Assessment of pollutants discharges and air pollution in the Tyumen region (without considering autonomous districts) and its urban districts

V A Sapega

Department of Technosphere Safety, Industrial University of Tyumen, Lunacharski str., 2, Tyumen, 625001, Russia

E-mail: sapegavalerii@rambler.ru

Abstract. The article provides an analysis of pollutants discharges in the Tyumen region, in the Tyumen region without considering autonomous districts, and in its urban districts for the period of 2013-2017. The researcher compares the number of stationary emission sources throughout the Tyumen region in 2017 and in 2013. The increasing amount of pollutants discharges has also been ranged from the Tyumen region (129083 tons) to its urban districts, namely Tyumen (16890 tons), Tobolsk (13723 tons). The decrease in emissions was noted in Ishim and Yalutorovsk in 2017 compared to 2013. It has been determined that the total amount of discharges in urban areas contained the average portion of solid discharge up to 5.0%, and of gaseous and liquid discharges up to 95.0%. Carbon monoxide and hydrocarbons (without VOCs) prevailed among gaseous emissions in the Tyumen region without considering autonomous districts (29.1 and 26.1% of all gaseous emissions respectively). Testing revealed the increase in the number of trapped and neutralized pollutants in the Tyumen region without considering autonomous districts and including urban districts in 2017 compared to 2013. In the analyzed period, the atmosphere in Tyumen and Tobolsk was characterized as slightly polluted.

1. Introduction

Nowadays one of the vital problems of ecology is the problem of the relationship between man and the environment [1-3]. The main environmental problem in most urbanized areas of this country is the increased level of air pollution [4-6]. Natural ecological processes and habitats are the most distorted in urban areas. The growth of cities and lack of investment in environmental protection worsen the situation [7, 8].

Industries and other types of economic activity of people cause indoor and outdoor air pollution [9-14].

Atmospheric pollutants (gaseous, aerosols, particulate matter) get into the air from both natural and anthropogenic sources [15-19]. Annually the total average amount of pollutant emissions throughout Russia makes up 20.8 million tons from stationary sources, and 13.2 million tons from mobile sources. The main air pollutants are nitrogen oxide and sulfur dioxide. On average, sulfur and nitrogen emissions per unit area amount to 0.38 and 0.12 t / km² per year from stationary and mobile sources respectively [20].
The risk of damage to human health is the highest of environmental risks. Air pollution is the most serious environmental problem for human health in the near or middle term, as its part, according to various sources, makes up 80 to 90% of all polluting factors [21].

In view of the mentioned above, it is necessary to study the changes in the basic parameters of air pollution in various regions and, in particular, in the Tyumen region and its urban districts. Data from the Report on Ecological Situation in the Tyumen Region in 2017 [22] and the Statistical Bulletin on Environmental Protection in the Tyumen Region for 2013-2017 were used for the research [23].

The area of the Tyumen region (without autonomous districts) is 160.1 thousand km². The population of the region was 1499.8 thousand people at the beginning of 2018. The average population density is 9.4 persons / km². The largest cities of the Tyumen region are Tyumen, Tobolsk and Ishim.

2. Results and Discussion
Industry is the most important factor in the development of the Tyumen region economy. But remarkable production growth trends in the key industries do not have a significant negative impact on the environment of the region.

It should be noted that the number of stationary sources of pollutant emissions throughout the Tyumen region was 128413 in the period of 2013-2017, and 21327 units in the Tyumen region without considering autonomous districts, which is 16.6% of the total number throughout the region (table 1). Over the analyzed period, there was observed an increase in the number of stationary sources of pollutant emissions. In particular, 4,700 stationary sources of pollutant emissions appeared in the Tyumen region without considering autonomous districts in 2017.

Air pollutant emissions from stationary sources over the Tyumen region made up 2341123 tons on average over the period of 2013-2017. And 129083 tons were discharged throughout the Tyumen region without considering autonomous districts (5.5% of total emissions in the region) (table 1). In general, there was a decrease in emissions by 414477 tons in the Tyumen region in 2017 compared to 2013, and an increase of 3.842 tons was observed in the Tyumen region without considering autonomous districts.

Table 1. Characteristics of the main indicators of air pollution in the Tyumen region (stationary sources).

| Indicator | The Tyumen region | The Tyumen region without autonomous districts |
|-----------|-------------------|-----------------------------------------------|
|           | 2013-2017  | 2017 compared to 2013 | 2013-2017  | % (of the indicators in the Tyumen region) | 2017 compared to 2013 |
| The number of stationary sources of pollutants discharge – total, units | 128413 | 100.0 | 9917 | 21327 | 16.6 | 4700 |
| Air discharged from stationary sources – total, t | 2341123 | 100.0 | -414477 | 129083 | 5.5 | 3842 |
| including: solid | 88449 | 3.8 | -24621 | 7221 | 8.2 | 36 |
| gaseous and liquid of them: sulfur dioxide | 2252674 | 96.2 | -389856 | 121862 | 5.4 | 3851 |
| | 11783 | 0.5* | - | 2250 | 19.1 | - |
| Indicator                              | The Tyumen region | The Tyumen region without autonomous districts |
|---------------------------------------|-------------------|-----------------------------------------------|
|                                      | 2013-2017 %       | 2017 compared to 2013 ± 2013-2017 % (of the indicators in the Tyumen region) | 2017 compared to 2013 ±
| carbon monoxide                       | 899039 39.9*      | 35522 4.0                                     | -                          |
| nitrogen oxide                        | 229005 10.2*      | 24293 10.6                                    | -                          |
| hydrocarbons (without VOCs)           | 783796 34.8*      | 31851 4.1                                     | -                          |
| volatile organic compounds (VOCs)     | 324698 14.4*      | 26573 8.2                                     | -                          |
| of them (of all emissions) discharged without purification, t | 2340211 99.9**   | 128482 5.5                                    | 3791                       |
| trapped and neutralized pollutants, t | 129997 5.6**      | 123774 96.5                                   | 116094                     |

* - of gaseous and liquid - total
** - to discharged - total

Judging by the data, gaseous and liquid discharges prevail in total discharges throughout the whole region - 96.2%.

The part of solid discharges in the Tyumen region without considering autonomous districts was 8.2% of the discharges throughout the whole Tyumen region. Gaseous and liquid ones made up 5.4%. There was registered a decrease by 36 tons in solid discharges as well as in both gaseous and liquid ones in the whole region in 2017 compared to 2013. However, the same period was marked by a slight increase, by 3851 tons, in all of the discharges in the Tyumen region without considering autonomous districts.

Over the given period among the discharged ingredients carbon monoxide prevailed in the Tyumen region - 899,039 tons (39.9% of gaseous and liquid discharges). Following were hydrocarbons (without VOCs) - 783,796 tons (34.8% of gaseous and liquid discharges). The same ingredients were most often observed in the discharged of the Tyumen region without considering autonomous districts (35,522 and 31,851 tons, respectively).

The amount of air pollutant emission without purification was 99.9% of all emissions in the Tyumen region. Over the period of 2013-2017 unpurified discharges amounted to 128.482 tons in the Tyumen region without considering autonomous districts that is 5.5% of emissions without treatment in the Tyumen region. Thus, proceeding from the ratio in the Tyumen region without considering autonomous districts, the bulk of all emissions and emissions without purification was observed in autonomous districts Khanty-Mansiysk and Yamalo-Nenets. Untreated emissions both in the Tyumen region as a whole and in the Tyumen region without considering autonomous districts increased by 128.482 and 3.791 tons in 2017 compared to 2013.

The portion of trapped and neutralized pollutants from all emissions is very low and amounts to 5.6% in the Tyumen region as a whole. The emission rate in the Tyumen region excluding autonomous districts amounted to 125464 tons for the period of 2013-2017. In this period the indicator increased both in the whole region (by 123774 tons) and in the Tyumen region excluding autonomous districts (by 116094 tons).

The analysis of the number of stationary sources of pollutant emissions in 2013-2017 showed that the portion of organized sources was 64.1% of their total number in the Tyumen region excluding autonomous districts (table 2).
Table 2. The number of stationary sources of pollutants discharges in the Tyumen region excluding autonomous districts and urban districts in 2013-2017.

| Region, urban district | Number of stationary emission sources - total | Of them organized |
|------------------------|---------------------------------------------|-------------------|
|                        | units | %* | 2017 compared to 2013 r. | units | of stationary sources - total, % |
|                        |       |    | units |                   |       |                              |
| Tyumen region without considering autonomous regions | 21327 | 100.0 | 4700 | 13669 | 64.1 |
| including |       |    |       |               |       |                              |
| Tyumen | 7212 | 33.8 | 1141 | 4589 | 63.6 |
| Zavodoukovsk | 890 | 4.2 | 338 | 547 | 61.5 |
| Ishim | 796 | 3.7 | -60 | 464 | 58.3 |
| Tobolsk | 826 | 3.9 | -36 | 464 | 56.2 |
| Yalutorovsk | 404 | 1.2 | -75 | 272 | 67.3 |
| In urban districts on average | 2026 | 9.5 | 262 | 1267 | 62.5 |

* - of the indicator for the Tyumen region without considering autonomous regions

Tyumen and Zavodoukovsk were registered as urban districts having the majority of stationary emission sources, namely 7,212 units and 890 units respectively. More than half of the stationary emission sources in all urban districts are organized. Their average share in urban districts is 62.5%. In 2017, compared to 2013, the number of stationary emission sources increased in Tyumen and Zavodoukovsk (by 1141 and 338 units, respectively) and decreased insignificantly in other cities.

Tyumen and Tobolsk were top cities among urban districts by the total amount of pollutant emissions in 2013-2017: 16890 tons and 13723 tons respectively (table 3). In terms of proportions, gaseous and liquid emissions prevail - from 84.1% (Ishim) to 97.3% (Tobolsk), while in the Tyumen region excluding autonomous districts their part was 94.4%.

Most of both solid and gaseous and liquid pollutants discharges were also noted in Tyumen (916 and 15,974 tons respectively) and Tobolsk (367 and 13,356 tons respectively).

On average, emissions in urban districts amounted to 6,650 tons. 95.0% of them were gaseous and liquid discharges.

The increase in total amount of emissions including solid, gaseous and liquid discharges in 2017 compared to 2013 was noted in Tyumen, Zavodoukovsk and Tobolsk. In particular, total amount of emissions in the above-mentioned cities increased by 913, 285 and 1650 tons, respectively, and in urban districts - on average by 496 tons.

The largest reduction in pollutant emissions over the given period was noted in Ishim - by 228, 62, and 165 tons (respectively, emissions are total, solid, gaseous and liquid). Analysis of emissions by individual ingredients of pollutants showed that carbon monoxide and nitrogen oxide predominated in gaseous emissions over urban districts. Thus, nitrogen oxide emissions in urban districts were measured from 76 tons (14.0%) in Yalutorovsk to 6849 tons (42.9%) in Tyumen, and on average in urban districts their content in gaseous emissions was only 45.3%.

Sulfur dioxide is the least emitted – 2250 tons (1.8%) in the Tyumen region without considering autonomous districts. Its part in urban districts gaseous emissions is from 0.2% (Yalutorovsk) to 3.1% (Tyumen) only.
Table 3. Ingredients characteristics of pollutants discharge into the atmosphere from stationary sources in the Tyumen region without considering autonomous districts and urban districts over the period of 2013-2017.

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 2017              | 2017  | 2017               | 2017     | 2017               | 2017           | 2017               | 2017 | 2017     | 2017 |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |

The Tyumen region without autonomous regions

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 120083            | 100.0 | 3842               | 2017     | 2017               | 2017           | 2017               | 2017 | 2017     | 2017 |
|                        |                   |       | 7221               | 5.6      | 36                 | 2250           | 1.8                | 35522 | 29.1     | 24293|
|                        | 121862            | 94.4  | 3851               | 38.1     | 250                | 2250           | 1.8                | 35522 | 29.1     | 24293|
|                        |                   |       |                    |          | t                  | %**            | t                  | %** | t        | %** |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |

Including Tyumen

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 1387              | 1.0   | 285                | 1.1      | 5                  | 1160           | 84.9               | 250   | 30       | 2.6  |
|                        |                   |       |                    |          | t                  | %**            | t                  | %** | t        | %** |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |

Zavodoukovsk

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 673               | 0.5   | -228               | 10.7     | 15.9               | -62            | 566                | 84.1  | -165     | 7    |
|                        |                   |       |                    |          | t                  | %**            | t                  | %** | t        | %** |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |

Iskum

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 13723             | 10.6  | 1650               | 2.7      | 2.7               | 184            | 13356             | 97.3  | 1406     | 202  |
|                        |                   |       |                    |          | t                  | %**            | t                  | %** | t        | %** |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |

Tobolak

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 596               | 0.5   | -137               | 55       | 9.2               | -1             | 541               | 90.8  | -136     | 0.9  |
|                        |                   |       |                    |          | t                  | %**            | t                  | %** | t        | %** |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |

Yalutorovsky

| Region, urban district | Discharged - total | solid | gaseous and liquid | of them | Trapped and neutralized pollutants |
|------------------------|-------------------|-------|--------------------|---------|-----------------------------------|
|                        |                   |       |                    | sulfur dioxide | carbon monoxide | nitrogen oxide | hydrocarbons (without VOCs) | volatile organic compounds | total | utilized |
|                        | 6556             | 5.2   | 465                | 5.0      | 83                | 6319           | 95.0              | 407   | 148      | 2.3  |
|                        |                   |       |                    |          | t                  | %**            | t                  | %** | t        | %** |
|                        | t                 | %**   | t                  | %**     | t                  | %**            | t                  | %** | t        | %** |
|                        | ± t               | ± t   | ± t                | ± t     | ± t                | ± t            | ± t                | ± t | ± t      | ± t |
The amount of trapped and neutralized pollutants discharges increased over the analyzed period by 11.6094 tons in 2017 compared to 2013 in the Tyumen region without considering autonomous districts, and by 17.132 tons in urban districts. The most part of captured and neutralized emissions is utilized - 97.3% in the Tyumen region without considering autonomous districts and 96.7% in urban districts.

The value of the atmospheric pollution index (API) for Tyumen and Tobolsk, the two largest cities of the Tyumen region without considering autonomous districts, is presented for the period from 2013 to 2017 (table 4).

Table 4. Atmospheric pollution index and characteristics.

| Year | Tyumen | Tobolsk |
|------|--------|---------|
|      | Atmospheric pollution index(API) | Atmospheric pollution characteristics | Atmospheric pollution index(API) | Atmospheric pollution characteristics |
| 2013 | 7 | slightly polluted | 2 | clean |
| 2014 | 8 | polluted | 2 | clean |
| 2015 | 6 | slightly polluted | 3 | slightly polluted |
| 2016 | 4 | slightly polluted | 3 | slightly polluted |
| 2017 | 4 | slightly polluted | 3 | slightly polluted |

The data reveal that Tyumen atmosphere was mostly characterized as slightly polluted in the analyzed period. At the same time, the pollution index decreased (from API = 7.2013 to API = 4.2017). In Tobolsk a slight reduction in the air pollution indicator was observed over the given period of time. In particular, in 2013-2014, the atmosphere was characterized as clean (API = 2), and in 2015-2017 it was slightly polluted (API = 3).

3. Conclusion
The average number of stationary emission sources in the Tyumen region without considering autonomous districts amounted to 21.327 units (16.6% of total emission sources in the region) in 2013-2017, and among urban districts the majority of them 7212 located in Tyumen. The number of stationary emission sources there increased in 2017 compared to 2013. Ishim, Tobolsk and Yalutorovsk are an exception.

The largest amount of pollutants discharges from stationary sources in 2013–2017 was recorded in the Tyumen region without considering autonomous districts. The rate rose up to 129083 tons (5.5% of total emissions in the region). Tyumen was recorded among the urban districts with the largest amount of emissions, namely 16890 tons, i.e. 13.1% of emissions in the Tyumen region without considering autonomous districts. The amount of emissions increased in 2017 compared to 2013. Ishim and Yalutorovsk are an exception.

Gaseous and liquid discharges prevailed in urban districts. Their range was from 84.1% (Ishim) to 97.3% (Tobolsk). Carbon monoxide and nitrous oxide were predominant elements in gaseous emissions.

In 2017 compared to 2013 the amount of trapped and neutralized emissions increased by 1.16094 tons in the Tyumen region without considering autonomous districts, and in urban districts - by 14.605 tons. Most of the captured and neutralized pollutants were utilized. According to the air pollution index in the analyzed period the atmosphere in Tyumen and Tobolsk was characterized as slightly polluted.

References
[1] Molchanova E V 2009 The impact of environmental and socio-economic factors on the health of the population of the region (the example of the Republic of Karelia) Ecology of urbanized territories 4 pp 31-6
[2] Bondarenko V L 2013 Criteria of environmental safety in natural-technical systems “natural environment - object of activity - population” *Ecology of urbanized territories* 1 pp. 39-45

[3] Lopatnikov D L 2006 Ecological Perspectives of the Post-Industrial World (Moscow: AVF) 312p

[4] Bityukova V R 2007 Environmental problems of Russian towns *The Bulletin of Moscow State University Ser. 5 Geogr.* 1 pp 13-21

[5] Kolomys E G 2000 *The state of forest ecosystems in a large city* Proc. of the Samara Scientific Center of the Russian Academy of Sciences (Samara vol 2) 2 pp 311-8.

[6] Bezuglaya E U 1980 *Meteorological Potential and Climatic Features of Urban Air Pollution* (Leningrad: Gidrometeoizdat) p 183

[7] Voronich S S 2012 Assessment of the impact of mobile sources of emissions on the atmosphere (the example of Moscow) *Ecology of urbanized territories* 3 pp 103-7

[8] Ivchenko T V 2014 Urban greening as compensation for air pollution by motor transport *Ecology of urbanized territories* 1 pp 30-3

[9] Vetoshkin A G 2008 *Processes and Devices for Environmental Protection* (Moscow: Higher school) 639 p

[10] Schonfeld B E 2012 On the issue of dust components in emissions into the air from the mining industry *Ecology of urbanized territories* 3 pp 88-92

[11] Krasnova T V 2013 Petrol stations as sources of air pollution in Orenburg *Ecology of urbanized territories* 2 pp 49-55

[12] Panov V P 2008 *Theoretical Foundations of Environmental Protection* (Moscow: Academy) 320p

[13] Bogdanov V N 2006 *Geoinformation Mapping of the Urban Environment orman* (Novosibirsk: Publishing House of the SB RAS) 80 p

[14] Grushko L M 1987 *Harmful Inorganic Compounds in Industrial Discharges into the Air* (Leningrad: Khimiya) 327 p

[15] Khaustov A P 2014 *Environmental Monitoring* (Moscow: Yurait) 637 p

[16] Petrova I F 2009 Mapping categories of pollution (the example of air pollution) *Ecology of urbanized territories* 5 pp. 21-5

[17] Ryaboshapko A G 2002 Ammonia discharges into the air from anthropogenic sources in the USSR: *Problems of environmental monitoring and ecosystem modeling* 18 pp 59-80

[18] Polonskiy V M 1979 Current researches of mercury vapor extraction from gases and ways of normalization of mercury concentration in gas emissions Coll. works of the republican scientific and technical conf.: Current state, prospects and trends in cleaning air and water basins of nonferrous metal enterprises in Uzbekistan (Tashkent) pp 75-7

[19] Polonskiy V M 1996 *Main trends in creating an information system for monitoring environmental condition* Scientific and technical conf.: Automated information systems in construction and maintenance of buildings, structures and life support objects (Samara) p 48

[20] Polonskiy V M 2006 Air Protection (Moscow: Publishing House of the Association of Construction Universities) 152 p

[21] Ganyukov S P 2012 Justification of a new approach to assessing the risk to public health due to the impact of technogenic discharges and heir transformation products *Ecology of urbanized territories* 4 pp. 62-9

[22] Goverment of the Tyumen region 2018 *Report on the Ecological Situation in the Tyumen Region in 2017* (Tyumen) 240 p

[23] Department of the Federal State Statistics Service of the Tyumen Region, Khanty-Mansiysk Autonomous Okrug – Ugra and the Yamalo-Nenets Autonomous Okrug 2018 *Environmental Protection in the Tyumen Region* (Tyumen) 152 p