Environmental activities of a petrochemical company as a sustainable factor of the city and region

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Abstract. The paramount objective of modern society is to preserve a livable environment for generations to come. In addition to the need to restore the impaired qualities of the environment, measures also must be taken to preclude environmental disasters from happening both now and in the future. The formation of a balanced regional system of cities is hampered by the deterioration of the environmental situation and a decrease in environmental quality indicators. The concentration of industrial sites and vehicles represents one of the biggest adverse anthropogenic factors which stems from the human impact on the environment. Growing industrial clusters and the rising number of vehicles in large cities result in a critical environmental situation. Environmental monitoring measures, once introduced, will facilitate the sustainable development of urban areas and the economy of the region.

Keywords: regional economy, sustainable development, system of cities, environment, ecological problems.

1 Introduction

The proportion of the urban population has been on a steady rise for quite a while, a process which is seen across all Russian regions. Uneven socio-economic territorial development in recent decades has resulted in territories, in particular, systems of cities, facing the problem of sustainable development [1-7]. The sustainable development concept can be traced back to the report on the World Conservation Strategy of the International Union for the Conservation of Nature which came out in 1980 but it was only following the publication of the Brundtland Report "Our Common Future" in 1987, prepared by the World Commission on Environment and Development (WCED), that the term gained widespread recognition [8-14]. The definition given the Brundtland Commission in 1987 reads that "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[1]. The transition to sustainable development calls for major transformations at the core of which lies the greening of almost all of the essential activities of mankind [2]. The economic component of the sustainable development concept focuses on reversing the exponential economic growth which entails increased pollution and environmental degradation, depletion of natural resources, disruption of the natural balance of the biosphere as well as climate change with the aim of achieving a qualitative growth that would leave room for "global dynamic equilibrium" [3].

Currently, cities are seen as the prevailing form of territorial and socio-economic organization of society. While the total urban area accounts for just one percent of the world's land, still, the majority
of the world's population live in cities. Cities also concentrate and use an immense amount of matter and energy which produces a major transformative effect on the environment. The impact of urbanization as it sweeps through cities extends to all natural components; the chief by-product of associated technogenic processes being air, soil, surface and underground water pollution, which generates a substantial environmental footprint [4, 15-17].

A lot of works by scientists of KSUAE and their colleagues (Romanova A.I., Burkeev D.O., Berval A.V., Ilina E.V., Safina R.S., Egorov D.A., Mingaleev G.F., Shinkevich M.V, Misbakhova Ch.A., Bystrov A.V., Romanova A.I. and Bulkin V.A. [18-20]) are devoted to the development of cities, including the environmental issues of urban economy.

2 Materials and methods

This study applies a retrospective method that uses data for a certain period of time, which allowed us to draw conclusions about the development of the city system of the Republic of Tatarstan and the dynamics of environmental pollution. The study also used General scientific methods-analysis, synthesis, description, generalization, as well as elements of statistical methods.

A growing city comes to unite more and more habitats. However, the average population density across this urbanized territory proves to be much lower than in individual areas usually located in the center of megacities. This can be attributed to the so-called uneven distribution of population across the area of agglomerations. The huge space of a city agglomeration offers a multi-level hierarchy of residential and industrial zones mixed with prosperous and stagnant neighborhoods, satellite cities and settlements of significantly varying economic development and welfare. The peripheral environment drawn into the range of influence of a metropolis is in no way conducive to administrative unification. Another outcome is the conglomeration of external settlements springing up around the city which typically feature cottages. Such buildings are usually located not too far from the central business part of the city, and usually close to a highway or a railway.

The Zipf's law on rank and size is employed for forecasting the development of a system of cities in a separate economic region or in a country [5]. Let us consider a system of cities. First, we will identify the most significant ones which is done through a preliminary distribution of cities by their importance within the system. The population size indicator can be used as a quantitative characteristic of the importance of the city and its status within the system. This choice is premised on the assumption that the economic importance of a city is largely defined by the total annual income of its residents or their total wealth. The values of these indicators are roughly proportional to the population size within a country homogeneous in its economic development. This explains the fact that many urban researchers have studied patterns of distribution of cities based on their population size. This pattern was discovered by Auerbach in 1913 which was followed by more significant generalizations by Georg Zipf in 1949. For this reason, this pattern has come to be known as the Zipf's law or the “rank – size” or “rang – dimension” pattern [5].

3 Results and discussion

Now let us look at the original wording of the “rank - size” pattern. The essence of the theory is premised on the following: if all the cities of a country are put in a list in descending order population-wise, each city can be assigned a rank, i.e. a number which would define it on the list. Further research into this pattern has made it possible to suggest existence of stability over time for this type of distribution of urban population in a country or a separate, economically independent region in cities of a different rank. This hypothesis is also valid for instances of the general population increase in each of the system of cities under examination. This has resulted in the hypothesis that the heterogeneity in the distribution of population by cities corresponds to the manifestation of market economy economic laws and is a mathematical description of the general pattern of functional division between cities [6]. However, this fact is not viewed as a refutation of the “rank – size” law as this law can only be applied in the context of the system of cities being relatively stable within the economic space under study. It is probably safe to assume proceeding from that premise that the end of the transitional period associated with the
establishment of independent economic systems in the former USSR republics will be marked by the re-established rank-size pattern in relation to the set of cities of each of the new economically independent Russian regions. This law can be checked against, from the perspective of independent economic system, the system of cities in the Republic of Tatarstan. For this purpose, we put the largest cities in the Republic of Tatarstan in the order corresponding to their population [7, 8].

Table 1. The “rank-size” dependence for cities in the Republic of Tatarstan.

| №, rank | City       | Population, thousand people* |
|---------|------------|-----------------------------|
| 1       | Kazan      | 1252                        |
| 2       | Nab.Chelny | 534                         |
| 3       | Nizhnekamsk| 239                         |
| 4       | Almetyevsk | 157,3                       |
| 5       | Zelenodolsk| 99,7                        |
| 6       | Bugulma    | 83,5                        |
| 7       | Elabuga    | 73,9                        |
| 8       | Leninogorsk| 61,9                        |
| 9       | Chistopol  | 59,8                        |
| 10      | Zainsk     | 40                          |
| 11      | Aznakaevo  | 34,6                        |
| 12      | Nurlat     | 32,3                        |

* Tatarstan population [8].

R is defined as the rank of a city in the system of cities in the Republic of Tatarstan while r represents the city population P (in thousands). After the calculation of the mathematical dependence \( \ln P = f(\ln r) \) we build a diagram (figure 1). As is evidenced by the analysis of the diagram obtained for the system of cities in the Republic of Tatarstan, the rank size law applies quite accurately. We use the least square method to establish the equation of the straight line \( \ln P = f(\ln r) \), an approximation of the calculated data [9]. In this case, the approximating line equation is \( y = -1.4839 x + 7.1551 \), where \( x=\ln r, y=\ln P \) (figure 1).

Figure 1. The “rank-size” dependence calculated for cities in the Republic of Tatarstan.

Considering the system of cities in Tatarstan, you can see the formation of large industrial clusters – machine-building, petrochemical, IT, educational, and agricultural [10, 11]. Urbanization, enterprises of the heat and power complex, oil industry, chemical and machine-building production, construction industry, agriculture, increase in the number of vehicles cause a high level of air pollution in Tatarstan and deterioration of the environment of Tatarstan as a whole. This problem is most pronounced in large cities such as Kazan, Naberezhnye Chelny, Nizhnekamsk, Almetyevsk, Bugulma and Zainsk.
Today, the level of air pollution in the capital of the Republic is described as a "high", and in Naberezhnye Chelny and Nizhnekamsk - as a "very high"[12]. The main share of environmental pollution in Tatarstan is accounted for by such enterprises as PJSC Tatneft, PJSC Kazanorgsintez, PJSC Nizhnekamskneftekhim, PJSC TAIFNK, PJSC Nizhnekamskshina, and others. The high level of air pollution is also a consequence of vehicle pollution. On January 1, 2011, more than 906 thousand vehicles were registered in the Republic of Tatarstan. In total, the volume of pollutants from the entire transport army amounted to 288.4 thousand tons, or 52.3% of the total emissions into the atmosphere. In 2019, the total gross emissions of pollutants from enterprises of the republic and vehicles amounted to 693 thousand tons against 690.9 thousand tons in 2018 [12]. The largest events were implemented at the enterprises of PJSC KAMAZ, PJSC Tatneft, PJSC Kazanorgsintez, PJSC Nizhnekamskneftekhim, OJSC Generation Company, and OJSC TGK-16. Over the past five years, there has been a downward trend in the number of vehicles with high levels of pollutants in the exhaust gas. The decrease is due to both an improvement in the quality of motor fuel itself and the replacement of the old fleet of cars with a high level of emissions with new, more "environmentally friendly" cars that meet the requirements of the 4th environmental class and higher.

Poor ecology is also associated with an increase in the incidence of population diseases, especially cancer. Currently, the number of cancer cases in the Republic of Tatarstan is 412,4 per 100 thousand people. According to this indicator, Tatarstan is on the 26-27 place in terms of cancer incidence. This figure is higher than in Europe. But the average life expectancy in Russia and Tatarstan is 71,6 and 72,8 years, respectively, while 83 years in Europe [13,14]. The lower incidence of diseases is partly due to the lower life expectancy of the population in the region. Poor ecology is also associated with an increase in the incidence of population diseases, especially cancer.

Consider the environmental activities of the largest petrochemical company in Tatarstan, JSC Tatneft, which has branches in more than 30 cities and towns in the region. Tatneft Company is one of the largest Russian oil companies today and is an internationally recognized vertically integrated holding. The industrial complex of the Company includes steadily developing enterprises of crude oil and gas production, petroleum refining, petrochemicals production, the tire-manufacturing complex, network of filling stations and services. Tatneft also has a stake in the financial sector companies (banking and insurance). Tatneft is one of the largest Russian public companies with a market capitalization of more than 28 billion us dollars at the end of 2019 [15].

An essential resource asset of PJSC Tatneft and a promising target to increase production are significant reserves of high viscosity oil (HVO). The HVO fields’ development project is being implemented with the support of government agencies, scientific research organizations of Russia and the Republic of Tatarstan.

A strategic program of developing the network of the Company’s filling stations and refueling complexes is being successfully carried out. Currently there are more than 690 filling stations operating as part of the PJSC TATNEFT Group of Companies.

As part of the strategy of the Tatneft Group until 2030, it is planned to increase oil production to 38.4 million tons with 100% replenishment of reserves, expand production of high-quality oil products, continue business diversification, and ensure the growth of investment efficiency.

One of the Company’s major projects is the construction of the "TANECO" Refining and Petrochemical Plants Complex in Nizhnekamsk (NPiNHZ Complex). The project implementation was started in 2005 with the aim of developing a new stage of the refining industry in Tatarstan. The construction was initiated by the Government of the Republic and TATNEFT. The first phase of the NPiNHZ Complex was put into commercial operation in 2011, the combined hydrocracking installation was put into commercial operation in 2014. July 2016 witnessed the comprehensive testing stage beginning of the delayed coking installation [15].

The NPiNHZ Complex is now a full-fledged member of the Russian oil refining industry and produces highly competitive, environmentally friendly products, including Euro-5 diesel fuel, jet fuel of RT, TS-1 and Jet A-1 grades, as well as Group II and Group III high index base oils. Completion of the Project will provide for production of a wide range of high added value oil products.
The petrochemical complex of PJSC TATNEFT is successfully developing providing for production and sale of tire products and carbon black. The tire manufacturing complex of TATNEFT comprises the high-tech enterprises of PJSC "Nizhnekamskshina", OOO "Nizhnekamsk Factory of Truck Tires" and OOO "Nizhnekamsk SSC Tire Factory", which produce about 300 tire commodity items such as car, agricultural machine, truck, light truck and solid-steel cord tires. The high quality of KAMA, KAMA EURO and Viatti tires, as well as innovative SSC tires has been confirmed by consumer reviews and victories at various prestigious contests.

Tatneft's structure incorporates leading enterprises which operate in the petrochemical complex of the Republic of Tatarstan. Tatneft Group pursues the 2030-Strategy which it designed to enhance its shareholder value by continuing to drive up competitiveness, keeping up its leading position in the industry and ensuring sustained growth. The Strategy seeks to ramp up oil production to reach 38.4 million tons coupled with 100% reserve replacement, achieve increased production of high-quality oil products, continue business diversification and secure growing investment efficiency. Now, Tatneft is above all an environmentally responsible company whose operations aim to:

- boost the industrial and environmental safety of hazardous production facilities through ensuring consistent and fault-free operation of process equipment as well as putting in place effective equipment technical diagnostics methods;
- identify, assess and reduce industrial hazards and risks;
- achieve more efficient monitoring of compliance with industrial and environmental safety requirements across its production facilities;
- achieve more efficient monitoring of compliance with industrial and environmental safety requirements across its production facilities;
- ensure rational use of natural resources and minimum oil and gas losses.

Generally, Tatneft carries out its environmental activities under environmental protection programs. In 2016, the company developed and adopted the fourth 2020 - Environmental Program; the idea behind it being to maintain the state of the environment in the region where Tatneft operates within permissible emission levels which would allow natural ecosystems to self-restore. Continuous monitoring activities to keep track of the effectiveness of Tatneft's environmental protection efforts help the senior management determine areas for improvement in environmental protection as well as discover potential for further reduction of the environmental footprint. In 2017, Tatneft took the first steps to roll out a system designed to account for and take inventory of greenhouse gases in compliance with newly-adopted Russian legislative requirements and international standards in the area of climate change.

A high level of APG effective utilization helps the company curb emissions by more than three million tons (in CO₂ equivalent) per annum. Tatneft has implemented targeted programmed actions which serve to ensure rational use of associated petroleum gas (APG), uphold compliance with the current standards which establish the permissible limits of pollutant emissions, and to further cut down pollutant emissions and greenhouse gas emissions. As of now, the APG utilization rate stands at 96.27%, one of the best performance indicators of the kind across the industry. The consistent implementation of environmental protection measures and technologies initiated by Tatneft has substantially eased the man-caused impact on the environment while also reducing the consumption of primary resources. The air protection activities which the company has been pursuing over the past 20 has led to the total volume of emissions of atmospheric pollutants emanating from stationary sources decreasing by 1.2 times.

The introduction of hydrocarbon vapor recovery units has helped curtail the atmospheric emissions of hydrocarbons by 3.5 times as compared to 1991. The current number of operational hydrocarbon vapor recovery units in place across Tatneft facilities is 44. All atmospheric emissions of harmful substances which come from stationary sources are well within the prescribed limits of standards relating to maximum permissible emissions. Indicators of environmental impact at the PJSC "Tatneft" are presented in the figures 2-6.
Figure 2. The gross emission of pollutants into the air by the Tatneft Company (according to [15]).

Figure 3. Specific emissions of pollutants into the atmosphere per 1 ton of oil produced (according to [15]).

Figure 4. The level of utilization of associated petroleum gas (according to [15]).

Figure 5. Percentage of neutralized industrial waste (calculated by the authors according to [15]).
Laboratory studies indicate that the quality of water in the largest rivers located within Tatneft's area of operations remains stable. The introduced major environmental activities are able to keep the content of chlorides along with dissolved and emulsified oil and oil products in rivers and in the vast majority of springs within the limits of established standards relating to maximum permissible concentrations of harmful substances in the water bodies of commercial fishing importance and within the sanitary and health and hygiene standards relating to maximum permissible concentration. It is currently observed that their groundwater concentration has been dwindling down steadily. Tatneft consistently works to cut down and dispose of waste generated during oil production processes by relying on waste processing, recycling and neutralization techniques. Beyond that, Tatneft has established a nature reserve comprised of 35 sites ranging from national natural parks and natural sites to wildlife sanctuaries all of which it finances. These sites span across the areas where the company carries out its operations.

4 Conclusions
The concept of sustainable development was a logical transition from the greening of scientific knowledge and socio-economic development. The most important criterion for sustainable development in the world is to achieve a strategic balance between human activity and maintaining the reproductive capabilities of the biosphere, so that human activity will not lead to irreversible violations in nature.

A number of outstanding Russian scientists and thinkers (D.I. Mendeleev, V.I. Vernadsky) already in the late XIX century and in the first quarter of the XX century predicted the inevitability of humanity's transition to a fundamentally new paradigm of development determined by knowledge, reason and morality [1].

In our view, sustainable development is continuously supported development that meets the needs of the present and does not compromise the ability of future generations to meet their own needs. Currently, elements of this concept have been introduced in developed countries, but are still little used in strategic planning of territorial development in Russia. Cities are the main form of territorial and socio-economic organization of society and therefore the study of sustainable development of urbanized territories is very relevant. At present, they are home to almost three-quarters of the human population, although the area of cities occupies only one percent of the land. A huge amount of matter and energy is concentrated and used here, which significantly transforms the natural environment [4]. High rates of population urbanization in the world and in Russia contribute to the growth of socio-economic and environmental problems of society. The problem of sustainable development of the urban environment is currently particularly acute and special attention is paid to its study. Some authors consider the environmental problems of large cities (V. A. Khomich etc.). The ways of sustainable development of Russian cities are shown, as well as the main directions for regulating the quality of the environment [16].

The growth of cities is accompanied by pollution of the air basin, water sources and soil, the reduction of agricultural land in adjacent territories. Today, the urban environment is largely
aggressive towards people. Environmental and economic monitoring at the macro level is ideal in terms of taking into account the environmental factor in the development of the region. Indeed, the factor of greening is the key to sustainable socio-economic development of territories. The current situation is when environmental degradation occurs during formal economic growth, and environmental correction can lead to a significant reduction in traditional economic indicators, up to negative values of their growth. In the field of environmental and economic indicators of sustainability, it is advisable to provide an economic cover for environmental problems or to combine environmental and economic aspects [17]. Then solving environmental problems should bring economic results to society. Therefore, an analysis of the implementation of the Ecology program by the largest petrochemical company in the region and Russia by PJSC Tatneft shows that the creation of stations for monitoring harmful atmospheric emissions, the development of nature reserves, parks throughout the region, and the deep cleaning of industrial effluents increase the quality of the human environment. Reducing the technogenic load in the territories located in the zone of influence of the Company's enterprises allows reducing the outflows of the population to other regions. This factor determines the stable sustainable growth of the city system in the region.

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