Research Article

# Assessment of urban air pollution by organic compounds

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## ABSTRACT

**Aim:** The present study deals with the assessment of air pollution degree by volatile organic compounds (VOCs) in the city of Naberezhnye Chelny. There was researched character of the change of the ingredients contained in the atmospheric air and also has been researched the composition of the organic matters which are present in the atmospheric air. **Material and Method:** Air sampling was carried out for these components, the analysis on a gas chromatograph, and processing results. **Result and Discussion:** Quantitative content of VOCs in the air samples has been calculated. Defined the nature VOCs concentration gradient toward the city of Nizhnekamsk. The content of light organic compounds (41 compounds) was determined in 23 test plots. With a view to assessing, the level of air pollution was defined by the complex air pollution index for 23 sample plots on the five priority VOCs. **Conclusion:** The nature of the change in KIZA5 from the VOCs studied (from a low level of air pollution to very high) indicates a very significant air pollution by light organic compounds as we approach Nizhnekamsk that there have been proposals to lower the VOCs contents in the atmospheric air.


**KEY WORDS:** Air pollution, Atmospheric air, KIZA5, Volatile organic compounds

## INTRODUCTION

With the development of the industry, with an urbanization and population increase, a number of species polluting substances and their number significantly increased, and therefore, anthropogenic pollution began to prevail over natural. Air pollution is accomplished due to natural factors, but with the exception of catastrophic cases, it does not violate the existing balance in nature. The key, and especially, dangerous polluters of the atmosphere is transport, production, and household emissions.[1] A significant proportion of polluting substances enters from the combustion of fossil fuels. During the combustion of the fuel to air are emitted many gases: Oxocarbon, nitrogen oxide, sulfur dioxide, soot (fine carbon particles), the various hydrocarbons, including methane, lead compounds, and other heavy metals.[2]

Many technological processes including various chemical processes are accompanied by the emission of pollutants, and some of which are toxic. Therefore, on metallurgical, chemical, pulp and paper, and other factories require regular monitoring to prevent or reduce to a safe level of emissions of toxic substances.

To date, the condition of the atmospheric air is characterized by a change of its natural structure. Harmful substances from sources of industrial emission enterprises are concentrated in the troposphere layer and form a dangerous cloud of impurities. Over the years, a number of pollutants accumulate and unevenly distributed, and in some areas, their concentration is unacceptably high.

Many volatile organic compounds (VOCs), such as chlorinated hydrocarbons (chloroform, carbon tetrachloride, and methylene chloride) and very fine particles of toxic metals and asbestos, are a threat to human health with prolonged inhalation.[3]

Especially, acute problem of ambient air quality is in the cities neighboring the industrial giants. The main problems of cities associated with excessive concentration on relatively small areas of population, transport, and industrial enterprises, with the formation of anthropogenic landscapes, far removed from condition ecological balance. One such example is the city of Naberezhnye Chelny.[4]

The city of Naberezhnye Chelny is the second city of the Republic of Tatarstan by population size, center


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of the trucks automotive industry of the Russian Federation. The city is located on the left bank of the Kama River. In the neighborhood with the cities of Nizhnekamsk, Mendeleevsk, Yelabuga, Zainsk, Menzelinsk, Almetyevsk, and Bugulma forms the Kama economic region where more than a half of the production capacity of the Republic of Tatarstan is concentrated.[5] The main branches - oil production, oil refining, and chemical industry include the production of automobile tires, electric power industry, trucks and automotive industry, tractor construction, buses production, engines, spare parts for motor vehicles, casting production, processing industry, and the food industry. The urbanized areas such as Naberezhnye Chelny, Yelabuga, Mendeleevsk, Nizhnekamsk are the big transport nodal point, namely, road, rail, air (International Airport), and fluvial (river-sea).

Due to the high concentration of industry, the atmospheric air in the city of Naberezhnye Chelny is experiencing a significant technological impact. The predominant wind rose, contributing to emissions of pollutants from Nizhnekamsk moving toward Naberezhnye Chelny, ensures the presence in the atmospheric air of a wide spectrum VOCs, which constitute a substantial part of harmful VOCs.

## EXPERIMENTAL PART

This paper was planning pilot sites for air sampling in the city of Naberezhnye Chelny, Nizhnekamsk in the territory between the cities along the highway. When planning, the sample plots were taken into account the wind rose, landscape areas, road infrastructure, geographical position of Naberezhnye Chelny, proximity to Nizhnekamsk with chemical production, and oil refining.

Selection of air samples was performed by means of an aspirator in the Tedlar bags.[6]

In the city of Naberezhnye Chelny was carried out the selection of air sampling on the main highways in 12 points (Figure 1).

On the way to an industrial zone city of Nizhnekamsk, outside the city of Naberezhnye Chelny, the selection of air sampling was carried out in the next 11 points (Figures 2 and 3).

## RESULTS

Analyses were carried out on a type of photoionized gas chromatograph (FGH-1) which is calibrated to 53 substances. We determined VOCs which can be

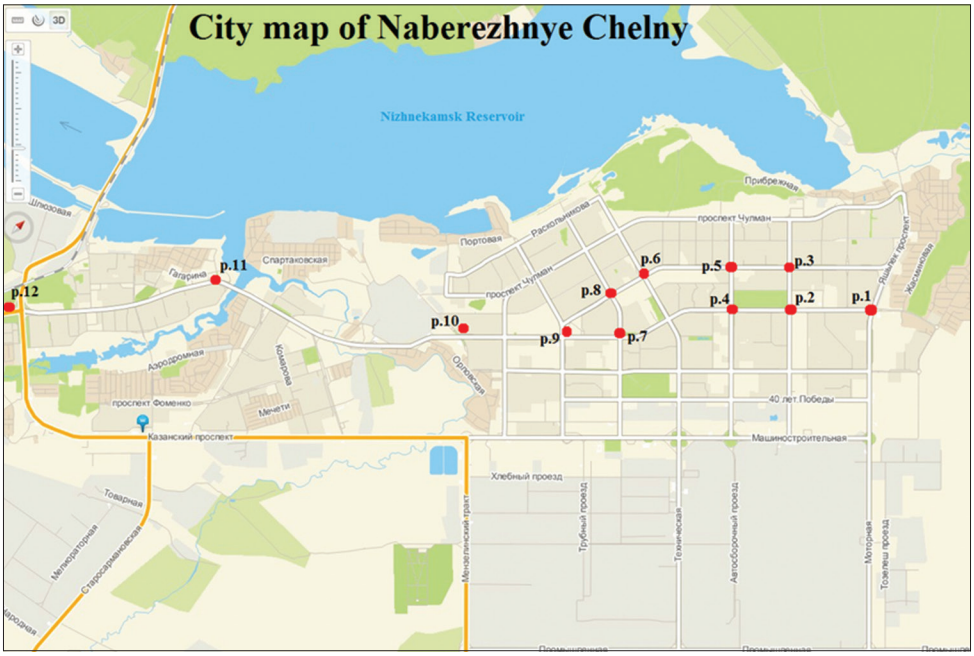


**Figure 1:** The sampling points in the city of Naberezhnye Chelny. Point 1. Mira Avenue/Yashlek Avenue; Point 2. Avtozavodskii Avenue/Mira Avenue; Point 3. Syuyumbike Avenue/Avtozavodskii Avenue; Point 4. Bus stop 30 complex; Point 5. Syuyumbike Avenue/Vakhitova Avenue; Point 6. Syuyumbike Avenue/Hassan Tufan Avenue; Point 7. Mira Avenue/Belyaeva Avenue; Point 8. Syuyumbike Avenue/Avenue Belyaeva. Point 9. Opposite shopping center "Omega;" Point 10. Prospect Mira/Narimanov Street; Point 11. Musa Jalil Avenue, near the shopping center "Detskiy Mir;" Point 12. Bus station. Point 13. GAI, in the direction to Nizhnekamsk. Point 14. The turn on Stariy Erikli. Point 15. The turn on Krugloe Pole. Point 16. Krugloe Pole. Point 17. The turn on Biklyan'. Point 18. Industrial zone, near the gas station Tatneft, Promyshlennaya Street; Point 19. Industrial zone, Shinny Street; Point 20. Industrial zone, tram stop "Factory of gasolines;" Point 21. Near the railway crossing at the station Biklyan'; Point 22. Ishteryakovo; Point 23. Prosti

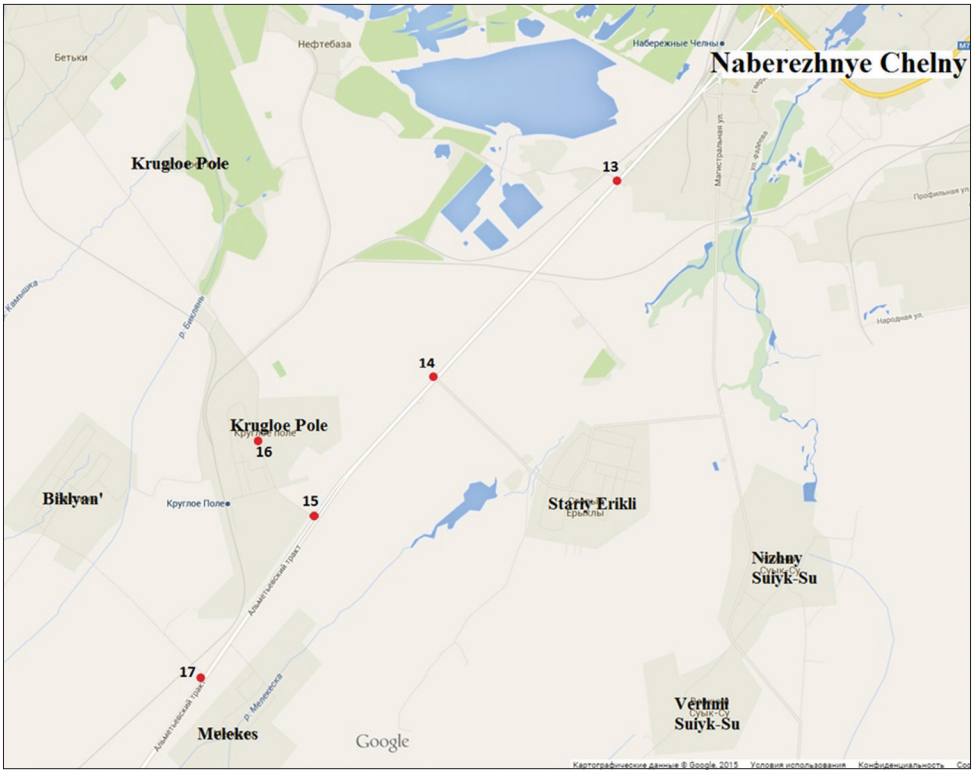


**Figure 2:** The sampling points outside the city of Naberezhnye Chelny in the direction city of Nizhnekamsk

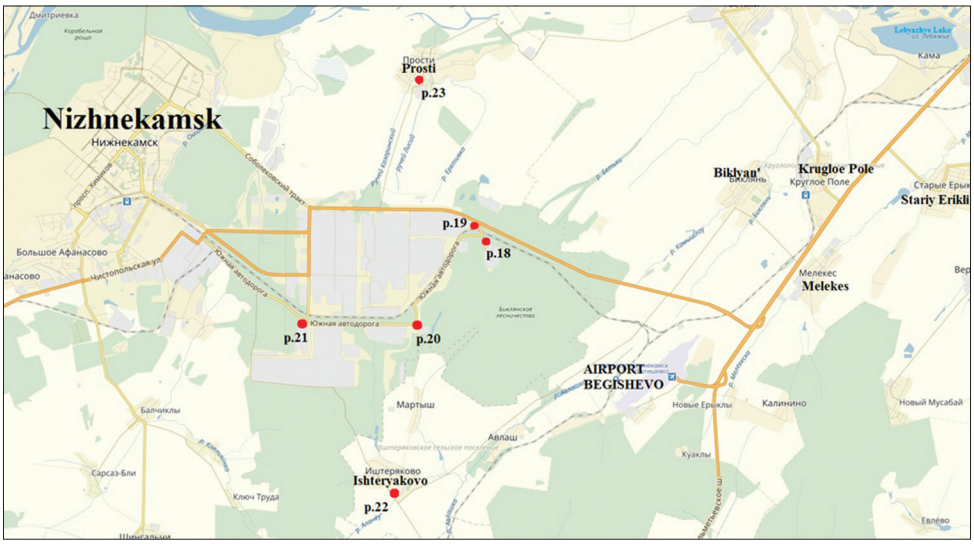


**Figure 3:** The sampling points in Nizhnekamsk (industrial zone)

thrown out by stationary sources petrochemical plants Nizhnekamsk.

The air samples in total were identified as a minimum of the following substances (41 compounds): Hexane, octane, methyl tert-butyl ether, acetone, ethyl acetate, butanone, ethanol, benzene, decane, isobutyl acetate, toluene, butyl acetic ether, allyl alcohol, butanol, alkenes (C2-C6, mainly amilen [pentilenums]), heptene, octene, carbon disulfide, turpentine, isobutyl alcohol, ethyl benzene, p-Xylene, m-Xylene, o-Xylene, styrene, perluxe, benzene chloride, methyl cellosolve, ethylcellosolve, mesitylene, pseudocumene, trichloroethylene, butane, isoamyl alcohol, pentane, isopropanol, epichlorohydrin, methylene chloride, and propyl alcohol.[7]

All these substances are included in the list 275 of pollutants which are officially declared by PJSC Nizhnekamsneftekhim in the project MCP.

It should be noted that the pollutants such as sulfur oxides, nitrogen and carbon, phenol, formaldehyde, sulfates, and dust are determined in the system of state environmental air monitoring and information published on the website

**Table 1: Indicators of atmospheric air**

| № | Air sampling points | Priority polluting substances | $KIZA_5$ (complex air pollution index) | The level of air pollution |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 1 | Mira Avenue/Yashlek Avenue | Allyl alcohol, butanol, ethanol, ethyl acetate, acetone | 2.0 | Low |
| 2 | Avtozavodskii Avenue/Mira Avenue | Butanol, allyl alcohol, ethyl acetate, isobutyl acetate, acetone | 3.1 | Low |
| 3 | Syuyumbike Avenue/Avtozavodskii Avenue | Ethanol, butanol, allyl alcohol, butyl acetic ether, acetone | 3.6 | Low |
| 4 | Bus stop 30 complex | Ethanol, butanol, allyl alcohol, ethyl acetate, isobutyl acetate | 3.2 | Low |
| 5 | Syuyumbike Avenue/Vakhitova Avenue | Ethanol, butanol, allyl alcohol, isobutyl acetate, acetone | 1.6 | Low |
| 6 | Syuyumbike Avenue/Hassan Tufan Avenue | Benzene, toluene, ethanol, allyl alcohol, acetone | 2.1 | Low |
| 7 | Mira Avenue/Belyaeva Avenue | Ethanol, butanol, allyl alcohol, isobutyl acetate, acetone | 5.1 | Heightened |
| 8 | Syuyumbike Avenue/Avenue Belyaeva | Benzene, ethanol, butanol, allyl alcohol, acetone | 3.4 | Low |
| 9 | Opposite shopping center "Omega" | Acetone, ethanol, butanol, allyl alcohol, butyl acetic ether | 6.0 | Heightened |
| 10 | Naberezhnochelninskiy Avenue/ Narimanov Street | Octane, butanol, allyl alcohol, butyl acetic ether, acetone | 6.2 | Heightened |
| 11 | Musa Jalil Avenue, near the shopping center "Detskiy Mir" | Ethanol, butanol, allyl alcohol, isobutyl acetate, butyl acetic ether | 6.7 | Heightened |
| 12 | Bus station | Ethanol, butanol, allyl alcohol, isobutyl acetate, butyl acetic ether | 8.3 | High |
| 13 | GAI, in the direction to Nizhnekamsk | Octene, ethylbenzene, styrene, isoamyl alcohol, carbon disulfide | 17.8 | Very high |
| 14 | The turn on Stariy Erikli | Octene, ethylbenzene, styrene, allyl alcohol, ethyl cellosolve | 11.5 | Very high |
| 15 | The turn on Krugloe Pole | Octene, styrene, isobutyl acetate, butyl acetic ether, carbon disulfide | 13.9 | High |
| 16 | Krugloe Pole | Octene, styrene, pseudocumene, allyl alcohol, carbon disulfide | 8.3 | High |
| 17 | The turn on Biklyan' | Hexane, octene, styrene, butyl acetic ether, carbon disulfide | 9.7 | Very high |
| 18 | Industrial zone, near the gas station Tatneft, Promyshlennaya Street | Pentane, amilene, allyl alcohol, ethylcellosolve, carbon disulfide | 22.5 | Very high |
| 19 | Industrial zone, Shinny Street | Hexane, amilene, isoamyl alcohol, acetone, epichlorohydrin | 39.5 | Very high |
| 20 | Industrial zone, tram stop "Factory of gasolines" | Hexane, amilene, allyl alcohol, acetone, isobutyl acetate | 27.0 | Very high |
| 21 | Near the railway crossing at the station Biklyan' | Hexane, octane, amilene, allyl alcohol, isoamyl alcohol | 15.3 | Very high |
| 22 | Ishteryakovo | Amilene, ethylbenzene, styrene, pseudocumene, allyl alcohol | 40.6 | Very high |
| 23 | Prosti | Pentane, amilene, styrene, isoamyl alcohol, acetone | 48.1 | Very high |

of the Federal Service for Hydrometeorology and Environmental Monitoring of Russia (Roshydromet).

With a view to identifying, the level of air pollution index was calculated KIZA5 (integrated air pollution index). The calculation was performed for 23 sample plots on five priority VOCs in the direction of the city of Naberezhnye Chelny (pr.Mira/pr.Yashlek) to the industrial zone Nizhnekamsk for 38 km.

The main applications IZA (complex air pollution index) are an integrated assessment of urban air pollution as a whole or areas, a comparison of levels of air pollution, the identification of long-term changes in atmospheric air quality.

**Table 2: The levels of air pollution**

| The levels of air pollution | KIZA5 | NP | SI |
|---|---|---|---|
| Low | 0-4 | <10 | <1 |
| Heightened | 5-6 | 10-19 | 1-4 |
| High | 7-13 | 20-50 | 5-10 |
| Very high | ≥14 | >50 | >10 |

The complex air pollution index (KIZA5) was calculated by the following formula (1):

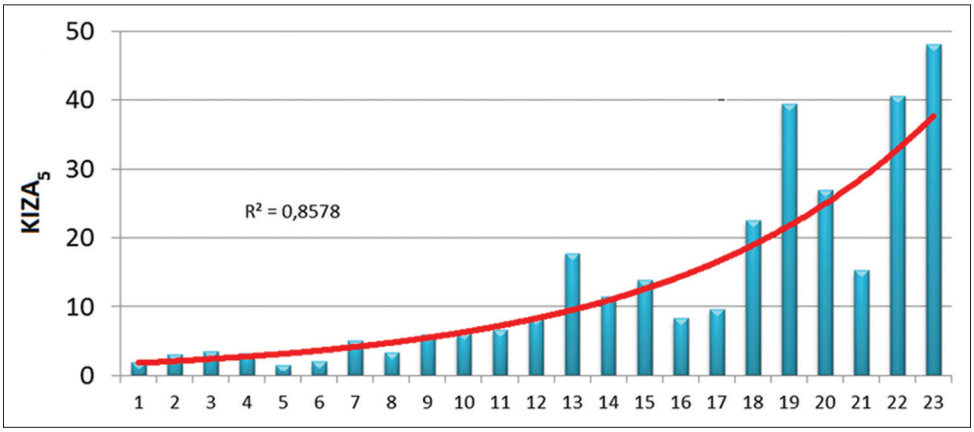


**Figure 4:** Numbers of sample plots from Mira Avenue/Yashlek Avenue to the industrial site Nizhnekamskneftekhim

$$I_5 = KIZA_5 = \sum_{i=1}^{5} \left( C_i / MPC \right)^{\beta_i}.$$

IZA (complex air pollution index) was calculated according to the formula (1), indicates what level of air pollution in fact correspond to the observed concentration of the substances, i.e., shows how many times the total level of air pollution exceeds the maximum permitted on the aggregate consideration of pollutants in general. A comprehensive IZA comparable for different stations, is calculated for the same amount (usually five) substances.[8]

The five priority pollutants (with the highest coefficient of concentration $\sum_{i=1}^{5} \left( C_i / MPC \right)^{2}{}_{i}$) from numbers defined VOCs, the calculated value of KIZA(5) (integrated air pollution index), and the level of air pollution are shown in Table 1 for each sample plot (Figure 4).[9]

The levels of air pollution are shown in Table 2.[10]

## DISCUSSION

Thus, the content of VOCs (41 compounds) in 23 sample plots, the assessment of the level of air pollution by VOCs in the city of Naberezhnye Chelny, and character change of KIZA5 (complex air pollution index) suggest about very significant air pollution of VOCs (from low levels of air pollution to very high), when approaching Nizhnekamsk.

Summing up this work, we can say that the level of air pollution in the city of Naberezhnye Chelny is at a high level. The reason for this is emissions of stationary sources and mobile sources. Predominant wind rose, which facilitates the movement of polluting emissions from Nizhnekamsk in the direction of Naberezhnye Chelny, therefore ensures the presence in atmospheric air a wide range of VOCs, which represent a substantial part of VOCs. In the area of the industrial zone of influence - level of air pollution in the direction of Nizhnekamsk is very high. Due to the high concentration of industry, the air in the city of Naberezhnye Chelny is experiencing significant technological impact, probable source of air pollution may be chemical production and oil refining.

## CONCLUSIONS

To minimize, air pollution must be the introduction of new enterprises saving technologies and systems, dust removal facilities, etc. In the city of Naberezhnye Chelny, it is recommended to install additional stationary air monitoring stations, as well as in neighboring areas for the control of emissions from Nizhnekamsk industrial hub, in the Mendeleev region considering launching a new plant for the production of ammonia OJSC "Ammonium."

## REFERENCES

1. Karpenkov SH. Ecology: Textbook. New York: Logos; 2014. p. 399.
2. Kovalchuk VK, Ivanov IL, Saenko AG, Kovalchuk VC, editors. Sanitary Protection Zones for Industrial Sources of Air Pollution: Guide. Vladivostok: Far East Medicine; 2010. p. 136.
3. Suleimanov IF. The assessment of the city air pollution by automobile transportation and industrial enterprises basing on calculation methods. World Appl Sci J. 2013;23(4):480-5.
4. Suleimanov IF, Mavrin GV, Sokolov MP, Suleimanova YE, Ardashirova LR. Reducing the negative impact on the environment through organization of traffic flows considering the emissions of industrial enterprises. ARPN J Eng Appl. 2016;11(15):9134-7.
5. Khabibullin RG, Makarova IV, Belyaev EI, Suleimanov IF, Pernebekov SS, Ussipbayev UA, *et al*. The study and management of reliability parameters for automotive equipment using simulation modeling. Life Sci J. 2013;10(12s):828-31.
6. Amann M, Gyarfas F, Schopp W, Boudri JC. Prévision d'air-un Système de Modélisation de la Contamination Atmosphérique, Emep. 2000. p. 87-170.

7. Kajino, M. Modelling Liquid Water Content of Atmospheric Aerosols. IIASA Interim Report. 03-046; 2003.
8. Suleimanov IF, Mavrin GV, Kharlyamov DA, Belyaev EI, Mansurova AI. Pollution of the air basin in the cities by motor transport and the industrial enterprises, quality assessment of atmospheric air with the use of calculation methods and instrumental control. Mod Appl Sci. 2015;9(4):12-20.
9. Sokolovsky AE, Kovalenko NA, Supichenko GN, Radion EV. Chromatographic Methods of Analysis. Minsk: Elsevier B.V; 2002. p. 35.
10. Suleimanov IF, Mavrin GV, Kharlyamov DA, Iamaletdinov DV. Assessment of urban air pollution caused by motor vehicle complex and industrial facilities. Res J Pharm Biol Chem Sci. 2015;6(1):1605-9.