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Review Article

Water as the Earth's Buffer and Immune System

Vladyslav V. Goncharuk

A.V. Dumansky Institute of Colloid Chemistry and Chemistry of Water, National Academy of Sciences, 42 Academician Vernadskoho Boulevard, Kyiv 03680, Ukraine

Correspondence should be addressed to Vladyslav V. Goncharuk; honch@iccwc.kiev.ua

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A comprehensive review on water as a buffer of the planet and its immune system is presented. The relationship between the quality of drinking water, the level of development of human intelligence, and its health is highlighted. The problems of obtaining cytogenetically and physiologically safe high-quality drinking water are discussed along with the problems of its decontamination. The solutions to maintain stable development of aquatic ecosystems are proposed. It is shown that tap water is the habitat of multiresistant genetically-mutated microorganisms.

1. Water Resources of the Planet

The bulk of the planet's water is concentrated in the seas and oceans and constitutes around 1350 million km^3. This is salt water, with an average mineralization of 35.0 g/L, which makes it unsuitable not only for drinking but also for agriculture needs. Fresh water is localized mainly in the North and South poles and in the mountains in the form of glaciers. This resource constitutes 30–50 million km^3. However, this source of fresh water is almost unobtainable for human use.

The earth's rivers and lakes contain about 0.4 million km^3 of fresh water that is accessible for mankind. Subterranean regions of the planet have substantial stocks of water, mainly saline and salt ones. At a depth of 800 m and up to 1600 m, the water resource constitutes around 4 million km^3.

Thus, our planet has only 3% of fresh water of its total amount, with its bulk in the pack ice of the Arctic and Antarctic. The resources of fresh water accessible to human constitute only 0.06%, 0.8 million km^3.

At present, more than 40 countries of the world experience an absolute water deficiency (e.g., the Near East, Africa, Indochina, and Australia). A fifth of the population in Europe and the Americas drinks contaminated water, which does not meet international standard criterion. According to the World Health Organization (WHO) official data, around 80% of human diseases around the globe are related to the consumption of low-quality drinking water [1].

The first attempts to establish priorities for conservation and functioning resilient natural resources were defined in the documents of the United Nations (UN) conference in Rio de Janeiro (June, 1992) and the World Summit on Sustainable Development in Johannesburg "Johannesburg Agreement on Sustainable Development" (August 2002) [2]. "Every inhabitant of the planet has the right for clean drinking water," is the formula declared by the UN [3, 4]. This humane statement is unfortunately not supported by any specific actions. An ill-advised economy, the pursuit of profits without accounting for ecological problems, and the harsh competitive struggle of monopolies have resulted in the majority of surface and underground drinking water supply sources being depleted and heavily polluted. As a result, polluted water penetrates rivers, seas, and oceans. A fourfold increase of the world population within the 20th century alone—from 1.5 to 6 billion people—has dramatically exacerbated this deficiency of fresh water, which is used not only for drinking purposes but also for industrial activity. All of this combined has resulted in the worsening of the global ecological situation.

Artesian groundwater is a source of drinking water that is reliably protected from human impacts. We currently know of more than 150 different types of freshwater and saline drinking water treatments.

The most abundant impurities in underground waters are two-valence iron and manganese, fluorine ions, nitrates, ammonia, hydrogen sulfide, hard salts, and an increased

salt content. Normally, these impurities substantially exceed maximum allowable concentrations for drinking water. Their presence is caused by natural factors of a geological nature. At the same time, one has to remember that high-quality water for human health should contain a wide spectrum of micro-impurities, vitally important, biologically active elements, and natural organic compounds. It is these compounds dissolved in water that provide its taste, smell, transparency and physiological properties.

Surface-level fresh waters are the second most common source of the drinking water supply. However, the global nature of human activities in the 20th century in terms of industrial development, progress in agriculture, transportation, urban utilities, the formation of megalopolises, and the growth of cities and settlements resulted in the wide-scale pollution and contamination of surface waters. The composition of wastewaters is constantly changing due to the synthesis of new chemical substances, often possessing toxic, carcinogenic, and mutagenic properties.

One can identify the following most hazardous types of pollutants entering the environment which eventually affect the water supply:

(i) chemical pollutants:

(1) inorganic compounds:

(a) heavy metal ions,
(b) salts,
(c) toxic, biologically active substances,

(2) organic compounds:

(a) oil products,
(b) phenols,
(c) pesticides,
(d) surface active substances,
(e) chlorine-containing compounds,
(f) xenobiotics;

(ii) bactericidal and viral pollutants;

(iii) radioactive substances of natural and anthropogenic origin
isotopes of elements;

(iv) mutagenic compounds of organic and inorganic origin;

(v) mycotic pollutants.

Seas and oceans may also serve as the source of drinking water supply. It is known that the average salt content in water constitutes about 35 g/l. It is natural that such water cannot be used for drinking. There are various approaches intended to desalinate water. In practice, desalinization technologies such as distillation, membrane, and electrochemical methods are used.

1.1. Advantages and Drawbacks of Water Desalination by Reverse Osmosis for Drinking Water Purposes. Desalination of sea (ocean) water is one of the fastest growing sectors of the economy. The introduction of reverse osmosis technology has had a big impact on the rapid development of desalination. Reverse osmosis is used for water treatment and purification of drinking water from heavy metals, nitrates, nitrites, surfactants, phenols, hardness, organic and microbiological contaminants, and organochlorine compounds.

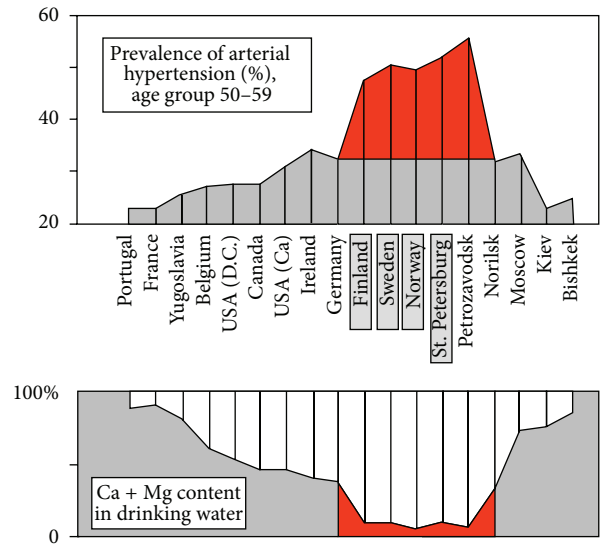

Figure 1: Effect of calcium and magnesium in the drinking water on the incidence of hypertonic disease [5].

At present, this method is one of the most popular methods of purifying drinking water, including artesian well water for the industrial production of bottled drinking water. The reverse osmosis method of water purification produces water which contains virtually no contaminants. This method has more economical operation and maintenance than any other technology. The effectiveness of using reverse osmosis technology for the desalination of sea water is three times more effective in terms of energy consumption and the degree of purification than the other methods.

At the same time, the obvious disadvantage of reverse osmosis is the lack of selectivity of the membranes to remove contaminants. This means that not only toxic impurities and microorganisms are removed, but also vital minerals and microelements. Will this water fulfill physiological requirements? Of course not! After all, purity of drinking water is not the only criteria of water quality. Also important is the extent to which drinking water is the source of elements necessary for normal body functioning. Water obtained by the reverse osmosis method cannot be called drinking water; one gets somewhat distilled water.

The results of studies on biotesting demineralized (distilled) water show that it affects both the physiological and intracellular processes in the body.

The required presence in the optimal drinking water content of calcium and magnesium is confirmed in Figure 1. Regions supplied by water with a low concentration of calcium and magnesium exhibit a significant (30–40%) increase in the incidence of hypertonic disease (see Figure 1).

It is necessary to do adjustments to the salt composition in water obtained by reverse osmosis [6]. This is achieved by

the introduction of salts required for normal human activity: calcium, magnesium, sodium, and potassium. Taking into account this fact, factories using the reverse osmosis method need to provide special mineralizers, in order to restore the optimal mineral content of water. Thus, an artificial formation of water for drinking purposes is created. This is not the best option, but is vitally necessary where there is no other source of fresh water.

1.2. The Proof of the Failure of World's Approach to Assessing the Quality of Drinking Water and New Scientifically-Based Approaches to Assessing Its Quality. Life on earth is only possible as a result of the presence of water. The emergence and development of biological diversity on our planet is due to the presence of water, which has unique physical and chemical properties. Almost a hundred years it is known that water—not a simple compound where apart of protium there are also heavy isotope patterns however no one has ever thought about why they exist and what their role.

The unique properties of water is determined by its isotope composition and, first of all, by the ratio of protium and deuterium. The natural concentration of deuterium in the world's oceans, in salt and fresh waters varies within the interval 90–180 ppm. The stable optima, concentration of deuterium in water, constitutes 150 ppm. It is within this concentration interval that our ordinary water possesses maximum biological activity both in sea and in fresh water bodies. A decrease or an increase of the deuterium concentration in water results in a radical change of its physicochemical and biological properties [7–9].

Water is currently viewed from fundamentally new positions. The comprehensive study of water has yielded quite new results [10]. It has been found that if the deuterium concentration in water is adjusted, all ideas about its fundamental properties accepted today are changed drastically. Both the melting point and the freezing point, and other water properties, are substantially changed depending on the relation of the isotope composition of hydrogen. If deuterium is completely removed from water, then it will not exist on our planet in its liquid state. Consequently, water structure, just as all physicochemical parameters, is determined by the presence of deuterium. The results regarding the influence of deuterium on water properties became the basis for the discovery of a fundamentally new method for monitoring water quality.

Here, questions arise. What is drinking water? How can the quality of drinking water be assessed? What are the optimal parameters that water should possess in order to be completely safe according to biological and physiological points of view?

The development and the setting of regulations and standards for drinking water quality in different countries since the late 19th and early 20th centuries have changed from simply regulating the macrocomponents of natural water to more insightful knowledge about the impact of anthropogenic contaminants and toxic microcomponents of water on human organisms [11].

In connection with the worsening of the ecological state of surface and underground sources, the issue of water quality control, used by people for drinking purposes, became more acute [12, 13]. As a result of the low quality of drinking water, real threats to the sanitary-epidemiological situation in various regions of the planet crop out.

An increase of the quality of the matter being controlled in national standards of various countries of the world does not solve the issue of obtaining safe drinking water at centralized water-treatment stations either. All this calls for ever more expensive equipment and the complication of technological processes. Special attention should be paid to the fact that over the last two to three decades, an uncontrolled sharp increase of chemical compounds in the environment took place [11].

While the environment experiences these catastrophic changes, the quality control of dozens of substances in tap water does not guarantee that it really is drinkable and safe for human health. A high level of a technogenic load on water bodies, the use of imperfect technologies of water treatment, and secondary contamination of the water in distribution networks result in the ingress to the drinking water of a substantial amount of inorganic and organic pollutants, whose joint effect on the human organism causes the effect of synergism known in chemistry and biology, threatening human health. In this situation there is no possibility to provide the population of any country and continent with quality drinking water that is safe for human health. In addition, drinking water obtained from surface sources is unsafe due to the presence microtoxins in it of. As a result of our research, we found the presence of toxic micromycetes in surface waters and distribution systems. These micromycetes are not disinfected by current techniques used at centralized water treatment stations, even when chlorinated with high doses.

Hence, classic approaches to the assessment of drinking waters are useless. The notion of "normalizing maximum allowable concentrations in drinking water of different toxicants" purportedly safe for human health, is, as a matter of fact, immoral.

2. Quality of Drinking Water: Problems and Solution

The harmonic development of Homosapiens concurrently with the planet's biosphere calls for the immediate prevention of environmental pollution. Our generation has witnessed qualitative changes of natural and drinking waters. For the first time in the history of mankind, the necessity of introducing quality standards for drinking water has appeared. These standards over time were improved, and new ones were introduced. Substances both of natural and anthropogenic origins were hazardous for human health and were strictly controlled. General human and worldwide approaches for drinking water quality evaluation were established. The first countries in the world that developed state standards for drinking water quality were the USA and the USSR. Owing to a high level of bacterial pollution of surface waters, drinking waters were disinfected with chlorine. This was one of the greatest mistakes of mankind. Since water always contains organic compounds, its chlorination inevitably results in

the formation of very toxic, mutagenic, and carcinogenic organochlorine compounds. For the first time in the history of mankind, people began to drink chlorinated water hazardous for human health—technogenic water!

At the beginning of the 20th century, the level of surface-water contamination with chemical and bacterial components did not achieve a critical state. Therefore, small doses of chlorine, used for disinfection of water, do not lead to the formation of substantial concentrations of hazardous organochlorine compounds. However, the turbulent development of industry, agriculture, the formation of megapolises, and a dramatic increase of the population size of the world (a fourfold rise over the 20th century) resulted in a catastrophic level of bacterial and chemical contamination of water sources used for conditioning drinking water. It entailed the necessity of using large doses of chlorine for the disinfection of water. As a result, there was an increase in the concentration of organochlorine compounds in drinking water. Given such a dangerous factor, new, more sophisticated technologies of water treatment began to be developed. These technologies include preliminary filtration from suspended particles, primary chlorination, and chemical water treatment by coagulation concurrent with aluminum, iron, and flocculants of organic and inorganic origin, then filtration on sand and carbon filters. For suppressing the development of microorganisms in pipelines, the water again is treated with chlorine of such a concentration that at the outlet of the faucet of every consumer the content of residual activated chlorine is within the range of 0.3–0.5 mg/dm^3.

Schematic chlorine dioxide, possessing a higher oxidizing potential, is used instead of chlorine in a number of countries, according to regulations. Potentials of some oxidants are given in Table 1.

The current technology has its advantages and disadvantages. Advantages include the fact that the decontamination process occurs more effectively. However, it also means that chlorine dioxide may produce a broader set of organochlorine compounds.

An especially negative side of the abovementioned technologies is the use of coagulants containing aluminum. On the one hand, this final introduction of many types of contaminants into the initial water is a necessary stage of treatment. On the other hand, it introduces a new, very dangerous contamination of drinking water with residual aluminum compounds. It was known for a long time that aluminum ions contained in drinking water are exceptionally toxic and affect human health. Several publications deal with this research. This is why the World Health Organization from year to year toughens the requirements regarding the concentration of residual aluminum in drinking water.

Based on these two important prerequisites, namely, the presence in drinking water of organochlorine compounds and aluminum, I allow myself to discuss drinking water not as tap water but as technogenic water. Never before has mankind consumed water for drinking purposes which contained very toxic organochlorine compounds and also aluminum ions, which are byproducts of the modern water treatment technology.

Table 1

Chemical substance and its formula		Oxidizing potential, eV
Chlorine	Cl_2	1.36
Chlorine dioxide	ClO_2	1.57
Hydrogen peroxide	H_2O_2	1.78
Ozone	O_3	2.07
Atomic oxygen	O	2.42
Hydroxyl radical	$HO^\bullet$	2.80

Contaminations of the initial water reached such a level that water treatment facilities built in compliance with the effective world standards already are not capable of preventing the ingress of substances to drinking water. In this regard, their joint effect became a real threat to human health [14].

All this results in the necessity of a search for new alternative water treatment technologies to obtain safe water. Here, first and foremost, one should pay attention to natural, ecologically safe oxidants, which could be used in advanced technologies for obtaining high-quality drinking water from the severely fouled sources.

In the last century, for the first time, Russian scientists proposed a fundamentally new approach in water treatment technology—the use of ozone instead of chlorine. The world first ozonizer was developed in Lomonosov Moscow State University, and the first ozonation station for water treatment was built and commissioned in St. Petersburg before World War I. Since then, many years passed before the world community started to treat this technology with due attention.

Below are specified the potential oxidants used today in water treatment, which are the most promising for creating new technologies.

The analysis of the cited data is evidence of the fact that the maximum reactivity is possessed by a hydroxyl radical, which is capable of oxidizing any organic compound into carbon dioxide and water. It is formed in interaction of the ozone with water or hydrogen peroxide with water by the following mechanism:

$$\begin{gathered}
O_3 + H_2O \longrightarrow H_2O_2 + O_2 \\
H_2O \xrightarrow{h\nu} HO^\bullet + HO^\bullet \\
O_3 + HO^\bullet \longrightarrow HO_2^\bullet + O_2 \\
O_3 + HO_2^\bullet \longrightarrow HO^\bullet + 2O_2 \\
O_3 + H_2O_2 \xrightarrow{\text{Very slowly}} HO_2^\bullet + O_2 + HO^\bullet \\
O_3 + HO_2^- \xrightarrow{\text{Quickly}} HO^\bullet + O_2^{\bullet-} + O_2 \\
O_3 + H_2O_2 \longrightarrow HO_3^\bullet + O_2^{\bullet-} + H^+
\end{gathered} \tag{1}$$

In aqueous alkaline solutions ozone is decomposed with the formation of $O_3^{\bullet-}$ according to the following reaction:

$$O_3 + HO^- \longrightarrow O_3^{\bullet-} + OH^\bullet \tag{2}$$

Then the process follows the schematic with separation of the anion radical of atomic oxygen $O_2^{\bullet-}$ superoxide anion radical $O_2^{\bullet-}$, and then molecular oxygen:

$$\begin{gathered} HO^{\bullet} + OH^{-} \longrightarrow O^{\bullet-} + H_2O \\ 2O^{\bullet-} + H_2O \longrightarrow O + 2OH^{-} \\ O^{\bullet-} + O \longrightarrow O_2^{\bullet-} \\ 2O_2^{\bullet-} + H_2O \longrightarrow HO_2^{\bullet-} + OH^{-} + O_2 \end{gathered} \tag{3}$$

Acid conjugate to anion radical $O_2^{\bullet-}$ that is, radical $HO_2^{\bullet-}$ is a weaker donor of electrons than $O_2^{\bullet-}$, while in the system as following:

$$O_3^{\bullet-} = O_2 + O^{\bullet-} \tag{4}$$

The most active particle is the anion radical of atomic oxygen. Therefore, many reactions of $O_3^{\bullet-}$ are actually reactions of $O^{\bullet-}$. In an aqueous solution, radicals $O_3^{\bullet-}$, $O_2^{\bullet-}$, and $O^{\bullet-}$ are also formed in photolysis or γ-radiolysis.

According to reactivity the active particles may be arranged in the following series:

$$HO^{\bullet} > O_2^{\bullet-} > O_3^{\bullet-} > O^{-} > HO_2^{\bullet} \tag{5}$$

It has been found that impurities of hydrogen peroxide produce a rather strong catalytic effect on ozone decomposition. Schematically it may be displayed as the following:

$$\begin{gathered} HO_3^{\bullet} > HO^{\bullet} + O_2 \\ O_3 + HO_2^{\bullet} > HO^{\bullet} + 2O_2 \\ O_3 + O_2^{\bullet-} > O_3^{\bullet-} + O_2 \\ O_3^{\bullet-} + H_2O > HO^{\bullet} + HO^{-} + O_2 \end{gathered} \tag{6}$$

The results of our research confirmed that the identified processes are substantially accelerated in the presence of catalysts (both homogenous and heterogeneous) and under ultraviolet radiation.

It is exactly these results that were used for creating fundamentally new water treatment technologies for any types of pollutants in combination with a set of physical-chemical and biological methods. The research of the kinetics and the mechanism of all processes taking place in aqueous systems provided us with the possibility to develop not only new complex technologies, but new equipment for water treatment. These methods may help obtain high quality drinking water from effectively any source of drinking water supply as far as pollution is concerned. They have an exceptionally great significance for solving the issue of water disinfection from any microbiological and chemical source of pollution.

We offer three ways to solve these problems in the selection of the appropriate parameters—concentration, temperature, pH environment, and other factors.

The first is a simple water treatment with ozone or hydrogen peroxide.

The second is photooxidative disinfection:

$$\begin{gathered} O_3 + H_2O \xrightarrow{h\nu} \\ H_2O_2 + H_2O \xrightarrow{h\nu} \\ O_3 + H_2O_2 + H_2O \xrightarrow{h\nu} \end{gathered} \tag{7}$$

The third is the combinated effect of three factors simultaneously:

(i) photocatalytic disinfection with ozone

$$O_3 + H_2O \xrightarrow{h\nu+\text{cat}} \tag{8}$$

(ii) photocatalytic disinfection with hydrogen peroxide:

$$H_2O_2 + H_2O \xrightarrow{h\nu+\text{cat}} \tag{9}$$

(iii) photocatalytic disinfection using the combined effects of ozone and hydrogen peroxide:

$$O_3 + H_2O_2 + H_2O \xrightarrow{h\nu+\text{cat.}} \tag{10}$$

(iv) photocatalytic disinfection with chlorine:

$$Cl_2 + H_2O \xrightarrow{h\nu+\text{cat.}} \tag{11}$$

To date, we are unaware of more efficient and environmentally friendly methods of water treatment.

3. Water and Human Health

The wide-scale use of chlorine in the technology for centralized drinking water supply stations is determined by the following three main reasons. The use of chlorine ensures:

(i) primary decontamination of raw water;

(ii) substantial improvement of the coagulation process whereby phyto- and zooplankton and many organic and inorganic substances are removed from water;

(iii) prevention of the biological fouling of treatment facility tanks, filtering media, water system networks and equipment.

However, as was indicated above, water treatment with chlorine is accompanied by the formation of a whole range of highly toxic halogen-containing organic compounds such as chlorinated methanes, phenols, aldehydes, ketones, acids and especially hazardous polychlorinated biphenyls up to dioxins—the most toxic matter known on earth. Many years of medical-biological research demonstrated that the long-term use of such drinking water results in an emergence of neurotoxins, cardiovascular diseases, and oncological diseases of liver, kidneys, and the hematopoietic system of human and produces mutagenic effects. It is these compounds that lead to the development of impotence. Therefore, the technology of water ozonation has been used increasingly in water treatment systems all over the world. Ozone as

an alternative reagent simultaneously plays both the role of a disinfectant and an oxidant. In addition, as was noted above, it possesses a higher oxidizing potential, especially the products of its interaction with water. Therefore, the rate of its interaction with all classes of organic compounds is very high. It decolorizes water very well, eliminates fetid smells and odors, removes iron and manganese, suppresses the growth of algae, and so forth. At the same time, one should remember that the use of ozone in the technology of water treatment is possible only in conjunction with other physicochemical methods.

3.1. Ecology—The Health of Human. Having addressed all the above problems, the world-wide issue of determining the degree of risk in the ecology-health system becomes a high-priority one [4]. The hygienic standards and regulations for the levels of environmental pollutants effective today are mostly of a declarative nature. In each specific country, in every region of the world, one needs to assess the priorities of pollutants by the risk levels to human health.

As sources of the risk I would separate four factors playing the most important part in the life of human:

(1) drinking water,

(2) air,

(3) soil,

(4) foods.

It is necessary to carry out a complex monitoring of all environmental aspects. Why is monitoring needed? First of all, for finding priority pollutants in each specific region that produces maximum negative impact on human health. Certainly, one may follow the path of eliminating all types of pollutions, but this requires fantastically large financial costs. The most expedient formula of the ecological policy in every country should be the following: minimum costs → maximum results, starting from that of the highest priority, the most dangerous pollutants to human health.

One should isolate such main priorities of risk levels:

(i) chemical pollutants,

(ii) bacterial pollutants,

(iii) radioactive and isotopic pollutants,

(iv) mutagenic pollutants.

One should not forget that complex pollution of the environment with different classes of toxic substances very often results in synergism of their effects, when each toxicant's individual effect is much weaker than a blend of different toxicants. The most glaring among the known examples of the synergetic effect is a joint presence of radioactive matter and asbestos, which strengthen the negative effect of each other sixfolds.

As risk indicators let us point out the following five factors whose presence may help unambiguously assess the state of the environment:

(i) genetic violations,

(ii) disease incidence,

(iii) birth rate,

(iv) death rate,

(v) average longevity.

3.2. Bottled Water: Issue of Disinfection and Preservation. Over the last two decades, the technology of water bottling and its sale through a wide network of shops has become very popular [14, 15]. There are just a few who would think about the enormous scientific and technical issues of preserving the quality of such waters. First of all, the water being subjected to bottling should be immaculate in terms of chemical, biological, and organoleptic indicators and in addition should preserve its qualities in a closed state.

We talked about the issue of water disinfection above, but the issue of its preservation requires a more detailed consideration. Carbon dioxide is the most common preservative, which diluting in water, forms carbonic acid. The taste of such acid water is experienced by everybody who drank aerated water in their lifetime. This water is used for extreme situations of quenching one's thirst rather than for its systematic consumption.

The other effective reagent preserving water is silver or, to be more accurate, silver ions. Since ancient times, the technology of water storage in silverware has been known. Such water can be drunk without worry since the concentration of silver ions is meaningless, but the disinfection process is rather lengthy. It can be amplified a thousand times using the electrochemical technology of silvering water. However, the excessive silver concentration is dangerous. Over time, silver ions are adsorbed on the walls of the vessel and rather quickly lose their disinfecting properties. Under these conditions, secondary bacterial contamination is possible.

Unscrupulous companies may use as preservatives special chemical substances whose functional properties have effects similar to those of antibiotics, which suppress or destroy microorganisms. These substances present enormous hazard for human health. The consumption of such water by drinking leads to the sterilization of the digestive tract causing a known disease—dysbacteriosis.

The chemical nature of the containers used is a very serious issue in the process of water bottling. There are a sufficiently large number of investigations, whose results are an evidence of the toxicity of polymer containers. The safest containers are glassware, glass containers, and enameled and ceramic ware.

4. "Green" Chemistry

The contemporary world early in the 20th century found itself on the verge of the global ecological crisis, which threatens the very existence of civilization. Industrial production still remains high-waste. That is why a new science has appeared and continues to develop effectively. This is the science of ecological economy, which tries to unite social, economic, and ecological systems. Ecological economy should take into account ecological costs when assessing the economic performance of production. A modern economy should develop with the account of ecological factor.

It is quite clear that the correction of the current unfavorable situation does not look to be an easy or quickly resolved issue. This results from the impossibility of allocating sufficient investments for the solution of the ecological issues.

In the world science, this area of science and technical investigations has been referred to as "green chemistry".

When we talk about drinking water quality we, first of all, should think and care about the quality of drinking water supply sources, and this is almost the entire water basin of the planet. The solution to the existing issue of protecting the whole ecosystem from the products of mankind's life activity lies in the quest for fundamentally new technical solutions. These solutions aim not only to overcome the consequences, but should prevent the causes, leading to the unfavorable ecological aftermath.

The most widely known water contamination, referred to as water "color," is caused by blue-green algae—cyanobacteria. An important adverse influence on the water basin is related to their ability to synthesize biologically active substances possessing very high toxicity. The ingress to water of such biogenic elements as phosphorus, nitrogen, potassium, sulfur, and also organic matter from industrial, domestic, rainfall, and waste waters of the agricultural production created the prerequisites for intensive development of algae of various systematic groups, which results in the formation of water "color".

The facts of the formation of toxins by algae have been known for a rather long time, as early as the 1960s, while the systematic research of the causes of this phenomenon and factors increasing the toxicity started about 20 years ago. The most serious attention at present has been drawn to the toxicant microcystine, produced by cosmopolite cyanobacteria, causing water "blooming" in water bodies of virtually all countries of the world. In terms of biological activity, toxins of cyanobacteria surpass by many times such known substances as strychnine, curare, a range of fungi toxins, and potassium cyanide. They exceed the toxicity of potassium cyanide by as much as 50–1000 times. Such a strong poison as curare exceeds them by least 10 times. Hence, it is quite obvious that such water presents a serious threat to the life of fish, birds, and humans. Even swimming in "blooming" water pools is dangerous for human health, not to mention the use of this water as a source of drinking water supply.

All these facts indicate the necessity of forming the Global World Program for the Protection of the Planet's Water Basin against Pollution.

5. The Biosphere and Civilization—The Issue of Compatibility

The biosphere in its classical state no longer exists. We are witnessing the apocalypse of the biosphere, which started in the middle of the 20th century. Transforming the environment—the biosphere, whose part is human himself—society underestimated the fact that creating the technogenic environment by its existence violates the basic laws of the biosphere, the laws of the universe.

Nowadays we live in the transition period of the coexistence of two worlds—the biosphere and the noosphere. There is no return to the biosphere. Man as a creature of the biosphere origin should find new ways for his survival and development. The gene pool of the biosphere has started to intensively rearrange itself—the turbulent process of evolution has begun, which has given birth to ecological changes on a global scale. Mass extinction of the existing species and emergence of new ones are observed across the board. Especially intensive is the evolution of infections. This is evidenced by a widely known fact of the adaptation of pathogenic microflora to antibiotics. This is an illustrative manifestation of mutagenesis—the emergence of a new, earlier absent quality—resistance to antibiotics. Complex genomes are created by nature during millions of years, while in modern laboratories they are created within a year. Man has designed a new artificial habitat, the TechnoSphere, kept safe from all biological processes of the biosphere, without connection with which he simply cannot exist.

The issues of nuclear energy and its impact on the environment bear a complex nature. Since the radioactivity phenomena have been discovered, the irreversible processes of dramatic increase of background radiation all over the planet have been seen [16].

The intensive development of the nuclear industry led to the emergence of a considerable number of objects presenting potential radiation danger: nuclear power plants with reactors of various types, chemical mining plants, and plants for processing nuclear fuel. The radionuclide compositions of pollutants emitted to the environment during the operation and also in emergency situations substantially differ, which makes the use of a single flow chart of purification impossible in all mentioned cases.

Among the numerous aspects of protecting the water basin from technogenic pollutants, one of the most important aspects is achieving the effective purification of various types of pollutants, including radioactive pollutants. Achievement of this task is hampered by the general worsening of the ecological situation, accompanied by the appearance in the waters of an ever larger amount of various toxicants of organic and inorganic nature. Together with the necessity of development and the employment of more complex and sophisticated technologies to achieve purification levels to meet the existing standards, this begs the question of the applicable range of the standards themselves. Here the ever increasing restraint, which currently manifests itself despite the sufficient theoretical and practical substantiation at the moment of adoption, is determined by insufficient accounting of the possibility for aggravation of the adverse influence of toxicants on live organism in their synergetic effect. The synergetic effect of pollutants of various types and radionuclides seems to be one of the most dangerous for human health.

The adverse effect of radioactive elements of the environment is of a complex nature. Despite the fact that it is well studied, the issue of the processing and burial of radioactive waste, which today like "a nuclear gene" are either on the sea bottom or in the mines under earth and are waiting for their time, is still outstanding.

There is one more aspect of this issue which has not been sufficiently studied yet. I mean the issue of the impact of nonradioactive isotopes on the development of biological objects

and, first of all, hydrogen isotopes, in particular, deuterium. The impact of the isotopic composition of substances on kinetic characteristics of numerous reactions has been known for a long time.

It turns out that deuterium strongly affects the chemical parameters of chemical and biological processes since it forms a stronger bond with oxygen in a water molecule, unlike light hydrogen—protium. It is also known that an increased concentration of deuterium in drinking water results in acceleration of the organism aging process. Deuterium manifests toxic properties with respect to living organisms [17].

Nowadays, one of the most serious issues is increased levels of background radioactivity and an increase of the concentration of heavy isotopes with respect to their light prototypes. First of all, it concerns vitally important elements such as hydrogen, oxygen, and carbon, which are a basis of protein life in our biosphere and affect the mechanism of biological evolution.

Thus, ecology is a science studied, strictly speaking, the state of the biosphere, where human is its indispensable part. However, today, when it is quite obvious that the biosphere is being transformed, in an increasing degree, to the noosphere transforming into the TechnoSphere, one cannot help taking into consideration that the world has really changed. It is necessary to have a clear notion of the place of human in a quickly changing world. Ecology transforms into a new geological phenomenon, into a new branch of science investigating the interaction of three globally coexisting constituent components of the universe: biosphere, noosphere, and TechnoSphere. The decisive role in their interaction is played by human. The future of our civilization is determined by the level of the awareness of the changes that have taken place in the environment.

6. A New Approach to the "Environment-Human Health" Problem

Nature built up self renewing systems in the process of evolution supporting life activity of all live bodies. Gastrointestinal tract (GI) is the most impressive system of people and animals. Actually this is a flow-through bioreactor inhabited by many microorganisms. Total number of microorganisms exceeds number of macroorganism's own cells and makes up about 10^{14}–10^{15} cells [18]. Total weight of microorganisms amounts to 3-4 kg. Intestinal tract of healthy people contains more than 500 types of microorganisms. In the different gastrointestinal tract segments, number of bacteria is different and correlate with the state of digestive system (Table 2).

Set of genes being a part of bacterial metagenome exceeds approximately 100 times set of genes of human organism [20]. Number of bacteria differs in the various segments of gastrointestinal tract. Number of microorganisms in the mouth cavity in acid environment conditions is little and makes up from 0 to 10^3 CGU (colonies of generatrices units) as per one milliliter of environment. In the lower sections of gastrointestinal tract number of microorganisms is much higher. The main factors determining reproduction of bacteria in the environment in the upper sections of gastrointestinal tract is a fast movement of food, secretion of bile and pancreatic juice. Environmental conditions in the colon are diametrically opposite, that is why number of bacteria in this section of gastrointestinal tract amounts to 10 CGU per one milliliter. *Bifidobacteria* and *Bacteroids* dominate among several hundreds of bacteria in the intestinal tract which share constitutes 25 and 30%, correspondingly, with regard to the total number of anaerobic bacteria. Intestinal tract of a child contains no bacteria before his birth. Fast innidiation of child's intestine with bacteria which are a part of the composition of intestinal and vaginal flora of the mother takes place at the moment of birth. As a consequence it is formed complicated community of microorganisms consisting of *Bifidobacteria*, *Lactobacteria*, *Enterobacteria*, *Clostridia*, and Gram-positive cocci.

Then composition of microbial population is subject to changes due to the influence of several factors of the environment, the most important of which is child's feeding. As early as 1900 Tissier proved that the main components of intestine microflora of the breastfed children are *Bifidobacteria*. Such bifidodominant microflora exercises protective functions and is instrumental in maturation of the mechanisms of child's immune response. On the other hand, artificially fed children have much less *Bifidobacteria* in the colon, and species' composition of intestine microflora is less diversified.

Composition of intestine microflora is fairly individual and is formed from the first days of child's life, nearing indices of an adult person by the end of the 1st-2nd year of life, and undergoes some changes at the elderly age (Table 3).

Numerous research works revealed that there is a connection between composition of intestine microflora and children's immune resistance [21–24]. Distribution of microorganisms in the gastrointestinal tract has quite exact laws. Most microorganisms (about 90%) are presented constantly in one or another section of gastrointestinal tract and represent the main (resistant) microflora, facultative (supernumerary, accompanying) microflora (makes up 10%), and 0.1–0.02% is accounted for accidental (transit or residual) microorganisms. Thus, the basic microflora in the colon is represented by anaerobic microorganisms, while aerobic bacteria make up an accompanying microflora. *Staphylococci*, *Clostridium, Proteus*, and Fungi belong in the colon to the residual microflora (Tables 2 and 3). Besides, there are about 10 intestine viruses and certain representatives of the nonpathogenic protozoa in the intestine. The quantity of strict and facultative anaerobes is always one order more than aerobes in the colon, and obligate anaerobes are immediately adhesived on epithelial cells, facultative anaerobes are located higher, followed by aerobic microorganisms. Thus, anaerobic bacteria (mainly *Bifidobacteria* and *Bacteroides*), which on the whole constitute about 60% of the total number of anaerobic bacteria, represent the most permanent and numerous group of intestine microflora carrying out the basic functions.

The whole complex of microorganisms and macroorganisms creates specific symbiosis. Recently some microbiologists declared a man and his microbes as one whole symbiotic superman. Progress in the development of methods of molecular biology thrust the scientists forward to the new level of understanding of processes of symbiosis of a man

Table 2: Composition of the intestinal organisms of the human [19].

Types of bacteria	Average concentration of microorganisms (as per 1 mL or 1 g)			
	Intestine	Small intestine	Twisted intestine	Colon
Total number	$0–10^3$	$0–10^5$	$10^2–10^7$	$10^{10}–10^{12}$
Anaerobes				
Bacteroides	Seldom	$0–10^3$	$10^3–10^7$	$10^{10}–10^{12}$
Bifidobacteria	Seldom	$0–10^4$	$10–10^9$	$10^8–10^{12}$
Enterococci	Seldom	$0–10^3$	$10^2–10^6$	$10^{10}–10^{12}$
Clostridia	Seldom	Seldom	$10^2–10^6$	$10^6–10^3$
Eubacteria	Seldom	Seldom	Seldom	$10^9–10^{12}$
Aerobes				
Enterobacteria	$0–10^2$	$0–10^3$	$10^2–10^7$	$10^4–10^{10}$
Streptococci	$0–10^2$	$0–10^4$	$10^2–10^6$	$10^5–10^{10}$
Staphylococci	$0–10^2$	$0–10^3$	$10^2–10^5$	$10^4–10^9$
Lactobacteria	$0–10^2$	$0–10^4$	$10^2–10^5$	$10^4–10^{10}$
Fungi	$0–10^2$	$0–10^2$	$10^2–10^4$	$10^4–10^6$

Table 3: Composition of intestine microflora in various age groups.

Name of the group of microorganisms	Children of the first year of life	Adult people	People at the elderly age
Bifidobacteria	$10^{10}–10^{11}$	$10^9–10^{10}$	$10^9–10^{10}$
Lactobacteria	$10^6–10^7$	$10^7–10^8$	$10^6–10^7$
Bacteroides	$10^7–10^9$	$10^9–10^{10}$	$10^{10}–10^{11}$
Fusobacteria	$<10^6$	$10^8–10^9$	$10^8–10^9$
Veillonella	$<10^5$	$10^5–10^6$	$10^5–10^6$
Eubacteria	$10^6–10^7$	$10^9–10^{10}$	$10^9–10^{10}$
Peptostreptococcus	$<10^5$	$10^9–10^{10}$	10^{10}
Clostridium (lecitinpositive)	$<10^5$	$<10^5$	$<10^6$
Clostridium (lecitinnegative)	$<10^7$	$10^7–10^8$	$10^8–10^9$
Enterobacteria: *Escherichia coli* (with typical properties)	$10^7–10^8$	$10^7–10^8$	$10^7–10^8$
	$<10^4$	$<10^7$	$<10^7$
Enterococci	$10^6–10^7$	$10^7–10^8$	$10^6–10^7$
Staphylococci: *Staphylococci epidermidis; Staphylococci aureus*	$<10^5$	$<10^4$	$<10^3$
	$<10^1$	$<10^2$	$<10^2$
Aerobic bacteria	$<10^3$	$<10^5$	$<10^5$
Fungi pertaining to *Candida* genus	$<10^3$	$<10^4$	$<10^4$

and his microflora. There seemed that processes of symbiosis of a man and his microflora were well studied and their further study will not give any specific surprise. However, quick growth of the speed with simultaneous fall of cost of methods of sequence analysis for deoxyribonucleic acid (DNA) (determining its nucleotide sequence), simultaneous growth of PC capacity, and development of Internet made it possible to analyze information about large areas of genomes. New (population) approach appeared in genetics of microorganisms after decoding of chromosomes of hundreds of types of certain bacteria: analysis of genes of all bacteria inhabiting a certain natural area at once. The population of "human bioreactor" is of course one of the most important for the investigation of microbial population. The first study made to look in a new way at the intestinal microbiota was published in 1999 by the group of scientists from the National Institute for Agronomic Research (France) and University of Reading (Great Britain). The authors decided to apply method of sequence analysis of genes of 16S RNA for the investigation of microbial population of intestines (16S RNA is certificate of identity of bacteria). Since Pasteur times the first and obligatory stage of identification of microorganisms was their cultivation in culture media. But a great number of important (useful and pathogenic) microbes do not grow in any media. Due to the development of bioinformatics and appearance of modern methods of molecular biology, it has become possible to study before inaccessible and uncultivated bacteria and to begin to put in order ultraentangled classification of already known prokaryotes [20].

It was established using new methods that only 24% of obtained sequences of 16S RNA belonged to the already known microorganisms. Three fourths of microflora in the intestine of each person avoided attention of the researchers armed by the methods of classic microbiology for more than

one-hundred years! The scientists just could not select conditions for cultivation of these bacteria because the most capricious inhabitants of intestine refused to grow in traditional microbiological media. Just the same situation is observed in the chlorinated water of the water supply system. For the time being it was established by means of molecular method that in the microbiota of an adult person are presented 10 out of 70 large bacterial taxons. About 90% of our microbes belong to Firmicutes type (to them belong, e.g., known by everybody as Lactobacteria responsible for milk souring) and Bacteroidetes—strict anaerobes (organisms able to live only in absence of oxygen). The last are often used as indicators of contamination of natural waters by sewage runoff. Remaining populations (10%) are divided between taxa Proteobacteria (among others intestinal bacteria (*Escherichia coli*) belong to them), Actinobacteria (from one of actinomycetes types was obtained antibiotic streptomycin), *Fusobacteria* (usual inhabitants of mouth cavity and are frequent cause of parodontosis), Verrucomicrobia (not long ago a type of these microbes was found in geothermal spring feeding methane which is more than enough in intestine due to the vital functions of other microorganisms), Cyanobacteria (they are often called "blue-green algae"), Spirochaetes, Synergistes, and VadinBE97.

Feeding of microorganisms inhabiting intestine are provided at the cost of so-called nutrients coming from superposed sections of gastrointestinal tract, which are not digested with their own enzymatic systems and are not soaked in the thin intestine. Proteins and carbohydrates not soaked in the thin intestine are exposed to deeper bacterial decomposition in the blind intestinal—mainly by intestinal bacteria and anaerobic microorganisms. These agents are needed to provide energy and flexible requirements of microorganisms. Ability to use nutrients for its vital functions depends on the enzymatic systems of various bacteria. According to this, the following types of bacteria are conditionally marked out:

(i) mostly with saccharolytic activities, carbohydrates are basic energy substrates which is characteristic for the saprophyte flora;

(ii) mostly with proteolytic activities which are used with proteins for energy goals (representatives of pathogenic and conditionally pathogenic flora);

(iii) bacteria with mixed activities.

Accordingly, predominance in food of one or another nutrient and violation of their digestion will stimulate growth of various microorganisms [25, 26]. Carbohydrate nutrients are especially needed for the normal vital functions of intestinal microflora. They were considered as "ballast", but later it was found out their importance for the intestinal microflora and people's health on the whole. According to the modern definition, prebiotics are partly or fully indigestible food which selectively stimulates growth and metabolism of one or several groups of microorganisms, providing normal composition of microbiocenosis [27–30].

Microflora of the gastrointestinal tract performs the following functions [31–35].

(i) Morphokinetic and energy effects (energy supply of epithelium, regulation of intestinal peristalsis, organism's thermal supporting, regulation of the differentiation, and regeneration of epithelial fabrics).

(ii) Forming of protective barrier of mucous membrane of intestine, suppression of growth of pathogenic microflora.

(iii) Immunogenic role (stimulation of immune system, stimulation of tissue immunity including generation of immunoglobulins).

(iv) Modulation of functions of cytochromes P450 in the liver and generation of P450-like cytochromes.

(v) Detoxication of toxic substances and compounds.

(vi) Production of various biologically active compounds, promotion of certain medicaments.

(vii) Mutagenic/antimutagenic activity (growth of resistance of increase of epithelial cells to the mutagens (carcinogens), destruction of mutagens).

(viii) Regulation of cavities' gas composition.

(ix) Regulation of behavioral reaction.

(x) Regulation of replication and gene expression of prokaryotic and eukaryotic cells.

(xi) Regulation of the programmed death of eukaryotic cells (apoptosis).

(xii) Depository of microbial genetic material.

(xiii) Participation in etiopathogenesis of the diseases.

(xiv) Participation in water-salt metabolism, sustention of organism's ionic homeostasis.

(xv) Forming immunological tolerance to the food and microbial antigens.

(xvi) Participation in colonization resistance.

(xvii) Providing homeostasis of symbiotic relations of prokaryotic and eukaryotic cells.

(xviii) Participation in the metabolic activity: metabolism of proteins, lipo (delivery of lipogenesis substrates), and carbohydrates (delivery of gluconeogenesis substrates) and regulation of bile acids, steroids, and other macromolecules.

Thus, gastrointestinal tract bioreactor is represented with sequencing circuit of microorganisms' specific communities each of which performs certain functions and transfers to the following community substances required for its life activity and functioning. Gastrointestinal tract bioreactor is now the most advanced advice providing complete destruction of the wide range of organic and inorganic matters.

Aerotanks and digestors are used in the practice of water treatment where aerobic and aerobic processes take place. However, each reactor works individually and, what is extremely important, a limited number of microorganisms participate in their work.

Creation of communities' chain of microorganisms where conditions necessary for their normal life activity (gastrointestinal tract type) will be will allow in the visible future

to develop an universal bioreactor for destruction of the wide spectrum of organic and inorganic matters in the waste waters.

7. Tap Water Is the Medium for Multiresistant Microorganisms—Mutants

As it is known, the main task of chlorine treatment of the drinking water is water sterilization against pathogenic microorganisms. However, this task is not fulfilled to the full extent because of high adaptive capacities of single-celled animals (protozoa).

Scientists of the Swiss Federal Institute for water supply problems found out with the new method of microbiologic control based on flow cytometry that the content of microorganisms 100–1000 times higher in the sanitarily pure drinking water than the standard method. What is happening with the chlorinated water in the obsolete water distribution systems of the centralized water supply of the people? Under these at-first-sight aseptic conditions, the conglomerate of various microorganisms multiresistant to chlorine and its compounds is developed. One-celled organisms, having large adaptive flexibility, completely adapt to the habitation in the tap water. They are developing and propagating themselves in the water and educe their metabolic by-products having toxicant properties into aqueous media. Thus, in the water supply lines of the water distribution systems is forming their own "microcosmos" of the communities of multiresistant microorganisms, including pathogenic ones. They die in the dechlorinated aqueous media.

Emergence of adaptation by combinative way sometimes results in the new mutations which being included into system of genotype changes a phenotype. This path is called the adaptation of a combinative. The use of sublethal concentrations of disinfectants in water treatment processes to the emergence of strains of microorganisms, resistant to chlorine and chlorine compounds.

Adaptation emerging in the combinatorial way sometimes leads to the new mutation which, being included in the genotype system, changes the phenotype. Application of sublethal concentrations of disinfecting agents used during drinking-water treatment contributes to the appearance of microorganism strains, resistant to chlorine and its compounds. This phenomenon is proved by the studies of Mokiyenko and colleagues [36, 37], who considered very important medical problem "drinking water—water-caused infections." The authors concern themselves with the nature of bacteria resistance to the biocides effect, including chlorine and its compounds. In this connection they take notice of deterioration of the situation with infectious diseases in Ukraine on account of the drinking water of poor quality [38]; they make a hypothesis of chlorine resistance of bacteria which rests on very complicated process. It consists of two stages: information-spatial interaction of the receptive body and a substrate [39, 40].

According to this hypothesis the problem of bacteria's adaptive multiresistance to chlorine is closely connected with hormesis. This phenomenon is determined with two-phase effect of chemical matters directed to the water disinfection. Small doses produce stimulating effect, and large doses result in the inhibition of biological processes. hormesis connections "dose-effect" are observed in the biota representatives of all levels of organization starting from viruses and bacteria and ending with endotherms and human beings within the wide range of doses [41, 42].

In the papers [43, 44], investigating dynamics of microbial cenosis in the bottled slightly carbonated and strongly carbonated mineral waters, the scientists come to conclusion as to inadequacy of the carbonation methods in question. It was noted substantial increase of saprophyte microorganisms even after the first month of storage of these waters. Saturation, according to the authors, does not guarantee sanitarian safety of the waters. The data is provided which testifies about adaptation of microorganisms to the high concentrations of carbon dioxide.

The mechanism of adaptation of microorganisms to the aggressive environment is based on the process of adaptation development. Process of adaptation development, as any other process, is inconsistent internally. It consists of interaction of two counter-parties: of partial disorganization of already fully formed norm of organism's and species' reaction and its next new organization [45, 46].

In the process of adaptation of microorganisms, takes place a change in the structure and physiological processes under the influence of the environmental factor. Degree of adaptation of microorganisms to the new conditions depends on resistance of this culture to the intensity of impact of external environmental factors. Some species of microorganisms, for example, acid-alcohol- alkali-resistant, diphtheritic group and fungi, are changeable somewhat less than typhous group, round bacteria, and anaerobes. The last adapt easier to the disturbing factors of the environment. Adaptation of the microorganisms is expressed mostly in the attitude to the temperature and availability of oxygen. The better and more perfect adaptation is realized, the slowly and gradually increases impact of the new factors [47].

New conditions can make microorganisms to become less demanding to the environment, limit their physiological requirements or sporulate. Thus, the morphology of microbical cell and its structure sometimes is changes.

Mutations lead to the emergence of bacteria strains with new properties. Mutagenic effect takes place often in case of encountering harmful chemical compounds in the environment where microorganisms usually reproduce themselves; a part of them die and the most stable survive and produce multiresistant strains, sometimes even towards antibiotics and immune serum.

The primary effect of mutagenic agent does not necessary lead to the true mutation. A new phenotype shows up only when changed gene starts to function. There is a possibility to accumulate and to highlight mutants with various defects: with violation of processes of transport or usage of the substrate, with the defects of intermediate metabolism, hypersensirivity to the temperature, and so on [48].

Theoretically, mutations provoked by radiations, chemical matters or other factors could lead to the extinction of bacterial population; however, there are biochemical mechanisms in any living cell that are able to fully or partially restore

parent structure of DNA. Complex of ferments catalyzing reactions of corrections of DNA damage make up systems of reparation. They differ fundamentally as to their biochemical mechanism of genome reconstruction. There are three known main mechanisms of correction of DNA defects: immediate reversion from DNA damage to the initial structure, excision (falling out) of damaged initial structure with the further reconstruction, and activation of mechanisms providing immunity to damage.

Thus, there is a high-scale possibility of formation in the tap water of multiresistant populations to the chloride and its compounds. It is largely due to the fact that prokaryotes are the most ancient living organisms on the Earth. They successfully existed during various eras owing to their unique adaptability to the drastic change of physical-chemical factors of media. They are widely presented in these latter days which are described dangerously increasing anthropogenic pollution of the environment.

Microorganisms adapt easily to the aggressive media because they have high mutagenic properties. They are agamic and are reproducing themselves by cell division that is also a positive factor for their adaptive possibilities. Thus, if in the changed media conditions survives at least one cell-mutant, in case of intensive division it forms a new population of microorganisms with changed phenotypic characteristics. Animal unit in such population of microorganisms differ from the natural forms by the appearance, structure of colonies, and physiological characteristics.

An important factor influencing the adaptation of *microbiotas* to biocides as well as to chloride is hormesis. It allows microorganisms to stimulate its biological activity on exposure of small doses of decontaminant. Such "training" increases immunity of the cells to the higher doses and increases number of mutations in the population holding out hope to the survival of microbiota in the aggressive media.

It is necessary to change from time to time decontaminant substances to make the process of adaptation of microorganisms to the tap water more difficult or impossible. For this purpose, it is necessary to use a set of biocides differing as to chemical composition and mechanism of action. But realization of such technological process of decontamination of drinking water at the water treatment works of the centralized water supply is not a trivial task.

8. Toxic Influence of Bacteria on Test Organisms in the Drinking Water

The influence of *Escherichia coli* bacteria and products of their metabolism on the toxic level of the drinking water was not studied before. As a result of our last research work [49] it was found that the drinking water including bottled water contains *colibacillus*. Standard research as to the usage of *Escherichia coli* bacteria as an index of sanitary-hygienic condition of the water does not include toxic evaluation of the water bacterized with *Escherichia coli*.

It is established that metabolites of *Escherichia coli* bacteria separated in the aqueous media considerably deteriorate its quality, inhibit roots' growth on the plant body, demonstrate chronic toxicity on hydra, and provoke acute toxicity on *Ceriodaphnia*.

The obtained results on the cellular level showed that deviations from control were observed starting from the concentration of microorganisms in the amount of 10^2. Even in case of finding few bacteria, the inflammatory processes affect hematological indices in the leucocytes of fish blood.

The leucocytes play a very important role for the protection of the organism against bacterial and mycotic infections. Growth of neutrocytosis in the blood is a response of the organism to the bacterial and many other infections. Lymphopenia (decrease of the number of lymphocytes) is typical for the initial stage of infectious-toxic process and is related with their migration from the vessels to the tissues (inflammatory tissue).

In the studied samples of the bottled drinking water with different concentrations of bacteria, significant increase of nucleus rate of the fish tissues is observed. Structural and quantitative changes of cell nucleus were observed in case of bacteria concentration equal to *Escherichia coli* 10^2. Changes in the components of cell nucleus which are carriers of genetic information leads to the mutation of cells. This can be a reason for error exclusion of one or another disease and lead to the proliferation of oncologic cells.

According to WHO acting hygienic requirements to the water quality from the centralized drinking water supply systems, total number of *E. coli* in 1 mL of water should not exceed 3 CGU. Our research proved that existence of bacteria *E. coli* in the drinking water is inadmissible.

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