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INTEGRATED ROADMAP FOR THE NANOTECHNOLOGY WATER PURIFICATION IN RUSSIA

Junior research fellow **Veselitskaya Nataliya**[1]
Research fellow **Vishnevskiy Konstantin**[1]
Deputy director **Karasev Oleg**[1]
[1]Foresight Centre of ISSEK HSE, **Russia**

ABSTRACT

On the Russian population opinion one of the most urgent ecology problems is the water pollution. By the data of Russian Federal Consumer Rights Protection and Human Health Control Service about 37% of the surface sources of centralized drinking water supply don't meet sanitary norms and rules and 22% of Russian citizens do not have access to centralized water supply [3].

The study outlined three possible ways of overcoming above marked problems. The first method is based on the modern industrial-management scheme which is traditional for water provision in Russia. The second option suggests cleaning up sources of water intakes. The third way shows an option of varying treatment methods and technologies, depending on customer needs.

The Roadmap developed by Higher School of Economics and Rosnano indentified that nanotechnologies increase the efficiency and decrease energy consumption of traditional as well as innovation processes of water purification. In particular the perspective area of nanotechnology application is lies in the sphere of innovation sorbents and coagulants. Moreover nanotechnologies can also be used in baromembrane processes and membrane bioreactors.

Innovation technologies, processes and products implementation should be specific to individual regions and municipalities. This approach is based on the compliance of centralized and decentralized water supply, inlet and outlet water quality.

The Roadmap results are designed for the formation of government and regional policy on the pure water provision for population and industrial water treatment. Furthermore it indicates the most relevant business ideas and evaluates projects for nanotechnology and nanoproducts used in this field.

Keywords: nanotechnology, nanoproducts, water purification, integrated roadmaps, government and regional policy

INTRODUCTION

Russian population consider water pollution as one of the most urgent ecology problems facing the country. In particular, experts identify following challenges:

- pollution of surface and underground water sources;
- significant depreciation of fixed assets of water supply and wastewater facilities;
- increasing in requirements to the consumed water quality.

According to Russian Federal Consumer Rights Protection and Human Health Control Service about 37% of the surface sources of centralized drinking water supply do not meet sanitary norms and rules and 22% of Russian citizens do not have access to the centralized water supply [3].

Currently, depreciation of fixed assets of the water supply and wastewater facilities in Russia is between 50 and 70%. Such deprecation leads to the secondary water pollution and as a result to the excess chlorination. According to World Health Organization, poor water quality causes the death of 12,000 people each year [2]. Depreciated equipment of the water supply system increases the accident rate, causing water loss, soil erosion, and damage of roads and buildings.

Main part

The study outlined three possible ways of overcoming problems of water pollution.

1. The first method is based on the modern industrial-management scheme which is traditional for the water provision in Russia.
2. The second option suggests cleaning up sources of water intakes.
3. The third way shows an option of varying treatment methods and technologies, depending on customer needs.

The Roadmap developed by Higher School of Economics identified that nanotechnologies increase the efficiency and decrease the energy consumption of the traditional and innovation processes of water purification.

To be more precise, firstly we focused on the main membrane processes for water purification based on nanotechnologies. They are divided into four categories:

- baromembrane processes;
- membrane bioreactors;
- electromembrane processes;
- membrane degassing.

Among baromembrane processes, we determined the following water purification products [1]:

- ultrafiltration membranes;
- microfiltration membranes;
- nanofiltrarion membranes;
- reverse osmosis.

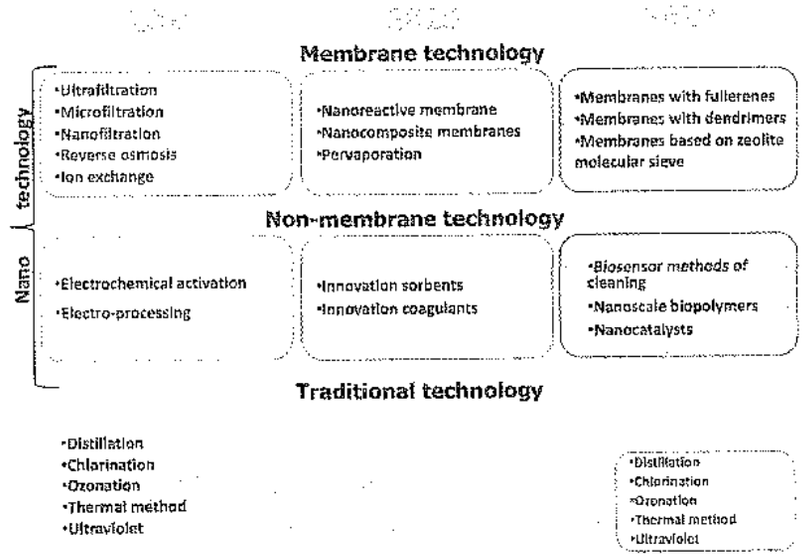
Furthermore, another group of membrane technological solutions related to nanotechnology is represented by:

- carbon nanotubes and fullerenes;
- dendrimers;
- zeolites;

It is interesting to emphasize that the promising area of nanotechnology application also is lies in the sphere of non-membrane processes such as innovation sorbents and coagulants.

Altogether the prospects of nanotechnology application until 2020 are represented in Figure 1.

Fig.1 **The perspectives of nanotechnology application**

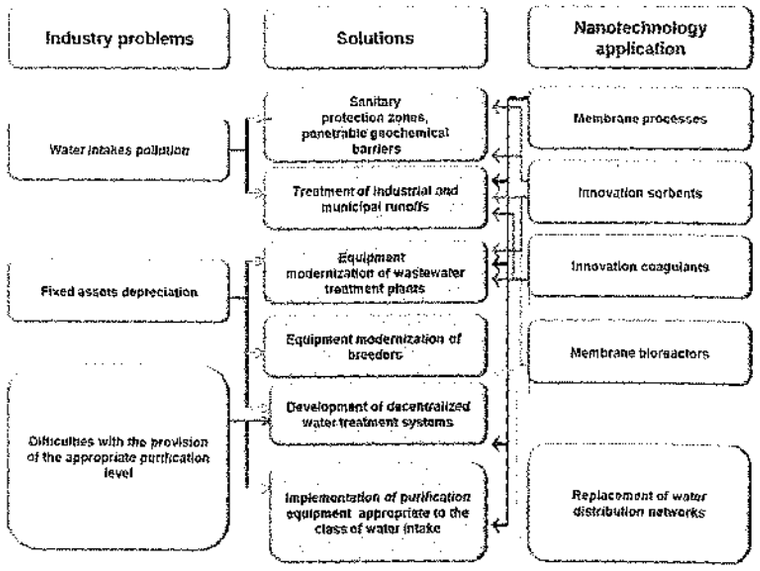


Source: Higher School of Economics

As shown in Figure 1 membrane and non-membrane processes based on the use of nanomaterials have broad opportunities for application in water treatment. In contrast, the importance of traditional water purification methods will decrease in the future but their efficiency will increase.

The next step of our analysis is the identification of opportunities of nanotechnology implementation in water treatment. The main directions of nanotechnology implementation in water treatment are summarized in Figure 2.

Fig.2 **The main directions of nanotechnology implementation in water treatment**



Source: Higher School of Economics

As illustrated in Figure 2 implementation of nanotechnologies (in particular, membrane processes, membrane bioreactors combined with the traditional technologies incorporating innovative components) can solve the most urgent problems of water supply sector as it increases significantly the water treatment efficiency.

Water treatment segments

To determine the development strategies and government support measures, we used the following segmentation of water treatment market:

- *Cleaning water for the population*
  - ✓ Centralized water treatment
  - ✓ Decentralized water treatment
- *Water treatment for industry*
  - ✓ General application in manufacturing
  - ✓ Special applications in production
- *Wastewater*
  - ✓ Municipal wastewater treatment
  - ✓ Industrial wastewater treatment

It should be mentioned that the requirements for the specific water quality in many segments leads to the strong demand for nanotechnologies from various industries.

At the next stage of our research we identified the fields of nanotechnology application for each segment (see Table 1).

Table 1

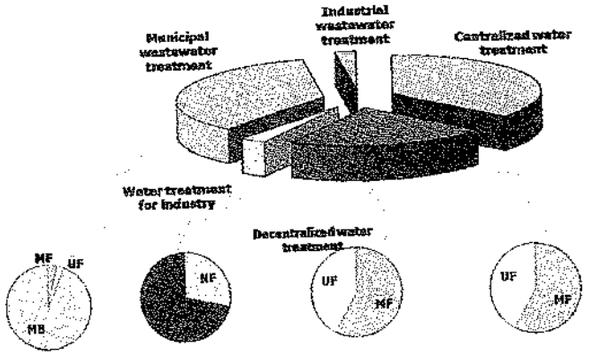
Opportunities of nanotechnology application on different segments of water treatment market

№	Segments	Nanotechnology application
	I. Cleaning water for the population	
1.	Centralized water treatment	• Ultrafiltration membranes • Microfiltration membranes • Innovation sorbents • Innovation coagulants
2.	Decentralized water treatment	• Ultrafiltration membranes • Microfiltration membranes • Innovation sorbents
	II. Water treatment for industry	
3.	General application in manufacturing	• Ultrafiltration membranes • Microfiltration membranes • Nanofiltrarion membranes • Reverse osmosis • Electrodialisis • Electro-deionisation • Innovation sorbents • Innovation coagulants
4.	Special applications in production	• Nanofiltrarion membranes • Reverse osmosis • Innovation sorbents • Innovation coagulants
	III. Wastewater treatment	
5.	Industrial wastewater treatment	• Ultrafiltration membranes • Microfiltration membranes • Membrane bioreactors • Innovation sorbents • Innovation coagulants
6.	Municipal wastewater treatment	

Source: Higher School of Economics

The proportion of some nanotechnolology applications on the different market segments is described on Figure 3.

Fig.3 **The scale of nanotechnology application in different segments of water treatment market**



Source: Higher School of Economics

As it is shown in the Figure 3 and Table 1 there are nanotechnology can be used in different proportions for water purification. From the experts' point of view, the scale of nanotechnology application is divided by the following way:

- membrane bioreactors is widely used in the segment of municipal wastewater treatment;
- reverse osmosis is efficient for the industry water treatment;
- microfiltration is applied for the centralized and decentralized water treatment.

It is worth emphasizing that innovation technology, processes and products implementation should be specific to individual regions and municipalities. This approach is based on the compliance of centralized and decentralized water supply, inlet and outlet water quality.

The next step of our research implies the determination of the water supply strategies depending on the market segment.

Strategies of the nanotechnology development for water purification

Innovation strategies of water treatment in different market segments are determined by the possibility of introducing new technologies in the field of centralized and decentralized water supply. Implementation of these strategies depends on the development of water consumption segments, their proportion in the market, replacement of worn-out distribution networks, etc.

The Roadmap describes two possible strategies of the nanotechnology development in water treatment.

The *aggressive strategy* involves the development segments with the maximum market potential. Aggressive strategy is determined by the current situation in the industry and by the fact that the quality of water purification is important factor of the nation health and ecological balance. This strategy contributes to the optimistic scenario of the market development.

There are several conditions determining this scenario:

- direct funding in the initial stage of the technology and equipment modernization;
- development of appropriate regulatory documents;
- stimulation of the demand the creation of privileges for consumers;
- improvement of customs regulation in the industry.

The *active strategy* implementation corresponds to the moderate scenario. This scenario is associated with the following conditions:

- government support of the water treatment development;
- maintain of the existing scientific potential and training of highly qualified scientific personnel for this sector;
- promotion of the nanomembranes consumption;
- establishment of collaboration with the world producers and consumer, including the creation of joint ventures with leading manufacturers.

CONCLUSIONS

The results of our study lead to the conclusion that one of the most important steps in the field of water purification is related to the solution of problems in centralized, decentralized, industry and wastewater treatment.

The system approach to this problem implies the development of the nanotechnology application segments of the highest efficiency.

The Roadmap results are designed for the formation of government and regional policy on the pure water provision for population and industrial water treatment. Furthermore it indicates the most relevant business ideas and evaluates projects for nanotechnology and nanoproducts used in this field.

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