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CONTENTS

HEALTH AND ENVIRONMENT: THE URGENT PROBLEM OF MODERN INTERDISCIPLINARY RESEARCH[1]

The problem of the relationships between humans and the environment is becoming increasingly urgent, which is reflected in studies of medical geographers, anthropologists, and scientists of other disciplines. The scope includes theoretical and experimental research on natural and anthropogenic risk factors, medico-geographical consequences of regional changes of the environment, population health of urbanized territories, background factors promoting the spread of infectious and parasitic diseases, organization of health care, etc. The interest to this problem has increased as a result of new challenges of the last decades, namely, global change of natural environment, increased population migration, appearance of a new group of "emerging" diseases, etc. The results of these research efforts have been presented at numerous medico-geographical and environmental anthropology conferences.

One of the sections of the Regional Conference of the International Geographical Union (IGU) held in Moscow in August of 2015 was devoted entirely to the issue of "Health and Environment." The section hosted 28 oral and 7 poster presentations from 12 countries.

Prior to the Regional Conference, the IGU Commission "Health and Environment" conducted a scientific and practical seminar on medical geography and human ecology in the city of Vladimir. Such workshops are a long-standing tradition of the Commission which organizes them immediately prior to the congresses or regional conferences in the hosting country. The 2015 seminar was organized by the Faculty of Geography of the Lomonosov Moscow State University and the Department of Biology and Ecology of A.G. and N.G. Stoletov Vladimir State University. The seminar was attended by 45 scientists from 7 countries; 19 oral and 11 poster presentations were made; the themes of the presentations were related to the most important modern problems.

One of the main traditional research areas is the effect of various environmental factors on the population health, which covers both the role of the individual components and their combined effects. Many researchers addressed one of the most important issues of this field of studies – the meteorological factor. The presentations included works on the bio-climatic and meteorological conditions in the Central (E. Kulagina et al.) and the North-Western regions of Russia (E. Semina et al.; M. Trubina) and on heat waves in the Kuban region (E. Carvajal Ciomina et al.). Natural hazards in Europe were analyzed by E. Semina et al. The role of geochemical factors (the content of arsenic in drinking water) in the spread of skin tumors was discussed by Y. Xia using Inner Mongolia as an example. Influence of a complex of environmental factors on the population health of an industrialized area was demonstrated on the example of the Vladimir region (Trifonova et al.). The study noted that in recent years there has been a continuous increase in the incidence rate in the populations of all age groups, which the authors attributed mainly to poor environmental conditions. Local geographical factors and their impact on health in Chechnya were analyzed by H. Eldarova.

Allergy has long been one of the most common problems of the population of

[1] The review is based on the Book of Abstracts of International Geographical Union (IGU) Commission on Health and Environment Pre-Conference Meeting on Medical Geography and Human Ecology, 13–16 August 2015, Vladimir, Russia. Vladimir, 2015. – 35 p. and the IGU 2015 Book of Abstracts, International Geographical Union: Moscow, 2015. – pp. 516–556.

developed countries. The role of biotic factors was demonstrated in the study on the distribution range of plants-allergens in Russia (Dikareva, Rumyantsev) who studied the main pattern of their distribution. A presentation by O. Konstantinova et al. was devoted to intoxication from snake-bites in the Republic of Guinea. The use of folk remedies by local communities was discussed on the example of the population in Maharashtra, India (Ravindra G. Jaybhaye, Bhaskar I. Gatkul). These interdisciplinary studies, based on traditional methods of biogeography, ecology, and human health geography, are a good example of cooperation between experts in different areas.

One of the problems of human ecology on the agenda at the beginning of the XXI century is the problem of population aging. This issue has been studied relatively well in China, where the share of the older population is growing because of the government demographic policy. There is now a substantial territorial differentiation of elderly population and its growth rate (Y. Cheng et al.). A faster growth of the elderly population is observed in rural areas, while the quality of life for people over 65 is much higher in large cities, due to the greater availability of medical care, medical drugs, and higher quality food. Natural and socio-economic factors play the significant role: a greater percentage of older people are in areas with a mild climate and a well-developed social infrastructure. The role of lifestyle for healthy aging is emphasized by W. Wang et al.; L. Wang et al. Spatial aspects of the health of older people in big cities are considered by S. Yang, Q. Zhu who used one of the world's largest cities, Beijing, as an example. The influence of environmental factors was analyzed as a factor of the longevity phenomenon. The conference also discussed the results of studies on similar problems in Europe (for example, Luxembourg by B. Koeppen et al.). The purpose of this kind of research is the creation of forecasts and making the information available to public authorities to improve the population policy and health protection measures.

Another important topic in modern research on medical geography and human ecology is urban health. Spatial and temporal patterns of population growth in large cities in China were discussed by Wang Wuyi et al. Conventional studies have focused on different aspects of the relationship of the environment and health. The results of assessment of the impact of air pollution on environmentally-dependent diseases were presented by Wang Wuyi et al. (Y. Cheng et al. and Xiaofeng Gao, Huiping Liu. The relationships between disease incidence in various population groups and the location of large industrial enterprises for a large industrial center (the city of Voronezh, Russia) were discussed by S. Kurolap et al. The scientists demonstrated that the use of GIS technology is a reliable tool for presentation of spatial differentiation of disease incidence and can be used in development of long-term health care programs for the populations of large cities.

A study conducted in St. Petersburg among the students who come to study from various regions with different climatic conditions and cultural and ethnographic characteristics focused on problems of physical and psychological adaptation (Y. Scoryk et al.). The urban environment has an impact on the physical and psychological state, however, this issue remains poorly understood.

Mortality is one of the key indicators of the state of public health. The territorial differences in the distribution of this indicator in the Russian Federation were considered by S. Timonin. The regions with the highest and lowest values of mortality were identified by N. Shartova, S. Malkhazova. The authors made an attempt to explain the differences by the influence of historical and contemporary natural and socio-economic factors.

Assessment of environmental and socio-economic values provided by urban ecosystems (climate regulation, maintenance of green spaces, etc.) allows identification of the benefits that may be received by society (the economy, health and well-being of the population) and the environment from the use of natural capital without additional investment. Identification of the key service functions as the structural elements of the ecological framework allows cities to assess their importance for improving the quality of the environment and health and well-being of the population (D. Dushkova et al.).

A new direction in environmental anthropology research is the study of the impact of lifestyle on health and the identification of risk factors. Studies in the US have identified the main causes of ill health in post-industrial countries, i.e., insufficient physical activity and poor diet, leading to the spread of cardiovascular disease, type II diabetes, and obesity (E. West). A study conducted in Romania by A.M. Talos showed the spatial differentiation in the level of health of the population caused by differences in lifestyle.

A significant number of studies were devoted to the territorial organization of the health care system, access to health care for the various categories of the population, and the international strategy for "health for all" (Global health) (T. Krafft, E. Pilot, Wang Li). Examples from different countries (India, Canada, Romania, and other European countries) were used to consider regional specificity of the work of health care services (M. Rosenberg, K. Wilson, L.K.P. Prem, A. Banerjee; K. Wilson et al.; A. Cruceanu et al.; L. Dumitrache et al.).

Traditionally, medical geography has focused on the geography of diseases caused by live disease-causing agents. These studies are aimed at identifying patterns of distribution of certain diseases or entire groups of diseases and development of new or improvement of existing methods of spatial-temporal analysis. Thus, the results of mathematical and cartographic modeling of tularemia in the Smolensk region (Russia) were presented by T. Vatlina; a retrospective analysis of the spread of plague in Europe was presented by R. Yue; a study on the spread of waterborne diseases (a case study of India) was presented by B.I. Gatkul; and the use of cartographic methods to study the propagation of natural focal disease in Russia was presented by S. Malkhazova et al. Improvement of methodologies of landscape-malaria regionalization conducted on the example of southern Uzbekistan was discussed by E. Soldatova, V. Mironova. Applied aspects of the geography of natural focal diseases in Russia were considered in a case study on their impact on tourism activities (S. Malkhazova et al.).

Scientific discussion of the most urgent issues of modern medical geography and human ecology allows prioritizing problems related to the area "Health – Environment," which need to be addressed in order to improve the quality of life and to better understand the modern natural and socio-economic processes that determine the level of public health.

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SPATIAL PATTERNS OF PUBLIC HEALTH IN RUSSIA

ABSTRACT. The paper presents the characteristics of the status of public health in the regions of Russia in 2002–2012 conducted considering life expectancy of men and women, as well as infant mortality. Public health trends were identified in comparison with 1990–2001. Five groups of regions with specific status of public health were isolated and analyzed. Cross-spectrum analysis of environmental and socio-economic factors was conducted in order to explain the existing level of mortality of the population.

KEY WORDS: public health in Russia, mortality, life expectancy, territorial differentiation, correlation analysis.

INTRODUCTION

Health of the population is one of the main criteria for the sustainable development of regions. It is characterized by such health and demographic indicators as morbidity, mortality, life expectancy, disability, temporary disability; its status is an indicator of the quality of the environment [Environment…, 1979; Urbanization and Health..., 2011]. It is necessary to draw a clear distinction between individual health and public (population) health. Individual health is a combination of all the individual systems of the body of a single person. Public health quite objectively reflects the socio-economic sphere of life and characterizes the environmental status of a particular region [Prokhorov, Shmakov, 2013]. Currently, the model of public heal is undergoing transformation into the model of "environmental public health." This concept treats a person as part of an ecosystem, not removed from it, but not at its center [Bentley, 2013]. The assessment criterion implies, as a rule, the population-based level of biological responses (physiological responses, morbidity, and mortality) to environmental changes [Revich, Avaliani, Tikhonov, 2004].

PROBLEM STATEMENT

The study of public health is a multifaceted problem. Initially in Russia (the beginning of the XX century), public health research mainly included assessment of incidence and identification of the causes of the spread of infectious diseases. These studies involved identification of the distribution of typhoid, smallpox, and malaria in Russia and relationship between these diseases and the railways and river routes, the quality of health monitoring, etc. The League of Nations Epidemic Commission noted that the statistical data provided by the People's Commissariat of Health for such work were quite correct, and sanitary measures implemented based on this research were very effective [Guest, 1923].

Subsequently, the importance of non-communicable diseases and the role of environmental factors in the status of public health were becoming increasingly apparent. However, by the middle of the XX century, despite the significant number of "descriptive" works on medical and demographic situation in Russia, virtually no studies that would present comprehensive information on mortality and morbidity, environmental factors, housing and sanitation conditions, social stratification etc., had been conducted [Brockington, 1956; Mazique, 1961]. It is also typical of the works of the later, post-Soviet period, when many of the factors that determine the health of the population in Russia were identified, however, they were usually not analyzed in depth [Heilig, 1999; Tkachenko, McKee, Tsouros, 2000].

By the beginning of the XXI century, a number of works analyzing the status of public health in Russia in great detail were published [Prokhorov, 2000; Public Health... 2007; Prokhorov, Gorshkova, Tarasova, 2003; Prokhorov, Tikunov, 2005; Prokhorov, 2009]. These works are based on a comprehensive comparison of the regional status of public health, the economic situation, and the levels of contamination of the environment and the comfort of natural conditions of the regions for the life of the population.

Dozens of indices and indicators of public health have been developed [Rothenberg et al., 2015]. The main characteristic of the health status of the population, according to the recommendations of the World Health Organization, currently include life expectancy for men and women, the infant mortality rate, i.e., mortality of children under 1 year of age per 1000 of live births [Bulletin..., 2009; Malhazova, Koroleva, 2011; Agenor, 2012].

This paper presents a medical-geographic assessment of the Russian territory for 2002–2012 based on one of the indices of public health to reflect the current situation and to identify its trends compared to 1990–2001. Several major environmental and socio-economic indicators have been analyzed to determine the possible causes of the specific status of public health [Malkhazova et al., 2014; Shartova, Krainove, Malhazova, 2015]. The indicators of public health used in the analysis and identification of the potential risk factors included the mortality of men and women by the causes of death and life expectancy in the cities, because urban population may have more distinct responses to environmental change [Addington, Weiss, 1999; Pascal et al., 2013].

Materials and methods

Medical-geographic assessment of the regions of Russia conducted using demographic indicators (life expectancy, infant mortality, the urban population mortality by causes) from the Federal State Statistics Service (Rosstat), published in the collected volumes "Regions of Russia" and "Demographic Yearbook of Russia" and bulletins "The Natural Movement of the Population of the Russian Federation" and "Healthcare in Russia" for 2003–2013.

For comparative assessment of public health in Russia by its regions, an integrated parameter was used, specifically, the index of Public Health (IPH) which combines coefficients of infant mortality and life expectancy for men and women [Prokhorov Tikunov, 2005]. Its calculation is based on an assessment algorithm that includes normalizing of the system of the initial parameters with the formula:

$$\hat{X}_{ij} = \frac{\left| x_{ij} - \overset{o}{x}_j \right|}{\left| {}_{\max/\min} x_j - \overset{o}{x}_j \right|},$$

$i = 1, 2, 3, \ldots, n$; $j = 1, 2, 3, \ldots, m$.

where $\overset{o}{x}$ is the worst conditions (for each parameter) out of all occurring situation over the entire period (maximum infant mortality and the lowest life expectancy); ${}_{\max/\min} x$ is the parameter that deviates the most from the $\overset{o}{x}$ values; *n* is the number of territorial units under consideration (83 regions and Russia as a whole); *m* is the number of indicators used for the calculations (3). The calculations were performed for 2002–2012.

Correlation analysis was used to identify the relationships between the status of public health and environmental factors. It was conducted using the 2010–2012 data for 168 Russian cities with a population of over 100 thousand. Two groups of parameters were selected as environmental factors. The first group includes ecological parameters, e.g., certain characteristics of atmospheric pollution. The second group includes socio-economic parameters that characterize the state of the economy, health care system, and social services (Table. 1). Based on the nature of the distribution of the data used in the calculation, the non-parametric Spearman correlation coefficient with the 0.95 confidence interval was used.

Table 1. Ecological and socio-economic indicators

Indicators	Units of measurement
Environmental	
Release from stationary sources, including:	*thousand tones/yr*
solids	
sulfur dioxide	
carbon monoxide	
nitric oxide	
hydrocarbons and volatile organic compounds	
Socio-economic	
Population density	*people/ha*
Increase (decrease) of population due to migration	*per 1000 people*
Number of retirees	
Average monthly wage of workers	*rouble*
Living area per one person	*m^2*
Number of doctors	*per 10 000 people*
Capacity of outpatient clinics	*per 1000 people*
Number of sports facilities	
Number of recorded crimes	

The mortality of men and women by the causes of death and life expectancy was used as a characteristic of public health in the analysis. A total of 24 parameters for men and women were utilized in the analysis (Table. 2). Mortality rates were standardized according to the European standard and presented per 100 000 population of the corresponding sex and age [Denisenko, Kalmykova, 2007].

Table 2. Public health indicators

Indicators	Units of measurement
Life expectancy for men/women	years
Overall mortality for men/women	per 1000 people
Mortality by cause of death for men/women	
Diseases of the respiratory system	*per 100 000 people*
Diseases of the digestive system	
Diseases of the circulatory system	
Disease caused by human immunodeficiency virus (HIV)	
External causes of death	
Congenital anomalies (birth defects), deformations, and chromosomal abnormalities	
Malignant melanoma of the skin	
Malignant neoplasms of breast	
Malignant neoplasms of female genital organs	
Malignant neoplasms of male genital organs	
Malignant neoplasms of the respiratory system	
Malignant neoplasms of the urinary tract	
Malignant neoplasms of digestive organs	
Coronary artery diseases	
Neoplasms	
Pneumonia	
Event of undetermined intent	
Deaths caused by alcohol	
Suicides	
Tuberculosis, all forms	
Murders (assault, rape)	
Cerebrovascular diseases	

Results and discussion

Changes in the socio-economic and political situation in Russia are accompanied by a change of basic health and demographic

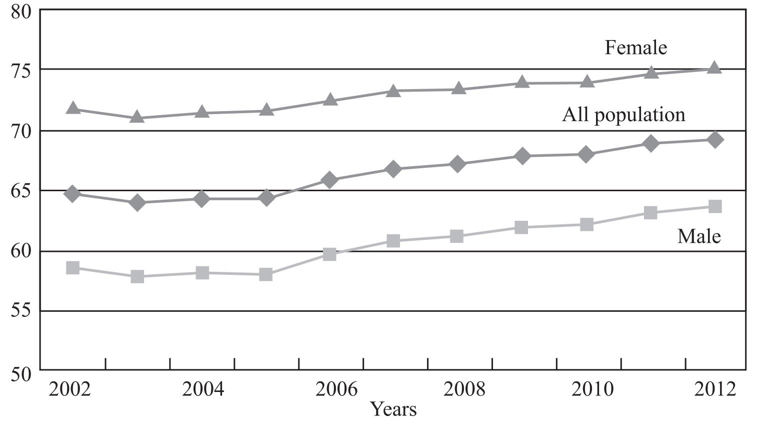

Fig. 1. Life expectancy in Russia in 2002–2012.

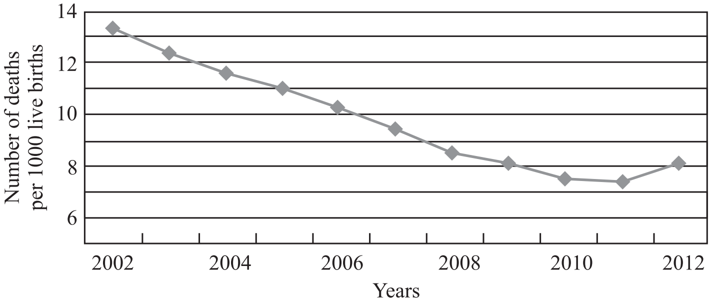

Fig. 2. Infant mortality in Russia in 2002–2012.

indicators. After the financial and economic crisis of 1998, the life expectancy in Russia was minimal and until 2005 did not exceed 65 yrs (Fig. 1). With the improvement of the socio-economic situation in the country, the average life expectancy has steadily increased, reaching 69.5 years in 2012, while male life expectancy has remained low (lower than 60 yrs in 2002–2006.).

Among the positive changes in health outcomes that have occurred in recent years, there is also a significant reduction in infant mortality, which, however, has stalled somewhat in 2012, probably as a consequence of the economic crisis at the end of the first decade of the XXI century (Fig. 2).

Overall, in 2002–2012, the status of public health in Russia varied (Fig. 3). From 2002 to 2006, it worsened, which was reflected in the decrease of IPH which reached the absolute minimum for this period. In subsequent years, there was a gradual improvement in medical and demographic situation, and in 2009–2010, the IPH value reached the level of 2002. However, in the next two years, the status of public health declined again, which may be partly due to changes in the statistical criteria of live births in infant mortality registration, which took place since 2011.

The status of public health for the 2002–2012 in average is presented on the map (Fig. 4). IPH calculation for each year has allowed ranking of the country's regions in terms of public health for each year and for 11 years overall for further comparative analysis. As a result, the regions were grouped into five categories according to the ranking.

The *first group* includes 8 regions with a satisfactory status of health: ranking from 1 to 8 (IPH 1.0–0.8) – Belgorod Oblast, the Republics of Dagestan, Ingushetia, Tatarstan,

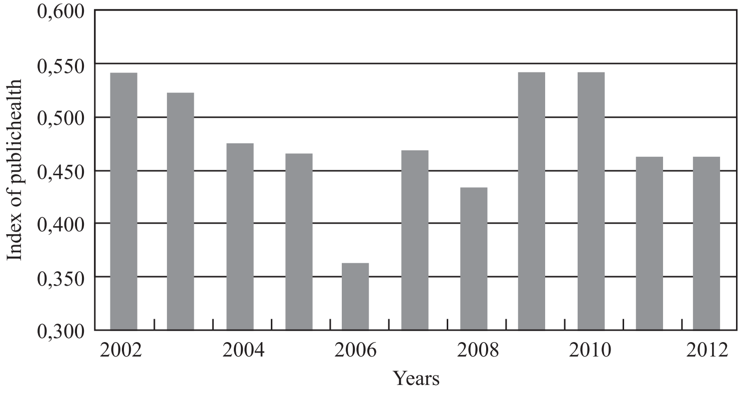

Fig. 3. The status of public health in Russia in 2002–2012.

Kabardino-Balkaria, Karachay-Cherkessia, and Moscow and St. Petersburg.

The *second group* is the most extensive and consists of 41 regions (ranking from 9 to 49 (IPH 0.8–0.7) with a somewhat worse health status. Almost all regions in this group have IPH above the average for Russia; however, they differ substantially among themselves. In this group, the highest status of public health is in the Krasnodar Krai, the Republics of Adygea and Chuvashia, and the Tambov Oblast. The lowest IPH values are in the Republic of Mari El, the Ryazan and Kaluga Oblasts, and the Altai Krai.

The *third group* includes 15 regions with a low health status (ranking from 50 to 64; IPH 0.7–0.6). This group includes Tula, Ivanovo, Kostroma, Smolensk, Leningrad, and Murmansk Oblasts, the Krasnoyarsk Krai, and the Republic of Yakutia.

The *fourth group* consists of 15 regions with very low health status (ranking from 65 to 78; IPH 0.6–0.5); the status is especially low in the Trans-Baikal and Khabarovsk Krais, the Republic of Khakassia, and the Magadan Oblast.

The *fifth group* includes 5 regions with critical health indicators (ranking from 79 to 83; IPH lower than 0.4): the Republic of Tyva, the Jewish and Chukotka Autonomous Districts, Altai Republic, and the Amurskaya Oblast.

The trend in the major regional IPH parameters over the past two decades shows relative stability of health and demographic indicators in most regions of Russia: in 56 out of the 83 subjects of the Russian Federation, the IPH ranking positions over 20 years have not changed; in 10 regions, the situation has worsened (especially in the Amur Oblast and the Chukotka Autonomous District); and only in 13 administrative units, including Moscow and St. Petersburg, the situation has improved.

Public health, especially the urban population, is influenced by environmental factors. For example, analysis of 25 European cities shows that air pollution is still playing a major role in determining the status of public health. Thus, reduction of the content of particulate matter and ozone in the atmosphere is expected to increase life expectancy and lower mortality [Pascal et al., 2013]. A number of studies found an association between low socio-economic status and high levels of morbidity and mortality from certain pathologies [Addington, Weiss, 1999]. Issues of health risk assessment of Russia's population in relation to exposure to pollutants in the atmosphere [Gurvich et al., 2004; Reshetin, Kazazyan, 2004; Zemlyanalya, Solenova, Kislitsyn, 2006; Lukjanova, Popova, 2011; Revich et al., 2015; Yakovenko, Kravchenko, 2015], as well as to the impact of socio-economic factors [Vandenheede et al., 2014; Chubirko et al., 2014; Trifonova, Shirkin 2015] at the regional level are considered in a relatively large number of works.

Fig. 4. Assessment of the status of public health in Russia in 2002–2012.

Table 3. Significant correlation coefficients (R) between the causes of death and environmental indicators

Environmental indicators / Causes of death	Release into atmosphere of pollutants from stationary soruces	including:			
		solid pollutants	nitrogen oxide	carbon monoxide	sulfur dioxide
Respiratory diseases, men	0.38*	0.40/0.41*	0.36*	0.36*	–
Respiratory diseases, women	–	0.36	–	–	–
Malignant neoplasm of the respiratory system, men	–	0.36/0.36*	–	–	–
Malignant neoplasm of the respiratory system, women	–	0.36*	0.37	–	–
Pneumonia, men	0.36*	–	–	–	–
Pneumonia, women	0.37*	–	0.37*	0.36*	–
Malignant neoplasm of the urinary system, women	0.35	–	0.36	–	–
Digestive diseases, women	–	0.35*	–	–	0.36*

Note. An asterisk indicates correlation coefficients for the sample of cities with a population between 100 and 800 thousand with a confidence interval of 0.95; values without an asterisk indicate correlation coefficients for the sample of cities with a population of 100 thousand to 11 million with a confidence interval of 0.95; dash indicates that a statistically significant correlation was not established.

The analysis conducted for the entire territory of Russia produced rather low correlation coefficients between the environmental parameters and public health parameters. The most significant coefficients are presented in Table 3. For example, mortality from respiratory diseases, including pneumonia, as well as malignant tumors of the respiratory system, has statistically strong association with release of solid pollutants into the atmosphere. A correlation between the mortality of men from respiratory diseases and emissions of nitrogen oxides and carbon monoxide has been established. Noteworthy the relationship between female mortality from cancer of the respiratory system and release of solid pollutants, and between diseases of the digestive system and release of solid pollutants and sulfur dioxide. The findings are consistent with other studies on the effects of air pollution on human health [Pascal et al., Shaposhnikov et al., 2014].

The calculations showed extremely low statistically significant correlation coefficients between the status of public health in the regions of Russia and the considered socio-economic parameters, which require additional research.

Conclusion

Analysis of long-term indices of life expectancy and infant mortality rates and the calculation of the integral IPH has allowed us to evaluate the medical and demographic situation in the regions of Russia and to reach the following conclusions:

– The subjects of the Russian Federation differ substantially in terms of public health, first and foremost, on infant mortality and life expectancy; a critical status is observed in the Far East (Chukotka Autonomous District, Jewish Autonomous District, Amur Oblast) and Southern Siberia (Altai and Tyva Republics);

– Trends in the status of public health for the 1990–2012 indicate a relative stability of the situation. In most regions of Russia, the status of public health has not changed; the deterioration occurred primarily in the Far East (Amur Oblast, Chukotka Autonomous District); in Moscow and St.

Petersburg, there has been a significant improvement in public health;

– Long-term dynamics of the basic indicators of public health reflects trends in socio-economic sphere of the country, above all, the consequences of the crisis period characterized by a general decline of the economy and an increase in social tension;

– Cross-spectrum analysis of the environmental and socio-economic factors, taking into account the health care system, can explain the current level of mortality or morbidity. Thus, a positive correlation between mortality from respiratory diseases, including pneumonia and malignant neoplasm of the respiratory organs, and emissions of pollutants into the atmosphere has been established. In order to obtain data on other causal relationships it is necessary to develop and use additional approaches and methods of medical and geographic analysis. ■

REFERENCES

1. Addington W.W., Weiss K.B. (1999) Chicago's response to the public health challenge of urban asthma // American College of Chest Physicians. № 116. pp. 132–134.

5. Agénor P.R. (2012) Public capital, growth and welfare: Analytical foundations for public policy. – Princeton University Press. – 252 p.

3. Bentley M. (2013) An ecological public health approach to understanding the relationships between sustainable urban environment, public health and social equity // Health Promotion International. Vol. 29. № . 3. pp. 528–537. DOI:10.1093/heapro/dat028

4. Brockington C.F. (1956) Public health in Russia // Lancet. Vol. 271. Pp. 138–141.

5. Bulletin of the World Health Organization (2009). 87: 714–719. DOI: 10.2471/BLT.08.058321

6. Chubirko M.I., Pichuzhkina N.M., Masajlova L.A., Lastochkina G.V. (2012) Otsenka vliyaniya social'no-ekonomicheskikh faktorov na mediko-demograficheskiye pokazateli (Assessment of the impact of socio-economic factors on health and demographic indicators) // Gigiena i sanitariya. № 6. S. 36–38.

7. Denisenko M.B., Kalmykova N.M. Demografiya: Uchebnoye posobiye (2007) (Demography: Textbook). M.: INFRA-M. 424 s.

8. Okruzhayushchaya sreda i zdorov'e (Environment and Health) (1979). M.: Nauka. 214 s.

9. Guest L.H. (1923) Public health in Soviet Russia // British Medical Journal. Part: 2. pp. 677–679.

10. Gurvich V.B., Plotko Je. G., Selyankina K.P., Nadeenko V.G., Ryzhov V.V., Sajchenko S.P., Veprintcev V.V. (2004). Dinamika zabolevayemosti detskogo naseleniya kak kriterij neobkhodimosti rekonstrukcii alyuminievykh zavodov (Dynamics of child morbidity as a measure of the need for reconstruction of the aluminum smelters) // Vestnik RAMN. № 3. S. 46.

11. Heilig S. (1999) A modern public health crisis: A physician speaks about healthcare in post-glasnost Russia // Cambridge Quarterly of Healthcare Ethics. Vol. 8 Issue 2. pp. 257–258.

12. Lukiyanova N.I., Popova E.S. (2011) Problems of risk assessment to public health in megacities (by example of some districts of St. Petersburg, Russia) // Russia Journal of General Chemistry. Vol. 81. Issue. 13. Pp. 2682–2687. DOI: 10.1134/S1070363211130093

13. Malkhazova S.M, Koroleva E.G. (2011) Okruzhayushchaya sreda i zdorov'e cheloveka (Environment and Health). M.: Geogr. f.-t MGU. 180 s.

14. Malkhazova S., Yang L., Wang W., Orlov D., Shartova N., Hairong L., Wang L. (2014) Health of urban population in Moscow and Beijing agglomerations // Geography. Environment. Sustainability. № 4. pp. 41–53.

15. Mazique E.C. (1961) Public health and medical care in Russia // Journal of the National Medical Association. Vol. 53. pp. 352–355.

16. Pascal M., Corso M., Chanel O., Declerq C., Badaloni C., Cesaroni G., Henschel S., Meister K., Haluza D., Martin-Olmedo P., Medina S. (2013) Assessing the public health impacts of urban air pollution in 25 European cities: Results of Aphekom project // Science of the Total Environment. 499: 390–400.

17. Prokhorov B.B. (2000) Obshchestvennoye zdorov'e v Rossii za 100 let (1897–1997) (Public Health in Russia over 100 years (1897–1997)) // Rossija v okruzhayushchem mire: 2000 (Analiticheskij yezhegodnik). M.: MNJePU. S. 133–168.

18. Prokhorov B.B. (2009) Social'naya stratifikatsiya obshchestva i zdorov'e naseleniya (Social stratification of society and the health of the population) // Problemy prognozirovaniya. № 3. S. 112–133.

19. Prokhorov B.B., Gorshkova I.V., Tarasova E.V. (2003) Usloviya zhizni naseleniya i obshchestvennoye zdorov'e (The living conditions of the population and public health) // Problemy prognozirovaniya. № 5. S. 127–140.

20. Prokhorov B.B., Shmakov D.I. (2013) Prichiny gibeli lyudej v mirnoye vremya i ekonomicheskaya otsenka stoimosti poter' (The causes of death of people in peacetime and economic valuation of losses) // Problemy prognozirovaniya. № 4. S. 139–147.

21. Prokhorov B.B., Tikunov V.S. (2005) Obshchestvennoye zdorov'e v regionakh Rossii (Public Health in the Russian regions) // Geografiya i prirodnyye resursy. № 2. S. 26–33.

22. Obshhestvennoye zdorov'e i ekonomika (Public Health and Economics) (2007) / Otv. red. Prokhorov B.B. M.: MAKS Press. 300 s.

23. Reshetin V.P., Kazazyan V.I. (2004) Public-health impact of outdoor air pollution in Russia // Environmental Modelling & Assessment. Vol. 9. Issue 1. pp. 43–50. DOI: 10.1023/B:ENMO.0000020889.41526.66

24. Revich B.A., Avaliani S.L., Tikhonova G.I. (2004) Ekologicheskaya epidemiologiya: Uchebnik dlya vyssh. ucheb. zavedenij. (Environmental Epidemiology: Textbook for Higher Educational Institutions). M.: Izdatel'skij tcentr "Akademija". 384 s.

25. Revich B.A., Shaposhnikov D.A., Avaliani S.L., Lezina E.A., Semutnikova E.G. (2015) Izmeneniye kachestva atmosfernogo vozdukha v Moskve v 2006–2012 gg. i riski dlya zdorov'ja naseleniya (Changes in air quality in Moscow in 2006–2012 and public health risks) // Problemy ekologicheskogo monitoringa i modelirovaniya ekosistem. № 1. S. 91–122.

26. Rothenberg R., Stauber C., Weaver S., Dai D., Prasad A., Kano M. (2015) Urban health indicators and indices – current status // BMC Public Health. 15:494. DOI: 10.1186/s12889-015-1827-x

27. Shaposhnikov D., Revich B., Bellander T., Bedada G.B., Bottai M., Lind T., Pershagen G., Kharkova T., Kvasha E., Lezina E., Semutnikova E. (2014) Mortality related to air pollution with the Moscow heat wave and wildfire of 2010 // Epidemiology. Vol. 25. № 3. pp. 359–364.

28. Shartova N.V., Krajnov V.N., Malkhazova S.M. (2015) Tekhnologiya integral'noj otsenki bioklimaticheskoj komfortnosti i zagryaznennosti vozdukha na urbanizirovannykh territoriyakh (Methodology of integrated assessment of bioclimatic comfort and air pollution in urban areas) // Ekologiya i promyshlennost' Rossii. № 1. S. 24–29.

29. Tkachenko E., McKee M., Tsouros A.D. (2000) Public health in Russia: the view from the inside // Healthy Policy and Planning. Vol. 15. Issue 2. pp. 164–169. DOI: 10.1093/heapol/15.2.164

30. Trifonova T.A., Shirkin L.A. (2015) The analysis of cumulative influence of factors of environment on the status of health of the population of Vladimir region // Global Journal of Health Science. Vol. 7. № 3. pp. 309–316.

31. Urbanization and health: Health equity and vulnerable populations. Case studies from the Eastern Mediterranean Region (2011). – WHO Regional Office for the Eastern Mediterranean. – 35 p.

32. Vandenheede H., Vikhireva O., Pikhart H., Kubinova R., Malyutina S., Pajak A., Tamosiunas A., Peasey A., Simonova, G., Topor-Madry R., Marmot M., Bobak M. (2014) Socioeconomic inequalities in all-cause mortality in the Czech Republic, Russia, Poland and Lithuania in the 2000s: findings from the HAPIEE Study // Journal of Epidemiology and Community Health. Vol. 68. № 4. pp. 297–303. DOI: 10.1136/jech-2013-203057.

33. Jakovenko O.N., Kravchenko N.A. (2015) Zagryazneniye atmosfernogo vozdukha g. Irkutska vybrosami ot peredvizhnykh istochnikov (primeneniye raschetnoj metodiki) (Air pollution of Irkutsk from mobile sources emissions (application of the calculation method)) // Gigiena i sanitarija. № 1. S. 64–68.

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DISTRIBUTION OF ALLERGENIC PLANTS IN RUSSIA

ABSTRACT. We analyzed, for the first time ever, the geographical distribution of the main allergenic plants in Russia. All materials were organized as database and attached to the map in GIS Mapinfo. For each region of Russian Federation, two indices were calculated: the total number of allergenic plants in the region and the "allergenic index". A series of maps was compiled: the number of spring-flowering species, the number of summer-flowering species, the total number of species flowering during the whole year, the overall allergen danger during spring and summer seasons, respectively, and the overall allergen danger during the whole year.

In terms of the number of allergenic species and by the "allergenic index," the most dangerous regions appeared to be the Ryazan and Voronezh Oblasts, while the less dangerous – the Chukotka Autonomous Okrug, and the Magadan Oblast. The maps may serve as a reference source for allergologists and allergy sufferers.

KEY WORDS: allergenic plants, pollinosis, allergenic index, cross allergy, maps of distribution.

INTRODUCTION

By the end of the XXth century allergy became one of the most widespread diseases in the industrial countries. One of the causes of allergy is plant pollen. Plant pollen allergy – *pollinosis* – is the disease of each fourth inhabitant of our planet.

More than 700 species of allergenic plants are known. Allergenic plants produce the largest amount of pollen early morning; that is why this time is the most dangerous for allergy sufferers. Maximum concentration of pollen in the air occurs during the warm sunny weather, while rain and dryness slow down the pollen ripening and allergy sufferers feel better in such weather.

Pollinosis symptoms appear when pollen concentration in the air reaches the threshold values. It is accepted that the dangerous limit is 10–20 pollen granules per 1 cubic meter of air. There are more than 700 species of allergenic plants. In medical literature allergenic plants are divided into three groups – trees, cereal grass, and weeds. They bloom during different periods and pollinosis exacerbations occur during two periods – spring-summer (from the beginning of April through the middle of June – trees) and summer (June-July – cereal grasses and from the end of June through the end of August – weeds). Usually the allergy sufferers react to the blooming of not one but several plants; that is why the seasonal exacerbations last approximately one month.

Pollen allergy takes the form of allergenic rhinitis and conjunctivitis and causes the symptoms of runny nose with clear discharge from nose, cough, and tickling feeling in the throat, as well as watering eyes, itch, and redness of eyes. Allergy may take the form of bronchospasm and bronchial asthma attack.

In Russian medical literature much attention is paid to various aspects of pollen impact on human organism. One can find the calendars of allergic plants flowering [www.kestine.ru], but the geographic distribution of those plants has not been analyzed. Foreign allergologists have been addressing this issue in detail beginning from the end of the XXth century [May, Smith, 2008; Rondónet al. 2011]. There is the website in the USA [www.pollenlibrary.com], which shows daily flowering and danger for all 300 allergic species in all states and large settlements.

The work presented herein is the first attempt of geographical analysis of the main allergenic plants distribution in Russia.

MATERIALS AND METHODS

We selected for analysis 119 allergenic species. Even this operation was difficult because there is no generally recognized list of such plants in Russia. In the workbook for allergologists [Allergologiya i immunologiya…, 2009; Poriadok okazaniya…, 2010], the most dangerous species and groups of species (often families) are named. We followed this workbook, internet resources [www.allergology.ru, www.pollenlibrary.com], and some additional literature sources [Esch et al, 2001].

We selected the most widespread species or the species that produce the largest amount of pollen – the most dangerous for allergy sufferers during flowering period. We included into this list only those decorative plants that overstep the limits of artificial plantings (for example, ash-leaved maple). For each species, the degree of allergenic danger was estimated on a three-grade scale: dangerous (3), medium (2) and weak (1). This estimation was based on the materials of the above-mentioned websites and on the available data of pollen production of selected species. The selected species were divided into two groups: spring-flowering (April-May – beginning of June) and summer-flowering (middle of June – beginning of September). The number of analyzed species according to the danger category and period of flowering is given in Table 1.

Table 1. Number of analyzed allergenic species by categories of danger and terms of flowering

Flowering period	Categories of allergenic danger			Total
	weak (1)	medium (2)	dangerous (3)	
Spring	4	24	18	**46**
Summer	6	33	34	**73**
Total	**10**	**57**	**52**	**119**

For the spring period, we selected only 4 weakly dangerous species. Those are: the dominant species in the communities (common beech and oriental beech) and the widespread species (common juniper). The bald cypress is an example of rare species but is frequently mentioned as allergenic in practically all foreign literature. For the summer period, we selected 6 weakly dangerous species widespread in the European territory of Russia (ETR) (see Table 1).

Data on the allergenic species ranges were obtained from the plants guide-books [Gubanov, et al., 1995; Sosudistie rasteniya Sovetskogo Dal'nego Vostoka, 1996; Flora Sibiri, 1987–2003] and from the database Agroatlas [www.agroatlas.ru]. The distribution of selected species was then associated with the subjects of the Russian Federation (RF). It is not well accepted in biogeographical mapping of taxonomic entities. But such approach is well understood by a large section of the population including allergologists and allergy sufferers.

The material was organized as database and the association with the subjects of the RF was mapped with the help of GIS Mapinfo. The database was created using the methodology developed by the authors for the database of the Russian terrestrial vertebrates [Rumiantsev, Danilenko, 1998]

For each region of the RF two indices were calculated: the total number of allergenic plants in the region and "allergenic index" – the sum of allergenic danger grades in the scale. For estimation we used the software applications Visual FoxPro and Statistika.

A series of maps were designed: the number of spring-flowering species (Fig. 1), the number of summer-flowering species (Fig. 2), the total number of species flowering during the whole year (Fig. 3), the overall allergenic danger during spring (Fig. 4) and summer (Fig. 5) seasons, respectively, and the overall allergenic danger during the whole year (Fig. 6).

RESULTS AND DISCUSSION

The results obtained through analysis of the compiled maps are presented below.

The maximum number of allergenic species that flower during spring (Fig. 1) is found in the central regions of the ETR. The number decreases towards north, south, and east and is the lowest in the Chukotka Autonomous Okrug and the Magadan Oblast. This can be explained by the fact that during spring flower, the allergenic deciduous trees and some coniferous trees are distributed in the southern part of the forest zone.

The maximum number of allergenic species that flower during summer (Fig. 2) is in the southern regions. Those are broadleaved forests, forest-steppe, steppe, and the forests of Ciscaucasia. The species are: cereal grasses, wormwoods, and "weeds" – goose-foot, pigweed, nettle, plantain etc., and for the trees – tillet. The number of such species is maximal in the zone of broadleaved forests.

The total number of allergenic species for the whole period of flowering (Fig. 3) is maximal in the central regions of the ETR, the Kaliningrad Oblast, the Karsnodar Kray, and Crimea. This can be explained by the fact that allergy is studied and registered mostly in the territory of the ETR and only local species are considered. The second reason is that the variety of allergenic species reflects the total species diversity in communities, which is the greatest in the broadleaved forest and forest-steppe zone. Allergenic species include weeds as well, which are the product of anthropogenic impact on vegetation, thus,

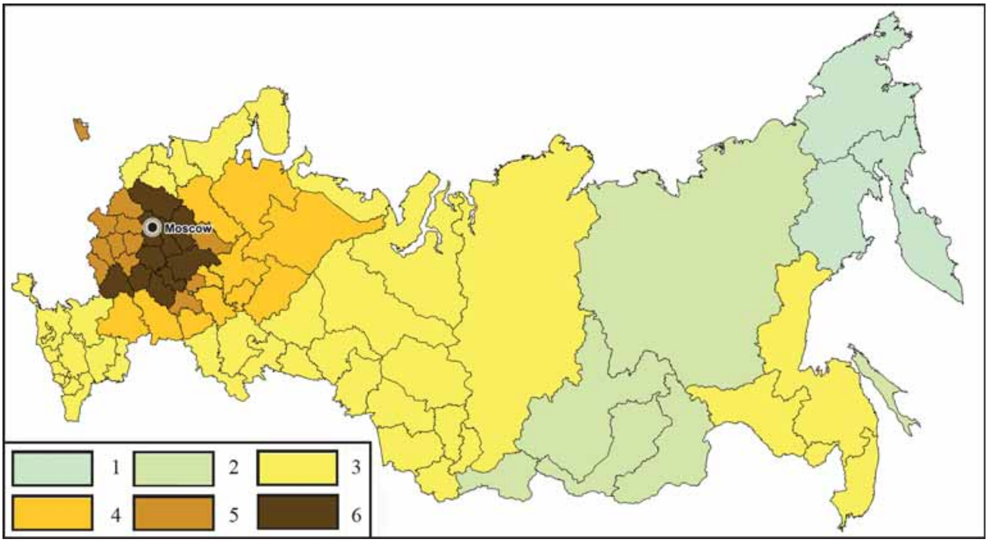

Fig. 1. Number of allergenic plant species flowering during spring:

1 – *10 and less (3),* **2** – *11–15 (6),* **3** – *16–20 (39),* **4** – *21–25 (11),* **5** – *26–30 (12),* **6** – *31 and more (11).*
(In brackets – number of administrative units within the range).

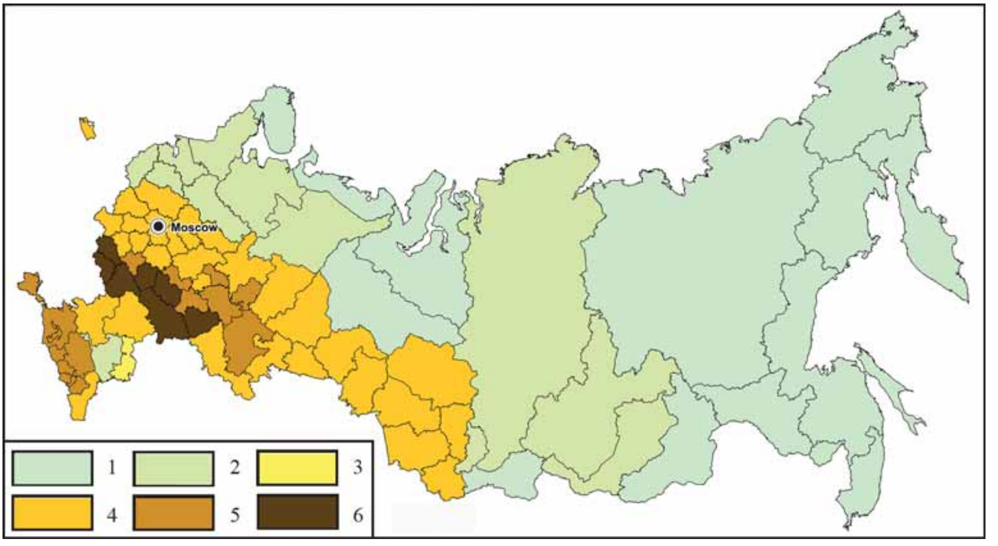

Fig. 2. Number of allergenic plant species flowering during summer:
1 *– 34 and less (15),* **2** *– 35–39 (12),* **3** *– 40–44 (1),* **4** *– 45–49 (31),* **5** *– 50–54 (16),* **6** *– 55 and more (7).*
(In brackets – number of administrative units within the range).

the impact is maximal in the well-developed regions of the ETR.

The concentration of allergenic species in the central regions of the ETR can be associated with one more factor. The allergy morbidity rate is higher in those regions where the indices of air, water, and food pollution are higher. The high level of pollution stimulates the so called "cross" allergenic response [Romaniuk, 2010], which makes human organism more sensitive to pollen. Thus,

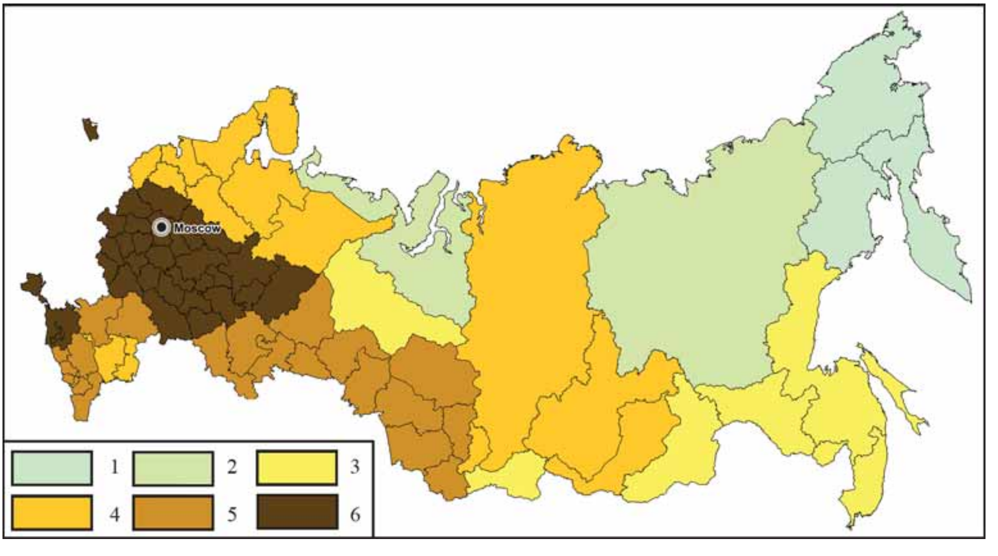

Fig. 3. Number of allergenic plant species flowering during the whole vegetation period:
1 *– 30 and less (3),* **2** *– 31–40 (3),* **3** *– 41–50 (8),* **4** *– 51–60 (14),* **5** *– 61–70 (21),* **6** *– 71 and more (33).*
(In brackets – number of administrative units within the range).

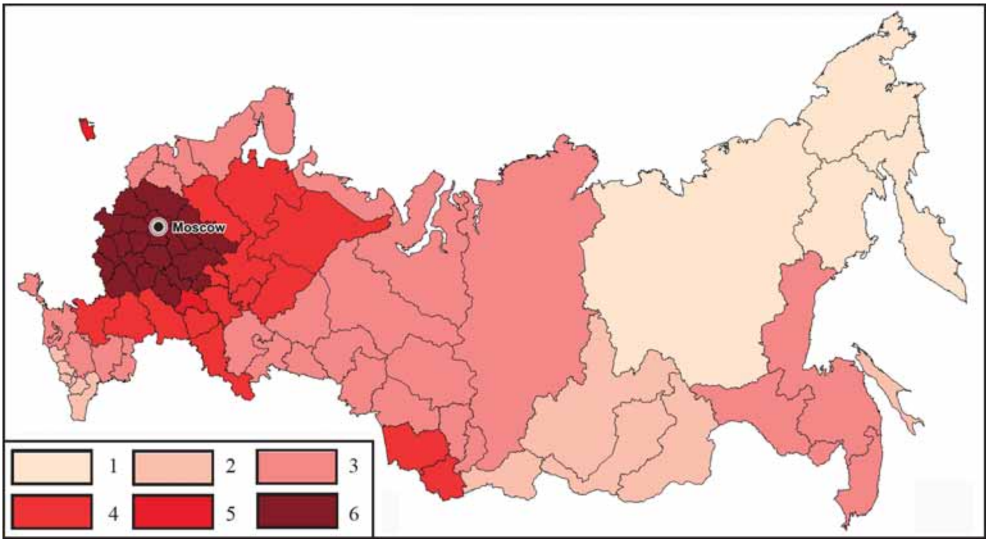

Fig. 4. Summarized "allergenic index" in spring:
1 – *30 and less (4),* **2** – *31–40 (11),* **3** – *41–50 (29),* **4** – *51–60 (15),* **5** – *61–70 (2),* **6** – *71 and more (21).*
(In brackets – number of administrative units within the range).

the allergenic species are concentrated in industrially developed and, because of this reason, polluted regions of Russia.

The highest overall allergy danger during spring (Fig. 4) is detected in the central regions of the ETR and the Kaliningrad Oblast; it decreases to the south and east. It is higher (but not much) in the Far East (the Primorsky Kray, the Khabarovsk Kray, the Amur Oblast, and the Jewish Autonomous Oblast). This fact can be explained by the high allergy danger

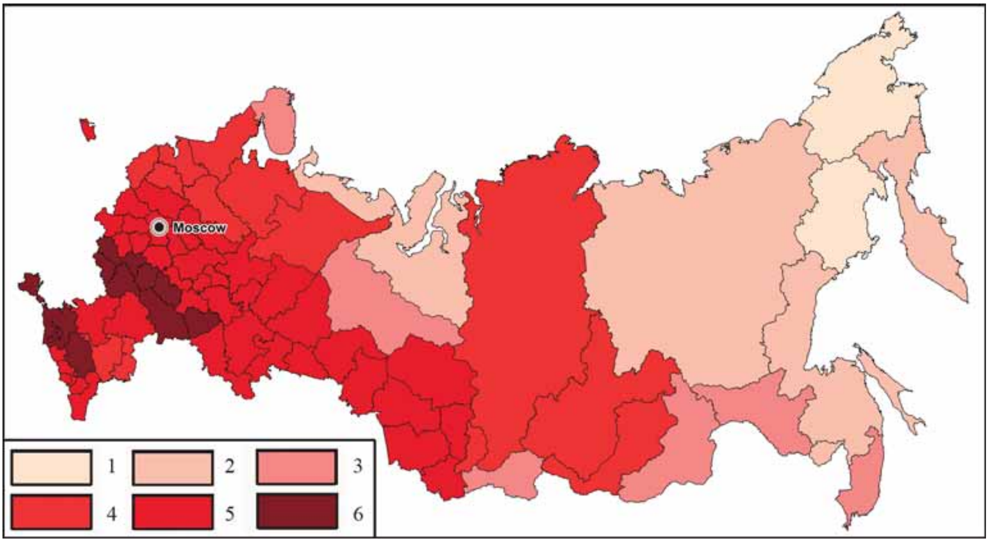

Fig. 5. Summarized "allergenic index" in summer:
1 – *40 and less (2),* **2** – *41–60 (7),* **3** – *61–80 (6),* **4** – *81–100 (13),* **5** – *101–120 (42),* **6** – *121 and more (12).*
(In brackets – number of administrative units within the range).

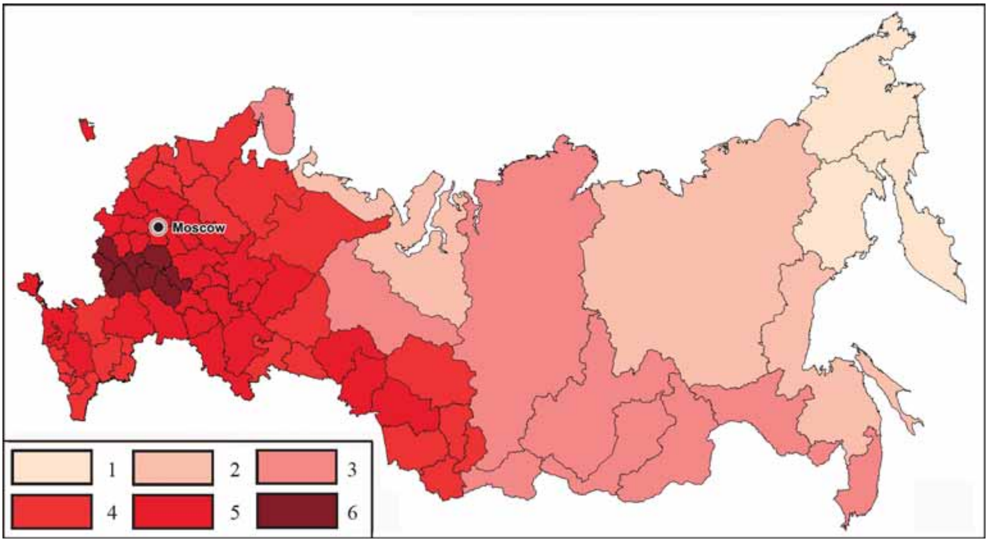

Fig. 6. Summarized "allergenic index" in the whole vegetation period:
1 – *70 and less (3),* **2** – *71–100 (5),* **3** – *101–130 (10),* **4** – *131–160 (24),* **5** – *161–190 (32),* **6** – *191 and more (8).*
(In brackets – number of administrative units within the range).

resulting from the predominance of willows and oaks in the broadleaved forests of the Far East. The allergy danger is minimal in the Sakha Republic, the Chukotka Autonomous Okrug, the Magadan Oblast, and the Kamchatka Kray, as well as in the Ciscaucasian republics during this period.

Forest-steppe and steppe regions of the ETR are the most dangerous for allergy sufferers during summer (Fig. 5): the Kursk, the Voronezh, the Saratov, the Samara, the Lipetsk, and the Penza Oblasts, as well as the Stavropol Kray and the Krasnodar Kray, Crimea, and the Republic of Adygeya. It can be explained by high allergenic danger of most cereal and wormwood species, abundant in the Russian steppes [Dikareva, 2004]. A relatively high danger is typical of broadleaved, smalleaved, and mixed forests, mostly because of the cereal species flowering. The minimum danger is typical of the northern and the Far East regions (the Sakha Republic, the Chukotka, the Nenets, and the Yamalo-Nenets Autonomous Okrugs, the Magadan and the Sakhalin Oblasts, the Kamchatka and the Khabarovsk Krays during this period).

For the whole period of flowering (Fig. 6), the most dangerous regions are the Kursk, the Belgorod, the Voronezh, the Ryazan, the Lipetsk, the Tambov, and the Penza Oblasts and the Republic of Mordovia. As it was mentioned above, these regions have developed industry and high level of environment pollution.

As a whole, according to the number of allergenic species and the "allergenic index," the most dangerous are the Ryazan and the Voronezh Oblasts, while the least dangerous are the Chukotka Autonomous Okrug and the Magadan Oblast.

CONCLUSION

Thus, the analysis revealed the principal laws of allergenic plants distribution in Russia.

The most dangerous for allergy sufferers region of Russia during spring and summer are the Ryazan and the Voronezh Oblasts, respectively. The least dangerous during spring and summer are the Chukotka Autonomous Okrug and the Magadan

Oblast, respectively; both regions were the least dangerous if the entire period was considered.

Further research on connection between pollinosis and environment pollution in the region is necessary. We also plan to compare our results with data on the pollinosis morbidity rate.

The compiled maps could serve as reference material for allergologists and allergy sufferers. These maps and the database could be used in development of an interactive information system.

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REFERENCES

1. Agroecologicheskiy atlas Rossii i sopredel'nykh stran. [Agroecological atlas of Russia and adjacent countries]. Available from: www.agroatlas.ru (in Russian).

2. Allergologiya i immunologiya: nacional'noye rukovodstvo. (2009). [Allergology and Immunology: national guidebook]. – Editors R.M. Haitova, N.I. Iliena – M.: GEOTAR-Media. (in Russian).

3. Allergologiya. [Allergology]. Available from: www.allergology.ru (in Russian).

4. Calendar' pyleniya. [Calendar of pollen production]. Available from: www.kestine.ru (in Russian).

5. Dikareva T.V. (2004). Okhrana biotsenoticheskogo i botanicheskogo raznoobraziya stepey Evrazii na territorii Rossii [Protection of biocoenotic and botanical diversity of Eurasian steppes on the Russian territory]. Aridnie ecosistemi [Arid ecosystems]. V. 10. № 22–23, pp. 69–80. (in Russian).

6. Esch Robert E. et al. (2001). Common allergenic pollens, Fungi, Animals and Arthropods. Clinical Reviews in Allergy and Immunology. V. 21, pp. 261–292.

7. Flora Sibiri. [Siberian Flora]. (1987–2003).Vv. 1–14. Novosibirsk: Nauka. (in Russian).

8. Gubanov I.A., Kiseleva K.V., Novikov V.S., Tihomirov V.N. (1995). Opredelitel' sosudistykh rasteniy tsentralnykh regionov Evropeyskoy territorii Rossii [Guide-book of vascular plants of the central regions of European Russia. – 2-nd edition, supplemented and revised]. – M.: Argus. (in Russian)

9. May, J.R.; Smith, P.H. (2008)."Allergic Rhinitis". In DiPiro, J.T.; Talbert, R.L.; Yee, G.C.; Matzke, G.; Wells, B.; Posey, L.M. Pharmacotherapy: A Pathophysiologic Approach (7th ed.). New York: McGraw-Hill. pp. 1565–1575.

10. PollenLibrary. Available from: www.pollenlibrary.com

11. Poriadok okazaniya meditsinskoy pomoshchi bol'nym s allergicheskimi zabolevaniyami i boleznyami assotsiirovannymi s immunodefitsitami. Prilozheniye k prikazu Ministerstva

zdravookhraneniya i social'nogo razvitiya Rossiyskoy Federatsii ot 4 fevralya 2010 goda. (2010). [Medical care procedure of allergy sufferers and patients with immunodeficiency. Enclosure to the order of the Public Health and social development Ministry of Russian Federation from February 4]. № 60н2. (in Russian).

12. Romaniuk L.I. (2010). Pollinoz i perekrestnaya pishchevaya allergiya. Problemi diagnostiki, lecheniya i profilaktiki. [Pollinosis and cross food allergy. Problems of diagnostics, cure and prevention] // Zdorovia Ukraina. № 1, pp. 46–48. (in Russian).

13. Rondón C., Blanca-López N., Aranda A., Herrera R., Rodriguez-Bada J.L., Canto G., Mayorga C., Torres M.J., Campo P., Blanca M. (2011). Local allergic rhinitis: allergen tolerance and immunologic changes after preseasonal immunotherapy with grass pollen. The Journal of Allergy and Clinical Immunology. 127 (4): 1069–1071.

14. Rumiantsev V.Yu., Danilenko A.K. (1998). Informatsionnaya Sistema "Naseleniye nazemnykh pozvonochnykh Rossii" [Data system "The population of terrestrial vertebrates of Russia"]. Problemi ecoinformatiki. Materialy tretiego mezhdunarodnogo simpoziuma. [Problems of ecological informatics. Materials of the third international symposium]. Moscow, pp. 126–129. (in Russian).

15. Sosudistye rasteniya Sovetskogo Dal'nego Vostoka. (1996). [Vascular plants of the Soviet Far East]. Vv. 1–8. – Editor S.S. Kharkevich. – Sankt-Petersburg: Nauka, (in Russian).

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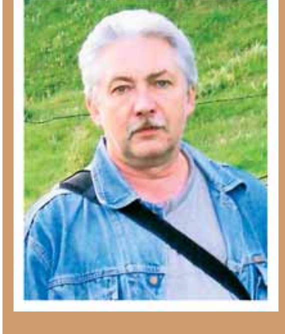

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NATURAL-FOCAL DISEASES IN THE VLADIMIR REGION (RUSSIA)

ABSTRACT. The paper describes a study that monitored the epidemiological situation of a complex of natural-focal diseases in the Vladimir region (Russia), from 1958 to 2012. The morbidity rates of these natural-focal diseases have been differentiated by territory using ArcView 3.1 (GIS software). The activity of natural foci for each zooanthroponosis varied between administrative districts in the region. A schematic map has been compiled; the map reflects the danger of infection caused by natural-focal diseases in the Vladimir region. The paper discusses the role of the anthropogenic factor in natural-ecosystem development: it likely promotes the transit and localization rates of carriers. Correlation and regression analysis of the data showed that climatic factors such as the average temperatures in July and September in the preceding year influence Lyme disease (Lyme borreliosis) patterns. This is likely related to particular stages in the life cycle of *Ixodidae* ticks. Using multiple linear regression analysis, a mathematical model for the prediction of Lyme borreliosis patterns has been created.

KEY WORDS: Vladimir region, epidemiological situation, natural-focal diseases, predicting.

INTRODUCTION

Today the study of patterns in the natural circulation of the infectious agents of natural-focal diseases is becoming increasingly relevant, especially in the context of climate change and anthropogenic territorial changes. Aside from that, natural-focal disease monitoring is gaining relevance due to active migration to certain regions, which leads to populations without an appropriate immune system response in various zones with natural foci. Similarly, the risk of infection has been rising because of the increased popularity of gardening and outdoor activities [Istomin, 2006].

Ranges of many wild animals and, in many cases, blood-sucking arthropods are localized in specific territories, where natural foci are formed. Natural foci boundaries are controlled by endotherm and arthropod (in transmissible infections) ecology. Within these boundaries, infectious agents are transmitted between animals. People only become infected only when they are within a natural focus [Zuyeva, 2005].

Active human impact on natural ecosystems, along with a decline in conservational, epizoological, and epidemiological activity, promotes the transmission of infectious agents of natural-focal diseases and intensifies their epidemiological manifestation. In terms of registered morbidity rates, natural-focal diseases are relatively insignificant in the structure of human infectious diseases. However, the endurance of natural foci and their often unpredictable spurts of activity increase the morbidity rates for these diseases [Kormilenko, 2010].

Determining factors that influence morbidity rates, analyzing territorial distribution, zoning by degree of epidemiological risk, and defining high-risk groups are the most pertinent objectives in research today [Utenkova, 2009].

A lack of necessary funding and absence of specialized entomologists and zoologists in Rospotrebnadzor's (the Russian Federal Service for Surveillance on Consumer Rights Protection) regional branches and of testing systems to gage the presence of infectious agents of natural-focal diseases in a carrier-present areas represent serious and sometimes impossible-to-overcome obstacles for objective research. Bearing in mind the problems listed above, only morbidity rates can objectively indicate the epidemiological situation and allow prediction.

Many authors note the relationship between zooanthroponoses disease patterns and ecological, socio-economical, and climatic factors [Antov, 2005, Aminev, 2013, Kolominov, 2012, Utenkova, 2004], however the data can be quite contradictory.

The ecological and geographical characteristics of a region influence the tick population size, whereas the infection rate is influenced by climatic factors [Suntsova, 2004].

A number of authors note that climate indices such as precipitation rates, humidity, and average monthly temperature in the months that precede the epidemic season influence natural-focal disease morbidity rates. Based on statistically significant data, attempts have been made to create a prognostic model [Aminev, 2013, Kolominov, 2012].

MATERIALS AND METHODS

The studies were conducted in the Vladimir region. The territory's topographic features are determined by its location within the East European Plain which has low elevations and minor terrain irregularity. The southwestern part of the region is occupied by the Meshchera lowlands – a homogenous and flat wetland area that is sometimes interrupted by sandy ridges. There are many forest lakes with turbid water, large wetlands overgrown with alders and aspens and sandy hillocks with tall pines, and juniper bushes and heather. The Oksko-Tsninskiy embankment, composed of limestone, stretches out longitudinally in the eastern part of the region, south of the city of Kovrov. The northwestern elevated part of the region consists of branches of the Klinsko-Dmitrovsky ridge. These branches take the shape of ridges and flat morainic hills. The absolute elevation reaches 240 meters. This is the most elevated area in the Vladimir region. The surface is heavily dissected by deeply embedded riverbeds, ravines, and gulches. The relative elevations reach 40–60 meters. The Nerlinsko-Klyazminskaya lowlands are located in the northern and northeastern part of the region, along the left bank of the Klyazma River. On its western side, they merge with the Balakhninskaya lowland in the Nizhny Novgorod region. This land is 100 meters above mean sea level and has an abundance of wetlands and lakes.

The Vladimir region is in a temperate and continental climate zone, which is characterized by a warm summer, moderately cold winter with stable snow cover, and well-defined intermediate seasons. The majority of the region is sufficiently humid. Precipitation is unevenly spread throughout the area, with the lowest precipitations rates in the eastern part.

The flora is quite diverse and consists of about 1200 species. Pines and birches dominate sandy soil and sandy loam, fir trees and aspens dominate clay soil and clay loam, and coniferous trees with underbrush dominate bog soil.

The fauna consists of 62 mammal species, 43 fish species, 212 bird species, 10 amphibian species, 6 reptile species, and approximately 1500 invertebrate species. The most epidemiologically significant species are rodents – bank voles (*Myodes glareolus*), tundra voles (*Microtus oeconomus*), striped field mice (*Apodemus agrarius*), house mice (*Mus musculus*), brown rats (*Rattus norvegicus*); and *Ixodidae* ticks – *I. ricinus* and *I. persulgatus*.

The materials from the authors' own field work on collecting epidemiological data in the Vladimir region, as well as statistical data from 1958 to 2012 were used in this study.

The data on natural-focal disease morbidity rates were taken from the Vladimir Oblast Center for Hygiene and Epidemiology, as well as from Rospotrebnadzor's official reports on infectious and parasitic diseases.

The degree of natural-focal disease infection risk in human population was gaged using a point system. Each natural-focal disease morbidity rate was calculated per 100 000 people. The morbidity rates for each separate zooanthroponoses in a particular district were summed and, based on the total, each district was assigned a rank that corresponded to the degree of risk: 1 (low risk), 2 (moderate risk), or 3 (high risk).

In order to evaluate the influence of hydrometeorological factors on the natural-focal disease morbidity rates, data on the following indices were used: average monthly temperature, number of days with precipitation per month, atmospheric pressure, snow cover size, and oxygen levels in the atmosphere from 1977 to 2012.

Initially, factors (predictors) were determined that were statistically significantly correlated with morbidity rates ($p \leqslant 0{,}05$), using Pearson's correlation coefficient. Elucidating factors like these is worthwhile even when cause-and-effect relations cannot be interpreted. As long as the correlation is statistically significant, a lack of knowledge about its role in shaping the dynamic of the process in question should not lead to a removal of these indicators from a prognostic equation [Caughley, 1979, Korotkov, 1999]. The influence of climate indices for the current and preceding years on morbidity rates was also taken into consideration when calculating the correlation coefficient (i.e. by shifting climate indices one year back relative to the morbidity rate).

Afterwards, by using multiple linear and nonlinear regression analysis the most significant predictors were incrementally determined. A prognostic equation was derived using the R^2 value and distribution of residuals. STATISTICA software was used to conduct correlation and regression analysis.

ArcView 3.1, GIS software, and Microsoft Paint were used to compile and edit the maps.

RESULTS AND DISCUSSION

Vladimir region's natural conditions allow for the circulation of the infectious agents of a number of natural-focal diseases, which is confirmed by the statistical data gathered in this study. The analysis demonstrates that territory is endemic to the following natural-focal infections: hemorrhagic fever with renal syndrome (HFRS), Lyme borreliosis (or Lyme disease), leptospirosis and tularemia. However, Lyme borreliosis has by far the highest morbidity rates among all infections.

The focal activity of different zooanthroponoses in the region varies. Therefore, the highest HFRS morbidity rates (per 100 000 people) from 1978 to 2012 were recorded in the Gorokhovetsky, Kameshkovsky, and Yuryev-Polsky districts; the highest leptospirosis morbidity rates in the same time period were recorded in the Gorokhovetsky and Petushinsky districts; the highest Lyme borreliosis morbidity rates from 2005 to 2012 were recorded in the Kolchuginsky, Petushinsky, and Kovrovsky districts; the highest tularemia morbidity rates from 1958 to 2012 were recorded in the Gus-Khrustalny district.

Experience shows that information on the degree of infection risk not just for a single infection, but for the entire complex of natural-focal diseases, is necessary for planning and human activity in any area.

In order to evaluate the territory in question, we suggest a method that involves equalizing all cases of zooanthoponosis infections with regard to their danger to public health. In

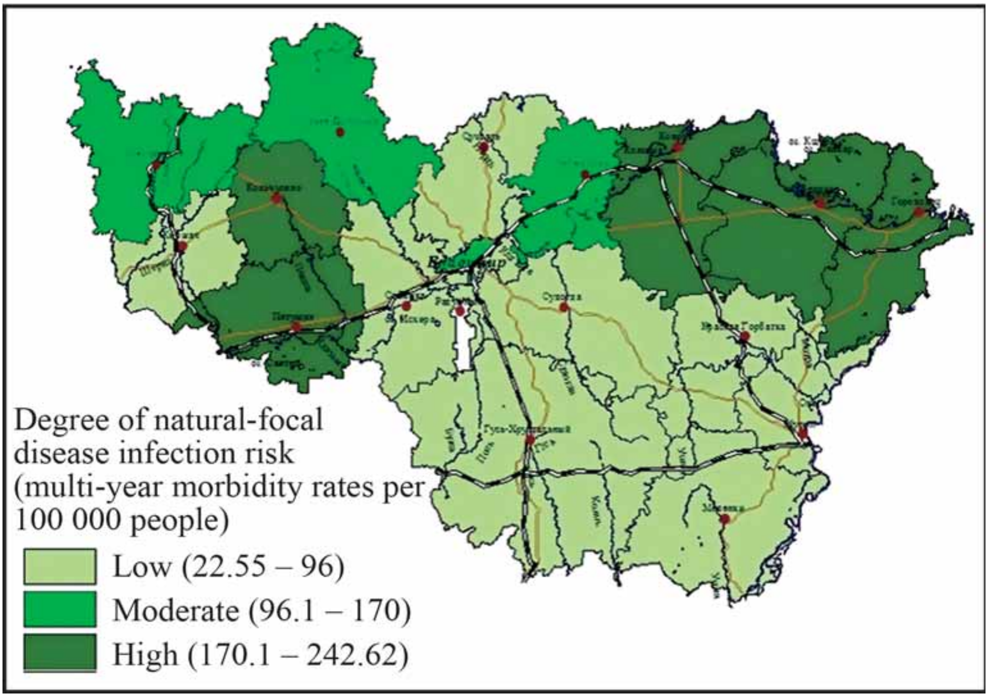

Fig. 1. Natural-focal disease infection risk in the Vladimir region.

other words, in this model, becoming infected with a carrier of tularemia poses the same health risk as becoming infected with a carrier of Lyme borreliosis.

The final map reflecting the natural-focal disease infection risk for the population of the Vladimir region was compiled based on ranking of the multi-year zooanthroponosis morbidity rates. Our analysis demonstrates that the natural-focal disease infection risk varies in different districts in the region (Fig. 1).

Furthermore, an attempt was made to locate factors that influenced the Lyme borreliosis epidemiological process, as cases of this disease were registered most frequently in this territory.

In the Vladimir region, Lyme borreliosis morbidity rates have been monitored since 2005. 1211 cases have been registered from 2005 to 2012, and the morbidity rates have increased by 46 %.

The highest morbidity rates have been recorded in the Kovrovsky, Kolchuginsky, and Petushinsky districts. The disease is unevenly distributed throughout the territory: for example, there has only been one case of infection in the Melenkovsky district during the entire monitoring period. However, the epidemiological situation in the north of the region is most serious, even though the southern districts are more heavily populated (Fig. 2).

First, the potential influence of land development on Lyme borreliosis was analyzed by conducting a spatial correlation analysis and comparing the Lyme borreliosis morbidity rates; then, the influence of forest and wetland cover were analyzed. This analysis established that there is no statistically significant correlation between the above indices ($r = -0.19$ $p = 0.47$; $r = -0.26$ $p = 0.33$ respectively) in the Vladimir region.

In our view, this fact deserves attention. A few decades ago, tick-borne infections generally

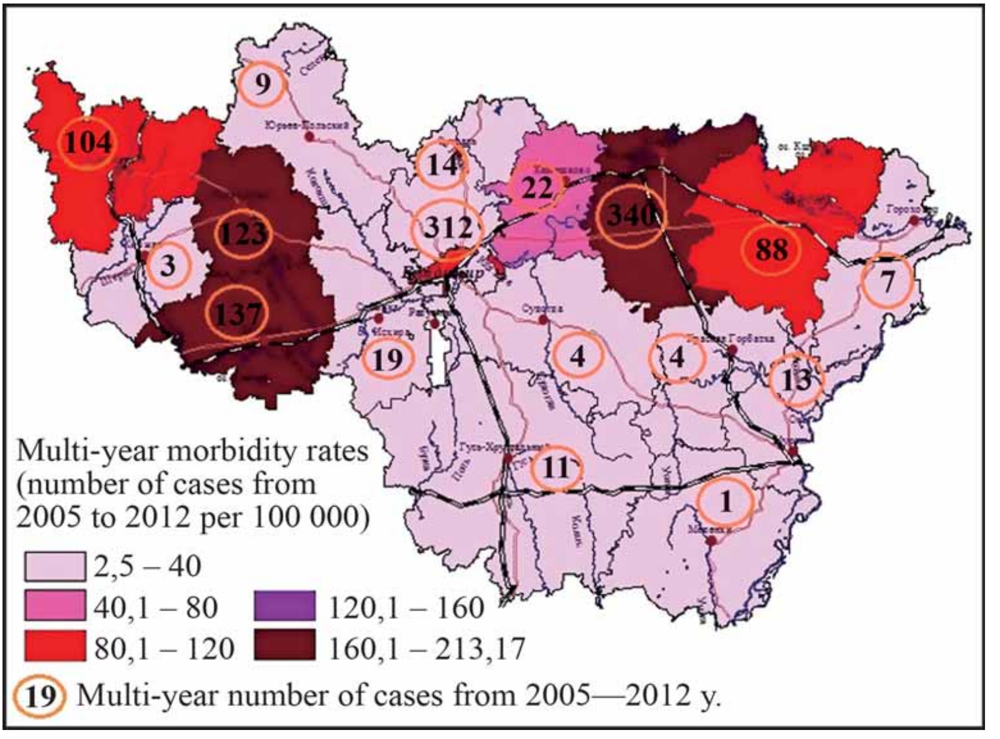

Fig. 2. Lyme borreliosis morbidity rates in the Vladimir region.

affected people living in the taiga or in forested landscapes; they were not very common among the urban population in central oblasts of the Nonchernozem belt. Evidently, that explains why there was no urgent need to organize medical monitoring in such areas. Today the situation has changed dramatically: morbidity rates have been increasing independently of differences in landscape characteristics. This can be explained by the fact that commercial land and land intended for development used to be quite isolated from one another. However, in the last 20–30 years Russia's population has significantly changed its way of life and thus its ecological niche. Human mobility has increased and far more suburban homes, vacation homes, summer cottages, rural recreational zones, and roads have been built. The structure of rural settlements has also changed because of the arrival of urban populations. Forests, especially on their outskirts, are often settled, as well as meadows and former arable land. Abandoned croplands are intensely overgrowing, creating new convenient ecological niches for the circulation of Ixodidae ticks and their hosts. Therefore, the boundaries of more or less isolated (naturally structured) ecosystems are disintegrating, leading to negative transformations. Evidently, it can be asserted that it is not climate change that is to blame for the spread of Lyme disease (by the way, this explanation has recently gained popularity, because it absolves humans of personal responsibility!); rather, anthropogenic activity which disrupts the ecological balance is the real culprit.

Our study also analyzed the potential influence of the following climate indices on Lyme borreliosis: average monthly temperature, the number of days per month with precipitation, humidity, atmospheric pressure, snow cover size, and monthly oxygen levels in the atmosphere from 2004 to 2012 (a total of about 100 different indices).

Correlation analysis of the array of indices revealed a statistically significant correlation between the Lyme disease morbidity rates and the following indices: the average temperature in July of the previous year ($r = 0.77$ $p < 0.05$), the average temperature in September of the previous year ($r = –0.91$ $p < 0.05$), the humidity in January of the previous year ($r = 0,71$ $p < 0.05$), snow depth in March ($r = 0.94$ $p<0.05$), and oxygen levels in the atmosphere in July of the previous year ($r = –0.94$ $p < 0.05$).

Because Lyme borreliosis' epidemiological process begins in late April, only the values that precede the beginning of the epidemiological process can be included in the model. Multicollinearity was ruled out in modeling by removing predictors with pair correlations from the prognostic equation.

Ultimately, the following predictors were used in the prognostic model: the average temperature in July of the preceding year, the average temperature in September of the preceding year, and the humidity in January of the preceding year (these indices do not have pair correlations with each other).

As a result of this incremental multiple nonlinear regression analysis, achieved via STATISTICA software, the most significant epidemiological predictors were determined and a prognostic equation was derived. Its validity was defined by the R^2 value and the distribution of residuals.

The software demonstrated that the most significant values influencing the epidemiological process are the average temperature in July of the previous year and the average temperature in September of the previous year. The software ruled out the humidity in January of the previous year because it did not have a significant effect on the epidemiological process, despite its high correlation with morbidity rates.

The final multiple nonlinear regression equation is shown below:

$$y = –577.938 – 0.84(x1^2) + 58.538(x2) – 0.037(x2^3);\ R^2 = 0.99\ p < 0.001$$

y – Lyme borreliosis morbidity rate in the population; x1 – average temperature in September of the previous year; x2 – average temperature in July of the previous year.

According to the equation, the epidemiological process of Lyme borreliosis depends on the average temperature in July of the previous year and the average temperature in September of the previous year; the dependence on July's temperatures is stronger.

The R^2 value allows us to infer that this model describes the epidemiological process with a probability of 99 %.

The data in Table 1 allows us to compare the observed morbidity rate values and the predicted values, as well as the residuals.

Table 1. Predicted Values and Residuals of Multiple Nonlinear Regression

Year	Observed Morbidity Rates	Predicted Morbidity Rates	Residuals
2005	150	157.4	–7.4
2006	127	129.0	–2
2007	96	91.9	4.1
2008	179	176.8	2.2
2009	194	194.4	–0.4
2010	94	93.5	0.5
2011	198	200.9	–2.9
2012	219	212.9	6.1

To ensure the accuracy of the derived equation, the distribution of recursive residuals was analyzed: the plot in Fig. 3 demonstrates that all the values lie close to the line and are normally distributed.

Therefore, the conclusion we have reached is statistically accurate [Trukhacheva, 2013].

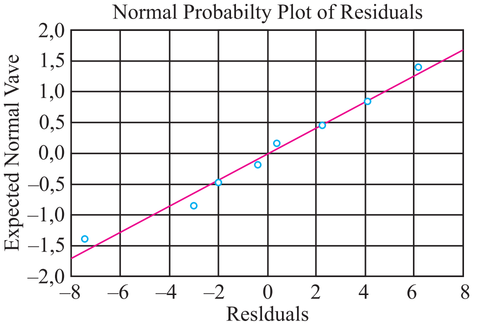

Fig. 3. Normal Probability Plot of Residuals in Multiple Nonlinear Regression.

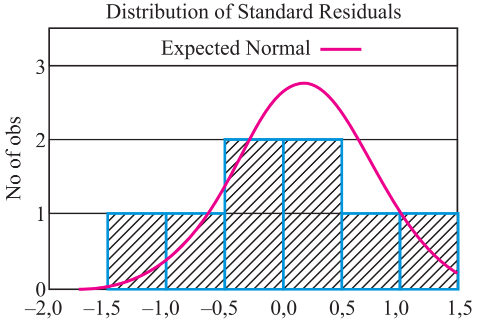

Fig. 4. Distribution of Standard Residuals.

The histogram of standard residuals that shows the distribution of residuals close to the normal (Fig. 4) also supports the validity of the model.

The derived model indicates that the epidemiological process of Lyme borreliosis depends on the average temperature in July of the previous year and the average temperature in September of the previous year. This can most likely be explained by the life cycle of *Ixodidae* ticks. The positive correlation between Lyme borreliosis and the average temperature in July can be explained by the abundance of hosts in this period, which contributes to the ticks' development and thus the spread of the infectious agent of Lyme borreliosis. The negative correlation between Lyme borreliosis and the average temperature in September can be interpreted in the following way: high temperatures in September cause recently molted females to search for hosts; which then (after the first frost) leads to their death and the death of their eggs (if the females found a host and had a sufficient food supply). Lower temperatures in September cause recently molted female ticks to enter diapause and successfully endure low temperatures in the winter.

Conclusions

1. The Vladimir region is endemic to the following natural-focal infections: HFRS, Lyme borreliosis, leptospirosis, and tularemia. The natural foci of these infections are confined to different territories. The compiled map reflects the risk of infection caused by various natural-focal diseases in the Vladimir region.

2. The Lyme borreliosis morbidity rate in the Vladimir region is not related to the extent of forest or wetland cover in any of the territories. These parameters were traditionally thought to define the spread of *Ixodidae* ticks. We have demonstrated that anthropogenic factors lead to the destruction of natural ecosystems and the delocalization of infectious agents and thus the disease itself.

3. The identified climate indices (the average temperature in July of the previous year and the average temperature in September of the previous years) are likely to have to affect the ticks' life cycle, which in turn impacts the epidemiological situation in the region.

4. The derived mathematical model can be used to predict the epidemiological situation and to take the appropriate steps to fight Lyme borreliosis. The model demonstrates that higher Lyme borreliosis morbidity rates are associated with a year preceded by hot July and cold September.

REFERENCES

1. Aitov, K. (2005) Prirodno-ochagovye transmissivnye kleshchevye infektsii Pribaykal'ya (Natural-Focal Transmissive Tick-Borne Infections in the Baikal Region): n. pag. *www.dissercat.com*. Web. 12 July 2015.

2. Aminev, R. (2013) Epidemiologicheskie i epizootologicheskie osobennosti gemmoragicheskoy likhoradki s pochechnym sindromom v stepnykh landshaftakh i ikh vliyanie na zabolevaemost' voennosluzhashchikh (Epidemiological and Epizootological Characteristics of Hemorrhagic Fever with Renal Syndrome in Steppes and their Influence on Morbidity Rates in Service Members). avtoref. dis. ... kand. med. nauk St. Petersburg. 23 pages.

3. Caughley, G. (2004) Analysis of Vertebrate Populations. Caldwell, N.J.: The Blackburn Press.

4. Istomin, A.V. (2006) Regional'nyy monitoring prirodno-ochagovykh infektsiy (Regional Monitoring of Natural-Focal Infections). Pskov Regionologichesky Zhurnal.

5. Kolominov, S.I. (2012) Epizootologicheskie i ekologicheskie aspekty rasprostraneniya i prognozirovaniya zabolevaemosti v prirodnykh ochagakh gemorragicheskoy likhoradki s pochechnym sindromom (Epizootological and Epidemiogical Aspects of the Distribution of Prediction of Hemorrhagic Fever with Renal Syndrome). avtoref. dis. … kand. med. nauk. Nizhny Novgorod. 24 pages.

6. Kormilenko, I.V. (2010) Ekologichskie i epidemiologicheskie aspekty KGL, Likhoradki Ku i iksodovykh kleshchevykh borreliozov v Rostovskoy oblasti (Ecological and Epidemiological Aspects of Congo-Crimean Hemorrhagic Fever, Q Fever and Lyme Borreliosis in Rostov Oblast). Avtoref. dis. ... kand. biol. nauk. Rostov-na-Donu. 24 pages.

7. Korotkov Yu.S., Okulova N.M. (1999) Khronologicheskaya struktura chislennosti taezhnogo kleshcha v Primorskom krae (The chronological structure of the taiga tick population in Primorsky Krai) // Parazitologiya. – 1999. – T. 33, vyp. 3. – pp. 257–266.

8. Suntsova O.V. (2004) Ekologo-parazitologicheskaya kharakteristika prirodnykh ochagov kleshchevogo borrelioza v Pribaykal'e (An ecological and Parasitological Characterization of the Natural Foci of Lyme Borreliosis in the Baikal Region). avtoref. dis. … kand. biol. nauk Irkutsck. 20 pages.

9. Trukhacheva, N.V. (2012) Matematicheskaya statistika v mediko-biologicheskikh issledovaniyakh s primeneniem paketa Statistica (Mathematical Statistics in Biomedical Research with the Use of Statistica Software). GEOTAR-Media.

10. Utenkova, E.O. (2009) Prirodno-ochagovye infektsii v Volgo-Vyatskom regione (Natural-Focal Infections in Volga-Vyatka Economic Region). avtoref. dis. ... d-ra med. nauk Kirov. 38 pages.

11. Zueva, L. and Yafaev, R. (2005) Epidemiologiya (Epidemiology). St. Petersburg: Izdatelstvo Foliant.

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IMPACT OF THE AMBIENT AIR PM2.5 ON CARDIOVASCULAR DISEASES OF ULAANBAATAR RESIDENTS

ABSTRACT. Mongolia is a landlocked country with a total land area of 1,564,116 square kilometers. The ambient annual average particulate matter (PM) concentration in Ulaanbaatar is 10–25 times greater than the Mongolian air quality standards (AQS). More than 40 percent of the nation's total population lives in Ulaanbaatar. The study aims at defining the relationship between the ambient air PM2.5 level and hospital admissions in Ulaanbaatar in 2011–2014. The pollution data included a 24-hour average PM2.5. The air was sampled daily and recorded by the national air monitoring stations located in Ulaanbaatar. The sampling frame of hospital admissions for cardiovascular disease (CVD) were the records of all outpatient hospitals of Ulaanbaatar. The data covered the period from January 2011 to January 2014. To test the differences of the results, appropriate statistical tests were employed. During 2011–2014, the highest concentration of PM2.5 was in the coldest period and the particulate matter level recorded was 3.7 times higher in the cold period than the warm period. The number of admissions for CVD were the highest during cold periods. Four days after exposure, the PM2.5 impact on hospital admissions weakened but there remained a positive correlation. For PM2.5, 100 $\mu g/m^3$ growth of the pollutant led to 0.65 % increase in the hospitalization for CVD on the exposure day. On the second day of exposure, 10 $\mu g/m^3$ growth of the pollutant led to 0.66 % increase; on the third day of exposure, 10 $\mu g/m^3$ growth of the pollutant led to 0.08 % increase of hospital admissions for CVD, and at the fourth day, such growth led to 0.6 % increase of CVD cases in 2011–2014 in Ulaanbaatar. In conclusion we may state that most incidences of CVD registered during the cold months in Ulaanbaatar in the last four years were a result of PM2.5 exposure. This shows that the PM2.5 exposure and hospital admissions for cardiovascular system chronic diseases are positively correlated. CVD in Ulaanbaatar residents was affected greater on the same and the third day of exposure.

KEY WORDS: PM2.5, exposure, CVD, health impact, Ulaanbaatar air pollution.

INTRODUCTION

Mongolia is a landlocked country with a total land area of 1,564,116 square kilometers. Steppes and deserts stretch in its southern and eastern parts, while mountains surround the northern and western parts. The country has extreme continental climates with long, cold winters and short dry summers. The average temperature in January and February is –20 °C, with winter night temperatures dropping to –40 °C (NSO 2015).

The atmosphere is a mixture of gaseous substance produced over the Earth's long history by biogenic, geologic, and atmospheric processes. By definition, air pollution is a mixture of solid, liquid, gaseous, and biological substances emitted to the atmosphere by natural and anthropogenic activities, which has detrimental effects on animals, human health, and economy (Godish, 2004).

The ambient annual average particulate matter (PM) concentration in Ulaanbaatar is 10–25 times greater than the Mongolian air quality standards (AQS) and is among the highest recorded measurements compared to any other world's capital. The Mongolian annual ambient air quality standard is 25 $\mu g/m^3$ for PM2.5 (MNS 2008).

More than forty percent of the total population of Mongolia lives in Ulaanbaatar (STU 2015). In 2014, over 184,000 households live in the "ger" areas of six central Ulaanbaatar districts and approximately 3,200 entities operated by the heating of low-pressure steam boilers in the capital. Eighty percent of air pollution comes from these pollution sources (CNAP et al 2014).

Particulate matter in the air of Ulaanbaatar is the main source of air pollution. According to the findings of relevant surveys, the content of particles (PM_{10} and $PM_{2.5}$) in household (indoor) air with furnaces is at the level which impacts negatively health (PHI 2007). Not many surveys have been conducted in relation to the PM2.5 level and health outcomes in Mongolia.

This study aims at defining the relationship between the ambient air PM2.5 level and hospital admission cases of Ulaanbaatar in 2011–2014.

MATERIALS AND METHODS

The data cover the period from January 2011 to January 2014.

Exposure data. The pollution data included a 24-hour average of PM2.5. The PM2.5 data come from a network of 2 monitoring stations. The air was sampled daily and recorded by the national air monitoring stations located in Ulaanbaatar. The air quality stations used an instrumental method, which utilizes automated equipment to analyze air quality.

Morbidity data. The data for hospital admissions for cardiovascular disease (CVD) were the records of all outpatient hospitals in Ulaanbaatar. The ICD-10 disease classification system was used by each hospital's statistics department.

Data analysis. The data were analyzed using SPSS Version 21.0. For testing the differences in the results, appropriate non-parametric tests were used. Kruskal-Wallis one way analysis of variance, Mann-Whitney U tests, and Spearman correlation and linear regression were also used.

RESULTS AND DISCUSSION

Ambient air PM2.5 level, 2011–2014

Air quality of Ulaanbaatar in 2014, as measured by particulate matters (PM2.5), was 64 $\mu g/m^3$ (2.6 times higher than the permissible level of the Mongolian air quality standard). The average PM2.5 concentration from October 2013 to April 2014 was lower by 27 $\mu g/m^3$ (21 %) than the concentration measured from October 2012 to April 2013. During 2011–2014, the highest concentration of PM2.5 was during the coldest periods. The PM2.5 level was relatively high during cold periods because of high household (indoor) burning of raw coal during cold temperatures. The following histograms show a 24-hour average PM2.5 level in cold and warm seasons.

According to the survey of Delgerzul. L (2012) of ambient air around Ulaanbaatar's Sukhbaatar district, the annual average PM2.5 level was 375.09±722.6 $\mu g/m^3$.

In comparison to Delgerzul's survey, the average PM2.5 concentration in ambient air declined during cold periods by 2.29 times.

Basically, our study found that the PM2.5 level is 3.7 times higher in colder periods than warmer periods (warm 34.15±20.39 $\mu g/m^3$, cold 127.6±11 $\mu g/m^3$) (Table 1).

Actually, the mixture of particles is likely to vary within the study areas by size, number,

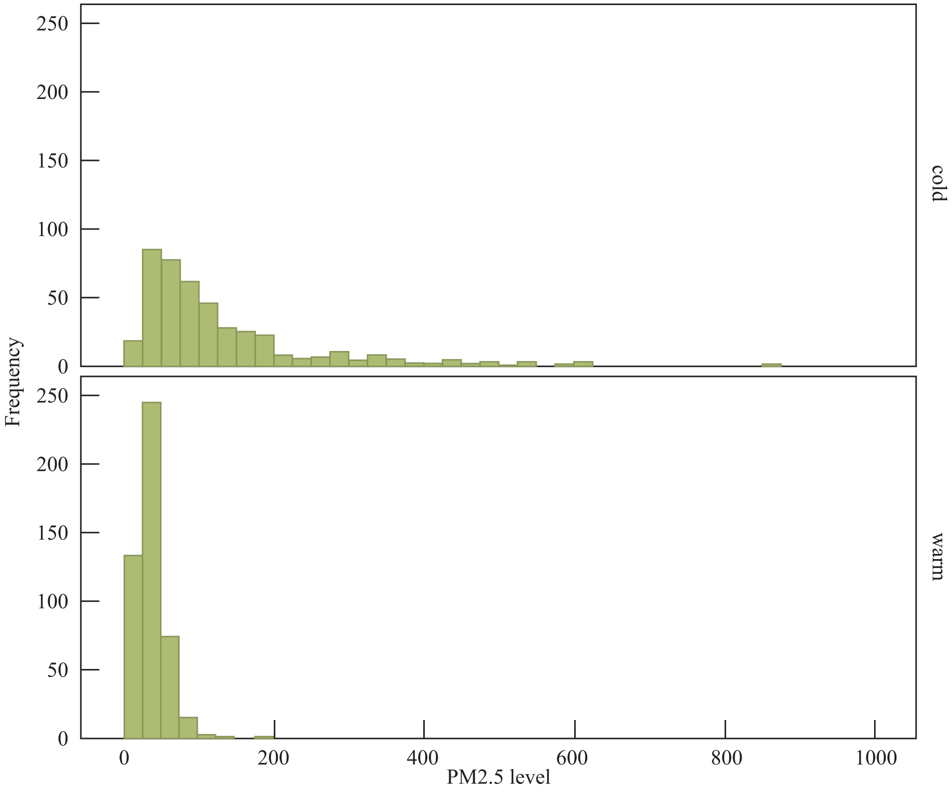

Fig. 1. Histogram of a 24-hour average PM2.5 level in Ulaanbaatar, 2011–2014.

Table 1. Some descriptive statistics on the PM2.5 level and daily admission cases for CVD

	PM2.5 μg3			CVD cases		
	Warm season	Cold season	Total	Warm season	Cold season	Total
Mean	34.15	127.60	80.08	54.13	79.63	68.42
Median	33	88	46.18	44	76	58.0
Std. Deviation	20.39	119.51	95.81	36.17	44.56	43.04
IQ Range	22	110	59	43	66.5	59
Minimum	2	14	2	10	10	10
Maximum	194	854	854	230	230	230
p value *	0.0001	0.0001				

* Mann-Whitney U test

and chemical composition. The toxicity of particulate matter depends on its chemical composition and size distribution. Fine particles (for instance, PM2.5) have been found to have bigger effects on health than PM10 (Bremner et al, 1999; Ha et al., 2001).

Cardiovascular disease admission, 2011–2014

The following figures show time sequence of seasonal cases of CVD. The number of cases increased in last 2 years and the highest number of cases was registered during the cold months (Fig 2).

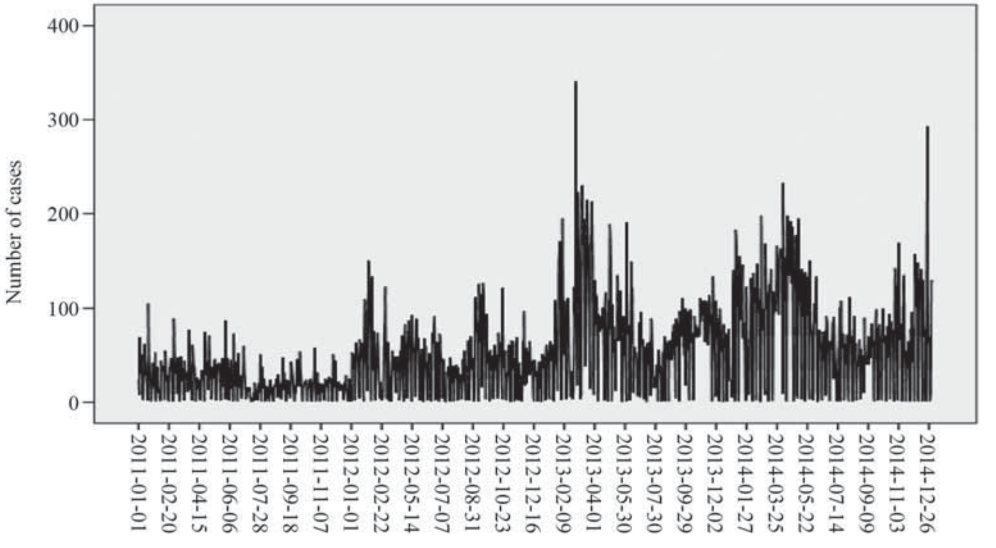

Fig. 2. Daily morbidity counts of CVD, by date, Ulaanbaatar, 2011–2014.

In spring, the most hospital admissions for CVD occurred, while during the summer months, the number of admissions declined. On the other hand, during cold periods, the most cases of hospitalization for CVD were registered (r^2 = 34.6, p = 0.00001) (Table 2).

Table 2. Distribution of CVD incidence, by season and gender, UB, 2011–2014

Seasons	Male	Female	Total
Summer (June 1–Aug 31)	5753 22.8 %	10157 24.6 %	15910 23.9 %
Autumn (Sep 1–Nov 31)	4400 17.5 %	7091 17.2 %	11491 17.3 %
Winter (Dec 1–Feb 28)	6771 26.9 %	10480 25.4 %	17251 26.0 %
Spring (Mar 1–May 31)	8254 32.8 %	13551 32.8 %	21805 32.8 %
Total	25178	41279	66457

The most common CVD of admitted cases in Ulaanbaatar during 2011–2014 were hypertension and ischemic heart disease (Fig. 3).

Impact of ambient PM2.5 on CVD of Ulaanbaatar residents

The research conducted in 2003 in major cities and towns of Mongolia found that respiratory diseases were caused by pollution. Its result

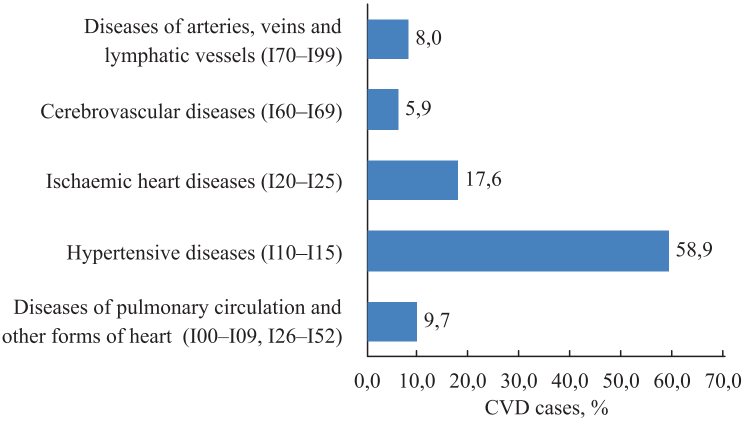

Fig. 3. Leading causes of CVD, Ulaanbaatar, 2011–2014.

shows the respiratory diseases have a direct moderate level relationship with carbon monoxide ($r = 0.538$ $p = 0.011$), sulfur dioxide ($r = 0.44$ $p = 0.019$), and nitrogen dioxide ($r = 0.34$ $p = 0.013$), respectively (PHI 2003).

According to the 2009 World Bank survey, PM2.5 and PM10 in the ambient air of Ulaanbaatar had a constant and strong correlation with hospital admissions for CVD. For PM2.5, 10 $\mu g/m^3$ growth of the pollutant led to a 0.8 % increase in CVD-caused hospitalization (WB 2009).

In this study, we estimated the correlation (Spearman's) between PM2.5 and CVD lag0-3. It was shown that after the fourth day of exposure, a weak positive correlation was observed (CVD lag0: $r = 0.13$, $p = 0.0001$, CVD lag1: $r = 0.21$, $p = 0.0001$, CVD lag2: $r = 0.12$, $p = 0.00001$, CVD lag3: $r = 0.09$, $p = 0.004$).

In 2011–2014 in Ulaanbaatar, on the first day of exposure, 2.7 %of hospitalizations for cardiovascular disease was due to PM2.5; on the second day, 2.2 %; on the third day of exposure, the rate of hospital admissions increased 2.8 %, and on the fourth day, CVD-caused hospitalizations were 2.1 %.

The impact of CVD was relatively low compared to the 2009 World Bank survey. For PM2.5, 10 $\mu g/m^3$ growth of the pollutant led to a 0.065 % increase in CVD- caused hospitalizations on the exposure day. On the second day of exposure, 10 $\mu g/m^3$ growth of the pollutant led to a 0.066 % increase in hospitalizations; on the third day of exposure,10 $\mu g/m^3$ growth of the pollutant led to a 0.08 % increase of CVD related hospital admissions, and on the fourth day, a 0.06 % increase in CVD cases (Fig. 4).

Many studies verify that CVD are caused by air pollution. For instance, scientists Dockery and Pope from Harvard University discovered that by reducing the content of PM10 in the air (until

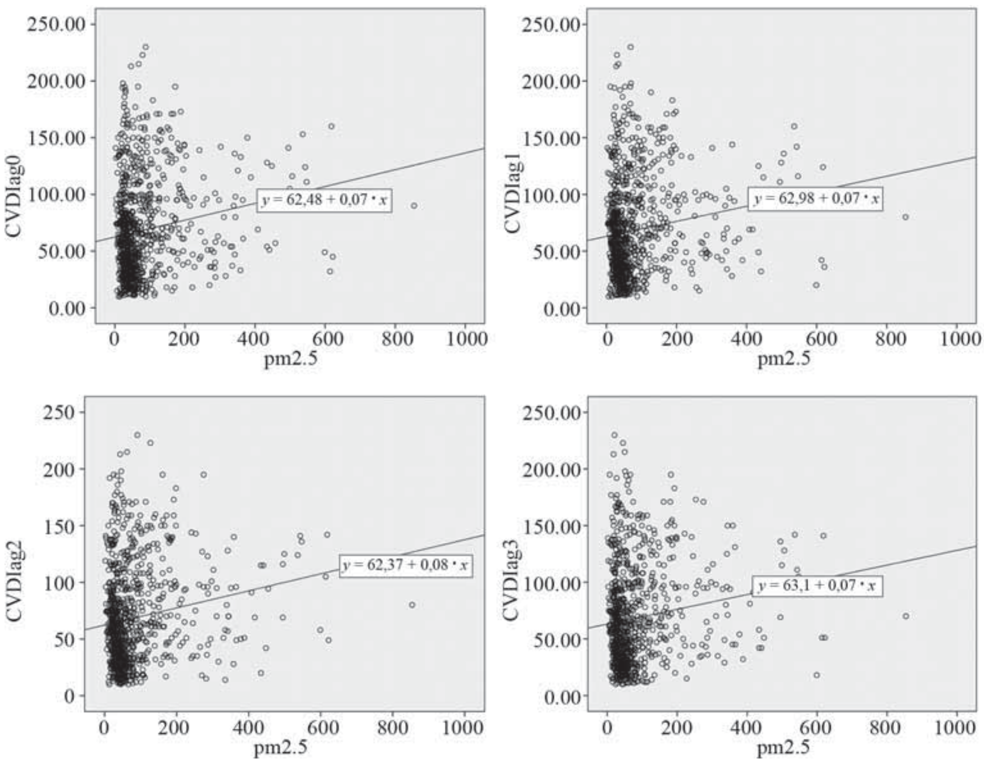

Fig. 4. Scatter diagram of Spearman correlation between CVD lag0-3 and ambient air PM2.5 annual level.

the standard rate), CVD-related mortality can be reduced by 15 percent (Dockery et al 1994; Pope et al 2002).

Similar findings were found in a survey conducted by Enkhjargal et al (2010), which showed the percentage of combined effects on respiratory diseases in the winter season is 52.9 for average temperature, humidity, nitrogen dioxide and PM10; the percentage of combined effects on cardiovascular diseases in the winter season is 37.2 for average temperature, humidity, nitrogen dioxide and PM10; the percentage in autumn is 5.4 for PM10 only, and the percentage in summer is 17.4 for wind speed and average temperature, while in autumn, the percentage of combined effects of sulphur dioxide, nitrogen dioxide, and PM10 is 25.4.

Time-series analysis

Variability of the PM2.5 level and acute disease admissions declined from 8.0 % to 3.9 % during days of 1–3 (lag0–lag3), respectively. In this variability, the highest PM2.5 level and acute CVD admissions was observed on the first day (8.0 %) and the lowest variability was observed on the third day (3.9 %). For the total acute admissions and the PM2.5 level, only lag0 significant correlation (4.0 %, $p = 0.02$) was observed. Variability significantly increased for chronic disease admissions and particular matter. Variability of chronic CVD admissions and the PM2.5 level was increasing to the second day (lag 2) (lag0, 12.1 %, $p = 0.00001$ – lag2, 15.9 %, $p = 0.000001$) and on the third day (lag 3) it decreased to 10.1 % ($p = 0.0003$).

Variability of chronic CVD admissions and the PM10 level was increasing to the second day (lag 2) (lag0, 10.91 %, $p = 0.0002$ – lag2, 11.1 %, $p = 0.0002$) and on the third day, (lag 3) it decreased to 7.1 % ($p = 0.0003$) (Table 1). Variability of chronic CVD and the PM2.5 level was the lowest on the first day (lag0, 6.5 %, $p = 0.004$) and the highest on the third day (lag3, 15.0 %, $p = 0.0001$). Variability of chronic CVD and the PM10 level was higher than variability of chronic CVD and the PM2.5 level in all 4 days. The highest variability was observed on the second day (lag1, 19.3 %, $p = 0.000001$) and the lowest was observed at the first day (lag0, 15.3 %, $p = 0.0001$).

CONCLUSION

Most incidences of CVD registered during cold months in Ulaanbaatar in the last 4 year were the result of ambient air PM2.5. However, the impact of exposure to other air pollutants and meteorological factors in Ulaanbaatar should be taken into consideration. Ambient air PM2.5 exposure positively influences chronic CVD admissions to hospitals. The hospitalizations for CVD in Ulaanbaatar residents were higher on the first and the third day of exposure.

REFERENCES

1. Bremner, S.A., Anderson, H.R., Atkinson, R.W., McMichael, A.J., Strachan, D.P., Bland, J.M., et al (1999) Short term associations between outdoor air pollution and mortality in London 1992–4. Occup Environ Med 56: 237–244.
2. CNAP, MOEGD, SICA (2014), Registration of stationary air pollutants, Ulaanbaatar, p. 25.
3. Delgerzul, L. (2013), Air particular matter (PM10 and PM2.5) influences to human health, master thesis, Ulaanbaatar.
4. Dockery, D.W. Pope, C.A. III (1994). Acute respiratory effects of particulate air pollution. Annu Rev Public Health 15: 107–132.
5. Enkhjargal A.B., Suvd B., Burmaa B., Enkhtsetseg Sh. (2010), Health impact assessment of PM10 and PM2.5 of Ulaanbaatar, Mongolian Journal of Medical Sciences, 4: 154–161.

6. Godish, T. (2004), Air quality, 4th edition. Boca Raton, USA: Lewis Publishers.
7. Ha, E.H., Hong, Y.C., Lee, B.E., Woo, B.H., Schwartz, J., Christiani, D.C. (2001). Is air pollution a risk factor for low birth weight in Seoul? Epidemiology 12: 643–648.
8. Mongolian national standard, (2008) Mongolian air quality standard, Ulaanbaatar.
9. PHI, MOH (2003) Hygienic assessment of some chemical, physical and biological risk factors to human health, Ulaanbaatar.
10. PHI, MOH (2003) Hygienic assessment of some chemical, physical and biological risk factors to human health, Ulaanbaatar.
11. Pope C.A. III, Burnett R.T., Thun M.J., Calle E.E., Krewski D., Ito K., Thurston G.D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. J. Am. Med. Assoc. 2002; 287 (9): 1132–1141.
12. Public health institute, Ministry of Health, World Health Organization, (2007), Indoor air quality survey, Ulaanbaatar.
13. Statistical department of UB (2015), available online at: http://ubstat.mn/StatTable.aspx?tableID = 20, 15 October 2015.
14. World Bank (2009), Mongolia – Air pollution in Ulaanbaatar: Initial assessment of current situation and effects of abatement measures (Mongolian), Ulaanbaatar, p. 35–52.

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INTEGRATED ASSESSMENT AND GIS-MAPPING OF THE ENVIRONMENTAL STATE OF THE CITY OF VORONEZH (RUSSIA)

ABSTRACT. The authors have created a geoinformation-analytical system (GIS) for integrated assessment and mapping of the ecological conditions of the territory according to the criteria of anthropogenic impact and quality of the urban environment, as well as the response of woody plants and the health of the child population (on the example of Voronezh – the largest industrial city of the Central Chernozem region).

It has been identified that anthropogenic pollution is formed by the industrial-transport sector and varies with regard to the features of the functional planning infrastructure; near the industrial facilities of the petrochemical profile in the left-Bank sector of the city, conditions for the existence of woody plants significantly worsen, which is manifested in the inhibition of their development; child morbidity rate is significantly higher in industrially polluted neighborhoods with high load of pollutant emissions from industry and transport. The diseases primarily associated with pollution are congenital anomalies, neoplasms, endocrine pathology and diseases of the urogenital area.

The industrial zone is the main contributor to the total pollution of air, but the transport zone is the main contributor to the total pollution of soil and snow cover.

KEY WORDS: geographical information system, industrial pollution, health of the population, environmental assessment, Voronezh.

INTRODUCTION

Modern large cities are the centers of the most acute ecological problems. The monitoring and mapping of the ecological status of the urban environment are important tools of spatial planning and environmental safety and contribute significantly to solution of the contemporary urbanization problems.

At the turn of XX–XXI centuries, increasing density of urban development in large industrialized cities and the increase of air and soil pollution contributed to the decline of the quality of the urban environment. This is manifested in a certain environmental response – the inhibition of development of woody plants. Morbidity of the population has also increased.

Research in the field urban ecology and environmental geochemistry of urban landscapes in combination with the concept of environmental risk supports the relevance of quantitative evaluation of correlations “dose-effect” for a wide range of factors that shape the ecological situation and public health in large cities.

Theoretical approaches to the study of this problem have been discussed in numerous works of national and foreign scientists in the field of urban ecology, ecological geochemistry and medical geography [Bezuglaya et al., 1991; Ekogeokhimiya gorodskikh…, 1995; Kasimov et al., 2013; Malkhazova et al., 2011, 2014; Revich, 2010]. This allowed justification of risk-based modern approach to the problem of “environment - health,” focused on the identification and quantitative estimation of environmental risk factors, as well as on minimization of their negative impact on the biota and population.

These problems are relevant for many large industrial centers of Russia, including the city of Voronezh. Earlier, a number of analytical studies on the environmental zoning of urban environment and risk assessment for public health from adverse environmental factors on the territory of Voronezh city was conducted [Kurolap, Klepikov et al., 2006, 2010]. Methodologically these studies were based on the leading environmental risk factors, particularly, air-technogenic and soil-geochemical. However, aspects of integrated environmental assessment of linkages in the system “atmosphere – soil – biota – health of the population” remain insufficiently studied.

The aim of this work is development and testing of approaches to integrated assessment of the ecological state of the territory of a large industrial center with application of modern geoinformation technologies. Voronezh is selected as a model city because it is a major industrial town of the Central Chernozem region with a population of over 1 million people.

MATERIALS AND METHODS

The following methods were used: methods of environmental, geochemical, biological, and GIS research and assessment of ecological risk for the health of the population. Methods of probabilistic and statistical analysis in MS EXCEL and STADIA, as well as GIS technologies in the of MapInfo Professional 9.0 environment were used as integrating instrument for a comprehensive assessment and mapping of the environmental situation of the urban environment.

We have developed an automated GIS system for ensuring environmental monitoring in the Voronezh territory (“ECOGIS Voronezh”), including the storage subsystem of the environmental-geochemical and health-geographical data, as well as program-algorithmic support of ecological risk assessment.

The main principles of creation of the specialized GIS are complex systematic organization of diverse environmental data, linking to an existing environmental control system, automatization of procedures of data analysis and calculation of environmental risks, and the potential of timely GIS-based mapping.

The source data for creating of “ECOGIS Voronezh” were obtained during experimental research by the authors and provided by the regional ecological and monitoring agencies of the city. The structure of the GIS is shown in Fig. 1.

The 5-year period (2009–2013) was selected as a basic time period for assessment of the quality of the urban environment. Three levels of information generalization were defined as operational territorial units (OTU): 1) functional planning city zones (6 zones and the background, altogether 7 territorial units); 2) areas of service children’s clinics in the city (12 areas); 3) special points of monitoring of the state of the urban environment (75 points, including fixed and mobile control posts of the air system of the hydrometeorological service, the sanitary-epidemiological service, and, additionally, the selected monitoring points for uniform coverage of the territory of the city environmental management system).

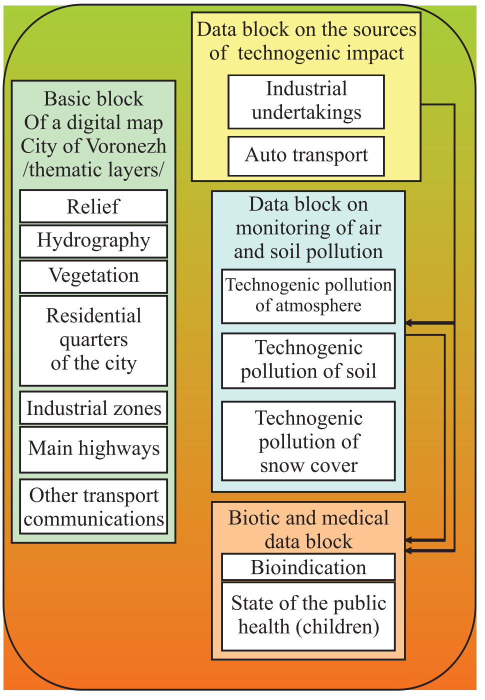

Fig. 1. The structure of the database for the integrated environmental assessment of the urban environment state.

Analysis of the formation of zones of technogenic pollution of the urban environment was conducted in several main directions: 1) influence of seasonal factors and dispersion of pollutants on the concentrations of pollutants in the atmosphere; 2) estimation of the statistical influence of the characteristics of industrial and transport load on concentrations of pollutants in the atmosphere, snow, and soil; 3) analysis of the correlation between pollution of soil and pollution of snow cover by comparing the pollution of these environments based on the most representative items of environmental monitoring.

All the objects on a digital map of Voronezh differentiated into the following basic thematic layers: 1) vegetation (intra-city and suburbs-native green areas, parks, squares, forming a "green frame" of the urban agglomeration); 2) hydrography (Voronezh reservoir, permanent and temporary watercourses); 3) residential blocks (divided into 3 functional sub-zones: "CH" – the Central historical part of the city, including multi-storied public-business development and "old" 5-storey building of the 1950s–1970s; "MD" – neighborhoods with modern high-rise buildings mostly from 9 floors and higher constructed in the 1980s – the beginning of this century; "PS"– the "private sector": predominantly low-rise and cottage resedential construction); 4) "Ind" – industrial zones (area occupied by industrial enterprises and their sanitary-protection zones); 5) "Tr" – traffic areas, including main automobile highways (and major traffic streets); 6) "R" – the recreational-residential zone covering the urban area and suburban "bedroom" micro-districts. Suburban territories outside of urban areas are selected as the background ("B").

The registry of 351 sources of technogenic pollution of the urban environment (199 industrial facilities and 152 transportation structures) with the characteristics of parameters of their impact (emissions of pollutants into the atmosphere, the intensity of traffic) was created to assess the impact of industry and transport on the urban environment; these data were "attached" to the spatial data.

Using the programming language MapBasic, the process of risk assessment for public health associated with chemical air pollution was automated. Was designed a special software module that implements calculations of quantitative risk levels for health in accordance with hygienic approaches [Onishchenko, Rachmaninov et al., 2002]. Formulas (1) and (2) were applied for calculating the levels of risk.

Carcinogenic risk (CR) in the course of life was determined by the formula (1):

$$CR = ADD*SF \quad (1)$$

where ADD is average daily dose in the course of a lifetime, mg/(kg*day); SF – carcinogenic potential factor.

Non-carcinogenic risk (for air pollution) was quantitatively evaluated by calculating the hazard ratio *(HQ)* by the formula (2):

$$HQ = Ci/RfC \qquad (2)$$

where HQ is the hazard ratio; Ci – average concentration (mg/m^3); RfC – reference (safe) concentration (mg/m^3).

Based on the created registry of industrial and motor vehicle contributors to the pollution of the atmosphere, an original technique for hazard assessment of the impact of sources of air pollution was developed. This technique includes a gradual implementation of the following calculation procedures (1)–(4).

1. Assessment of the potential hazard of industrial contribution. For each industrial facility (industrial site), the hazard indexes of emissions of polluting substances were calculated. The hazard classes of substances were taken into account. The weighted average index of ecological danger of the enterprise was determined similarly to the approach in [K.A. Bushueva, 1979], used to calculate the total air pollution index – K_{atm}, according to the formula (3):

$$K_{Atm} = \left(\frac{C_1}{N_1 MPC_{C_1}} + \frac{C_2}{N_2 MPC_{C_2}} + \ldots + \frac{C_n}{N_n MPC_{Cn}}\right)t, \qquad (3)$$

where C_i is the average annual concentration of i-substance; MPC_i – average daily maximum permissible concentration of i-substance; N_i is a constant that takes values 1; 1,5; 2; 4 respectively for substances 1, 2, 3, 4 hazard classes; t = P/P_o, where P – average annual percentage frequency of calms, %; R_o = 12.5 percent.

Using weight constants, the following formula was applied (4):

$$I_{ind} = \frac{I_{1cl}}{N_1} + \frac{I_{2cl}}{N_2} + \frac{I_{3cl}}{N_3} + \frac{I_{4cl}}{N_4}. \qquad (4)$$

Separately was determined the risk index of emissions of carcinogenic pollutants (CR) – total emissions of substances with an established carcinogenic effect in % of citywide emissions (I_{CR}). The carcinogens considered were the emission of carcinogenic substances belonging to groups 1, 2A and 2B according to the IARC classification given in [Onishchenko G.G., Rakhmanin et al., 2002].

2. Evaluation of potential hazards of motor vehicle contribution. First, the average intensity of movement of vehicles for each of the main streets the city was determined taking into account their category [Yakushev et al., 2013]. Further, according to the Directory of the streets, indices of the potential danger of emissions from motor vehicles were determined: index of the potential danger of emissions from passenger vehicles /I_{lgc}/ – they are the ranking indicators according to the traffic flow of vehicles through the streets of various categories; similarly, for trucks /I_{grs}/, buses /I_{awt}/, and the total grade of vehicle load by the total intensity of vehicles on the street of a given category /I_{atn}/.

3. Calculation of the total index of environmental burden of industrial and transport infrastructure (I_Σ) on the urban environment for any operational territorial unit is based on weighting the importance of the three main indicators of risk of emissions of pollutants from stationary and mobile sources of air pollution (for example, in the service area of the pediatric clinic) by the formula (5):

$$I_\Sigma = \sum_{i=1}^{n}\left(I_{ind} + I_{CR} + I_{atn}\right), \qquad (5)$$

where i...n is the number of objects (industrial areas, street slopes) within a given territorial unit.

4. Creation of digital maps of hazard of technogenic impact on the urban environment. It is performed by spatial interpolation of values of indices of environmental risk of industrial and motor vehicle contributors by the method of isolines. As a result, we calculated **areal rates** of emission of pollutants and the intensity of traffic through the residential areas of the city (example of the spatial distribution of the emission load is presented in Fig. 2).

To assess the response of biota to industrial pollution we have used special bioindicative research methods. The most abundant species of woody plants-bioindicators were selected: birch (*Betula pendula Roth.*) and Lombardy poplar (*Populus pyramidalis Borkh.*). This analysis of the leaves samples following the accepted techniques for analysis of fluctuating asymmetry of leaf plates made it possible to calculate the integrated indicator of stability of development. Various morphometric parameters of the lamina of these species in different functional zones of the city were evaluated as biological criteria.

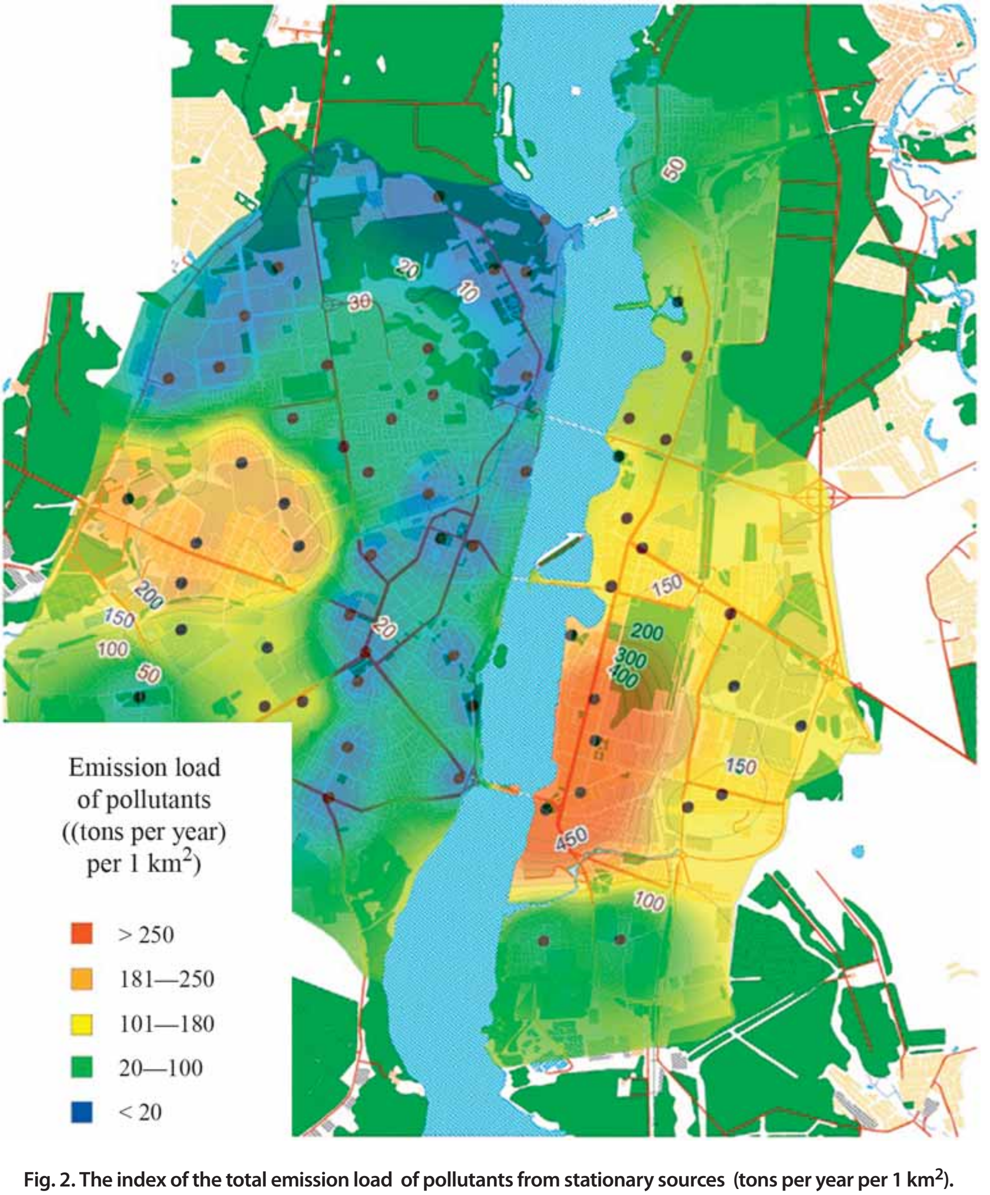

Fig. 2. The index of the total emission load of pollutants from stationary sources (tons per year per 1 km^2).

The analysis of internal interactions in the system "atmosphere – snow – soil – biota – population health," as well as the evaluation of the dependence of child morbidity on the parameters of technogenic pollution of the urban environment were based on the standard correlation and regression analysis with coverage of data on the territorial polyclinics of the city and on formal territorial interpolation for specially allocated items of monitoring of the urban environment.

RESULTS AND DISCUSSION

The analysis of correlations in the system "sources – pollution – transit environment – sequestering abiotic environment" has shown, in general, a logical pattern: in the total number of correlations, significant positive coefficients dominate (mostly in 55–84 % of cases for the majority of the criteria). The most stable relationships are marked by the most massive emissions of substances 3 and 4 classes of hazard, carcinogens, as well as the intensity of the total industrial traffic load, determined largely by passenger vehicles and the contribution of carcinogens, which present in the emissions from stationary sources. A fragment of the most typical links is shown in Table. 1.

A ranking of the reverse "response" of geochemical indicators on the industrial traffic impact showed stronger response criteria for the quality of atmosphere and soil and lesser for snow. The priority geochemical indicators include: carbon black and formaldehyde in the atmosphere, nitrogen compounds in snow, the total index of soil contamination by mobile forms of heavy metals – lead, zinc, copper, and cadmium.

The most polluted are the industrial and transport areas, and between the integral indicators of atmospheric pollution and soil there is a proved positive correlation,

Table 1. Generalized indicators of the stability of correlations between the parameters of the impact of industrial traffic loads and indices of air, snow and soil pollution

Impact criteria (P_i)		"Response" criteria	
Designation	Impact rate *	Ecological and geochemical criteria	Correlation coefficients P_i **
Index of integral industrial and transport load (I_Σ)	84.2 %	the atmosphere (formaldehyde)	0.39
		the atmosphere (carbon black)	0.51
		the atmosphere (K_{atm})	0.38
		snow (NO_3^-)	0.41
		snow (Pb^{2+})	0.32
		soil (Pb)	0.44
		soil (Cd)	0.65
		soil (pH)	0.45
		soil (AIP)	0.49
The ratio of total vehicle load ($T_{атн}$)	60.5 %	the atmosphere (carbon black)	0.43
		snow (pH)	0.68
		snow (mineralization)	0.54
		snow (Cl^-)	0.51
		snow (NH_4^+)	0.66
		snow (NO_3^-)	0.44
		soil (benzopyrene)	0.63

*) The proportion of positive significant correlations
**) Statistically significant correlation coefficients (r) > 0.56.

indicating a significant dependence of the aerogenic pollution of the soil by the inflow of pollutants (r = 0,77).

Conducted bioindicative studies based on the technique [Zakharov, Clark, 1993] using a scale to evaluate the favorability of species growing conditions showed that the zones with adverse conditions are located near industrial plants and major transport routes, which is most clearly manifested in the left-Bank sector of the city, near JSC "Voronezhsintezkauchuk" and CHP-1. The safest indicators of environmental quality are found in the recreation area and the residential district of the private sector. Most of the city's territory has the average level of deviations from conventional norms, which is a moderate degree of anthropogenic pollution of the urban environment.

The correlation of biological indices for functional planning zones is shown in Fig. 3. In general, the deviation of the integral index of stability of development from the physiological norm is higher in the left-bank part of the city. This is due to the concentration there of many industrial objects, and also to features of low-lying terrain, which are not conducive to purification of the atmosphere.

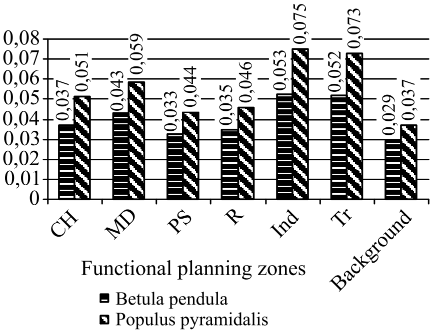

Fig. 3. The integrated indicator of stability of development of silver birch (*Betula pendula*) and poplar (*Populus pyramidalis*).

Selective statistical analysis of bioindicative features supported the conclusion that the data on the quality of the environment, obtained by calculating fluctuating asymmetry, are generally consistent with available information on the concentrations of various pollutants in ambient air, as well as with the layout of the main industrial pollution sources of the urban environment.

Quantitative assessment of the impact of industrial traffic pressure criteria and of the environmental and geochemical indicators of the quality of the atmosphere, snow and soil showed prevalence of positive correlations (about 60 % of cases), confirming the

Table 2. The main geochemical criteria of the ecological state of the functional and planning areas of Voronezh

Functional planning zones	Atmosphere (substances – mg/m^3)				Snow			Soil	
	Sulfur oxide IV	Formal-dehyde	Phenol	K_{atm}	pH	Mineraliza-tion, (mg/l)	NO_3^- (mg/l)	Lead (mg/kg)	AIP*
Residential (MD)	0.071	0.037	0.072	0.48	6.03	123.9	8.10	2.26	29.8
Residential (CH)	0.050	0.069	0.101	0.66	6.27	109.5	8.69	2.99	23.4
Residential (PS)	0.081	0.083	0.071	0.55	5.72	112.9	3.25	2.71	18.0
Industrial (Ind)	0.138	0.179	0.251	1.05	6.11	135.0	9.73	2.45	52.9
Transport (Tr)	0.144	0.181	0.202	0.97	6.55	143.5	17.30	3.92	66.0
Residential-Recreational (R)	0.036	0.014	0.032	0.31	5.74	116.0	5.80	2.02	12.2
Background	0.028	0.007	0.029	0.26	5.39	104.5	1.56	2.00	16.1

*) AIP – the aggregate index of soil pollution with heavy metals

increase in morbidity of children living in technogenically-loaded areas.

The priority health risk factors (for common weight positive significant correlations) are: the ratio of the emission load of carcinogenic substances, especially, the indices of road congestion. In such areas, children have generally higher levels of morbidity for several diseases (congenital anomalies, neoplasms, endocrine pathology and diseases of the urogenital area). The majority of correlations are reliable.

The indicator parameters of chemical pollution of snow cover that reflect general industrial and transport pollution include the total dissolved solids, nitrogen compounds, chloride ions and the presence of lead in the melting snow.

A multifactorial model (formula (6)) was built based on the priority risk factors; the model

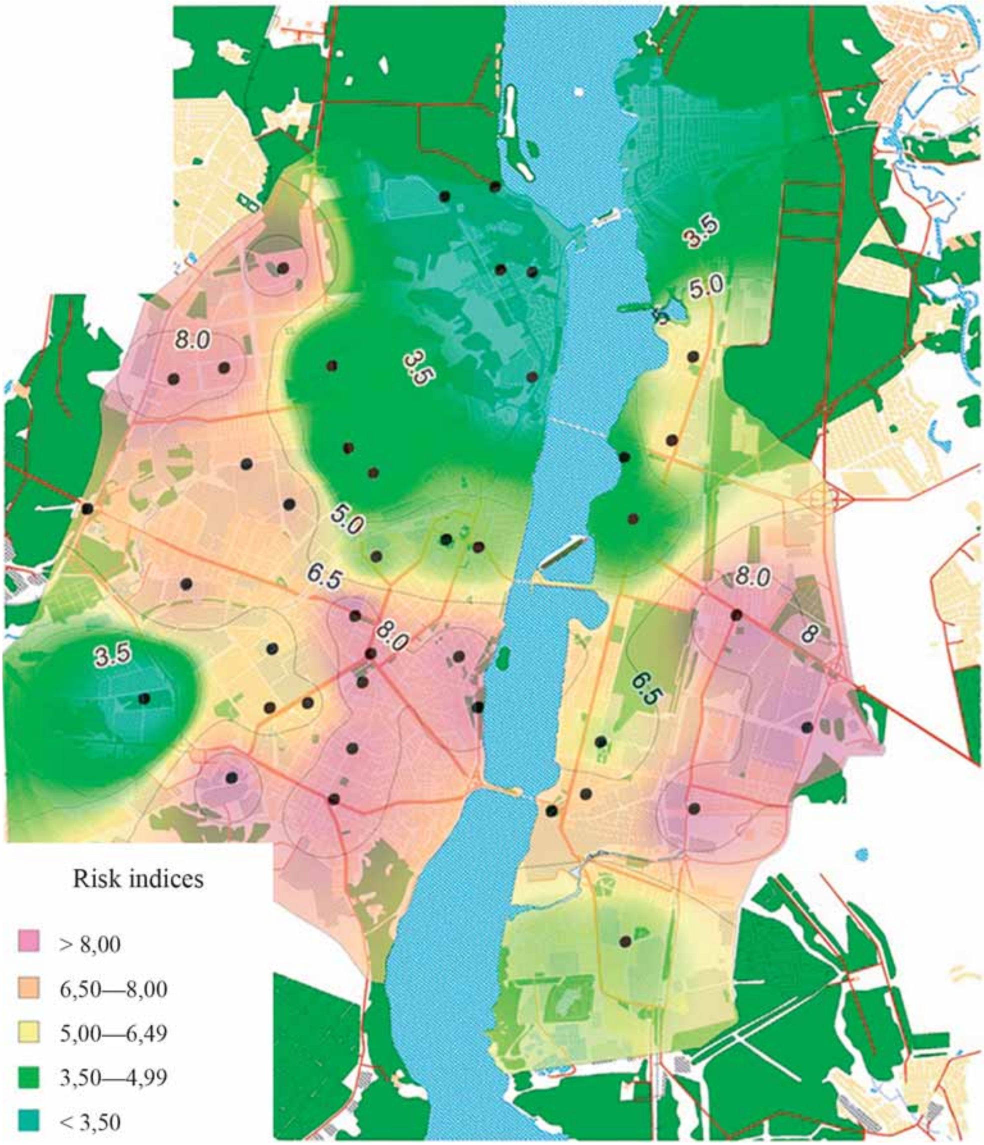

Fig. 4. Integrated assessment of the ecological condition of the territory of the city of Voronezh (method IDW interpolation).

reflects the total effect of the 5 risk factors on the overall morbidity rate of the children population (multiple correlation R = + 0.82):

$$Y = -88.34 - 25.18(X1) + 0.0037(X2) +$$

$$+ 545.59(X3) + 4.70\,(X4) + 8.93\,(X5), \qquad (6)$$

where X1 – (P_{CR}) – coefficient of emission levels of carcinogens (t/year per 1 km^2); X2 – (T_{atn}) – the total traffic intensity of vehicles (auto/h per 1 km^2); X3 – is the comprehensive index of atmospheric pollution (K_{atm}); X4 is the total mineralization of snow cover (mg/l); X5 – the total index of soil pollution with heavy metals (SDRs).

To increase the validity of zoning, we applied methods of multivariate statistical analysis. In particular, the use of cluster analysis has led to a more accurate classification of functional-planning areas according to the similarity of the nature of environmental pollution and feedback of living organisms. Three cluster groups were isolated: a) industrial and transportation zones together (the most technogenic polluted); b) residential, including all the sub-zones regardless of the number of floors and historical-compositional construction (areas of moderate contamination); c) residential recreation and the background (the most environmentally safe, comfortable).

The main geochemical criteria of the ecological state of the urban environment are shown in Table 2. We have calculated the integral evaluation score based on set of particular indicators of the ecological state of the urban environment and children health. This score was obtained by calculating a weighted average of scores characterizing the degree of medico-ecological tension of the area.

The final element of the integrated assessment was the creation of a map which shows gradient differences of environmental risk indices. The data was processed in respect to 46 of the most representative monitoring points (Fig. 4). The compiled map illustrates spatial differences, of up to about three-fold level, in risk indexes in affluent suburban neighborhoods and the community center, as well as the industrial and transportation areas of the city.

CONCLUSION

The conducted research allows us to formulate several basic conclusions: 1) industrial pollution is formed by industrial-transport sector and functional planning of the city infrastructure; 2) quality criteria for soil and atmosphere give a stronger response to industrial and traffic impacts; snow is a geochemical indicator with a significantly smaller effect; 3) near industrial petrochemical enterprises in the left-Bank sector of the city, conditions for the existence of woody plants are significantly worse. This is manifested in the deviation from the background of the indicator of stability of development of silver birch and poplar; 4) there is a statistically valid increase in the incidence of children diseases in the areas of technogenic load. Diseases with the greatest environmental dependence include congenital anomalies, neoplasms, endocrine pathology and diseases of the urogenital sphere; 5) the priority health risk factors – the ratio of the emission load of carcinogens and indices of road congestion; 6) the territory of Voronezh industrial zone "leads" in the total pollution, while transport "leads" in the total pollution of soil and snow cover.

The identified trends may be useful for regional environmental and hygienic services for the development of targeted environmental monitoring programs and may reduce the risk of ecologically caused diseases of the population in the conditions of intensive technogenic pollution of the urban environment. In particular, there is a need for a targeted environmental policy to reduce environmental risk and to improve the urban environment of Voronezh. Its components may include the following: reconstruction of transport networks by increasing their width and the average speed of movement of vehicles and enhancing quality of road surface; creation of "transport corridors" similar to "organic systems" of urban transportation in many European cities; change in the fuel balance of the thermal power generation industry with a complete transition to gas as fuel; larger green urban space with the introduction of pollution resistant green plantings and a more widespread use of "vertical gardening" of walls and roofs, based on the experience of several major cities in Europe, which will reduce air pollution near the highways.

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REFERENCES

1. Bezuglaya Y.E. Rastorguev, G.P., Smirnov V.I. (1991). Chem dyshit promyshlennyi gorod (What industrial city breathes). – L.: Gidrometeoizdat. – 256 p. (in Russian)

2. Bushueva K.A., Sluchanko I.S. (1979). Metody i kriterii otsenki sostojanija zdorovja naselenja zagrjazneniem okruzhajuschei sredy (Methods and criteria for evaluating the health status of the population affected by pollution). – M.: Medicine. – 160 p. (in Russian)

3. Ecogeokhimiya gorodskih landshaftov (Eco-geochemistry of urban landscapes) (1995) / ed. by N.S. Kasimov. – M.: Publishing house of Moscow state University. M.V. Lomonosov Moscow State University, 1995. – 336 p. (in Russian)

4. Kasimov N.S., Nikiforova E.M., Kosheleva N.E., Khaybrakhmanov T.S. (2013). Geoinformatsionnoe landshaftno-geohimicheskoje kartografirovanie gorodskih territorij (na primere VAO Moskvy) (Geoinformation landscape-geochemical mapping of city territories (on the example of the Eastern administrative district of Moscow)). Landscape-geochemical map // Geoinformatics. No. 1. S. 28–32. (in Russian)

5. Kurolap S.A., Eprintsev, S.A., Klepikov O.V. and others (2010). Voronezh: sreda obitanija i zony ekologicheskogo riska (Voronezh: habitat and areas of environmental risk). – Voronezh: Istoki. – 207 p. (in Russian)

6. Kurolap S.A., Mamchik N.P., Klepikov O.V. (2006) Otsenka riska dl'a zdorov'a naseleni'a pri tehnogennom zagrjaznenii gorodskoj sredy (An assessment of risk to the health of the population from technogenic pollution of the urban environment). – Voronezh: VSU. – 220 p. (in Russian)

7. Malkhazova S.M., Koroleva E.G. (2011). Environment and Human Health: A Training Manual. – M.: Geography Faculty of Moscow State University. – 180 p.

8. Malkhazova S.M., Linsheng Y., Wuyi W., Orlov D.S., Shartova N.V., Hairong L., Li W. (2014). Health of urban population in Moscow and Beijing agglomerations // Geography. Environment. Sustainability. № 4 (v. 7). pp. 41–53.

9. Osnovy otsenki riska dlja zdorovja naselenija pri vozdejstvii himicheskih veschestv, zagrjaznjajauschih okruzhajuschuju sredy (Principles of risk assessment for health when

exposed to chemical substances polluting the environment) (2002) / ed. by Yu. A. Rakhmanin, G.G. Onishchenko. – M.: Institute of STATE and ECH. – 408 p. (in Russian)

10. Revich B.A. (2010) Environmental priorities and health: vulnerable areas and populations // Human Ecology. № 7. pp. 3–9.

11. Yakushev, A.B., Kurolap S.A., Karpovich, A.M. (2013). Ekologicheskaja otsenka vozdejstvija avtotransporta na vozdushnij bassejn gorodov Tsentral'nogo Chernozemja (Environmental assessment of the impact of transport on air basin of the cities of the Central Chernozem region). – Voronezh: Publishing house "Scientific book." 207 p. (in Russian).

12. Zakharov V.M., Clark D.M. (1993). Biotest. Integral'naja otsenka zdorovja ekosistem I otdel'nyh vidov (Biotest. Integrated assessment of health of ecosystems and individual species). – M.: Moscow DEP. Intern. Fund Biotest. – 68 p. (in Russian).

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ENVIRONMENTAL MECHANISM OF REGIONAL LONGEVITY IN CHINA

ABSTRACT. The integrated study on environment of typical China's longevity areas was conducted by using comprehensive methods of health geography. It was found that Chinese longevity areas mainly located in the south China and clustered in Sichuan-Chongqing, Central plain and Southeast region, the Yangtze River Delta and Pearl River Delta; in which drinking water was of weakly alkaline, Se, Fe, K content was moderate, higher content of Ca, Co, Mn, and low Cr, Cd, Pb; the concentration of trace elements benefit for health in soils and food staples was higher; hair of centenarians had higher Li, Mg, Mn, Ca, Zn content, lower concentration in Cd, Cr, Cu, Ni; healthy centenarians were also benefited from a favorable social environment factors, such as physiological health, psychological state, light meals and higher proportion of vegetables. The study was the first time to reveal quantitatively the relationship between longevity and the natural and human environment, and provided a scientific basis for the promotion of development of China's longevity area, to achieve the construction of ecological civilization.

KEY WORDS: regional longevity, environment, centenarians, chemical elements.

INTRODUCTION

China has entered into the aging society, and it is in the rapid aging period. According to the sixth national census data in 2010, the population of aged over 60 years old is 177,648,705 people, accounting for 13.26 % of the total population of China, and the population aged 65 and over is 118,831,709 people, accounting for 8.87 % of the total population. Compared with last national census in 2000, the proportion of the population aged 60 and over has increased by 2.93 %, the proportion of the population aged 65 and over has increased by 1.91 %. These data suggest that the construction of healthy aging society has become an important issue, but also an important task to cope with rapid aging. The so-called healthy aging refers to a healthy state of complete physical, mental and social functions to the most of elderly in the aging society, but also means that the social development would not be excessively influenced by fast population aging. Therefore, it is necessary to reveal the mechanism of the formation for longevity, especially carrying on a comprehensive analysis on aspects of physiology, psychology, socio-economy with natural environment.

For a long time, we observed the problem of aging in China and found the phenomenon of regional longevity, in another words, the distribution of longevity people has been of the geographic clustering in China [Wang et al., 2008; Lv et al., 2011; Wang et al., 2014]. Centenarians have been a symbol of health and longevity, and it can be considered as the outcome of interactions between lifestyle, heredity, environmental, health care level and psychological factors. Among these, environment could play an extremely important rule resulted in the regional distribution of longevity in China. The reason we study regional longevity in China will be as the follows:

First, the regional longevity in China is an objective phenomenon, which requires a multiple study to reveal the factors on longevity for scientific understanding and better explanation. Forming of region longevity is the result from the integration of many factors. As a typical case, the longevity area, in which centenarians gathering live, more influenced by the geographical environment. The so-called geographical environment refers to the earth's surface in which mankind depends on, survival and development, is the unity of two parts as the nature environment and human environment. Natural environment is consisted of rock, soil, water, air, biological and other components (elements), all these integrate to form the natural complex. According to the perspective of the earth's sphere, the natural environment could be divided into the lithosphere, hydrosphere, atmosphere and biosphere. Human environment is the regional combination of social, cultural and production activities, including various components such as population, ethnic, settlement, politics, society, economy, transportation, military, social behavior, and others (elements). They constitute the spheres of the earth's surface, called the humanities sphere, also known as social sphere. Geographical environment consisted of natural environment and human environment plays a decisive role on human health. Until now there are many studies on the factors of longevity, but no satisfied explanation to longevity of regional aggregation has been reached; some studies just made simple comparison on the different factors of the longevity environment; the study on the relationship between longevity and the chemical elements only present single correlation analysis, lack of research on the multi-chemical elements from environmental transfer to human, and lack of a comprehensive study to find out the common characteristics of the different regions.

Second, it is the needs to summarize the comprehensive features of natural environment and human environment for building healthy aging society. The mechanism of longevity environment could provide a scientific basis for the government, institutions, and public to promote environmental protection, social development and economic growth, and will be benefit for actively respond to the challenge of aging.

Third, learning from the different experiences of innovative measures to protect the local elderly in the typical longevity areas could provide economic and effective way to be implemented for the construction of healthy aging society, and these would be suitable to diversity of natural environment, varying degrees of aging, and different economic regions.

Therefore, we did a comprehensive study on environmental factors of longevity region. This article briefly described the distribution feature of aging and longevity population. Contrary to the defects of the former studies on longevity with natural environmental factors and social factors, five typical "longevity county", Xiayi in Henan province, Mayang in Hunan province, Zhongxiang in Hubei province, Yongfu in Guangxi Autonomous region, Sanshui in Guangdong province were chosen to study. By sampling of water, soil, food and hair of centenarians, and macro and trace elements of analysis, the relationship between trace elements and longevity could be established, and the chemical elements spectrum impacting longevity could be identified. Therefore the common regular pattern of the natural environment to health and longevity could be initially revealed. Simultaneously, the human geographical environmental characteristics of typical of longevity areas were also analyzes, and preliminary discussion to build up China's "longevity county" was present.

METHODOLOGY

Human health refers to the structure and functions of the human body systems continuing in a relatively stable state, and maintains dynamic equilibrium with the external environment. Health and longevity are the important indicators of earth's environmental quality. Based on the close relationship between human health and the geographical environment, the main academic idea of this study is focused on the environmental characteristics of longevity area in China, and revealing the factors of longevity with the environment.

The technical approach is that with geography's ideas and methods, we study the distribution features of longevity areas and their environmental characteristics; at the same time, using comparison on the environment to find out the differences and similarities between longevity and non-longevity areas; and then propose suggestion for promoting health and longevity.

The demographic database of the sixth census of China in 2010 was utilized mainly and the statistical yearbooks in recent years for our studies. With the support of ArcGIS software, we constructed the spatial and attribute database of the centenarians using the map of China and the sixth census population data. Before that, field survey and sampling in different counties, and chemical analysis were carried on. The water, soil, food, hair samples were prepared according to the methods of national standard for quality control, and using ICP-OES to analyze for the content of Al, Ba, Ca, Fe, K, Mg, Mn, Mo, Na, P, Sr, V, Zn and others, the concentration of Cd, Co, Cr, Cu, Li, Ni, Pb and Se were determined by ICP-MS. All the statistical analysis was done with different modeling methods.

RESULTS

The spatial distribution of centenarians in China

According to China's sixth census, the geographical distribution of longevity population is of significant regional characteristics. Figure 1 shows those sub-provincial administrative units with the centenarian rate 2.7 per 100,000 people, which is the current average level of the centenarian rate in China. The gathering areas of centenarians in China are distributed mainly in the south of the country, located substantially on the south boundary of the North-South climate stripe of China; more in Sichuan-Chongqing region, the Central Plains region of China; most along the river watershed distribution such as the Yangtze River, Pearl River; and more gathered in the Yangtze River Delta, Pearl River Delta region; the areas distributed in the hilly and alluvial flood plains; non endemic areas. These show that the distribution of longevity areas relates to natural and human environment factors.

In provinces, autonomous regions and municipalities as the administrative unit, the proportion of centenarians in Hainan province is 18.75/100,000 as the highest in the China. Guangxi autonomous region (7.80/100,000), Sichuan province (4.21/100,000) and Guangdong province (3.65/100,000) respectively ranked as second to four. The longevity index referred to the ratio of population over 65 years old to 90 years and above in Hainan province is 2.89 % ranking the first in China, Shanghai (2.63), Guangdong province (2.41) and Guangxi autonomous region (2.31), respectively ranked as second to four.

Making comparison analysis on meteorological data with the longevity areas, it was found that China's longevity areas mostly located in warm climate type zone, average temperatures were between 8.6–24.9 °C, relatively abundant rainfall, relative humidity more than 68 %, and average annual sunshine hours higher than 821.5 hours in the most longevity areas.

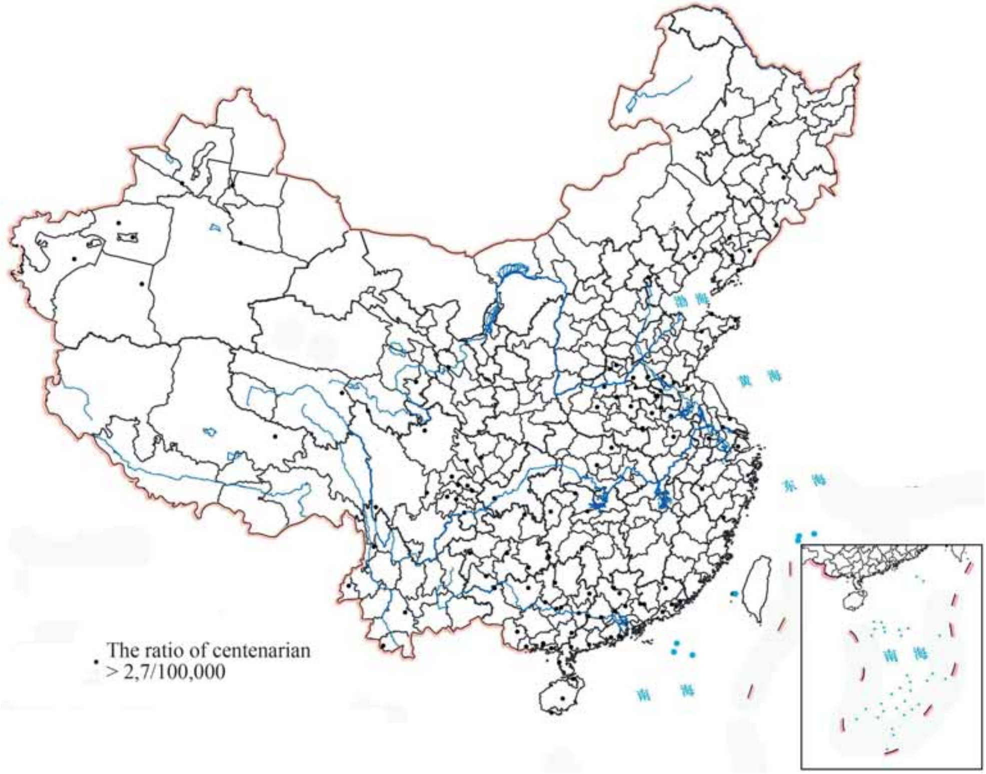

Fig. 1. The distribution map of centenarians in China.

The correlation analysis on chemical elements in the centenarian and the environment

Selected five typical "longevity county" of China, Xiayi county in Henan province, Mayang county in Hunan province, Zhongxiang city in Hubei province, Yongfu county in Guangxi autonomous region, Sanshui district in Guangdong province as the study areas, the chemical environment where centenarians live in was studied. The samples of drinking water, soils, staple grains and hairs of centenarians were collected and the contents of chemical elements were analyzed to find the impact of chemical elements on health and longevity.

Characteristics of chemical elements content in drinking water

Drinking water may make an important contribution to total dietary intake of required macro- and trace elements essential for human health and affect the desirable balance of these elements. In this study, the pH and Na, Fe, Ba, Cd, Cr, Cu, Mn, Mo, Ni, Pb, Se, Zn, F concentrations of the collected 182 drinking water samples from longevity areas were compared with the national standards for drinking water quality GB 5749–2006 and World Health Organization guidelines. The results show the quality of drinking water samples could meet these standards and had pH > 7, these were classed as weakly alkaline, which is beneficial to health and longevity according to some studies. All these results show as well that the drinking waters of longevity areas are clean and free from pollution, and with enough contents of Se, Fe and Ca, this is the important factor to local longevity.

Characteristics of chemical elements content in soil

Soil quality is not only the indicator of local environmental quality also affects the levels

Table 1. The content of chemical elements in rice(μg/g)

Element	Ca	Cu	Fe	K	Mg	Mn	P	Zn	Se*
Minimum		0.369	0.259	197.1	39.54	2.024	196.9		18.35
Maximum	6272.	7.558	291.3	4993.	1749.	45.65	4127.	45.90	199.6
Mean	233.0	2.895	24.15	2234.	751.2	14.42	1951.	20.26	56.69
Standard deviation	38.54	0.125	2.464	107.1	39.13	0.878	81.60	0.679	2.445
Median	81.64	2.332	15.74	1485.	629.5	9.2	1724.	16.64	49.44

* μg/kg

of nutrients in food crops. By analyzing the collected 325 soil samples, the results shown that content of Cd, Cr, Cu, Pb, Zn, Ni and other heavy metals could meet well the national soil environmental quality standard as the grade II which means no pollution of heavy metals in the soils of longevity areas. Nevertheless, Fe, Se, Zn are relatively affluent, and these would be benefit for health [Liu et al., 2013].

By the multiple regression analysis on the background values of chemical elements in soils of China according to the national survey, with the centenarian index (number of centenarians/per 100,000 people) and the longevity index (number of centenarians/the population of 65 years old and above) it was found:

$\tilde{Y}$ (centenarian index) =

1.679 – 0.205 Ni + 0.413 Co +

+ 0.006Se ($R^2 = 0.402$, $p < 0.01$);

$\tilde{Y}$ (longevity index) =

= 3.425 – 0.262Ni + 0.435 Co +

0.006 Se ($R^2 = 0.369$, $p < 0.01$).

The regression equation shows that the trace elements, cobalt and selenium which are benefit for health are positively correlated with centenarian index and longevity index, and nickel is negatively correlated with these two indicators. These imply that longevity could be result from the good soil environmental quality.

Characteristics of chemical elements content in rice as the staple grain

The grains could directly affect human health. Table 1 presents the concentration of chemical elements in 235 staple grain samples collected from longevity areas. The data shows that sufficient supply of essential chemical elements from food is beneficial to health and longevity. For example, selenium content in the grain level from the national perspective, less than 25 μg/kg is the level of selenium deficiency, 40–70 μg/kg selenium is middle level, greater than 1000 μg/kg is excess selenium levels [Tan 1989]. The selenium content in rice of longevity areas is the averaged 56.69 μg/kg, the median is 49.44 μg/kg, which means moderate selenium content good for health.

Characteristics of chemical elements content in the hair of centenarians

Collected 153 samples of hair from longevity people, the results of chemical element level of hair are shown in Table 2 with reference values. Compared with the reference value [Miekeley et al. 1998], centenarian's hair is significantly enriched for Ca, Li, Mg, Mn with low level of Cr, Cd, Cu, K, Ni, and Fe, P, Pb, Sr, Zn, Se are within the normal reference range.

Due to the presence of extreme values, a simple average value of the chemical element could not reflect the true distribution feature of the elements, so we further calculated the probability inside and outside of the reference range of the element content in hair. Table 3 shows the probability of element content

Table 2. The content of chemical elements in the hair of centenarians (µg/g)

Element	Reference	Mayang	Sanshui	Xiayi	Zhongxiang	Yongfu
Ca	350-860	1743	993	1049	1252	630
Cd	<1.0	0.112	0.214	0.047	0.039	0.046
Cr	0.78-1.0	0.020	0.860	0.046	0.016	0.038
Cu	13-35	5.15	7.33	6.50	6.54	7.07
Fe	6.0-15	12.95	31.44	10.33	12.79	10.22
K	17-140	16.83	12.25	13.29	11.37	12.42
Li	0.05-0.3	1.651	0.083	0.660	0.963	0.643
Mg	40-110	180	93.76	147.36	134.49	65.76
Mn	0.26-0.75	1.91	1.04	2.97	1.14	3.50
Ni	<1.6	0.037	0.653	0.035	0.020	0.034
P	120-180	137	152.38	107.34	112.98	106.67
Pb	<6.0	3.47	6.95	2.66	1.67	2.77
Sr	1.0-7.6	4.85	3.27	5.17	3.82	2.07
Zn	125-165	170.78	176.03	135.15	151.08	140
Se	0.38-0.7	0.39	0.58	0.24	0.39	0.31

Table 3. Probability inside and outside of the reference range of the element content in hair of centenarians (RVs, %)

< RVs	Cr	Cd	Cu	Ni	Ca	Li	Mg	Mn	Zn
Mayang	100	99.9	100	100	3.1	4.3	2.6	2.24	8.0
Sanshui	100	96	99.5	100	19.8	15.2	2.62	1.73	18.6
Xiayi	100	100	99.8	100	6.8	0.2	0.58	11.2	33.2
Zhongxiang	100	100	99.9	100	18.3	0.46	22.6	17.9	25.6
Yongfu	100	99.2	100	100	2.7	18.4	4.1	23.2	23.9
≈RVs	**Cr**	**Cd**	**Cu**	**Ni**	**Ca**	**Li**	**Mg**	**Mn**	**Zn**
Mayang	0	0	0	0	0.73	2.6	11.6	4.2	31.7
Sanshui	0	0	0.5	0	2.32	4.2	31.4	10.7	23.8
Xiayi	0	0	0.2	0	1.97	4.0	16.8	3.2	44.6
Zhongxiang	0	0	0.1	0	20	9.7	44	2.1	55.1
Yongfu	0	0	0	0	14.4	4.5	22.2	5.2	32.8
> RVs	**Cr**	**Cd**	**Cu**	**Ni**	**Ca**	**Li**	**Mg**	**Mn**	**Zn**
Mayang	0	0.1	0	0	89.6	93.1	85.9	73.4	60.4
Sanshui	0	4.0	0	0	57.0	80.6	42.4	72.0	57.7
Xiayi	0	0	0	0	73.5	95.8	77.4	85.6	22.3
Zhongxiang	0	0	0	0	61.8	85.7	33.4	80.0	19.4
Yongfu	0	0.8	0	0	82.9	77.2	73.6	71.6	43.3

in the hair within the range by identifying the normal distribution of the sample. [Chojnacka et al. 2005; Chojnacka et al. 2006; Zaichick 2010].

As shown in Table 3, compared with the reference value of elements in the hair, the content is generally higher in Li, Mg, Mn, Ca, Zn, lower in Cd, Cr, Cu, Ni and no significant different to other elements. This commonality of chemical elements contents of centenarians may be the important factors for longevity.

Using Stepwise-MLR analysis, centenarians age ($\tilde{Y}$) as the dependent variable, with trace element contents in hair as the independent [Li et al. 2011], it was found that:

$$\tilde{Y} = 101.156 - 0.796Cr + 0.008Zn - 0.034Pb +$$
$$+ 2.270Se - 7.335Cd$$
$$\times (R^2 = 0.37;\ F\ (5,101) = 3.26,\ P < 0.01).$$

This shows that positive relation of zinc and selenium, negative relation of chromium, lead and cadmium is the main feature. This may suggest that supply of Se, Zn and less exposure of heavy metal are helpful for the health of centenarians.

Life and psychological characteristics of centenarians

Social environmental factors including family situation, physical health, self-care and activities of daily living, mental health status and lifestyle are of major impact on health and longevity. To understand this, the interview survey to centenarians and other elderly people were conducted, and 2674 questionnaires were collected from Sanshui district of Guangdong province, Mayang county of Hunan province, Zhongxiang city of Hubei province, Xiayi county of Henan province, Yongfu county of Guanxi autonomous region and other longevity areas. By statistical analysis, it was found that longevity people have not only healthy physiological function, but also in positive mental status, in addition they have a light style of meal, with high proportion of vegetable intake.

Healthy physiological function

Sleeping and disease status is the main indicator of health for the elderly. Fair sleeping quality and enough sleeping hour are the important effects for health and longevity. According to the study on the elderly people who had no sleeping interferers in Pittsburgh, it was shown that mortality could be increased with sleeping efficiency decreasing [Dew et al. 2003].

Concerning sleeping time in our survey, it was shown that centenarians had 9.6 sleeping hours in average, 80 to 99 year old people had 8.33 hours, and 60–79 years younger elderly had only 7.64 hours of sleeping time. This gave us an image that centenarians had more adequate sleeping time and its sufficiency could ensure the physical recovery of centenarians. We graded the sleeping quality of centenarians into five types as very good, good, fair, poor and very bad, and found that centenarians had very good and good sleeping accounted for 76.64 %.

The average illness and hospitalization times for centenarians were 0.71 and 0.76 per two years respectively, considerable lower than the national hospitalization average level of 5 times per year. Some research indicated that with age increasing, the elderly tended to use health services more frequency, our survey found that this tendency might stop at the very old age. Among older age groups, illness and hospitalization declined especially to the centenarians very much, and it suggested that these individuals were either more robust physically to begin with and/or better adapted to tackling the challenges brought about by old age.

Positive mental state

The longevity group had a relatively positive mental state, characterized by reporting that they had a "let it be" attitude when faced with adversity, and that they felt "as happy as when I was young". A negative mental state was characterized by reporting as "feeling nervous or fearful," and "feeling lonely". In the interviews, most of the longevity group had a positive mental state, and more than 80 % of the aging group had a "let it be" attitude. The proportion for centenarians was even higher as "let it be" accounted for more than 50 % (Fig. 2).

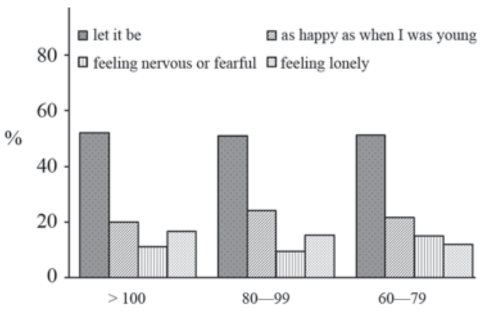

Fig. 2. The mental state of centenarians and elderly.

Light dietary and high proportion of vegetables

Regarding the food habit, the centenarians ate rice and flour as the major staple grains, accounting for 90 % of all staple food consumption. As shown in Fig. 3, they ate relatively light, plain food which means a light taste, not salty, not spicy, and not oily. The typical feature is that they had lots of vegetables for meal accounted for 60 % above every day.

DISCUSSION AND CONCLUSIONS

The longevity phenomenon is the integrated effect of many factors, including physical environment, custom habit, cultural characteristic, health care system and heredity factors and so on. Other factors may include as life style, physical exercise, nutrition status, social relationships and the psychological factor. This paper intended to explain mainly the longevity mechanism from the prospect of geographical environment including natural and human environment. The main findings are as follows:

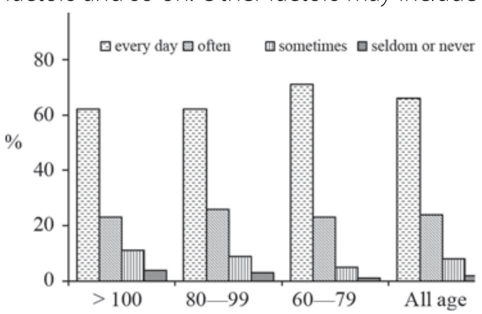

Fig. 3. The vegetables consumption for centenarians and elderly.

1) the distribution of centenarians are aggregated roughly in the south of China, especially along the Yangtze River basin, Pearl River and their Delta.

2) preferable natural environment factors, such as mild climate, clean water, sufficient trace elements including calcium, selenium, zinc, and cobalt in the environment and low exposure of heavy metals are beneficial for longevity and health.

3) health and longevity are also benefited from a favorable social environment factors, the common feature of centenarians is the positive mental state, the light meal with higher ratio of vegetable.

Longevity is the comprehensive indicator of the harmonious development on environment-society-economy-health. We believe that the "longevity county" is not simply shown how much population of longevity in certain region, but contains a wealthy content of the harmonious development in the regional environment, society, economy and health. The so-called comprehensive indicator, which contains a wide range of meanings, can be mainly summarized as four points:

First, the longevity is long term formed and could not be established in a short period. Because people's longevity is the result of long-term to maintain a healthy state in several decades or even centuries in the good natural environment, social and family conditions for the formation of long-term accumulation.

Second, the longevity is an interactions result from multi-factor and multi-condition of the genetic, psychological, physical and social environment. The longevity is also the result of government, institutions, communities, families and individuals working together to continuously improve the social security, economic development, health care coverage, education, culture improvement, environmental protection and other aspects of the society.

Third, the longevity is the most concentrated expression of harmonious relations between the human and material world.

Fourth, the longevity is a dynamic development progress. Longevity embodies the harmonious development of man and the environment both in the past and the current situation, but it is also the enlightenment and requirements for the future development.

In summary, we must fully understand that longevity is the comprehensive result of regional development on environment, society, economy and human health, and improve the awareness of the construction of longevity society to achieve sustainable development.

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REFERENCES

1. Chojnacka K., Górecka H., Chojnacki A., Górecki H. (2005) Inter-element interactions in human hair. Environmental Toxicology and Pharmacology, 20: 368–374.
2. Chojnacka K., Górecka H., Górecki H. (2006) The influence of living habits and family relationships on element concentrations in human hair. Science of the Total Environment, 366: 612–620.
3. Dew M.A., Hoch C.C., Buysse D.J., Monk T.H., Begley A.E., Houck P.R. (2003) Healthy older adult's sleep predicts all-cause mortality at 4 to 19 years of follow-up. Psychosomatic Medicine, 65: 63–73.
4. Li Y.H., Yang L.S., Wang W.Y., et al. (2011) Trace element concentrations in hair of healthy Chinese centenarians. Science of the Total Environment, 409: 1385–1390.
5. Liu Y., Li Y.H., Jiang Y., et al. (2013) Effects of soil trace elements on longevity population in China. Biological Trace Element Research, 153: 119–126.
6. Lv J.M., Wang W.Y., Li Y.H. (2011) Effect of environmental factors on the longevous people in China. Archives of Gerontology and Geriatrics, 53: 200–205.
7. Miekeley N., Dias Carneiro M.T.W., Porto da Silveira C.L. (1998) How reliable are human hair reference intervals for trace elements? Science of the Total Environment, 218: 9–17.
8. Tan J.A. (1989) Environmental selenium and health. Beijing: People's Medical Publishing House.
9. Wang L., Wei B.G., Li T.H., et al. (20140 A study of air pollutants influencing life expectancy and longevity from spatial perspective in China. Science of the Total Environment, 487: 57–64.
10. Wang W.Y., Yang L.S., Li H.R., et al. (2008) The effect of environment on longevity. China Society Periodical, 32: 21–23.
11. Zaichick S., Zaichick V. (2010) The effect of age and gender on 37 chemical element contents in scalp hair of healthy humans. Biological Trace Element Research, 134: 41–54.

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DRINKING WATER, SANITATION AND HEALTH IN KOLKATA METROPOLITAN CITY: CONTRIBUTION TOWARDS URBAN SUSTAINABILITY

ABSTRACT. In an urban area, the water is supplied through centralised municipal tap water system. For the present enquiry, the municipal supply of water for drinking and sanitation purposes has been assessed in terms of its availability and accessibility to the people, possible sources of water contamination and related health issues in Kolkata. The relevant data have been accessed from various secondary sources where the published data from West Bengal Pollution Control Board (WBPCB) and Kolkata Municipal Corporation (KMC) are noteworthy. The data thus obtained have been assessed qualitatively to depict the ground reality on sanitation and health related issues. The analyses of the data reveal that in Kolkata, the availability of good quality drinking water is not sufficient as the supply is low and inadequate. On the other hand, the underground water which is considered as the alternative source to the people is found to be contaminated with heavy metals like arsenic and lead. The non-availability of sufficient water for drinking and sanitation purposes and consumption of contaminated water may result into poor health condition with various water borne diseases. The data on diseases from dispensaries (aided by KMC) in Kolkata has revealed that people with water borne diseases are significant in number where they are found to be affected with diseases like Acute Diarrhoeal Infection and Dysenteries. Some suitable measures have been proposed whereby applying those, the availability and accessibility of water for drinking and proper sanitation could be enhanced and the occurrences of diseases might be avoided.

KEY WORDS: drinking water, sanitation, health, water borne diseases, dispensary, KMC.

INTRODUCTION

The availability and quality of fresh water resources is the most pressing of many environmental challenges in India [Central Pollution Control Board, 2013]. Although 89 per cent of the urban population in India has access to water supply, the average availability is less than four hours a day and in some areas water is supplied only for one hour on alternate day [Asian Development Bank, 1997]. The human body requires minimum approximately 3 litres per capita per day (lpcd) intake of drinking water to sustain life before dehydration occur in tropical climate [White et al., 1972]. When other uses like hygiene (washing and cleaning) get added to it, the requirement increases to 45–55 lpcd [Bhandari and Gupta, 2010]. Safe drinking water is essential for good health as is sanitation [Bhandari and Gupta, 2010], and lack of these two essential elements result in significant increasein morbidity and mortality conditions [Jalan and Ravallion, 2001; Shreshtha, 2006; World Bank, 2006]. In developing world, majority of children and adults suffer from repeated episodes of infectious diarrheal diseases annually, where water is considered as the major source of exposure to diarrheal pathogen [Sobsey et al., 2003].

Urban India largely depends upon water supply system that either draws from proximate surface or subsurface water bodies [Bhandari and Gupta, 2010]. There has been a constant problem regarding the availability of safe drinking water to the inhabitants in an urban area. In Kolkata, the problem is severe. Despite its location along the east bank of the River Hugli which means availability of abundant water in its vicinity, instead the city faces a grave problem of good quality water supply [Tata Energy and Research Institute, 2013]. The problems are acute to those living in the slum [Kundu, 2003]. On the other hand, in the absence of efficient surface water availability, people depend on underground water sources where its overuse leads to an increase in the arsenic concentration in many wards of the city [Shaban and Sharma, 2007]. Groundwater is generally less susceptible to contamination and pollution as compared to surface water bodies. But its intensive use for irrigation and industrial purposes causes aquifer contamination which resulted into mineralization of water resource [West Bengal Pollution Control Board, 2011].

Poor living conditions and lack of adequate city services such as safe piped water and sewage, lead to serious health and sanitation problems [Douglas, 1983]. It is estimated that throughout the world nearly 1.5 billion people lack safe drinking water and that at least 5 million deaths per year can be attributed to waterborne diseases [Krants and Kifferstein, 1998]. A variety of pathogens infect water supplies in circumstances where poor sanitation allows exerted waste to contaminate drinking water [Anthamatten and Hazen, 2011]. Water borne diseases are caused by viral or bacteriological contamination of water. This is exemplified by the fact that a single gram of faeces can contain 10 million viruses, 1 million bacteria, 1,000 parasite cysts and 100 eggs of worms [Water Supply and Sanitation Collaborative Council, 2002]. Water borne diseases are among the highest cases of morbidity and child mortality in India. India loses about 1.5 million children under 5 years of age annually to diarrhoea, and this might be an under estimate [Planning Commission, 2002].

In order to have a proper understanding of the water related problems and health issues in urban India, the present study is concerned with identification of problems related to municipal supply of drinking water and health issues in Kolkata. The major area has been covered are the sources of water supply, factor affecting the water supply, sources of water pollution and the resulted health outcome due to non-availability of water and consumption of contaminated water. It has also focuses on the sanitation problems where the availability of sufficient water for household purposes, efficient drainage facilities and proper garbage disposal facilities to the city inhabitants were evaluated to assess the health consequences.

STUDY AREA

The present study has conducted by taking case study of Kolkata, the capital city of West Bengal (Fig. 1). Spread roughly north-south along the east bank of the River Hugli, Kolkata sits within the lower Ganga Delta of Eastern India. The city lies about 136.79 kilometres (86 miles) away from the sea and 4.57–6.09 metres (15–20 feet) above the mean sea level [Imperial Gazetteer of India, 1984]. Its latitude and longitude are 22°56′ North and 88°36′ East respectively. According to the Census of India [2011], Kolkata had 4.5 million population with density 24,252 persons per Km^2.The annual mean temperature is 26.8 °C (80°F)

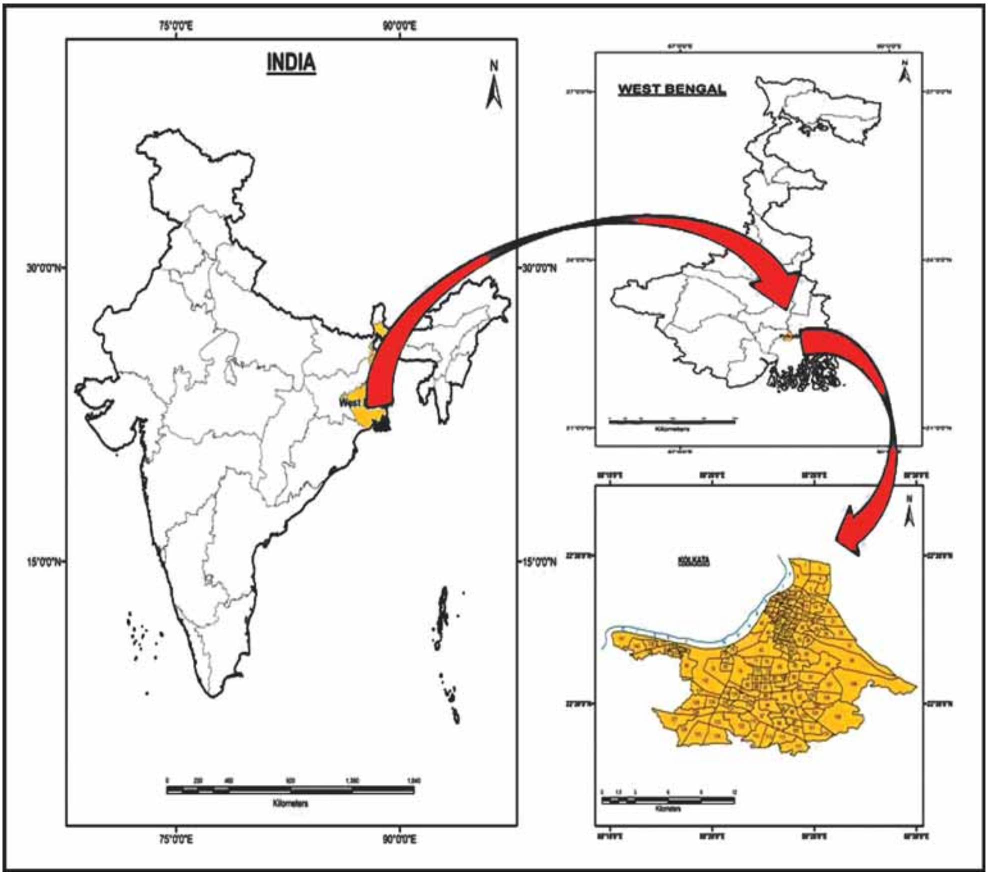

Fig. 1. Location of the study area.

and monthly mean temperatures ranges from 19 °C to 30 °C (67°F to 86°F).Maximum rainfall occurs during the month of August (306 mm) and the average annual total is 1,582 mm [District Census Handbook, 2001]. Kolkata is an unplanned city that has grown gradually to accommodate the influx of people from across the city, state and national borders. As a result, it is characterized by poor drainage and resulted water logging, waste effluent and sewage which create health risks for the city dwellers [Hasan and Khan, 1999].

DATABASE AND METHODOLOGY

The study has been completed based on mainly secondary sources of data along with observation of the researcher that are substantiated with images from the study area to reflect the ground reality of health related problems resulted from non-availability of water for proper sanitation and drinking purposes to the city inhabitant. The relevant data have been gathered from the existing literatures available in the form of research articles, published government reports, books etc. The important sources are West Bengal Pollution Control Board (WBPCB), Kolkata Municipal Corporation (KMC), and District Census Handbook etc. The data thus obtained have been reviewed and assessed qualitatively. The data on groundwater quality have obtained from WBPCB and the assessments were done through comparing the data with the Indian Standards (IS) specification for drinking water along with their desirable and permissible limit and possible health effects (Appendix 1). The data pertaining to diseases have been obtained from the dispensaries run by KMC. Initially, the data were available in weekly format which later converted into monthly format for interpretation. The monthly data then interpreted by looking at the variation in the total number of patients with water borne diseases.

STATUS OF WATER RESOURCES IN KOLKATA

The city of Kolkata has a centralised filtered water supply which is distributed to the city dwellers via a complex network of pipelines. Two most common allegations against the existing water supply network is the inadequacy of the quantity and deteriorating quality of water [Roy et al., 2004]. The majority of the greater Kolkata's water is treated surface water from the Hugli branch of the River Ganges [Dudley and Stolton, 2003], along with groundwater from various deep and hand tube wells and private pumps [Segane, 2000]. Kolkata Municipal Corporation is claims that 94 per cent of the city's households are connected to piped water and the water is supplies continuously up to 20 hours per day. However, a study by the Asian Development Bank (ADB) in 2007 on the water utilities in India found that only 74 per cent of the households in Kolkata are connected to piped water supply and that the average time of daily uninterrupted water supply is 8.3 hours. The households not connected to the water supply system mainly extract groundwater through private wells and pumps.

A brief overview of the water resource in Kolkata covering the domestic use, its access at the household level, loss due to leakage, treatment of waste water, sources of water supply and associated problems etc. reveal that about 80 per cent of the households have access to the supplied piped water. About 35 per cent of the supplied water gets wasted due to leakage whereas only 52 per cent households are connected with the sewerage services and merely 20 per cent of the waste water is treated before its final dumping. Inefficiency in the use of water resources at the end point is the major problem followed by pollution and flooding (Table 1).

Table 1. Water statistics in Kolkata

Domestic Water Use	130 litre per capita
Households with Water Access	79 per cent
Water Loss due to Leakage in Pipe	35 per cent
Household with Sewerage Services	52 per cent
Wastewater Treated	20 per cent
Main Water Sources	Surface water from the Hugli branch of the Ganges Groundwater from deep and hand tube wells
Main Water Problems	Water use inefficiency Pollution Flooding Ecosystem destruction International dispute

Source: WWF Report, 2011.

The daily water supply needs for Kolkata Municipal Authority (KMA) is 2.75 million cubic metres per day of which KMC accounts for 1.63 million cubic metres. Taking into account the average utilization of the existing capacity, KMA faces a supply deficit of filtered water of about 1.18 million cubic metres per day. This is partially met through pumping of ground water using deep tube wells with average yield of 0.6 million cubic metres per day [World Bank, 2011]. Kolkata and the Ganges delta lie in a geological zone with naturally occurring arsenic in deeper layers of the bedrock and thus the groundwater naturally contains varying levels of arsenic [Segene, 2000].

An analysis of ground water quality in Kolkata revealed that the concentration of mercury in locations near Tangra (3.649 mg/l), Cossipore (1.755 mg/l), Dhapa (0.932 mg/l) and Inside Kolkata Leather Complex (0.719 mg/l) have exceeded the permissible limit (0.001 mg/l). The concentration of Total Dissolve Solid (TDS) has found beyond the desirable limit (500 mg/l) in all the monitoring stations and it was beyond the permissible limit (2000 mg/l) at the location near Cossipore (2080 mg/l) (Table 2).Mercury is a highly toxic liquid metal and consuming water with mercury

Table 2. Ground water quality in Kolkata

Sl. No.	Ground Water Stations	pH	Nitrate	Faecal Coliform MPN/100ml	Total Coliform MPN/100ml	Fluoride	Total Pesticide	Arsenic	BOD	Mercury	TDS
	Water Quality Criteria	**6.5–8.5**	**45 mg/l**	**< 2500/100ml**	**< 5000/100ml**	**1.0 mg/l**	**–**	**0.05 mg/l**	**30 mg/l**	**0.001 mg/l**	**500 mg/l**
1	Tangra,Calcatta, West Bengal	7.6	0.09	2	5	0.34	0	NT	0.6	3.649	1888
2	Topsia, Calcatta, West Bengal	7.8	0.1	4	7	0.49	0	NT	1.4	0.588	1370
3	Dhapa, Calcatta, West Bengal	7.9	0.04	8	14	0.37	0	NT	0.4	0.932	1218
4	Garia, Calcatta, West Bengal	8.2	0.04	4	9	0.61	0	NT	1.4	BDL	896
5	Behala, Calcatta, West Bengal	7.8	0.1	–	–	0.41	0	NT	1.1	BDL	826
6	Cossipure- North Kolkata	7.2	0	80	110	0.4	0	NT	0.9	1.755	2080
7	Central Kolkata	7.8	0.04	2	4	0.42	0	NT	0.9	BDL	1292
8	Inside Kolkata Leather Complex	7.8	0.11	2	13	0.37	0	NT	0.5	0.719	1036

Source: WBPCB, Annual Report 2010–11.

contamination over many years could result into kidney damage. Similarly, when TDS levels exceed 1000 mg/l, it is generally considered unfit for human consumption.

SOURCES OF WATER CONTAMINATION IN KOLKATA

The contamination of water takes place when external substances with the possibility to modify the water in negative manner get discharged into it. In general, the sources of municipal waste water are domestic, industrial, storm water and by ground water seepage entering the municipal sewage network [Purkait et al., 2008]. The possible sources of water pollution in Kolkata are as following:

Industrial discharge

In the eastern part of Kolkata near Tangra-Topsia-Tiljala, leather industries are located and the industrial effluents released from the tanneries causes serious environmental hazards through polluting the *bheries* (fishing pond), wetlands and agricultural fields. The manufacturing of leather in these industries produce large quantities of waste which is discharged into the natural water bodies directly or indirectly through open drains, causing pollution and leading to serious health hazards [Ganguly, 2012].

Table 3. Possible sources of metal contaminants in water

Contaminants	Sources of Contaminants in Drinking Water	
	WHO	US EPA
Cadmium (Cd)	Impurity in the zinc of galvanized pipes, water heaters, water coolers and taps	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; run off from waste batteries and paints
Chromium (Cr)	Leather tanning industry, the manufacturing of catalysts, paints, fungicides, the ceramic and glass industry, photography, chrome alloy chromium metal production, chrome plating and corrosion control	Discharge from steel and pulp mills; erosion of natural deposits
Lead (Pb)	Production of lead-acid batteries, solder and alloys. Its presence is primarily from plumbing systems containing lead in pipes, solder, fittings or the service connection to homes	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (Hg)	Industrial uses.	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands

Source: Based on Chacraverti et al., 2011.

Table 4. Number of samples showing detection of metal contaminants

Metals	All samples			River water samples			Drinking water samples		
	No. of samples	No. of detections		No. of samples	No. of detections		No. of samples	No. of detections	
		Dry season	Wet season		Dry season	Wet season		Dry season	Wet season
Cd	56	0	0	8	0	0	48	0	0
Cr	56	3	6	8	3	6	48	0	1
Pb	56	51	56	8	8	8	48	43	48
Hg	56	0	3	8	0	1	48	0	2

Source: Chacraverti et al., 2011.

A study by Chacravarty et al. [2011], traced the source of contaminants in water through testing the level of mercury (Hg), lead (Pb), cadmium (Cd) and chromium (Cr) in samples taken from tube wells, river Hugli and taps at different sites in the KMA during both the dry and wet seasons (Table 3). The detection of lead in river water and drinking water were very much noticeable in almost all the samples in both summer and winter seasons while the presence of chromium has been noticed in river water during wet seasons (Table 4).The drinking water although has been found free from the chromium and cadmium contamination, the presence of mercury during wet season has detected in some places.

Leakage from the landfills

Landfills are huge pile of city garbage. The disposal of garbage is a big problem in India and other developing countries where open dumping at road sides, in open spaces, in front of the riverbanks [Hogland and Marquis, 2007] and any other unorganised places are practised which may pollute the adjacent environment (Fig. 2). When it rains, the landfills get leaked and the leakage pollutes the underground water. One severe problem associated with open dumping is the infiltration of leachate into the surrounding environment and subsequent contamination of the land and water [Walker, 1969; Chain and Dewalle, 1976; Kelley, 1976; Masters, 1998]. In Kolkata, the major disposal site i.e., Dhapa is located at the eastern fringe of the city. The quality of natural leachate sampled from the disposal site (Dhapa) has shown that the concentration of solids, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and chloride were much higher than it is allowed to discharge into inland surface water [Mandal, 2007].

Fig. 2. Disposal of solid waste in Kolkata: (a) Taltala (b) Hatibagan (c) & (d) Park Street.

Leakage from piped water supply

The quality of water at the end use point depends to a great degree on the state of the network of pipelines through which the water flows over vast distances. Nothing is more dangerous to public health than intermittent water supply [Ghosh, 2002]. The intermittent supply of water leads the iron pipelines to be idle for long stretches, augmenting their rusting process, which in turn is largely responsible for the fall in the quality of water. Faecal contamination of drinking water is often associated with untreated water distribution systems through leaking and cracked pipes and causes shallow wells to become contaminated [Roy et al., 2004].

Sewage and waste water disposal

Of the total wastewater generated in metropolitan cities, barely 30 per cent is treated before its final disposal. Untreated water finds its way into water system such as rivers, lakes, ground water and coastal water [Government of India, 2002]. It is estimated that 75 to 80 per cent of the water pollution by volume is caused by domestic sewage [The Energy and Research Institute, 2003].The sewage and waste water generated at the household level is released into the river and fresh water bodies without proper treatment [Bhandari and Gupta, 2010].

Wastewater generated in Kolkata gets discharged into East Kolkata Wetlands (EKW); 12,500 ha. of marshy wetlands connected to the Hugli branch of the Ganges and treating about 2.8 billion litters of sewage from the city [WWF Report, 2011]. The vegetables are grown in Kolkata sewage fed land shows variable toxicity [Gupta et al., 1990],which when mix with water bodies leads to its contamination. On the other hand, recycling of waste water often causes contamination of ground water by mixing of toxic elements like heavy metals and pathogens [Mitra, et al., 1998].

WATER AND HUMAN HEALTH

India though improves it's conditions in terms of water supply and sanitation in last few decades, but still not commensurate with the requirements. Health outcome therefore, continue to be adversely affected and show up as infant mortality, prevalence of communicable diseases and overall morbidity [Bhandari and Gupta, 2010]. It is estimated that about 89 per cent of Indians use drinking water that could be classified as 'safe drinking water' but only about 28 per cent have access to improved sanitation [World Health Organisation, 2009]. India stand far behind when compare to other emerging countries in meeting the water and sanitation needs to its population (Table 5). Safe and good quality drinking water and sanitation is an essential aspect of public health. Vulnerable groups such as children, the elderly and immune compromised patients (e.g., those who are undergoing chemotherapy) are at special risk of diseases caused by water contamination [USEPA, 1999; Tibbettes, 2000].

Table 5. Access to safe drinking water and improved sanitation in emerging economics (per cent)

Country	Drinking water	Sanitation
India	89	28
Brazil	91	77
China	88	65
Mexico	95	81
South Africa	93	59

Source: World Health Organisation, 2009.

Most of the diseases associated with water are communicable and preventable. Although water is the key to sustenance of life; poor water quality due to sewage disposal, dumping of industrial and agricultural effluent can mean increased exposure to carcinogenic compounds, insecticides such as DDT and heavy metals [Brain, 1999]. It may also mean infection with a range of enteric pathogens causing diarrhoeal diseases estimated to be responsible for 4 million child deaths per year in India. Inadequate sanitation implies reduced levels of personal and domestic hygiene, which lead in particular to the faecal oral transmission of diarrhoea, dysentery, gastroenteritis etc. [Brian, 1999].

In Kolkata, it could be evaluated the ground reality of inadequate sanitation for those living in the congested area (referred to as slum) while looking at them to wash their utensil in dirty water and presence of uncovered drain at their vicinity (Figs. 3, 4). In some places people are also seen having their bath at roadsides. These are some of the issues of grave health concern where the improvement in availability of sufficient water at the household level for sanitation purposes must be given priority for a better well-being and for that the KMC need to play the pivotal role.

Safe water supply is not always available in the less developed regions of the world, where water borne diseases represent a significant public health threat [Friis, 2007]. Even piped water which is available in big cities gets mixed with number of impurities causing jaundice, cholera, typhoid and gastroenteritis etc. [Kudesia, 1980].

Fig. 3. Washing of utensils in dirty water.

Fig. 4. Open drainage in Garden Reach, Kolkata.

Table 6. Water borne diseases in Kolkata

2012	Acute Diarrhoeal Disease (Include acute gastroenteritis)			Total	Bacillary Dysentery			Total
	Narkel-danga Dispensary	Ultadanga Dispensary	Rajabazar Dispensary		Narkel-danga Dispensary	Ultadanga Dispensary	Rajabazar Dispensary	
January	24	13	55	**92**	0	76	0	**76**
February	50	36	76	**162**	0	129	0	**129**
August	103	118	95	**316**	0	172	0	**172**
September	103	26	64	**193**	0	129	0	**129**
Total	**280**	**193**	**290**	**763**	**0**	**506**	**0**	**506**

Source: Kolkata Municipal Corporation, 2012.

According to World Health Organization Report [2004], 88 per cent of diarrhoeal diseases are attributed to poor sanitation and hygiene, lead to 1.8 million deaths per year. Children under five years of age comprise 90 per cent of these deaths. Young children have little time to adapt physiologically to local disease causing pathogens, which make them practically susceptible. According to Shanmuganandan [1999], around 105 million children under 5 years of age die each year due to water borne diseases and India experienced a loss of 200 million man-hours a day every year because of these diseases.

In Kolkata, the data on diseases from dispensaries covering Narkeldanga Dispensary, Ultadanga Dispensary and Rajabazar Dispensary reveal that the patients with *acute diarrhoeal diseases* (include acute gastroenteritis) and *bacillary dysentery* occupying major share among other diseases (Appendix 2). These are water borne diseases resulted due to consumption of contaminated drinking water and non-availability of sufficient water for drinking and sanitation purposes at household level. The dispensaries are the destination for medical check-up mainly follows by those residing in slums and having poor living standards where they get their treatment with free of cost. There are more than 25 major dispensaries and many more minor dispensaries operating throughout Kolkata and these are fully aided by KMC. It has been inferred that the patients with acute diarrhoeal diseases are present in almost all the stated dispensaries while the patients with dysentery are mainly concentrated in Ultadanga dispensary. The concentrations of patients with water borne diseases have found few in number in the month of January (92 with diarrhoeal infection and 76 with dysentery) while it is higher in the month of August (316 with diarrhoeal infection and 172 with dysentery) (Table 6). The more concentration of patients in the month of August may be due to the monsoonal rainfall where the rainwater get mixed with the municipal piped water through broken pipes and leakages and thus contaminate the water at its sources of supply. Therefore, the direct consumption of water supplied through the broken municipal pipes with mixed impurities may result into several water borne diseases.

MEASURES FOR SUSTAINABLE WATER MANAGEMENT

Water is one of the basic resources as it is essential for the very existence of human life. The use of water is manifold i.e. domestic, industrial, recreational and for aesthetic purposes. Among the various facets of uses of water, the availability of good quality water for consumption is of utmost importance for sustenance of human life and for healthy wellbeing. Supplying safe drinking water is therefore an important issue for sustainable development which requires explicit

Fig. 5. Municipal supply of tap water in Kolkata.

emphasis on quality. Following are some of the measures which could be made functional in bringing sustainability for water resources in Kolkata:

Availability and accessibility of safe drinking water

The problem regarding the water in Kolkata is poor availability of drinking water at the household level as the supply of water is low. The ever increasing size of the population and their demand for potable drinking water has always been a big problem for KMC to successfully cope up. Therefore, securing the availability of safe drinking water must be taken as a fundamental issue to bring sustainability in the society.

Connect household with processed municipal tap water

In an urban environment the slum dwellers are seldom connected with the municipal supply of piped water system. In Kolkata, the urban poor are living in a condition where there is less connectivity of piped water within the premises as well as near premises. Therefore, all households especially the slums need to be connected with the piped water so that the requirement of water can be fulfilled at the domestic level and the contaminations of water get controlled (Fig. 5).

Minimize the wastage of water: practice inclusive use of water

In Kolkata, one of the major drawbacks of the water supply is the wastage of water from the direct tap water (Fig. 6). The water supplied through KMC gets wasted without its proper utilization and even reaching to the beneficiaries. This wastage of water must be stopped by taking strict action. Proper utilization of water must be practised at every stage as the wastage of water at one place will create scarcity in another place. So, for the enhancement of sanitation and healthy well-being, an inclusive use of water should be the main focus for the urban planner and municipal supplier of water resources.

Improvement in sewage treatment and disposal

Sewage treatment plant helps in removing the contaminants from wastewater including household sewage and runoff. It produces environmentally safe fluid waste suitable for disposal and reuse. With suitable technology, it is possible to re-use sewage effluent for drinking and sanitation purposes. Therefore, by looking at the utility, the establishment and

Fig. 6. Wastage of water from the tap in Kolkata.

proper functioning of sewage treatment plant is required. It will helps to curb the problem of shortage of water for drinking and sanitation purposes and can bring sustainability through making water available at the household level.

CONCLUSION

Kolkata is blessed with abundant water resources where the River Hugli is the biggest source of surface water for human consumption after it gets filtered. Throughout Kolkata the water is supplied through piped water as a major source of water supply with underground water as a secondary source. The two major problem regarding water supply in Kolkata are the availability of good quality water and its accessibility to the city inhabitants. Among the major sources of contamination of water, the release of industrial effluent to the water bodies without its proper treatment is the prominent one which is followed by domestic sewage and leakages from piped line. The industrial effluents may result into the contamination of underground water where the presence of leather industries in Tangra led to the lead contamination to the nearby underground water. On the other hand, the leakage of pipe may contaminate the underground water and if continue for a long duration may also contaminate the surface water. The solid wastes are disposed without taking proper care and when it rained, theplastic waste get choked with the mouth of the drain and resulted into flooding.

Lack of availability and accessibility of sufficient water for drinking and sanitation purposes at the household level exert a great pressure in sustenance of human life. It has been noticed that due to absence of sufficient water for sanitation purposes at the household level, people are having their bath at roadside. These are very common phenomena for those living in the slums where they also use dirty water for washing the utensil. These are the serious health issues, where there is a need to focus in sufficient supply of water for sanitation purposes. In this regard, the role of KMC is of prime concern as municipalities are the custodian of main supply of water resources to the city inhabitants. On the other hand, the consumption of water with mixed impurities may result into several water borne diseases where acute diarrhoeal infection is the pressing one. It has been found that the patients with water borne diseases at dispensaries like acute diarrhoeal infection and dysenteries are quite alarming. Water borne diseases are mainly the outcome of consumption of contaminated drinking water and non-availability of sufficient water for proper sanitation. Measures such as; make water available at household level, connect every household with proposed municipal tap water, minimize wastage of water and practice inclusive use of water are of prime significance in enhancing the availability and accessibility of water resources at household level. Once the problem with the availability of water for drinking and sanitation purposes gets controlled, the related health issues will be minimized at greater extent.

REFERENCES

1. Anthamatten, P. and Hazen, H. (2011). An Introduction to the Geography of Health. Routledge. Tayler and Francis Group. London and New York.
2. Asian Development Bank. (1997). Urban Infrastructure in Asian Countries. ADB, Manila.
3. Asian Development Bank. (2007). 2007 Benchmarking and Data Book of Water Utilities in India, In: Big Cities Big Water Big Challenges, Water in an Urbanised World, WWF Report 2011, WWF Germany, Berlin.
4. Bhandari, L. and Gupta, A. (2010). Inputs for Health. In: Mahal et al. (Eds.), India Health Report 2010, R.K. Books, New Delhi.
5. Brian, H.K. (1999). (Eds.), Water Resources: Health, Environment and Development. Taylor & Francis. London and New York.
6. Census of India. (2011). Provisional Population Totals, Paper 1 of 2011, West Bengal Series 20. Office of the Registered General and Census Commissioner, India. Ministry of Home Affair. Government of India.
7. Central Pollution Control Board. (2013). Status of Water Quality in India-2011. Ministry of Environment and Forests, Government of India, New Delhi.
8. Chacraverti, S., Dey, B.C., Mallick, S., Ghosh, R. and Mallick, S. (2011). The Kolkata Metropolitan Area: Probing for Four Toxic Metals in Drinking Water. Society for Direct Initiative for Social and Health Action (DISHA).
9. Chain, E.S. K. and Dewalle, F.B. (1976). Sanitary Landfill Leachates and their Treatment. In: Municipal Solid Waste Management in Kolkata, India: A Review by Chattopadhyay et al. 2008, Waste Management, Vol. 29 (4), Pp. 1449–1458.
10. District Census Handbook. (2001). Census of India 2001. Registrar General and Census Commissioner, India.
11. Douglas, I. (1983). The Urban Environment. Edward Arnold (Publisher). Ltd., London.
12. Dudley, N. and Stolton, S. (2003). Running Pure: The Importance of Forest Protected Areas to Drinking Water. World Bank/WWF Alliance for Forest Conservation and Sustainable Use. In: Big Cities. Big Water. Big Challenges. Water in an Urbanised World, WWF Report 2011.

13. Friis, H. Robert. (2007). Essentials of Environmental Health. Jones and Bartlett Publishers. Sudbery, Massachusetts, USA.

14. Ganguly, S. (2012). Leather Processing Industries Generate Effluents Causing Environmental and Water Pollution: An Asian Perspective. In: Water Pollution from Various Sources and Human Infringements: An Editorial. Indian Journal of Scientific Research and Technology. Vol. 1 (1). Pp. 54–55.

15. Ghosh, G.K. (2002). Water of India (Quality and Quantity). A.P. H. Publishing Corporation. New Delhi.

16. Government of India. (2002). India Assessment 2002: Water Supply and Sanitation. Planning Commission, GOI, New Delhi.

17. Gupta, S.K., Mitra, A. and Adhikari, S. (1990). Post Irrigation Effects of Calcutta Sewage Effluents on Soil and Vegetation. In: Impact Assessment on Various Parameters Polluting Ganga Water in Kolkata region: A Study for Quality Evaluation and Environmental Implication by Purkait et al. Environmental Monitoring Assessment. Vol. 155. Pp. 443–454.

18. Hasan, S., and Khan, M.A. (1999). Community Based Environmental Management in a Megacity Considering Calcutta. Cities, Vol. 16, (2). Pp. 103–110.

19. Hogland, W. and Marques, M. (2007). Sustainable Waste Management: International Perspective. In: Municipal Solid Waste Management in Kolkata, India: A Review by Chattopadhyay et al. 2008. Waste Management. Vol. 29 (4). Pp. 1449–1458.

20. Imperial Gazetteer of India. (1984). Provincial Series Bengal. Usha Publication, Ansari Road, Darya Ganj, New Delhi. Vol. 1. Pp. 393–421.

21. Jalan, J. and Ravellion, M. (2001). Does piped water Reduce Diarrhoea for Children in Rural India? Indian Statistical Institute. In: Mahal et al. (Eds.), India Health Report 2010. R.K. Books, New Delhi.

22. Kelley, W.E. (1976). Groundwater Pollution near a Landfill. In: Municipal Solid Waste Management in Kolkata, India: A Review by Chattopadhyay et al. 2008. Waste Management. Vol. 29 (4). Pp. 1449–1458.

23. Kolkata Municipal Corporation. (2012). Weekly Reports of Diseases at Narkelanga, Razabazar and Ultadanga Dispensary. Government of West Bengal, India.

24. Krants, D. and Kifferstein, B. (1998). Water Pollution and Society (September 23, 2004); http://www.umich.edu.

25. Kudesia, V.P. (1980). Water Pollution: Principles of Disinfection of Drinking Water and its Analysis. Pragati Prakashan, Meerat, India.

26. Kundu, N. (2003). Understanding Slums: Case Studies for the Global Report on Human Settlements. Urban Slums reports: The Case of Kolkata, India. Institute of Wetland Management and Ecological Design, Kolkata.

27. Mandal, M. (2007). Leachate from Municipal Solid Waste- Generation, Characteristics and Effects. In: Municipal Solid Waste Management in Kolkata, India: A Review, Chattopadhyay et al. 2008. Waste Management. Vol. 29 (4). Pp. 1449–1458.

28. Masters, G.M. (1998). Introduction to Environmental Engineering and Science. In: Municipal Solid Waste Management in Kolkata, India: A Review by Chattopadhyay et al. 2008. Waste Management. Vol. 29 (4). Pp. 1449–1458.

29. Mitra, A., Adhikari, S., Gupta, S.K. (1998). Pollution Metal Content of Vegetables Irrigated with Sewage Water. Journal of the Indian Society of Soil science. Vol. 46 (1). Pp. 153–155.

30. Planning Commission. (2002). India Assessment 2002, Water Supply and Sanitation. A WHO- UNICEF Sponsored Study.

31. Roy, J., Chattopadhyay, S., Mukherjee, S., Kanjilal, M., Samajpati, S. and Roy, S. (2004). An Economic Analysis of Demand for Water Quality: Case of Kolkata. Economic and Political Weekly. Vol. 39 (2). Pp. 186–192.

32. Segane, R. (2000). Water Management in Mega-Cities in India: Mumbai, Delhi, Calcutta, and Chennai. Water for Urban Areas, Challenges and Perspectives. United Nations University Press. In: Big Cities Big Water Big Challenges. Water in an Urbanised World. WWF Report 2011, WWF Germany, Berlin.

33. Shaban, A. and Sharma, R.N. (2007). Water Consumption Pattern in Domestic Households in Major Cities. In: TERI Environmental Survey, 2013. The Energy and Research Institute, India Habitat Centre, New Delhi, India.

34. Shanumganandan, S. (1999). Water Quality, Water Resources and Health Water Quality in Relation to Human Health: A Study with References to Water Borne Diseases and Major Environmental Issues in Indian Subcontinent. Working Paper, Madurai Kmaraj University, India.

35. Shreashtha, L.B. (2006). Life Expectance in the United States. Congregational Research Service. In: Mahal et al. (Eds.), India Health Report 2010. R.K. Books, New Delhi.

36. Sobsey, M.D., Handzel, T., Venczel, L. (2003). Chlorination and Safe Storage of Household Drinking Water in Developing Countries to Reduce Waterborne Diseases. In: Diarrheogenic Escherechia Coli in Potable Water Source of West Bengal, India by Batabyal et al. Acta Tropica. Vol. 127. Pp. 153–157.

37. Tata Energy and Research Institute. (2013). TERI Environmental Survey. TERI. India Habitat Centre, New Delhi, India.

38. The Energy and Research Institute. (2003). The Energy Data Directory and Yearbook 2002–03. TERI, New Delhi.

39. Tibbetts, J. (2000). Water World 2000. Environmental Heath Perspective, Vol. 108. Pp. A69–A73.

40. USEPA. (1999). Drinking Water and Health: What You Need to Know! United State Environmental Protection Agency. Available at: http://www.epa.gov/safewater/ dwh/dw-health.pdf.

41. Walker, W.H. (1969). Illinois Groundwater Pollution. In: Municipal Solid Waste Management in Kolkata, India: A Review by Chattopadhyay et al. 2008. Waste Management. Vol. 29 (4). Pp. 1449–1458.

42. Water Supply and Sanitation Collaborative Council (WSSCC). (2002). It's the Big Issue. Available at http://www.wsscc.org.

43. West Bengal Pollution Control Board. (2011). Annual Report 2010–11. WBPCB, Government of West Bengal, Kolkata.

44. White, G.F., Bradley, D.J. and White A.U. (1972). Drawer of Water: Domestic Water Use in East Africa. In Mahal et al. (Eds.), India Health Report 2010. R.K. Books, New Delhi.

45. WHO. (2004). Water, Sanitation and Hygiene Links to Health. World Health Organisation. Available at: www.who.int/water_sanitation_health/facts2004/en.

46. WHO. (2009). World Health Statistics. In Mahal et al. (Eds.), India Health Report 2010. R.K. Books, New Delhi.

47. World Bank. (2006). India Inclusive Growth and Service Delivery: Buildings on India's Success. Development Policy Review. In Mahal et al. (Eds.), India Health Report 2010. R.K. Books, New Delhi.

48. World Bank. (2011). Vulnerability of Kolkata Metropolitan Area to Increased Precipitation in a Changing Climate. Environment, Climate Change and Water Resources Department, South Asia Region. Document of the World Bank.

49. WWF. (2011). Big Cities Big Water Big Challenges. Water in an Urbanised World. World Wide Fund for Nature. WWF Germany, Berlin.

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Appendix 1. Indian Standard (IS) Specifications for Drinking Water

Sl. No.	Parameters	Desirable Limit	Permissible Limit	Health Effects
1	Total pesticide (ppb)	Absent	No Relaxation	Affect Central Nervous system.
2	Arsenic (mg/l)	0.05	No Relaxation	Toxic, Carcinogenic, Affect Central Nervous system.
3	BOD (mg/l)	30	100	
4	Mercury (mg/l)	0.001	No Relaxation	Highly Toxic, causes minamata' disease, neurological impairment.
5	TDS (mg/l)	500	2000	Undesirable taste, gastro intestinal irritation.
6	Temperature	5 °C		
7	pH	6.5–8.5		Bitter taste, affects aquatic life.
8	Nitrate (mg/l)	45	No Relaxation	Algal growth, blue baby disease.
9	Faecal Coliform	< 2500MPN/100 ml	–	Gastrointestinal illness.
10	Total Coliform	< 5000 MPN/100 ml	–	Gastrointestinal illness.
11	Fluoride (mg/l)	0.6–1.2	1.5	Dental and skeletal fluorosis.

Source: Indian Standard, 10500–1991.

Appendix 2. Major Diseases at Dispensaries in Kolkata

2012		Acute Diarrhoeal Disease (Include acute gastroenteritis)			Total	Bacillary Dysentery			Total	Acute Respiratory Infection			Total	Malaria			Total	Fever of Unknown Origin (PUO)			Total
		N*	U*	R*		N*	U*	R*		N*	U*	R*		N*	U*	R*		N*	U*	R*	
January	1st week	5	5	23	33	0	22	0	22	55	121	234	410	2	34	28	64	18	0	0	18
	2nd week	8	4	6	18	0	17	0	17	25	97	178	300	2	25	0	27	10	0	11	21
	3rd week	5	2	18	25	0	14	0	14	59	157	226	442	0	30	39	69	9	0	0	9
	4th week	6	2	8	16	0	23	0	23	26	110	109	245	0	15	13	28	17	0	0	17
	Total	**24**	**13**	**55**	**92**	**0**	**76**	**0**	**76**	**165**	**485**	**747**	**1397**	**4**	**104**	**80**	**188**	**54**	**0**	**11**	**65**
February	1st week	3	8	17	28	0	42	0	42	93	152	261	506	2	30	41	73	26	0	0	26
	2nd week	10	15	24	49	0	41	0	41	105	195	263	563	4	1	26	31	28	57	0	85
	3rd week	12	7	16	35	0	21	0	21	94	190	210	494	3	33	28	64	25	0	0	25
	4th week	25	6	19	50	0	25	0	25	59	147	189	395	2	36	45	83	30	0	0	30
	Total	**50**	**36**	**76**	**162**	**0**	**129**	**0**	**129**	**351**	**684**	**923**	**1958**	**11**	**100**	**140**	**251**	**109**	**57**	**0**	**166**
August	1st week	19	50	23	92	0	2	0	2	135	150	221	506	92	0	81	173	0	230	0	230
	2nd week	18	12	27	57	0	33	0	33	111	302	223	636	96	132	77	305	0	0	0	0
	3rd week	16	13	7	36	0	24	0	24	237	401	138	776	121	159	112	392	0	0	0	0
	4th week	21	17	20	58	0	51	0	51	156	402	193	751	210	203	109	522	0	0	0	0
	5th week	29	26	18	73	0	62	0	62	356	370	315	1041	227	365	136	728	0	0	0	0
	Total	**103**	**118**	**95**	**316**	**0**	**172**	**0**	**172**	**995**	**1625**	**1090**	**3710**	**746**	**859**	**515**	**2120**	**0**	**230**	**0**	**230**
September	1st week	23	9	19	51	0	42	0	42	268	542	240	1050	315	423	194	932	0	0	0	0
	2nd week	22	2	19	43	0	41	0	41	234	668	284	1186	322	414	245	981	0	0	0	0
	3rd week	23	8	23	54	0	30	0	30	265	423	240	928	241	300	270	811	0	0	0	0
	4th week	35	7	3	45	0	16	0	16	122	210	290	622	266	275	302	843	0	0	0	0
	Total	**103**	**26**	**64**	**193**	**0**	**129**	**0**	**129**	**889**	**1843**	**1054**	**3786**	**1144**	**1412**	**1011**	**3567**	**0**	**0**	**0**	**0**

Note: N* Narkeldanga Dispensary, U* Ultadanga Dispensary, R* Razabazar Dispensary.
Source: Kolkata Municipal Corporation, 2012.

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GEOGRAPHY, CULTURE, AND SOCIETY FOR OUR FUTURE EARTH

INTERNATIONAL GEOGRAPHICAL UNION CONFERENCE IN MOSCOW, 17–22 AUGUST 2015

IGUmoscow2015

In 2015 (from August 17 to 21), Moscow hosted the Regional Conference of the International Geographical Union (IGU) for the third time since the International Geographical Congress of 1976, when over 2,000 participants from around the world gathered in the Soviet capital for lectures, discussions, workshops, and excursions. The motto of the conference was "Geography, Culture, and Society for our Future Earth". The IGU 2015 conference was preceded by the IGU Congress took place in Cologne in 2012 and the IGU regional conferences in Tel Aviv (2010), Santiago (2011), Kyoto (2013), and Krakow (2014).

The IGU 2015 Regional Conference was organized by the Faculty of Geography of Lomonosov Moscow State University, the Institute of Geography of Russian Academy of Sciences, and the Russian Geographical Society. Its venue was Moscow State University. It gathered 1658 participants from 73 countries. Naturally, Russian geographers represented the largest group – 764 participants. Many participants came from China (173), India (90), USA (57), Germany (38), Spain (28), and Brazil (28) (Table 1). The "IGU Moscow 2015" was focused on five main themes: Urban Environment, Polar Studies, Climate Change, Global Conflict, and Regional Sustainability. The program was based on principles of diversity and interdisciplinary exchange. It featured a variety of meetings, including plenary sessions, lectures, panel discussions, workshops, and other events.

The conference had 32 working Commissions. A number of "thematic" sessions were held on the initiative of separate scholars and research teams. Oral sessions were composed of three, four, or five presentations. When three or four presentations took place in a single time slot, the duration of each presentation was set at 20 minutes with a short discussion after each presentation. When five presentations took place in a single time slot, the duration of each presentation was set at 15 minutes with a 5-minute-long discussion after each presentation.

Key note and interdisciplinary "thematic" lectures were in the focus of the conference and were attended by many participants. Professor **Gordon Macbean** (Canada), a well-known climatologist and President of ICSU, discussed different views on the problem of climate change and its challenges to the international scientific community and in particular the program "Future Earth". Professor **Georg Gartner** (Austria), President of the International Cartographic Association, talked about the role of cartography in contemporary

Table 1. List of countries by attendance

Country	Number of partici-pants	Country	Number of partici-pants	Country	Number of partici-pants	Country	Number of partici-pants
Russian Federation	764	Canada	22	Romania	12	Saudi Arabia	8
China	173	South Africa	22	Finland	10	Poland	8
India	90	Italy	21	Australia	9	Czech Republic	7
Japan	59	Mexico	20	Iran	9	Egypt	7
United States of America	57	Turkey	20	Portugal	9	Singapore	7
Germany	38	Republic of Korea	17	Netherlands	9	Hungary	6
Spain	28	United Kingdom	17	Belgium	8	Kazakhstan	6
Brazil	27	Israel	15	Indonesia	8	Norway	6
France	24	Switzerland	11	Nigeria	8	Sweden	6

society. **Benno Werlen** (Germany), Chair of the IGU Commission on Cultural Approach in Geography and Coordinator of the International Year of Global Understanding, informed the audience about the progress of this ambitious project initiated by the IGU. Professor **John O'Loughlin** (USA), one of the world leading political geographers, focused his presentation on the results of a large interdisciplinary project on the impact of global change on violence in Africa. Professor **Alexander Murphy**, former President of the Association of American Geographers, raised the question of the future of geographical disciplines facing dynamic transformations in society and environment. Professor **Solomon Kroonenberg** (the Netherlands) discussed the problem of geographical forecasts and predictability using the case of the Caspian Sea. Professor **Valery Tishkov**, the most prominent figure in the studies of identities, ethnology, and cultural anthropology in Russia, entitled his lecture "Culture Complexity of Contemporary Nations". Professor **Vladimir Kolosov**, President of the IGU, summarized specific features and the main trends in the development of geography in Russia. Professor **Shirlena Young** (Singapore) offered a key lecture on the achievements of the IGU Commission on Gender in Geography which was recognized the most active IGU Commission in 2014.

The lectures given by Professors **Karl Donert** (UK, President of Eurogeo), **Céline Rozenblat** (Switzerland), **Elena dell'Agnese** (Italy), **Takashi Yamazaki** (Japan), **Cosimo Palagiano** (Italy), **Brad Coombes** (New Zealand), **Melinda Laituri** and **Lee Schwartz** (USA), and **Alexander Pelyasov** and **Nadezhda Zamiatina** (Russia) were related to diverse themes of interest to experts and gathered full classrooms.

A special room was designated specifically for the social program and contained presentations of various geographical enterprises and institutions, conference partners, and exhibitors.

Geographical education and integration of young scholars was central to each of the Conference themes. The program included special events:

"The Day of Young Scholars", with a competition for the best presentation and other awards; a master Class "Fundraising and Writing Proposals" (led by **Andrey Petrov** and **Dmitry Streletskiy**; YES Network – IGU joint Session "Geoheritages, a Recorder of the Global Change Along the Silk Road for Future Sustainable Development" (led by **Meng Wang**); a panel discussion "The Role of Young Researchers' Networks in Shaping the Future of Geographical Sciences"; and a video-training workshop "Improving Your Presentation Skills" (by **Joos Droogleever FORTUIJN** and **Joop van der SCHEE**). To support attendance by young scientists, the Local Organizing Committee grants were given to postgraduate students and early career scientists from low income countries (50 in total).

The Commission on Geographical Education held the Day of Geography Teacher together with the Russian Association of Geography Teachers. Special sessions included "Academic Geography for Secondary Schools" and "Teaching Geography in the University". The "IGU Moscow" also conducted the 2015 International Geographical Olympiad.

The IGU 2015 Organising Committee encouraged Conference participants to enjoy campus tours and a variety of other excursions in and around Moscow. Following the conference, there was a series of trips to St. Petersburg and Kazan.

Sergey R. Chalov, Vladimir A. Kolosov

HEALTH MANAGEMENT.
A MEDICAL GEOGRAPHICAL PERSPECTIVE

At the conclusion of the eleventh meeting, held in "Sala delle Adunanze" in Palazzo Manzoni, home of the Department of Humanities – Languages, Literature and Civilization ancient and modern at the University of Perugia in December 2014, I think it is necessary and useful to give some interesting results to the national and international scientific community.

First of all I would like to make some general reflections on medical geography seminars taking place now for over 30 years and whose acts are regularly published.

I would like to point out, with some pride, that we had come so far from when in Rome, in the wonderful setting of Villa Mirafiori, where Gabriella Arena and Cosimo Palagiano, thanks to their intuition, started, with diligence and determination this path: none knew that we could get for now, until 2014. During this last seminar, I noticed with pleasure the presence of friends, old and new, that I would like to thank: the first to have been close throughout this period, the other for having accepted our invitation with enthusiasm, enriching this workgroup. In the context of clearly defined and equal relationship between man and the environment, which for Medical Geography can be expanded to include relationships that are established between society, territory and the disease, find full realization that it can be compared to the State of human health.[1]

That reality includes many implications that affect, inevitably, on the social level, population, settlement, economic, political, ethical, ... whole populations, with important and inevitable effects on the entire range of human activity. As a result, the relationship between health and medical facilities is strong, at first for their presence and accessibility in the context of territorial reference, and after for the many consequences that can generate not only on the general framework of help to those who need it the most but also for the opportunity to put in place preventive measures designed to protect and safeguard the health of entire communities.

In fact, not just the weak and marginalized to need the help and the support of others, and among them, are there those whose health is in danger or has already been lost, most in need of care and assistance? That's why this issue is fully relevant with the peculiarities inherent in the concept of health.[2]

In a very simple ecosystem it is easier to find cause-effect than complex systems with radical transformation of an increasingly artificial plus the changed conditions of life and relationship between human groups. However, it should also be pointed out that in such systems, the company – this is the cohort targeted by the Medical Geography which is not so interested in the "health" of the individual, as that of the entire human group that lives in that territory – has provided to achieve strong changes in environments favorable to the development of infections, not separated from the fundamental development of medicine, with drugs and techniques more and more advanced, it aims to control the disease, even those which lack the triggers, so to note that today, in the more developed countries, people live better and longer lives but more with the disease, unlike the situation that exists in those developing countries where the whole society undergoes strong and mortality rates indigence.

This can be appropriately synthesized with the phenomenon that Palagiano simply called "health artificial" and that has its points in the best conditions of life determined not only by an improved relationship of human

[1] The problems associated with the disease and its treatment, which at first glance might seem closely related to specific fields of disciplines such as medicine, epidemiology, hygiene, ... also greatly affect the work of the geographer especially because they are increasingly close reports that tend to establishment and intertwining between medicine and geography, as they fall into that sphere which highlights the relationship between man and environment. Geography, understood primarily as a science of synthesis, looking, in fact, to identify the relationships that interact between man and the environment. Therefore man should be seen in the complex of multiple interventions that creates the environment and the specific events that are to affect the socio-economic life of the same individual, but also of entire communities; in this context it cannot be ignored by a particular state of man, what the disease, because of the huge inter-generating against the company and, consequently, fall in the same territory.

[2] Health is a state of complete physical, mental and social, not just a mere absence of disease or infirmity. The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, and political belief, economic or social condition. The health of all peoples is fundamental to the achievement of peace and security and is dependent on the broader cooperation of individuals and States. The commitment of every State in the promotion and protection of health is useful for the world. The unequal development among countries in the promotion of health and control of communicable diseases is a danger to everyone.

groups with the environment – especially in countries with Advanced Development –, the introduction of external factors such as medications, diets, diets and healthier life, sports practices, reduction of smoking cigarettes or drugs, sports and/or in the open air..., which add health and surgical interventions offered by health facilities.

Sure, there would never be the aim of the giving assistance and help those who are fine and have a good quality of life. If, then, of those suffering from disease or malnutrition or other diseases or in serious financial difficulties, often due to serious conditions, the help that is given without receiving something in return is required to be crucial for better quality of life.

Closely connected with what has been said is the theme proposed and developed during the work of the Eleventh International Seminar, about health management, at which interventions have focused mainly on how health is managed in health care systems in the world, both for the enormous impact that creates the person and, consequently, the whole society, and for the possibility of access to all facilities of care and protection even and especially against those who are in trouble and needs help.

The work was divided into three main sessions:

FIRST SESSION – General aspects (related to health, human, law, economics, social, territory...) linked to health management as a way to promote and improve the quality of life.

The first session intended to focus in a general way about how the health protection depends almost completely on the management of health services and about their accessibility. Particularly it focused on the effects on society in a way to create an improvement of health conditions and wellness of the subjects that are studied, both the ones that are objects of solidarity as the ones that make this behavior leave.

SECOND SESSION – Health management in different health systems.

The session intended to know more about the role and the differences that work in several systems in each country determined on health protection and on the uses of services, not forgetting That in a lot of cases we are facing a real and proper industry that takes advantage of pain of people, with consequent economical management of the funds and political development on a big scale.

THIRD SESSION – The practical applications and the impact on the community determined by the type of service operating at the local level in relation to the combination of public/private.

This session examined, however, the practical effects that different types of health management can have on society both in health, both at the local level, since the presence of shelters often leads to urbanization and territorial transformations.

Common background, which allows tracking of a unit within the various contributions, has been the intent to focus on the relationship between health management and the types of health services in the context of a world in full globalization and in which the differences of health care in place in highly developed countries and those in the developing world are increasingly tending to increase, partly because of the serious economic and financial crisis that for several years affects the entire Earth system.

The review made according to the global, found a full accomplishment in the many references to local situations in rich countries, which is a trend to a progressive differentiation in health management that goes hand in hand with the growth of the gap between the lower classes and the economically better-off.

The comparisons resulted in the vastness of these issues was possible thank to the convinced participation of many colleagues, Italian and foreigners, old and new scholars in

the discipline of Medical Geography: what came out from the reports presented and discussions, has found its rightful place in the volume of Acts[3] that collects, in over 550 pages of text, as many as 41 papers published in the language of presentation and equitably distributed in sections which the jobs were divided.

At a methodological level, characteristics of the Acts are mainly good internationalization of the topics and the constant interdisciplinary[4]: next to the contribution of foreign scholars and Italian colleagues have shown that while the Italian situation and that of other countries, should be recorded, like the presence of not only geographers, but also doctors, epidemiologists, historians, archaeologists, economists, sociologists, philosophers, psychologists who have permission to enlarge the field of investigation and the possibility of enhanced interaction with the methodologies of other disciplines. Both features are appreciated thanks to the interesting discussions that followed the different reports, whose faithful and accurate transcription opens the volume.

Very satisfying and very important – this is an element that has always characterized the seminars – was also see the significant presence of so many young people, with results extremely flattering, are catching up, some for the first time, the issues of medical geography, finding in it a fertile ground for discussion.

The volume is a worthy conclusion Appendix represented Catalogue decades of reports presented in previous seminars, in 1982 to 2012, which lists the titles of more than 600 papers discussed at meetings and published in the Proceedings. It is an important reference tool that can offer multiple interpretations, helping to put once again to light the remarkable and consistent interdisciplinary approach that has always characterized this discipline.

Giovanni De Santis

[3] Giovanni De Santis (a cura di), *Gestione della Salute*, "Atti dell'Undicesimo Seminario Internazionale di Geografia Medica (Perugia, 18–20 dicembre 2014)", Perugia, Edizioni Guerra, 2015, pp. 552, ISBN 978-88-557-0553-0.

[4] It is worth citing, as an example, the contention in key pedagogical and philosophical, Chiara De Santis (pp. 133–146): *"The discussion about what actually can be referred to as 'health', it is more open than ever and current, especially since the given the profound change recorded by the epidemiological picture in recent years, with the increasing prevalence of chronic diseases and the need to revise the concept of health, in terms of dynamic balance between the individual and the environment. Critical reflection of this debate is extremely relevant to an assessment of health management in all its complexity. In particular, it is noted as the contribution of the human sciences, and pedagogical reflection in particular, from the account of the act of education as a process of increasing participation of the population and of the individual to protect his health."*

MEDICAL-GEOGRAPHICAL ATLAS OF RUSSIA "NATURAL-FOCAL DISEASES"

(Edited by S.M. Malkhazova. – Faculty of Geography, Lomonosov Moscow State University, Moscow, 2015. – 208 p.)

Natural-focal disease prevention is one of the most important problems of public health. The agents and vectors of these diseases are part of natural landscapes and the spread of these diseases, which may be a serious hazard for the population, is determined by natural factors. Therefore, medical geography has an important task: evaluating the risk of epidemic hazard of natural ecosystems and providing public health authorities with recommendations necessary to prevent disease outbreaks and conduct epidemiological surveillance. Considering the importance of the problem, a team of researchers at the Faculty of Geography of Lomonosov Moscow State University (Russia) has published a Medico-geographical Atlas of Russia "Natural-Focal Diseases" – a first cartographic generalization of diverse and multifaceted information about diseases caused by agents circulating in natural environment independently from humans. The spatial distribution of natural-focal diseases is considered at different hierarchic levels. In the readily understandable way the Atlas informs about their historical and current distribution in Russia, epidemiological aspects, natural and socio-economic determinants conducing natural foci. The series of maps depicts population morbidity rates in the particular regions as well as countrywide in 21st

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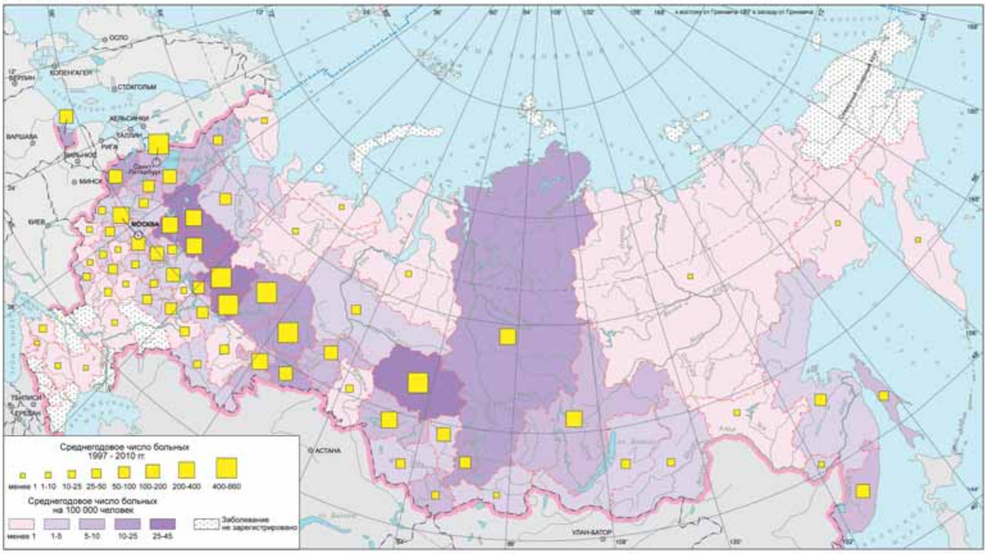

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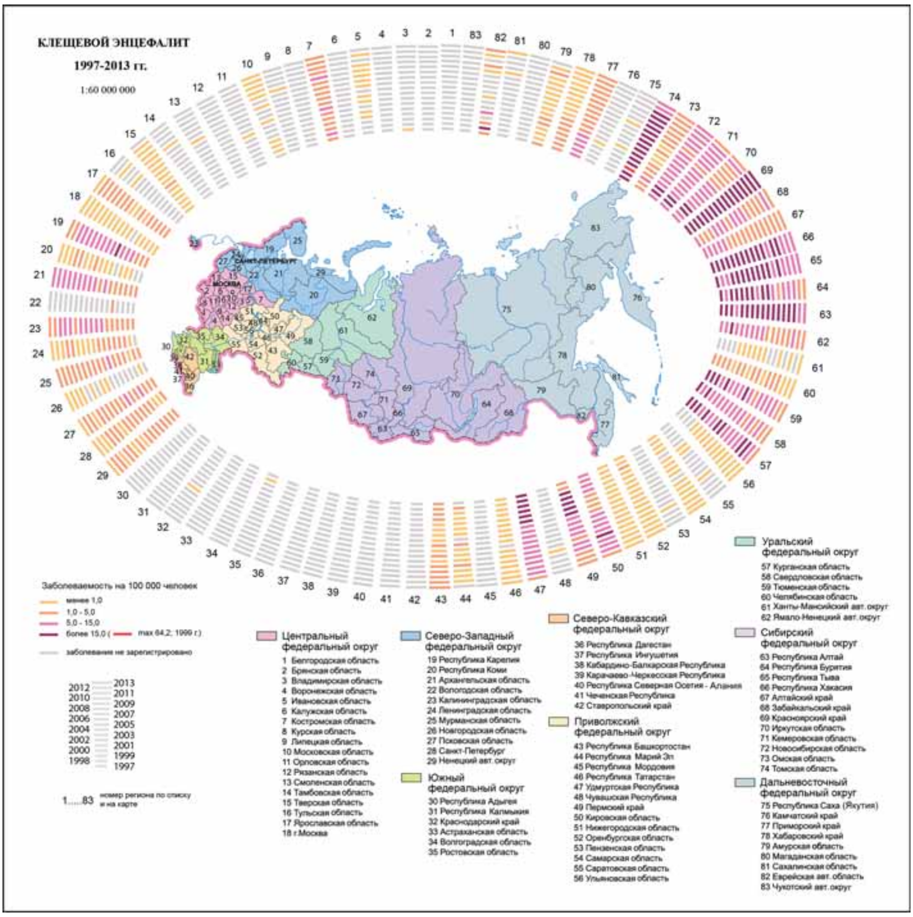

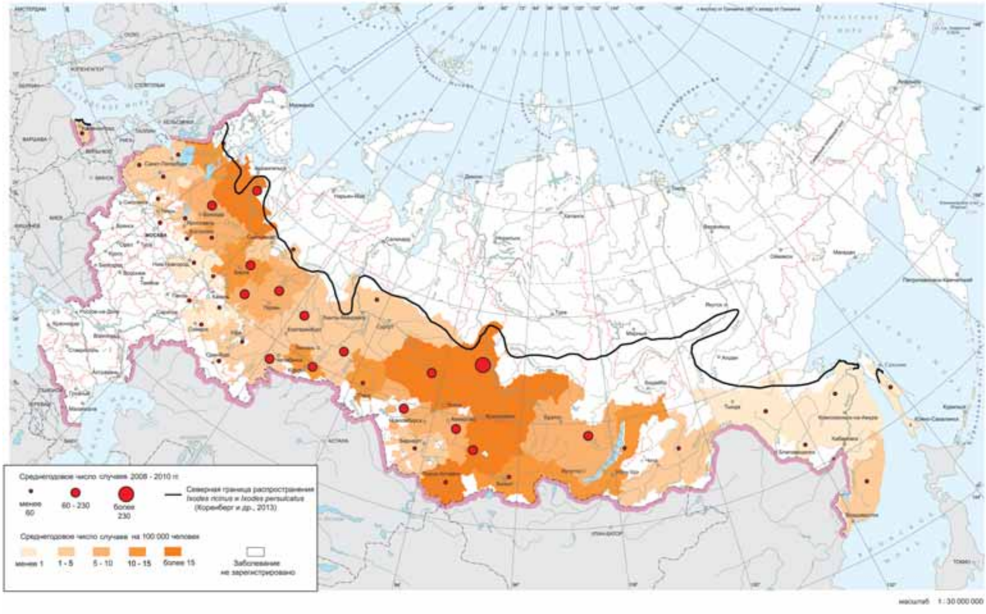

century. The publication features numerous color illustrations and oriented toward mainstream audience.

The Atlas has five thematic blocks and more than 100 maps. The Introductory section covers the theory of natural-focal infections and invasions as a complex set of interdependent populations of pathogens, animal hosts and arthropod vectors that represent a biological component organically bound with natural territorial complexes. Also, this block consists of the comprehensive information on the scientific-methodological and practical experience of the national medico-geographical mapping and on the cartographic coverage of natural focal diseases in Russia. The Natural and Socio-economic Conditions block comprehensively describes the characteristics and current conditions of the natural environment that influence the formation and functioning of the parasitogenic disease systems (agent–vector–host) in the territory of the Russian Federation and also includes maps on the patterns of the population distribution within the Russian territory and on its demographic indices. The Natural Hosts and Vectors of Natural-Focal Diseases block contains the maps of geographic ranges of animals - potential hosts of infections. The Spread of Primary Natural Focal Diseases block contains the description of 23 primary natural focal diseases of Russia along with maps based on the official statistics, showing the average long-term incidence of certain natural-focal infections and their multi-annual dynamics. The Organization of Public Health System block reflects the spatial structure of public health service in Russia.

The Atlas can be of interest for geographers, environmental workers, epidemiologists and other specialists invested in environmental and public health issues.

Tatiana A. Trifonova

INSTRUCTIONS FOR AUTHORS CONTRIBUTING TO "GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY"

AIMS AND SCOPE OF THE JOURNAL

The scientific English language journal "GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY" aims at informing and covering the results of research and global achievements in the sphere of geography, environmental conservation and sustainable development in the changing world. Publications of the journal are aimed at foreign and Russian scientists – geographers, ecologists, specialists in environmental conservation, natural resource use, education for sustainable development, GIS technology, cartography, social and political geography etc. Publications that are interdisciplinary, theoretical and methodological are particularly welcome, as well as those dealing with field studies in the sphere of environmental science.

Among the main thematic sections of the journal there are basics of geography and environmental science; fundamentals of sustainable development; environmental management; environment and natural resources; human (economic and social) geography; global and regional environmental and climate change; environmental regional planning; sustainable regional development; applied geographical and environmental studies; geo-informatics and environmental mapping; oil and gas exploration and environmental problems; nature conservation and biodiversity; environment and health; education for sustainable development.

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