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Assessing Atmospheric Air Quality by Social Media Users: A Case Study of Two Single-Industry Towns

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Abstract: The article explores how digital footprints can be used as a data source revealing citizens' assessment of the environment. The rapid digitalization in recent years has enabled the use of non-traditional sources of data about the state of environment. These may include social media, search queries, video hosting, and other sources. The use of non-traditional data sources has given rise to new environmental research directions, including "ecological culturomics" and "Internet ecology" (iEcology). Drawing on these methodological approaches, the study examines air quality perceptions among VKontakte users in the single-industry towns of Magnitogorsk and Cherepovets. The semi-automatic search identified 481 air-quality-related posts: 433 in Magnitogorsk and 48 in Cherepovets community discussions. Posts with the highest levels of user engagement were identified through a quantitative analysis of key metrics: reactions, comments, and shares. Confirming our hypothesis, the most popular posts highlight the issues most relevant to users, accurately reflecting their key concerns about air quality. The study reveals a significant dissonance between the official assessments of air quality and the public perception as expressed by social media users. Citizens assess the air quality far less optimistically than the officials do.

Keywords: environmental protection, air quality, Internet ecology, digital footprints, social media

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оригинальная статья

Оценка качества атмосферного воздуха пользователями социальных медиа: кейс двух моногородов

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Аннотация: В статье рассматриваются возможности применения цифровых следов в качестве источника данных для оценки горожанами состояния окружающей среды. Бурное развитие процесса цифровизации в последние годы создает предпосылки для использования нетрадиционных источников информации о состоянии окружающей среды. В качестве таковых могут выступать социальные медиа, поисковые запросы, видеохостинги и другие источники. Сформировались новые направления в исследовании окружающей среды, опирающиеся на нетрадиционные источники информации – экологическая культуромика и интернет-экология (iEcology). Используя методологические ресурсы этих направлений, в статье проанализировано восприятие качества атмосферного воздуха пользователями социальной сети ВКонтакте в двух моногородах – Магнитогорске и Череповце. Цель –разработать методику анализа восприятия качества атмосферного воздуха жителями городов. В результате полуавтоматического поиска было отобрано 481 сообщение, характеризующее качество воздуха в выбранных городах (в сообществах Магнитогорска – 433 сообщения, Череповца – 48 сообщений). Опираясь на количественный анализ онлайн-метрик, отражающих различные формы онлайн-активности (реакции, комментарии, репосты) пользователей, были выделены сообщения, которые привлекли наибольшее внимание пользователей. В соответствии с гипотезой исследования темы самых популярных сообщений являются наиболее актуальными для пользователей и отражают действительно проблемные моменты, связанные с восприятием качества воздуха. Результаты исследования показывают, что имеет место очень серьезное противоречие между оценками качества воздуха, которые выражают представители органов власти, и восприятием пользователей. Качество атмосферного воздуха горожане оценивают гораздо менее оптимистично в сравнении с официальными лицами.
Ключевые слова: охрана окружающей среды, качество воздуха, интернет-экология, цифровые следы, социальные медиа

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Introduction

In the context of deep digitization of public life, digital footprints are becoming a key source of information. Analyzing digital footprints enables research into various dimensions of environmental problems, including how urban residents perceive air quality. This is a relatively new approach. Accordingly, the concept of "ecological culturomics" [Ladle et al. 2016] emphasizes the use of non-traditional data sources – including social media, search engine queries, and video platforms – in tackling a variety of environmental challenges. Later, the concept of "Internet Ecology" (iEcology) was introduced by I. Jarić et al. [Jarić et al. 2020; 2021]. It extends beyond ecological culturomics to include the direct study of non-human-driven biological processes in nature. This research direction is just beginning to gain traction in Russian sociology, as exemplified by the works [Kranzeeva et al. 2024; Rastorguev, Tyan 2021].

The purpose of the study is to develop a methodological framework for assessing public perception of urban air quality, using the cases of Magnitogorsk and Cherepovets. The proposed approach can pinpoint the most contentious topics in public discourse about urban air quality as perceived by residents. To address this research question, our study employs data sourced from VKontakte (VK), the dominant social media platform in Russia. The two case studies are both classified as monotowns, or single-industry cities dominated by a major "city-forming" enterprise[1]. They are the largest ferrous metallurgy plants: the Magnitogorsk Iron and Steel Works (MMK) and the Cherepovets Steel Mill (Severstal). A key characteristic of monotowns as centers of industrial production is their complex environmental and social situation.

These cities were chosen as case studies for their comparable profiles alongside meaningful geographic and historical distinctions. The two cities have similar population scales, with 410,000 inhabitants in Magnitogorsk and 312,000 in Cherepovets (as of January 1, 2021). Neither city is an administrative center of its region (oblast). As Cherepovets and Magnitogorsk are fairly large cities, they exhibit a high rate of Internet users, including social media users. As of early 2021, VK (VKontakte), the dominant Russian social media platform, had 185,000 registered users in Magnitogorsk and almost 174,000 in Cherepovets. VK's penetration rate in these cities reaches 45% and 56%, respectively.

Furthermore, Magnitogorsk and Cherepovets are widely known as cities with a challenging environmental situation, with air quality being a primary concern. Researchers' evaluations corroborate this view[2] [Kuzmin et al. 2021; Saltykova et al. 2020]. Both cities are part of the "Clean Air" federal project[3], which aims to improve the environmental situation and reduce emissions of pollutants into the atmosphere. This led us to hypothesize that the environmental agenda is inherently relevant to these cities' residents and, consequently, would generate a significant volume of related posts on VK.

Thus, air quality is framed as a pressing environmental and social issue, given its direct impact on human well-being. Studies demonstrate that air pollution negatively impacts public health, thereby undermining the environmental aspect of life quality [Belik, Kamdina 2018; Vasenina, Sushko 2020]. Beyond direct adverse health effects, air pollution can lead to sensory discomfort and a perceived reduction in life quality, often associated with foul smells. Consequently, air quality constitutes a key element of environmental risk, impacting the resilience of both urban and regional systems, particularly in large industrial hubs.

Methods and materials

The material selection methodology follows the authors' previous research [Shchekotin et al. 2023]. We compiled a database of 250 online communities that publish locally relevant information for the two cities under study (103 communities for Cherepovets and 147 communities for Magnitogorsk). At the next stage, the content of the selected communities was retrieved for the timeframe spanning from January 1, 2020 to October 31, 2022, comprising 136,777 posts from Cherepovets and 192,992 from Magnitogorsk. We then analyzed this dataset using a previously developed algorithm [Shchekotin et al. 2021] and filtered the posts pertaining to environmental issues. This process yielded a final dataset

[1] On approval of the list of single-industry towns (monotowns). Decree No. 1398-r of July 29, 2014. [Об утверждении перечня моногородов. Распоряжение № 1398-р от 29.07.2014.] URL: http://government.ru/docs/14051/ (accessed 15 Nov 2025).

[2] Key environmental performance indicators. Statistical Bulletin. Moscow: Rosstat, 2021, 114. (In Russ.) [Основные показатели охраны окружающей среды. Статистический бюллетень. М.: Росстат, 2021. 114 с.]

[3] The "Clean Air" federal project (a national environmental initiative aimed at reducing air pollution in industrial cities). [Федеральный проект «Чистый воздух».] URL: https://www.mnr.gov.ru/activity/clean-air/ (accessed 15 Nov 2025).

of 3,805 ecology-related posts from 92 communities, with the following distribution: 2,621 posts from 54 communities in Magnitogorsk and 1,184 posts from 38 communities in Cherepovets. Next, using content analysis, we identified 481 posts that specifically addressed air quality in the selected cities, including 433 from Magnitogorsk communities and 48 from those in Cherepovets. We analyzed both the text of these posts and user engagement metrics, specifically the number of reactions ("likes"), comments, and shares. This dataset of posts served to pilot-test the proposed methodological approach.

Our analysis of the selected posts focused on user engagement metrics for these posts to gauge public perception of air quality in the two cities. Reactions, shares, and comments serve as key metrics which provide quantifiable data on user engagement on specific topics [Lobodenko et al. 2022; Su, Li 2023; Xu et al. 2018]. Our working hypothesis was that analyzing high-engagement posts would reveal how urban residents perceive air quality. This analysis led us to the conclusion that various user reactions reveal different dimensions of online engagement. For instance, research on political communication in social media [Myagkov et al. 2018] suggests that an elevated comment-to-engagement ratio indicates a contentious and polarizing topic, fueling user disputes and outrage. A high volume of reactions signals user interest in the topic or endorsement of the post's thesis. A high share count often signifies an intention to bookmark the content for later or to disseminate it within one's social network. Depending on the post's topic, a viral spread of a post can reflect various user intentions – from issuing a public warning to expressing awe or approval of the reported event. Occasionally, a single post may achieve the highest scores simultaneously in all three metrics of online engagement. This type of post acts as a diagnostic "hotspot", signaling topics with substantial inherent conflict, significant public resonance, and a viral dissemination impulse.

The proposed methodology follows a structured step-by-step sequence:

1) selecting topic-based posts,
2) identifying high-impact posts through quantitative metric analysis,
3) detecting posts (if present) that are top-ranked across the full spectrum of all three metrics. Functioning as focal points for discourse, such posts attract peak engagement and, consequently, signaling the most contentious issues.

A formal representation of the algorithm is given in:

$$PC = L_{max} + Sh_{max} + C_{max},$$

where *PC* stands for potentially contentious topic,
L_{max}, maximum volume of reactions ("likes"),
Sh_{max}, maximum volume of shares,
C_{max}, maximum volume of comments.

Results

The following section implements the proposed algorithm on a dataset of posts from Magnitogorsk and Cherepovets. The analysis focuses on the three highest-ranking posts for each online engagement metric. The three posts with the highest number of reactions in Magnitogorsk communities are presented below.

1. **Post 1**: *Okay, maybe I could buy the morning fog being from a temperature drop. But fog at 3:30 in the afternoon in the new districts? Yeah, right. Like they're purposely polluting the air to the max today!* This post garnered 189 comments, 635 reactions, 208 shares, and over 40,000 views.
2. **Post 2**: *Chelyabinsk has become the most polluted city in Russia. Magnitogorsk also made the list of cities with the most polluted air. According to the vice-premier's press service, the most polluted among them in 2020 were Chelyabinsk, Nizhny Tagil, and Magnitogorsk* (203 reactions).
3. **Post 3**: *Magnitogorsk and Chelyabinsk are named the dirtiest cities in Russia. The top three cleanest cities were Tambov, Sochi, and Maykop. Meanwhile, the two largest cities of the Southern Urals were deemed the dirtiest and most environmentally troubled: Magnitogorsk took the top spot in the negative ranking, with Chelyabinsk coming in second. They are joined in the 'black list' by Norilsk, Krasnoyarsk, Cherepovets, Lipetsk, Novokuznetsk, Mednogorsk, and Nizhny Tagil* <…> (167 reactions).

The top three posts by comments are listed below:

1. **Post 1** (189 comments).
2. **Post 4**: *The Russian Deputy Prime Minister announced the better air in Chelyabinsk cities. Chelyabinsk and Magnitogorsk ranked among the top performers in reducing air pollution levels. Russian Deputy Prime Minister Viktoria Abramchenko made the statement at a Cabinet meeting presided over by President Vladimir Putin. "Novokuznetsk, Chelyabinsk, and Magnitogorsk led in cutting down air pollution emissions. This falls under the "Clean*

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Air" project", RIA Novosti reports, citing the Deputy Prime Minister (93 comments).

3. **Post 5**: *Residents of Magnitogorsk are complaining less about emissions* (60 comments).

The top three posts by number of shares are listed below:

1. **Post 1** (208 shares).
2. **Post 3** (160 shares).
3. **Post 6**: *Forecasters are warning Magnitogorsk residents of a dangerous weather phenomenon. Avoid going outdoors during this period* (80 shares).

With the highest aggregate score across all metrics (PC = 1032), Post 1 clearly resonates as a deeply troubling air pollution topic for the local community of Magnitogorsk. It is also noteworthy that each of the three most-reacted posts claims that the air in Magnitogorsk is severely polluted. This presents a radical divergence from the high-comment Posts 4 and 5, which relay the official position that the air in Magnitogorsk is getting cleaner. We hypothesize that the surge in comments signals public dissent and outrage in response to the official statements presented in these posts. These posts, at a minimum, ignited a heated discussion. Regarding shares, the top-performing Posts 1 and 3 suggest a user-driven effort to amplify the reach of this content. Conversely, Post 6 adopts a factual tone, detailing adverse weather conditions responsible for a spike in pollution levels. Users likely shared this post extensively to alert their relatives or friends to the impending danger.

As for the posts in Cherepovets communities, we observe a very similar pattern. The top three posts ranked by reactions are listed below:

1. **Post 7**: *Rosprirodnadzor (the Federal Service for Supervision of Natural Resources) named the three cities with the most polluted air. Svetlana Radionova, Head of the Federal Service for Supervision of Natural Resources (Rosprirodnadzor), stated that Norilsk tops the ranking, accounting for 1.8 million tons of annual pollutant emissions – equivalent to 11% of Russia's total. The city of Cherepovets in the Vologda region ranked second for the worst air quality, with annual emissions of 280,000 tons (1.7% of the national total). Rounding out the top three is Novokuznetsk (Kemerovo region), with industrial plants releasing 278,000 tons of toxic emissions per year, which is 1.6% of the national total* (198 reactions, 56 comments, 368 shares, 21470 views).
2. **Post 8**: *From a subscriber: Friends and fellow citizens! When will Cherepovets Steel Mill finally filter its emissions? I demand to know! I want the mobile lab data, ecoactivist feedback, and satellite evidence. We haven't been able to breathe since Sunday! I can't even open a window for three days! My home is saturated with the stench from the plant... Now the entire city is blanketed in a strange pink fog. Someone has to stop this!* (106 reactions, 29 comments, 31 shares).
3. **Post 9**: *Metallurgists can no longer cycle to work. Starting April 1, employees will be unable to commute using the most environmentally friendly, economical, and health-beneficial mode of transport. Not a sensible decision from the viewpoint of employee health preservation* (66 reactions, 49 comments, 156 shares).

The top 3 posts by number of comments are the same three messages, but in a slightly different sequence: Post 7 leads, followed by Post 9 and then Post 8. Similarly, the most-shared posts are led by Posts 7 and 9, with **Post 10** ranking third: *An incident took place at the Apatit fertilizer plant in Cherepovets this morning (7:12 AM): a safety system was activated after an unexpected equipment failure, causing a minor, short-lived ammonia leak* <...> (113 shares, 22 reactions, 0 comments).

In the case of Cherepovets, we also see that the post which resonated most was the one stating that Cherepovets leads in air pollution. This message provoked a strong reaction from users (PC = 622). The third by number of shares was the post about the accident and ammonia release. The high number of shares for this post is apparently related to users' desire to warn other people – relatives and acquaintances – about the impending danger.

Thus, the analysis indicates clear user discontent regarding air quality on social media. Additionally, there is an evident public opposition towards the government's air quality claims (Posts 4 and 5). The high volume of comments reflects public dissent from the authorities' upbeat portrayal of improving conditions.

Discussion and conclusion

The air quality concern plays a key role in shaping perceptions for environmental risks. Air quality is particularly crucial for residents in proximity

to industrial plants [Dettori et al. 2020]. This research confirms that the thesis is equally valid for the urban populations in large industrial hubs. Air quality-related environmental risks are perceived as most severe in Magnitogorsk, whereas the issue of air quality receives less coverage in social media in Cherepovets. Our future research will aim to uncover the drivers behind the differing public reactions to environmental risks stemming from air pollution, which is a question of considerable importance.

The proposed approach is a quantitative, metric-based method to pinpoint high-conflict themes in environmental online discussions. Posts with the highest levels of online engagement (i.e., reactions, shares, comments) signal the greatest conflictogenic potential. The pilot testing of this methodology showed that a vigorous response was elicited by posts about high levels of air pollution, which contained both references to official field studies and statements from the users themselves. The authorities are making certain efforts to improve air quality, implementing the large-scale "Clean Air" federal project; however, the post that the air quality in the studied cities is improving caused an influx of comments. In other words, the post sparked public debate and almost certainly signals a rejection of that official viewpoint. The proposed methodological approach enables the detection of key *hotspots* in public discussions concerning specific environmental issues.

We support the view that public concern for environmental issues, specifically air quality, stems directly from local environmental perceptions: the worse conditions are perceived to be, the greater the civic engagement with ecological problems will grow [Rybakova, Zvereva 2022]. We can assess public concern for these issues through social media analysis. It provides a fast and efficient way to gauge how people in a given area perceive their local environment. Moreover, social networks play a crucial role in setting the environmental agenda. Social media are the leading source of environmental information in Russia, surpassing television and all other media[4].

We agree with N. J. Bennett's perspective that human environmental perceptions are crucial for effective conservation management. Yet, the reality of governance in Russia demonstrates a consistent overlook of this factor by the state [Bennett 2016]. The case in point is the "Clean Air" project, the most ambitious environmental effort tackling air pollution since the Soviet era. A projected budget for its implementation exceeds 57 billion rubles through 2030[5]. During its initial phase (launched in 2019), the project's designers sought to incorporate subjective measures into its performance evaluation. Thus, one of the indicators of the project's successful implementation (albeit an additional one) was defined as achieving a percentage of citizens satisfied with the quality of atmospheric air at 90%[6]. Yet, by 2020, Rosprirodnadzor – the supervising ministry – had reportedly moved to drop the public satisfaction metric, dismissing it as overly subjective[7]. Regrettably, this metric appears to have been removed in the federal project's latest official documentation[8].

Air pollution-driven environmental risks constitute a major threat to the resilience and sustainable growth of cities and regions. However, while air pollution can be quantified through field measurements, detecting and assessing unpleasant odors often eludes purely objective instrumental analysis [Arias et al. 2018; 2022; Pascariello et al. 2022; Teixeira et al. 2021; Zarra et al. 2021]. Within this framework, data from citizen science initiatives represent a viable source for air quality monitoring [Mahajan et al. 2022; Özkal 2023; Samulowska et al. 2021]. Overall, citizen science serves as a key instrument for evaluating a range of risks within the context of the Sustainable Development Goals (SDGs) [Fraisl et al. 2023]. Beyond citizen science, user-generated digital traces – from social media activity to search engine queries – can also serve this purpose. We argue that

[4] The environmental agenda: Ten months before the State Duma elections. Analytical report by WCIOM (Russian Public Opinion Research Center), 2020, November 30. [Экологическая повестка: за десять месяцев до выборов в Госдуму. *ВЦИОМ*. 30.11.2020.] URL: https://wciom.ru/analytical-reports/analiticheskii-doklad/ehkologicheskaja-povestka-za-desjat-mesjacev-do-vyborov-v-gosdumu (accessed 15 Nov 2025).

[5] Tilda. URL: http://min.prirodyair.tilda.ws/project (accessed 15 Nov 2025).

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[7] Vasilyeva A., Shapovalov A. Rosprirodnadzor does not trust the sense of smell of Russians. *Kommersant*. 2020, May 13. [Васильева А., Шаповалов А. Росприроднадзор не доверяет обонянию россиян. *Коммерсантъ*. 13.05.2020] URL: https://www.kommersant.ru/doc/4343285?from=four_strana (accessed 15 Nov 2025).

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public perception of air quality is a critical metric for evaluating the success of environmental risk management programs.

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Contribution: E. V. Shchekotin developed the research concept, formulated the hypothesis and objective, methodology, and drafted the manuscript. V. V. Kashpur collected the empirical research data, proofread the manuscript, supervised the research, and fund acquisition. A. A.-K. Abbasova analyzed the data, administrated the data and project.

Критерии авторства: Е. В. Щекотин – формулирование идеи, гипотезы, цели исследования, разработка методологии, написание текста статьи. В. В. Кашпур – сбор данных, редактирование текста, научное руководство проектом, получение финансирования. А. А.-К. Аббасова – анализ данных, управление данными, управление проектом.

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