

# Ecological passportization of urban population in the Northwest Russia

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**Abstract.** The paper presents important criteria for human health estimation in urbanized industrial areas. On the contrary, environmental and economic conditions are successfully identified on the basis of population' elemental status. Cause-effect relations between micro and macro element consumption (lack or abundance) and public health in North-West Federal District of the Russian Federation have been established using the open press sources. Data capturing and visualization are made. Spatial digital maps presenting element consumption for non-personalized groups as well as their main disorders are obtained. The environmental situation in urbanized regions should be used to make future modeling possible for the purposes of a green economy. The paper demonstrates the real picture of availability of macro and micro elements, their lack or abundance. Maximum disease cases per 1000 people appear in the Republic of Karelia, and minimum is in the Leningradskaya Oblast. In practice, mercury abundance is a stimulating agent for most disorders of different origin, which primarily, for example, neoplasms and leukemia. Monitoring and correction of chronic toxic metal exposure at the individual and population levels can significantly reduce expenses on educational and medical services, increase labor efficiency.

## 1 Introduction

Within environmental economics, risk management for public health is an important aspect of large projects, such as sustainable development of cities [1-5] and municipalities [6], or environmental planning in coastal zones [7, 8], including marine pipe line [9-11]. For such risk management, we propose to use geo-information support [12-14], based on the principles of geo-information management for complex geographically distributed systems [15-20]. If the projects are implemented in the Arctic and subarctic regions [21], the composition of these risks must take into account climate change, for example, because of the influence of black carbon [22] the inflow into the Arctic ocean of Pacific and Atlantic waters [23, 24], as well as the flow of Arctic rivers [25].

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North-West Federal District of Russian Federation (NWFD-RF) is the biggest and most urbanized area in the country. Its territory of 1 677 900 km<sup>2</sup> occupies Russia's 10.5 %, 81.8% of population being urban. Industrial facilities high concentration in NWFD-RF along with the Arctic coast quick development results in new flows of human migration to the area. It is not surprising that in such taugth circumstances public health becomes a challenge. To control the situation, it is necessary to make valid connections between elemental chemical composition of natural or anthropogenic origin, coming to people's organisms from environment, and human health. So called population 'environmental passport' could work well enough not only for NWFD-RF as a whole, but also for its 11 regions. Such a 'passport' is designed for big groups of people and is non-personal. It is aimed at arranging environmental situation of urbanizes regions in a prioritized order to make possible future simulation for the purposes of environmental economics.

## **2 Methods and data**

In research, we used risk management approach, theory of decision making under uncertainties. As part of geographic information management, we structured geo-space to allocate the interconnected components of the solution space [15, 18].

The data from different sources: statistical, medical, demographic, and hydrometeorological yearbooks have been aggregated for the purpose of our research. Such kind of information is hardly accessible for general public in Russia. Nevertheless, it contains a lot of useful primary local environmental and health characteristics. Benchmarking was used to reveal interconnections between environmental conditions and health in the regions and republics of NWFD-RF.

Investigations determining the elemental status of people have already been carried out in Russia. Base material obtained by mass-spectrographic analysis in Trace element institute for UNESCO, Lyon, France, which reveals concentration of elements in human hair, used for a medical and biological assessment of a given area. Correlation analysis of the elemental status for different age groups established environmental and economic peculiarities of the Federal subjects.

We based digital maps of micro and macro element consumption for non-personalized groups, inhabiting NWFD-RF, on data capturing and visualization, and we ranged the regions, according to main disorders.

## **3 Results**

Today NWFD-RF includes 11 federal subjects, which are all of different size and geographical location and size. Being the most urbanized among Russia's federal districts, NWFD-RF has significant deposits of raw materials: ferrous and nonferrous metal ores in Kola Peninsula and Karelia, coper-nickel ores stocks in Murmanskaya Oblast area, bauxite and phosphorite deposits. The importance of titaniferous and apatite deposits in the mountains of Murmanskaya Oblast is recognized at the federal level.

Due to numerous industrial facilities in NWFD-RF a serious background for unexpected technogenic catastrophes exists there. There are 55 chemical plants, more than 400 ones belong to oil and gas industry. An extra threat for human health and environment is coming from nuclear power plants as well as from the nuclear waste storage and transportation. Leningradskaya Oblast is a place where radioactive scrap metals for future development from European Russia delivered. While the influence of some pollutants affecting human organism is clarified today, functional role of another remains questionable and even

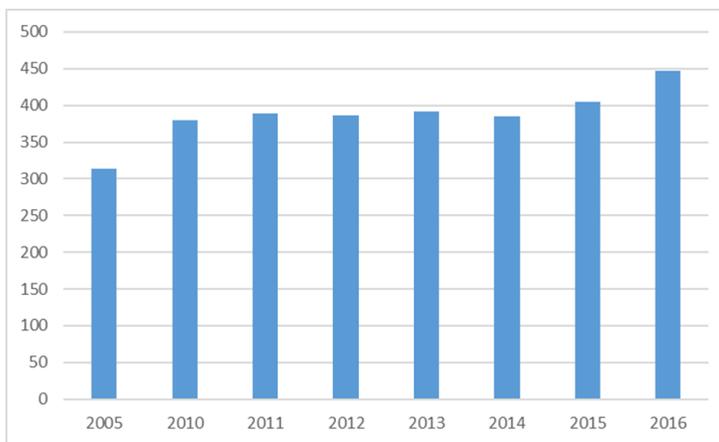
controversial. It especially concerns nuclear pollution of the vast Arctic territories in Murmanskaya Oblast and Arkhangelskaya Oblast.

As for heavy metals, many of them occur naturally in the earth's crust. They are released into the environment from volcanic activity, weathering of rocks and as a result of human activity. The last is the main cause of mercury releases, particularly coal-fired power stations, residential coal burning for heating and cooking, industrial processes, waste incinerators and as a result of mining for mercury, gold and other metals. According to WHO mercury is leading in a broad array of human disorders. Mercury exists in various forms: elemental (or metallic) and inorganic (to which people may be exposed through their occupation); and organic (e.g., methylmercury, to which people may be exposed through their diet). These forms of mercury differ in their degree of toxicity and in their effects on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes, and may be fatal. Cooking does not eliminate mercury. Once in the environment, mercury can be transformed by bacteria into methylmercury. Methylmercury then bio-accumulates (bioaccumulation occurs when an organism contains higher concentrations of the substance than do the surroundings) in fish and shellfish. Methylmercury also biomagnifies. For example, large predatory fish are more likely to have high levels of mercury as a result of eating many smaller fish that have acquired mercury through ingestion of plankton.

Heavy metals certainly impact on intellectual disability and neuro-psychic disturbances that require special education, as well as the economic costs of these services for the government. In particular, lead exposure is associated with intelligence quotient (IQ) loss, increased risk of attention deficit hyperactivity disorder (ADHD), autism spectrum disorders, antisocial and aggressive behavior, predisposition to alcoholism, narcomania, and criminal activities.

Excessive mercury impact is also associated with IQ loss, decreased mental development, higher risk of ADHD, autism spectrum disorders, as well as elevated predisposition to violations. The relevant data on arsenic, cadmium, manganese, and other heavy metal influence on human health have been presented in the world press.

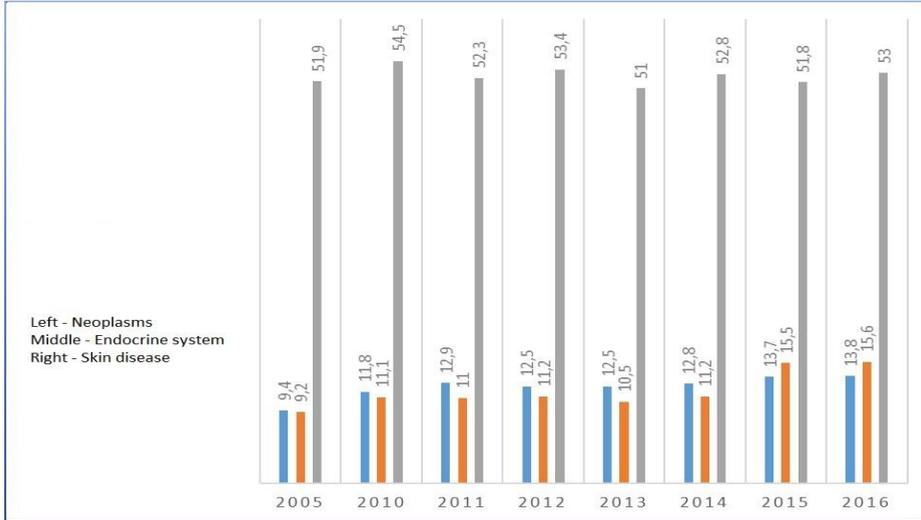
It has been revealed the number of people become ill in North-West Federal District increasingly growing. First of all, it concerns respiratory organs (450 people per 1000) which fig. 1 illustrates. Then disorders of endocrine system (15 people per 1000) and neoplasms (13 people per 1000) come.



**Fig. 1.** Average number of respiratory organs disorders (per 1000) among NWFDF-RF population.

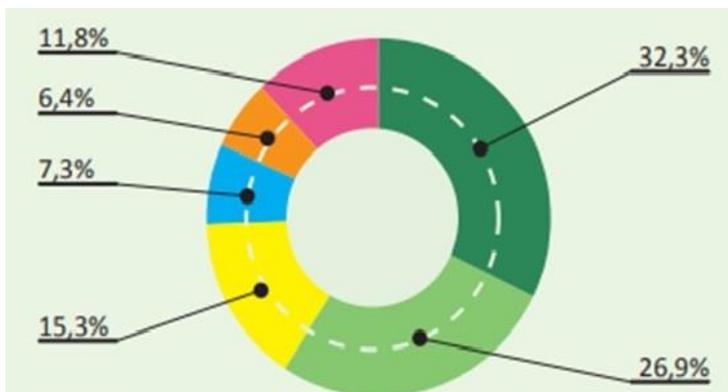
About half of the urban population being monitored is exposed to air pollution that is at least 2.5 times higher than the levels WHO recommends. In most cities where there is enough data to compare the situation today with previous years, air pollution is getting

worse. Many factors contribute to this increase, including reliance on fossil fuels such as coal fired power plants, dependence on private transport motor vehicles, and inefficient use of energy in buildings. Statistic data analysis identified three basic groups of disorders familiar for NWFD-RF, which are: neoplasms, endocrine system disorders, and skin disease (fig. 2).



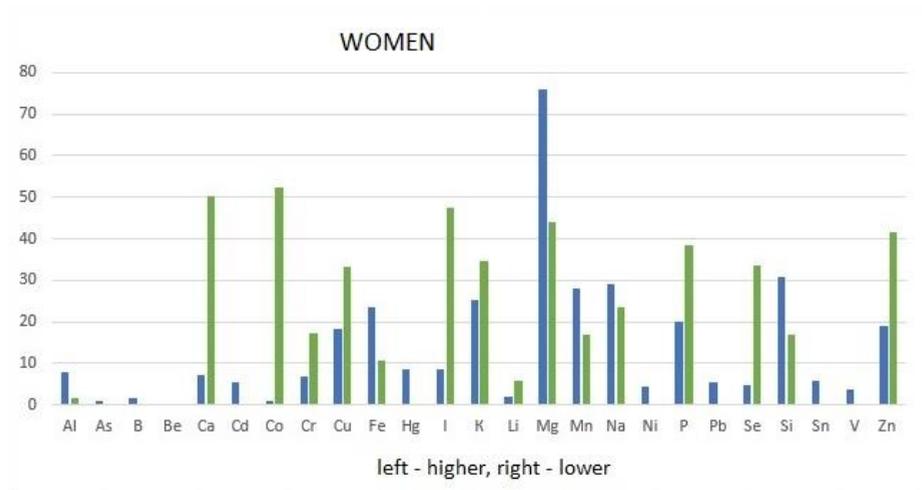
**Fig. 2.** Basic groups of disorders (per 1000) among NWFD-RF population.

As for drinking water quality, additional cases of disease rate and population mortality are highly dependent on chemical pollution with manganese, barium, boron, strontium, cadmium, and many other metals. According to fig. 3, such complex pollution gives rise to urogenital, cardiovascular, endocrine, and digestive system diseases as well as to neoplasms and problems with skin.

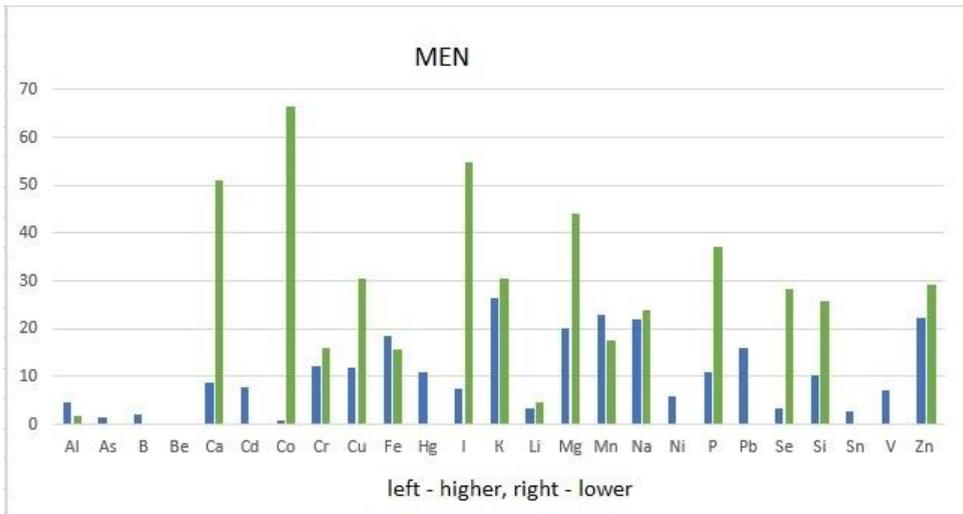


**Fig. 3.** Additional disease cases associated with water pollution, where: 32.3% - urogenital; 26.9% - digestive system; 15.3% - skin disorders; 7.3% - neoplasms; 6.4% - locomotor system; 11.8% - others.

In fig. 4 and fig. 5, we present frequency of elemental deviation from the norm in the hair of adult population (women and men separately).



**Fig. 4.** Frequency of elemental deviation from the norm in the hair of adult women.

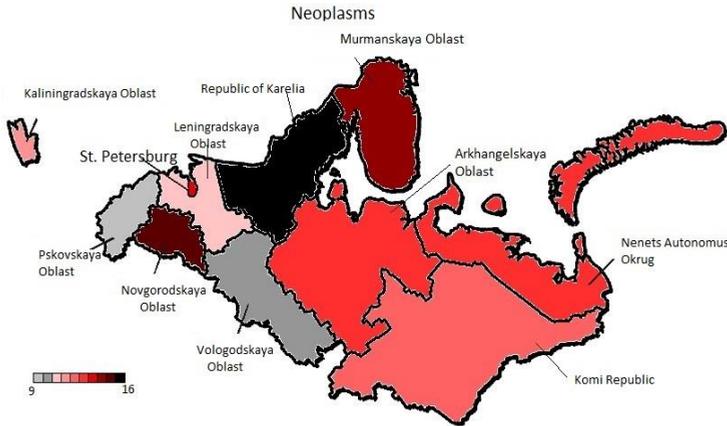


**Fig. 5.** Frequency of elemental deviation from the norm in the hair of adult men.

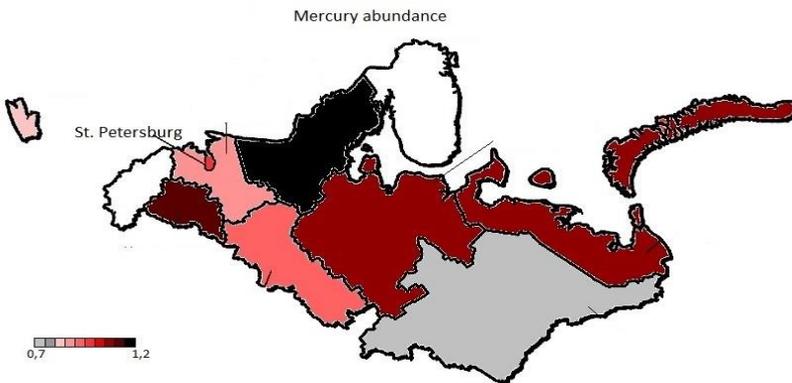
Research results are important for public health risk management to urban population within environmental economics.

## 4 Discussion

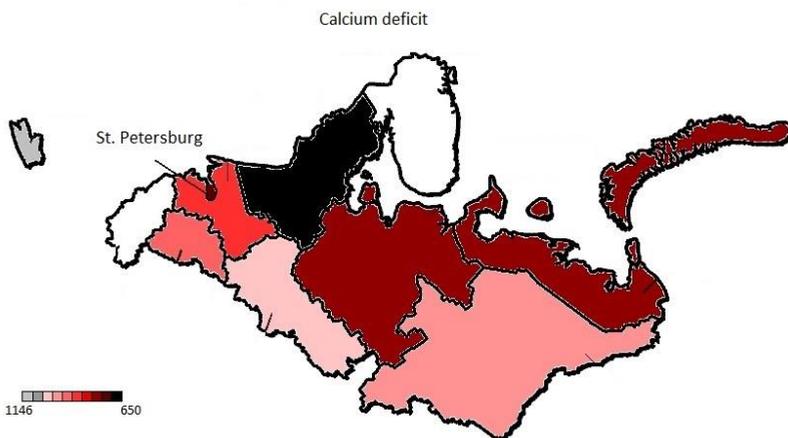
We made visualization of the data on the NWFD-RF map, according to correlations between population elemental status and their basic disorders. For instance, oncological situation (neoplasms) presented strongly correlated with lack of calcium and mercury abundance (fig. 6-8).



**Fig. 6.** Neoplasms distribution throughout NWFD-RF population.



**Fig. 7.** Mercury abundance in the elemental content of NWFD-RF population.



**Fig. 8.** Calcium deficit in the elemental content of NWFD-RF population.

The research results demonstrated a real picture for availability of macro and micro elements, their lack or abundance. Maximum disease cases per 1000 people appear in the Republic of Karelia, minimum we see in Leningradskaya Oblast. In practice mercury

abundance is a stimulating agent for most disorders of different origin, like neoplasms and leukaemia, are coming first. The rate of mortality increasingly growing due to *Hg* and *Mn* abundant, while Ca, Mg, K, Na and P deficit,

## 5 Conclusion

Substance content in the hair of the North-West Federal District population varied significantly between every Federal Subject. While research, we visualized average chemicals concentrations in the hair of adult population (women and men separately). We demonstrated a real picture for availability of macro and micro elements, their lack or abundance. Maximum disease cases per 1000 people appear in the Republic of Karelia, minimum we see in Leningradskaya Oblast. In practice, mercury abundance is a stimulating agent for most disorders of different origin, which come first, for example, neoplasms and leukaemia. The rate of mortality increasingly growing due to Ca, Mg, K, Na and P deficit, while Hg and Mn abundant. Basically, people's elemental status is closely connected with human lifetime.

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