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THE STUDY OF POPULATION MORBIDITY BASED ON THE SPATIAL DIFFUSE MODELS IN OLD INDUSTRIAL REGION OF KRIVBASS

In the old industrial regions of Kryvbas iron-ore basin ecology-dependent morbidity of population presents a substantial problem. Its decision is possible by means of theoretical approaches and methods of society geography. The possibility of application and adaptation of spatial diffusions models for the research of diseases spreading is investigated in the article. The analysis of spreading the morbidity on the basis of the adapted model of spatial diffusion and other methods of spatial analysis is performed. Approaches are worked out and the ecology-pathogenic districting of the territory of Kryvbas is performed.

Key words: old industrial region, ecology-dependent morbidity, spatial diffusions, common ways of spreading diseases, ecology-pathogenic region.

Сергій Сонько, Дарья Шиян. ДОСЛІДЖЕННЯ ЗАХВОРЮВАНОСТІ НАСЕЛЕННЯ НА ОСНОВІ МОДЕЛЕЙ ПРОСТОРОВИХ ДИФУЗІЙ В СТАРОПРОМИСЛОВОМУ РЕГІОНІ КРІВБАССА. *У старопромислових регіонах, до яких належить Криворізький залізорудний басейн, еколого-залежна захворюваність населення являє істотну проблему. Її рішення можливе за допомогою теоретичних підходів і методів суспільної географії. У статті досліджена можливість застосування і адаптації моделей просторових дифузій для вивчення розповсюдження захворювань. Виконаний аналіз розповсюдження захворюваності в м. Кривому Розі на основі адаптованої моделі просторової дифузії і інших методів просторового аналізу. Розроблені підходи і виконано еколого-геопатогенне районування території Кривбасу.*

Ключові слова: старопромисловий район, еколого-залежна захворюваність, просторові дифузії, закономірності розповсюдження хвороб, еколого-геопатогенний район.

Сергей Сонько, Дарья Шиян. ИССЛЕДОВАНИЕ ЗАБОЛЕВАЕМОСТИ НАСЕЛЕНИЯ НА ОСНОВЕ МОДЕЛЕЙ ПРОСТРАНСТВЕННЫХ ДИФФУЗИЙ В СТАРОПРОМЫШЛЕННОМ РЕГИОНЕ КРИВБАССА. *В старопромышленных регионах, к которым относится Криворожский железорудный бассейн, эколого-зависимая заболеваемость населения представляет существенную проблему. Ее решение возможно с помощью теоретических подходов и методов общественной географии. В статье исследована возможность применения и адаптации моделей пространственных диффузий для изучения распространения заболеваний. Выполнен анализ распространения заболеваемости в г.Кривом Роге на основе адаптированной модели пространственной диффузии и других методов пространственного анализа. Разработаны подходы и выполнено эколого-геопатогенное районирование территории Кривбасса.*

Ключевые слова: старопромышленный район, эколого-зависимая заболеваемость, пространственные диффузии, закономерности распространения болезней, эколого-геопатогенный район.

Actuality. The health status of the population and the increasing life expectancy of citizens are the strategic guidelines of any nations. A special place among the objects of geographical study of disease belongs to the old industrial regions («OIR»), as places of high concentration of productive forces and the population. In the city of Kriviy Rig, as the centre of OIR with the length of more than 60 km and the population of about 650 thousand people there is an extremely high concentration of giant mining plants (8 of 11 enterprises of Ukraine). Almost all enterprises, which are the main sources of pollution, are located near residential areas. The average annual emissions make up more than 700 tons per 1 sq. km. of the city territory, and 470 kg. per 1 inhabitant, it is a direct consequence of morbidity and mortality increasing. This under-researched phenomenon is the phenomenon of synergism. So, environmentally dependent diseases, «superimposed» on the traditional, create a qualitatively new complex effect.

Kriviy Rig, as an object of study, is also interesting because in the former Soviet Union, it took a disappointing second place (after Norilsk, Russia) in the level of atmospheric air pollution. Has the situation changed during the last 25 years? This is the question, the answer to which may be of great interest to scientists.

Due to the large area of the city (more than 40 000 hectares), it is characterized by a complex of problems, which have strong spatial expression and the solution of which depends largely on such purely geographical categories as «distance», «farness», «center», «periphery». The concept of «space» and «spatiality» are traditionally in the subject area of society geography. Ecological status, the spread of toxic substances, the development of ecologically dependent diseases in this list is a fairly new problem, as it was always in the subject field of medical geography. In our opinion, the classical models of spatial diffuse, entered into geography by T.Hegerstrand, is one of the best way to study such spatial

processes, as the spread of morbidity. However, their use requires special theoretical ground and adaptation. In fact, in the application of methodological approaches and methods of society geography to the solution of the problem of morbidity is the relevance and novelty of the proposed research.

Objects and methods of research. Since quantitative parameters characterizing the public health and the environment of Kriviy Rig are used in the work, we used statistical and mathematical methods, which gave the material for later application of traditional comparative geographical analysis. A special place in the methodological tools of research belongs to GIS and cartographic method, the need of their application is due to such characteristics of the urban environment as:

- close relationship of the etiology and mass emerging diseases with features of industrial and residential building area of the city;
- the dependence of the dynamics of morbidity from these geographical categories as «space», «distance», «area»;
- spatial overlay of environmental factors on social, giving a new negative quality in the result of synergism;
- spatial differentiation of specific diseases depending on demographic and geographical characteristics of the city.

The source of information for study was a large array of statistical data, in particular, the morbidity of the population of the city of Kriviy Rig for the period from 2005 to 2009, 54 diseases in section 239 of the medical service districts. According to these indicators Kriviy Rig was chosen not by chance, in 2010 it took the second place in Dnipropetrovsk region because of morbidity (21308,0 people per 10 thousand inhabitants). Taking into consideration that the population, attached to one medical service district (in accordance with regulations of the Ministry of health of Ukraine) is relatively stable (approximately 2000 people), the absolute frequency of diseases is representative assessment of morbidity (i.e., converted to 2000 people).

For analysis of the collected statistical information in MS Ecxel, as well as in Mapinfo Professional made graphs, charts, thematic and integrated maps that show various trends in the morbidity of population, pollution, establish links between the

distance to stationary sources of pollution and morbidity, help to establish center of outbreaks of ecologically dependent diseases.

The object of our study is the old industrial region of Krivbass in which there is a high level of ecologically dependent diseases of the population. The subject of the research is the spatial characteristics of the population morbidity in the city of Kriviy Rig. The aim of this work is to identify spatial characteristics of the population morbidity in the city of Kriviy Rig using the methodology of socio-geographical researches. To achieve this goal the following tasks were solved:

- analysis of previous studies of morbidity from positions of social geography;
- explore the possibility of applying and adapting models of spatial diffuse to study the spread of diseases;
- analysis of the spread of morbidity in Kriviy Rig on the basis of an adapted model of spatial diffusion and other methods of spatial analysis.

Methodological base of the research was the main approaches of theoretical and applied geography, shown in the works of P. I. Baklanov, M. A. Glazovskaya, S. A. Kurolap, S. M. Malkhazova, D. V. Nikolaenko, V. S. Tikunov, V. O. Shevchenko, T. Hegerstrand and other scientists.

The results of research and discussion. Old industrial region is a holistic territory, formed during a long historical period as a result of specific types of nature management under the influence of the interaction between landscape, economic and social conditions, and which is characterized by profound changes in the natural environment that adversely affect the health status of the population.

But, scientists have been recently interested in the impact on the morbidity of predominantly natural components of the environment [1,2], in the last decade, the main priority is given mainly to the peculiarities of the influence of social and technological environment [3], which are the objects of study of social and geographical Sciences. The main theoretical and methodological provisions of geographical studies of morbidity traditionally are the following:

- the problem of morbidity of the population is not determinated without reference to the territory, so even in the early works of this direction mapping method is used;

- the spread of disease in the form of epidemic, epizootic and epifitotic into a certain geographic model, «center-periphery» [4], as well as in the classic models of the centre places and diffusion of innovations T. Hegerstrand [5].

Therefore, on the level of industrial megalopolis in the OIR two models can «work» at the same time:

1. Industrial enterprise with stationary sources of pollution («center») plus the area affected by the emissions («periphery»), forming elementary concentric distribution of morbidity.

2. The focus/foci of contamination as the primary cause of morbidity (source «innovations») plus the area that is experiencing the impact of pollution (the spread of diseases due to diffusion processes successive stages). In large industrial centers, such as Kriviy Rig periodically (explosive) activity of a stationary source is observed, because the emissions of the enterprises are not evenly distributed during the days, months, and seasons of the year.

The widest application of models of contagious diffusion (the spread of infectious diseases as a result of contacts) have been found in medical geography. But in our case, this model is not suitable, because the etiology of ecologically dependent diseases is not characterized by contagious [6]. The studying process of diffusion of environmental pathology, rather reminds a cascading diffusion, but within a large industrial city it is difficult to find those levels of the spatial hierarchy, referred to in the classical theory, and through which any phenomenon «passes» from the top to the down.

In our case, similar innovations (environmentally dependent diseases) are being «formed» in the OIR for some time. While the root and the main object of diffusion are not diseases, but the certain quality of environment which belongs to the individual (in our case, concentric) plots the geographical space. Then ecopathology,

«stratifies» on this space and in its distribution overlaps partially with its ecological characteristics.

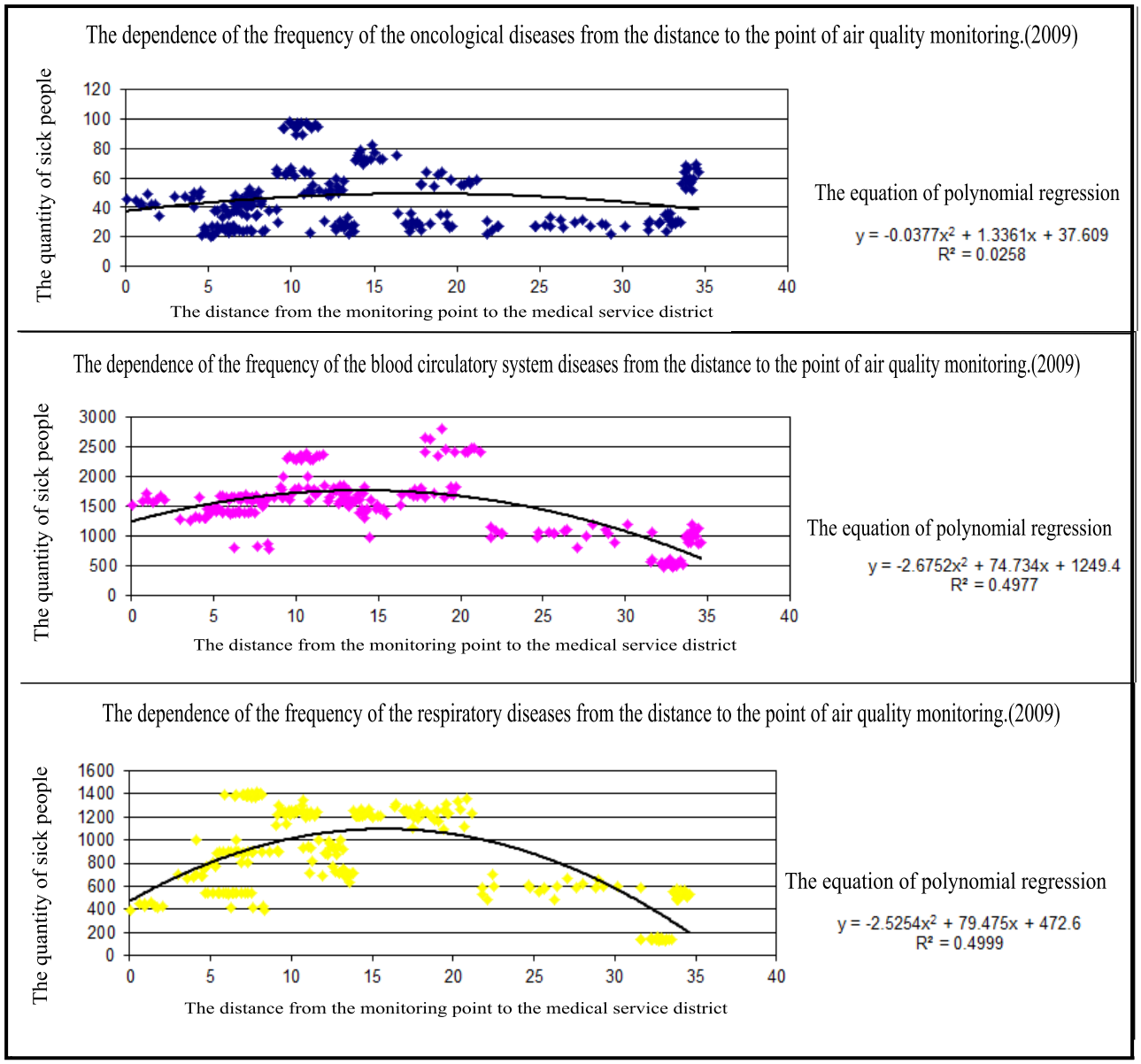
Thus, diffusion of environmentally dependent diseases has both characteristics the diffusion of displacement (but without the «fading» of primary cell) and extensions. Under the characteristic the diffusion of extension is neither «contagious» nor «cascade». Apparently, we can talk about intermittent explosive wave of diffusion, whereby ecopathology spreads from cells of pollution (under the circumstances of their periodic activation – «explosions»), losing its activity from the centre to the periphery (like waves after the explosion on the water surface). However, verification of this assumption requires the use of more accurate, in particular, mathematical methods.

Examining possible options of the mathematical formalization of the process of periodic explosive wave diffusion, we came to the conclusion that the best way to describe this process is with the help of polynomial dependence. Possible statistical model here may be a regression equation describing the dependence of the absolute frequency of the specific disease from the distance to the point of air quality monitoring.

Using standard software (MS Excel, graphics of the specific disease is obtained (Fig.1). From a visual analysis of trend lines, each of the graphs shows that more than 50% of the total number of patients is concentrated at distances up to 15 km from IMP (item monitoring pollution). It is established that the greatest dependence (determination) on the quality of the air basin is observed for diseases of the circulatory system (R2 = 0.47 - 0,49); ischemic heart disease (R2 = 0.50 to 0.52 in); hypertension (R2 = 0,45 - 0,49); respiratory diseases (R2 = 0,30 - 0,50); diseases of the digestive system (R2 = 0,43 - 0,49). Much less dependence was established for the musculoskeletal system (R2 = 0,17 - 0,25), genitourinary system (R2 = 0,15 - 0,23) and tumors (R2 = 0,01 - 0,08). However, despite the extremely small values of the coefficient of determination for tumors, this group of diseases has the greatest degree of risk to life and therefore, even a weak manifestation depending on the environmental situation is important.

The necessity of taking into account even the low coefficients of determination is reasoned by the fact that the etiology of oncological diseases is not fully investigated because of its complex characteristics, dependent on many factors. However, with high probability, it is proved that the "start" to complex physiological processes of oncopathology is given by a certain quality of the environment [7].

The data shown in Fig.1., indicate that the highest frequency of diseases (including cancer), is observed at distances from 5 to 10 km from the point of quality control of atmospheric air (which are located in the license area, the area of stationary pollution sources of industrial enterprises) to medical service districts. It is the characteristic that variance depends from this distance.



Pic.1. Regression models of the diseases dependence from the distance to the point of air quality monitoring (2009)

The analysis of all built regression models shows that the dependence of the incidence of specific disease groups from environmental factors, in particular, the condition of atmospheric air, in most cases, quite accurately is described by a polynomial of the second degree with significant coefficients of determination. This makes it possible to justify certain conclusions and recommendations for the prevention of harmful influence of environmental factors on population health.

The statistical models indicate that between disease incidence and environmental factors on the territory of Kriviy Rig there is a reliable relationship with ambiguous probabilistic in nature, but surely proving the fact of the harmful environmental impact of urban environment on health. Apparently, it gives the right to say that in OIR Krivbass ecologically dependent incidence is widespread and the dynamics of which is most correctly described by the model of periodic explosive wave diffusion.

Subsequent analysis of the research problem is to establish the abnormal manifestations of the incidence of specific disease groups within urban districts, Kriviy Rig. In simplified form it is advisable to determine the criteria for the identification of anomalies, as the ratio of the frequency of the disease on individual medical service district to the average value across the inner-city area. Then plots with a criterion value, more than 1 will geographically identify anomalous (eco-geopathic) zone. In MS Ecxel this task is accomplished by constructing the radar chart.

Consider the allocation of ecological geopatogenic areas on the example of a group of oncological diseases, as the most dangerous to human life in the Central residential area. In the area (corresponding Saksaganskiy inner-city area):

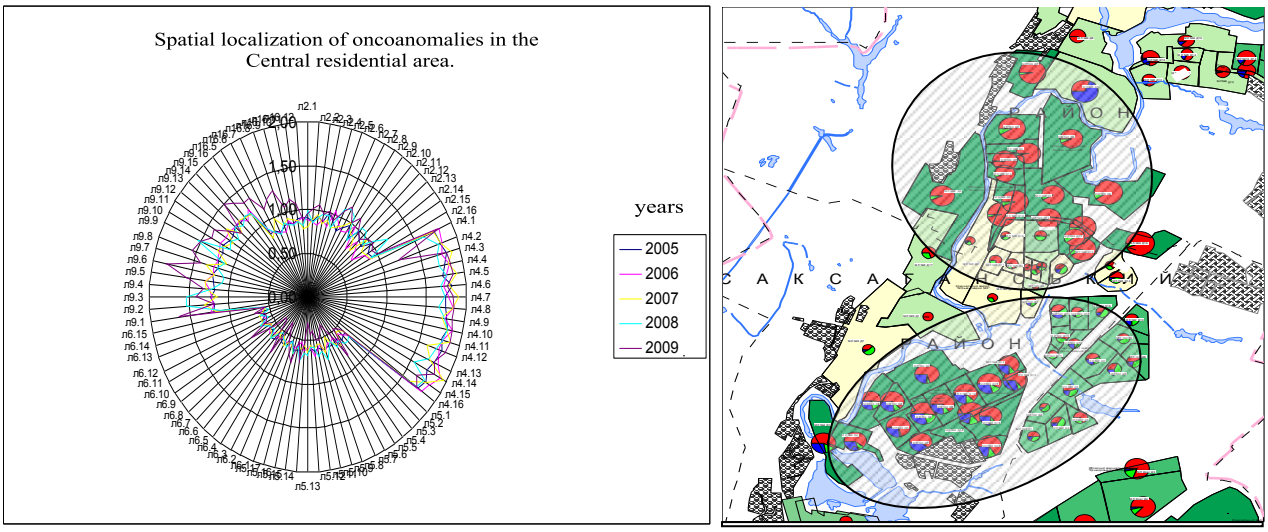
- there is no such a concentration of industrial enterprises as in the southern industrial areas.

- it is the largest residential area, home to more than 250 thousand people (1/3 of the total number of the city's population), the majority of whom work at the

enterprises of the southern industrial areas of the city, and who were under the influence of all the negative factors of metallurgical, mining and other hazardous industries for a long time.

- in close proximity to residential areas (zone transfer) there are enterprises of South industrial complex, comprising: Europe's largest metallurgical plant «Arcelor Mittal» with a full metallurgical cycle and a coke-chemical plant, that regularly emits the multiple compounds, such as oxides of sulphur, nitrogen, carbon, and benzapiren and phenols into the atmosphere; a large cement plant and two powerful mining and processing plants (SOMC and NKOMK), which are the main sources of air dustiness.

Paired analysis of radar charts and related kartodiagramms with certain medical areas (Fig.2) gave the ability to spatially localization of carcinogenic anomalies. And doing similar research procedures in all areas of the city gave the option of using the analytical method of surfaces MapInfo professional to obtain 3-D image of oncoanomalies (Fig.3).



Pic.2. Spatial localization of oncoanomalies in the Central residential area.

The logical conclusion of any geographical studies of disease is a medical-geographical zoning. In large cities it is usually complicated by a weak spatial identification of modern (mostly urban) environment of emerging diseases, «blur» etiology of their occurrence, intensity and rapidity of the pace of modern society.

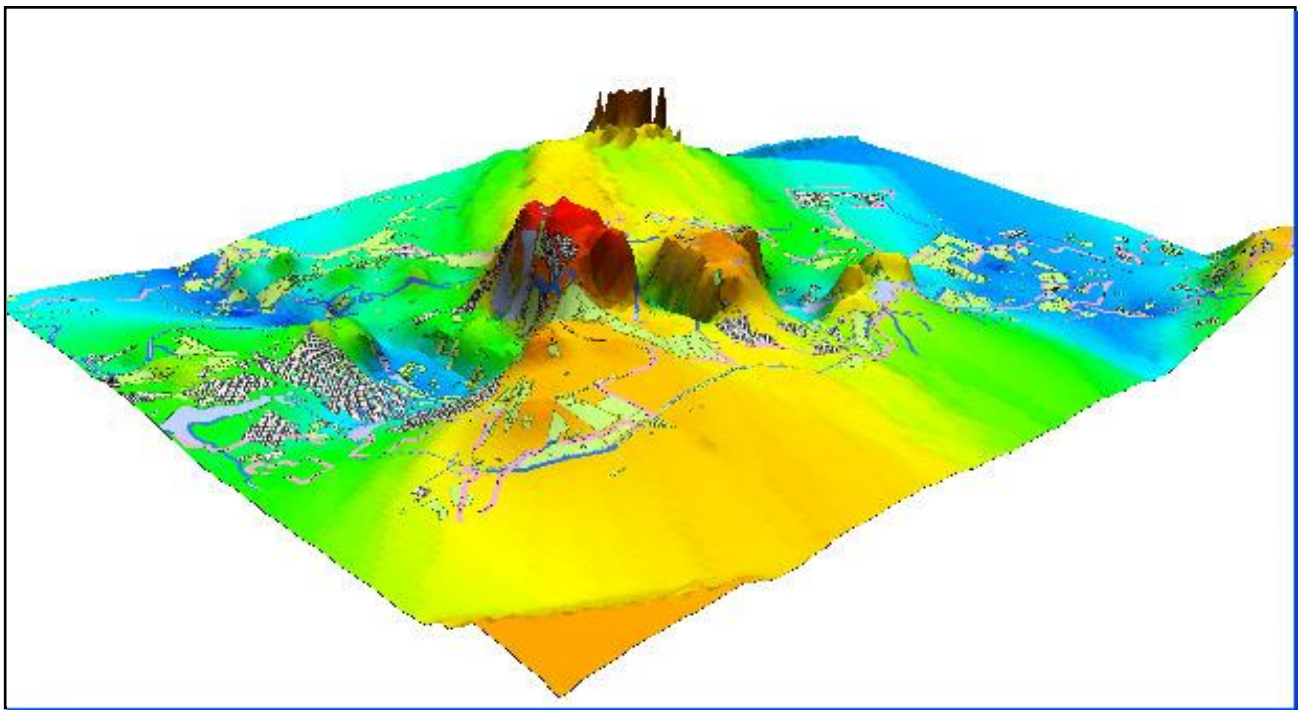
This encourages the development of new scientific approaches to zoning, requiring some modification of the traditional concepts of medical-geographical area.

In our opinion, the positioning problems of morbidity in a narrower (coverage), and wider (by subject area) context can be described by the concept of eco-geopathic area. You must take into account three types of diseases:

- environmental illness: occupational diseases, cancer, congenital disorders, genetic defects, allergies, anaemia, endemic diseases

- social diseases: infectious and parasitic diseases, diseases of the digestive system, chronic obstructive pulmonary disease, tuberculosis, cirrhosis, alcoholism, diseases of the blood;

- synergistic disease: increased frequency of allergic diseases, abnormalities in mental and physical development, outbreaks of respiratory disease, high frequency of endocrine diseases, notable secondary immunodeficiency, the frequency of chronic pathologies of the digestive system and kidneys.



Pic.3. Oncological diseases in 3 D. The highest level of oncoanomalies is observed in Saksagan district

However, due to discussions the final classification of diseases to one or another group we believe this division to be rather conditional, but sufficient to show

the spatial pattern of their distribution in the study area. The term «eco-geopathic zone» (zoning), assumes that the spatial manifestation of environmentally related diseases in certain areas, because in the transition to a larger scale [8] (medical service district within a large city), you can study the dynamics of all kinds of diseases, and especially, the occurrence of which depends on environmental conditions, changed by economic activities [9].

Eco-geopathic zone is a geographically holistic continuum component of urbogeosystem, with a predominance of anthropogenic landscapes transformed by certain endogenous and exogenous material and energy flows, determining the incidence of urban population environmentally sensitive, socially deterministic and synergistic disease.

The logical result of the generated ideas which was made by us is ecology-geopathic zoning of the territory of Kriviy Rig, in which in addition to these incidence rates demographic characteristics of the population, remoteness from stationary sources of pollution, particularly residential and industrial development, economic and geographical position of the city were taken into account.

There are only 4 eco-geopathic zones in the territory of the city:

1. South mining zone includes 31 medical service districts (about 62,000 people) Ingulets and parts of the Central inner-city districts: with the prevalence of morbidity among ecologically dependent - tumors (with the advantage of Oncology diseases of the ovary and breast cancer) and respiratory diseases (mainly chronic dust bronchitis, laryngitis and tracheitis), among synergistic - allergic (mainly diseases of the upper respiratory tract), diseases of the genitourinary system (mainly chronic pielonefrit, cystitis, diseases of the prostate gland), and nervous system.

2. Southern metallurgical zone, consisting 76 medical service districts (about 152 000 people) Dolgintsevskiy, Dzerzhinskiy and parts of the Central inner-city districts: with the prevalence of morbidity among ecologically dependent neoplasm (mainly benign neoplasms of the skin and mammary gland), occupational diseases (associated with metallurgy, coking by product Industries, the cement industry); among synergistic - endocrine system diseases, nervous system diseases, diseases of

organs of digestion (mainly gastritis and duodenitis), allergic (mostly allergic rhinitis), diseases of the genitourinary system (mainly kidney infections, kidney stones and urinary tract infections), and nervous system.

3. Central residential zone has 84 medical service districts (about 168000 people) Saksaganskiy and the southern part of the Oktyabrskiy districts with prevalence of disease: social diseases (infectious and parasitic diseases, diseases of the digestive system, chronic obstructive pulmonary disease, cirrhosis, diseases of the musculoskeletal system (mainly rheumatoid and salt arthritis), blood diseases, diseases of the organs of sight and hearing, among synergistic - allergic, nervous and mental diseases, endocrine diseases, chronic diseases of the digestive system and kidneys.

4. Northern mining-industrial zone consists of 63 medical service districts (about 126000 people) Ternivskiy and the Northern part of the Oktyabrskiy administrative districts with prevalence of morbidity among ecologically dependent - fragmentary manifestation of diseases neoplasms (with a predominance of benign tumors of the ovary), allergic diseases and respiratory diseases; some social diseases such as liver cirrhosis, chronic obstructive pulmonary disease, injury and poisoning; some synergistic diseases such as diseases of the nervous system, salt and rheumatoid arthritis.

Conclusion. As a result of the research:

- established territorial peculiarities of the dynamics and causes of morbidity of the population depending on the state of environment in micro protrusions level of medical sites within, Kriviy Rig;

- developed and tested social geographic research methodology of problems of morbidity in the OIR which made it possible to ascertain the distribution and typology of diseases characteristic of OIR, including using models of spatial diffusion;

- made eco-geopathic zoning of the territory of Kriviy Rig, emitting the corresponding anomalies of morbidity.

- improved socio-geographical approach to the classification of diseases prevalent in the OIR (environmental, social, synergistic disease) depending on the complex socio-economic and environmental characteristics of separate parts of its territory.

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