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ECOGEOGRAPHICAL PROBLEMS OF AIR POLLUTION IN THE BIG CITIES OF AZERBAIJAN

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ЭКОГЕОГРАФИЧЕСКИЕ ПРОБЛЕМЫ ЗАГРЯЗНЕНИЯ АТМОСФЕРЫ КРУПНЫХ ГОРОДОВ АЗЕРБАЙДЖАНА

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Abstract. In connection with the development of urbanization, the protection of cities and the environment, issues of restoring the ecological balance become an urgent issue. The scale and intensity of product development in Azerbaijan enhance the anthropogenic impact on the nature of the regions. Such an effect is manifested in the pollution of soils with industrial, household waste, chemical fertilizers, the burning of hydrocarbons, the emission of harmful substances in the water and vehicles into the environment. Like in the whole world and in Azerbaijan, such negative processes are no exception. In this regard, the environmental problems of cities and urban agglomerations around the world are in the focus of attention of specialists and scientists. The presented article considers environmental and geographic problems that arose as a result of air emissions in 8 cities of Azerbaijan. The historical properties of studying atmospheric pollution in cities are analyzed, ecogeographic methods for studying atmospheric pollution of cities are identified, environmental pollutants of large cities and the ecogeographic properties of their influence are considered. The ecological properties of the geographical condition, meteorological climatic conditions in air pollution, aerospace research in the study of atmospheric pollution in large cities and the effect of pollution on the health of the population of large cities are studied. The transport system of cities, their geography, and the effect of emissions of harmful, poisonous substances into the atmosphere by vehicles on public health were also noted. Based on the methods for predicting atmospheric air pollution in large cities and the non-linear regression technique, a mathematical model of ecogeographic forecasting of air pollution is applied. Comprehensive indicators and the level of air pollution in unfavorable conditions for urban agglomerations are determined.

Аннотация. В связи с развитием урбанизации, охрана городов и окружающей среды, актуальными становятся вопросы восстановления экологического равновесия. Масштабность и интенсивность развития производства в Азербайджане усиливает антропогенное воздействие на природу регионов. Такое воздействие проявляется в загрязнении почв промышленными, бытовыми отходами, химическими удобрениями, сжиганием углеводородов, выбросами в акватории вредных веществ и транспортными средствами в окружающую среду. Как и во всем мире, в Азербайджане такие негативные процессы не исключение. В связи с этим экологические проблемы городов и городских агломераций во всем мире находятся в центре внимания специалистов и ученых. В представленной статье рассмотрены экогеографические проблемы, возникшие в результате выбросов в атмосферу в 8 городах Азербайджана. Проанализированы исторические аспекты загрязнения атмосферы в городах, определены экогеографические методы исследования атмосферного загрязнения городов, рассмотрены факторы загрязнения атмосферного воздуха крупных городов, экогеографические свойства их влияния. Изучены экологические свойства географического условий, метеорологические климатические условия в загрязнении атмосферы, аэрокосмические исследования в изучении загрязнения атмосферы крупных городов и влияние загрязнения на здоровье населения крупных городов. Отмечены также воздействие транспортной системы городов, их география, влияние выбросов в атмосферу транспортными средствами вредных, ядовитых веществ на здоровье населения. На основе методов прогнозирования загрязнения атмосферного воздуха в крупных городах и методике нелинейной регрессии, применена математическая модель экогеографического прогнозирования загрязнения атмосферы. Определены комплексные показатели и уровень загрязнения атмосферы в неблагоприятных условиях по городским агломерациям.

Keywords: meteorological and climatic conditions, aerospace, ecological and geographical, favorable weather conditions, synoptic processes, mathematical model.

Ключевые слова: метеоролого-климатические условия, аэрокосмические, эколого-географические, благоприятные метеоусловия, синоптические процессы, математическая модель.

Several big-scale air pollution disasters were recorded in the world in the XX century. For example, the valley of Moz (Belgium) in 1930, almost became poison trap as a result of air pollutants emitted to the atmosphere by the coke ovens, steel and zinc smelting plants, glass factories and sulfuric acid plants located in the valley. The result was devastating, causing 63 deaths and 600 positioned by the industrial sulfuric oxide [1].

The first disaster caused by air pollution in the United States occurred Donora, Pennsylvania in 1948. The pollutants emitted from several industrial enterprises such as sulfuric acid plant, steel and zinc production plants settled on the land surface as a result of temperature inversion and created the fog and air mixture causing breathing difficulty. As a result, 6000 people complained about dizziness and sore throat and during the 3 days, 20 people died [2].

Among the many scientists who studied air pollution and its impact on living beings D. Anjelkovich, C. Tolby, M. Saymons (1976), I. Barnes, V. Bastian, K. Beker, Z. Tong (1990), C. Bond, A. Dahl, R. Henderson, L. Bönbaum (1987), L. Vichers, C. Nolan, D. Uinsett, D. Ledbeta, A. Kodavanti, U. Skladveyler, M. Kosta, D. Uatkinson (2004) should be mentioned.

Preparation of methods for the study of air pollution in USSR started in the 1960 s. In this regard the scientific works of M. E. Berlyand, T. G. Berlyand (1968), E. Y. Bezuglaya, L. R. Sonkina (1971), M. T. Dmitriyeva, G. P. Sidorenko (1976) and many others can be specifically mentioned. Regarding the study of the air pollution and implementation of the prepared methodology in Azerbaijan SSR the scientific works of A. A. Gorchiyev (1969), R. M. Rafiyev (1970), R. B. Abdullayev (1993), B. H. Mammadov, B. A. Mammadov (1987), Sh. I. Mammadova (1993–1998), M. A. Jabbarov (1973) and others' can be mentioned. The scientific works of A. M. Shikhlinski (1968), A. A. Madatzada (1948, 1953, 1963), A. J. Ayyubov (1962, 1989), M. A. Jabbarov (1973), B. A. Mammadov (1985), B. H. Mammadov, I. A. Jafarova (1978, 1980), A. A. Gorchiyev (1978, 1979, 1982), B. M. Madatzada (1987), R. Sh. Hasanov (1992, 1994) and others' have been devoted to the study of the role of climatic and meteorological conditions in the dispersion of air pollutants in Azerbaijan. The Russian scientists such as M. E. Berlyand, T. K. Berlyand (1985), E. Y. Bezuglaya, L. R. Sonkina (1971), R. I. Onikul (1971), B. B. Goroshko,

L. S. Gandi, V. K. Petrenko, V. I. Arishkova (1973), S. I. Ponomarenko (1975) played an important role in the preparation of theoretical and methodological base for the study of the role of meteorological aspects in the dispersion of air pollutants.

First of all, the study of urban air pollution as a subject was reflected in the sources of ecological and geographical sciences. The studies conducted mainly covered the typological directions of the urban atmosphere [3].

Generally, the conceptual base of air pollution is the preparation of plans and programs for the improvement of air quality management.

As being a strong and constant aspect of atmosphere air pollution has an impact on human health and the environment. This problem is especially actual in big industrial cities. Clustering of multi-profile industries, over-developed transportation systems, the existence of industrial and household waste problem in big cities results in a huge impact on all components of the environment.

The geographical studies conducted in the Azerbaijan Republic play an important role in the development of geographical science not only within boundaries of the CIS but also outside of its limits. Furthermore, most of the geographers in Azerbaijan have the opportunity to study the geographical problems both at the regional and global scale.

During the Soviet period, the scientific research activities of geographers in Azerbaijan were mainly focused on two major directions. First and the most important direction was research activities and studies focused on the geographical problems within the boundaries of Azerbaijan SSR. The second direction in the geographical research was together with scientists of Institute of Geography of USSR Academy of Sciences to contribute to the studies of scientific problems which had all union importance.

Research studies in the field of geography and geographical ecology started in the 80s of the XX century and are still ongoing. (H. A. Aliyev, B. A. Budagov, Kh. Hasanov, Sh. Y. Goychayli, M. A. Salmanov, N. K. Mikhailov, T. A. Khalilov, R. B. Abdullayev and others).

The democratization of public and social spheres in Azerbaijan as a result of the transition to the new development path had a huge impact on the transformation of science and its rapid development.

Analyzing geography and ecology together might help us to clarify the following problems: firstly, the integration of geography with newly emerged political and economic sciences at the beginning of the XX century, formation of political geography; secondly, while studying natural and social processes identification of not only patterns of earth layer and social production but also direct and indirect impact of the space processes and solar system on the earth layer and social production; thirdly, right assessment of linkage and synthesis of geography with other sciences and clarify the misinterpretation of geographical ecology (geo-ecology) and etc. It should be noted that, some scientists is-assessed the idea of ‘unified geography’ which was the discussion topic 150–200 years ago and reappeared again in the 70s of XX century (D. N. Anuchin, Y. G. Saushkin, and others). They insist that the above-mentioned idea does not lead to the right results. However, it is not acceptable. We can already witness the results of attention paid by the scientists to the idea of ‘unified geography’ in the second half of the XX century even though it is late. At the end of XX century the re-activation of political geography, the emergence of geographical ecology and other sub-disciplines happened purely on the bases of the idea — ‘unified geography’. The emergence of ecological geography on the bases of both physical and human geographies indicates the development of geography not only as theoretical and methodological science but also its applied fields.

All the above studies we analyzed and implemented have contributed to the development of science in Azerbaijan. However, geomorphological, landscape, hydrometeorological, economical

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geography, landscape–ecology and other studies never researched the air pollution and its reasons in cities and environment. Unlike the studies mentioned above, we first time in Azerbaijan conducted research where the problems caused by the air pollution in the cities of Azerbaijan were studied in a complex way, the role of meteorological-climatic conditions in dispersion of air pollutants investigated and the sources of air pollution in the cities and its impact on human health have been studied and correlation between them have been identified. İn addition, by utilizing the aerospace methods the air pollution areas in the cities have been spotted and prognosis/prediction schematics have been prepared for the big cities of Azerbaijan. Diverse natural conditions and rich natural resources create opportunities for the development of Azerbaijan Republic. The modern territorial production complexes of the Republic developed based on the local natural resources and conditions and as a result, the main sectors of urban production have emerged. The creation of sustainable social and economic base of cities depends on the efficient assessment of the ecological and geographical situation of the country and its regions.

Each of above-mentioned source has its own share in air pollution. Pollutants originating from stationary sources such as energy, machine-building, chemistry, agriculture, light industry and etc. are in the form of gas, dust and some as a liquid. Every air pollutant to some extent depending on the meteorological condition play an important role in the deterioration of the ecological situation.

The assessment of the role of the meteorological conditions in the air pollution of big cities of Azerbaijan

The natural climatic conditions have a big role in the air pollution of cities. As the main component of climatic conditions, the speed and direction of the wind, synoptic conditions, temperature, humidity ratio, fog, cloudiness and etc. have been considered. The main focus of this research was synoptic processes, temperature, humidity, the speed and direction of the wind and under the aerospace analysis, it was fog and cloudiness (Table 1).

Table 1.

FREQUENCY OF ATMOSPHERIC PROCESSES (%)

Types of Atmospheric processes	*Annual frequency in %*	*Repeat on seasons (%)*			
		winter	*spring*	*summer*	*autumn*
Global air circulation	36	20	27	28	25
Entrance of tropical air masses	27	37	28	14	21
Impact of continental air masses	21	24	24	28	24
Impact of southern cyclones	16	31	27	23	19

One of the actual problems of ecogeographical research is the study of the air pollution of multi-functional big cities and the protection of their atmosphere. Even though there were many studies dedicated to this problem still some aspects of this problem have not been studied enough. The studies indicate that in air pollution of cities meteorological conditions also play an important role besides the anthropogenic impacts [4]. Thus, while studying the air pollution of cities and spreading of polluted particles in the air it is important to consider not only, anthropogenic aspects but also meteorological parameters of the area and the seasonal change of synoptic processes during the year which also have crucial scientific and practical importance. Since the boundaries of modern cities cover very big areas, the change of existence and share of air pollutants in the atmosphere are impacted by the mesoscale and macroscale climatic processes.

The studies found that the movement of air pollutants in the atmosphere, once they are formed, depends on whether condition and height, the shape of chimneys of the air pollutant

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emitting sources. It is known that maximal reach distance of air pollutants from a stationary source in the windless condition is 20 to 40 times more depending on the height of air pollution source. Supposing that the industrial enterprise chimney height is 120 m then based on the above-mentioned assumption maximum density on the land surface has to be within the 2.4–4.8 km and this distance is enough to cover industrial and residential areas around the air pollution source.

Generally, there are 10 synoptic–climatic regions in Azerbaijan: Guba-Shamakhi, Absheron–Gobustan, Central–Steppe, Jeyranchol–Bozdag, Lankaran–Astara, Oguz–Ismayilli, Zagatala–Shaki, Ganja–Gazakh, Higher Karabagh, Nakhchivan. Let's review the regions were cities under the study located.

As a result of studies, it was found that the traffic is the main reason of higher anthropogenic air pollutants such as carbon monoxide and nitrogen during the warmer periods of the year in the cities of our Republic. The share of traffic emissions in the air pollution of industrial cities of Azerbaijan is 65–70% [5–10].

The analysis of observation data indicates that except Sumgait city there were differences in the quantities of traffic emissions into the air of big industrial cities in separate years. The quantities of such pollutants in Baku in 2000 was 229,9 thousand tons but, in 2007 it was 410,7 thousand tons, in Ganja city it was respectively 20,8 and 37,2 thousand tons and in Sumgait, the city it was 14,3 and 8,2 thousand tons [11].

The studies indicate [12–13] that unfavorable weather conditions such as light breeze, high temperature and humidity and foggy weather have more impact on the increased concentration of air pollutant particles in the atmosphere. As a result of the several occurrences of such unfavorable weather conditions in Sumgait city in last two years the air pollutants exceeded the allowable density thresholds such as dust 1.2–2.0 times, nitrogen 4-oxide 1.5–2.5 times, carbon dioxide 2.0–3.0 times and in Ganja city dust, nitrogen 4-oxid concentrations were higher than maximum threshold. However, in other cities of Azerbaijan, the concentration of air pollutants in the atmosphere were within the tolerances.

As a result of observations and analysis it was found that the level of air pollution in Baku city is average, in Sumgait and Ganja it is moderate and in other cities it is low. The air pollution almost was not observed in Nakhchivan city.

The role of aerospace research in the study of air pollution of cities

The results of large-scale studies of atmospheric processes utilizing satellite imagery are given below-mentioned studies [14–16]. Those studies cover the investigation of earth surface weather conditions based on the aerospace data.

It can be concluded from the above-mentioned assumptions that anthropogenic pollution of urban air is a pressing problem that many researchers have studied in modern times. At the same time, not all aspects of the problem have been fully studied yet. Many scientists refer either to the surface discrete surveillance data or aerospace data in their research, However, surface and aerospace surveillance data should be used to give a clearer picture of urban anthropogenic pollution [17]. Images from artificial satellites allow us to identify trends in the development of anthropogenic landscapes, identify ways to disperse atmospheric pollutants, identify areas of accumulation of pollutants and so on. However, to fully understand the state of atmospheric contamination, comprehensive use of appropriate surface and direct aerial (radiosonductivity) measurements with multi-field space shots is required. Only in this case can the maximum effect be monitored by air pollution. Such an approach is more appropriate in exploring urban anthropogenic pollution. These researches allow us to determine the general patterns of air pollution and the dynamics of pollution hoses in cities, as well as the relationship between pollutant concentrations and meteorological conditions.

The main problem of cities in the creation and maintenance of a favorable environment for people. Cleanliness is a necessary condition for a person's existence, but also an important factor in the well-being of his or her life, and a means to meet his spiritual and aesthetic needs. With the growth of industrial facilities and other stationary sources, conditions for anthropogenic pollution of the environment are created, which negatively affects human health.

The Absheron megapolis area is home to large industrial centers with numerous sources of pollution, as is known from the quantitative and qualitative methods of estimating harmful gas mixtures and water vapor in the atmosphere. An infrared spectrometer (ICOs-25) was mounted on the AN-30 to study atmospheric gas mixtures in the Absheron peninsula. The purpose of the measurements is to investigate the impact of large enterprises on the composition of atmospheric gas on the basis of an integrated amount of minor gas mixtures, to predict the environmental impact of the data obtained, and to determine the absorption strips in the measurement ranges. Measurements were made at a height of 500 m to 6000 m. At that time, it was divided into sheets that differed 50 Pa by atmospheric pressure. Measurements were made at the boundaries of all layers except the last layer. Based on earlier experiments, the average temperature in the sheet was calculated based on the amount of water vapor [17].

Analysis of aerobiotic conditions revealed that the smoke cloud over the Absheron peninsula is formed at < 2 m/sec wind speed, high relative humidity (>90%) and strong inversion. At this point, the smoke of the mentioned cities occurs. Thus, at nighttime, in the steady temperature stratification and high air humidity, no harmful impurities are scattered, and their accumulation occurs on the surface. At nightfall, when the surface inversion is more intense, high concentrations of harmful impurities are recorded in the air. In the morning, surface inversion collapses and height inversion forms due to the Sun's surface heating and wind speeds forming (Figure 1). The lower boundary of such inversion is gradually increasing, and in this connection, the volume of air is increased, which also includes harmful impurities from sources of pollution. At this time, a cloud of smoke is formed in the inversion layer at high air humidity [16–20].

It should be noted that industrial fumes usually have strip monograde in space images, while the texture is matte or fibrous. Fogs of industrial origin often form on cities. Such fumes tend to have a clearer tone and higher albedo value in space images. Such fumes are characteristic of the coastal strip of the city of Sumgait and are clearly visible in the photographs from the YSP [17, 20]. They have a clear tone in the photos and are formed by the inversion layer as well as by the high humidity (>90%). Presence of harmful substances in the atmosphere.

In addition, the appearance deteriorates due to the conversion of SO_2 into the aerosol. Thus, the rate of rotation is sometimes up to several percent per hour. This is due to the fact that sulfur dioxide is more readily soluble in fumes than in gases. This is due to the fact that there are some micronutrients that have catalyst properties, usually in fumes. Due to these micronutrients, oxidation is becoming more intense. If the fume contains metal sensors (manganese, iron, copper) or ammonia, the oxidation process is accelerated. At the same time, the weight of the harmful mixture increases, with 1 g of sulfuric acid produces 1.5 g of sulfuric acid [11, 15, 17, 21].

It is not always possible to identify smog pollution at the land based meteorological stations. However, it is possible to identify smog with the multicomponent satellite images. On the satellite image which has spectral range of 0.7–1.1 microns (Figure 2–3) it is possible to see that tone of image of area covered with the industrial smog is closer to the tone of water object image. Thus, it is difficult to distinguish the outlines of Baku and Sumgait cities. This is occurred not only due to the temperature inversion but also as an impact of 'heat islands'. Constant temperature stratification

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causes the creation of smog in the sub-inversion layer and formation of industrial smog pollution. The urban 'heat influence' increases the inversion. The upper boundary of created smog has higher temperature compared to the temperature on the land surface. Therefore, in infrared images the industrial smog is seen darker than fog in the space.

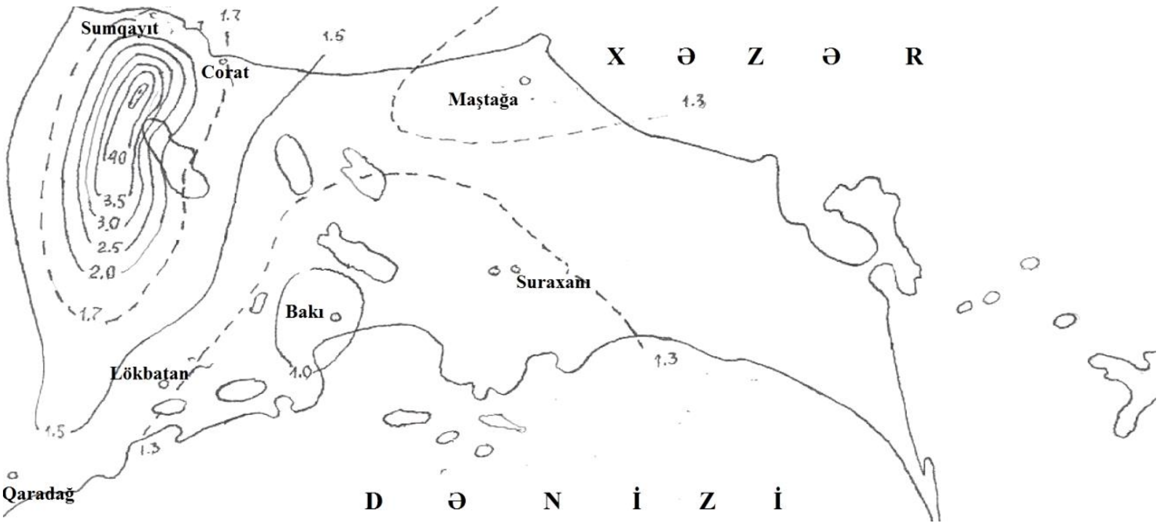
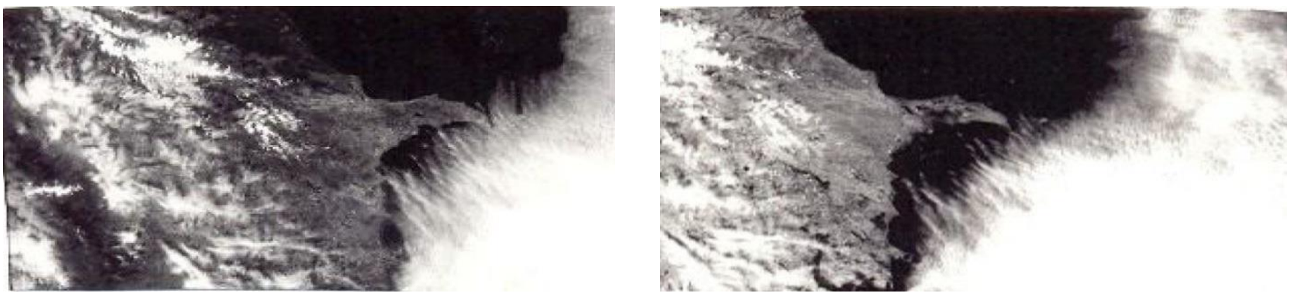


Figure 1. The distribution area of SO_2 at the highest/dangerous speed limit of northern wind.

Using the satellite information creates an opportunity to study the overall tendencies of air pollution levels of cities, distribution of air pollutants in the air and to identify the correlation between the density of air pollutants and meteorological conditions. The obtained study results have practical/applied importance. These results can be used for a wide range of purposes such as the organization of monitoring of the air pollution, urban planning and development, planning of the location of the industrial and residential areas, implementation of air protection activities and etc.

a) b)

Figure 2. A snapshot of satellite imagery of Absheron peninsula. Meteor a) 0.5–0.7 mkm, b) 0.7–1.1 mkm.



a) b)

Figure 3. A snapshot of satellite imagery of Absheron peninsula. Meteor 0.5–0.7 mkm, b) 0.7–1.1 mkm.

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The assessment of the impact of air pollution on the human health in the big cities of Azerbaijan

It is indicated in the studies that [15, 17, 21–23] there is a correlation between the level of air pollution and some diseases (such as damage to the upper respiratory tract, heart problems, bronchitis, asthma, pneumonia, pulmonary emphysema, eye diseases and etc.).

One of the most pressing ecogeographical problems is the air pollution of the urban environment and protection of the health of the urban population.

Year by year analysis indicate that the number of deaths among working-age population decreased 11030 persons in 1990 and 12084 persons in 2000. However, the rise in the mortality rates in this group again was observed in 2005 and 2006 (respectively, 13945; 14243 people) [24] (Figure 4).

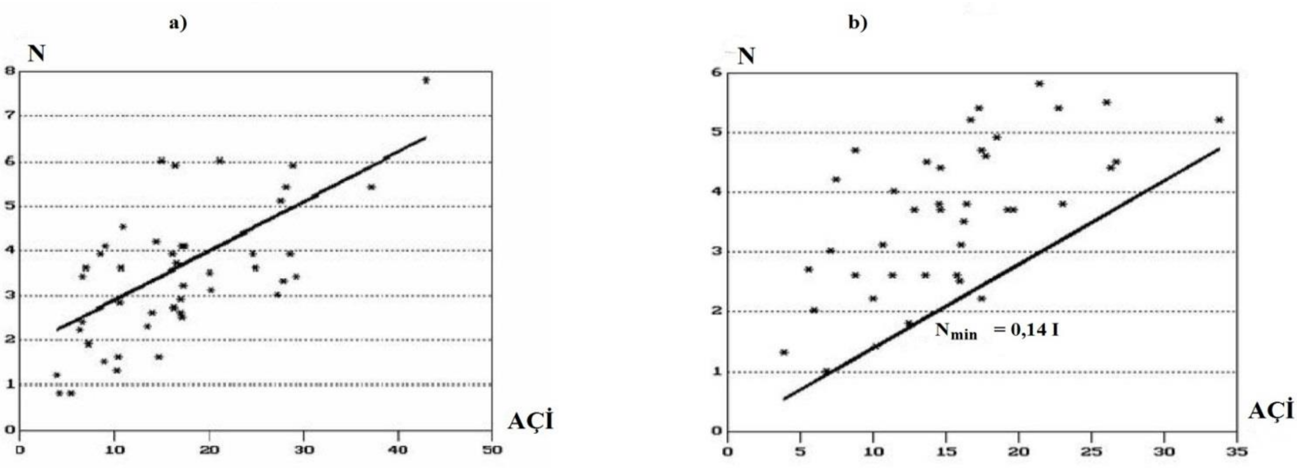

Figure 4. The dependence of the number of malignant tumor diseases on Air Pollution Index (per 1000 person) a) year 2006; b) between years 2002–2006.

Babies who are most susceptible to air pollution are almost an indicator of the quality of the environment and human health. The statistical indicators clearly confirm this fact. Infant mortality was 4193 in 1990 and 1508 in 2006. The infant mortality decreased in 2906 between 1990–2004. Unfortunately, this type of infant mortality numbers is again at the risk of increase.

The infant mortality indicators among the cities of Azerbaijan Republic was as following: Baku city — 769 in 1990, 511 in 2006, Sumgait city — 127 in 1990, 83 in 2006, Ganja city — 61 in 1990, 38 in 2006, Shaki city — 81 in 1990, 47 in 2006, Lankaran city — 70 in 1990, 22 in 2000, Shirvan — 35 in 1990, 7 in 2006, Mingachevir city — 44 in 1990, 9 in 2006, Nakhchivan city — 18 in 1990, 6 in 2006 [24–25].

Table 2.

THE RESULTS OF THE ANALYSIS OF CORRELATION BETWEEN AIR POLLUTION INDEX AND THE MALIGNANT TUMOR DISEASE FOR FIVE YEARS PERIOD

Year	a	σ_a	b	σ_b	R	r^2	n
2002	1.59	1.06	0.11	0.03	0.69	0.48	
2003	1.47	1.17	0.13	0.03	0.58	0.34	
2004	1.94	0.95	0.10	0.02	0.69	0.46	
2005	1.93	1.25	0.11	0.04	0.42	0.18	
2006	1.58	1.16	0.11	0.02	0.66	0.43	
For all periods	1.80	1.11	0.11	0.01	0.60	0.36	
Average for period	1.67	1.00	0.12	0.02	0.62	0.38	

In the Table 2 *a* — free limit of regression equation; *b* — API-coefficient; *r* — correlation factor; *n* — number of cities in the study.

It is obvious from the Table 2 that the correlation between air pollution index and malignant tumor diseases is high and sustainable. All statistical parameters (a, σ_a, b, σ_b, R) change very little from year to year. Between years 2002–2006 the correlation coefficient was 0.60 $\pm$0.07. The correlation between Air Pollution Index and malignant tumor diseases is illustrated in the Figure 4 below.

Location of the city in the mountainous or hilly area can cause rapid diffusion of air pollutants if the natural terrain cuts the wind speed the level of air pollution might increase. That is why in the cities which are located in the valleys the air pollutants get trapped and as a result the level of air pollution increases. Even though the wind speed can decrease the air pollution near the pollution source, it causes the air pollutants to diffuse into wider areas. The sun light causes the increase in the air pollution level by causing the start of formation of photochemical smog and decomposition of moist pollutants in the air or formation of new compounds. However, the rain cleans the air and decreases the air pollution.

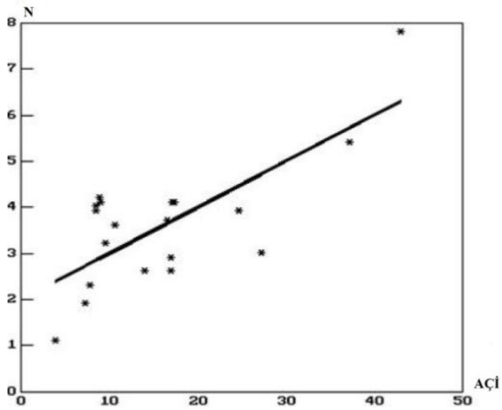

Figure 4. The dependence of the number of malignant tumor diseases on Air Pollution Index (per 1000 person) For the big cities of Azerbaijan (Baku, Ganja, Sumgait).

It was found that there was decrease in the concentration of different air pollutants (nitrogen, carbon dioxide) in the years 2000–2010. However, the ratio of some pollutants per person started to decrease in 2010 [26].

The transport system geography of Azerbaijan and assessment of its environmental impact

The transport system is the base of modern economic infrastructure of Azerbaijan Republic. Currently, there are more than 860 thousand motor vehicles in the Republic. The increasing usage of motor vehicles per year leads to the high concentrations of non-burning hydrocarbons, as well as lead, mercury compounds, sulfur, nitrogen, carbon monoxide, benzopyran and other hazardous substances. Hazardous emissions from the motor vehicles enter into the active zone of the biosphere and affect it. Lead, which is a part of the used gas emissions, is highly toxic which might affect the human body. The emissions entering into the lower layers of the atmosphere are poorly distributed when no windy weather is observed. In that case since warm air mass strongly rises in the central streets of the city, the toxic emissions are unable to spread largely. Mostly the emissions are accumulated between skyscrapers, in the lower relief areas. The pollution of air in the cities by the transport emissions also impact health of urban population.

The main emissions from the motor vehicles include toxic gases such as sulfur compounds, nitrogen oxide, carbon dioxide and carbon monoxide and mechanical gas mixtures (Table 3).

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CO_2 (carbon dioxide) of course is the number one pollutant and most of it emitted by the motor vehicles. The industry emissions of carbon dioxide are 5 times less compared to the emissions of motor vehicles [2].

Since the CO has a toxic effect it is more dangerous to human life and it is lighter than oxygen by interacting with the hemoglobin in the blood creates stable carbohydrobulin. As a result, human body has an oxygen deficiency. CO also causes disorders of the cardiovascular system. Carbon dioxide (CO) has lethal threat to the people who has cardiovascular diseases [27].

Table 3.

COMPOSITION OF EXHAUST GASES EMITTED FROM AUTOMOBILES MG/M^3

Compounds	*The quantity of pollutants emitted to the air under different conditions*		
	When engine is idle	Low speed	High speed
NO_x	0–50 mln^{-1}	1000 mln^{-1}	4000 mln^{-1}
CO	3–10 size, %	3–8 size, %	1–5 size, %
HC	300–8000 mln^{-1}	200–500 mln^{-1}	100–300 mln^{-1}
CO_2	6.5–8.0 size, %	7–11 size, %	12–13 size, %

Nitrogen oxides are involved in photochemical processes. There is a close connection between the level of photochemical pollution in the air and driving mode. Huge amounts of nitrogen oxide and hydrocarbon gases emitted to the air during the mornings and evenings when the traffic intensity is especially high. These gases emitted to the air react with each other and cause photochemical contamination of air. People with chronic cardiovascular and respiratory diseases are highly sensitive to nitrogen oxides [28].

The level of overloading of streets and main roads of the city leads to the fact that, at a specified speed, the vehicles operating time may be less than 30% of the total time-limit of traffic in the city, the length of the acceleration and braking (slowdown) areas is about 70–80% of the total distance traveled by the vehicle. Engine idle run time is 15–45%; slowdown — 13–32%; acceleration 18–37%; the set speed is 12–54%.

Study of impact of the transport emissions on the human health

50% of diseases caused by environmental factors cause more serious complications in the elderly. In the atmospheric air, there are mainly organic and inorganic pollutants of anthropogenic origin. The main reason for their diffusion in the atmosphere is industrial enterprises, road transport, and most pollutants play a major role in human morbidity, including sulfur dioxide, nitrogen oxides, carbon dioxide and carbohydrates. Sulfur, phenol, styrene, hydrogen-chloride, hydrogen-fluoride, formaldehyde, ethylbenzene, chlorine, benzopyrene, metals, and others also play a role in air pollution. Respiratory, digestive, nervous, endocrine, cardiovascular, blood and gastrointestinal diseases, diabetes, allergies, malignant tumors, anomalies, complications of pregnancy and so on.

Babies who are most susceptible to air pollution are almost an indicator of the quality of the environment and human health. The statistical indicators clearly confirm this fact. Infant mortality was 4193 in 1990 and 1508 in 2006. The infant mortality decreased in 2906 between 1990–2004. Unfortunately, this type of infant mortality numbers is again at the risk of increase.

Too many vehicles in the big cities increases the degree of air pollution in those cities. The share of pollutants originating from transport emissions constitute the 40–50% of overall air pollution.

The actual studies of the traffic flow on the highways and crossroads are recommended to carry out within 20 minutes from 08:00 to 10:00 and from 17:00 to 19:00 in rush hours of the traffic movement.

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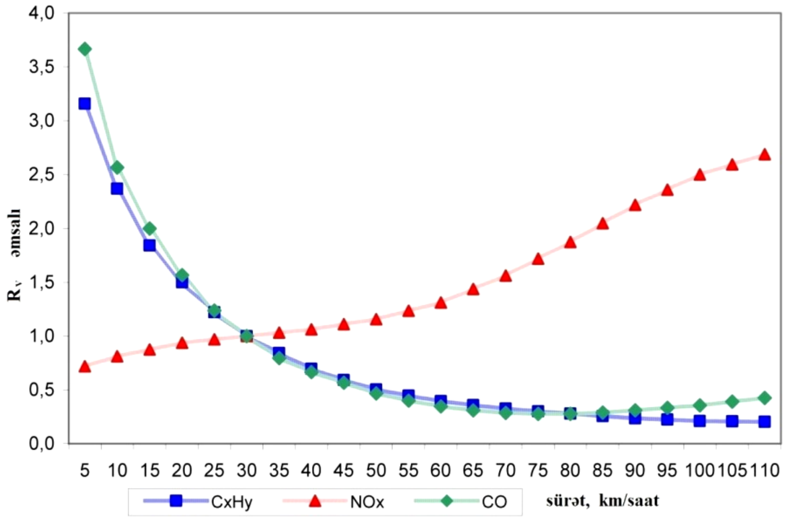
The studies indicate that there is non-linear dependence between traffic speed and density. This dependence calculated using Greenshields model and is expressed as traffic density (Figure 5).



ρ .

Figure 5. Dependence of R_V coefficient on the traffic speed.

When the traffic density — ρ increases (increase in the number of vehicles on the roads), the drivers in order to ensure safe driving distance decrease the speed — V.

When the traffic flow with mixed content is 120 per veh/km, provided that the free movement velocity of the motor vehicles is 60 km/hour in the city, then N_{max} share of the maximum intensity of the traffic flow across one strip of the highway under urban conditions could be shown as follows (Figures 6–7):

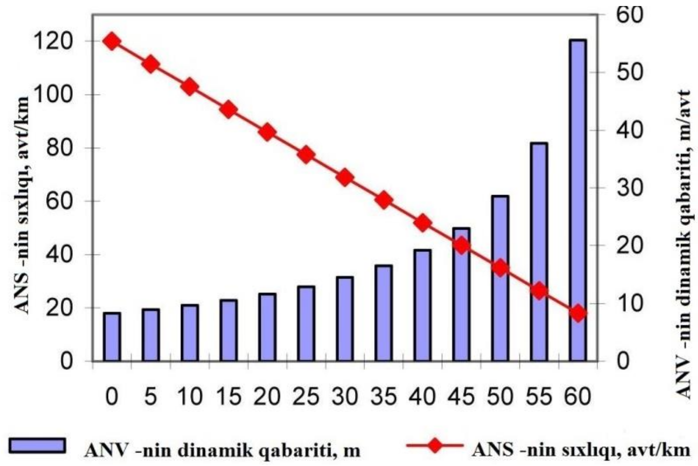


Figure 6. Dependence of traffic intensity and its overall dynamic dimensions on traffic speed.

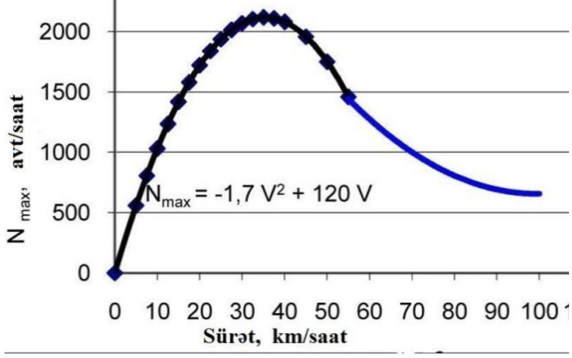


Figure 7. The dispersion of maximal traffic intensity — Nmax.

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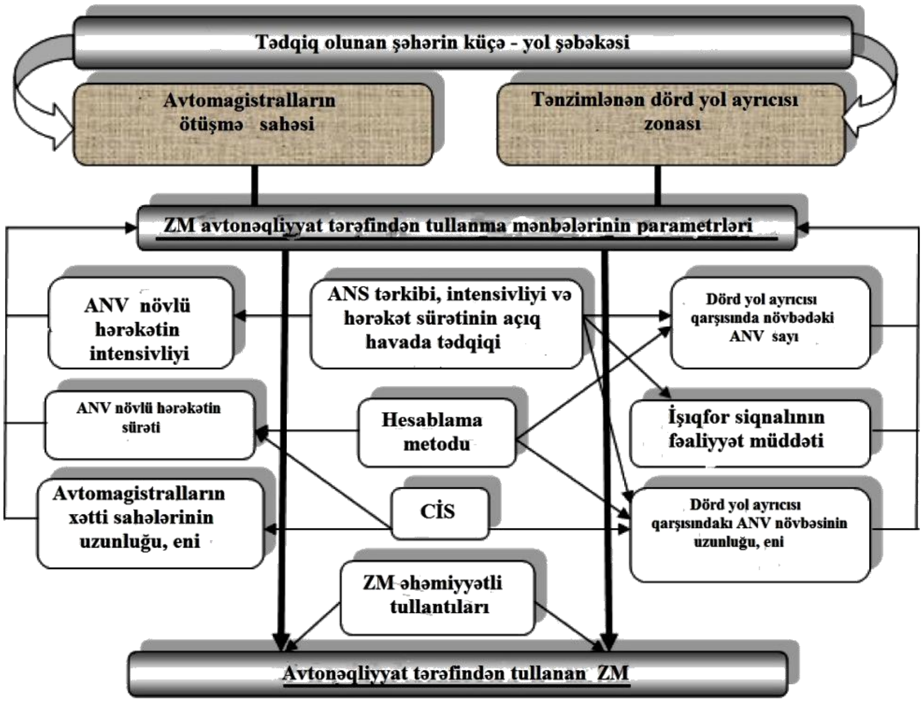
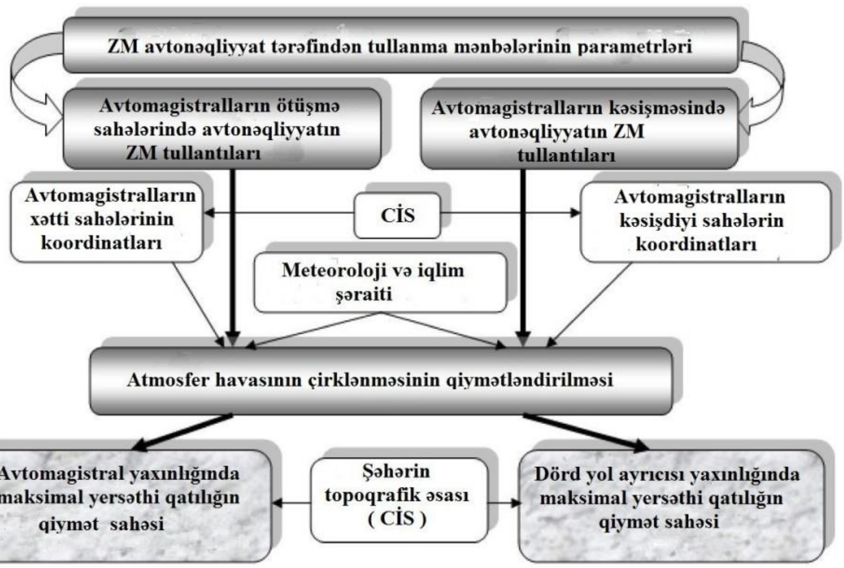
Currently, when the studies of the highways are carried out, the velocity of the motor vehicles of different types is evaluated based on the visual method, which leads to the major errors regarding the results. Therefore, it would be more reasonable to use internet based geographical information services. These systems inform the observer of the street-road network condition on an operational basis.

As experience shows, to define the queue length in front of a crossroad based on the visual method is difficult. Hence, the calculation method is recommended to use. This method is based on the maximum intensity, velocity and density values of the traffic flow. The geographical information system is recommended to be applied in operative mode together with the internet-services in the major cities with high traffic intensity of motor vehicles, which is considered more accurate and reasonable [24].



Block diagram for calculation of the maximal indicators of transport emissions using GIS.



Air pollution assessment scheme on the highways and at the crossroads using GIS.

As calculations represent, when the traffic speed is reduced at the highway crossroads, CO emissions increase, while NO_2 emissions decrease.

When the traffic intensity increases, the maximum surface concentrations also increase. When the traffic speed is reduced from 60 km/h to 5 km/h, the density of carbon dioxide in the linear areas of highways increases 1.5–8.0 times, while the density of nitrogen oxide decreases 1.1–1.6 times.

When the queue length increases (from 30 m to 250 m) at the regulated crossroads, the level of air pollution with carbon dioxide increases 5.0-6.5 times on average and thus, exceed 1 ADL (the allowable density limit).

The method of prediction of air pollution in the big cities

One of the methods used in environmental studies in urban areas is monitoring, which is one of the most important scientific issues of the economy and environment. The main objective of monitoring the megacities is to achieve environmental assessment, control and forecasting in an area where millions of people live, and hundreds of industries operate [17].

In the large cities, the followings are the factors that are considered environmentally sound:

1. Optimal location of large industrial enterprises, thermal power plants (TPP), high-density transport arteries and concentration of pollution sources in a particular area.

2. The direction of winds that play a key role in the transport of pollutants, that is, the relative preference.

The expected concentration of pollutants at specific points should be calculated, taking into account the location and production capacity of enterprises in the city in order to establish environmental monitoring of atmospheric air when implementing application issues.

Based on the calculations, it is possible to draw up a thematic environmental map on the urban area plan that reflects the expected concentration of pollutants. The map should be designed in such a way that it can be continuously corrected and can provide additional information.

Recent measurements show that NO, CH_4, CO_2 emissions can be recorded at a distance of 1.0–1.5 km, while the concentration of gases at a temperature of 30 °C is 10 ppm. Currently, a number of foreign firms (Bruner, Vicolet) produce Furye spectrometers that work on various applications. It allows quantitative and qualitative estimation of a number of gas mixtures by means of devices, and also allows determining the temperature of gas mixtures.

It has been established that the temperature in the water spectrum corresponds to the temperature determined by the carbon dioxide (CO) spectrum. The accuracy of setting the temperature varies depending on the source temperature. When the source temperature is 1000 °K, the measurement accuracy is not less than 20 °K. To determine the atmospheric concentration of CO, NO_2, CH_4 gases, a special noise reduction program is applied at the system entrance. The minimum concentration of gases varies for different gases: For example, 0.07 ppm for CO; 0.5 ppm for NO; 0.1 ppm for CH_4 [15, 17].

Ecogeographic prediction of air pollution using non-linear regression method

Development of methods for forecasting air pollution is one of the key issues that arise in the context of air protection problems. Predictions and warnings of high air pollution are considered as the basis for the regulation of wastes during the meteorological conditions and for mitigation measures.

Regression analysis examines the relationship between one dependent variable and several independent variables. This relationship is expressed by the mathematical model, that is, the equation that connects the dependent variable to the independent variables. In the context of regression analysis, this model is expressed as follows:

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The effectiveness of the developed prediction scheme (used to establish regression equations) and independent (not involved in the regression equation) is monitored.

The work done is aimed at improving the quality of pollution assessment using a new forecast method. The model can be proposed for operational use in industrial cities, as well as for warning of the dangerous level of air pollution (Figures 8–10).

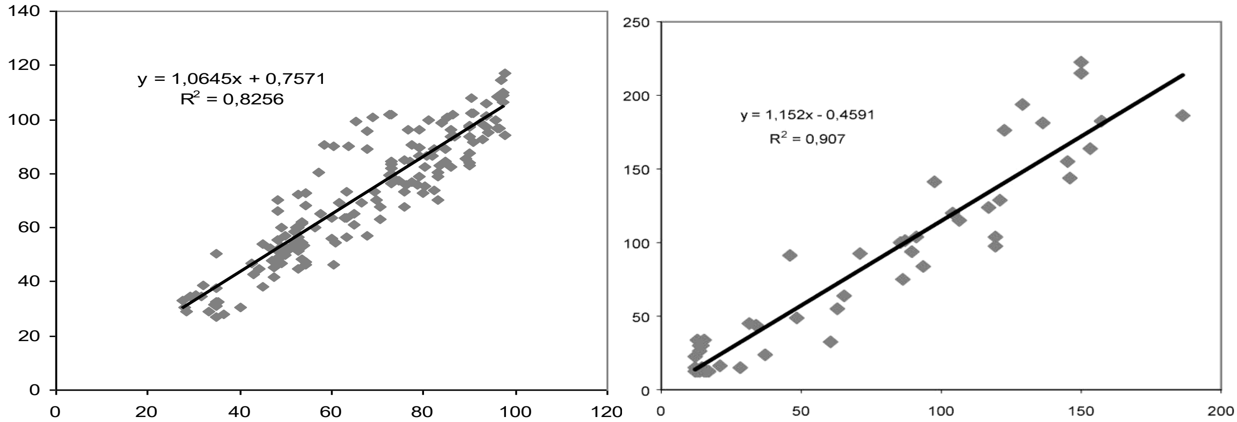

Figure 8. Correlation graph of the maximum daily nitrogen oxide measured and predicted daily concentrations (in Baku city).

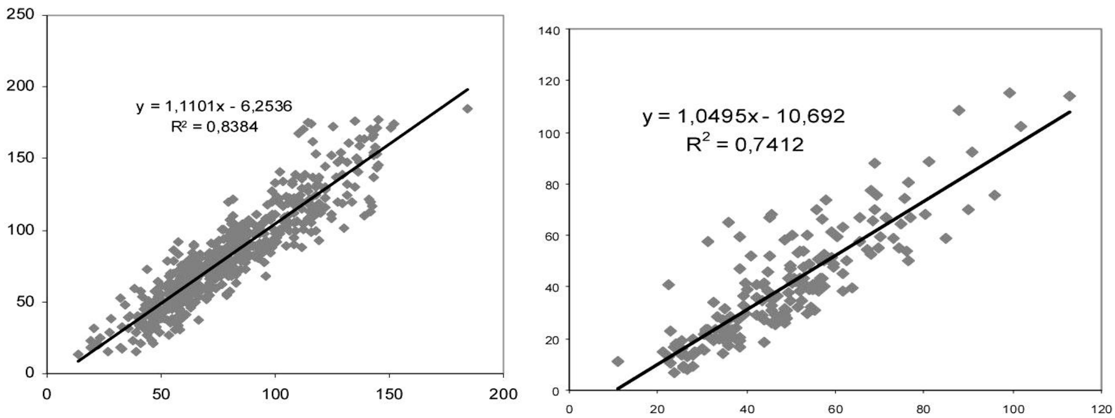

Figure 9. Correlation graph of the maximum daily nitrogen oxide measured and predicted daily concentrations (in Sumgait city).

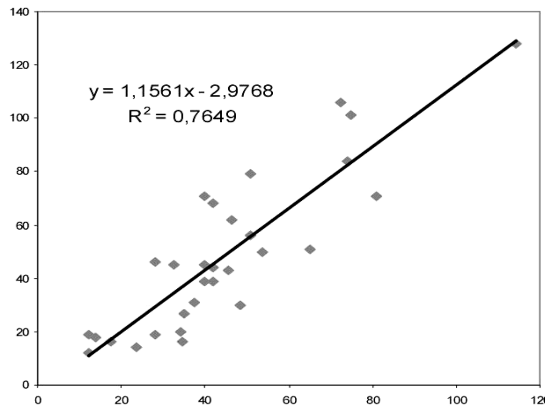

Figure 10. Correlation graph of the maximum daily nitrogen oxide measured and predicted daily concentrations (in Minghachevir city).

The main goal of implemented study is to improve the quality of air pollution assessment using a new prognosis method. The model can be offered for operational use in the industrial city, as well as for warning of the dangerous level of air pollution.

Mathematical model of prognosis of air pollution in industrial cities

As a key criterion for assessing atmospheric air pollution, the permissible mix of the hazardous mixture is taken into account Concentration allowable limit (CAC). The total mass of the mixture is used as a key indicator of air pollution risk. However, this is true for dust and aerosols, as for gases.

From the foregoing it can be said that the wind is the one that most influences the speed of dissolution in the air, or rather its velocity. So, when there are $V \leq 3-5m/san$ persistent events in the atmosphere, there are unfavorable conditions for scattering of impurities. Subsequently, precipitation has the necessary effect on the change in the concentration of atmospheric pollutants. For example: mixtures that are soluble in fog are almost completely absorbed by water droplets. The formation of acids occurs. Thus, sulfur dioxide is converted to sulfuric acid under mist. At the same time, when $\succ 0{,}05mm$ the amount of rainfall is around the clock, pollutants are washed away, which leads to their purification. In addition, it has been established that the presence of pollutants in the atmosphere changes $T \succ 0$ and $T \prec 0$ attaches itself.

Determination of complex indicators and levels of air pollution in unfavorable meteorological conditions

Many researches address complex indicators of atmospheric pollution. Such indicators are used to determine the relationship between the pollution of the population with atmospheric pollution, the determination of comprehensive standards for atmospheric cleanliness, the prioritization of settlements and so on. The study addresses complex indicators for the short-term regulation of industrial waste emissions [23, 27, 29–31].

Three working modes are proposed in unfavorable weather conditions (UWC). Under the first production regime, emissions are reduced through organizational measures. In the second production mode, the capacity of auxiliary production is reduced. At the end, they move to the third production mode, reducing the main production.

There are many approaches to the determination of atmospheric pollution levels [32–34]. Here are two problems: what pollution will be determined by atmospheric pollution and how many levels and levels of pollution should be determined. For example, in the USA [33] there are four levels of high atmospheric pollution: reserve, excitement, danger, and extreme danger.

Atmospheric contamination is characterized by pollutants contained in it. The greater the content of the contaminant, the stronger the pollution. So, because there are different substances in the atmosphere, the same value of their presence does not mean that they are the same. As we know, the harm of a substance is characterized by its CAC. To compare risk or collect different pollutants, it is necessary to look at their ratio to CAC. Based on this, the following sequence of atmospheric pollution assessment is proposed, taking into account the disadvantages and weaknesses of the methods discussed above.

Initial data for the determination of atmospheric pollution are taken into consideration at the *p* — point of the I — ingredient at the p-point, which is done three times a day, for example at 7^{00}, 13^{00}, 19^{00}. In cities, it can be measured from the *N* station. The normalized ratio of each ingredient is as following:

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$$C_{pl} = q_{pl} / YVQH_l$$

here q_{pl} — the intensity measured at any moment of observation; $YVQH_l$ — one-time maximum YVQH.

We can record the average value of the normalized l — component for all points:

$$C_l = \frac{1}{N_l} \sum_{n=1}^{N_l} C_{pl_i}$$

here N_l- i — is the number of stations with measured concentrations of the ingredient.

When estimating the level of contamination, it should be noted that during the average atmospheric pollution, C_p, C^p, S will be equal to one unit. Then, high atmospheric pollution will characterize the change in these indicators from one unit to the maximum.

According to the research, the most harmful ingredient for Baku city is soot and dust, formaldehyde for the Ganja city, and dust, soot and hydrogen sulfide for Sumgait city.

Results and recommendations

1. Generally, the concept of air pollution reflects the certain events and processes which lead to the worsening of the actual and natural quality of atmosphere. In a narrow sense, according to the agreed conception of the Comecon states, the air pollution is defined as emission of pollutants into the air in the solid, liquid and gas form. The protection of atmosphere cannot be successful only by the one sided or half implemented activities that directed to the specific pollution source. İn this regard, the better results can be achieved only by objective and multifaceted approach to the identification of each pollution source and mitigation of their impacts.

2. Even though many studies have been conducted up to now, generally accepted model of dispersion of pollutant compounds in the air is not existing yet. The difficulty and difference of these processes linked with the subjective aspects. For 10 km distance 10 km Pasquill-Gifford model is used and this is working model of International Atomic Energy Agency. Among other models used for identification of air pollutants’ dispersion the model prepared by the Experimental Meteorological Institute can be mentioned. This model is used for 100 km distance. The scientific foundation of model and its comparison with Pasquill-Gifford model is given.

3. Air temperature, wind direction and speed and also average monthly and annual indicators for the carbon monoxide in the atmosphere of Baku city based on the data gathered in recent years (1990–2012) observations was calculated. As curves indicating the dynamics of change of average monthly density of the carbon monoxide in the air of Baku city for last five years depending on the temperature and wind speed, it is seen that even though the air temperature was higher in August, the concentration of carbon dioxide was higher in June and July when the wind speed is relatively lower. In general, it was found that there is high correlation between courses of curves (correlation coefficients change from 0.73 to 0.88).

4. Studies indicate that since the chemical composition of rains changes over the seasons the density of compounds calculated based on average annual indicator for the current year. According to the results of the observations and studies the average annual composition of rain in Baku city is as following: 19.5% sulphate, 9.5% nitrate, 1.0% ammonium, 11.0% chloride, 20.5 hydrocarbon, 0.02% phosphate, 8.73% calcium and 3.75% magnesium ions. More than half of the identified air

pollutants are transport emissions. Specifically, higher intensity of traffic in Baku considerably differs it from other cities of Republic in terms of share of toxic substances in the rain.

5. Studies found that the main reason of higher concentration of harmful ingredients of anthropogenic origin such as carbon monoxide, nitrogen compounds in the air of cities during the warmer periods of the year is motor vehicles' emissions. The share of motor vehicles in the overall ingredients of the air pollutants in industrial cities of Azerbaijan is between 65–70%. First time in Azerbaijan we observed that, except Sumgait city there were differences in the quantities of traffic emissions into the air of big industrial cities in separate years. The quantity of such pollutants in Baku in 2000 was 229.9 thousand tons but, in 2007 it was 410.7 thousand tons, in Ganja city it was respectively 20.8 and 37.2 thousand tons and in Sumgait city it was 14.3 and 8.2 thousand tons.

6. Babies who are most susceptible to air pollution are almost an indicator of the quality of the environment and human health. The statistical indicators clearly confirm this fact. Infant mortality was 4193 in 1990 and 1508 in 2006. The infant mortality decreased 2906 between 1990–2004. Unfortunately, this type of infant mortality numbers is again at the risk of increase. First time in Azerbaijan the study was conducted and the infant mortality indicators among the cities of Republic were identified as following: Baku city — 769 in 1990, 511 in 2006, Sumgait city — 127 in 1990, 83 in 2006, Ganja city — 61 in 1990, 38 in 2006, Shaki city — 81 in 1990, 47 in 2006, Lankaran city — 70 in 1990, 22 in 2000, Shirvan — 35 in 1990, 7 in 2006, Mingachevir city — 44 in 1990, 9 in 2006, Nakhchivan city — 18 in 1990, 6 in 2006.

7. As a result of studies we found that existence of harmful pollutants in the air increases the diseases of population 30–40%. Moreover, the correlation analysis between air pollution index and malignant tumor diseases have been carried out and the correlation percentage of 36–38% was found.

8. It was found that, in some cities of Azerbaijan (Baku, Ganja, Mingachevir, Sumgait) the correlation coefficient between air pollution index and respiratory diseases is low. It should be mentioned that, when air pollution index increases or decreases then its indicator changes also in the density of sulfur dioxide. It is found that when air pollution index changes, the number of respiratory diseases is increases. For example, the change in the air pollution index just for two units, corresponds to the 100 mkg/m^3 change in the density of sulfur dioxide. Such an increase in air pollution causes 12% increase in overall disease numbers. This is closer to the indicators of other researchers.

9. First time in Azerbaijan with the aid of multi-zone satellite images the clouds of smoke were observed over the Sumgait city area, to the south from it and west of Absheron peninsula and it was identified that the main mass of the air pollutants concentrated up to the 60m height. Furthermore, smog was recorded over the Baku city based on the analysis of satellite images and according to the tone of the images the smog was lighter than the one observed over Sumgait industrial area. The comparison of image of smoke clouds and the dispersion areas of the density of SO_2 gas indicates that the density of SO_2 in Baku area has smaller indicator (up to 2 allowable density limit) than in the industrial areas of Sumgait under the strong/dangerous wind condition (U_m = 1.7 m/sec).

10. The remote optical method is more efficient method of studying the area of atmospheric aerosol. This method creates the opportunity to get operative, precise and reliable information about the dispersion areas of brightness of the background aerosol in the atmosphere. In this regard, the method of study of the angular structure of the brightness of the aerosol pollution in the atmosphere over the Baku city was considered.

11. It was found that when the traffic speed is reduced at the highway crossroads, CO emissions increase, while NO_2 emissions decrease. When the traffic intensity increases, the

maximum surface concentrations also increase. When the traffic speed is reduced from 60 km/h to 5 km/h, the density of carbon dioxide in the linear areas of highways increases 1.5-8.0 times, while the density of nitrogen oxide decreases 1.1–1.6 times. When the queue length increases (from 30 m to 250 m) at the regulated crossroads, the level of air pollution with carbon dioxide increases 5.0–6.5 times on average and thus, exceed 1 ADL (the allowable density limit).

12. According to the analysis which were carried out first time in Azerbaijan, the highest level of air pollution with the basic and specific compounds in the Republic are observed in Sumgait, Baku and Shirvan cities. The highest average annual density of air pollutant ingredients was observed in Sumgait city and the concentration of chlorine was 2.7 times; hydrogen fluoride 2.0 times; nitrogen 4-oxide 2.2 times above the allowable density limit.

13. The observations of air pollution in Baku city are carried out at 9 observation stations located at the Sabail, Nizami, Narimanov, Binagadi, Khatai, Yasamal and Sabunchu districts of the city and observations covered dust, sulfur dioxide, dissolved sulfates, carbon dioxide, nitrogen 4-oxide, nitrogen 2-oxide, hydrogen sulfide, smoke black, solid fluorides, hydrogen fluoride, chlorine, ammonia, sulfuric acid, formaldehyde, furfural concentrations in the air.

14. The meteorological capacity of atmosphere was determined by us on the sample of Ganja city first time in Azerbaijan. Annually, there are 90.74 days with the wind speed of 0–1 m/sec in Ganja. The repetition of the such winds occur between September and December (8.15–9.89 days). During other months such windy days constitute 6.06–7.44 days. The average annual recurrence of days with the wind speed of 6 m/sec is 9.77. These days are observed in III, IV, VII and VIII months (5.21–5.55). It varies between 2.07–3.04 in October, November, December and January.

15. The correlation graph reflecting the difference between actual and prognosed density of pollutants was used in order to ensure efficiency of prepared prognosis/prediction schematic and first time in Azerbaijan the efficiency of the prognosis/prediction schematic for several cities of Republic was provided. Main purpose of utilizing the prognosis method was to increase the quality of air pollution assessment level. The end result model might be proposed for operative use in industrial cities for the warning of dangerous level of air pollution in them.

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