Drinking water quality and health state of population in the Arkhangelsk Oblast

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Today chemical and biological contamination of drinking water from surface sources takes one of the leading places among the factors causing health problems among population. This happens due to steady growth of water consumption, qualitative changes in water sources, which suffer from practically uncontrolled anthropogenic impact, and also because the existing water treatment methods are inappropriate in fighting against the strongest representatives of virus micro flora. Traditional practice for water treatment does not guarantee its high quality and absolute safety for people's health any more.

It is a well-known fact that the influence of water resources on the health and life conditions of people is determined by availability of sufficient and safe household and drinking water supply, sanitary arrangement of inhabited settlements, as well as by the climatic conditions in the region.

One of the most unfavorable areas in Russia in terms of supplying good quality drinking water to population is **the Arkhangelsk Oblast**. Here the parameters of chemical and biological contamination of drinking water in the water supply network 2.5 times exceed the average Russian figures.

(According to Rospotrebnadzor in the Arkhangelsk Oblast in 2009 in the Arkhangelsk Oblast the number of drinking water samples which did not meet the existing hygienic norms for sanitary and chemical parameters was 42.2 %, for microbiological parameters – 10.1 %).

The main reason for unsatisfactory quality of drinking water in the cities of the Arkhangelsk Oblast is still high percentage (70–90%) of equipment depreciation and disrepair of water supply networks, thus causing frequents breakdowns.

Over the recent years among the most widespread chemical substances contaminating drinking water in the centralized water supply systems of industrial cities in the Arkhangelsk Oblast have been identified *aluminum, ferrum, manganese, arsenic, formaldehyde, chlorine, cadmium, methanol, lignin substances,* which appear in the water in the result of industrial wastewater being discharged into water bodies, and also in the process of water treatment and water transmission.

Besides, today the quality of wastewater is also different: due to urbanization process and mass distribution of modern detergents chemical microbial composition of industrial and household wastewaters has changed, heavy-metal and organic pollutants concentrations have grown.

Pollution of water environment and concentration of harmful substances (toxicants) in the water lead, in their turn, to deterioration of water's physical and chemical properties, violation of biological activity, self-purification process, and in the long run, - they are bad for people's health.

Accordingly, method and systems that are used for water treatment, as well as technologies for treatment of industrial wastewaters, prove unable to their tasks and urgently need to be reconstructed and upgraded.

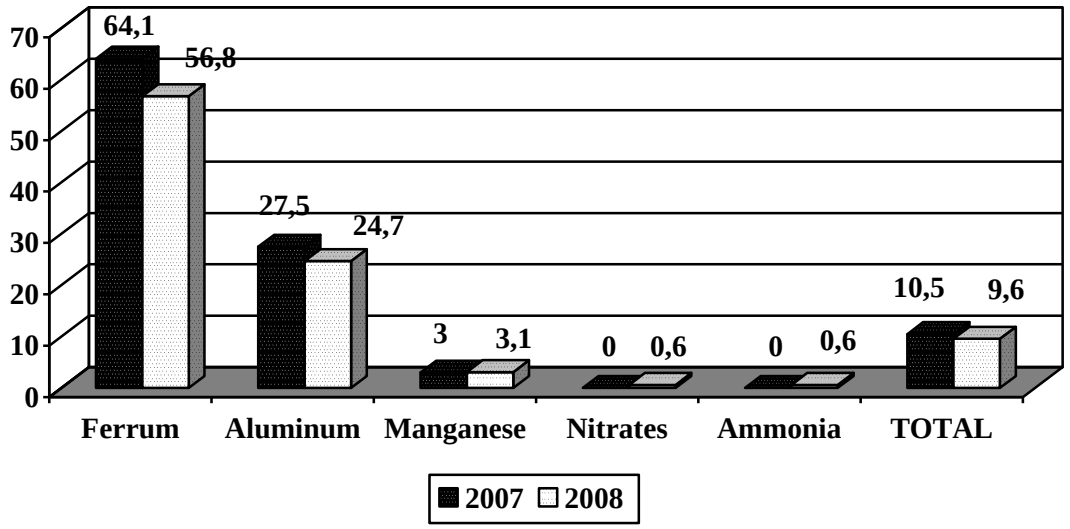
The Northern Dvina river is a water source for centralized water supply for the Oblast center (Arkhangelsk) and a large industrial regional city (Novodvinsk). Actually, the river should not be used for drinking water supply purposes, because industrial wastewaters from 6 large pulp and paper mills in the Komi Republic, Vologda and Arkhangelsk Oblasts are discharged into it.

It is also necessary to remember the fact that the water intake facilities in Arkhangelsk are located within the same zone where city's household, storm and industrial wastewaters are discharged into the river, thus not excluding negative impact on the water quality in the source of centralized water supply and health state of the population during bathing and recreation.

On the territory of the Arkhangelsk Oblast the biggest sources of wastewaters are Arkhangelsk (32 %) and Kotlas (17%) pulp and paper plants. Through discharge of wastewaters to surface water bodies they create a constant threat for the environment and people's health in the large cities of the Oblast – Arkhangelsk, Novodvinsk, Koryazhma, and Kotlas.

According to the monitoring performed by local offices of Gossanepidnadzor (State Sanitary and Epidemiological Surveillance Department) tap water of the large cities in the Arkhangelsk Oblast in 2007-2008 was found to contain aluminum, ferrum, manganese, nitrates, ammonia, and other substances in the amounts exceeding maximum permissible concentrations (picture 1). The largest share of water samples not meeting the target values was found mainly in the ferrum content (56,8%) and residual aluminum (24,7%). At that,

most of the tap water samples which did not meet the hygienic norms for the above-mentioned ingredient in 2008 were taken in large industrial cities of the Oblast: Severodvinsk and Kotlas (picture 2**).**



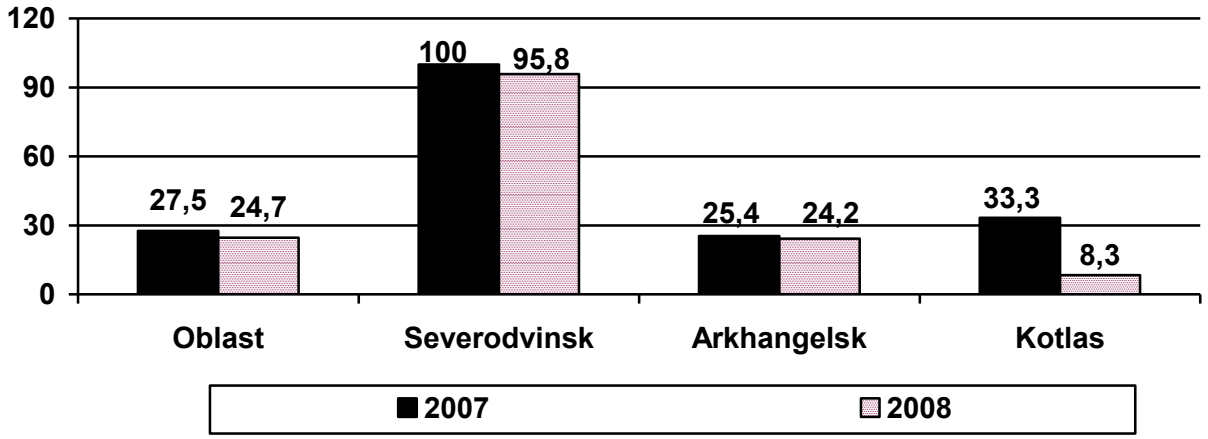
Picture 1.Share of tap water samples which did not meet the hygienic norms for non-organic substances content in 2008, %.

Northern waters are characterized by intensive color and rather low water temperatures even in warm seasons (0-5^{0}C), which makes the water treatment process more complicated. The main technologies that are included in the water treatment scheme are the following: coagulation, flocculation, filtration and disinfection. The most frequently used coagulants are aluminum sulfate, sodium aluminate, aluminum chloride, ferric chloride, etc. Exactly because of these coagulants residual aluminum appears in tap water if water treatment after the coagulation is not performed efficiently enough.

It has been proved that concentration of aluminum in the amount of 0.3 mg/liter (whereas the norm is 0.5 mg/liter) often causes consumers' complaints for sedimentation of aluminum hydrochloride flocculus in the water distribution systems. When the aluminum concentration is more than 0.5 mg/liter bitter taste appears, and also rust stains on the clothes after washing. Although its metabolism with human beings has yet not been studied well enough, but epidemiological researches show that cerebral affection is related to aluminum in drinking water. Some forms of surplus amoun of any element continue to be related to aluminum also: simple accumulation of aluminum in the central nervous system or chronic "benignant aluminosis" at people over 65, deposition of aluminum during Alzheimer disease, aluminum dialysis encephalopathy, etc.

According to researchers (Baksheeva Yu. A., and others, 2008) biological abilities of aluminum received with drinking water are *stronger* than when it is received from other sources. Aluminum compounds dissolved in water are absorbed in the proximal colon of the duodenum and in the stomach, and after binding with proteins they get into blood in 24 hours after drinking. Most of the aluminum compounds are accumulated in tissues (cerebrum, liver, kidneys, and bones). Up to 40-50% of the received amount of this chemical element remains in the body. The time period for its presence in a body is about 300 days. Excretion of aluminum is mainly performed via intestinal canal (84-94%) and kidneys (6 -16%).

Monitoring analysis of the drinking water quality in the Arkhangelsk Oblast in 2008 showed that the number of tap water samples which do not meet the existing hygienic norms for content of residual aluminum is 24.7%. Considerable excess (more than 3 times) of the regional figure showing content of residual aluminum in water is detected in Severodvinsk (picture 3).



Picture 2. Share of tap water samples which did not meet the corresponding hygienic norms for content of residual aluminum in the cities of the Arkhangelsk Oblast in 2008, %.

Table 2.

Ratio of tested tap water samples for content of residual aluminum (%) in different parts of the Arkhangelsk Oblast in 2008 (MPC = maximum permissible concentration)

Part of the Oblast	up to 1,0 MPC	1,1-2,0 MPC	2,1-5,0 MPC	>5,1MPC
Arkhangelsk Oblast	**75,3**	**14,8**	**9,3**	**0,6**

Kotlas district	100,0	0,0	0,0	0,0
Onega district	100,0	0,0	0,0	0,0
Arkhangelsk	75,8	19,7	4,5	0,0
Kotlas	91,7	8,3	0,0	0,0
Koryazhma	100,0	0,0	0,0	0,0
Novodvinsk	100,0	0,0	0,0	0,0
Severodvinsk	4,2	41,7	50,0	4,2

Deterioration of water quality in surface water sources and more requirements to the quality of water supplied for drinking purposes to population lead to searching for new, more efficient and less dangerous methods of its treatment in many Russian cities (as an example we can mention change under certain circumstances of a traditional coagulant – aluminum sulphate for aluminum oxychloride (Bopak-E), palygorskite clays, and other coagulants).

Another chemical agent is chlorine. It is used for water disinfection (liquid chlorine or chlorine gas) as the most widespread, available and efficient agent. Being very popular the chlorine treatment still has its serious drawbacks, with chlorination by-products also being dangerous for people's health.

Researchers have found out that chlorine reacts with organic compounds of natural origin which are contained in water and thus produces different chemically toxic substances (cancerogenes). The latter make up for about 30% of chlorination by-products which are harmful for human health. Most of them are halogen-containing compounds (GCC). Among those the most relevant are trihalomethanes (THM).

Occurrence of such substances in water is explained by pollution of water sources with industrial wastewaters from some of manufacturers. However, the main reason for appearance of such substances in drinking water turned out to be connected with drinking

water disinfection processes (chlorine treatment) which result in the formation of hundreds of GCC. Their qualitative and quantitative composition depends on the initial content of *humic acids, fulvic acids, quinones and phenols* in water. In the result of drinking water chlorine treatment compounds can be produced which are able to transform into dioxine ones.

Thus compounds of aluminum, ferrum, chlorine, and other substances in water, especially drinking water, under certain circumstances, combinations and quantities, to this or that extent may produce negative impact on the human body. Broad comprehensive researches are required to study biological properties of the water in the Northern Dvina, chemical components in the water and their combinations, as well as the impact of some chemical substances (aluminum, ferrum, manganese, chlorine, etc.) on the human health. This will help to identify the safest concentration of separate chemical compounds or their complexes in drinking water of Northern areas, as well as to reconsider and improve the existing water treatment technologies (to use more up-to-date and efficient methods and harmless chemical agents).

Impact study of some chemicals (aluminum, ferrum, chlorine, etc.) contained in the water of the Northern Dvina on the people's health, identification of their least harmful concentrations make it possible to develop criteria for calculation of norms for a number of chemical substances (aluminum, ferrum, chlorine, etc.) in the drinking water of this specific area, taking into account their comprehensive effect on the human body: water composition in the local water sources, location of large industrial facilities, and other specific features of the Northern area.

Literature analysis shows that there is no perfect water treatment method among the existing ones. That is why for modern technologies of water treatment it is also important to search for a method which would combine best properties of the known chemical agents and eliminate their negative impact.

One of the efficient methods to analyze impact from environmental pollution on the people's health is *risk assessment***,** i.e. qualitative and (or) quantitative characteristics of harmful effects which may occur in the result of environmental influence on a specific group of people under specific circumstances of exposure. This method is used at present by specialists from Rospotrebnadzor Directorate in the Arkhangelsk Oblast to calculate

risk levels for a human being from the impact of some chemical substances in water in different parts of the Oblast (Novodvinsk, Severodvinsk, Kotlas, Koryazhma, etc.).

It is worth mentioning that there is a target regional program "Pure Water" working in the Oblast (Decree of the Arkhangelsk Oblast Administration №4-pa/2 from January 20, 2009), and also regional program "Environmental protection and environmental safety for 2009-2011", which includes the issues of water supply and water discharge in the inhabited areas of the Oblast.

However, the implementation of the adopted programs today is moving forward very slowly, but they will have to, in the long run, to enhance sanitary and technical reliability of water supply systems, improve water quality and stabilize sanitary-epidemiological situation in the Oblast.

The existing situation in the Oblast can be conceptually changed by an alternative water source – ground fresh water.

So, the present unfavorable environmental and hygienic situation in the Arkhangelsk Oblast imposes the necessity to change our attitude to water environment, and in principle, to change water management policy in the Oblast.

Conclusions:

1. In the result of long-term industrial construction and arrangement in the mouth of the Northern Dvina river extreme conditions have been created for the population of the Arkhangelsk Oblast in terms of using water resources:

- *Surface water quality in the basin of the Northern Dvina river cannot be characterized as good for water consumption.*

2.Natural and industrial organic pollution of the water in the mouth of the Northern Dvina river with hard oxidizable organic substances makes the main water chemical burden for the population.

3.Chemical treatment of the cold colored water in the mouth of the river contaminated with liquid wastewaters from the pulp-and-paper industry may be attended by formation of toxic compounds in drinking water (organic chlorine compounds, residual aluminum, formaldehyde, methanol, etc.);

4.The performance and capacities of water treatment facilities in the city have not been enhanced with the help of modern best technologies and methods of water treatment.

5.Construction of local water treatment facilities in places at industrial enterprises, which are users of sewage networks in settlements, is not regulated on the State level.

6.There are no alternative sources for centralized water supply in large cities (ground water).

In such situation the most important thing is to provide environmental and hygienic education for children, youth, teachers, journalists, specialists and managers of all levels, development of their environmental and hygienic thinking. Through them it is possible to influence all strata of society, age, social and demographic groups, authorities and decision-makers.

Development of environmental and hygienic thinking reduces costs for municipal and State organizations. Environmental and hygienic education is the first step within measures to improve life environment, water quality and ensure sustainable development of the Arkhangelsk Oblast.