environmental Reality and the Limits of Public
Knowledge

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Author's Note



Natalia Zubkova.

Almost whenever the environmental situation in Kiselyovsk is discussed, a strange discrepancy emerges. What residents describe on social media, in local communities and in personal conversations often appears considerably more severe than the picture presented by official information.

When you are physically present in Kiselyovsk, much of this needs no explanation. You see the dust. You see snow that ceases to be white. You

notice the smell. At times you can literally feel the dust between your teeth. You see how closely industrial activity approaches residential neighbourhoods. For someone who lives there, all of this forms part of everyday reality.

But how can this reality be conveyed to someone who has never been to Kiselyovsk? How can something that seems self-evident to a local resident be demonstrated to an outsider?

For years, residents of Kiselyovsk have said that they experience their living conditions as an environmental catastrophe. Yet personal testimony, a photograph of black snow, a smell, or the sensation of coal dust cannot substitute for instrumental measurements. An outsider is entitled to ask: what exactly is present in the air? At what concentrations? Where and when was it measured? How frequently were permissible limits exceeded? Who recorded the exceedances? What did government authorities and industrial operators do in response?

This is where another problem arises. Information about ambient air is produced primarily by those with the capacity to take measurements: government bodies, regulatory authorities, specialised organisations and industrial operators themselves. Yet much of that information never becomes available to an ordinary resident in a form or at a level of detail that would make it possible to understand the situation as a whole.

The result is a paradox. A person living in Kiselyovsk may be entirely certain that they inhabit a severely adverse environment because they see it every day and experience it physically. But someone thousands of kilometres away who attempts to verify these accounts through open sources may encounter a far less definite picture.

This study grew out of that contradiction.

I do not want to ask readers to believe the residents of Kiselyovsk simply because they live there. Nor do I think it is right to dismiss their observations, accumulated over many years, merely because those observations have not been recorded in a laboratory protocol.

We therefore attempted something different: to take the ambient air of Kiselyovsk as a specific object of study and determine what picture can be reconstructed from documents, measurements, official statistics, inspection records, statements by regulatory authorities, data produced by industrial operators, and residents' testimony. We then asked what may be an even more important question: to what extent did this information allow an ordinary person to understand what they were breathing?

If the data contain gaps, where exactly do those gaps arise? How significant are they? Can they alter the picture of the state of the air? Why did they appear? Are they the product of shortcomings in the systems for observation and publication, or are there individual cases in which there are grounds to speak of information being deliberately omitted? And what role was played by the authorities responsible for environmental and public-health oversight?

I was not born in an environmental-monitoring table. I know Kiselyovsk as a place where I lived.

That is precisely why it is not enough for me to tell the reader: "I was there. I saw it. I breathed it."

I want to understand whether it is possible, using verifiable data, to show someone who has never been to Kiselyovsk what was happening in the city. And if it is impossible to do so completely, I want to understand—and show—why it is impossible.

Abstract

This study examines the ambient air of Kiselyovsk both as a physical medium affected by industrial activity and as an object of public knowledge. Its purpose is to establish what the available body of sources allows us to say about air conditions in an industrial city, which information gaps constrain that reconstruction, and to what extent an ordinary resident could find out, in a timely manner, what they were breathing.

The corpus brings together official replies and government reports, public-health indicators, emissions statistics, production environmental control (ПЭК; the Russian enterprise-level environmental-control system), court and regulatory materials, scientific publications, residents' complaints and testimony, photographs, video, and satellite imagery. Sources are assessed by their origin, the interests of their authors, the method by which the data were obtained, their completeness, and their independent convergence. The study consistently distinguishes the mass of emissions from concentrations in ambient air and human exposure; visual testimony from chemical analysis; and the existence of data from their actual accessibility to the public.

It is established that nine open-pit coal mines were operating simultaneously in Kiselyovsk in May–June 2020. Between 2020 and 2024, the officially recorded mass of emissions from stationary sources ranged from 16.282 to 22.335 thousand tonnes per year, including between 5.869 and 6.906 thousand tonnes of solid pollutants. Together with the industrial geography, these figures confirm a high industrial burden, but do not by themselves determine concentrations in residential areas.

According to an official reply dated 22 April 2020, the Kemerovo Centre for Hydrometeorology and Environmental Monitoring was not conducting regular observations in Kiselyovsk at that time. The absence of a state monitoring network is also confirmed for several other reference years, including 2024. Instead of a single city-wide time series, there were public-health investigations, modelled background concentrations, production environmental control, and inspections triggered by complaints. These subsystems served different purposes and did not constitute a public, continuous, and spatially representative dataset.

Taken together, the documents confirm individual exceedances of total suspended particulates and other pollutants. Ground-level photographs and video, satellite imagery, the structure of the city's industrial activity, and instrumental measurements establish that the recurring episodes of contaminated snow originate in coal-industry activities, without determining the chemical composition of every sample or the contribution of a particular operator. No regular city-wide PM₁₀ or PM_{2.5} time series was established in the body of sources examined.

Information gaps were identified across time periods, neighbourhoods, pollutants, industrial sites, primary laboratory protocols, and the final outcomes of regulatory intervention. None of the eight reconstructed public regulatory chains contains every link from the initial signal

through to repeat measurement and a durable outcome. Regulatory authorities were capable of identifying individual violations and taking action, but the system identified in the sources did not provide the public with a coherent picture of the city's combined ambient air.

There is insufficient evidence to conclude that government authorities or industrial operators engaged in a general, deliberate concealment of information. At the same time, systemic information deficiencies and the recurring failure of public regulatory chains to reach a traceable conclusion are established independently of motive.

The study ultimately concludes that, despite the established high industrial burden, an ordinary resident could know individual facts and observe pollution but could not independently reconstruct—from the available data system, with spatial precision—the composition, concentrations, and duration of the air pollution to which they were exposed at their place of residence.

Keywords: Kiselyovsk; ambient air; coal mining; industrial pollution; environmental information; monitoring; production environmental control; black snow; regulatory oversight; information gaps.

Ambient Air in Kiselyovsk: Environmental Reality and the Limits of Public Knowledge

Introduction: What It Means to Know the State of the Air in an Industrial City

A resident of an industrial city learns about the air in two fundamentally different ways. The first is direct: they see dust or darkened snow, notice a smell or a deposit on the windowsill, and associate reduced visibility with the operation of a nearby industrial site. Such observations are real and carry evidentiary value, particularly when they have a date and location, are documented in photographs or video, and recur in accounts from independent observers. But neither the senses nor an image can determine a substance's concentration, particle size, or public-health risk.

The second way is instrumental and institutional. Laboratories take samples; industrial operators conduct environmental monitoring; government bodies compile public-health indicators and emissions statistics; and regulatory authorities carry out inspections. These data can potentially clarify what cannot be established visually. Yet the mere existence of a measurement does not mean that its result is accessible to a resident, relates to their neighbourhood, was obtained at the relevant time, or permits an assessment of long-term exposure.

This study examines the ambient air of Kiselyovsk both as a physical medium and as an object of public knowledge. Its task is to establish what happened to the city's air within the limits of the available evidence, and to what extent the observation system then in place enabled an ordinary person to form a reliable understanding of it. The subject of analysis is therefore not the number of documents collected, but the relationship between the industrial burden, the phenomena actually observed and measured, and the information available to the public.

The study presupposes neither that environmental information was deliberately concealed nor that the existing system was adequate. An information gap can arise for different reasons: a substance was not measured; measurements were infrequent; monitoring locations did not represent the whole city; results were aggregated; a document existed within a government or corporate system but was not published; a publication was not preserved; or the material could not be found. These conditions cannot all be described by the single phrase "there are no data". Still less can the failure to locate a document be turned into proof that the event itself did not occur.

At the same time, caution must not create false uncertainty. If the industrial structure, technological processes, official measurements, spatial pattern, photographs, video and recurring testimony converge, the absence of a laboratory analysis of every individual snow sample does not nullify the evidence as a whole.

The study distinguishes between facts established directly; conclusions established by converging independent evidence; the most probable explanations; cases of genuinely insufficient data; circumstances that remain unestablished; and unresolved contradictions.

Principal distinctions

In this study, an **emission** means the release of pollutants from a source, often recorded as a mass over a given period. **Concentration** means the quantity of a substance in a specified volume of air at a particular place and during a particular time interval. **Exposure** means a person's contact with a pollutant, taking account of its concentration, duration and recurrence. These measures are related, but they are not interchangeable.

The annual mass of emissions characterises the scale of recorded releases, but does not tell us what a person breathed on a particular street. Concentration depends on the location and height of emission sources, their operating conditions, terrain, wind, temperature, precipitation and chemical transformations. A single short-term concentration, in turn, does not describe annual average exposure. Finally, one sample's compliance with a regulatory limit cannot be extended into a claim that conditions were satisfactory throughout the city or throughout the year.

Sources and limits of the reconstruction

The corpus brings together government reports, official replies, court judgments, environmental impact assessment materials, production environmental control data, scientific publications, emissions statistics, statements by regulatory authorities, media reports, residents' testimony and visual materials, including satellite imagery.

The source classes are not arranged in an automatic hierarchy of truth. An official document reliably establishes that an authority reported a particular result, but the truth and completeness of that result must be assessed in light of the method used and the underlying appendices. A resident's testimony reliably conveys an observed event within the limits of that person's capacity to observe it, but does not by itself determine chemical composition.

Public accessibility is assessed historically. The question is not what a researcher was able to assemble by 2026 after a prolonged search, but what an ordinary resident could find and understand at the time of the event. An archived copy of a disappeared webpage is important to the reconstruction, but it does not transform a fragmentary publication in the past into a functioning public-information system.

1. Kiselyovsk as a City with a High Industrial Burden



Open-pit coal workings and mining transport equipment, 22 January 2019. Kiselyovsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

1.1. Not a Label, but the Physical Structure of Production

It is not enough simply to call Kiselyovsk a coal-mining city. To answer the question of whether it bears a high industrial burden, it is necessary to show the physical structure of the activity: how many sites were operating simultaneously, which processes produced emissions, and how industrial territory related spatially to residential areas.

In this study, “high industrial burden” does not describe Kiselyovsk’s position in a ranking of Russian cities: the source corpus contains no comparable ranking dataset. It is an operational description of a territory in which numerous large open-pit mining sites and associated industries are concentrated at the same time, a substantial mass of emissions is recorded each year, and sources of environmental impact overlap spatially with the urban environment. A comparative claim that the burden was “higher than in a particular other city” would require a separate normalised dataset and is not made here.

The clearest dated snapshot was found for May–June 2020. The industry publication *Ugol Kuzbassa* (*Coal of Kuzbass*), issued as a joint project with the regional office of Rosstat, reported that no operating underground mines remained in the city and that nine open-pit mines were in operation. The list comprised the Kiselyovsky, Polyany, Lugovoye, Invest-Uglesbyt/Yuzhny, Shakhta No. 12 LLC and Oktyabrinsky open-pit mines; the Vakhrushevskoye field of the Krasnobrodsky open-pit coal mine; Uchastok Koksovy; and the Karagailinskoye mine administration (*Ugol Kuzbassa* and Kemerovostat 2020; Appendix, Table 5). **The transliteration and legal form of each operator name remain subject to bibliographic verification.**

The legal names of some operators may contain the Russian word for an underground mine (*shakhta*) or mine administration (*shakhtoupravlenie*), but for the analysis of air pollution the physical method of extraction is what matters. The 2020 source groups all nine listed sites specifically as operating open-pit mines. Typical dust-generating activities at such sites include overburden removal and coal extraction, breaking up and moving the rock mass, loading, transporting coal and rock in mining vehicles, operating haul roads, and handling material.

This does not mean that every site generated an equal burden or that the contribution of each has already been quantified. It means that, during the same period, the city lay within the area of influence of numerous active open-pit workings.

A simultaneous list of this kind is methodologically more important than a total assembled from enterprise names spanning different decades. It avoids the error of adding together operations that closed and opened at different times to produce an artificially inflated figure. For December 2020, when measurements were taken following complaints by Natalia Zubkova, this snapshot provides evidence, close in time, of the industrial context.

1.2. The Combined Set of Sources

Documentary photograph. Railway and industrial infrastructure. Kiselyovsk, 8 March 2019. Photo: Smogman. The photograph records a visually observable condition; by itself, it does not establish chemical composition, pollutant concentration, or the contribution of a particular industrial operator.

Open-pit mining was not the only source of impacts on the air. Coal preparation, material storage and transshipment, coal-haulage trucks, and rail transport all form part of the coal-production cycle. Boiler plants and other stationary sources also operated in the city. The air in

residential areas was therefore shaped by a mixture of emissions rather than by a single operator.

Two limitations follow. First, a substance detected at a residential monitoring location cannot automatically be attributed to the nearest site: information is required about emissions composition, operating times, meteorological conditions and alternative sources. Second, the inability to separate the contributions of nine open-pit mines does not make the question of the combined burden from coal-industry activities indeterminate. For a resident, the object of exposure is the air mixture as a whole. This is what a city-wide monitoring system would have needed to characterise.

The spatial proximity of industrial operations and housing is not uniform. Some sites and transport routes directly adjoin residential areas, while others lie farther away. The expression “the average air of Kiselyovsk” may therefore conceal substantial differences between neighbourhoods.

A preliminary comparison of the 2020 monitoring locations shows that they were concentrated predominantly in the central and eastern parts of the city. Krasny Kamen, described by residents as a more exposed and cleaner neighbourhood on higher ground, is not represented by those locations (map data – source/archive file: КАРТА_ДААННЫЕ.csv; see Evidence Map). A comparison of winter satellite scenes is provisionally consistent with a lighter snow cover in Krasny Kamen on several selected dates, but this observation does not substitute for measurements of ambient air and is used here only as supporting evidence of spatial heterogeneity (Copernicus Sentinel-2; Appendix, Table 11).

1.3. Reported Mass of Emissions

The 2024 state report contains a retrospective municipal time series for emissions from stationary sources in the Kiselyovsk Urban District. The total recorded mass was 22.335 thousand tonnes in 2020, 17.622 thousand tonnes in 2021, 21.512 thousand tonnes in 2022, 16.282 thousand tonnes in 2023, and 19.284 thousand tonnes in 2024 (Ministry of Natural Resources and Environment of Kuzbass 2025, 291–292; Appendix, Table 3). Thus, even the minimum value in the five-year series exceeded 16 thousand tonnes per year, while the maximum exceeded 22 thousand tonnes.

Documentary photograph. Open-pit coal workings in a winter landscape. Kiselyovsk, 2 January 2019. Photo: Smogman. The photograph records a visually observable condition; by itself, it does not establish chemical composition, pollutant concentration, or the contribution of a particular industrial operator.

Solid pollutants accounted for between 5.869 and 6.906 thousand tonnes during these years. This is a particularly significant category for ambient air and visible deposition, although the statistical category “mass of solid pollutants” provides no information about particle-size distribution and does not substitute for PM₁₀ or PM_{2.5} measurements.

The gaseous component was reported separately for sulfur dioxide, carbon monoxide, nitrogen oxides, volatile organic compounds, and hydrocarbons excluding VOCs. Sharp changes in the last category require caution: they may depend on methane, changes in the set of reporting facilities, and the accounting methodology.

The total tonnage therefore cannot be turned into a simple graph stating that “the air became better” or “the air became worse”. The series establishes a narrower but important fact: every year, government statistics recorded a substantial mass of stationary industrial emissions in the urban district.

It does not establish the concentration near a particular home, provide the spatial distribution, describe short-term peaks, or allow the contribution of mobile sources or surface dusting to be isolated. The decline in total mass from 22.335 thousand tonnes in 2020 to 16.282 thousand tonnes in 2023 does not by itself demonstrate a corresponding improvement in the air residents breathed. Nor is the subsequent rise to 19.284 thousand tonnes in 2024 a direct measurement of increased exposure.

1.4. Interim Answer

Kiselyovsk is a city with a high industrial burden. This conclusion is established not from the city’s reputation or a single image, but by converging direct evidence: the simultaneous operation of nine open-pit mining sites in the documented 2020 snapshot, the presence of associated production and transport processes, and the substantial mass of stationary-source emissions recorded each year.

The level of evidence is high with respect to the existence and material significance of the industrial burden itself. These data do not establish the population’s precise exposure or the contribution of each site.

This distinction leads to the study’s next question: was the scale and spatial complexity of the industrial system matched by an equally developed system for monitoring the air in residential neighbourhoods?

2. The Atmosphere as an Indicator of Environmental Conditions



Urban development and visually observable emissions, 2 January 2019. Kiselyovsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

2.1. Why Air Pollution Is Particularly Noticeable

Air is not the only environmental medium affected by industry, but it is particularly revealing in Kiselyovsk for three reasons.

First, a substantial proportion of open-pit mining operations produces emissions directly into the atmosphere. Second, the transport of airborne contaminants rapidly connects an industrial site with residential territory, and the resulting pattern changes with the wind and operating conditions. Third, part of the pollution becomes observable without an instrument—in the form of dust deposits, reduced visibility, or darkened snow cover.

Visibility is both helpful and potentially misleading. Dark snow can reliably establish the deposition of visible particles when the place and date of the image are known. But snow accumulates contamination over a period of time, whereas an air sample characterises a defined interval. Colour does not reveal the concentration of particles in the air people breathe, nor does it detect invisible gaseous pollutants. Visual and instrumental evidence therefore answer different questions and should be compared, not treated as mutually exclusive.

2.2. Which Pollutants Appear in the Materials Located

Total suspended particulates, nitrogen dioxide, carbon monoxide and sulfur dioxide recur across the systems identified. Some public-health datasets also include soot, formaldehyde, phenol and benzo[a]pyrene. The production environmental control programme at Shakhta No. 12 LLC additionally included xylene, manganese compounds and iron oxide. The lists of pollutants, however, differed between programmes (Appendix, Table 4; the sources for the individual programmes are identified row by row).

The gap between measurements of total suspended dust and measurements of the PM₁₀ and PM_{2.5} fractions is particularly important. The documents located confirm measurements of total dust and individual exceedances. No regular city-wide PM₁₀ or PM_{2.5} time series was established in the body of sources examined. These indicators cannot be reconstructed by converting total dust measurements without information about particle-size distribution.

The system consequently recorded part of the particulate burden, but did not produce a comparable time series for the fractions most significant to assessments of long-term inhalation exposure.

2.3. The Combined Nature of the Impact

For the central question of this study, it is not necessary to prove that every black-snow episode was caused by the same operator. It is sufficient to test a more meaningful causal proposition:

- whether the city contains numerous major coal-related sources;
- whether the observed deposition is consistent with the nature of their operations;
- whether such events recur in different years;
- whether ground-level observations are consistent with the spatial pattern visible in satellite imagery;
- whether laboratories recorded suspended particulates; and
- whether there are evidence-based alternative explanations on a comparable scale.

For the episodes in 2019 and 2022, the timing of ground-level photographs or video corresponds with cloud-free winter Sentinel-2 scenes showing spatial heterogeneity in the snow surface (Copernicus Sentinel-2 scenes of 11 February 2019 and 8 February 2022; register of visual sources).

For February 2019, a court record separately connected exceedances of suspended particulates at a residential monitoring location and at the boundary of the sanitary protection zone with the Cherkasovskaya coal-preparation plant. The reported results were 2.4 times the maximum permissible average daily concentration (ПДК_{с.с.}; Russian regulatory limit) at the residential

location, and 1.2 and 1.38 times the maximum permissible single-exposure concentration (ПДКм.п.; Russian regulatory limit) at the boundary of the sanitary protection zone (Kiselyovsk City Court 2020, case No. 1-148/2020; Appendix, Table 8).

In December 2020, an official reply from Rospotrebnadzor recorded total suspended dust of 0.7 mg/m³ on 15 Kommunalnaya Street, against a maximum permissible single-exposure concentration (ПДКм.п.; Russian regulatory limit) of 0.5 mg/m³. Carbon monoxide was measured at 7.15 mg/m³ against the applicable maximum permissible concentration of 5 mg/m³ (Rospotrebnadzor, reply concerning Zubkova's complaints, December 2020; Appendix, Table 6).

These data do not form a single quantitative time series and do not apportion responsibility among all sources. Together with the industrial structure and recurring visual episodes, however, they allow the analysis to move beyond the proposition that “the origin of the dark snow is unknown”.

The best-supported general conclusion is that the recurring episodes of visible snow contamination originated in coal-industry activities. The level of attribution differs between individual episodes and sites. For the Cherkasovskaya coal-preparation plant in 2019, it is substantially higher because of the measurements linked to the legal proceedings.

2.4. Interim Answer

The state of the atmosphere can serve as a revealing indicator of environmental conditions in Kiselyovsk. Ambient air directly receives emissions from open-pit mining, processing, transport and fuel combustion, and the resulting impact appears both in instrumentally recorded concentrations and in recurring observable deposition.

The level of evidence is high for the existence of an industrial burden and for individual pollution episodes. Converging independent evidence establishes that the recurring contamination of the snow cover originated in coal-industry activities.

At the same time, the population's quantitative chronic exposure, PM₁₀ and PM_{2.5} concentrations, and the shares attributable to individual operators remain insufficiently determined. This is no longer because there are no grounds for identifying an industrial burden on the air, but because of the way the observation system was structured.

3. What Is Actually Known About Ambient Air in Kiselyovsk

3.1. Not One System, but Several Disconnected Data Streams

The air in Kiselyovsk cannot be described by a single ready-made observation series. Information is distributed among several distinct systems: Roshydromet's state network; public-health investigations and social and hygienic monitoring (the Russian socio-hygienic monitoring system); production environmental control; project-based modelling; statistics on the mass of emissions; and inspections triggered by complaints. These systems differed in purpose, frequency, monitoring locations, lists of pollutants and accessibility of results.

The existence of numerous documents is therefore not the same as completeness of knowledge. Statistics report how many tonnes stationary sources emitted during a year. Project documentation models atmospheric dispersion under specified conditions. Production environmental control examines the area affected by a particular operator. A public-health air sample answers a question about concentration at a particular location and during a particular interval. A stationary monitoring site operating under a standard programme would produce a comparable time series.

In Kiselyovsk, these forms of data were not combined into a public system capable of describing the air in residential neighbourhoods consistently over time.

3.2. The State Stationary Monitoring Network

The absence of a station belonging to the state air-pollution monitoring network is confirmed for several reference years: 2008, 2011, 2020, 2023 and 2024 (Kemerovo Centre for Hydrometeorology and Environmental Monitoring 2020; state reports for 2011, 2023 and 2024; Appendix, Tables 1 and 9). For 2024, this is stated explicitly in the state environmental report's dedicated section on Kiselyovsk. In its reply of 22 April 2020, the Centre likewise stated that regular observations were not being conducted in the city.

This wording cannot be mechanically extended to every day of the entire study period: the evidence relates to specific years and official reference points. The sequence of confirmations before and after 2020 nevertheless supports a more substantive conclusion. The available corpus contains no identified period in which Kiselyovsk was covered by a standard, regular state monitoring-station time series comparable to the published series for cities in which such stations were listed.

The absence of a station does not mean that the air was never measured. It means that one specific and fundamentally important kind of knowledge was absent: regular independent observation at a permanent location under a consistent programme. Without it, seasonal

cycles, the frequency and duration of episodes, year-to-year changes, and the persistence of exceedances are difficult to identify.

3.3. Modelled Background Concentrations

In the absence of regular observations, the Centre for Hydrometeorology and Environmental Monitoring provided background concentrations for Kiselyovsk using a calculation method. These values were used in project documentation to set emissions requirements and model atmospheric dispersion (Kemerovo Centre for Hydrometeorology and Environmental Monitoring 2020; Appendix, Table 9).

This is a lawful and practically necessary tool for project assessment where no monitoring station exists, but its purpose is fundamentally different from observation. A modelled background concentration does not state what concentration was actually recorded on a street during a particular hour or month. It depends on the methodology, input parameters and the applicability of the analogies selected.

The statement that “a background concentration has been established for Kiselyovsk” must therefore not create the impression that a measured city-wide time series exists. Within the information architecture, calculation partially substituted for the absent observations for permitting purposes, but did not provide residents with a retrospective history of the air they breathed.

3.4. Public-Health Investigations and Social and Hygienic Monitoring

State reports make it possible to reconstruct the percentage of public-health air samples in Kiselyovsk that exceeded the applicable maximum permissible concentration (ПДК; Russian regulatory limit) from 2004 to 2019. The indicator ranged from 12.1% in 2005 to 0% in 2019. Intermediate reported figures include 1.2% in 2008, 3.26% in 2011, 0.55% in 2015, 2.37% in 2017 and 2.40% in 2018 (state public-health and environmental reports for 2008–2019; Appendix, Table 2).

These figures confirm that public-health measurements were taken and that exceedances were recorded in different years. The published city-level row, however, does not disclose the number of samples, the number of exceedances, addresses, the sampling calendar, or the full list of pollutants. It therefore does not reveal whether a change in the percentage represents a change in the air, a change in the sampling programme, or both at once.

The zero reported for 2019 is particularly instructive. Its literal meaning is that the proportion of exceedances among the samples included in the calculation was 0%, or was rounded to zero. It does not establish an absence of pollution in the city throughout the year. In February 2019, a court judgment recorded three suspended-particulate results above the applicable Russian regulatory limits: 2.4 times the maximum permissible average daily concentration (ПДКс.с.) at

a residential monitoring location, and 1.2 and 1.38 times the maximum permissible single-exposure concentration (ПДКм.р.) at the boundary of the sanitary protection zone of the Cherkasovskaya coal-preparation plant (Kiselyovsk City Court 2020, case No. 1-148/2020; Appendix, Table 8).

This does not necessarily mean that either source was erroneous. The samples considered by the court may not have formed part of the annual public-health aggregate, may have belonged to a different programme, or may have been counted differently. The comparison does establish, however, that an indicator of “0%”, presented without its denominator or sampling design, cannot by itself describe every known episode during the year. The aggregate can be formally correct within its own dataset while presenting a non-specialist with a substantially more favourable picture than the available evidence as a whole.

A scientific study drawing on the regional information fund for social and hygienic monitoring for 2015–2019 confirms that a more detailed concentration dataset existed within the system. The publication does not disclose the underlying rows, addresses, dates, number of observations, or coefficients required to reproduce the analysis. Some data therefore existed, but were presented to the public mainly as a final analysis and as percentages of exceedances. This is an important distinction between the absence of measurements and the absence of public verifiability.

3.5. Production Environmental Control

The archive’s most detailed production environmental control dataset concerns Shakhta No. 12 LLC. A 2018 table contains results for five residential or boundary locations and two locations at the external spoil heap. The programme covered total dust, nitrogen dioxide, carbon monoxide, sulfur dioxide, xylene, manganese compounds, carbon and iron oxide (environmental impact assessment for Shakhta No. 12 LLC 2019; Appendix, Table 7).

This table disproves the proposition that the operator conducted no observations at all. It does not, however, turn site-specific production environmental control into city-wide monitoring. The primary protocols and sampling calendar were not found; the meteorological conditions and operating state of the sources are unknown. PM₁₀, PM_{2.5}, benzo[a]pyrene, phenol and formaldehyde are absent from the programme as extracted. Without the protocols, identical recurring values for some substances do not reveal whether they reflect the limit of determination, rounding practices, or actual concentrations.

The minutes of a 2020 public hearing state that, from 2017 to 2019, four samples were taken monthly at each of five locations, with a further 24 samples per year during blasting. Project representatives stated that 250 routine samples were taken annually, although the arithmetic described yields 240. This discrepancy does not prove that the programme as a whole was unreliable, but demonstrates the need for sampling logs. The corpus contains no complete, publicly available set of results for those years.

A scientific publication by the system's developers states that the complex was tested using the operator's real-world data from 1 to 8 October 2019 and entered long-term pilot operation in 2020. According to the authors, dust-particle concentrations and simultaneous meteorological parameters were measured every 20 minutes, concentration fields were calculated, and results were retained in an archive. A later article showed the interface as applied to the mining area of Shakhta No. 12 LLC (Schastlivtsev et al. 2021; Korchagina, Potapov and Schastlivtsev 2022).

This confirms the existence of an information infrastructure technically more detailed than the public annual aggregates suggest. The publications, however, do not disclose the numerical time series, sensor configuration, calibration, duration of actual continuous operation, or the groups of users who had access. The confirmed pilot launch must therefore neither be ignored nor treated as proof of long-term monitoring accessible to residents.

3.6. Measurements of 3 December 2020

Evidence card: document

Date: December 2020 **Organisation:** Rospotrebnadzor **Document:** Reply concerning Natalia Zubkova's complaints; the full electronic text corresponds in substance to letter No. 3007 of 15 December 2020. **What it directly establishes:** Address-specific measurements taken on 3 December 2020 and the results reported. **What it does not establish:** It does not permit the measured concentrations to be attributed to a single source; the archive contains no result of the inspection of Boiler House No. 25. **Limit concerning document details:** The outgoing number and date fields are blank in the available DOC file; the document details require comparison with the PDF that was sent or with email metadata.

The full electronic text of Rospotrebnadzor's reply retained in a personal archive, and corresponding in substance to letter No. 3007 of 15 December 2020, permits the reconstruction of one of the most informative episodes. The outgoing number and date fields are blank in the available DOC file, so the document details require final comparison with the PDF that was sent or with email metadata. The measurement content itself has been preserved in full.

The measurements were taken on 3 December following complaints by Natalia Zubkova. At 15 Kommunalnaya Street, suspended particulates measured 0.7 mg/m^3 against a maximum permissible single-exposure concentration (ПДК_{м.п.}; Russian regulatory limit) of 0.5 mg/m^3 —1.4 times the limit. Carbon monoxide measured 7.15 mg/m^3 against the applicable limit of 5 mg/m^3 —1.43 times the limit (Rospotrebnadzor, reply concerning Zubkova's complaints, December 2020; Appendix, Table 6).

The reply also reports benzo[a]pyrene values at several locations. Numerically, they are above the maximum permissible average daily concentration stated in the document. Without the complete protocol, however, the sampling duration and the validity of comparing an individual

sample with an average daily regulatory limit cannot be verified. The existence of the reported values is therefore established directly, but their multiple of the limit cannot unreservedly be presented as a proven regulatory exceedance.

The reply stated that an unscheduled inspection of Boiler House No. 25 was being prepared. No result of that inspection was found in the archive.

One week later, on 10–11 December, four samples were taken near the boundary of the sanitary protection zone of Shakhta No. 12 LLC and at 3 Rasshchupkina Street. The official reply stated that the results complied with the applicable limits, but provided neither the individual concentrations nor the precise times or operating state of the sources (Rospotrebnadzor, reply concerning Zubkova’s complaints, December 2020; Appendix, Table 8).

Documentary photograph. Haul road within an open-pit coal working. Kiselyovsk, 2 January 2019. Photo: Smogman. The photograph records a visually observable condition; by itself, it does not establish chemical composition, pollutant concentration, or the contribution of a particular industrial operator.

The two episodes cannot be reduced to the formula “first there was an exceedance, then everything returned to normal”. They involved different locations and times, and possibly different sources and conditions. The second result does not cancel the first and is not a repeat sample taken at the same place under comparable conditions.

Together, they demonstrate the system’s capacity to identify an individual exceedance and, at the same time, the available dataset’s inability to explain its duration, territorial extent, or the final outcome of the regulatory response.

3.7. Other Inspection Episodes

In 2012, following a complaint by a resident of 80 Omskaya Street, measurements of outdoor and indoor air for five substances were reported, with no exceedances found. The primary letter, dates, numerical results, and relationship between the sampling time and blasting operations were not located (*Sibdepo* 2012; Appendix, Table 8). The conclusion applies to the samples taken, but does not characterise long-term exposure.

In December 2021, inspections following reports of smog and black snow identified different violations at several facilities: non-compliance for suspended particulates at the municipal enterprise Istok; an exceedance of an emissions limit at the Krasnokamenskaya central coal-preparation plant; and other violations. Administrative proceedings and formal representations were reported, but the corpus contains neither the primary protocols nor information about implementation or repeat measurements (Prosecutor’s Office of Kemerovo Region–Kuzbass 2021; Appendix, Table 8).

By March 2024, an inspection initiated in response to media and online publications had resulted in sampling at the boundary of the sanitary protection zone of the Shakhta No. 12 LLC coal-preparation plant and near the closest residential development. The Prosecutor's Office reported suspended particulates at twice the applicable maximum permissible concentration and stated that a claim had been upheld (Prosecutor's Office of Kemerovo Region–Kuzbass 2024; Appendix, Table 8).

In November of the same year, Rosprirodnadzor reported that its analysis of the operator's submitted reports had identified no exceedances, while also announcing that a formal warning had been issued (Ministry of Natural Resources and Environment of Kuzbass 2024; Appendix, Table 8).

These reports are not directly contradictory. The first concerns physical public-health samples in a specific episode that has not yet been fully dated. The second concerns primarily a documentary review of operator environmental-monitoring reports and the Russian 2-TP reporting form for 2023. Their subject matter, period and method differed. The brief statement that “no exceedances were identified” describes only what was examined and cannot be extended to the air of the city as a whole.

In December 2024, photographs and video of dark snow in Afonino prompted a publicly announced inspection involving the Prosecutor's Office, Rospotrebnadzor and the Centre for Hygiene. Several publications confirm that a response was initiated, but all derive from a single official statement. No laboratory result, source attribution, measures taken or repeat inspection was found (publications concerning the Afonino inspection, December 2024; Appendix, Table 8).

3.8. Black Snow and Independent Observations



Winter industrial landscape. Kiselyovsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

SATELLITE OBSERVATION · COMPARABLE PAIRS

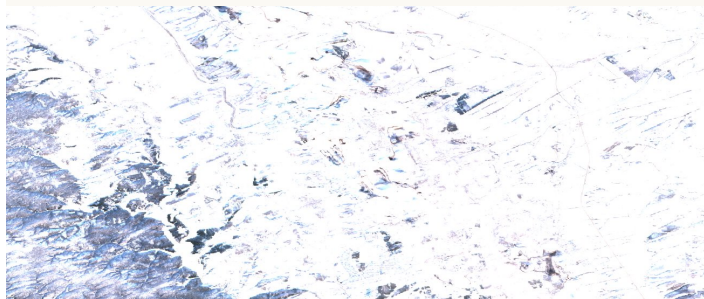
Changes in the appearance of snow cover within a single winter



22 December 2021
Sentinel-2A · 45UVV



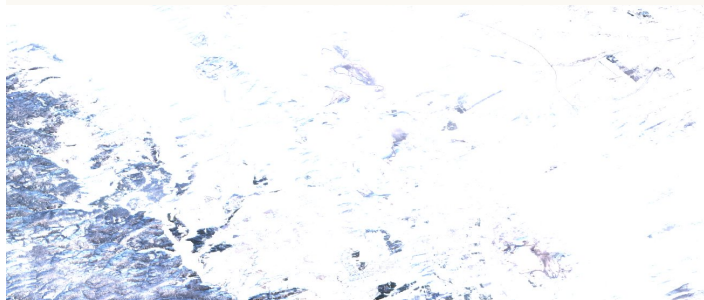
8 February 2022
Sentinel-2B · 45UVV



12 December 2023
Sentinel-2A · 45UVV



26 January 2024
Sentinel-2B · 45UVV



29 December 2025
Sentinel-2B · 45UVV



14 February 2026
Sentinel-2B · 45UVV

Three within-season pairs covering the same part of Kiselyovsk. All scenes use the same bounds (86.3–86.95° E, 53.75–54.2° N), true colour, Sentinel-2 L2A. Changes in surface reflectance and appearance are directly observable. The images alone do not establish the chemical composition or origin of dark areas, or the contribution of a particular enterprise. Source: Contains modified Copernicus Sentinel data 2021–2026; Element 84 Earth Search catalogue. Image preparation by the authors.

Satellite observation: comparable pairs

Changes in the appearance of the snow cover within a single winter

- 22 December 2021 — Sentinel-2A, tile 45UVV
- 8 February 2022 — Sentinel-2B, tile 45UVV
- 12 December 2023 — Sentinel-2A, tile 45UVV
- 26 January 2024 — Sentinel-2B, tile 45UVV
- 29 December 2025 — Sentinel-2B, tile 45UVV
- 14 February 2026 — Sentinel-2B, tile 45UVV

Three within-season pairs showing the same area of Kiselyovsk. Every image uses the same bounds: 86.3–86.95° E and 53.75–54.2° N; true colour; Sentinel-2 Level-2A. Changes in surface reflectance and appearance are directly observable. The images alone do not establish the chemical composition or origin of the dark areas, or the contribution of any particular industrial operator.

Source: Contains modified Copernicus Sentinel data 2021–2026; Element 84 Earth Search catalogue. Image preparation by the authors.

Materials produced by residents and the media confirm that dark snow was not an isolated story associated with a single author. Dated visual evidence relates to at least 2019, 2021, 2022 and 2024 (register of visual sources; Appendix, Table 10). Its evidentiary strength varies: not every image is precisely geolocated, publication may occur some time after recording, and several media outlets often republish the same video.

The strongest episodes are those in which independent classes of sources converge. A cloud-free Sentinel-2 scene from 11 February 2019 shows spatially heterogeneous darkening of the snow surface, while ground-level materials from 11–15 February record grey-black snow. A similar temporal correspondence is established between the Sentinel-2 scene of 8 February 2022 and a video published on 9 February (Copernicus Sentinel-2 scenes of 11 February 2019 and 8 February 2022; register of visual sources). In 2019, the visual record is also close in time to laboratory exceedances linked through legal proceedings to the Cherkasovskaya coal-preparation plant.

A satellite image does not determine the chemical composition of a pixel: brightness is affected by snow, exposed ground, vegetation, shadows and industrial surfaces. This is a limitation of the satellite method; it does not nullify the other evidence.

The following form a converging body of independent evidence: nine open-pit coal-mining sites operating in May–June 2020; coal-preparation facilities; coal transport and transshipment; known dust-generating processes; the officially recorded mass of solid pollutants; instrumentally recorded exceedances; recurrence over multiple years; ground-level images produced by different authors; and satellite observations corresponding in time.

The body of sources examined revealed no evidence-supported non-coal source on a comparable scale capable of explaining the character, geography and recurrence of the phenomenon together. The origin of Kiselyovsk's recurring snow-cover contamination in coal-industry activities is established by converging independent evidence.

This conclusion does not require chemical analysis of every individual snow sample. The absence of such an analysis means only that the composition of that particular sample was not determined directly. It does not make every theoretically conceivable explanation an equally supported alternative.

At the same time, the general class of origin must not be confused with individual attribution. The precise chemical and particle-size composition of the deposit, the concentration of particles in the air people breathed, and the contribution of each specific operator have not been established for every episode. For the Cherkasovskaya coal-preparation plant in February 2019, the site-specific link is strengthened by measurements close in time and by the court judgment. For Afonino in December 2024, a particular source facility has not been established in the public record. These narrower unknowns do not create uncertainty about the already established coal-industry origin of the recurring phenomenon.

3.9. What the Evidence as a Whole Establishes

The body of sources does not permit the construction of a continuous air-quality time series for the whole of Kiselyovsk. It does, however, support several positive conclusions.

First, the industrial burden was accompanied by measurable emissions of total dust and gaseous pollutants. Exceedances for suspended particulates were documented in different years and within different monitoring systems.

Second, episodes of visible snow-cover contamination recurred and are confirmed by different kinds of sources. Their origin in coal-industry activities is established by the evidence as a whole, although the distribution of contributions among operators has not been established.

Third, spatial and temporal variation was substantial. A result from a particular location and date cannot be extrapolated to the city as a whole. The absence of a distributed network is especially significant in a city containing multiple sources and dissimilar neighbourhoods.

Fourth, the system identified was better at documenting individual events and the reported mass of emissions than the population's chronic exposure. No regular city-wide PM₁₀ or PM_{2.5} time series was established. It is therefore impossible to calculate, on an evidentiary basis, what residents of different neighbourhoods were breathing and at what average daily or annual concentrations.

The conclusion of this chapter is not that “nothing is known” about the air in Kiselyovsk. Enough is known to establish a high industrial burden, actual pollution episodes, and individual samples that did not comply with applicable limits. The data are insufficient for a

continuous quantitative reconstruction of exposure. This deficiency is not an external caveat attached to the study; it is one of the principal characteristics of the information system examined.

3A. What Has Actually Been Established About Ambient Air in Kiselyovsk

HOW TO READ THE EVIDENCE



Established directly
A document, measurement, or observation directly records the fact.



Established by converging independent evidence
The conclusion follows from a consistent body of sources.



Limit of the evidence
The available information does not permit a stronger conclusion.

How to read the evidence

- **Established directly** A document, measurement or observation directly records the fact.
- ◆ **Established by converging independent evidence** The conclusion follows from a mutually consistent set of sources.
- ? **Limit of the evidence** The available information does not support a stronger conclusion.

This section brings together conclusions about the air itself, rather than documents as such. They differ in scale and evidentiary strength: some concern a particular address and hour; others concern a recurring city-wide phenomenon; still others mark the boundary of what is known. A local measurement is therefore not turned into a description of the whole city, while the absence of a city-wide time series is not turned into a claim that pollution did not exist.

3A.1. Facts Established Directly

Pollutants that were measured

Suspended particulates, carbon monoxide, nitrogen dioxide, sulfur dioxide, soot and benzo[a]pyrene were measured in Kiselyovsk within different datasets that did not form a single system. Operator and project programmes for individual industrial sites contained their own lists of pollutants and monitoring locations. The list of substances “measured at some point” is therefore broader than the list of substances “measured regularly in residential neighbourhoods”; the inclusion of an indicator in a programme does not demonstrate the existence of a continuous public time series.

Documented exceedances

A court judgment concerning the Cherkasovskaya coal-preparation plant reproduces three suspended-particulate results from February 2019. On 14 February, the concentration in a residential area was 0.36 mg/m³, or 2.4 times the maximum permissible average daily concentration (ПДКс.с.; Russian regulatory limit). On 15 and 18 February, concentrations at the boundary of the sanitary protection zone were 0.60 and 0.69 mg/m³, or 1.2 and 1.38 times the maximum permissible single-exposure concentration (ПДКМ.п.; Russian regulatory limit). This is direct documentary evidence of exceedances at the specified locations and on the specified dates. It is not a measurement of the entire city and does not permit reconstruction of the population's average annual exposure.

On 3 December 2020, Rospotrebnadzor took samples following a resident's complaint. The document records haze and a light north-westerly wind of 0.1–0.6 m/s. At 15 Kommunalnaya Street, suspended particulates measured 0.70 mg/m³ against a maximum permissible single-exposure concentration of 0.50 mg/m³—1.4 times the limit. Carbon monoxide measured 7.15 mg/m³ against the applicable limit of 5 mg/m³—1.43 times the limit. These results directly establish exceedances for two indicators at one residential location during a specific episode of weak dispersion. They do not justify attributing the result to a single source and do not automatically characterise other neighbourhoods.

The same reply reports benzo[a]pyrene exceedances at six locations. The full Protocol No. 43135 is not present in the research corpus. What is established is therefore the content of the authority's official report of exceedances; the available copy does not permit independent verification of the sampling duration, method, or validity of the comparison with the regulatory limit. This is not the same as denying the exceedance, but it requires a distinction between a result reported by an authority and one fully examined against the primary protocol.

In December 2021, public materials from a regulatory inspection reported non-compliance for suspended particulates at the municipal enterprise Istok and an exceedance of an emissions limit at the Krasnokamenskaya central coal-preparation plant. In 2024, the Prosecutor's Office reported suspended particulates at twice the applicable maximum permissible concentration at the boundary of the sanitary protection zone of the Shakhta No. 12 LLC coal-preparation plant and near the closest residential development. In these cases, the study has the authority's official public report of the result, but not the complete primary laboratory materials. The fact that a regulatory authority publicly recorded an exceedance is therefore established; detailed re-examination of the measurement is constrained by the material that was published.

Mass of emissions

The 2024 state report gives a total annual mass of emissions from stationary sources in the Kiselyovsk Urban District ranging from 16.282 to 22.335 thousand tonnes during 2020–2024, including 5.869 to 6.906 thousand tonnes per year of solid pollutants. These figures directly establish a substantial recorded emissions burden and an annual flow of solid pollutants measured in thousands of tonnes.

A tonne of emissions, however, is not a concentration outside a person's home. Gross mass does not reveal what proportion reached a particular neighbourhood, the short-term concentration, or the duration of exposure. The emissions series confirms the existence of sources of environmental burden but does not substitute for air-quality measurements.

3A.2. What Is Established by Converging Independent Evidence

The recurring particulate burden was not an isolated episode

Exceedances of suspended particulates recur in materials from different years, locations and institutional systems: the court judgment concerning the events of February 2019; Rospotrebnadzor's reply concerning the December 2020 measurements; and public reports of inspections in 2021 and 2024. These are supplemented by official data on annual emissions of thousands of tonnes of solid pollutants, dated photographs and videos produced by residents, and spatial observations of contaminated snow cover.

Together, this evidence establishes that the particulate burden in Kiselyovsk was a recurring environmental problem rather than a single chance exceedance. It does not permit calculation of the annual average concentration in each neighbourhood or the proportion of residents exposed at a particular level: that would require a comparable, continuous city-wide time series, which is absent.

Coal-industry origin of the recurring snow contamination

Ground-level photographs and videos spanning several years show recurring darkening of snow in different parts of Kiselyovsk. The events were not recorded by only one author or in only one year. Sentinel-2 scenes from 11 February 2019 and 8 February 2022 provide independent spatial context and correspond in time with ground-level materials from those periods.

The city's industrial setting included nine open-pit coal-mining sites operating in May–June 2020, coal-preparation facilities, coal transport and transshipment, and other dust-generating industrial processes. Government reporting records annual emissions of solid pollutants measured in thousands of tonnes, while instrumental measurements on specific dates recorded exceedances of suspended particulates.

These lines of evidence are not repetitions of a single report. They comprise industrial statistics, instrumental results, court and regulatory materials, ground-level observations by different authors, and satellite imagery. The body of sources examined revealed no evidence-supported non-coal alternative capable of explaining the scale, geography and recurrence of the phenomenon together.

The coal-industry origin of Kiselyovsk's recurring snow-cover contamination is therefore established by converging independent evidence. The absence of a chemical analysis for every individual snow sample does not negate this conclusion; it means that the composition of that

particular sample was not determined directly.

At the same time, the precise chemical and particle-size composition of the contamination in every episode, the concentration of particles in the air people breathed, and the contribution of each specific operator have not been established. Attribution of the general class of phenomenon and attribution to an individual source are separate evidentiary tasks. For example, the link with the vicinity of the Cherkasovskaya coal-preparation plant during the February 2019 episode is strengthened by measurements close in time, whereas no specific source facility was established in public materials for Afonino in December 2024.

3A.3. What Is Known About Gaseous Pollutants

An exceedance of carbon monoxide at 15 Kommunalnaya Street on 3 December 2020 is directly documented. Nitrogen dioxide and sulfur dioxide were measured during the same episode, but the available text does not report exceedances for them. Official stationary-source emissions reporting confirms emissions of carbon monoxide, sulfur dioxide, nitrogen oxides, volatile organic compounds and hydrocarbons.

Taken together, these data establish the presence of gaseous pollutants within the structure of the industrial burden and one episode of regulatory significance involving carbon monoxide. They do not permit construction of a chronology of gaseous-pollutant concentrations in the city's residential air. There are grounds neither to extrapolate the Kommunalnaya Street result to all of Kiselyovsk nor to conclude, from the absence of other exceedances located in the sources, that no chronic or short-term gaseous burden existed elsewhere.

3A.4. Which Areas Are Represented by Data

The best-documented locations are individual points that became the subject of a complaint, inspection, project assessment or production environmental control: Kommunalnaya Street; the vicinity of Druzhby Street; Tuskaya Street; Kazanskaya Street near Boiler House No. 25; the zone of the Cherkasovskaya coal-preparation plant; the vicinity of the Shakhta No. 12 LLC coal-preparation plant; and several other addresses. Their representativeness is local and depends on the purpose of the sampling.

A measurement at a residential location answers a question about the air at that location and moment under the meteorological conditions then present. A measurement at the boundary of a sanitary protection zone concerns a different regulatory and spatial object. An operator's monitoring location characterises compliance with that operator's programme but does not replace a city monitoring station. The results can be compared as parts of a broader picture, but cannot be mechanically averaged into a single city-wide time series.

Large parts of the urban territory have virtually no representation in regular public measurements. Even neighbourhoods appearing in complaints or visual evidence are represented by episodes rather than a continuous series. Krasny Kamen, which residents describe as a better-ventilated and comparatively clean neighbourhood, cannot serve as a control description for the entire city without systematic comparable measurements. It is a valuable spatial hypothesis and testimony, not a ready-made quantitative series.

3A.5. Principal Limit of the Evidence

In the official reference years 2008, 2011, 2020, 2023 and 2024, Kiselyovsk had no stationary monitoring site belonging to the state air-pollution monitoring network. In 2020, the Centre for Hydrometeorology and Environmental Monitoring stated explicitly that regular observations were not conducted in the city or urban district and that background concentrations were calculated for emissions-regulation purposes.

Individual public-health, regulatory and operator measurements existed, but they served different purposes, were taken at different locations and followed different programmes. They do not form an open and comparable city-wide time series. The available data therefore do not reliably establish:

- annual average and long-term concentrations of the principal pollutants in residential neighbourhoods;
- the frequency, duration and seasonal distribution of severe episodes;
- the spatial exposure of different neighbourhoods and population groups;
- the contribution of each operator and each source type to the concentration outside a particular home;
- changes in air quality measured using one consistent methodology; or
- PM₁₀ and PM_{2.5} concentrations in the form of a complete, public, city-wide time series.

This is not a list of phenomena that did not exist. It is a list of questions to which the observation and public-data system provides no evidence-based answer.



Dark areas of snow surface in an industrially modified landscape, 27 April 2019. Kiselyovsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

3A.6. Synthetic Conclusion

The available evidence supports a stronger conclusion than “nothing is known about the air in Kiselyovsk”. Individual exceedances of suspended particulates and carbon monoxide are established directly; exceedances of benzo[a]pyrene and the results of other regulatory measurements were officially reported; and emissions reporting records a persistent annual mass of solid and gaseous pollutants measured in thousands of tonnes.

A recurring particulate burden and the coal-industry origin of the long-term phenomenon of contaminated snow are established by converging independent evidence.

The evidence does not, however, form a complete portrait of the air that residents breathed every day. It shows actual episodes and recurring signs of impact, while the observation system leaves their city-wide frequency, duration, spatial distribution and the population’s long-term exposure unknown.

The precise conclusion is therefore not a choice between “pollution has been proven everywhere and at all times” and “pollution has not been established”. Pollution and exceedances are documented at specific places and dates. The recurring coal-industry character of the particulate phenomenon is established by the evidence as a whole. The quantitative scale of chronic impact across the city’s different neighbourhoods cannot be reconstructed from the available public data.

Evidence Map

Kiselyovsk: industrial territory, housing, and points of knowledge about air

Sentinel-2 base image, 2 December 2020. Address coordinates: OSM Nominatim; accuracy is shown by symbols.

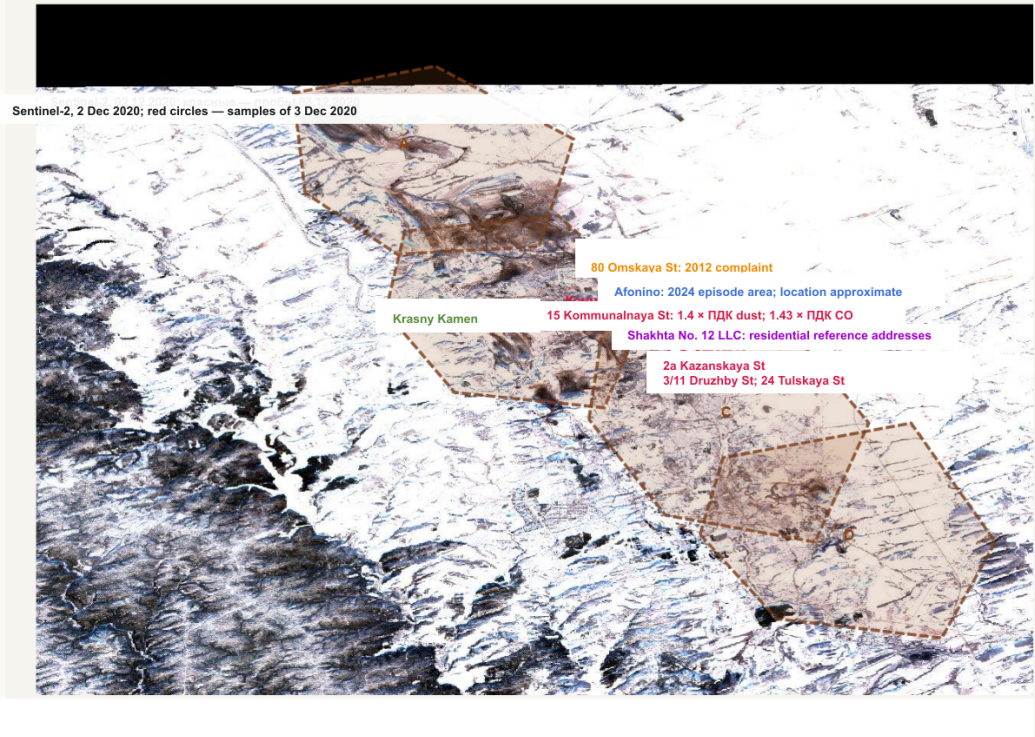


Figure — evidence map from the third review pass. It is not a map of licence areas or sanitary protection zones.

Sources: Sentinel-2 L2A S2B_45UVV_20201202_0_L2A; Rosпотребнадзор reply on samples of 3 Dec 2020; OSM Nominatim, checked 2 Sep 2026; Table 50.

Industrial context, May–June 2020

Nine operating open-pit mines were documented: Kiselyovskiy; Polyany; Lugovoye; Invest-Uglesbyt / Yuzhny; Shakhta No. 12 LLC; Oktyabrinsky; the Vakhrushevskoye field of the Krasnobrodsky open-pit mine; Uchastok Koksovy; and Karagailinskoye. Outlines A–D show only visually distinguishable areas of open industrial or disturbed surface. They are not allocated among the nine operators because no single verified geometry of the facilities for 2020 was found in the archive.

Evidentiary result: sources and housing are spatially intermingled, while measurements form several local groups. Unknown exact facility and sanitary-zone geometry limits attribution, but does not negate the established scale of open-pit production.

How to read the map

Red — address-specific sample, 3 Dec 2020
Orange — address of a complaint
Blue dashed line — episode area, not a filming point
Purple dashed line — residential district references
Green — comparative district, not an air sample

What the base image shows

Light surfaces are snow.
Dark and brown areas are spatially heterogeneous exposed ground, industrially disturbed surfaces, shadows, and contaminated snow. The satellite image does not determine chemical composition.

Not plotted as exact locations

- Cherkasovskaya processing plant and its sanitary protection zone: coordinates not confirmed.
- 3 Rasshchupkina St: geocoding was inconclusive.
- Boundaries of nine open-pit operations and their sanitary protection zones: no single verified geometry for 2020 was found in the archive.
- Exact location of the Afonino video.

Absence of a marker means that reliable coordinates are absent; it does not mean that an object or event is absent.

Evidentiary meaning

Known measurements form separate local groups rather than an evenly distributed network. The map does not transfer results from one point to the whole city. It shows why a spatially heterogeneous industrial city required regular, distributed observation.

Evidence map. Industrial territory, residential reference points, and known air-data locations. Exact, approximate, and district-level locations are distinguished on the map; absence of a point does not indicate favourable conditions.

Evidence map: industrial territory, residential reference points, and known locations for ambient-air data. Precise locations, approximate locations and neighbourhood-level locations are distinguished on the map itself. The absence of a data point does not indicate satisfactory environmental conditions in that area.

Figure 1. Evidence map. Outlines A–D show visible open industrial or disturbed surfaces, not licence boundaries. Sources and limitations concerning coordinates are listed in `map data – source/archive file: КАРТА_ДАННЫЕ.csv`.

4A. 2019: How a Formally Correct Aggregate Can Conceal a Local Event



Comparison of two datasets

0%

Aggregate indicator Percentage of samples exceeding a regulatory limit in public-health reporting for 2019

AND, AT THE SAME TIME

2.4 times ПДК_{с.с.}

Local measurement Suspended particulates at a residential location, February 2019

This is not “falsehood versus truth”. The aggregate indicator and the locally documented exceedance belong to different programmes and datasets. Without disclosure of the aggregate’s structure, a resident cannot see the complete documented picture.

The state summary table reports that 0% of the ambient-air samples examined in Kiselyovsk in 2019 exceeded a maximum permissible concentration (ПДК; Russian regulatory limit). For February of the same year, a court judgment concerning the Cherkasovskaya coal-preparation plant reproduces three suspended-particulate exceedances: one at a residential location and two at the boundary of the sanitary protection zone.

At first sight, the two statements appear incompatible. Before either is declared false, however, it is necessary to establish what exactly was counted.

Which datasets are being compared

The 0% indicator is an annual aggregate from public-health monitoring. The published city-level row does not disclose the addresses, dates, pollutants, number of samples, or rules governing which results were included in the denominator. Consequently, 0% means only that there were no exceedances among the samples included in that particular aggregate—or that the percentage was rounded to zero. It is not equivalent to a statement that no exceedance was recorded anywhere in Kiselyovsk throughout 2019.

The second dataset contains results from a specific episode documented in legal proceedings. The court judgment gives three values for one indicator on 14, 15 and 18 February:

- 0.36 mg/m³ in a residential area against a maximum permissible average daily concentration (ПДКс.с.; Russian regulatory limit) of 0.15 mg/m³;
- 0.60 and 0.69 mg/m³ at the boundary of the sanitary protection zone against a maximum permissible single-exposure concentration (ПДКм.п.; Russian regulatory limit) of 0.50 mg/m³.

These data served a different purpose, covered a different geography and probably belonged to a different reporting system from the annual public-health row.

The available materials do not establish whether the three February results were included in the denominator of the annual indicator. Several substantively plausible but unverified explanations exist: different government datasets; different programmes; exclusion of sanitary-protection-zone monitoring locations from the city public-health aggregate; or other accounting rules. None may be presented as established without the methodology and underlying table.

What the resident receives

Both statements may be formally correct within the boundaries of their respective datasets. Their informational effects, however, are not symmetrical. A row reading “0%”, without a denominator or geography, looks like a description of the city for the entire year. The local episode documented in legal proceedings, with three exceedances, remains within a court record and is invisible to a reader of the aggregate.

A person using only the official summary row could therefore form a substantially more favourable impression than a person who had access to both sources.

The comparison directly establishes the following informational effect: the published 0% indicator did not encompass—or at least did not disclose—all exceedances documented in 2019 and known from another official dataset. It does not establish that there was no air pollution in the city during that year.

What remains unestablished is why the discrepancy arose and whether the aggregation was deliberately structured in this way. Answering that would require the underlying sample, the method used to construct the denominator, and a documented account of how the three February results moved through the reporting system.

The case does not necessarily demonstrate that the official information was false. It demonstrates the capacity of formally correct aggregation to create an incomplete impression when the scope of an indicator is not explained to the ordinary reader.

4. Was Information Accessible to an Ordinary Resident of Kiselyovsk?

4.1. Accessibility as an Independent Property of Data

Environmental information can exist while remaining practically inaccessible to the public. A laboratory retains a protocol; an operator retains an environmental-monitoring log; a government body retains rows from social and hygienic monitoring; and a statistical authority retains emissions-reporting forms. Residents can use these data only when they know that the data exist, can locate them in time, understand their territorial and temporal scope, and verify what the published figures mean.

This chapter therefore applies four consecutive criteria of accessibility:

1. **Physical accessibility:** Was the result published, or could it be obtained without a dedicated research project?
2. **Timeliness:** Was it available when the information could affect behaviour and public scrutiny, rather than only years later?

3. **Comprehensibility:** Could a non-specialist identify the place, time, pollutant, regulatory limit and meaning of the result?
4. **Verifiability:** Did the published information disclose the method, primary values and limits of the conclusion?

The existence of an official document does not automatically satisfy these criteria. A state report available online is physically accessible, but a row stating “percentage of samples above ПДК: 0%”, without the number or addresses of the samples, does not tell a resident about the air outside their home. Conversely, a resident’s social-media post can be accessible and timely while providing no chemical or quantitative assessment.

4.2. Which Channels Existed

Residents could obtain information from regional state and public-health reports, brief agency statements, replies to their own complaints, public-consultation materials, and publications by the municipal administration and media. Individual results became known through court cases or statements from the Prosecutor’s Office. Industrial operators disclosed some information through environmental impact assessments and public hearings. Residents also made direct observations and shared photographs and videos.

These multiple channels did not form a single point of access. Different organisations published sources in different formats and after different delays. To reconstruct a single episode, this study had to combine an official letter, project documentation, media reports, court judgments and archived copies of webpages that had disappeared. An ordinary resident did not possess such a retrospective corpus when the event occurred.

4.3. State Reports: an Accessible Summary Without the Necessary Context

Regional reports provided two important kinds of information: the mass of emissions from stationary sources by municipality, and the percentage of public-health samples above a maximum permissible concentration. Both indicators could be public, yet neither directly answered the question: “What is the air like now, or ordinarily, in my neighbourhood?”

The mass of emissions was expressed in thousands of tonnes per year. It did not show concentrations, locations of impact, source operating conditions, or the contribution of transport and fugitive dust. The city-level row giving the percentage of samples above ПДК did not disclose the number of samples, addresses, dates or pollutants. Correct interpretation required residents to understand the distinction between emissions and concentrations, and between the proportion of collected samples and the proportion of time during which pollution was present. The summary tables did not turn these distinctions into a comprehensible neighbourhood-level description.

The 2019 example is particularly significant. The official annual aggregate shows 0% of samples above ПДК, while a court judgment records three suspended-particulate exceedances in February of the same year, linked to the Cherkasovskaya coal-preparation plant. The available corpus does not establish why these results were not reflected in the aggregate. For a resident, however, the final row presented without a description of the sample could create the impression that no problems had been recorded during the year, while the more detailed procedural source demonstrates the opposite for a specific episode.

4.4. Reply to a Complaint: Information Available Only to an Active Applicant

The full electronic text of Rospotrebnadzor's reply retained in a personal archive, corresponding in substance to letter No. 3007 of 15 December 2020, contained specific addresses, pollutants, results and information about the authority's intended follow-up. The outgoing-document fields are blank in the available DOC file and require comparison with the final copy that was sent. This text is substantially more informative than the annual aggregate.

That level of detail arose, however, only after complaints by Natalia Zubkova and was sent to the applicant. The corpus contains no evidence that the full reply was simultaneously published for all city residents. Even the applicant did not receive the complete laboratory package. The letter names Protocols Nos. 11485 and 43135, but the protocols themselves—with sampling times, methods, detection limits and other details—are absent from the archive. For benzo[a]pyrene, this prevents verification of the regulatory comparison. The statement that an inspection of Boiler House No. 25 was being prepared is not accompanied by any result of that inspection located in the sources.

A complaint could therefore produce an important fragment of knowledge, but access depended on individual initiative and the result did not become part of a public history of the event. Another resident could not open a city time series and see the measurements of 3 December as part of the overall picture.

4.5. Production Environmental Control: Existing Data Without City-Wide Access

The monitoring programme at Shakhta No. 12 LLC demonstrates a particularly important distinction between the existence and accessibility of data. The programme included several locations, routine sampling and monitoring during blasting. The developers separately reported tests of an automated system in October 2019 and its entry into long-term pilot operation in 2020, with dust-particle concentrations and meteorological parameters measured every 20 minutes. At least a test dataset therefore existed; during pilot operation, a considerably more detailed series than the regional annual tables may have been generated.

The public, however, had access only to a summary table for 2018 within the environmental impact assessment, descriptions of the programme at hearings, and scientific reports about the technical system. The full concentration series, calendar, blasting data and archive of the automated system were not found in the public domain. The developers' reference to possible analysis of the archive in response to public requests is not equivalent to proven open publication: no evidence was established concerning actual disclosure, eligible users or the period of actual operation.

In November 2024, Rosprirodnadzor reported that it had analysed the operator's environmental-monitoring report and Russian 2-TP reporting form for 2023. This confirms that reporting existed and was submitted to the regulatory authority. The statement itself, however, discloses neither the report nor the monitoring locations, concentrations or basis for the formal warning issued. The state and the operator possessed data that were not made sufficiently available in the public statement to permit independent verification of the conclusion.

4.6. Could Residents Find Out About the Air in Their Own Neighbourhood?

Answering this question would require a network of locations permitting comparisons between neighbourhoods over time. No such network exists in the public data located. A stationary state monitoring site was absent in the confirmed reference years. Public-health aggregates did not disclose addresses. Operator monitoring characterised the zones of individual industrial sites. One-off inspections were conducted where a complaint, dispute or specific regulatory task arose.

The map of the December 2020 measurements shows several addresses, predominantly in the central and eastern parts of the city. It provides no basis for extrapolating the result to Krasny Kamen or other unrepresented neighbourhoods. The reverse is equally true: potentially cleaner air on the exposed higher ground of Krasny Kamen does not establish satisfactory conditions in neighbourhoods near intensive operations and transport routes.

A resident could therefore learn the result of a sample at a specific address if a sample was taken and the result communicated. Under the existing public system, they could not compare their neighbourhood with others, determine a typical daily or seasonal profile, or verify how conditions changed after operators altered their activities.



Residential street, 29 July 2019. Kiselevsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

4.7. Was Information About Exceedances and Sources Available?

Information about exceedances was published on occasion—in official replies, statements from the Prosecutor’s Office and court judgments. Publication usually concerned an individual episode. Complete protocols rarely accompanied a brief announcement. Statements that “an exceedance was identified” or “no exceedances were identified”, presented without locations, times or methods, appeared symmetrical even though they could concern fundamentally different inspections.

Identifying a source required a still larger dataset: operating conditions, wind direction, emissions composition and spatial comparison. In the case of the Cherkasovskaya coal-preparation plant, the link was confirmed through legal proceedings. During the episode of 3 December 2020, the measurement at 15 Kommunalnaya Street led to preparations for an inspection of Boiler House No. 25, but the data located do not complete the causal chain. For most black-snow events, the evidence as a whole supports a coal-industry origin but does not apportion contributions among operators.

An ordinary resident consequently had access to stronger information about the existence of a general industrial problem than about the legally and quantitatively established source of each episode.

4.8. Final Answer on Accessibility

An ordinary resident of Kiselyovsk did not have access to sufficient information to know the state of ambient air precisely at their place of residence.

This conclusion does not mean that no information existed. A resident could observe pollution, read annual aggregates, see individual reports of inspections, and obtain a more detailed reply after submitting a complaint. The insufficiency lay in the absence of a publicly accessible combination of four elements: regular measurement, neighbourhood-level detail, primary results, and a complete history of the regulatory response.

The available information therefore allowed residents to learn individual facts, but not to construct a verifiable picture of the composition, concentrations and duration of exposure.

5. Map of Information Gaps

5.1. Gaps Must Be Described Precisely

The phrase “there are few data” conceals distinctions that determine interpretation. The gaps below are classified by subject and probable origin. Where their origin is unknown, this is recorded separately.

5.2. Temporal Gaps

The principal temporal gap is the absence of a continuous city-wide time series. There are annual aggregates, one-off samples and individual production environmental control programmes, but no sequence of comparable concentrations by hour, day, season and year. It is therefore impossible to determine the frequency of episodes, the duration of elevated levels, or a persistent year-to-year trend.

The origin of this gap is partly established: Kiselyovsk had no regular Roshydromet station during the confirmed years. More detailed measurements existed within the public-health system but were publicly aggregated. Part of a production environmental control series may have been retained by an operator and government bodies, but was not found in the public sources examined.

5.3. Territorial Gaps



Industrially modified terrain and spoil tips in the urban landscape, 29 July 2019. Kiselyovsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

There is no public network representing different residential neighbourhoods while accounting for terrain, exposure to wind and proximity to sources. Addresses of public-health samples are not disclosed in the annual rows. The known locations from individual episodes form a sample shaped by complaints and regulatory tasks, rather than by the design of city-wide observation.

It is consequently impossible to compare quantitatively Krasny Kamen, the central area, eastern residential territories, Afonino, and neighbourhoods near particular production and transport facilities. The cause is a combination of the absence of a state network and the lack of

public detail about the design of other programmes.

5.4. Gaps by Pollutant

Total suspended dust was monitored in several systems. No regular city-wide PM₁₀ or PM_{2.5} time series was established. The total mass of suspended particulates cannot be used to reconstruct particle-size fractions. Soot, benzo[a]pyrene, phenol, formaldehyde and other substances appear only in some programmes and episodes.

For one pollutant, the result of an individual sample may be known while chronic exposure is unknown; for another, the annual mass of emissions may be known but not the concentration; for a third, there may be a reference in a public-health analysis without the underlying series. The origins of these gaps differ: a programme's limited pollutant list, the absence of a stationary site, aggregation, or non-publication.

5.5. Gaps by Operator and Source

Documentary photograph. At coal-industry sites in Kiselyovsk. Photo: Smogman. The image records a visually observable condition; by itself, it does not establish chemical composition, concentration, or the contribution of a particular industrial operator.

Public municipal totals are not disaggregated by operator. Complete historical 2-TP forms and operator environmental-monitoring reports for key operators are absent from the corpus. Fugitive dust, transport and short-duration operations are less visible in annual statistical aggregates than stationary sources.

These gaps do not prevent the combined high industrial burden from being established, but they prevent responsibility from being apportioned and impede assessment of how a change in the operation of a particular facility affected residential air.

5.6. Gaps in Individual Episodes

For the measurements of 3 December 2020, the complete laboratory protocols and the result of the inspection of Boiler House No. 25 are absent. For the monitoring on 10–11 December, the individual values and sampling conditions are unavailable. For events in 2021 and 2024, the start of an inspection and a brief outcome are often available, but not the appendices, implementation of measures, or repeat samples. Some visual materials lack an established precise address or recording date.

The correct formulation is: “the documents were not found in the body of sources examined or in the public domain”. It cannot be asserted that measurements were not taken or actions did not occur. For a resident and an independent researcher, however, a non-public result

functionally creates a break in knowledge regardless of why it is absent.

5.7. Gaps in Regulatory Response

None of the eight reconstructed chains publicly contains every link: signal, primary protocol, decision, measure, implementation, repeat measurement and durable final outcome. The chain concerning the Cherkasovskaya coal-preparation plant is the most complete: exceedances, a criminal case, termination on non-exonerating grounds, and a judicial fine. Even there, no public confirmation of sustained elimination of the pollution through repeat protocols was found.

In most episodes, public visibility is greater at the beginning of the process, when an inspection is announced, and lower at its final stage. The reasons may differ: an appendix was not published; there was no obligation to disclose it; media interest ended; the action remained incomplete; or the webpage was lost. What matters to the principal conclusion is the established result: the public did not receive a reproducible, closed account showing whether the air changed after intervention.

5.8. Consolidated Typology of the Origins of Gaps

The corpus confirms the following mechanisms:

- **Not collected by the system concerned:** the city was not covered by a stationary monitoring site; PM₁₀ and PM_{2.5} are absent from the Shakhta No. 12 LLC operator programme located.
- **Collected irregularly:** measurements triggered by complaints and individual inspections.
- **Aggregated:** city percentages of public-health samples above ПДК and municipal totals for the mass of emissions.
- **Existed within a system, but complete publication was not established:** the social and hygienic monitoring dataset, production environmental control reports, and automated-system data.
- **A final result was publicly reported without primary appendices:** a number of inspections between 2012 and 2024.
- **May have existed but was not found:** complete protocols and final follow-up documents.
- **Cause unknown:** the disappearance or absence of some results from the public chain.

The map of gaps is therefore not a list of lost files. It is a description of how knowledge about the atmosphere was structured.

6. How Information Gaps Alter the Picture of Atmospheric Conditions

6.1. An Aggregate and an Event Can Produce Different Pictures

An official aggregate is useful for concise comparison, but its meaning depends on an underlying structure that is not visible. The percentage of samples above ПДК can fall because the locations, number of samples or pollutant list changed. The mass of emissions can fall because the set of reporting facilities or the classification of methane changed, without simultaneously describing dust concentrations near housing.

The 2019 comparison demonstrates the practical consequence. A non-specialist may read the row “0% of samples above ПДК” as meaning that no pollution was recorded. A court document from the same year reports specific exceedances of total dust. These items are not necessarily logically incompatible, but the summary indicator creates an incomplete picture when the sample underlying it is not disclosed.

6.2. What the System Could and Could Not See

One-off address-specific samples can detect severe short-term pollution if the sampling coincides with it in place and time. They are poorly suited to assessing chronic exposure. Annual public-health aggregates can show that exceedances occurred, but without the underlying rows they cannot identify seasons or neighbourhoods. Production environmental control can describe the zone of a particular facility in detail, but not the city’s combined air. Emissions statistics show the reported industrial burden, but not exposure.

In the form identified, the system could therefore detect individual violations and total mass, but was substantially less capable of seeing:

- the duration of pollution;
- the recurrence of brief peaks;
- differences between residential neighbourhoods;
- PM₁₀ and PM_{2.5} as separate fractions;
- simultaneous impact from multiple operators; and
- changes in the air after a regulatory measure.

6.3. Spatial Heterogeneity

A preliminary satellite comparison shows that the winter surface in Krasny Kamen was consistently lighter in the selected scenes than the central and eastern comparison windows. This is not a quantitative indicator of air quality, but it provides a factual basis for investigating territorial differences.

If the city is heterogeneous, a measurement in one part is not a conservative description of another. The absence of a distributed network therefore does more than reduce the amount of information: it can conceal the most heavily affected local zones within a city-wide average.



Urban panorama with visually observable haze and emissions, 2 January 2019. Kiselyovsk. Photo: Smogman. The photograph records a visually observable condition; by itself it does not establish chemical composition, pollutant concentration, or the contribution of a specific enterprise.

6.4. Recurrence and Seasonality

Photographs, videos and satellite scenes record dark snow during different winters. These materials demonstrate the recurrence of visible deposition more effectively than official annual aggregates. Without regular ambient-air measurements, however, it is impossible to determine how long the episodes lasted, which concentrations accompanied them, or whether comparable invisible pollution occurred outside the snow season.

Documentary photograph. Urban and industrial territory during winter. Kiselyovsk, 2 January 2019. Photo: Smogman. The photograph records a visually observable condition; by itself, it does not establish chemical composition, pollutant concentration, or the contribution of a particular industrial operator.

The visual archive therefore broadens the picture beyond the official summaries while simultaneously emphasising the system's limit: residents could see the result of particle deposition without receiving a quantitative explanation of their exposure.

6.5. The Official Picture and the Combined Reconstruction

A resident relying only on readily accessible official information saw a sequence of disconnected statements: an annual mass of emissions; a small percentage—or an absence—of exceedances in public-health samples; an isolated announcement of an inspection; and, sometimes, a statement that results complied with regulatory limits. From these elements, it was possible to conclude that controls existed and individual violations were addressed through routine procedures.

The combined corpus produces a more complex picture. For May–June 2020, it shows a city with nine open-pit mining sites operating simultaneously. For 2020–2024, it shows substantial annual masses of emissions. For several verified reference years, it shows the absence of a regular state monitoring station. It also shows the existence of non-public or only partially disclosed public-health and operator datasets, individual proven exceedances, recurring black snow, differences between neighbourhoods, and public regulatory chains that systematically break before the final outcome.

This does not establish that every official statement was false. The distortion arises primarily at the level of the overall picture: formally correct fragments did not reveal their spatial, temporal and causal relationship.

6.6. Answer to the Control Question

An ordinary resident's understanding, when based solely on officially accessible information, could not fully correspond to the picture reconstructed from the sources as a whole. The degree of discrepancy varied by period and neighbourhood. A resident who obtained an address-specific inspection could know more than the average resident. A neighbourhood close to a source could experience an episode absent from the city aggregate. Individual measurements existed for total dust, while a quantitative picture for PM₁₀ and PM_{2.5} remained practically inaccessible.

Documentary photograph. Residential environment in Kiselyovsk, 29 July 2019. Photo: Smogman. The photograph records a visually observable condition; by itself, it does not establish chemical composition, pollutant concentration, or the contribution of a particular industrial operator.

The level of evidence for this answer is high with respect to the architecture of the information system. It is impossible to quantify precisely how far the official picture understated or otherwise distorted actual exposure, because the continuous and spatially representative time series required for that calculation is the very dataset that is absent. The inability to calculate the magnitude of the discrepancy does not negate the established structural mismatch between the city's industrial complexity and the available observation system.

7. Can the information gaps be regarded as deliberate omissions by public authorities and coal companies?

7.1. Information inadequacy and intent are different conclusions

The preceding chapters establish an information problem regardless of the motives of those involved. Kiselyovsk had no confirmed regular state monitoring-station time series; sanitary data were published predominantly in aggregated form; the detailed production environmental control and social and hygienic monitoring datasets remained incomplete for public scrutiny; and the results of supervisory action often could not be traced through to follow-up monitoring. These characteristics of the system can be established from documents.

A deliberate omission is a stronger conclusion. Showing that useful information was not published is insufficient. It would be necessary to establish who possessed the information, what duty that party had, whether it understood the significance of the gap, whether it was able to correct it, and whether it acted or failed to act with the purpose of restricting information. A general intent cannot be inferred from the system's unsatisfactory outcome.

This study distinguishes three possible levels of responsibility:

1. **Structural inadequacy:** the law, allocation of powers, or design of observation did not create a complete citywide time series.
2. **Persistent organisational inadequacy:** the problem was known, but observation or public information remained insufficient; the existence of a duty, the possibility of a specific remedy, and motive must be assessed separately.
3. **Deliberate restriction:** evidence shows that specific information was intentionally withheld or distorted, or that observation was altered in order to prevent assessment.

The assembled corpus makes it possible to establish the first level with confidence and persistent signs of the second. The evidence is currently insufficient for a general conclusion at the third level.

7.2. Regulatory and organisational architecture

The control system was divided among Roshydromet, Rospotrebnadzor, Rosprirodnadzor, regional and municipal authorities, laboratories, and the enterprises themselves. Each component collected data for its own purpose. Roshydromet operated the state observation

network; the sanitary system assessed environmental factors affecting human health; enterprises monitored their own impacts; statistics recorded the mass of emissions; and supervisory bodies took measures where the relevant legal grounds existed.

This division alone can generate a gap without any centralised decision to conceal something. Data may exist in incompatible formats, cover different territories, and be published on different schedules. A one-off inspection prompted by a complaint does not automatically have to become part of continuous monitoring. Production environmental control is intended to monitor the operator's impact and, by design, does not replace a citywide network.

Within social and hygienic monitoring, the regulatory system provided for authorities and the public to be informed through analytical materials, including state reports, bulletins, and website publications. The rules examined, however, do not imply an automatic duty to publish the entire primary anonymised dataset in machine-readable form. Therefore, without an additional legal basis, the absence of an open record-level export from the social and hygienic monitoring system cannot be characterised as a violation or concealment.

Similarly, the absence of a Roshydromet monitoring station in a particular city does not itself prove a deliberate refusal to conduct observations. Network placement depends on the regulatory programme, resources, technical requirements, and decisions made at different levels. These explanations, however, do not automatically answer whether the system was adequate for a major industrial city. The legality of a minimal arrangement and its informational adequacy are separate assessments.

7.3. Indications requiring closer examination

The corpus contains circumstances that do not prove concealment, but that prevent the issue from being reduced to a neutral description of technical difficulties.

First, the system was aware of the pollution problem. Sanitary exceedances had been published since the 2000s; residents repeatedly complained; in 2019 pollution led to a criminal case; and in 2020, 2021, and 2024 the authorities again responded to exceedances or reports of black snow. The absence of a complete citywide picture therefore cannot be explained by complete ignorance of the problem itself.

Second, some parts of the system held more detailed data than the public received. A scientific paper confirms the existence of a social and hygienic monitoring concentration dataset for 2015–2019. Shakhta No. 12 LLC reported hundreds of production-environmental-control samples and tested a measurement system with twenty-minute intervals. Rosprirodnadzor analysed the production environmental control report for 2023. What is publicly available consists mainly of summaries and narrative conclusions. This establishes a gap between organisations' internal knowledge and the possibility of external verification. A conclusion that access was deliberately restricted would, however, require the specific access rules, requests, replies, grounds for refusal, and the subsequent fate of the data. Non-publication alone does not reveal motive.

Third, no sustained improvement in transparency is visible after publicly known episodes. In 2020, an official reply reported exceedances and preparations for an inspection, but its outcome was not found. In 2024, brief notices were again published without protocols or a completed follow-up monitoring chain. The recurrence of this break is an indication of persistent organisational inadequacy. It is compatible with a low priority being given to public information, but does not itself establish either that motive or a coordinated purpose to conceal pollution.

Fourth, statements such as “complies with the standards” or “no exceedances were identified” were sometimes published without an adequate description of what had been examined. In November 2024, the conclusion followed from an analysis of an enterprise’s report rather than from described independent citywide sampling. Such wording may be literally accurate while giving readers a broader impression of acceptable air quality than the method permits. Proving deliberate deception would require evidence of the author’s intent and the context in which the statement was prepared; no such data are available.

7.4. Symmetry in assessing enterprises and the state

A corporate report is not accepted as evidence of generally acceptable conditions merely because it is official. Nor are its results automatically rejected because the enterprise has an interest in them. The sampling locations, methods, completeness of the programme, laboratory, and availability of the primary protocols are assessed.

The same standard is applied to state materials. A judicial decision can reliably establish the procedural outcome and its account of measurements, but the absence of the attached protocols limits independent scrutiny of the laboratory component. A brief prosecutor’s-office notice reliably establishes that an inspection began, but does not substitute for its outcome. State provenance increases certainty about the origin of a document; it does not automatically make the knowledge contained in it complete.

Residents’ testimony is likewise treated neither as proof of chemical composition nor as an informational zero. Its recurrence and convergence with images, satellite scenes, and measurements increase the weight of the conclusion that pollution episodes were real. At the same time, testimony about a layer of dust does not become a numerical concentration without analysis.

7.5. Answer concerning deliberate omission

The information gaps identified cannot, as a whole, be evidentially characterised as deliberate concealment by public authorities or coal enterprises. The assembled corpus contains insufficient evidence of a common intent, purposeful alteration of observations, or knowing distortion of specific results.

At the same time, a persistent organisational inadequacy of the information system is established. The problem was repeatedly known; more detailed data existed within individual systems; public information remained aggregated and fragmentary; and after significant episodes the public often received no traceable final outcome.

Whether this resulted from the regulatory minimum, divided responsibilities, organisational inertia, a low priority assigned to public disclosure, or a conscious decision by particular individuals has not been established in general terms.

Level of evidence: high for systemic information inadequacy and the recurrent failure to complete public information chains; insufficient for a conclusion of general deliberate concealment.

The inability to prove intent does not weaken the established conclusion that the information environment was inadequate for residents to make a complete independent assessment of the air.

8. The role of supervisory authorities

8.1. Supervision as a response and as a source of knowledge

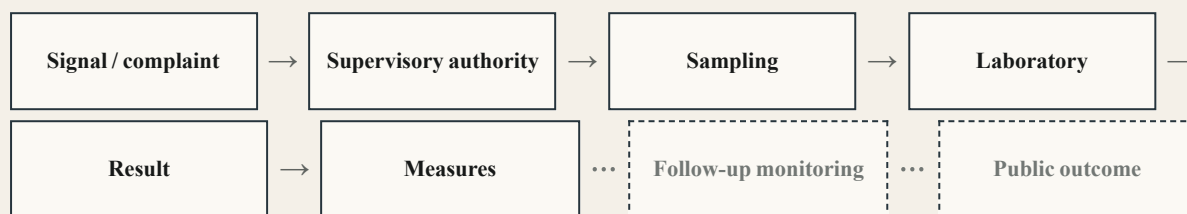
Supervisory authorities performed two related functions. They responded to complaints, publications, and identified violations, while their documents became one of the few routes by which concentration data entered the public domain. The effectiveness of supervision must therefore be assessed not only by whether a sanction was imposed, but also by whether the chain made it possible to see that the impact had been remedied.

The working model has eight links: signal; measurement; result; determination of a violation or its absence; measure; implementation; follow-up monitoring; final state.

A complete re-examination of eight episodes confirmed that none is represented in the public corpus by every link through to a comparable follow-up measurement and confirmation of a sustained environmental outcome (Appendix, Table 8). This is a conclusion about public traceability, not proof that an unreported action was never performed.

8A. Eight publicly traceable chains of supervisory response

SUPERVISORY CHAIN



? A break means only that the next link cannot be traced in the examined public corpus; it is not proof that the action itself did not occur.

SUPERVISORY CHAIN

Signal / complaint → Supervisory authority → Sampling → Laboratory → Result → Measures ... Follow-up monitoring ... Public outcome ?

A break means only that the next link cannot be traced in the examined public corpus; it is not proof that the action itself did not take place.

Counting inspections and fines is insufficient for assessing the role of supervision. What matters is the complete cycle: signal — measurement — result — classification of a violation — measure — remediation — follow-up monitoring — confirmed outcome. The table brings together eight episodes for which at least two links in this sequence could be reconstructed from the examined corpus.

Episode	Signal and measurement	Established result	Response	Follow-up monitoring and final outcome
80 Omskaya Street, 2012	Complaint about dust and gas after blasting; outdoor and indoor air examined	The account of the reply reported no exceedances	Rospotrebnadzor inspection	Original letter, numerical results, and subsequent monitoring not found

Episode	Signal and measurement	Established result	Response	Follow-up monitoring and final outcome
Cherkasovskaya processing plant, February 2019	Laboratory measurements: suspended particulate matter at 2.4 times the maximum permissible average daily concentration (ПДКс.с.); 1.2 and 1.38 times the maximum permissible single-exposure concentration (ПДКм.р.) at the sanitary protection zone boundary	Criminal case; termination on non-exonerating grounds; judicial fine of RUB 20,000	Technical remediation of the harm was mentioned	Follow-up protocols and a sustained outcome not found
Address-specific measurements, 3 December 2020	Resident's complaints; samples from several addresses	At 15 Kommunalnaya Street: suspended particulate matter at 1.4 times ПДКм.р. and CO at 1.43 times ПДКм.р.; benzo[a]pyrene was also reported	Preparations announced for an unscheduled inspection of Boiler House No. 25	Inspection outcome and comparable follow-up monitoring at the original locations not found
Shakhta No. 12 LLC, 10–11 December 2020	Four samples over 24 hours at the sanitary protection zone boundary and near 3 Rasshchupkina Street	Reported compliance with the standards	Sanitary monitoring of the enterprise	Numbers and subsequent monitoring not published; this was a different area, not a direct repeat of the 3 December samples
Black snow, December 2021	Reports by residents and media; laboratory sampling and inspections of enterprises	Suspended particulate matter violations at the Istok municipal enterprise, an emission-limit violation at the Krasnokamenskaya central processing plant, and other violations	Administrative proceedings, submissions, orders, and warnings	Implementation and follow-up protocols not found
Shakhta No. 12 LLC, November 2024	Complaints; analysis of Form 2-TP (Air) and the 2023 production environmental control report	No exceedances identified in the reports	Warning	No new measurement of air in residential areas or subsequent monitoring described
Shakhta No. 12 LLC processing plant, before March 2024	Media and internet publications; samples near the sanitary protection zone and the nearest housing	Prosecutor's office reported a twofold exceedance of the maximum permissible concentration for suspended particulate matter	Prosecutor's claim upheld	At the date of the announcement, the judgment had not entered into force; implementation and follow-up measurements not found
Afonino, December 2024	Photographs and video of black snow; involvement of sanitary authorities announced	Numerical laboratory result not found in the public record	Prosecutor's office announced an inspection	Outcome, measures, and follow-up monitoring not found

The full version, with separate columns for every link and the limits of the evidence, is provided in Appendix, Table 8.

What the comparison shows

All eight episodes confirm that supervisory authorities responded to individual signals: they conducted or announced inspections, arranged measurements, initiated proceedings, or applied to a court. It would therefore be inaccurate to describe the system as entirely inactive.

For none of the eight chains, however, was it possible to follow the complete sequence in the publicly available corpus through to a comparable follow-up measurement and confirmation of a sustained environmental outcome. The most detailed chain—the Cherkasovskaya processing-plant case—extends to a judicial decision and a reference to remediation of the harm, but contains no publicly available repeat laboratory confirmation of sustained remediation. For the episode of 3 December 2020, the specific concentrations and announced response are known, but the outcome of the inspection then being prepared was not found. The samples taken on 10–11 December relate to different locations and therefore do not close the original episode.

This conclusion concerns public traceability. It does not mean that the unreported action necessarily did not occur: implementation, a repeat sample, or an internal agency decision may have existed outside the open corpus. For a resident, however, the chain broke at the point where it ceased to be possible to verify whether the identified problem had been remedied.

Supervision is therefore documented as a mechanism for responding to individual episodes, but the public data found do not show it functioning as a system that provided residents with a verifiable cycle from signal to sustained outcome.

8B. December 2020: measurement, response, and the missing public outcome

DECEMBER 2020 · DIFFERENT DATES AND DIFFERENT LOCATIONS

Residents' submissions		The signal after which address-specific measurements were taken.
3 December		15 Kommunalnaya Street. Suspended particulate matter at 1.4 times ПДКм.р. and CO at 1.43 times ПДКм.р. were recorded.
10–11 December		Other locations: the Shakhta No. 12 LLC sanitary protection zone boundary and 3 Rasshchupkina Street. This was not a direct repeat at 15 Kommunalnaya Street.
Public outcome		? The inspection outcome and comparable follow-up monitoring at 15 Kommunalnaya Street were not found in the public record.

DECEMBER 2020 · DIFFERENT DATES AND DIFFERENT LOCATIONS

The December 2020 episode is important because it makes almost the entire mechanism by which environmental information emerged visible—as well as the precise point at which that mechanism broke.

3 December: the initial event

Following submissions by Natalia Zubkova, Rospotrebnadzor conducted address-specific measurements in haze and a light north-westerly wind of 0.1–0.6 m/s. At 15 Kommunalnaya Street, suspended particulate matter was directly measured at 1.4 times the maximum permissible single-exposure concentration (ПДКм.р.), and carbon monoxide at 1.43 times ПДКм.р. The agency also reported benzo[a]pyrene exceedances at six locations, but the absence of the complete protocol prevents independent verification of the method and regulatory comparison for this indicator.

The reply states that an unscheduled inspection of Boiler House No. 25 was being prepared. This establishes that the submission led not only to measurements but also to an announced supervisory response. It does not establish that the boiler house was proven to be the sole or principal source of all exceedances.

Residents' submissions The signal after which address-specific measurements were taken.

3 December — 15 Kommunalnaya Street Suspended particulate matter at 1.4 times ПДКм.р. and CO at 1.43 times ПДКм.р. were recorded.

10–11 December — other locations The sanitary protection zone boundary of Shakhta No. 12 LLC and 3 Rasshchupkina Street. This was not a direct repeat measurement at 15 Kommunalnaya Street.

Public resolution ? The outcome of the inspection of Boiler House No. 25 and comparable follow-up monitoring at 15 Kommunalnaya Street were not found in the public record.

10–11 December: a different measurement series

One week later, four samples were taken over a 24-hour period at the boundary of the sanitary protection zone of Shakhta No. 12 LLC and near 3 Rasshchupkina Street. The agency reported compliance with sanitary and hygiene requirements. These data cannot be ignored: they are an officially reported negative result from a separate monitoring series.

They were not, however, a direct repeat of the initial measurement. The locations and dates had changed, as inevitably had the meteorological and operating conditions. Without Protocol No. 12386, the individual concentrations and time of each sample remain unknown. The notice concerning 10–11 December therefore characterises the named monitoring locations in a new observation series; it does not show whether the exceedances at 15 Kommunalnaya Street had ceased or establish the outcome of the inspection of Boiler House No. 25.

Where the chain breaks

The publicly reconstructed sequence is:

submission → address-specific measurements on 3 December → specific exceedances → announced preparation of an unscheduled inspection of Boiler House No. 25 → public outcome of the inspection not found.

A separate sequence is:

monitoring on 10–11 December near Shakhta No. 12 LLC and 3 Rasshchupkina Street → reported compliance → numerical results and subsequent monitoring not published.

Combining these sequences would create the false impression that the second result tested and closed the first. The available data do not permit that conclusion.

Established directly: an exceedance of suspended particulate matter and CO at one residential location on 3 December; an official report concerning benzo[a]pyrene; preparations for an inspection; and a separate negative result on 10–11 December at other locations.

Not established from the public corpus: whether the unscheduled inspection was completed, whether the boiler house's contribution was confirmed, what measures were taken, and whether the air at the original location returned to compliance.

The absence of a result found in the public record does not prove an absence of agency action. From a resident's perspective, however, it means that the outcome of an identified exceedance cannot be traced. This is the precise point at which an environmental episode becomes an information gap.

9. Seven final answers of the study

9.1. Is Kiselyovsk a city with a high industrial burden?

Answer: Yes.

Level of evidence: established directly and by converging independent evidence.

Basis: Nine open-pit mines were operating simultaneously in May–June 2020; the city included associated processing, transport, and energy sources; and state statistics recorded 16.282–22.335 thousand tonnes of annual emissions from stationary sources in 2020–2024, including 5.869–6.906 thousand tonnes of solid pollutants.

Limitation: These data do not determine the concentration at every home or the share attributable to each facility.

Remaining gap: There is no single verified spatial layer covering all facilities or comparable time series of actual production for the entire period studied. This gap does not change the answer concerning the high industrial burden.

9.2. How indicative is the atmosphere of the environmental situation?

Answer: Air is among the most indicative environmental subjects for Kiselyovsk because open-pit mining and related processes produce dust and gaseous emissions that can be transported into residential environments and may in part appear as visible deposition.

Basis: The city's industrial structure; officially recorded emissions of solid and gaseous pollutants; documented exceedances of suspended particulate matter and carbon monoxide; and recurring ground-based and satellite observations of contaminated snow.

Level of evidence: The mechanisms and individual exceedances are established directly; the recurring coal-industry character of the contaminated snow is established by converging independent evidence.

Limitation: Air does not substitute for the study of other environmental media; visual data do not provide complete chemical composition or chronic dose.

Remaining gap: There is no continuous spatial time series enabling a quantitative assessment of the long-term exposure of different districts.

9.3. Did residents have access to sufficient information?

Answer: No. Individual aggregates, notices, and sample results were available, but there was no public, continuous, spatially representative, and reproducible time series for a resident's place of residence.

Basis: In the confirmed temporal snapshots there was no state stationary monitoring network in the city; sanitary data were published predominantly as aggregates; and production environmental control and the results of individual inspections did not form a unified district-level system with open primary time series.

Level of evidence: Established directly from the characteristics of the systems identified.

Limitation: It would be incorrect to state that the air was never measured or that residents knew no facts at all.

Remaining gap: The complete list of publication channels operating during some periods has not been reconstructed, but the channels identified do not constitute an adequate district-level system.

9.4. What information gaps were identified?

Answer: There was no integrated picture across time, districts, PM fractions, enterprises, and the final outcomes of official responses. Primary data were often replaced by aggregates or brief conclusions; some detailed datasets existed within social and hygienic monitoring, production environmental control, and supervisory systems, but their complete public availability has not been established.

Basis: The coverage matrix shows breaks across periods, territories, and pollutants; the registers of production environmental control, sanitary observations, and supervisory chains show different data systems that were not connected to one another.

Level of evidence: The gaps are established directly; the origin of each is classified where possible.

Limitation: “Not found in the public domain” does not mean “did not exist.”

Remaining gap: For some missing datasets, it is impossible to distinguish whether the data were never collected, were not published, or were not preserved in an accessible archive.

9.5. How substantially do the gaps affect the picture of the atmosphere?

Answer: Substantially. The system could show annual mass emissions and individual samples, but did not allow chronic exposure, spatial differences, the frequency of peaks, or the sustained effect of measures to be assessed. An aggregated indicator could create a more favourable impression than detailed sources from the same period.

Basis: In 2019, an aggregate of 0% coexisted with local exceedances documented in judicial proceedings; in December 2020, the initial measurement, subsequent samples at other locations, and the final outcome of the official response do not form a comparable public time series.

Level of evidence: The structural effect is established by the architecture of the data and specific comparisons taken together, especially those for 2019 and 2020.

Limitation: The magnitude of the distortion cannot be calculated without the missing time series.

Remaining gap: The complete underlying sample for the 2019 sanitary aggregate is unknown; the precise mechanism of its divergence from the measurements documented in the proceedings therefore cannot be reconstructed.

9.6. Are there grounds to regard the gaps as deliberate omissions?

Answer: A general intent on the part of authorities or enterprises has not been established. What has been proven is systemic information inadequacy and the recurrent failure to complete public information chains: the problem was known and detailed data partly existed, but the public did not receive a coherent, verifiable picture.

Basis: The incompleteness recurs across independent systems and periods, while documents confirm the existence of more detailed agency, sanitary, and operator data than were published in summary notices.

Level of evidence: High for information inadequacy and the observed breaks in the chains; insufficient for a conclusion about motives or general deliberate concealment.

Limitation: A conclusion of intent in a particular case requires evidence of possession of the information, a duty, a decision, and motive. An inability to prove intent does not mean there is no problem.

Remaining gap: The decisions and motives of specific officials or enterprises that would allow a conclusion of systemic inadequacy to be elevated to proven intent have not been established.

9.7. What role did supervision play, and how effective was it?

Answer: Supervisory authorities were capable of responding, taking measurements, establishing individual violations, and applying measures, but they did not provide the public with systematic knowledge of the city's air as a whole and, in most cases studied, did not enable the environmental outcome to be traced through to follow-up monitoring.

Basis: The eight reconstructed episodes contain actual inspections, measurements, legal claims, orders, or sanctions, but none can be publicly traced through every link to comparable follow-up monitoring and confirmation of a sustained outcome.

Level of evidence: High for individual actions and sanctions; moderate for the general conclusion that the system was reactive; insufficient data to assess long-term air-quality improvement.

Limitation: The absence of a public final document does not prove the absence of a non-public action.

Remaining gap: For the eight chains, no publicly verifiable set of implementation records and comparable follow-up monitoring through to a sustained environmental outcome was found.

10. What must change to make air information accessible

The study shows not an absence of all measurements, but a mismatch between a spatially complex industrial burden and a fragmented system of knowledge about the air. Reform must therefore do more than increase the number of documents. Residents must receive timely answers about their districts, be able to see where a number came from, and trace the consequences of an identified violation.

The proposals below constitute a research-based model of an information system. They are not presented as organisations' current legal duties unless such a duty has been established separately.

10.1. A permanent citywide network instead of dependence on an individual complaint

Problem identified. In the confirmed temporal snapshots, Kiselyovsk had no stationary monitoring station in the state network. Sanitary and supervisory measurements occurred episodically, often after a submission or public controversy.

Why this obstructs understanding. A one-off sample may confirm a specific exceedance, but it does not show the frequency, duration, seasonality, or year-to-year trend of the impact. If an instrument arrives only after a complaint, the most severe part of the episode may have ended before sampling begins.

Necessary change. The city needs a permanent observation network comprising several reference stations using methods suitable for regulatory purposes and a denser layer of indicative sensors. Low-cost sensors must not substitute for verified analysers: their purpose is to show the spatial and temporal picture, detect acute episodes, and direct laboratory investigation to where it is needed.

10.2. Locate monitoring points according to industrial geography, housing, wind, and terrain

Problem identified. The known monitoring locations form local clusters and do not evenly represent the city's elongated and spatially heterogeneous territory. Some districts are represented by complaints or visual material, but not by permanent time series.

Why this obstructs understanding. A single citywide indicator does not characterise in the same way districts near open-pit workings, processing facilities, and transport routes; more distant residential areas; and elevated, well-ventilated districts. Nor can a local exceedance automatically be extrapolated to the entire city.

Necessary change. Network design should be justified by a combination of residential density, source locations, the wind rose, terrain, and anticipated impact zones. It requires background or comparison locations, locations in potentially most-affected residential districts, and monitoring on different sides of major industrial systems. The rationale for each position and the radius for which it is representative must be published.

10.3. Measure what characterises the industrial burden people inhale

Problem identified. Different programmes measured different lists of pollutants. The general category of suspended particulate matter appears more often, while the study identified no complete public citywide time series for PM₁₀ and PM_{2.5}. Only individual samples or notices are available for a number of toxic components.

Why this obstructs understanding. The mass of solid emissions and visible deposition do not answer the question of the concentration of inhalable fractions. A limited list may fail to capture a substantial part of the impact.

Necessary change. At a minimum, a permanent programme should include PM₁₀ and PM_{2.5}, the principal gaseous pollutants, meteorological parameters, and those substances whose inclusion is warranted by an inventory of Kiselyovsk's actual sources. For pollutants requiring laboratory sampling, the portal should show the start and end times of sampling, the date by which the result is expected, and the protocol itself. Instantaneous knowledge must not be depicted where the method requires a laboratory delay.

10.4. Primary data instead of self-sufficient percentages

Problem identified. Annual shares of samples exceeding the maximum permissible concentration were published without addresses, dates, pollutants, or the denominator being visible in the city-level row. The 2019 case shows that an indicator of 0% could coexist with exceedances in another official dataset.

Why this obstructs understanding. Readers cannot see the percentage's scope of application and may take it as a description of the entire city and year.

Necessary change. An aggregate must be published together with the number of samples, list of locations, sampling dates and times, pollutants, individual values, regulatory limit, method for including results, and rounding rules. Every percentage must be disaggregable into the observations from which it is calculated. If some measurements are excluded, the exclusion criterion must be explained.

10.5. A standard record for every measurement

Every published sample or automated reading requires a minimum set of fields:

- date and exact time, or sampling interval;
- coordinates, address, or documented description of the area;
- type of location: residential area, sanitary protection zone boundary, industrial site, background, or another category;
- pollutant, unit, and measured value;
- regulatory limit applied and type of averaging period;
- measurement method, instrument, laboratory, or operator;
- verification, calibration, and quality-control status;
- meteorological conditions;
- designation as a preliminary or final result;

- link to the protocol and to any corrections to the record.

Without these fields, identically phrased statements that “an exceedance was found” and “no exceedance was found” may describe incomparable locations, intervals, and methods.

10.6. An open archive and machine-readable access

Problem identified. Reconstructing the history requires PDF files, replies to submissions, judicial decisions, agency notices, and enterprise web pages to be connected. More detailed datasets may have existed within social and hygienic monitoring, production environmental control, and experimental systems, but did not form an accessible citywide time series.

Why this obstructs understanding. Even a published document is effectively inaccessible for analysis if it is hidden in an unsystematic PDF, disappears when a website is updated, or is not linked to previous measurements.

Necessary change. All time series should have an open archive, CSV/JSON downloads, and a documented API. Previous versions, corrections, and gaps must be preserved. A missing value must be shown as missing data, not replaced with zero or a green status. Residents and researchers must be able to compare years, districts, locations, and pollutants without manually extracting hundreds of documents.

10.7. Production environmental control as a separate but visible system

Problem identified. Production environmental control creates more detailed facility-level data, but the accessible corpus consists predominantly of individual tables, programme descriptions, and narrative conclusions. Monitoring by one enterprise does not characterise the city’s combined air burden.

Why this obstructs understanding. A resident cannot verify a source’s operating conditions at the time of an episode, compare enterprises in a standard format, or see the combined burden.

Necessary change. Where legal conditions permit or can provide for it, production environmental control results should be published in a standardised, machine-readable format including locations, times, methods, and source operating conditions. On the portal they must be clearly labelled as enterprise data and displayed alongside—but not merged without explanation with—state and sanitary monitoring.

10.8. A complaint must become a publicly traceable chain

Problem identified. Individual links in the response can be seen in all eight reconstructed episodes, but no public chain reaches comparable follow-up monitoring and confirmation of a sustained outcome.

Why this obstructs understanding. A person may learn that an inspection began or a fine was imposed, but not whether the impact was remedied.

Necessary change. Every submission or publicly registered episode needs a record structured as follows: signal → measurement → result → determination of a violation → inspection → measure → implementation → comparable follow-up monitoring → final outcome. If a link has not yet occurred, the record should show the deadline and responsible authority. If a document is not subject to publication, the basis must be explained and a verifiable minimum published. A repeat sample must be comparable in location, indicator, and purpose; a measurement one week later in another part of the city cannot be presented as closure of the original episode.

10.9. An interactive map as the principal user interface

A public map should begin not with an agency or enterprise, but with a person's place of residence. After selecting an address, the user should see:

- the nearest state, sanitary, operator, and indicative locations as distinct data classes;
- the current value and history of every pollutant measured;
- the radius and limit of each location's representativeness;
- wind direction and the positions of known sources;
- active alerts and instrument malfunctions;
- the latest laboratory samples;
- related complaints, inspections, measures, and follow-up monitoring;
- the ability to download the underlying records.

The map must not colour a district green merely because there is no instrument nearby. The correct designation in that situation is "insufficient data."

10.10. One access system, but not one undifferentiated dataset

Problem identified. Information is distributed among Roshydromet, sanitary supervision, environmental supervision, enterprises, courts, and replies to submissions.

Why this obstructs understanding. An ordinary resident must perform the work of a months-long study in order to connect one exceedance with an inspection and its possible outcome.

Necessary change. A single public access point should link data held by different entities through common identifiers for the location, event, enterprise, and inspection. Provenance must not be erased: a state measurement, production environmental control record, resident's testimony, and modelling result must remain visually distinct. A single window means connected data, not the commingling of evidentially different data.

10.11. What an answer to a resident could look like

Instead of a statement that “no exceedances were identified” without parameters, a user should receive a record with approximately the following structure:

Kommunalnaya Street; nearest location: 420 m. PM2.5: current value and 24-hour average; PM10: current value and 24-hour average; wind direction; time of last update; organisation that owns the instrument; data-quality status. A rise in concentration was recorded at 06:40. A mobile laboratory has been dispatched. The sample was taken from 08:10 to 08:30. The protocol is expected on [date]. The inspection is linked to the event record. Following the measure taken, repeat sampling has been scheduled at a comparable location.

Some indicators can be displayed almost in real time; others only after laboratory analysis. An honestly displayed delay is better than a false appearance of completeness.

The system's ultimate purpose is not to promise immediate identification of every substance, but to allow a person, using a single address, to see what is being measured now, what the system does not know, and how the response to an identified problem ended.

10.12. Practical conclusion

Kiselyovsk needs a spatially distributed permanent network, open primary data, and a public link between measurements and supervisory outcomes. Only the combination of these three elements closes the gap identified by the study:

1. the network creates regular knowledge, rather than a chance coincidence between a sample and an event;
2. open data make it possible to verify what a published conclusion means;
3. a traceable chain shows whether anything changed after pollution was identified.

Such a system would not in itself resolve the environmental problem. It would end the situation in which a resident sees and experiences an impact but cannot obtain a timely, verifiable description of the air or the final outcome of the state response.

Conclusion

Kiselyovsk is not a case in which all knowledge is absent, but one in which the complexity of industrial impacts is mismatched with the architecture of accessible information. The state, enterprises, and laboratories collected a significant volume of information. Emission masses were known; sanitary and operator measurements were conducted; exceedances were identified; proceedings were initiated; and measures were applied. Residents created their own visual archive of recurring pollution.

This knowledge, however, existed in fragments. Nine open-pit mines operating in May–June 2020 and other sources created a combined burden, while monitoring was divided by agency and facility. Annual mass did not answer the question of concentration. Modelled background concentrations did not substitute for observation. A one-off sample did not establish chronic exposure. One operator’s environmental monitoring did not represent the city. A brief notice about an inspection did not show a sustained final outcome.

The body of data identified makes it possible to establish the reality of industrial air pollution and recurring episodes of deposition of coal-industry particulates. It does not permit a quantitative reconstruction of what each district’s residents breathed or for how long. This evidential boundary results not only from incompleteness in the research archive that has survived, but also from the design of observation and publication itself.

An ordinary resident could see the problem before receiving a measurement, and could receive a measurement without receiving a complete explanation. Official information was not necessarily false: its fragmented character allowed each individual statement to remain formally accurate while preventing an overall picture from emerging.

The evidence is insufficient to establish general deliberate concealment. But the absence of proven intent does not make the information environment adequate.

The study’s principal finding is more exacting: given the established high industrial burden, the existing public system did not enable residents to assess air conditions independently, promptly, and with spatial precision; and supervision predominantly responded to individual signals without creating a traceable history of the combined impact and its remediation.

Bibliography

Bibliographic entries follow a working English-language adaptation of Chicago style. Unless otherwise stated, online sources were accessed on 2 September 2026. The complete register, including local paths and the class and purpose of every source, is provided in `source register`

(archive filename: ИСТОЧНИКИ.csv).

Official and archival documents

Kemerovo Centre for Hydrometeorology and Environmental Monitoring, a branch of the Federal State Budgetary Institution West Siberian Administration for Hydrometeorology and Environmental Monitoring. Reply to Natalia Zubkova, *Novosti Kiselevska*, concerning observations and background concentrations. 22 April 2020. No. 08-10/107-1196. Personal archive of Natalia Zubkova.

Ministry of Natural Resources and Environment of Kuzbass. *State Report on the Condition and Protection of the Environment in Kemerovo Region—Kuzbass for 2024*. Kemerovo, 2025. https://kuzbasseco.ru/wp-content/uploads/2025/06/doklad_v2-1.pdf.

Regional environmental-protection authorities. *Report on the Condition and Protection of the Environment in Kemerovo Region in 2011*. Kemerovo, 2012. https://kuzbasseco.ru/wp-content/uploads/2025/03/doklad_ecolog_2011_final.pdf.

Ministry of Natural Resources and Environment of Kuzbass. *State Report on the Condition and Protection of the Environment in Kemerovo Region—Kuzbass for 2023*. Kemerovo, 2024. https://kuzbasseco.ru/wp-content/uploads/2025/02/DOKLAD_2023.pdf.

Territorial Department of the Rospotrebnadzor Directorate for Kemerovo Region—Kuzbass in Kiselyovsk, Prokopyevsk, and Prokopyevsky District. Reply to submissions by Natalia Zubkova. December 2020. Personal archive of Natalia Zubkova. The available electronic copy contains the complete text but has blank fields for the outgoing number and date; its content is associated with Reply No. 3007 of 15 December 2020.

Rospotrebnadzor Directorate for Kemerovo Region and regional natural-resources authorities. *State Reports on the Sanitary and Epidemiological Well-Being of the Population and on the State of the Environment, 2008–2019*. The issues and record-level attribution of indicators are specified in Appendix, Table 2.

INECA Consulting LLC and Shakhta No. 12 LLC. *Environmental Impact Assessment of the Proposed Activities of Shakhta No. 12 LLC: Book 1 and Appendices*. 2019. Research archive.

Organisers of the public consultations and Shakhta No. 12 LLC. *Minutes of the Public Consultations*. 13 February 2020. Research archive.

Judicial decisions and supervisory materials

Kiselyovsk City Court of Kemerovo Region. Decision in Case No. 1-148/2020, unique case identifier 42RS0010-01-2020-000360-25. 27 February 2020. <https://sudact.ru/regular/doc/NNFK3Z6Lb8HK/>. The database heading gives 26 February

2020; the discrepancy between the dates has been retained.

Ministry of Natural Resources and Environment of Kuzbass. “The South Siberian Interregional Directorate of Rosprirodnadzor Inspected the Operations of Shakhta No. 12 LLC.” 28 November 2024. <https://kuzbasseco.ru/2024/11/28/yuzhno-sibirskoe-mezhregionalnoe-upravlenie-rosprirodnadzora-proverilo-rabotu-ooo-shaxta-12/>.

Prosecutor’s Office of Kemerovo Region—Kuzbass. Notice concerning the results of the inspection of black snow in Kiselyovsk. 14 December 2021. The original page was not recovered; the text survives in concordant republications by A42, Sibdepo, VSE42, and Province.ru. The republications are treated as one source.

Prosecutor’s Office of Kemerovo Region—Kuzbass. “Following a Claim by the Novokuznetsk Interdistrict Environmental Prosecutor, the Court Ordered a Commercial Enterprise to Ensure Compliance with Ambient-Air Protection Legislation.” 19 March 2024. <https://myseldon.com/ru/news/index/309530895>. The official text survives in republication; the primary protocols and complete judicial decision are absent from the corpus.

Scientific and technical publications

Korchagina, T. V., V. P. Potapov, and E. L. Schastlivtsev. “Digital Monitoring of the Natural and Technogenic Environment to Ensure the Environmental Safety of Mining Enterprises.” *Ugol*, no. 6 (2022): 59–67. <https://doi.org/10.18796/0041-5790-2022-6-59-67>.

Rozhkova, K. A., and S. E. Starodubtseva. “Hygienic Assessment of Chemical Pollution of Ambient Air and Its Effects on Public Health in the Cities of Prokopyevsk and Kiselyovsk, 2015–2019.” In *Problems of Medicine and Biology: Proceedings of the International Scientific and Practical Conference of Young Scientists and Students*, part 2, 129–131. Kemerovo: Kemerovo State Medical University, 2021. https://kemsu.ru/science/sci_events/Проблемы%20медицины%20и%20биологии%20часть%20%202.pdf.

Schastlivtsev, E. L., A. A. Bykov, N. I. Yukina, and I. E. Kharlampenkov. “Hardware and Software System for Monitoring Atmospheric Pollution.” Conference abstracts, 2021, 62–63. <https://rio.ksc.ru/data/documents/tezisi-gorb-2021.pdf>.

Publications and visual sources

“Air Within the Standard.” *Sibdepo*. 6 June 2012. <https://sibdepo.ru/news/vozduh-v-norme.html>.

“The Economy of Kiselyovsk.” *Ugol Kuzbassa*. May–June 2020. Joint project with Kemerovostat. <https://uk42.ru/index.php?id=10730>.

Photographs and videos by Afonino residents showing dark snow. December 2024. Preserved, among other places, in a VSE42 publication: <https://vse42.ru/news/33600542>. The exact filming location and composition of the deposit have not been established.

European Union. *Copernicus Sentinel-2 Imagery: Winter Scenes of Kiselyovsk, 2019–2026*. Local copies and processing log in the research archive. The satellite scenes are used to analyse spatial heterogeneity of the snow surface, not as chemical analysis or a measurement of concentration in the air.

Tabular appendices

The tables reproduce the prepared research dataset. Rows preserve data provenance, limitations, and reference keys; an empty field is not interpreted as a zero value.

TABULAR APPENDIX

Table 1. Chronology of observation systems

Part 1 of 3

system_id	period	system_or_episode	operator	where	what_was_monitored
AIRSYS-001	2004–2008	sanitary investigations of ambient air	Rospotrebnadzor / centres for hygiene and epidemiology	Kiselyovsk; location types and addresses not disclosed in the summary table	pollutants; no city-specific list provided
AIRSYS-002	confirmed snapshots for 2008 and 2011	Roshydromet state ambient-air pollution monitoring network	Kemerovo Centre for Hydrometeorology and Environmental Monitoring / Roshydromet	official lists include 18 stations only in Kemerovo, Novokuznetsk, and Prokopyevsk; Kiselyovsk is absent	station programmes apply only to the three listed cities
AIRSYS-003	2009	sanitary investigations of ambient air	Rospotrebnadzor / centres for hygiene and epidemiology	Kiselyovsk; addresses not disclosed	pollutant list not disclosed in the city-level row
AIRSYS-004	2010	sanitary investigations of ambient air	Rospotrebnadzor / centres for hygiene and epidemiology	Kiselyovsk; addresses not disclosed	pollutant list not disclosed in the city-level row
AIRSYS-005	2016–2019, provisional range	observations of the chemical composition of snow cover at the Kiselyovsk meteorological station	Kemerovo Centre for Hydrometeorology and Environmental Monitoring / Roshydromet	Kiselyovsk meteorological station	sulphates, nitrates, ammonium, chlorides, bicarbonates, calcium, magnesium, pH, and electrical conductivity

system_id	period	system_or_episode	operator	where	what_was_monitored
AIRSYS-006	2018	Shakhta No. 12 LLC production environmental control of ambient air	enterprise and contracted laboratory; laboratory name not extracted	five residential-area locations: 1 Chernomorsky Lane, 2 Minskaya Street, 7 Okrainaya Street, 75A Kolkhoznaya Street, and the intersection of Shakhtostroevskaya and Maiskaya Streets	NO ₂ , suspended particulate matter, SO ₂ , and CO
AIRSYS-007	2019-04-12	sanitary/project sample associated with the environmental impact assessment of the Severny spoil tip	laboratory and commissioning party require identification	location 6/1, Krasny Kamen area	pollutant list and numerical values not fully reproduced in the preserved replies
AIRSYS-008	2020-04-22	official description of the state system and background concentrations	Kemerovo Centre for Hydrometeorology and Environmental Monitoring	Kiselyovsk and Kiselyovsk Urban District	the Centre conducted no regular observations; background values were issued for emission regulation
AIRSYS-009	2020-12-03	sanitary measurements following Natalia's submissions	territorial Rospotrebnadzor and the Federal Centre for Hygiene and Epidemiology	3 and 11 Druzhby Street, 15 Kommunalnaya Street, 24 Tulsкая Street, and background-designated and downwind-plume locations near Boiler House No. 25	suspended particulate matter, NO ₂ , SO ₂ , CO, black carbon, and benzo[a]pyrene
AIRSYS-010	2020-12-10—2020-12-11	subsequent 24-hour sanitary monitoring near Shakhta No. 12 LLC	Rospotrebnadzor and the Federal Centre for Hygiene and Epidemiology	background-designated and downwind-plume locations at the sanitary protection zone boundary, 3 Rasshchupkina Street	suspended particulate matter, NO ₂ , SO ₂ , CO, and black carbon
AIRSYS-011	through 28 February 2026	system for forecasting adverse meteorological conditions (HMY)	Kemerovo Centre for Hydrometeorology and Environmental Monitoring and regional authorities	Kemerovo, Novokuznetsk, Prokopyevsk, and Novokuznetsk District; Kiselyovsk was not included in the system identified	meteorological dispersion conditions and prescribed emission reductions, not concentrations themselves
AIRSYS-012	from 1 March 2026	expanded system for forecasting adverse meteorological conditions (HMY)	Kemerovo Centre for Hydrometeorology and Environmental Monitoring and regional authorities	all cities in Kuzbass, including Kiselyovsk	forecast of adverse conditions and emission-reduction measures
AIRSYS-013	2011–2019	sanitary investigations of ambient air with publication of annual shares of exceedances	Rospotrebnadzor / centres for hygiene and epidemiology	Kiselyovsk; locations and their continuity between years not disclosed in the summary rows	pollutant list for the city-level row not disclosed
AIRSYS-014	2022-08—2022-10	publicly announced plan to expand the stationary network	Kuzbass Ministry of Natural Resources, citing an agreement with federal authorities	new stations planned in Kiselyovsk, Belovo, Mezhdurechensk, and Leninsk-Kuznetsky	future programme not disclosed

system_id	period	system_or_episode	operator	where	what_was_monitored
AIRSYS-015	2023	federal state observation network	Roshydromet / Kemerovo Centre for Hydrometeorology and Environmental Monitoring	18 stations only: 8 in Kemerovo, 8 in Novokuznetsk, and 2 in Prokopyevsk; a station for Kiselyovsk was only planned	station programmes did not cover Kiselyovsk
AIRSYS-016	2024	state ambient-air pollution observation network	Roshydromet / Kemerovo Centre for Hydrometeorology and Environmental Monitoring	18 stationary stations: 8 in Kemerovo, 8 in Novokuznetsk, and 2 in Prokopyevsk; the section specifically concerning Kiselyovsk expressly states that the state network was absent	standard federal-station programmes did not cover Kiselyovsk
AIRSYS-017	2024-11	supervisory response to residents' complaints concerning Shakhta No. 12 LLC	South Siberian Interregional Directorate of Rosprirodnadzor	processing-plant sources according to enterprise documents; residential locations not specified in the publication	pollutant list not published
AIRSYS-018	2012; sampling date unknown	sanitary measurements following a complaint by a resident of 80 Omskaya Street	Rospotrebnadzor Directorate and laboratory; identifying details not published	outdoor air near the house and indoor air; house 480 m from the mining allotment of Shakhta No. 12 LLC	suspended particulate matter, NO ₂ , CO, SO ₂ , and phenol
AIRSYS-019	13–18 February 2019; monitoring period through 14 March 2019	sanitary measurements and investigation of pollution by Cherkasovskaya Processing Plant LLC	Federal Centre for Hygiene and Epidemiology, Rosprirodnadzor, investigative authorities, and court	residential location at No. 5 on an anonymised lane and two downwind-plume locations at the 500 m sanitary protection zone boundary	suspended particulate matter
AIRSYS-020	2021-12-02—2021-12-14	prosecutorial inspection of reports of smog and black snow	prosecutor's office with Rospotrebnadzor and a laboratory	Kiselyovsk, sanitary protection zone boundary of the Istok municipal enterprise boiler house and monitoring of facilities; other locations not published	suspended particulate matter and hard-coal dust; complete list unknown
AIRSYS-021	2019-06	series of measurements during underground combustion near Malinnaya and Razdolnaya Streets	Rospotrebnadzor, VostNII, and the Kiselyovsk municipal administration	residential streets near workings of the closed Kiselyovskaya mine; exact locations not published	CO, harmful substances, and particles; complete list unknown

system_id	period	system_or_episode	operator	where	what_was_monitored
AIRSYS-022	2015–2019; publication in 2021	regional social and hygienic monitoring information repository and its scientific analysis	Rospotrebnadzor / Federal Centre for Hygiene and Epidemiology as repository holder; researchers from Kemerovo State Medical University and the Centre for Hygiene	Kiselyovsk locations not disclosed	NO ₂ , suspended particulate matter, CO, soot, formaldehyde, phenol, and other pollutants; complete list not published
AIRSYS-023	2017–2019; disclosed at consultations on 13 February 2020	regular Shakhta No. 12 LLC production environmental control programme and monitoring during blasting	Shakhta No. 12 LLC; sampling/investigations by Centre for Hygiene Assessment LLC	five addresses in the regular programme and two addresses during blasting	eight indicators in the regular 2018 summary; list for blasting not disclosed
AIRSYS-024	1–8 October 2019; extended pilot operation reported from 2020	Shakhta No. 12 LLC hardware and software system for atmospheric-pollution monitoring and modelling	Federal Research Centre for Coal and Coal Chemistry, Siberian Branch of the Russian Academy of Sciences / Shakhta No. 12 LLC	open-pit mine impact zone and urban sources; sensor coordinates not published	dust-particle concentration without a specified size fraction, wind, temperature, pressure, and humidity
AIRSYS-025	before March 2024	sanitary inspection of Shakhta No. 12 LLC following media and internet publications	Novokuznetsk Interdistrict Environmental Prosecutor's Office jointly with Rospotrebnadzor	processing-plant sanitary protection zone boundary and nearest housing; addresses not published	suspended particulate matter, described as coal dust in the notices
AIRSYS-026	13 December 2024 and subsequent days	inspection of a report of black snow in Afonino	Kiselyovsk prosecutor's office with Rospotrebnadzor and the Centre for Hygiene and Epidemiology	Afonino area; sampling locations not disclosed in the public notice	ambient-air protection was announced as the subject; list of analyses not published

Part 2 of 3

system_id	frequency	data_type	what_is_available	industrial_context	verification_level
AIRSYS-001	unknown; annual shares of samples exceeding the maximum permissible concentration were published	actual sanitary samples aggregated into percentages	annual shares of non-compliant samples: 7.9%, 12.1%, 4.1%, 6.1%, and 1.2%	coal mining, boiler houses, transport, and other urban sources, without attribution from the aggregate	official regional report for 2008
AIRSYS-002	regular station-based observation	actual stationary observations outside Kiselyovsk	network lists in the state reports for 2008 and 2011	Kiselyovsk had an industrial burden but was not represented in the state station network	official regional reports; for 2011, PDF pp. 23 and 37

system_id	frequency	data_type	what_is_available	industrial_context	verification_level
AIRSYS-003	unknown	actual samples, aggregated	1.3% of samples exceeding the maximum permissible concentration	the city's contemporary mix of industrial sources	official regional report for 2009
AIRSYS-004	unknown	actual samples, aggregated	1.3% of samples exceeding the maximum permissible concentration	the city's contemporary mix of industrial sources	official regional report for 2010
AIRSYS-005	annual/seasonal samples; exact design requires verification	measurement of atmospheric deposition in snow, not airborne concentration	multi-year table in the 2019 regional report	combined winter deposition from all sources	official regional report; primary protocols not obtained
AIRSYS-006	the environmental impact assessment provides the annual mean and maximum; number and calendar of samples are absent	actual production environmental control measurements as reported in a project document	table in the 2019 environmental impact assessment	open-pit operations and other facilities of Shakhta No. 12 LLC	project document with a quantitative table; primary protocols absent
AIRSYS-007	one-off protocol	actual measurement	reference to sanitary protection zone Protocol No. 76 of 12 April 2019	Severny spoil-tip project at the Vakhrushevskoye field	secondary account in a project document
AIRSYS-008	state of the system on the date of the reply	not an air-quality measurement, but an official reply concerning the system and modelled background	Letter No. 08-10/107-1196	all regulated sources that used the background values in emission projects	primary official reply from Natalia's archive
AIRSYS-009	one sampling episode	actual laboratory measurements in an official account	Rospotrebnadzor reply, exceedance values, and Protocol Nos. 11485 and 43135	Boiler House No. 25, domestic heating, transport, and industrial sources; contributions not apportioned	primary official reply; complete protocols absent
AIRSYS-010	four samples over 24 hours	actual measurements in an official account	notice of compliance with requirements and Protocol No. 12386	sources of Shakhta No. 12 LLC and other urban sources	primary official reply; protocol absent
AIRSYS-011	for forecast episodes	forecast and regulatory signal	regional procedures and official explanations for 2024/2026	Kiselyovsk's industrial and municipal sources did not receive a general citywide signal under the previous system	official regional documents require renewed archiving in the current corpus
AIRSYS-012	for forecast episodes	forecast, not concentration measurement	official notice concerning the reform	all regulated sources in the city	official notice requires preservation and verification of implementation

system_id	frequency	data_type	what_is_available	industrial_context	verification_level
AIRSYS-013	unknown; one annual aggregate was published	actual sanitary samples reduced to a percentage of samples exceeding the maximum permissible concentration	3.26%, 1.20%, 0.37%, 0.30%, 0.55%, 1.35%, 2.37%, 2.40%, and 0.00% for 2011–2019	combined citywide burden without source attribution	official state reports for 2011, 2013, 2014, 2015, and 2019
AIRSYS-014	not applicable	plan, not observation	two official publications concerning a future station	recognition of the need to expand the network in industrial cities	official notices from the regional authority
AIRSYS-015	regular station-based observation outside the city	actual stationary observations outside Kiselyovsk plus an expansion plan	official state report for 2023	Kiselyovsk Urban District is identified as an area with a high volume of gross emissions where a station is planned	official state report
AIRSYS-016	regular station-based observation outside the city	official description of the network actually in operation	2024 state report, PDF pp. 48–49 and 291	19,284 thousand tonnes of emissions from stationary sources were recorded in Kiselyovsk Urban District, but the state network did not measure concentrations in the city	official state report with an explicit territorial statement
AIRSYS-017	analysis of annual reporting for 2023; no new sampling described	documentary review of production environmental control, not an independent air measurement prompted by the complaint	official notice reporting that no exceedances were identified and that a warning was announced	coal processing by Shakhta No. 12 LLC	official notice; primary inspection record and production environmental control reports absent
AIRSYS-018	one or more samples; number unknown	actual laboratory measurements in the account of an official reply	no exceedances were reported	Shakhta No. 12 LLC, unidentified open-pit mine, and blasting operations	secondary publication quoting a Rospotrebnadzor reply
AIRSYS-019	three specific results in a judicial decision	actual laboratory measurements	0.36 mg/m ³ against a ПДКс.с. of 0.15; 0.60 and 0.69 mg/m ³ against a ПДКм.р. of 0.50; Protocols 978, 1049, and 1056/1	storage, crushing, conveyors, loading, and unloading of coal by Cherkasovskaya Processing Plant LLC	judicial decision; primary protocols absent
AIRSYS-020	one-off inspection episode	combination of air measurements, emissions monitoring, and documentary inspection	reported: non-compliant air near the Istok municipal enterprise; an emission-limit exceedance at the Krasnokamenskaya central processing plant; absence of a declaration by the Kristall municipal enterprise; and risks from mass blasting by Polyany JSC and Lugovoye JSC	boiler house, treatment facilities, coal processing, and open-pit mining	several concordant accounts of the official notice; original and protocols not found

system_id	frequency	data_type	what_is_available	industrial_context	verification_level
AIRSYS-021	daily samples were reported during part of the period	actual measurements in conflicting public accounts	RIA reported deviations; Interfax reported no exceedances of maximum permissible concentrations on the same day; Rossiyskaya Gazeta later reported no deviations in daily samples	underground combustion, a waste dump, and workings of a closed mine; the published materials do not definitively establish the source	three news reports citing authorities; primary protocols absent
AIRSYS-022	multi-year dataset, but the number of samples, calendar, and programme continuity are unknown	the authors combined actual social and hygienic monitoring concentrations with sample shares from state reports and emission masses from environmental reports	exceedances of 1.1–2 and 2.1–5 times the maximum permissible concentration and a conclusion that pollution increased by 2019 were reported, but the underlying time series were not provided	combined set of urban sources; no causal attribution to individual facilities was performed	complete text of the conference paper by Rozhkova and Starodubtseva, pp. 129–131
AIRSYS-023	four samples per month at each regular location and 24 samples per year during blasting were reported	actual laboratory measurements organised by the enterprise; only the 2018 summary and programme description are available	no exceedances of ПДКм.р. were published in the 2018 summary	ongoing operations and blasting by Shakhta No. 12 LLC	consultation minutes and preliminary 2019 environmental impact assessment
AIRSYS-024	measurements and modelling every 20 minutes	combination of sensor measurements and dispersion modelling under MRR-2017 in ERA-Air 3.0 atmospheric-pollution modelling software	the scientific paper describes testing on real data and archiving of measurements and calculations	enterprise sources, municipal boiler houses, roads, and the private-residential sector were separated into modelling groups	primary scientific publication by the developers, without the dataset itself
AIRSYS-025	number and dates of samples not published	actual laboratory investigations in the prosecutor's-office account	a twofold exceedance of the maximum permissible concentration and the upholding of a claim for remediation of the violations were reported	Shakhta No. 12 LLC processing plant	several concordant publications originating from the prosecutor's office; judicial decision and protocols not yet found
AIRSYS-026	inspection announced; programme and frequency not disclosed	at the time of the available notice, only regulatory action; measurement results not published	residents' visual reports and the start of an inspection are confirmed	nearby coal facilities were named by residents; no official source was established	several independent news publications with the same prosecutor's-office provenance

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system_id	principal_limitation	next_minimum_step	sufficiency_status
AIRSYS-001	the number of samples, dates, addresses, pollutants, and sampling programme are unknown; percentages may therefore be incomparable between years	obtain annual sanitary tables/forms and sample logs with numerators and denominators	partly sufficient to establish the existence of sanitary monitoring; insufficient for exposure
AIRSYS-002	the 2008 and 2011 snapshots do not prove the absence of a station in every intervening, earlier, or later year	verify other years only if an exact historical boundary is required	sufficient for network status in 2008 and 2011; insufficient for a continuous historical boundary
AIRSYS-003	numerator, denominator, addresses, dates, and pollutants absent	obtain primary city-level sanitary monitoring forms	partial
AIRSYS-004	numerator, denominator, addresses, dates, and pollutants absent	obtain primary city-level sanitary monitoring forms	partial
AIRSYS-005	does not substitute for air measurement; temporal resolution is low; annual table labels require page-by-page verification	extract the complete 2016–2019 table, sampling methodology, and station coordinate	insufficient, but important as a distinct type of observation
AIRSYS-006	dates, number of samples, method, meteorological conditions, accreditation, and programme completeness are unknown; the list does not include PM10/PM2.5 or benzo[a]pyrene	obtain the production environmental control programme and primary protocols for 2018	partial
AIRSYS-007	one location and date; primary protocol absent; the statement that no exceedances occurred does not characterise long-term exposure	obtain sanitary protection zone Protocol No. 76 and the location diagram	insufficient
AIRSYS-008	does not answer whether stations existed in other periods and does not provide the requested background values from 1991 onward	verify historical network boundaries and obtain modelled background values with the methodology	sufficient for status on the stated date; historically insufficient
AIRSYS-009	a one-off episode does not establish chronic exposure; comparison of benzo[a]pyrene with the maximum permissible average daily concentration requires the sampling methodology	obtain Protocols 11485 and 43135	partial; critical gap
AIRSYS-010	individual values, times, coordinates, detection limits, and data on source operation are absent	obtain Protocol 12386	partial

system_id	principal_limitation	next_minimum_step	sufficiency_status
AIRSYS-011	absence of warnings does not mean absence of pollution or conditions resembling adverse meteorological conditions	archive the primary instruments from 2005, 2006, 2012, 2024, and 2026	sufficient for the architectural conclusion after the instruments are rechecked
AIRSYS-012	short observation period; a specific Kiselyovsk episode and actual concentrations have not yet been found	check the warning archive after 1 March 2026 and the publication mechanism for Kiselyovsk	insufficient to assess implementation
AIRSYS-013	a change in percentage may reflect not only the air but also the number, location, timing, and composition of samples, which are not published in the city-level row	obtain city-level forms, programmes, and denominators; compare pollutant lists	sufficient to establish sanitary monitoring; insufficient for an exposure trend
AIRSYS-014	the announcement does not prove that a station was commissioned or data obtained	check subsequent state reports and commissioning records	sufficient as evidence of a plan, not of implementation
AIRSYS-015	planning does not create a historical time series or characterise the city's districts	find the procurement, location, commissioning record, and data from the planned station, or confirm non-implementation by the next reporting snapshot	sufficient for the status of the federal network in 2023
AIRSYS-016	absence of the state network does not exclude sanitary, route-based, mobile, and operator measurements, which must be considered separately	separately verify whether a regional, non-federal station existed and examine the 2024 sanitary programmes	sufficient for the conclusion that the state station network was absent in 2024
AIRSYS-017	the statement concerning maximum permissible concentrations at sources does not disclose the applied standard, while analysis of enterprise reporting does not characterise the air throughout the city	obtain the inspection record/details, warning, 2023 production environmental control programme and report, and Form 2-TP (Air)	partial; an important example of the limited verifiability of responses to complaints
AIRSYS-018	dates, values, protocols, meteorological conditions, and correspondence between sampling and the time of blasting are absent	obtain the original letter and protocols	partial
AIRSYS-019	three episodes do not form an annual time series; the residential location's address is anonymised	obtain protocols and follow-up measurements after remediation	strong evidence for the episode; insufficient for chronic exposure
AIRSYS-020	different classes of violation are combined; values, protocols, and a final follow-up inspection are absent	obtain the original notice, administrative-case materials, and follow-up measurements	partial; a significant episode of supervisory response
AIRSYS-021	conflicting results and causal explanations; the early explanation involving a waste dump does not resolve the subsequent drilling of 29 boreholes	obtain the VostNII findings, Rospotrebnadzor protocols, and borehole results	insufficient; discrepancy preserved
AIRSYS-022	primary tables, number of observations, and correlation coefficients are absent; the authors' causal language is stronger than the study design	obtain an anonymised social and hygienic monitoring export and the authors' calculation tables	sufficient to establish the existence of an internal dataset; insufficient to reproduce the conclusions

system_id	principal_limitation	next_minimum_step	sufficiency_status
AIRSYS-023	the reported 250 samples do not match the arithmetic total of 240; primary protocols and results during blasting are absent	obtain the programme, 2017–2019 logs, protocols, and blasting calendar	the potential time series is highly valuable, but at present mainly a statement and one year's summary indicators are confirmed
AIRSYS-024	sensor locations, calibration and type, continuity of operation, and archive availability are unknown; fixed source parameters from the permissible-emissions documentation may have differed from actual operation	request the commissioning record, sensor layout, methodology, archive of 20-minute values, and data-transfer rules	the potential time series is highly valuable; sustained operation and data availability have not yet been established
AIRSYS-025	absolute concentrations, type of maximum permissible concentration, addresses, meteorological conditions, and entry of the judgment into force are unknown	find the case record and text of the judicial decision, claim, protocols, and subsequent monitoring of implementation	high for the fact of an officially established episode; partial for its parameters and final outcome
AIRSYS-026	protocols, numerical values, source finding, measures, and follow-up inspection are absent	request the inspection outcome, protocols, and information on measures	sufficient for the fact of the event and response; insufficient for air quality and the final outcome

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 2. Shares of sanitary samples exceeding the maximum permissible concentration, 2004–2019

Part 1 of 3

year	share_of_samples_exceeding_ПД K_percent	territory	type_of_observation	source	source_table
2004	7,9	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2008	Table 2.7
2005	12,1	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2008	Table 2.7
2006	4,1	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2008	Table 2.7

year	share_of_samples_exceeding_ПД K_percent	territory	type_of_observation	source	source_table
2007	6,1	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2008	Table 2.7
2008	1,2	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2008	Table 2.7
2009	1,3	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2009	Table 2.8
2010	1,3	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2010	Table containing the 2006–2010 series
2011	3,26	Kiselyovsk	sanitary investigations of ambient air	State Report on the Condition and Protection of the Environment in Kemerovo Region for 2011	Table 2.9
2012	1,20	Kiselyovsk	sanitary investigations of ambient air	State Report on the State of the Environment in Kemerovo Region for 2013	Table 2.16
2013	0,37	Kiselyovsk	sanitary investigations of ambient air	State Report on the State of the Environment in Kemerovo Region for 2013	Table 2.16
2014	0,30	Kiselyovsk	sanitary investigations of ambient air	State Report on the State of the Environment in Kemerovo Region for 2014	Table 2.16
2015	0,55	Kiselyovsk	sanitary investigations of ambient air	State Report on the State of the Environment in Kemerovo Region for 2015	Table 2.15
2016	1,35	Kiselyovsk	sanitary investigations of ambient air	State Report on the Sanitary and Epidemiological Well-Being of the Population in Kemerovo Region for 2019	Table 2.15

year	share_of_samples_exceeding_ПД K_percent	territory	type_of_observation	source	source_table
2017	2,37	Kiselyovsk	sanitary investigations of ambient air	State Report on the Sanitary and Epidemiological Well-Being of the Population in Kemerovo Region for 2019	Table 2.15
2018	2,40	Kiselyovsk	sanitary investigations of ambient air	State Report on the Sanitary and Epidemiological Well-Being of the Population in Kemerovo Region for 2019	Table 2.15
2019	0,00	Kiselyovsk	sanitary investigations of ambient air	State Report on the Sanitary and Epidemiological Well-Being of the Population in Kemerovo Region for 2019	Table 2.15

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year	number_of_samples	number_of_exceedances	monitoring_location_addresses	list_of_pollutants	methodological_note
2004	not published in the city-level row	not published	not published	not published for the city	The aggregated share does not describe long-term exposure and may not be comparable between years without the sampling programme
2005	not published in the city-level row	not published	not published	not published for the city	Same source
2006	not published in the city-level row	not published	not published	not published for the city	Same source
2007	not published in the city-level row	not published	not published	not published for the city	Same source
2008	not published in the city-level row	not published	not published	not published for the city	Same source
2009	not published in the city-level row	not published	not published	not published for the city	Same source
2010	not published in the city-level row	not published	not published	not published for the city	Same source
2011	not published in the city-level row	not published	not published	not published for the city	Same source

year	number_of_samples	number_of_exceedances	monitoring_location_addresses	list_of_pollutants	methodological_note
2012	not published in the city-level row	not published	not published	not published for the city	Retrospective value in a five-year series
2013	not published in the city-level row	not published	not published	not published for the city	The aggregate is below the regional average of 0.6%, but this does not prove low chronic exposure
2014	not published in the city-level row	not published	not published	not published for the city	Aggregated indicator
2015	not published in the city-level row	not published	not published	not published for the city	Aggregated indicator
2016	not published in the city-level row	not published	not published	not published for the city	Retrospective value in a five-year series
2017	not published in the city-level row	not published	not published	not published for the city	Retrospective value in a five-year series
2018	not published in the city-level row	not published	not published	not published for the city	Retrospective value in a five-year series
2019	not published in the city-level row	0 or a rounded value; the numerator was not published	not published	not published for the city	Zero percent means that no exceedances occurred among the samples taken; without the denominator and sampling design, it does not mean an absence of pollution

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year	status
2004	verified against the official publication
2005	verified against the official publication
2006	verified against the official publication
2007	verified against the official publication
2008	verified against the official publication

year	status
2009	verified against the official publication
2010	verified against the official publication
2011	verified against the official PDF
2012	verified against the official PDF
2013	verified against the official PDF
2014	verified against the official PDF
2015	verified against the official PDF
2016	verified against the official PDF
2017	verified against the official PDF
2018	verified against the official PDF
2019	verified against the official PDF

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 3. Emissions from stationary sources, 2020–2024

Part 1 of 3

year	total_mass_thousand_tonnes	solid_pollutants_thousand_tonnes	gaseous_and_liquid_pollutants_thousand_tonnes	SO2_thousand_tonnes	CO_thousand_tonnes
2020	22,335	5,869	16,466	1,102	3,963
2021	17,622	6,552	11,070	1,105	4,373
2022	21,512	6,906	14,606	1,110	5,365

year	total_mass_thousand_tonnes	solid_pollutants_thousand_tonnes	gaseous_and_liquid_pollutants_thousand_tonnes	SO2_thousand_tonnes	CO_thousand_tonnes
2023	16,282	6,500	9,781	0,866	5,235
2024	19,284	6,045	13,239	1,060	6,803

Part 2 of 3

year	NOx_as_NO2_thousand_tonnes	VOC_thousand_tonnes	hydrocarbons_excluding_VOCs_thousand_tonnes	other_gaseous_and_liquid_pollutants_thousand_tonnes	source
2020	1,274	0,206	9,811	0,110	State Report on the Condition and Protection of the Environment in Kemerovo Region—Kuzbass for 2024, Table 3.1, retrospective series
2021	1,728	0,318	3,447	0,100	Same source
2022	2,687	0,363	4,670	0,412	Same source
2023	2,177	0,800	0,290	0,414	Same source
2024	3,325	0,784	1,091	0,177	State Report on the Condition and Protection of the Environment in Kemerovo Region—Kuzbass for 2024, Section 3.1, PDF pp. 291–292

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year	data_type	limitation
2020	statistical reporting on the mass of emissions from stationary sources	Not a measurement of ambient-air concentration and does not describe exposure by district
2021	statistical reporting on the mass of emissions from stationary sources	Comparability requires verification of the reporting facilities and inventory methodology

year	data_type	limitation
2022	statistical reporting on the mass of emissions from stationary sources	Same source
2023	statistical reporting on the mass of emissions from stationary sources	Same source
2024	data from the South Siberian Interregional Directorate of Rosprirodnadzor	District-wide emission mass does not establish residents’ concentrations, the contribution of individual enterprises, or the actual operation of sources during a specific episode

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 4. Pollutant coverage by observation systems

Part 1 of 2

pollutant_or_group	state_stationary_network_Kiselyovsk	public_health_and_environmental_monitoring_2015_2019_as_published	Mine_No_12_operator_environmental_monitoring_2018	complaint_80_Omskaya_2012	Natalia_submission_2020_12_03
suspended particulate matter (total dust)	no monitoring station	yes; listed among pollutants with exceedances	yes	yes	yes
PM10	no monitoring station	not stated	absent from the extracted table	no	no
PM2.5	no monitoring station	not stated	absent from the extracted table	no	no
nitrogen dioxide	no monitoring station	yes; listed among pollutants with exceedances	yes	yes	yes
carbon monoxide	no monitoring station	yes; listed among pollutants with exceedances	yes	yes	yes; an exceedance was officially reported
sulphur dioxide	no monitoring station	mentioned in the risk assessment; annual measurement status not disclosed	yes	yes	yes

pollutant_or_group	state_stationary_network_Kiselyovsk	public_health_and_environmental_monitoring_2015_2019_as_published	Mine_No_12_operator_environmental_monitoring_2018	complaint_80_Omskaya_2012	Natalia_submission_2020_12_03
soot	no monitoring station	yes; listed among pollutants with exceedances and risk factors	no	no	yes
formaldehyde	no monitoring station	yes; listed among pollutants with exceedances and risk factors	no	no	no
phenol	no monitoring station	yes; used in correlation analysis	no	yes	no
benzo[a]pyrene	no monitoring station	not mentioned in the text of the publication	no	no	yes
hydrocarbons excluding VOCs	no monitoring station	51.7 percent refers to emission mass, not concentrations	no	no	no
volatile organic compounds	no monitoring station	composition not disclosed	no	no	no
methane	no monitoring station	not reported separately	no	no	no
dimethylbenzene (xylene)	no monitoring station	not disclosed	yes	no	no
manganese and its compounds	no monitoring station	not disclosed	yes	no	no
carbon (soot)	no monitoring station	yes; listed among pollutants with exceedances	yes, under the name carbon	no	yes, as soot
iron oxide	no monitoring station	not disclosed	yes	no	no

Part 2 of 2

pollutant_or_group	Cherkasovskaya_episode_2019	Form_2_TP_Air_2020_2024	what_can_be_concluded	principal_limitation
suspended particulate matter (total dust)	yes	yes, as the mass of solid emissions	monitored by several different systems, with documented exceedances	one-off samples and non-comparable aggregates do not form a continuous exposure time series
PM10	no	not reported separately in the municipal aggregate	regular citywide measurement not established	total dust does not substitute for fraction-specific PM10

pollutant_or_group	Cherkasovskaya_episode_2019	Form_2_TP_Air_2020_2024	what_can_be_concluded	principal_limitation
PM2.5	no	not reported separately in the municipal aggregate	regular citywide measurement not established	total dust does not substitute for PM2.5, the fraction most relevant to chronic-risk assessment
nitrogen dioxide	no	yes, within the NOx aggregate	the pollutant was included in sanitary and operator programmes	no public comparable time series by location and time
carbon monoxide	no	yes	monitored in several episodes	no continuous time series or complete laboratory documentation for the 2020 episode
sulphur dioxide	no	yes	included in several programmes	no sampling calendar or primary export from social and hygienic monitoring
soot	no	not reported separately	measured at least in individual sanitary programmes	not covered by the identified Shakhta No. 12 LLC production-environmental-control programme, and no public time series exists
formaldehyde	no	not reported separately in the municipal aggregate	data existed within social and hygienic monitoring	locations, concentrations, number of samples, and a reproducible time series are absent
phenol	no	not reported separately	measured in individual sanitary programmes and present in the social and hygienic monitoring dataset	there are no grounds for attributing phenol across the city to a specific source, including Podzemgaz
benzo[a]pyrene	no	not reported separately	one measurement episode is documented by an official reply	the complete protocol and a verifiable regulatory comparison are absent
hydrocarbons excluding VOCs	no	yes	a substantial share of the recorded emission mass, probably including methane	does not characterise inhaled concentration; the category's composition changed and facility-level forms are absent
volatile organic compounds	no	yes, total mass only	mass is recorded statistically	chemical composition and spatial exposure are unknown
methane	no	included in the hydrocarbons-excluding-VOCs row, but not reported separately in the municipal series	historically had a material effect on the city's emission mass	not a direct measure of toxic exposure and complicates interpretation of total tonnage
dimethylbenzene (xylene)	no	may be included within total VOCs	included in Shakhta No. 12 LLC production environmental control in 2018	all five means and maxima are identical at 0.12 mg/m³; without the protocols, the quantification limit and number of samples cannot be determined

pollutant_or_group	Cherkasovskaya_episode_2019	Form_2_TP_Air_2020_2024	what_can_be_concluded	principal_limitation
manganese and its compounds	no	not reported separately	included in Shakhta No. 12 LLC production environmental control in 2018	all values are 0.001 mg/m³; primary protocols are absent
carbon (soot)	no	not reported separately	covered by social and hygienic monitoring, production environmental control, and an individual submission	terminology and methods may not be comparable between systems
iron oxide	no	not reported separately	included in Shakhta No. 12 LLC production environmental control in 2018	maximum values are absent from the summary table; an average daily regulatory limit was applied

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 5. Nine open-pit mining facilities

Part 1 of 2

source_id	snapshot_period	facility_or_operator	physical_type	dust_generating_processes_relevant_to_air	source_of_list
OPEN9-01	May–June 2020	Kiselyovsky open-pit mine	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	Ugol Kuzbassa magazine in collaboration with Kemerovostat, https://uk42.ru/index.php?id=10730
OPEN9-02	May–June 2020	Polyany	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source
OPEN9-03	May–June 2020	Lugovoye	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source
OPEN9-04	May–June 2020	Invest-Uglesbyt / Yuzhny	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source

source_id	snapshot_period	facility_or_operator	physical_type	dust_generating_processes_relevant_to_air	source_of_list
OPEN9-05	May–June 2020	Shakhta No. 12 LLC, open-pit operations	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source, plus judicial and project documents
OPEN9-06	May–June 2020	Oktyabrinsky	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source
OPEN9-07	May–June 2020	Krasnobrodsky open-pit mine, Vakhrushevskoye field	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source, plus the environmental impact assessment
OPEN9-08	May–June 2020	Uchastok Koksovy LLC	open-pit coal mining	overburden removal and extraction, movement of coal and rock, and mine haulage	same source, plus the PMH official website and judicial documents
OPEN9-09	May–June 2020	Karagailinskoye Mine Administration	open-pit coal-mining site in the source list used	overburden removal and extraction, movement of coal and rock, and mine haulage	Ugol Kuzbassa magazine in collaboration with Kemerovostat

Part 2 of 2

source_id	status_for_combined_analysis	what_is_still_needed
OPEN9-01	included in the dated concurrent list of nine operating open-pit mines	verify only the period of actual operation for other selected episodes
OPEN9-02	included in the dated concurrent list of nine operating open-pit mines	verify the period for other selected episodes
OPEN9-03	included in the dated concurrent list of nine operating open-pit mines	verify the period for other selected episodes
OPEN9-04	included in the dated concurrent list of nine operating open-pit mines	verify correspondence between names for mapping purposes without extending the inquiry into corporate history
OPEN9-05	included in the dated list; open-pit operations independently confirmed	compare with the 2019–2024 episodes
OPEN9-06	included in the dated concurrent list of nine operating open-pit mines	verify the period for other selected episodes
OPEN9-07	included in the dated list; open-pit mining confirmed by several classes of sources	compare with the episodes and map

source_id	status_for_combined_analysis	what_is_still_needed
OPEN9-08	included in the dated list; large-scale open-pit mining established	compare with the episodes and map
OPEN9-09	included in the dated concurrent list of nine operating open-pit mines	verify the geography only to the minimum extent necessary

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 6. Rospotrebnadzor measurements, December 2020

Part 1 of 3

measurement_id	sampling_date	location	location_type	indicator	result
AIR-2020-12-03-01	2020-12-03	15 Kommunalnaya Street	residential area / Kemerovo Region state healthcare institution KPND	suspended particulate matter	0.7
AIR-2020-12-03-02	2020-12-03	15 Kommunalnaya Street	residential area / Kemerovo Region state healthcare institution KPND	carbon monoxide	7.15
AIR-2020-12-03-03	2020-12-03	3 Druzhby Street	residential area	3,4-benzo[a]pyrene	6.6E-6
AIR-2020-12-03-04	2020-12-03	11 Druzhby Street	Polytech state vocational educational institution	3,4-benzo[a]pyrene	10.6E-6
AIR-2020-12-03-05	2020-12-03	15 Kommunalnaya Street	Kemerovo Region state healthcare institution KPND	3,4-benzo[a]pyrene	13.3E-6
AIR-2020-12-03-06	2020-12-03	24 Tulsкая Street	Kindergarten No. 55	3,4-benzo[a]pyrene	9.8E-6
AIR-2020-12-03-07	2020-12-03	Boiler House No. 25, 2a Kazanskaya Street	background-designated location at the sanitary protection zone boundary	3,4-benzo[a]pyrene	7.0E-6
AIR-2020-12-03-08	2020-12-03	Boiler House No. 25, 2a Kazanskaya Street	downwind-plume location at the sanitary protection zone boundary	3,4-benzo[a]pyrene	10.6E-6

measurement_id	sampling_date	location	location_type	indicator	result
AIR-2020-12-10-11	2020-12-10—2020-12-11	sanitary protection zone boundary of Shakhta No. 12 LLC and 3 Rasshchupkina Street	background-designated, downwind-plume, and residential locations	suspended particulate matter, NO ₂ , SO ₂ , CO, and black carbon	numerical values not provided
NOISE-2020-12-04-01	2020-12-04	residential premises at Natalia's address	bedroom; daytime measurement while Boiler House No. 25 was operating	equivalent sound level	44

Part 2 of 3

measurement_id	unit	regulatory_limit	type_of_regulatory_limit	multiple_as_stated_in_reply	source
AIR-2020-12-03-01	mg/m ³	0.5	maximum permissible single-exposure concentration (ПДКМ.р.)	1.4	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-02	mg/m ³	5.0	maximum permissible single-exposure concentration (ПДКМ.р.)	1.43	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-03	mg/m ³	1E-6	maximum permissible average daily concentration (ПДКс.с.)	6.6	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-04	mg/m ³	1E-6	maximum permissible average daily concentration (ПДКс.с.)	10.6	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-05	mg/m ³	1E-6	maximum permissible average daily concentration (ПДКс.с.)	13.3	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-06	mg/m ³	1E-6	maximum permissible average daily concentration (ПДКс.с.)	9.8	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-07	mg/m ³	1E-6	maximum permissible average daily concentration (ПДКс.с.)	7.0	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-03-08	mg/m ³	1E-6	maximum permissible average daily concentration (ПДКс.с.)	10.6	Rospotrebnadzor reply concerning Zubkova's submissions
AIR-2020-12-10-11		sanitary and hygiene requirements			Rospotrebnadzor reply concerning Zubkova's submissions
NOISE-2020-12-04-01	dBA	40	permissible daytime level	exceedance by 4 dBA	Rospotrebnadzor reply concerning Zubkova's submissions

Part 3 of 3

measurement_id	primary_protocol	status	limitation
AIR-2020-12-03-01	No. 11485 of 7 December 2020	confirmed by the text of the reply	complete protocol absent
AIR-2020-12-03-02	No. 11485 of 7 December 2020	confirmed by the text of the reply	complete protocol absent
AIR-2020-12-03-03	No. 43135 of 8 December 2020	confirmed through the account given in the reply	without the protocol, the sampling duration and method and the validity of comparing a single sample with an average daily limit cannot be verified
AIR-2020-12-03-04	No. 43135 of 8 December 2020	confirmed through the account given in the reply	same limitation
AIR-2020-12-03-05	No. 43135 of 8 December 2020	confirmed through the account given in the reply	same limitation
AIR-2020-12-03-06	No. 43135 of 8 December 2020	confirmed through the account given in the reply	same limitation
AIR-2020-12-03-07	No. 43135 of 8 December 2020	confirmed through the account given in the reply	the term ‘background’ denotes the location’s role in the sampling programme; it does not prove the absence of influence from all sources
AIR-2020-12-03-08	No. 43135 of 8 December 2020	confirmed through the account given in the reply	does not establish the boiler house’s contribution without the methodology and data on plume direction and source operation
AIR-2020-12-10-11	No. 12386 of 14 December 2020	reported in the reply as complying with the requirements	four samples over 24 hours; without the protocol, the individual results, exact coordinates, and detection limits are unknown
NOISE-2020-12-04-01	No. 11466 of 4 December 2020	confirmed by the text of the reply	the address contains personal data and is not intended for publication without redaction

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 7. Shakhta No. 12 LLC production environmental control, 2018

Part 1 of 2

location	address	pollutant	annual_mean_of_single_exposure_values_mg_m3	maximum_mg_m3	ПДКм.р._mg_m3
1	1 Chernomorsky Lane	nitrogen dioxide	0,01942	0,066	0,2
1	1 Chernomorsky Lane	suspended particulate matter	0,2214	0,26	0,5
1	1 Chernomorsky Lane	sulphur dioxide	0,00965	0,03	0,5
1	1 Chernomorsky Lane	carbon monoxide	1,6292	3,0	5
2	2 Minskaya Street	nitrogen dioxide	0,0202	0,074	0,2
2	2 Minskaya Street	suspended particulate matter	0,2252	0,26	0,5
2	2 Minskaya Street	sulphur dioxide	0,00965	0,03	0,5
2	2 Minskaya Street	carbon monoxide	1,6654	3,2	5
3	7 Okrainaya Street	nitrogen dioxide	0,0196	0,068	0,2
3	7 Okrainaya Street	suspended particulate matter	0,2222	0,26	0,5
3	7 Okrainaya Street	sulphur dioxide	0,00965	0,03	0,5
3	7 Okrainaya Street	carbon monoxide	1,623	3,0	5
4	75A Kolkhoznaya Street	nitrogen dioxide	0,02076	0,087	0,2
4	75A Kolkhoznaya Street	suspended particulate matter	0,2268	0,26	0,5
4	75A Kolkhoznaya Street	sulphur dioxide	0,00965	0,03	0,5
4	75A Kolkhoznaya Street	carbon monoxide	1,6682	3,4	5
5	intersection of Shakhtostroevskaya and Maiskaya Streets	nitrogen dioxide	0,01822	0,072	0,2
5	intersection of Shakhtostroevskaya and Maiskaya Streets	suspended particulate matter	0,2246	0,26	0,5

location	address	pollutant	annual_mean_of_single_exposure_values_mg_m3	maximum_mg_m3	ПДКм.р._mg_m3
5	intersection of Shakhtostrovskaya and Maiskaya Streets	sulphur dioxide	0,00965	0,03	0,5
5	intersection of Shakhtostrovskaya and Maiskaya Streets	carbon monoxide	1,6128	3,3	5
1	1 Chernomorsky Lane	dimethylbenzene (xylene)	0,12	0,12	0,2
1	1 Chernomorsky Lane	manganese and its compounds	0,001	0,001	0,01
1	1 Chernomorsky Lane	carbon (soot)	0,031	0,05	0,15
1	1 Chernomorsky Lane	iron oxide	0,00001		0,04
2	2 Minskaya Street	dimethylbenzene (xylene)	0,12	0,12	0,2
2	2 Minskaya Street	manganese and its compounds	0,001	0,001	0,01
2	2 Minskaya Street	carbon (soot)	0,0032	0,07	0,15
2	2 Minskaya Street	iron oxide	0,00001		0,04
3	7 Okrainaya Street	dimethylbenzene (xylene)	0,12	0,12	0,2
3	7 Okrainaya Street	manganese and its compounds	0,001	0,001	0,01
3	7 Okrainaya Street	carbon (soot)	0,0312	0,05	0,15
3	7 Okrainaya Street	iron oxide	0,00001		0,04
4	75A Kolkhoznaya Street	dimethylbenzene (xylene)	0,12	0,12	0,2
4	75A Kolkhoznaya Street	manganese and its compounds	0,001	0,001	0,01
4	75A Kolkhoznaya Street	carbon (soot)	0,0336	0,09	0,15
4	75A Kolkhoznaya Street	iron oxide	0,00001		0,04
5	intersection of Shakhtostrovskaya and Maiskaya Streets	dimethylbenzene (xylene)	0,12	0,12	0,2
5	intersection of Shakhtostrovskaya and Maiskaya Streets	manganese and its compounds	0,001	0,001	0,01

location	address	pollutant	annual_mean_of_single_exposure_values_mg_m3	maximum_mg_m3	ПДКм.р._mg_m3
5	intersection of Shakhtostrovskaya and Maiskaya Streets	carbon (soot)	0,0328	0,07	0,15
5	intersection of Shakhtostrovskaya and Maiskaya Streets	iron oxide	0,00001		0,04

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location	source	page	limitation
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	primary protocols and number of measurements not found
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same

location	source	page	limitation
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	primary protocols and number of measurements not found
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
1	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	the maximum value is shown as a dash in the table; the regulatory limit is an average daily value
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	primary protocols and number of measurements not found

location	source	page	limitation
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	same
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	the mean of 0.0032 differs markedly from 0.031–0.0336 at the other locations; verify against the primary document
2	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	42	the maximum value is shown as a dash in the table; the regulatory limit is an average daily value
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	primary protocols and number of measurements not found
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
3	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	the maximum value is shown as a dash in the table; the regulatory limit is an average daily value
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	primary protocols and number of measurements not found
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
4	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	the maximum value is shown as a dash in the table; the regulatory limit is an average daily value
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	primary protocols and number of measurements not found
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	same

location	source	page	limitation
5	Environmental Impact Assessment of Shakhta No. 12 LLC, Book 1	43	the maximum value is shown as a dash in the table; the regulatory limit is an average daily value

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TABULAR APPENDIX

Table 8. Supervisory chains

Part 1 of 3

chain_id	episode	signal_or_complaint	measurement	result	violation_established
AIR-CHAIN-01	80 Omskaya Street, 2012	resident’s complaint about dust and gas after blasting	outdoor and indoor air; five pollutants; primary protocols absent from the corpus	the public account reported no exceedances	no; a causal connection with the named nearby underground and open-pit mines was not established
AIR-CHAIN-02	Cherkasovskaya processing plant, February 2019	air pollution and black snow against a background of previously recorded violations	three suspended-particulate-matter results reproduced in a judicial decision	2.4 times ПДКс.с. at a residential location; 1.2 and 1.38 times ПДКм.р. at the sanitary protection zone boundary	yes; the episode was procedurally linked to Cherkasovskaya Processing Plant LLC
AIR-CHAIN-03	measurements of 3 December 2020	Natalia Zubkova’s submissions concerning air pollution	address-specific samples near homes, children’s facilities, and Boiler House No. 25	at 15 Kommunalnaya Street: suspended particulate matter 0.70 mg/m³, 1.4 times ПДКм.р.; CO 7.15 mg/m³, 1.43 times ПДКм.р.	benzo[a]pyrene exceedances at six locations were also officially reported
AIR-CHAIN-04	Shakhta No. 12 LLC, 10–11 December 2020	sanitary monitoring after the December submissions; no exact link to each original address was shown	four samples over 24 hours at the sanitary protection zone boundary and near 3 Rasshchupkina Street	compliance with the standards was officially reported	no; according to the reported result, no violation was identified

chain_id	episode	signal_or_complaint	measurement	result	violation_established
AIR-CHAIN-05	black snow, December 2021	numerous residents' reports and media publications	laboratory air sampling and inspections of several enterprises	a suspended-particulate-matter violation at the Istok municipal enterprise, an emission-limit exceedance at the Krasnokamenskaya central processing plant, and other violations were reported	yes, for individual violations; no single source for the entire observed episode was established
AIR-CHAIN-06	Shakhta No. 12 LLC, November 2024	residents' complaints	no new air sampling was described; Form 2-TP and the 2023 production environmental control report were examined	no exceedances were identified from the reports	this method did not test for an ambient-air violation in residential areas
AIR-CHAIN-07	Shakhta No. 12 LLC processing plant, before March 2024	media and internet publications	sanitary samples at the sanitary protection zone boundary and near the closest housing	the prosecutor's office reported suspended particulate matter at twice the maximum permissible concentration	yes; the violation was procedurally attributed to the processing plant
AIR-CHAIN-08	black snow in Afonino, December 2024	photographs, video, and residents' online reports	the involvement of Rospotrebnadzor and the Centre for Hygiene was announced; the sampling programme and whether sampling occurred were not publicly disclosed	no public numerical result was found	unknown; no specific source was officially established

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chain_id	inspection	order_or_sanction	remediation	follow_up_monitoring	final_confirmed_outcome
AIR-CHAIN-01	the Rospotrebnadzor inspection is confirmed through the account of the reply	not reported	not reported	not found	only the reported conclusion of the one-off inspection is confirmed
AIR-CHAIN-02	criminal proceedings initiated under Article 251(1) of the Criminal Code of the Russian Federation	proceedings terminated on non-exonerating grounds with a judicial fine of RUB 20,000	the judicial decision mentions technical remediation of the harm, without accessible primary materials	follow-up laboratory protocols not found	the exceedances, procedural link, and outcome of the case are known; a sustained environmental outcome has not been publicly confirmed

chain_id	inspection	order_or_sanction	remediation	follow_up_monitoring	final_confirmed_outcome
AIR-CHAIN-03	yes, as to the exceedances; the source of the entire episode was not established	preparations for an unscheduled inspection of Boiler House No. 25 were reported	no outcome of an order or sanction was found	not established	the measurements of 10–11 December were taken at other locations and cannot automatically be treated as follow-up monitoring of the original addresses
AIR-CHAIN-04	sanitary monitoring of a specific enterprise	not reported	not required on the reported result	subsequent monitoring not found	the official conclusion from a separate series of samples is confirmed, without accessible numerical values
AIR-CHAIN-05	prosecutorial and supervisory inspections of several facilities	administrative proceedings, submissions, orders, and warnings were reported	implementation could not be reconstructed from the public record	follow-up protocols not found	the initial violations and announced measures are confirmed; a sustained outcome was not established
AIR-CHAIN-06	documentary analysis of a specific enterprise's reporting	a warning was announced	not reported	not found	a documentary response is confirmed, but not the condition of the air in the residential area
AIR-CHAIN-07	prosecutor's-office inspection and subsequent application to the court	the prosecutor's claim was upheld; at the date of the notice, the judgment had not entered into force	implementation not found	follow-up measurements not found	the officially reported exceedance and judicial response are confirmed; the final environmental outcome was not established
AIR-CHAIN-08	the prosecutor's office announced an inspection	not reported	not established	not found	the observed snow contamination and beginning of the official response are confirmed; the inspection outcome is unknown

Part 3 of 3

chain_id	degree_of_public_traceability	limit_of_the_evidence
AIR-CHAIN-01	breaks after the report that there were no exceedances	dates, values, correspondence with the timing of blasting, and the original letter are unknown
AIR-CHAIN-02	traceable through to the judicial decision, but not to a confirmed sustained outcome	no primary protocols; the exact residential address is withheld; no follow-up inspection was found

chain_id	degree_of_public_traceability	limit_of_the_evidence
AIR-CHAIN-03	exceedances at a specific location are confirmed; the final outcome of the intervention cannot be traced	breaks after the reply stating that an inspection was being prepared
AIR-CHAIN-04	the conclusion is public, but the primary dataset is not	Protocol No. 12386, coordinates, sampling times, numerical values, and information about source operating conditions are absent
AIR-CHAIN-05	traceable through to the announcement of measures	primary protocols, the complete list of facilities, implementation, and final inspection are absent
AIR-CHAIN-06	only the brief conclusion from the documentary analysis is publicly traceable	the reports themselves, basis for the warning, residential-air measurements, and subsequent monitoring are absent
AIR-CHAIN-07	traceable through to a judicial decision that had not entered into force	protocols, absolute values, addresses, a judicial decision in force, implementation, and follow-up monitoring are absent
AIR-CHAIN-08	breaks at the announcement of an inspection	the programme, protocols, result, attribution, measures, and follow-up monitoring are absent

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 9. Data coverage matrix

Part 1 of 2

data_id	data_type	period	what_it_measures_or_describes	spatial_coverage	temporal_coverage
AIR-COV-01	Roshydromet state stationary monitoring stations	confirmed absent in 2008, 2011, 2020, 2023, and 2024	pollutant concentrations under a standard regular programme	Kiselyovsk not covered	no citywide time series
AIR-COV-02	sanitary investigations by Rospotrebnadzor / Federal Centre for Hygiene and Epidemiology	2004–2019; individual later episodes also confirmed	one-off concentrations and the share of samples exceeding the maximum permissible concentration	locations generally not disclosed in annual summary rows	annual aggregate without a sampling calendar

data_id	data_type	period	what_it_measures_or_describes	spatial_coverage	temporal_coverage
AIR-COV-03	measurements following submissions, 3 December 2020	2020-12-03	concentrations of suspended particulate matter, CO, NO ₂ , SO ₂ , soot, and benzo[a]pyrene	several addresses and locations near Boiler House No. 25	one episode
AIR-COV-04	subsequent sanitary episode near Shakhta No. 12 LLC	2020-12-10—2020-12-11	four samples for several pollutants	sanitary protection zone boundary and 3 Rasshchupkina Street	approximately 24 hours
AIR-COV-05	Shakhta No. 12 LLC production environmental control	2017–2019, 2023	air concentrations in residential areas, at the sanitary protection zone boundary, during blasting, and near the external spoil tip	five regular residential/boundary locations, two addresses during blasting, and two locations near the external spoil tip	project representatives reported four samples monthly at each of five locations and another 24 samples per year during blasting; no sampling calendar is available
AIR-COV-06	Form 2-TP (Air) and the municipal emission-mass summary	2020–2024, with earlier historical snapshots	annual reported mass of emissions from stationary sources	administrative district, without distribution by residential area	annual
AIR-COV-07	modelled background concentrations from the Centre for Hydrometeorology and Environmental Monitoring	system status confirmed by a reply dated 22 April 2020; values used in the environmental impact assessment	background for emission regulation and dispersion modelling	modelled territory/project locations	issued for a project-specific purpose, not a continuous time series
AIR-COV-08	chemical composition of snow cover at the meteorological station	provisionally 2016–2019	accumulated atmospheric deposition in snow	one meteorological station	seasonal/annual
AIR-COV-09	documentary inspection following complaints concerning Shakhta No. 12 LLC	2024	analysis of Form 2-TP (Air) and the enterprise's production environmental control report	enterprise sources; residential locations not described	analysis of annual reporting for 2023
AIR-COV-10	regional social and hygienic monitoring information repository	at least 2015–2019 according to a scientific publication	pollutant concentrations in the ambient air of populated areas and related sanitary indicators	city locations exist but are not disclosed in the publication	multi-year dataset; frequency unknown
AIR-COV-11	Shakhta No. 12 LLC monitoring hardware and software system	tested 1–8 October 2019; extended pilot operation reported from 2020; application interface published in 2022	sensor readings for dust particles and meteorological parameters, modelling of dispersion and contributions from source groups	mining area and modelling zones; sensor coordinates not published	a 20-minute interval was reported; actual continuity is unknown
AIR-COV-12	sanitary samples near the Shakhta No. 12 LLC processing plant	before March 2024	suspended particulate matter concentration relative to the maximum permissible concentration	sanitary protection zone boundary and nearest housing; addresses not published	one inspection episode; number of samples unknown

data_id	data_type	period	what_it_measures_or_describes	spatial_coverage	temporal_coverage
AIR-COV-13	visual evidence of black snow and an announced inspection in Afonino	December 2024	visually, deposition of dark particles on snow; officially, only the start of an inspection	Afonino area; exact address of the source material not established	brief episode

Part 2 of 2

data_id	independence_from_enterprise	public_detail	can_residents_air_be_assessed	principal_gap
AIR-COV-01	high	stations, pollutants, and annual indicators are published for the other three cities	no	regular independent citywide time series absent
AIR-COV-02	high relative to enterprises, though the programme may be risk-oriented	percentage of exceedances without numerator, denominator, addresses, or a city-level pollutant list	limited; only for the specific samples	representativeness and comparability between years are unknown
AIR-COV-03	high	official account and individual values; complete protocols absent	only for the specific time and locations	protocols, benzo[a]pyrene methodology, and a complete subsequent monitoring chain are absent
AIR-COV-04	high	only the official conclusion, without individual values	only for the specific episode	Protocol No. 12386, coordinates, timing, and source operating conditions are absent
AIR-COV-05	the regulated enterprise organises and funds the data collection; an external laboratory, Centre for Hygiene Assessment LLC, is named	2018 table in the environmental impact assessment; programme described in the consultation minutes; only a brief Rosprirodnadzor conclusion is available for 2023	potentially yes for the impact zone once protocols are obtained, but not for the entire city	primary protocols and programme; arithmetic discrepancy of 250 versus 240; meteorological conditions, operating conditions, and results during blasting
AIR-COV-06	facility self-reporting with state statistical collection	municipal aggregate is public; facility-level forms not found	no; this is neither concentration nor exposure	composition of reporting facilities, facility-level rows, and changes in the methane category
AIR-COV-07	methodologically external to the enterprise, but input parameters require verification	values appear in project documents; a complete historical series was not provided	no, as a direct measurement	calculation method for a city without a station, input data, and analogue cities
AIR-COV-08	high	summary table in the state report	not directly	exact years, methodology, coordinates, and inability to extrapolate to the entire city

data_id	independence_from_enterprise	public_detail	can_residents_air_be_assessed	principal_gap
AIR-COV-09	the supervisory authority is organisationally independent, but no new measurements were described	brief official notice without appendices	no	inspection record, reports, basis for the warning, and absence of independent sampling in the residential area
AIR-COV-10	state sanitary system	primary export is not public; only a scientific analytical account is available	potentially yes after the study design is verified, but currently not reproducible	export by dates, locations, pollutants, methods, and grounds for sampling
AIR-COV-11	the system was developed by a scientific organisation for the enterprise and uses parameters of its sources	the architecture, description, and interface images are public, but the time series is not	potentially yes for a limited area if sensors and data are of sufficient quality; in practice, independent verification is impossible	commissioning record, sensor locations and calibration, dust fractions, archive, gaps, and access for authorities and the public
AIR-COV-12	prosecutor’s office with the involvement of Rospotrebnadzor	the conclusion reporting a twofold exceedance and upheld claim is public, without protocols	only the fact of an exceedance at an undisclosed location and during an undisclosed period	absolute values, type of maximum permissible concentration, dates, addresses, court record, implementation, and follow-up monitoring
AIR-COV-13	the visual source is independent of the enterprise; the inspection is governmental	photographs/video and the inspection announcement are available; the result was not found	no for chemical composition and airborne concentration; yes for the fact of visible particle deposition	composition analysis, locations and protocols, source, measures, and follow-up inspection

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.

TABULAR APPENDIX

Table 10. Media, testimony, and visual sources

Part 1 of 3

event_id	publication_date	estimated_event_date	territory	type	source_author
AIR-WIT-001	2019-02-12	no later than 2019-02-12	Kiselyovsk; exact location requires verification	resident’s video in republication	original author not established; FaceNews
AIR-WIT-002	2019-02-15	February 2019	Kiselyovsk	female resident’s video in the media	Kiselyovsk resident / Moskovsky Komsomolets

event_id	publication_date	estimated_event_date	territory	type	source_author
AIR-WIT-003	2019-02-14	February 2019	Kiselyovsk and other cities in Kuzbass	collection of residents' photographs/videos	NEWSru citing social media
AIR-WIT-004	2019-02-25	February 2019	Kiselyovsk	residents' videos and publications, plus a Ministry of Internal Affairs notice	Channel 5
AIR-WIT-005	2019-11-06	filmed no later than November 2019	Kiselyovsk, districts near open-pit operations	video report with residents' interviews	Current Time / Realities
AIR-WIT-006	2024-03-19	sampling date currently unknown	sanitary protection zone boundary of the Shakhta No. 12 LLC processing plant and nearest housing	official prosecutor's-office notice in republications	Prosecutor's Office of Kemerovo Region—Kuzbass
AIR-WIT-007	2024-11-28	2024; exact date of complaints unknown	Shakhta No. 12 LLC; locations covered by the documentary inspection not disclosed	official notice	Kuzbass Ministry of Natural Resources / Rosprirodnadzor
AIR-WIT-008	2020-01-23	filming predominantly from 2019	Kiselyovsk, several districts	documentary film and residents' interviews	Sergey Khazov-Kassia, Andrey Kostyanov, and Pyotr Solovyov / Radio Free Europe/Radio Liberty
AIR-WIT-009	2022-12-14	correspondent's observation in 2022; exact date not stated	Shakhta No. 12 LLC settlement, Gorelaya Tyoshcha, road to the central processing plant	report, photographs, and attributed testimony	Vladimir Vasilyev, witness Alexander Lapshin / Volost
AIR-WIT-010	2020-02-05	filming date not established	Kiselyovsk / Shakhta No. 12 LLC	archived web page with embedded video	Volost
AIR-WIT-011	2024-12-12—2024-12-16	12–16.12.2024	Afonino area; exact address of the original video not established	video, photographs, residents' reports, and media publications	residents via local social-media groups; republications by VSE42, Argumenty i Fakty, Rossiyskaya Gazeta, and Interfax
AIR-WIT-012	2019-02-11	2019-02-11	Kiselyovsk and the surrounding industrial landscape	Sentinel-2 image and ground photographs/videos from the following day	Copernicus Sentinel-2; authors' comparison with residents' and media publications of 11–15 February 2019
AIR-WIT-013	2022-02-08	2022-02-08—2022-02-09	Kiselyovsk; exact geolocation of the ground footage requires frame-by-frame verification	Sentinel-2 image and resident's video	Copernicus Sentinel-2; Max Uchvatov's YouTube channel, published 9 February 2022

Part 2 of 3

event_id	what_is_directly_observable_or_established	author_statement	independent_verification	limitations	url
AIR-WIT-001	dark snow within the city	black snow fell in Kiselyovsk	confirmed by numerous independent publications from the same period	upload date is not the exact filming date; chemical composition cannot be established from the image	https://www.facenews.ua/video/2019/312232/
AIR-WIT-002	black snow in the streets	pollution covers streets in the city	consistent with other footage and the subsequent official response	exact address and author of the original recording are not disclosed; particle composition is not visible	https://www.mk.ru/video/2019/02/15/v-kemerovskoy-oblasti-vypal-chnyy-sneg-kadry-s-ulic.html
AIR-WIT-003	numerous images of dark snow from several cities	residents compared the extent of snow contamination	widespread public discussion is confirmed by independent media	without the original, not every image can be attributed specifically to Kiselyovsk	https://www.newsru.com/russia/14Feb2019/blacksnow.html
AIR-WIT-004	visible black snow; a female resident's report to the police was recorded	a large amount of coal dust was deposited in the city	the fact of the report itself is confirmed through the Ministry of Internal Affairs account	the source and chemical analysis of the specific images are not disclosed	https://www.5-tv.ru/news/241220/ugolovnoe-delo-vozbuzheno-posle-vypadenia-chnogo-snega-vkiselevske/
AIR-WIT-005	residential areas near workings, residents' interviews, and visible dust/industrial landscape require frame-by-frame review	residents continually encounter black snow, dust, and polluted air	facilities and statements can be compared with maps and official materials	edited journalistic material; dates of individual shots may differ	https://www.youtube.com/watch?v=gIGRUWPFJ-U
AIR-WIT-006	sampling and a twofold exceedance of the maximum permissible concentration for suspended particulate matter were officially reported	inspection initiated after media and internet publications	confirmed by several contemporaneous republications of the official text	protocols, addresses, numerical values, and residents' original publications are absent	https://myseldon.com/ru/news/index/309530895
AIR-WIT-007	reports were analysed without newly described sampling	no exceedances were reported as identified	compared with Forms 2-TP and production environmental control	the indicator, locations, and basis for the warning are unclear	https://kuzbasseco.ru/2024/11/28/yuzhno-sibirskoe-mezhregionalnoe-upravlenie-rosproisrodadzora-proverilo-rabotu-ooo-shaxta-12/
AIR-WIT-008	industrial landscape, visible dust, and residents' testimony require frame-by-frame annotation	dust entered homes, clothing, and snow; after pollution-control equipment was installed at one plant, the situation improved	some facilities and chronology can be compared with the environmental impact assessment, official notices, and maps	edited footage, different dates and districts; chemical composition cannot be established visually	https://www.svoboda.org/a/30393575.html

event_id	what_is_directly_observable_or_established	author_statement	independent_verification	limitations	url
AIR-WIT-009	intensive coal-truck traffic was observed for one hour; some bodies were uncovered and loaded above the sides; photographs were published	a resident reported a layer of dust accumulating over a day in his garden and prolonged correspondence with authorities	the transport route and operator responsible for haulage can be checked through documents; visual features through original photographs/videos	the layer's thickness and composition were not measured; effects on crops are the resident's testimony	https://kuz-news.ru/budesh-meshat-vredit-ljudjam-razobem-kameru/
AIR-WIT-010	Common Crawl confirmed the page, date, and YouTube ID NQ8UMAUr8zI, but the video is currently unavailable and the page contains no independent text	the heading reports no exceedance of maximum permissible concentrations for harmful substances	archived HTML and WARC preserved locally	the author of the statement, locations, sampling dates, pollutants, laboratory, numerical results, and method are unknown	https://kuz-news.ru/quot-shahta-12-quot-v-kiselevske-net-prevysheniya-pdk-vrednyh-veshchestv/
AIR-WIT-011	a pronounced grey-black deposit is directly visible on the snow; a dark snowman was made from the contaminated snow	residents associated the phenomenon with coal dust and a nearby coal facility; the prosecutor's office began an inspection	several newsrooms preserved the visual and textual record; the official start of the inspection is confirmed	particle composition, concentration, specific source, and duration cannot be established visually; the inspection outcome was not found	https://vse42.ru/news/33600542
AIR-WIT-012	the cloud-free winter image shows a spatially heterogeneous dark snow surface; ground material from the same period shows grey-black snow	snow contaminated with coal dust fell and/or accumulated in the city	the temporal convergence of two independent classes of observation, industrial structure, and recurrence of the episode support a coal-industry origin of the contamination	the satellite does not determine chemical composition or individual enterprises' shares; surface brightness also depends on shadows, exposed ground, and land-use type	local copy of the scene and AIR-WIT-001-004
AIR-WIT-013	the satellite scene shows heterogeneous darkening of the snow surface; ground video from the following day records dark snow in the urban environment	the video's author associates the pollution with coal activity	the temporal convergence of independent visual sources and recurrence of the pattern strengthen the conclusion that the episode was real	without a laboratory sample, the satellite image and video do not provide quantitative concentration, particle composition, or a specific source's share	local copy of the scene, https://www.youtube.com/watch?v=T1bYijDyKTM

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event_id	status
AIR-WIT-001	candidate; original requires geolocation
AIR-WIT-002	geography stated by the media

event_id	status
AIR-WIT-003	mixed geography; use frame by frame
AIR-WIT-004	linked to an official response
AIR-WIT-005	priority for frame-by-frame review
AIR-WIT-006	official result; primary appendices absent
AIR-WIT-007	do not extrapolate to residential air
AIR-WIT-008	priority for complete frame-by-frame review
AIR-WIT-009	strong, localised testimonial source
AIR-WIT-010	partially recovered; do not use the heading as evidence of measurement results
AIR-WIT-011	strong visual evidence of the event; attribution and sanitary assessment not established
AIR-WIT-012	established by converging independent evidence as an episode of widely observed coal-industry snow contamination, without apportioning contributions among enterprises
AIR-WIT-013	strong cross-source confirmation of the event; exact geolocation of individual images is required

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TABULAR APPENDIX

Table 11. Snow brightness: Krasny Kamen

Part 1 of 3

date	site	lon	lat	window_pixels	approx_window_km
2018-12-11	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2018-12-11	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9

date	site	lon	lat	window_pixels	approx_window_km
2018-12-11	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2019-01-15	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2019-01-15	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2019-01-15	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2019-02-11	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2019-02-11	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2019-02-11	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2019-12-01	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2019-12-01	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2019-12-01	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2020-01-07	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2020-01-07	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2020-01-07	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2020-03-25	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2020-03-25	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2020-03-25	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2020-12-02	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2020-12-02	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2020-12-02	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2021-01-06	eastern residential belt	86,72	53,98	41x41	1.3x0.9

date	site	lon	lat	window_pixels	approx_window_km
2021-01-06	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2021-01-06	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2021-02-20	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2021-02-20	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2021-02-20	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2021-03-17	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2021-03-17	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2021-03-17	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2021-12-22	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2021-12-22	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2021-12-22	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2022-01-14	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2022-01-14	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2022-01-14	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2022-02-08	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2022-02-08	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2022-02-08	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2022-12-07	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2022-12-07	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9

date	site	lon	lat	window_pixels	approx_window_km
2022-12-07	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2023-02-05	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2023-02-05	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2023-02-05	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2023-02-10	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2023-02-10	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2023-02-10	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2023-12-12	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2023-12-12	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2023-12-12	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2024-01-16	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2024-01-16	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2024-01-16	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2024-01-26	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2024-01-26	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2024-01-26	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2024-03-09	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2024-03-09	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2024-03-09	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2024-12-26	eastern residential belt	86,72	53,98	41x41	1.3x0.9

date	site	lon	lat	window_pixels	approx_window_km
2024-12-26	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2024-12-26	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2025-01-15	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2025-01-15	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2025-01-15	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2025-02-17	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2025-02-17	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2025-02-17	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2025-03-06	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2025-03-06	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2025-03-06	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2025-12-29	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2025-12-29	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2025-12-29	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2026-01-28	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2026-01-28	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2026-01-28	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2026-02-14	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2026-02-14	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9

date	site	lon	lat	window_pixels	approx_window_km
2026-02-14	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9
2026-03-21	eastern residential belt	86,72	53,98	41x41	1.3x0.9
2026-03-21	Krasny Kamen (OSM neighbourhood)	86,5504116	54,0001905	41x41	1.3x0.9
2026-03-21	approximate centre of Kiselyovsk	86,64	54	41x41	1.3x0.9

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date	mean_luminance_0_255	dark_fraction_lum_lt_180	mean_R	mean_G	mean_B
2018-12-11	195,1	0,377	195,6	194,3	201,5
2018-12-11	228,4	0,117	222,4	229,3	237,6
2018-12-11	202,8	0,283	205,6	201,4	208,9
2019-01-15	211,5	0,238	212,6	210,3	220,3
2019-01-15	232,3	0,096	229	232,5	240
2019-01-15	203,1	0,275	206,5	201,2	211,2
2019-02-11	200,3	0,314	205,9	197,9	208,3
2019-02-11	254,6	0	254,6	254,6	254,6
2019-02-11	161	0,709	182	155,7	151,8
2019-12-01	229,8	0,101	225,7	230,4	236,2
2019-12-01	245,9	0,009	241,8	246,8	249,2
2019-12-01	237,1	0,06	235,6	237,2	240,5
2020-01-07	242,5	0,016	243,2	241,9	246,8
2020-01-07	247,7	0,007	243,6	248,6	250,6

date	mean_luminance_0_255	dark_fraction_lum_lt_180	mean_R	mean_G	mean_B
2020-01-07	235,7	0,054	237,3	234,6	241,9
2020-03-25	69,6	0,986	87,7	66,2	50,4
2020-03-25	218,2	0,192	225,8	216,7	211,5
2020-03-25	76,4	0,996	102,3	71,4	49,2
2020-12-02	189,8	0,407	189,3	188,7	202,8
2020-12-02	219,9	0,164	215,6	220,3	229,4
2020-12-02	148,4	0,747	153,2	145,6	161,7
2021-01-06	230,9	0,087	230	230,3	238,7
2021-01-06	235	0,068	229,9	235,6	243,9
2021-01-06	223	0,128	225,6	221,3	233
2021-02-20	225,1	0,136	227,1	224,3	226,5
2021-02-20	243,4	0,033	242,7	243,5	244,6
2021-02-20	234,4	0,07	237	233,7	234,2
2021-03-17	239,4	0,09	241,2	239,1	237,6
2021-03-17	255	0	255	255	255
2021-03-17	252,6	0	253,1	252,6	251,2
2021-12-22	234,9	0,074	233,4	234,9	239,2
2021-12-22	253,7	0,001	253,3	253,8	254,2
2021-12-22	241,1	0,035	241,3	240,8	243,9
2022-01-14	220,2	0,171	221,1	219,6	223
2022-01-14	242,9	0,033	240,2	243,3	246,5
2022-01-14	229,9	0,09	234,1	228,5	231,9
2022-02-08	178,4	0,429	185,8	176,6	175,2

date	mean_luminance_0_255	dark_fraction_lum_lt_180	mean_R	mean_G	mean_B
2022-02-08	230,3	0,112	231,4	229,9	230,8
2022-02-08	131,2	0,81	141,3	128,4	128,8
2022-12-07	229,6	0,058	230,8	228,4	237,5
2022-12-07	253	0	251,6	253,3	253,9
2022-12-07	254,7	0	254,8	254,6	254,7
2023-02-05	206,8	0,264	208	206,2	209,2
2023-02-05	247,4	0,004	247,2	247,4	248
2023-02-05	216,4	0,181	220,9	215,1	216,1
2023-02-10	230,7	0,105	228,8	230,8	235,3
2023-02-10	251,1	0	249,3	251,5	252,4
2023-02-10	248,7	0,007	248,9	248,5	249,9
2023-12-12	237,8	0,057	238,7	237	243,4
2023-12-12	249,2	0,005	246,1	249,9	251,6
2023-12-12	247,3	0,001	247,7	246,8	250,1
2024-01-16	211,2	0,218	209,7	210,5	222,8
2024-01-16	244,1	0,016	239,3	245,1	248,7
2024-01-16	230,8	0,086	230,8	230	238
2024-01-26	156,6	0,583	157,6	155	168,7
2024-01-26	235	0,065	233,1	235,1	239,3
2024-01-26	189	0,431	193,7	186,9	196,3
2024-03-09	202	0,255	201,7	201,7	205,5
2024-03-09	252,4	0,001	251,6	252,5	253,4
2024-03-09	246	0,007	246,9	245,7	246,6

date	mean_luminance_0_255	dark_fraction_lum_lt_180	mean_R	mean_G	mean_B
2024-12-26	215,2	0,177	215,6	214	226
2024-12-26	236,2	0,051	230,2	237,2	244,6
2024-12-26	226,7	0,078	226,3	225,8	236,4
2025-01-15	207,1	0,238	204,7	206,9	216,4
2025-01-15	235	0,064	229,4	235,9	242,3
2025-01-15	216,4	0,19	216,2	215,5	225
2025-02-17	221,8	0,151	224,5	221,4	217,5
2025-02-17	247,4	0,011	247	247,5	247,4
2025-02-17	237,1	0,033	240,5	236,6	232,2
2025-03-06	237,8	0,062	238,6	237,5	237,9
2025-03-06	248,4	0,008	248,1	248,5	249,1
2025-03-06	241,5	0,016	243,6	241	240,5
2025-12-29	251,4	0,005	250,8	251,4	252,8
2025-12-29	254,7	0	254,5	254,7	254,8
2025-12-29	254,6	0	254,3	254,6	254,7
2026-01-28	254,2	0	254,3	254,2	254,3
2026-01-28	255	0	255	255	255
2026-01-28	253,7	0,001	253,8	253,6	253,9
2026-02-14	153,1	0,623	155	151,8	160,8
2026-02-14	243,3	0,03	241,9	243,5	245,5
2026-02-14	183,7	0,454	188,6	181,9	188,1
2026-03-21	183,2	0,348	184,4	182,6	185,8
2026-03-21	252,8	0,002	252,5	252,8	253,2

date	mean_luminance_0_255	dark_fraction_lum_lt_180	mean_R	mean_G	mean_B
2026-03-21	233,6	0,074	236,1	232,8	233,7

Part 3 of 3

date	source_file
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2019-01-15	2019-01-15_S2B_45UVV_20190115_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2019-01-15	2019-01-15_S2B_45UVV_20190115_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2019-01-15	2019-01-15_S2B_45UVV_20190115_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2019-02-11	2019-02-11_S2B_45UVV_20190211_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2019-02-11	2019-02-11_S2B_45UVV_20190211_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2019-02-11	2019-02-11_S2B_45UVV_20190211_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2019-12-01	2019-12-01_S2B_45UVV_20191201_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2020-01-07	2020-01-07_S2B_45UVV_20200107_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2020-01-07	2020-01-07_S2B_45UVV_20200107_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2020-01-07	2020-01-07_S2B_45UVV_20200107_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2020-03-25	2020-03-25_S2A_45UVV_20200325_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2020-03-25	2020-03-25_S2A_45UVV_20200325_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2020-03-25	2020-03-25_S2A_45UVV_20200325_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg

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2020-12-02	2020-12-02_S2B_45UVV_20201202_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-01-06	2021-01-06_S2A_45UVV_20210106_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2021-02-20	2021-02-20_S2B_45UVV_20210220_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-02-20	2021-02-20_S2B_45UVV_20210220_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-03-17	2021-03-17_S2A_45UVV_20210317_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-03-17	2021-03-17_S2A_45UVV_20210317_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-03-17	2021-03-17_S2A_45UVV_20210317_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-12-22	2021-12-22_S2A_45UVV_20211222_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-12-22	2021-12-22_S2A_45UVV_20211222_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2021-12-22	2021-12-22_S2A_45UVV_20211222_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2022-01-14	2022-01-14_S2A_45UVV_20220114_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2022-01-14	2022-01-14_S2A_45UVV_20220114_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2022-02-08	2022-02-08_S2B_45UVV_20220208_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2022-02-08	2022-02-08_S2B_45UVV_20220208_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2022-12-07	2022-12-07_S2A_45UVV_20221207_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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date	source_file
2022-12-07	2022-12-07_S2A_45UVV_20221207_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2023-02-05	2023-02-05_S2A_45UVV_20230205_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2023-02-05	2023-02-05_S2A_45UVV_20230205_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2023-02-05	2023-02-05_S2A_45UVV_20230205_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2023-02-10	2023-02-10_S2B_45UVV_20230210_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2024-01-16	2024-01-16_S2B_45UVV_20240116_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2024-01-16	2024-01-16_S2B_45UVV_20240116_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2024-01-26	2024-01-26_S2B_45UVV_20240126_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2024-01-26	2024-01-26_S2B_45UVV_20240126_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2024-03-09	2024-03-09_S2B_45UVV_20240309_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2024-12-26	2024-12-26_S2A_45UVV_20241226_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
2025-01-15	2025-01-15_S2A_45UVV_20250115_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg

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2025-02-17	2025-02-17_S2C_45UVV_20250217_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg
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2026-03-21	2026-03-21_S2C_45UVV_20260321_0_L2A_bbox_86.3_53.75_86.95_54.2.jpg

Sources and notes are provided in the table fields. Compiled by the authors from the materials identified in each row. In wide tables, the first identifying column is repeated in each successive part.