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Influence of Environmental Factors on the Population Health: Regional Approach for the Medical-Ecological Analysis (for Example, the Sumy Region of Ukraine)

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Abstract

Today is still insufficiently developed the methods of associative analysis of the medical, ecological and demographic parameters that would make it possible to determine the nature and extent of the influence of environmental factors on the population health, establish the basic laws of territorial differentiation of human diseases and to identify ways to optimize the environment. Identifying of such influence and its evaluation is the primary task of our study. The correlations between the environmental pollution of and level of morbidity prevalence of population of the Sumy region we obtained by the mathematical methods. In the analysis, we obtained the 143 pairs for which the correlation is significant at the level ≤0.05 and 50 pairs – for which the correlation is significant at the level ≤0.01, reflecting the most closely dependencies between prevalence of morbidity and the state of the environment. In the integrated form, the quality of drinking water is the most important factor, which closely correlated with the prevalence of diseases among the population of Sumy region. The influence of the ecological state of the air, including the gamma-background level, chemical and radioactive contamination of soils and crop production are also important, although less markedly.

Keywords: medical-ecological analysis, environmental pollution, correlation, prevalence of diseases, Sumy region.

Introduction

Medical and environmental research is relevant scientific field, which develops on the interface of ecology and medicine. Due to the state of the environment, health problems are occupying a special place in scientific investigations. Now there is an active search of criteria of optimal interaction between society and the environment, which will provide the necessary quality of living conditions. Nowadays methods of associative analysis of the medical, ecological and demographic parameters which will make it possible to determine the nature and extent of the influence of environmental factors on the human body, establish the basic laws of territorial differentiation of human diseases and to identify ways of optimizing the environment are still insufficiently developed. Therefore, the primary task is the identifying of such influence and evaluation of it.

All medical-ecological problems irrespective of reasons that caused them, are inextricably linked to a particular territory. Their sharpness depends on the structure of environmental management and presences of appropriate natural or social factors on the territory, especially the demographic situation and the level of medical care. Uneven distribution of these factors causes differences in the magnitude of anthropogenic load which is based on the national, regional and local levels.

The regional level is the most relevant and dynamic. On this level the most fully medical and environmental problems of the natural-social interaction are manifested.

All regions, that have a high density of population, developed mining and manufacturing industries, especially if the latter are based on resource - and energy-intensive technologies have to face with problems of the impact of the environment on human health. The Sumy region, which occupies 3.9% (2383.2 ths. ha) of territory of Ukraine, where according to data of 01.01.2014 inhabit 2.5% (1130.8 ths. people) of Ukraine's population, is not an exception. The average population density is 47 persons per 1 square km.

Materials and methods

Deterioration in the health of the population, the growth of the primary disease and the prevalence of different nosologies aroused the search for causes, which might cause such an increase. Most scientists are agreeing that this factor may be the quality of the environment. Therefore, finding and assessment of the linkages between different types of diseases and parameters of the environment is an important component of medico-ecological research. A direct correlation between the pollution of environment and level of morbidity prevalence of the population we established by the mathematical methods. All calculations and computations, as well as graphical representations were obtained by using the capabilities of the computer package SPSS Statistic 17.0 from the SPSS inc., Microsoft Excel 2010 of Microsoft corporation and Statistica 10 from the StatSoft Inc.

Based on the correlation analysis the array data about quality of the environment, and the prevalence of specific nosology or their classes, we established dependence of the latter from the indicators of the environment. In the analysis, we obtained 5940 Pearson's pair correlation coefficients between the 44 parameters characterizing the quality of the environment and the prevalence of 135 diseases of population of Sumy region, belonging to 15 nosological classes [3].

From the resulting array we are selected the 143 pairs for which the correlation is significant at the level ≤0.05 and 50 pairs – for which the correlation is significant at the level ≤0.01, reflecting the most closely between prevalence of morbidity and the state of the environment. Thus, from all correlation array only the 193 (3.2%) coefficients of correlation are statistically significant. Of all the environmental indicators that we considered a most affect on the prevalence of diseases in population of Sumy region are chemical and radioactive contamination of soil, drinking water quality and the level of air pollution.

Results

Deterioration in the health of the population, the growth of the primary disease and the prevalence of different nosologies aroused the search for causes, which might cause such an

increase. Most scientists are agree that this factor may be the quality of the environment. Therefore, finding and assessment of the linkages between different types of diseases and parameters of the environment is an important component of medical-ecological research. A direct correlation between the pollution of environment and level of morbidity prevalence of the population we established by the mathematical methods. All calculations and computations, as well as graphical representations were obtained by using the capabilities of the computer package SPSS Statistic 17.0 from the SPSS inc., Microsoft Excel 2010 of Microsoft corporation and Statistica 10 from the StatSoft Inc.

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Soil pollution and its impact on the prevalence of diseases in populations. Ecological conditions of soil, in particular their radioactive contamination by Cs^{137}, is most strongly influences to the prevalence of diseases of the endocrine system, especially nodular goiter ($r = 0.476$, $p = 0.04$) (Fig. 1) and hypothyroidism, particularly the postoperative hypothyroidism ($r = 0.67$, $p < 0.01$).

Postoperative hypothyroidism is also reliably correlates with the radioactive contamination of crop production by Cs^{137} ($r = 0.461$, $p = 0.04$) and Sr^{90} ($r = 0.507$, $p = 0.02$) (Fig. 2). In both cases, the big prevalence of these nosologies is in the Shostka district, where this problem is most acute.

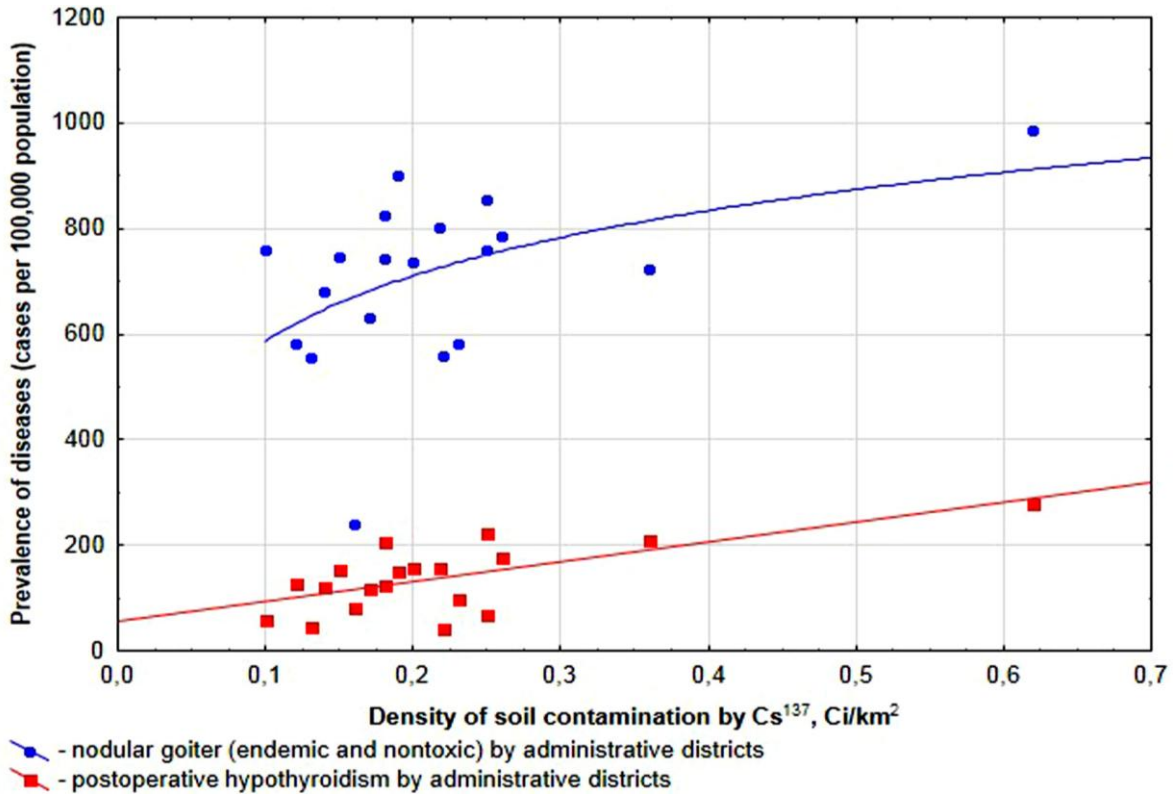

Fig. 1. Dependence the prevalence of goiter in the population of Sumy region from the density of soil contamination by Cs^{137}

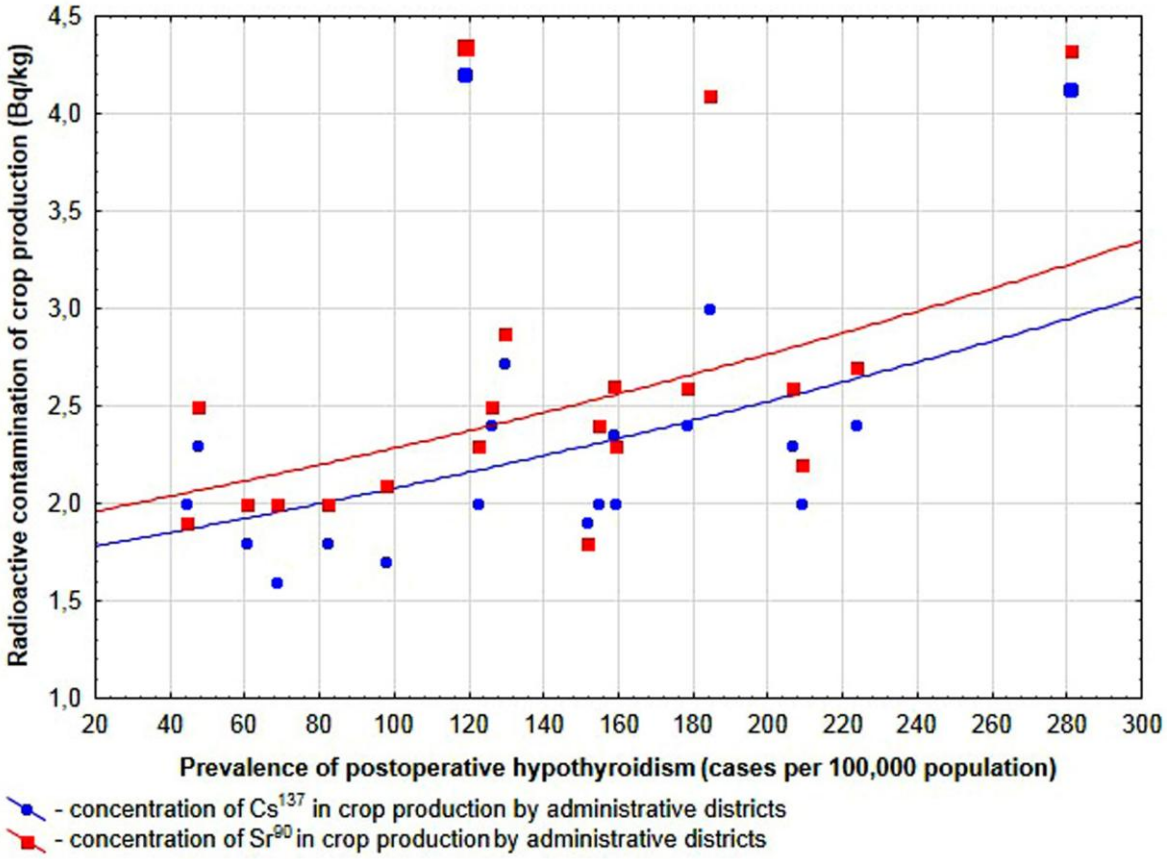

Fig. 2. Correlation between the postoperative hypothyroidism in the population of Sumy region and the radioactive contamination of crop production

No less serious is the problem of soil contamination by heavy metals. For example, the agrochemical certification [5] in 2013 were surveyed 178.8 thousand ha of agricultural land in five districts. Studies indicate that the content of Pb in soils of farms Buryn' district was 0.24-1,86 mg·kg^{-1}, Krolevets' – 0.32-1,7, Krasnopillya – 0.28-2,12, Putyvl' – 0.35-1,83, and Yampil' disrticts – 0.18-1,34 mg·kg^{-1} etc. The content of Cd in soils of administrative districts was – 0.05-0.32 mg·kg^{-1}, Cu – 0.07-0.28 mg·kg^{-1}, Zn – 0.25-2,2 mg·kg^{-1}, Co – 0.08-0.36 mg·kg^{-1}, and Mn – 6,7-38,0 mg·kg^{-1}.

Special attention is attracted to the Pb and Cd, given their negative impact on human health. With these contaminations with medium and large closeness of the relationship are correlate 12 diseases of such nosological classes: blood diseases and blood-forming organs (anemias), endocrine system diseases, digestive disorders, metabolic disorders (obesity), skin diseases (atopic dermatitis), and diseases of musculoskeletal systems and connective tissue (gouty arthritis and podagra).

However most closely with the content of Pb in soils are correlated the diseases of circulatory system (Fig 3): acute and repeated myocardial infarction ($r = 0.574$, $p = 0.01$), non-rheumatic involvement of cardiac valves ($r = 0.565$, $p = 0.01$), atrial fibrillation and atrial flutter ($r = 0.461$, $p = 0.05$). Also closely the contents of Pb in soils are correlated the diseases of digestive organs (Fig. 4): duodenal ulcer ($r = 0.539$, $p = 0.02$), gastritis and duodenitis ($r = 0.614$, $p = 0.01$), diseases of peritoneum and bowel ($r = 0.569$, $p = 0.011$), cholelithiasis ($r = 0.6$, $p = 0.01$).

Somewhat less noticeable is the impact on the prevalence of diseases another heavy metal – Cd. As in the case of Pb, there is a fairly reliable connection between the content of Cd in soils Sumy region and the prevalence of anemia, acute and recurrent myocardial infarction, non-rheumatic involvement of cardiac valves, atopic dermatitis. More close relationship we observe between the content of Cd and prevalence of diseases of the digestive system (Fig. 5): gastric ulcer and duodenal ulcer ($r = 0.57$, $p = 0.01$), gastritis and duodenitis ($r = 0.68$, $p < 0.01$), dyspepsia ($r = 0.509$, $p = 0.03$), peritoneum and intestinal diseases ($r = 0.59$, $p = 0.08$), cholelithiasis ($r = 0.6$, $p = 0.01$).

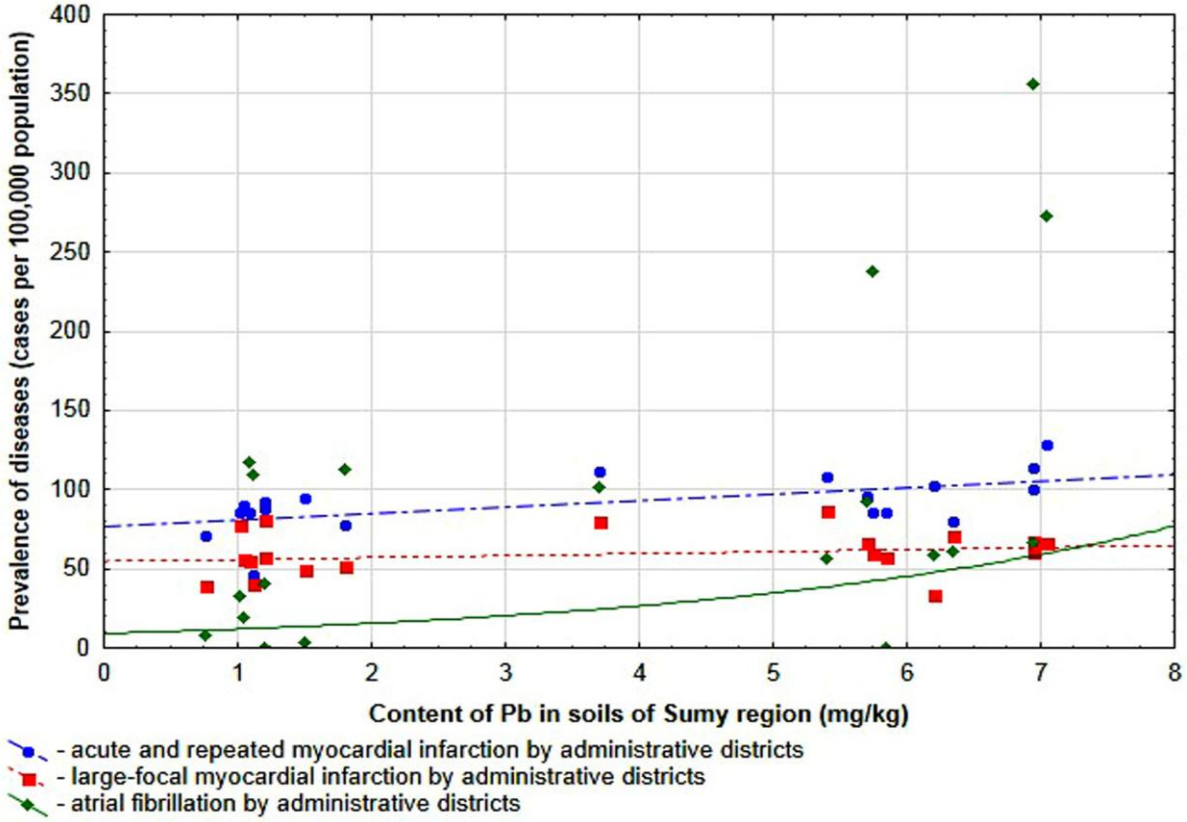

Fig. 3. The impact of soil pollution by Pb on the prevalence of some diseases of heart

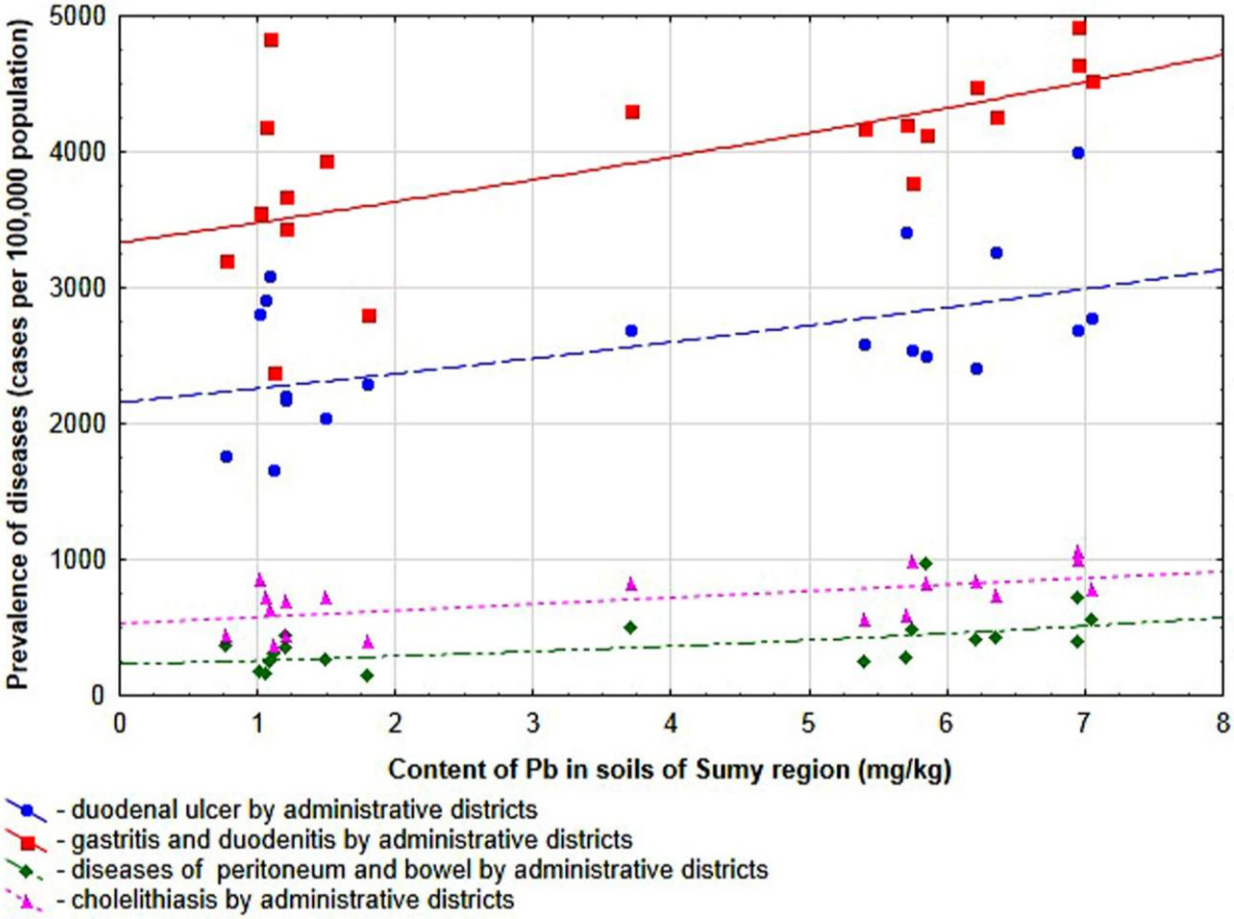

Fig. 4. The impact of soil pollution by Pb on the prevalence of diseases of the digestive system

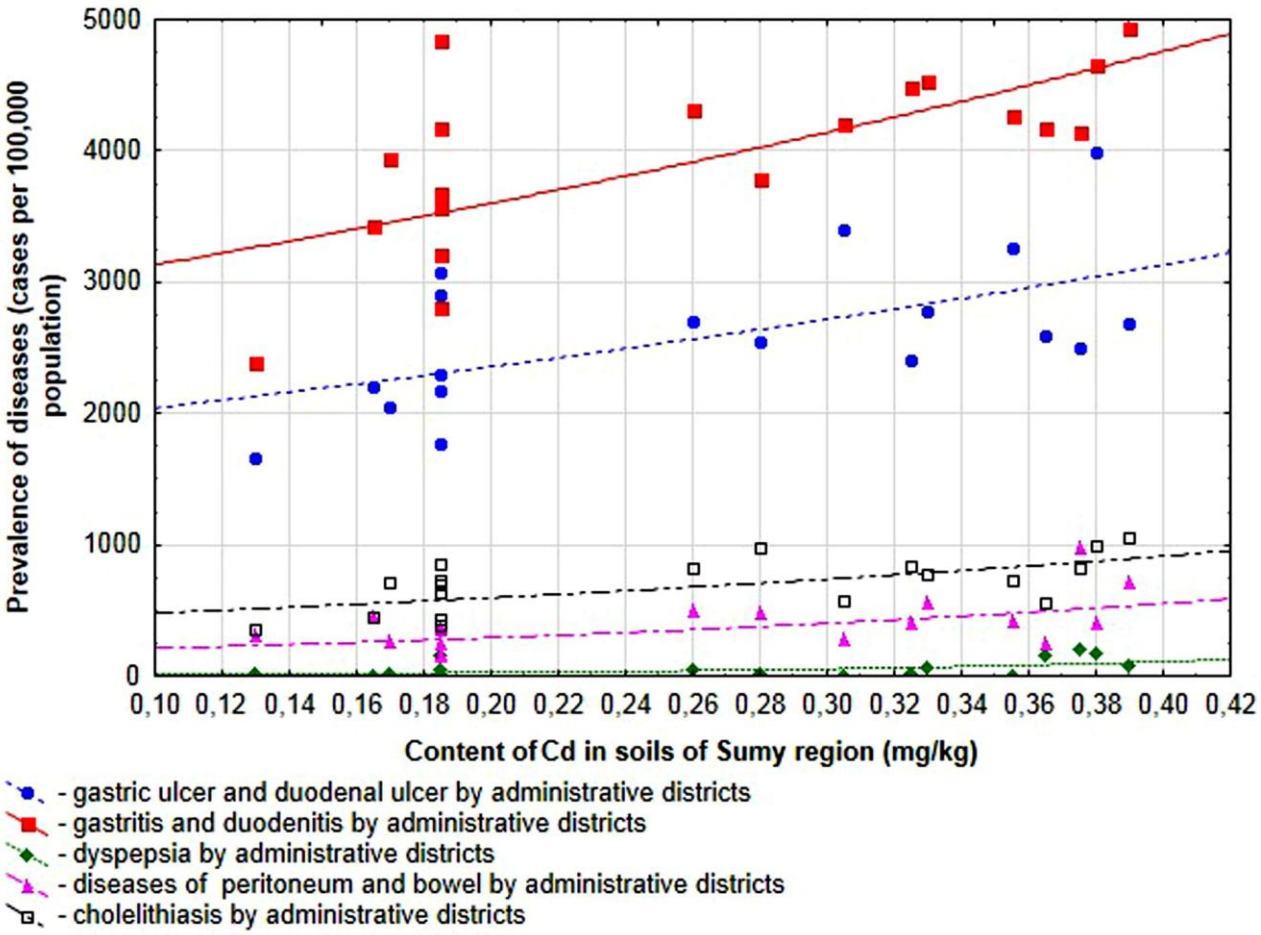

Fig. 5. The impact of soil pollution by Cd on the prevalence of diseases of the digestive system

Correlation of public health and air pollution level. Atmospheric pollution of Sumy region is due to the emission of pollutants from stationary and mobile sources, their cross-border transfer, and the conditions of the air self-cleaning. The presence and character of stationary pollution sources are determined by the development in the region the mining, chemical industry, machinery, food industry and other sectors of the economy that make emission of pollutants to the air. As of 01.01.2014, in the region there 213 industrial enterprises and objects (in 1990 there were 422), which carried out the emission of harmful substances into the atmosphere [7].

The results of many medical-ecological studies are show that there is close links between pollution of surface layer of the atmosphere and the health of the population both in time and in space. For example, in [2], which concerns to medical and ecological assessment of the Chernivtsi region was found that the most vulnerable human organs are organs of direct exposure (the respiratory organs). In the same paper was received extremely high correlation coefficients (r = 0.9) between air pollution and disease of children by bronchial asthma, as well as the dependence of mortality due to respiratory diseases from overall emissions of air pollutants. It is also alleged existence of a link between air pollution and the development of tumors and other clinical forms.

Our study did not confirm the existence of such dependencies. But most closely and with a high degree of reliability is the relationship between air pollution emissions from stationary pollution sources and prevalence of cardiovascular diseases, particularly infarctions (Fig. 5).

Since 1984, volume of emissions from mobile means was exceed the emissions from stationary sources of pollution. Since 1991, due to the rapid decline of industrial production and decrease of intensity of freight and passenger traffic, there was a sharp reduction the emissions of pollutants to the air. The emissions over the past 5 years remain at one and the same level. However, a very sparse network of monitoring stations for air pollution in the region and a small number of them do not allow objectively evaluate the air quality in the region as a whole. In addition, in the Sumy region there are no point observations for transboundary air pollution.

Emissions to the atmospheric air from the territory of Sumy region are uneven. The largest anthropogenic pressures is in atmosphere of the cities. In the city of Sumy from stationary pollution sources in 2013 was emitted – 9.86 thousand tons of hazardous substances (32.3% of emissions from stationary sources of the region), in Sumy district – 10.08 ths. tons (33%), in the town of Romny – 0.24 ths. tons and Romny district – 3.7 ths. tons (12.12%), in the town of Okhtyrka – 0.68 ths. tons and Okhtyrka district – 3.37 ths. tons, or (11.03%), in the cities of Shostka – 0.57 ths. tons, Konotop – 0.26 ths tones. The highest density of pollutant emissions from stationary sources per 1 km² in 2013 were in the cities of Sumy (67.97 tons), Okhtyrka (22.02 tons), Shostka (15.73 tons), Romny (8.23 tons).

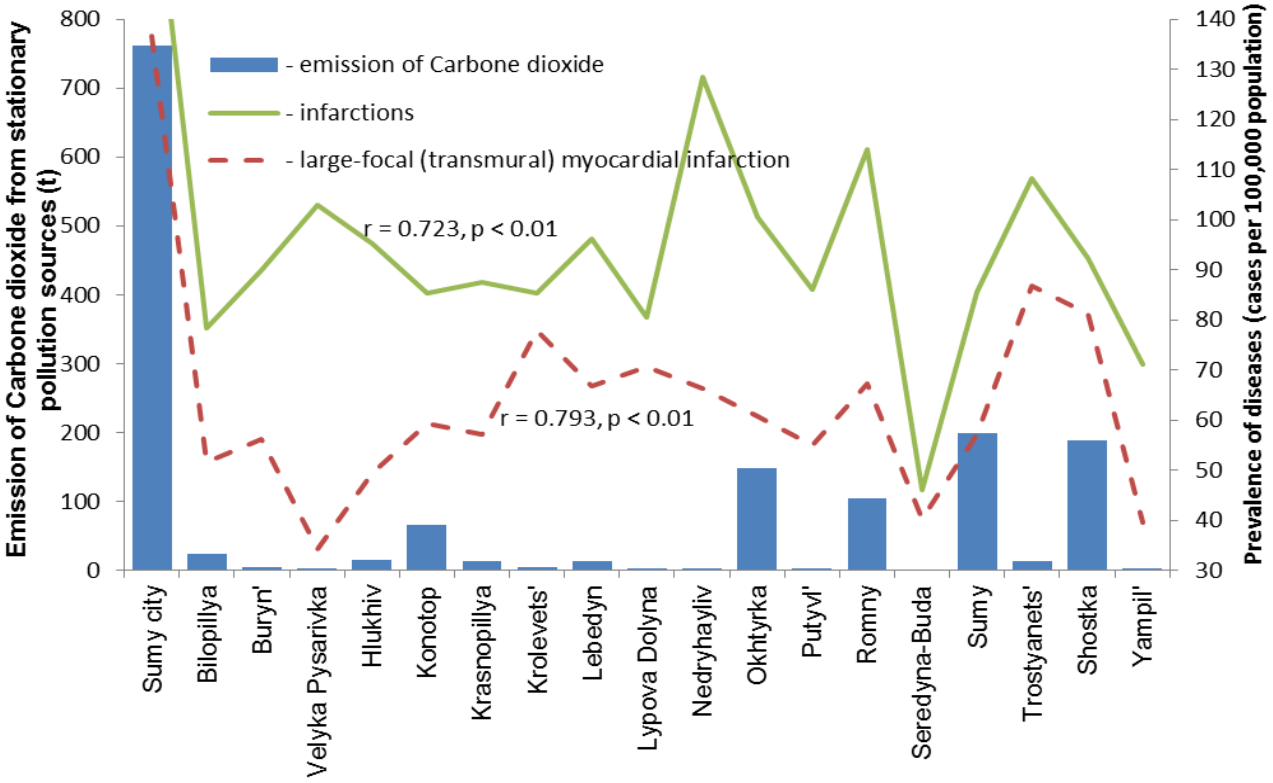

Fig. 6. The relationship between the incidence of infarction and the emission of CO_2 to the atmospheric air of Sumy region from stationary pollution sources by districts

Most closely the prevalence in the population of some administrative units of Sumy region the large-focal (transmural) myocardial infarction and infarctions at all is related with the amount of air emissions from stationary pollution sources by SO_2, C and CO_2. It is worth noting that between disease prevalence and emissions of pollutants to the atmospheric air from mobile transport means, reliable correlations can not be traced.

With the volume of Carbon emissions from stationary pollution sources is closely related the prevalence of heart nosology (Fig. 7), such as disorder of cardial conduction ($r = 0.905$, $p < 0.001$), atrial fibrillation and flutter ($r = 0.829$, $p < 0.001$) and diseases of mammary gland ($r = 0.852$, $p < 0.001$). With emissions of methane to the atmospheric air from stationary pollution sources is reliably correlate only diseases of bowel and peritoneum ($r = 0.737$, $p < 0.001$).

In addition to CO_2 and Carbon emissions, a significant number of diseases are reliably correlated with the SO_2 air emissions from stationary pollution sources. Among them are such nosological forms as disorders of the immune mechanism ($r = 0.601$, $p = 0.006$), hypothyroidism ($r = 0.531$, $p = 0.019$), pancreatic diabetes with complications ($r = 0.606$, $p = 0.006$), contact dermatitis ($r = 0.615$, $p = 0.005$) and male sterility ($r = 0.576$, $p = 0.009$).

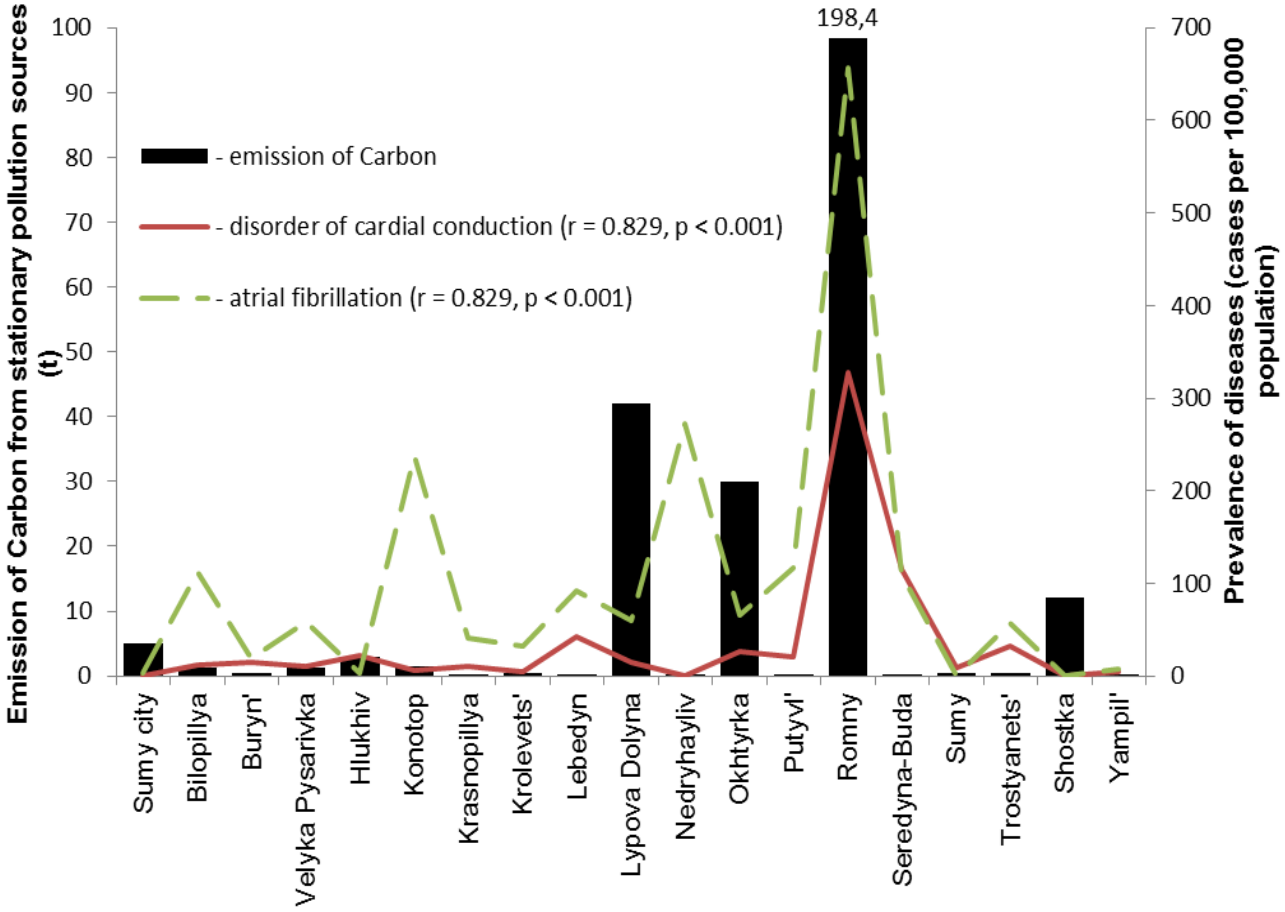

Fig. 7. The relationship between the heart nosologies and the emission of Carbon to the atmospheric air of Sumy region from stationary pollution sources by districts

Note that, such polluting component as SO_2, we have chosen not by chance, but because namely to it are normalized emissions of other pollutants, taking into account their harmfulness. Our results are differ significantly from the results obtained in [2], which can suggests the presence of significant differences of medical-ecological situation in different regions of Ukraine.

The quality of drinking water and the prevalence of diseases in the population of Sumy region. The basis of assessment of water as a food product is its compliance with sanitary standards for a number of features that are limited. Each region has its own drinking waters by chemical properties and contribution to the biochemical balance of the person. Therefore, often there is a close link between the character of the diseases, which are most often founded among the population, and sanitary parameters of sources household and drinking water. According to the WHO, 80% of all diseases are caused by consumption of contaminated water [1].

Ecological and geochemical assessment of natural waters, made by various researchers, make it possible the identify links between the different diseases and the concentrations of chemical elements and compounds in water. Among them, the occurrence of endemic goiter, which is caused by low iodine content; increased the cardiovascular diseases in connection with the use of drinking water with a low content of Ca^{2+} and Mg^{2+} cations; caries, dental fluorosis and other pathological of tissues teeth, which are caused by deficiency or conversely, an excess of fluoride with respect to its standard ratio for drinking water.

In recent years, many numbers of scientific papers are about of impact of the quality of drinking water on noncommunicable diseases. It was found that the balance of minerals in the body is important in the genesis and prevention of a number of systemic diseases, is closely related to the mineral composition of drinking water [2].

Most of the contaminants are enters into surface water with sewage, the volume of which in recent years has increased slightly. In 2013, the total discharge of wastewater into surface water bodies was amounted to 60.09 mln. m^3, of which only 7.3 mln. m^3 before being discharged into

water bodies was provided to normative cleaning at of wastewater treatment facilities, that accounting for 12.15%. The main part of polluted wastewater – 26,91 mln. m^3 (44.78%) was discharged into surface water bodies of insufficiently treated waters, and another 0.066 mln. m^3 – without treatment. Also without purification was discharged 25,82 mln. m^3 normative clean water [4]. Most of insufficiently treated and untreated sewage are fall from housing and utilities.

On the territory of Sumy region are 66 complexes of treatment facilities with a total capacity of 296 ths. m^3 per day. 48 of them are operating in a mode of artificial biological treatment with subsequent discharge of treated or inadequately treated sewage into water bodies. Total length of sewage network region is 1.03 ths. km, including dilapidated requiring replacement – 0.37 ths. km [5]. Discharge of untreated and inadequately treated wastewater is due to inefficient operation of the existing wastewater treatment facilities, and their lack of quantity. Also, do not contribute to the improvement of the ecological status of water bodies the existing technological schemes of water treatment facilities, outdated treatment technology, a significant deterioration of the existing water and sewer networks.

In connection with the moral and physical deterioration of facilities and equipment, is inefficient working of treatment plants in the towns of Konotop, Romny, Sumy, Yampil', Buryn', Lebedyn, Trostyanets', Nedryhayliv. Due to violations of the technological mode of wastewater treatment project did not come to good operation the treatment plants in town of Bilopillya and others. From these enterprises into water bodies is discharges of wastewater, that do not meet the standards for phosphates, organic substances and nutrients. With the wastewaters into surface waters in 2013 were discharged 30.3 ths. tons of pollutants. The volume of these substances in comparison with 2012 was increased by 4.37 ths. tons. The main sources of pollutants into water bodies of the region are public utilities enterprises and the chemical industry.

By tracking the quality of drinking water in the Sumy region in 2010-2011, we have calculated the coefficient of water quality by bacteriological indicators by administrative-territorial units. Values of coefficient were calculated by formula:

$$Rib = Rib_c \cdot ke_c + Rib_d \cdot ke_d + Rib_{wm} \cdot ke_{wm},$$

where Rib – coefficient inconsistencies of water quality (bacteriological); Rib_c – the proportion of water samples from sources of centralized water supply that does not satisfy of sanitary requirements (bacteriological); Rib_d – the proportion of water samples from decentralized water sources that does not satisfy of sanitary requirements (bacteriological); Rib_{wm} – the proportion of water samples from the water mains that do not satisfy of sanitary requirements (bacteriological); ke_c – the coefficient of ensure of population by centralized water supply; ke_d – the coefficient of ensure of population by decentralized water supply; ke_{wm} – the share of housing that is connected to mains water.

With the quality of drinking water may be associated various diseases, that are related to various nosological classes. The most closely and reliably are correlated with it the mammary neoplasms ($r = 0.588$, $p = 0.01$), acuta and chronica otitis ($r = 0.667$, $p < 0.01$ and $r = 0.676$, $p < 0.01$ respectively), rheumatic fever without involvement of heart ($r = 0.669$, $p < 0.01$), disorder of cardial conduction ($r = 0.584$, $p = 0.01$), liver cirrhosis ($r = 0.643$, $p < 0.01$) (fig. 8), disasters of prostate gland ($r = 0.577$, $p = 0.01$), including the hyperplasia ($r = 0.567$, $p = 0.01$).

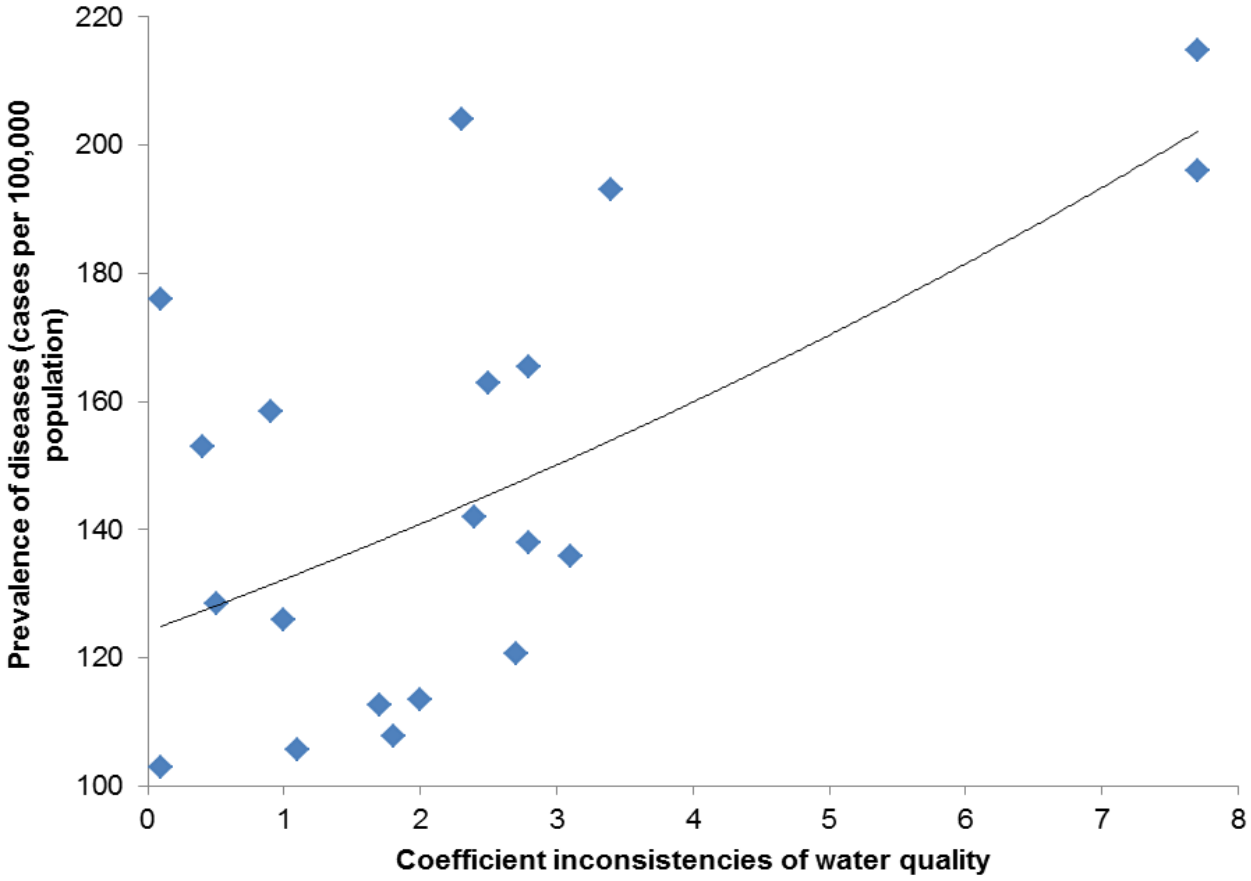

Fig. 8. Influence of drinking water quality for the prevalence of morbidity by liver cirrhosis by administrative district

Analysis of water quality in 2010-2011 shows that every tenth samples of water from the public water supply, every sixth water samples from the departmental water supply and every third samples from rural water supply did not satisfy of sanitary requirements. These standards are not consistent with every tenth sample from wells intakes. Half of water samples from wells of public water consumption are not satisfy of sanitary standards by chemical and bacteriological parameters. However, the study of influence of the drinking water quality, namely its degree of mineralization, microelements and other chemicals on human health and sanitary conditions of life in Sumy region not carried out.

The remaining 17 nosologies (anemias, immunodeficiencies, goiter of 1st degree, obesity, ischemic fit, cataract, acute rheumatic fever, atrial fibrillation and atrial flutter, atherosclerosis, pneumoconiosis, gastroesophageal reflux, infection of external integuments and subcutaneous fat, disorder of intervertebral disks of the cervical and another parts, disasters of mammary gland and neck of uterus, emmeniopathy and another female disorders have somewhat lower, albeit significant association with the quality of drinking water. The values of correlation coefficients for these nosologies are varies from 0.449 to 0.539 at a level of reliability $r \leq 0.02 \leq 0.05$.

Discussion

As you can see, the dependence of prevalence of the various diseases from various ecological parameters of the environment is quite complicated. On the one hand, due to the peculiarities and disadvantages of medical statistics, and on the other – due to the complexity of assessing the quality of the environment. The latter is also caused by disadvantages of environmental statistics, imperfect measurement of environmental parameters, an insufficient number of posts and points, where is the monitoring of environmental quality, disregard of transboundary transport of pollutants. Of course, on the prevalence of diseases is not affect environmental condition only, but other factors: socio-economic conditions, the level of medical care, etc., which act together with the

factor of environmental quality. Consequently, can be different compensations, when the influence of the environment can hide behind a greater or lesser influence of other factors, that are also affects to health. In addition, environmental factors are also doing not act alone but together, which further complicates our task.

In order to establish a universal relationship between the state of the environment and the prevalence of diseases of the population, it is advisable to move from individual parameters, that characterizing a particular component of the environment, to a more generalized indicators. For this purpose, we calculated the coefficients of correlation between the quality of the three main components of the environment: 1) air pollution, including the level of gamma-background, 2) chemical and radioactive contamination of soils and crop production, and 3) the quality of drinking water and the prevalence of diseases.

Of the many known coefficients to calculate the aforementioned dependences, we have selected the τ-b Kendall coefficient, which is a measure of rank correlation. The dependence of the prevalence of disease in the population of Sumy region from emission of pollutants to the atmospheric air from stationary pollution sources is 0.583, soil pollution is correlates with prevalence of diseases slightly better (τ-b = 0.639). And the greatest closeness of the relationship have the prevalence of diseases and the quality of drinking water (τ-b = 0.777). All obtained coefficients were checked for authenticity by using χ^2 test and are significant at level <0.05.

Conclusions

Anthropogenic factors are playing a significant role in shaping the medical-ecological situation in the administrative districts of Sumy region. Although this region has a moderate level of environmental pollution, and the decline in industrial production is continues, the diseases of population by majority of nosologies are growing, like and the prevalence of most diseases. On the one hand, this is due to an aging population, but influence of environment quality, as shown by our study, is also enough perceptible, especially for some nosologies, that are common among residents of Sumy region.

In terms of specific diseases, the greatest dependence from the state of the environment has the nosological classes of circulatory system diseases, digestive diseases and diseases of the genitourinary system. They are characterized by the maximum number of significant correlation coefficients (21, 12 and 12, respectively) with the individual parameters of the environment. Among the individual indicators is best correlated the Carbon emissions to the atmospheric air from stationary pollution sources and disorder of cardial conduction ($r = 0.905$, $p < 0.001$), fibrillation and atrial flutter ($r = 0.829$, $p < 0.001$) and diseases of mammary gland ($r = 0.852$, $p < 0.001$).

The comparative evaluation of the impact of environmental factors made possible to identify the leading of them. Found that the most influential are levels are chemical contamination of soils by Pd and Cd (12 and 9 reliable correlation coefficients, respectively), and the contamination of drinking water, especially from the centralized water supply sources (11 dependencies). In the integrated form, the quality of drinking water is the most important factor, which closely correlated with the prevalence of many diseases among the population of Sumy region. The influence of the ecological state of the air, including the gamma-background level, chemical and radioactive contamination of soils and crop production are also important, although less markedly.

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