SCIENTIFIC AND METHODICAL APPROACHES TO RISK ANALYSIS IN HYGIENE AND EPIDEMIOLOGY

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FOOD RISKS ANALYSIS AND WATER SAFETY

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Water in its native form or as a component of various food products is the greatest and most frequently consumed part of daily nutrition. Scientifically justified criteria of its quality include epidemiologic and radiation safety, chemical harmlessness, and favorable organoleptic (aesthetic) properties. Over recent years in Russia more than 91.5 % population, and more than 96% in cities, have access to drinking water that conforms to all safety requirements. However, about 4–5 % of water samples taken from centralized water supply systems are not safe as per epidemiologic criteria. A drastic growth in chemical contamination of surface drinking water sources is another great concern.

The authors focus on a modified procedure for detecting dextrose-positive bacteria that is, apart from being greatly informative, makes performance of sanitary-epidemiologic analysis much faster (approximately 1 day faster). It is confirmed that microbiologic control over blue pus bacilli occurrence is vital. The authors also show that when an internationally accepted term "mineral water" is divided into "mineral drinking curative water" and "mineral drinking curative and table water" accepted in Russia, it requires adjustment of some legal and regulatory documents and strict definition of parameters that are subject to control. It is recommended to develop regulatory and legal base so that it could promote manufacturing of bottled high quality water, including that for children nutrition.

Overall, the authors show that development of drinking water market as a part of food market in the country requires updating of regulatory and methodical base for control over water quality and safety; improved systems of monitoring over epidemiologic safety based on up-to-date examination procedures and tools; putting health risk assessment methodology into practice in relation to consumption of water with diverse qualitative and quantitative structure.

Key words: *drinking water, microbiological control, epidemiologic safety, legal and regulatory base.*

Water, either in its native form or as a component in a structure of various food products, is the greatest and most frequently consumed part of our daily ration. Scientifically substantiated criteria of its quality include epidemic and radiation safety, absence of chemical hazards, and favorable organoleptic (aesthetic) properties [1–3]. Water is the only natural cleaning fluid on the earth and it is constantly exposed to primarily chemical and biological contamination; this contamination becomes more and more intense thus exceeding any technological possibilities for necessary water purification and its natural ability for self-purifying. Given all that, water supplying organizations more and more frequently find themselves unable to provide population with good quality drinking water. Moreover, our knowledge is constantly enriched with data on new necessary parameters and standards related to quality of water consumed by people and these new data should also be taken into account.

In 2017 133.956 million people living in the RF (91.5% population) were provided with drinking water conforming to all the safety standards[1]. 96.0% people living in urban settlements were provided with drinking water

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[1] On sanitary-epidemiologic welfare of the population in the RF in 2017: The State Report. – M.: The Federal Service for Surveillance over Consumer Rights Protection and Human Well-being, 2018. – 274 p.

conforming to safety standards in 2017; as for people living in rural areas, 78.3% out of them were provided with such water.

In spite of all the achieved success, we have to ascertain that in Russia on average 4–5% samples of water taken from centralized water supply systems don't conform to epidemic safety requirements; it is especially true for the Far East region (more than 6–7% samples). There were high risks that hazardous infectious diseases (cholera, poliomyelitis, typhoid fever, dysentery, infectious hepatitis and others) and parasitic diseases (lambliosis, cryptosporidiosis and other helminthiasis) could spread with water and it substantiated large-scale implementation of various chemical and physical technologies for water purification and disinfection as well as creation of the fastest and the most reliable techniques for indentifying relevant bacterial, virus, and parasitic agents in water.

Experts are also preoccupied with a drastic growth in chemical contamination of surface water objects. There are more than 170 million registered chemicals in the world (Chemical Abstracts Service, Register, USA), and more than 150 thousand of them enter the environment. Annually more than 1,000 new chemical compounds appear in our life, but only 15% of them are examined by toxicologists. As per the WHO data, in 2011 exposure to specific chemicals that occurred in the environment and at workplaces caused 4.9 million death cases all over the world (8.3% from the total deaths) and 86 million years of life lost due to mortality and disability. There are some forecasts that chemicals market will be growing by 3% annually up to 2050.

To disinfect water, chemicals reagents, primarily such strong oxidizers as chlorine and ozone, were applied, and experts revealed their adverse ability to create certain chemical compounds. These compounds were hazardous as they could cause remote mutagenic and carcinogenic effects on human health. For example, it was detected that when aniline-containing water was disinfected with chlorine reagents, 12% compounds that appeared in the process were mutagenic or carcinogenic, and up to 11% compounds that appeared when toluene-containing water was disinfected with ozone had similar properties.

As we have already pointed out, water is the only natural cleaning fluid on the planet; so, it becomes the most massive concentrator of various pollutants as well as a medium where these pollutants undergo chemical and biological transformation [4–6]. Experts all over the world are well aware of health risks that occur when contaminated drinking water is consumed [7–11]

Given all the above mentioned, it is not surprising that hundreds and even thousands of variable chemicals have started to appear in water, especially in surface water objects. In spite of approved hygienic standards fixing maximum permissible concentrations for more than 2,000 chemicals, there are no fixed permissible concentrations for the greatest share of detected compounds [5]. Thus, for example, when water taken from Izhevsk pond and drinking water supplied to people living in Izhevsk was analyzed with chromatography-mass-spectrometry, the analysis results revealed that there were 232 volatile hydrocarbons in original water and there were no hygienic standards for 222 out of them; as for purified water, 103 compounds occurred in it including 94 not regulated by any safety standards (Table 1).

We examined the results of monitoring over quality of drinking water taken from centralized water supply systems in the RF Central Federal District collected in 2006–2011; the results revealed that water didn't conform (temporarily or permanently) to hygienic standards in all 18 regions of the District as per 18 parameters, including the most frequent nonconformity related to concentrations of Fe, Mn, ammonium, nitrite, and nitrate N, B, sulfates, and chlorides in water (Table 2).

On average, 6 parameters that were higher than MPC were detected in the northern regions in the District (but apart from the parameters shown in Table 2, hygienic standards were additionally violated in Moscow as per chloroform; in Moscow region, as per petroleum products, thrichloromethane, tetrachloro- and trichloroethylene). 5–6 parameters didn't conform to hygienic standards in the western regions; 7–8 parameters on average, in the southern regions. Mo concentrations were also higher than MPC in Tambov region. As for the eastern regions in the District, 11–12 parameters of drinking water didn't conform to hygienic standards there. Increased Cr concentrations (apart from the admixtures shown in table 2) were registered in Vladimir region; increased concentrations of As, Cu, Zn, hexachlorocyclohexane, and 2, 4 dichlorophenoxyacetic acid were detected in Yaroslavl region.

Table 1

Results of chromatography-mass-spectrometry analysis of water taken from Izhevsk pond and water supplied to people living in Izhevsk [2]

Chemicals category	Izhevsk pond		Drinking water	
	Overall number	Regulated	Overall number	Regulated
Alkanes	44	0	22	0
Alkylbenzene	29	2	12	2
Cycloalkanes	19	0	12	0
PAH	17	1	5	1
Phthalates	9	2	8	3
Acids and their ethers	33	1	11	0
Spirits, simple ethers	21	0	1	0
Ketones	13	1	3	1
Aldehydes	4	1	1	1
Halogen-containing substances	6	1	6	0
Sulfur-containing substances	9	0	9	0
Other compounds	28	1	19	1
TOTAL	232	10	103	9

Table 2

Results of monitoring over quality of drinking water taken from centralized water supply systems in the RF Central Federal District (2006–2011)

No.		Regions	Number of samples			Parameters exceeding MPC																	
			Tota	Higher than MPC		Fe	Mn	NO_3	$NH_4NH_3(N)$	F	B	NO_2	SO_4	Cl	Mg	Cd	Cl_2	Sr	Pb	Al	H_2S	PO_4	Li
				no	%																		
1	north	Moscow[1)]	20	2	10	+																	
2	north	Moscow region[2)]	42	19	45	+	+	+	+	+	+	+		+				+	+		+		+
3	north	Smolensk	33	7	21	+	+	+	+				+		+			+					
4	north	Tver'	31	5	16	+	+		+	+							+						
5	west	Tula	31	8	26	+	+	+	+				+			+		+	+				
6	west	Orel	28	6	21	+	+	+	+		+		+										
7	west	Bryansk	27	4	15	+		+		+											+		
8	west	Kaluga	20	8	40	+	+	+	+	+	+						+						+
9	west	Kursk	16	2	13	+	+																
10	south	Ryazan	33	11	33	+	+	+	+	+	+	+	+	+		+				+			
11	south	Belgorod	30	4	13	+	+	+				+											
12	south	Tambov[3)]	29	7	24	+	+	+		+					+	+							
13	south	Lipetsk	28	8	29	+	+	+	+	+	+	+			+								
14	south	Voronezh	23	7	30	+	+	+		+	+	+		+									
15	eats	Vladimir[4)]	30	10	33	+	+	+	+	+			+		+					+		+	
16	eats	Yaroslavl[5)]	25	16	64	+	+	+	+		+	+	+	+		+	+			+			
17	eats	Ivanovo	20	11	55	+	+	+	+	+	+	+		+	+				+			+	
18	eats	Kostroma	18	8	44	+	+	+	+	+	+		+	+									
Central Federal District			50	32	64	18	16	15	12	11	9	7	7	6	5	4	3	3	3	3	2	2	2

Chemical pressure on water objects causes substantial health risks not only directly via drinking water consumption but also indirectly via adverse effects produced by variable chemicals on food chains that include exploited water flora, fauna, fish resources, agricultural, vegetative, and animal products. Eventually anything that pollutes the environment one way or another returns to people. We can give some typical examples of such ecological water-food chains when contamination causes serious pathologies, even with fatal outcomes; they are Minamata disease (when methyl mercury migrates from water into water flora and fish and then into a human body) and Itai-Itai disease (when Cd migrates out of water into rice and then into a human body).

As surface water objects are intensely contaminated, and hundreds of chemicals are constantly detected both in these objects and in drinking water taken from communal water supply systems, people tend to switch to bottled water taken from sources that have not yet been contaminated by anthropogenic activities. Bottled drinking water taken from mostly underground water sources is becoming the most popular and the most widely consumed water product.

Drinking water as a food product should not only be pure as per its chemical and microbe parameters but also contain biogenic macro- and micro-elements that are essential for life activity. On one hand, completely desalinated water is not suitable for permanent consumption; on the other hand, when certain mineral components are not consumed in sufficient quantities with daily ration (for example, Ca, Mg, J, F), water can supply them into a human body [12]. This statement was fixed in the Order by Rospotrebnadzor No. 5 dated July 11, 2000, and then in the Sanitary-Epidemiologic Requirements 2.1.4.1116-02 "Drinking water. Hygienic requirements to bottled water quality. Quality control"[2] and the Methodical Guidelines 2.1.4.1184-03[3] on implementation and application of this document approved by the RF Ministry of Justice, as well as in the Interstate Standard R 52109-2003 "Bottled drinking water. Overall technical conditions" (the 2nd edition issued as GOST 32220-2013)[4], and in "The Unified sanitary-epidemiologic and hygienic requirements to goods that are subject to sanitary-epidemiologic surveillance (control)" approved by the Customs Union Commission, the Decision No.299 dated May 28, 2010[5].

Over the last decades a necessity to supply consumers with natural high quality water has led to a drastic growth in bottled water production, both in Russia and abroad [12, 13]. Approximately 64% of such water is consumed in Europe; 21%, in the USA; 3.5%, in the eastern countries; 11.5%, in all other regions. Domestic bottled drinking water appeared on the Russian market more than 20 years ago; it has become a truly mass product consumed everywhere. By now, consumption of bottled drinking water in Russia has grown from 5 liters per man a year to 5 liters per man a week. Bottled drinking water market is one of the most rapidly growing consumer markets in Russia. As per data provided by RBK group, it has been growing by 15–16% annually over recent years. Recently, a range of bottled drinking and mineral water has increased substantially. There are manufacturers of bottled water in practically every Russian region [13, 14].

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[2] On adjustment of drinking water quality as per biogenic elements concentration: The Order by the RF Chief Sanitary Inspector No.5 dated July 17, 2000. [web-source]. – URL: http://www.businesspravo.ru/Docum/DocumShow_DocumID_17027.html (date of visit June 05, 2018).

[3] MG 2.1.4.1184-03. Drinking water. Hygienic requirements to bottled water quality. Quality control: methodical guidelines for implementation and application of sanitary-epidemiologic rules and standards fixed in the SER 2.1.4. 1116-02 [web-source]. – URL: https://znaytovar.ru/gost/2/MU_214118403_Metodicheskie_uka.html (date of visit June 05, 2018).

[4] GOST 32220-2013. Bottled drinking water. Overall technical conditions [web-source] // KODEKS: an electronic fund of legal and reference documentation. – URL: http://docs.cntd.ru/document/1200107341 (date of visit August 05, 2018).

[5] The Unified sanitary-epidemiologic and hygienic requirements to goods that are subject to sanitary-epidemiologic surveillance (control) (last edited on May 10, 2018) [web-source] // KODEKS: an electronic fund of legal and reference documentation. – URL:http://docs.cntd.ru/document/902249109 (date of visit August 05, 2018).

Requirements to bottled drinking water safety are stricter than to water taken from centralized water supply systems [12, 15]; these requirements differ for water from various categories (first class water, premium water, and water for children nutrition or so called "drinking water for children") (Tables 3 and 4).

Table 3

Regulated organic water pollutants

No.	Parameter	Drinking water safety parameters, mg/l, not higher	Stricter parameters for bottled drinking water, mg/l, not higher		
			1 class	Premium	Children
1	Benzpyrene	0.00001	0.000005↓ (2 times)	0.000002↓(5 times)	0.000002
2	Bromdichloromethane	0.03	0.01↓ (3 times)	0.001 ↓ (30 times)	0.001
3	Bromoform	0.1	0.02↓ (5 times)	0.001↓ (100 times)	0.001
4	Dibromochloromethane	0.03	0.01↓ (3 times)	0.001↓(30 times)	0.001
5	Formaldehyde	0.05	0.025↓ (2 times)	0.025	0.025
6	Chloroform	0.06 (0.2)	0.03↓ (2–6.7 times)	0.001↓ (60–200 times)	0.001
7	Chlorinated carbon	0.002	0.002	0.001↓ (2 times)	0.001
8	Petroleum products	0.1	0.05↓ (2 times)	0.01↓ (10 times)	0.01
9	Lindane	0.002	0.0005↓(4 times)	0.0002↓ (10 times)	0.0002
10	Atrazine	0.002	0.0002 ↓ (10 times)	0.00005 ↓ (4 times)	0.00005
11	DDT (sum of isomers)	0.002	0.0005↓ (4 times)	0.0002↓ (2.5 times)	0.0002
12	2,4 D	0.03	0.001↓ (30 times)	0.001	0.001
13	Simazine	1	0.0002 ↓ (5000 times)	0.00005 ↓(4 times)	0.0002
14	Heptachlor	0.05	0.00005 ↓ (1000 times)	0.00002↓(2.5 times)	0.00002

Table 4

Regulated mineral components in water

No.	Parameter	Drinking water safety parameters, mg/l, not higher	Stricter parameters for bottled drinking water, mg/l, not higher, (mg/l, within limit)		
			1 категории	Высшей категории	Детских
1	Nitrites (NO_2)	3.3	0.5↓ (6.6 times)	0.005 ↓(660 times)	0.005
2	Aluminum (Al)	0.2 (0.5)	0.1↓ (2–5 times)	0.1	0.1
3	Ammonia (NH)	1.5	0.1↓ (15 times)	0.05↓ (30 times)	0.05
4	Manganese (Mn)	0.1(0.5)	0.05↓ (2–10 times)	0.05	0.05
5	Sulfates	500	250↓ (2 times)	150↓(3.3 times)	150
6	Chlorides	350	250↓ (1.4 times)	150↓ (2.3 times)	150
7	Barium (Ba)	0.7	0.7	0.1↓ (7 times)	0.1
8	Boron (B)	0.5	0.5	0.3↓ (1.7 times)	0.3
9	Bromide (Br)	0.2	0.2	0.1↓ (2 times)	0.1
10	Arsenic (As)	0.01	0.01	0.006 ↓(1.7 times)	0.006
11	Lead (Pb)	0.01	0.01	0.005↓ (2 times)	0.005
12	Chromium (Cr)	0.05	0.05	0.03↓ (1.7 times)	0.03
13	Cyanides	0.07	0.035↓ (2 times)	0.035	0.035
14	Zinc (Zn)	5	5	3↓ (1.7 times)	3
15	Cadmium (Cd)	0.002	0.001↓ (2 times)	0.001	0.0005 ↓ (2 times)
16	Mercury (Hg)	0.001	0.0005↓ (2 times)	0.0002↓ (5 times)	0.0001 ↓ (2 times)

17	Sodium (Na)	200	200	100↓ (2 times)	20 ↓ (5 times)
18	Nitrates (NO_3)	45	20 ↓ (2.3 times)	10 ↓ (4.5 times)	5 ↓ (2 times)
19	Selenium (Se)	0.01	0.01	0.01	0.005 ↓ (2 times)
20	Bicarbonates (HCO_3)	400	400	30–400 (13 times)	30–300↓
21	Potassium (K)	–	20	2–20	2–10↓
22	Calcium (Ca)	–	130	25–80	25–60↓
23	Magnesium (Mg)	–	50	5–50	5 – 35↓
24	Fluorides (F)	1.5	1.5	0.6–1.2 ↓ (2.5–1.3 times)	0.6 – 1↓
25	Hardness, mg-eqv./l	7	7	1.5–7 ↓(4.7 times)	1.5 – 6↓
26	Alkalinity, mg-eqv./l	6.5	6.5	0.5–6.5 ↓ (13 times)	0.5 – 5↓
27	Salinity, mg/l, within limits	1,000(1,500)	1,000 ↓ (1.5 times)	200–500 ↓ (5–2 times)	200–500
28	Iodine (J), mg/l, within limits	0.125	0.125	0.04–0.06 ↓ (3–2 times)	0.04–0.06

Bottled drinking waters differ greatly as per their safety parameters and qualitative properties. These differences are caused by additional criteria being introduced: quality should be stable over time (as it takes much longer time for bottled drinking water to be supplied to an end customer; water from a centralized water supply system is delivered within much shorter time period, from several hours to 2–3 days, but bottled water can be delivered to an end consumer within a period from 3, 6 or 12 months to even 2–5 years after it was manufactured); water should be physiologically valuable (drinking water should not contain any adverse chemical admixtures that are hazardous for health, but it should contain certain biogenic elements necessary for proper life activity, especially those that are hard to find in food products or their quantity in food is insufficient). It is also important to note that there is a much longer list of parameters that are obligatory for examination fixed for bottled water (there are 56 priority parameters for water taken from centralized water supply systems, but there are 93 such parameters for bottled water) [16].

Bottled drinking waters from the first category are regulated by much stricter standards (from 2 to 5,000 times stricter) against water from centralized water supply systems as per 24 parameters for contents of chemicals that belong to the 1st and 2nd hazard category. Bottled waters from the premium category are regulated by even stricter standards than the waters from the first category as per 17 parameters; such waters are optimal in terms of being physiologically valuable (within minimum necessary and maximum permissible levels) as per 9 parameters for contents of vitally essential biogenic elements. Bottled drinking waters from the premium category are not only as safe as possible but they also produce preventive and health-improving effects. They are recommended to be consumed by children, pregnant women, ill people, sportsmen, and people who work under high physical loads, that is, by consumers who have the highest need for biogenic elements (Figure 1).

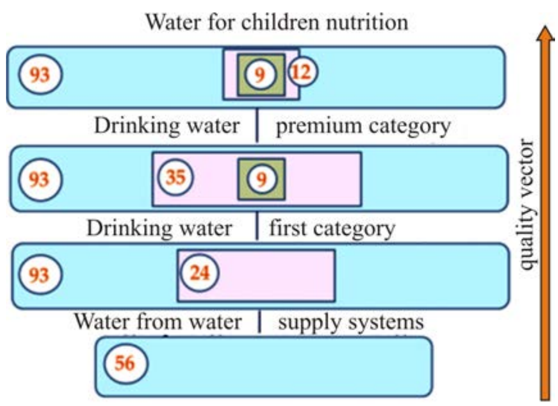

Figure 1. The pyramid for bottled drinking waters quality as per safety parameters and physiological value

Waters for children nutrition are basically to meet the same requirements as the premium drinking waters but they should not contain Cd and Hg even in minimum quantities, and maximum permissible concentrations of nitrates, Se, Na, K, Ca, Mg, F, and bicarbonates in them are also adjusted. Besides, parameters of water hardness and alkalinity fixed for such waters are optimal for a child body.

The above mentioned differences are based on criterial calculations made with application of methodology for assessing population and individual risks, taking into account age-related peculiarities of water consumption and development of a body, and comparative analysis performed on more than 850 bottled waters distributed on the Russian market (Table 6).

Table 5

Bottled drinking water production, including premium water, in the RF regions

Total/Premium water

Severo-Zapadniy Federal District	Zhentralniy Federal District	Yuzhniy Federal District	Privolzhskiy Federal District	Uralskiy Federal District	Sibirskiy Federal District	Dal'nevostochniy Federal District
Arkhangelsk 9/0	Belgorod – 1/1	Astrakhan 1/0	Kirov 5/1	Kurgan 5/2	Altai 20/2	Amur 6/1
Vologda – 7/1	Bryansk – 5/1	Volgograd – 12/2	Nizhniy Novgorod 29/3	Sverdlovsk – 33/2	Transbaikal 2/0	Kamchatka 2/1
Kaliningrad 4/1	Vladimir – 10/1	Krasnodar 37/5	Orenburg 20/2	Tyumen 30/3	Irkutsk 19/2	Magadan 1/0
Murmansk 1/0	Voronezh 8/2	Adygei 7/1	Penza 8/1	Chelyabinsk – 11/2	Kemerovo – 6/1	Primorye 23/3
Novgorod – 8/2	Ivanovo – 3/1	Rostov 32/(4	Perm 16/1		Krasnoyarsk 19/4	Yakutia 16/1
Pskov – 8/3	Kaluga 8/3	Kabardino-Balkaria 1/1	Bashkortostan – 34/2		Novosibirsk 12/3	Sakhalin 2/0
Karelia – 1/1	Kostroma 4/1	Karachai-Cherkess 5/4	Mari El – 11/1		Omsk 10/0	Khabarovsk 17/0
Komi – 6/1	Kursk 9/5	Dagestan 2/(1	Mordovia 3/0		Buryatia 5/1	Jewish Autonomous Region 2/0
Leningrad – 21/1	Lipetsk 6/4	North Ossetia – Alania 4/0	Tatarstan – 28/6		Khakassia 2/0	Chukchi – 1/0
	Moscow – 59/22	Stavropol 18/6	Samara 20/6		Tomsk 6/0	
	Orel 2/0		Saratov – 12/5			
	Ryazan 4/0		Udmurtia 7/1			
	Smolensk – 8/6		Ul'yanovsk 6/3			
	Tambov – 4/4		Chvashia 4/0			
	Tver' 18/4					
	Tula 12/2					
	Yaroslavl – 9/0					
Total: 65/10	Total: 170/54	Total:119/24	Total 203/32	∑ 79/9	∑ 101/13	Total 70/6
European part of the RF 557 – 70%				**Asian part of the RF 250 – 30%**		

Bottled drinking water from the first category guarantees greater chemical safety and provides better health preservation. Premium waters and waters for children nutrition are practically free from any adverse chemicals (xenobiotics) and it is confirmed by all the existing analysis techniques; that is, such waters are practically completely safe. They are also the most useful mass product for health as they contain biogenic elements that are necessary for a body; as a result, these waters not only preserve health but also improve it considerably.

Greater epidemiologic safety was also a significant part in regulating quality of bottled drinking waters. To achieve this goal, experts adjusted techniques for control over epidemic safety of bottled drinking water by introducing a new and more reliable integral parameter for glucose+ bacteria (GPB) into SER[6]. This parameter comprises the whole group of bacteria from *Enterobacteriaceae* family, that is, it guarantees that examined water doesn't contain either lactose+ bacteria (E.coli, total coliforms, or thermotolerant coliforms) or pathogenic (Salmonella) and potentially pathogenic bacteria that don't ferment lactose. The parameter is based on two basic signs, a differential sign of glucose fermentation and negative oxidase test. These signs are genetically native for the whole *Enterobacteriaceae* family and it provides stability of the GPB parameter as a necessary property of an indicator microorganism thus making it truly reliable in terms of water quality control [17–19]. Tables 7 and 8 show results of comparative analysis performed on existing sanitary-indicator parameters for epidemiologic safety of water.

Reliability of the parameter was convincingly conformed by long-term research results. Thus, in 2013 Zhuravlev [20] determined a long-term period during which salmonella survived in drinking water (42 days in centralized water supply systems). Indicator value remained only for a group of glucose+ coliforms as their vegetating dynamics completely corresponded to that of salmonella. A parameter of thermotolerant E.coli didn't provide epidemic safety of water under the same conditions as regards salmonella as E.coli were detected in water during a shorter period of time (28 days), and salmonella were detected when E.coli were absent. It was detected during an experiment that salmonella were more resistant to chlorine than E.coli and total coliforms. Salmonellas died when a contact lasted for 4 hours, while it took E.coli only 1 hour, and total coliforms 2 hours, to die. Glucose+ coliforms died after 4 hours, just like salmonella, but indicator value as regards pathogenic bacteria still persisted.

Table 7

Comparative characteristics of coliform parameters

Parameters	Glucose+ coliforms	Total coliforms	Thermotolerant coliforms	E.coli
Identification signs	Glucose, acid and gas, 37 °C	Lactose, acid, and gas, 37 °C	Lactose, acid, and gas, 44 °C	Lactose, acid, and gas, 44 °C, indole
Stems from *Enterobacteriaceae* family	Escherichia	Escherichia	Escherichia	Escherichia
	Klebsiella, Citobacter Enterobacter	Klebsiella, Citobacter Enterobacter	Klebsiella	
	Rahnella Buttiauxella	Rahnella Buttiauxella	Water with standard quality	
	Gafnia, Morganella Edward-siella, Providencia, Serattia Proteus, Salmonella			
Essence of a sign	Wide-scale, hygienically reliable, integral, provides epidemiologic safety	Less wide, integral, not stable	Narrow, not stable	The most narrow, stable

[6] On implementation of sanitary-epidemiologic rules and standards "Drinking water. Hygienic requirements to quality of bottled water. Quality control. SER 2.1.4.1116-02" (together with "SER 2.1.4.1116-02. 2.1.4. Drinking water and water supply to settlements. Drinking water": The Order by the RF Chief Sanitary Inspector dated March 19, 2002 No. 12 (last edited on June 28, 2010) [web-source] // KonsultantPlus. – URL: http://www.consultant.ru/document/cons_doc_LAW_6030/ (date of visit September 01, 2018).

Table 8

Epidemiologic reliability of identification techniques: comparative assessment

Identification as per lactose (LPB)	Identification as per glucose (GPB)
Sporadic morbidity on the south of the country caused by opportunistic pathogenic bacteria (Kattakurgan, Azov)	Episodes and sporadic morbidity were not registered during 30 years when a standard parameter for water quality per State Standard 2874-73 was applied
Episodes of enteric infections in Moscow region (Protvino, Oktyabrskiy)	
Water-related episodes abroad when coliforms were not detected Liverpool (1965) Seligmanm Reiteer Riverside (1968) Yallager, Spino	
More than half of 126 water-related episodes in the USA occurred when there were no coliforms in drinking water	

A modified procedure for determining glucose+ bacteria, apart from being more informative, streamlines sanitary-microbiologic analysis (making it approximately 1 day shorter) (Table 9). There is also a substantiated necessity to perform microbiologic control over blue pus bacillus occurrence.

Stricter requirements to quality and safety of drinking water call for regulatory base updating [21–23]. Today we should indicate that there are some incorrect positions fixed in subordinate documents of the sanitary legislation. For example, "mineral water" and "drinking water" are considered to be identical notions in some of them and it contradicts to conceptual determination of such waters in well-known encyclopedias and reference books. Then, a new term, "mineral table drinking water" was introduced into world practice; certain documents allow 10 times higher concentration of xenobiotics belonging to the 1st and 2nd hazard category (Hg, Pb, and As) for such water as compared with standards fixed even for water taken from communal water supply systems. Such water can cause serious health risks not only for children but also for adults and it can't be permitted for consumption as "Water for children nutrition".

Table 10 shows some recommendations on adjustments that should be made in certain subordinate acts. We should also note that there are a lot of uncertainty factors related to separation of an internationally accepted concept and term "mineral water" into Russian ones "mineral drinking therapeutic water" and "mineral drinking therapeutic and table water", not to mention an absurd "table mineral drinking water" concept. It is also confirmed by substantial differences in a number of controlled parameters for such waters in comparison with existing Russian and international regulatory documents (Figure 2).

Table 9

Techniques for coliform bacteria determination: comparative characteristics

A day of sample inoculation	ISO 9308-1:2000 technique	MG 4.2.1018-01 technique	Developed quick test
	Inoculation via membrane filtration		
	Incubation for 18–24 hours under 37 °C in a lactose selective medium		
After 24 hours	Selective inoculation of colonies on nonselective agar Incubation for 18–24 hours under 37 °C	Selective oxidase test on colonies Microscopy after Gram stain Fermentation in a lactose medium for 24–48 hours under 37 °C	Oxidase test performed simultaneously on all the colonies on a membrane filter. Final results after 18–24 hours
After 48 hours	Determination of oxidase activity	Preliminary accounting of gassing	
After 72 hours		Final accounting of gassing	
TOTAL	48 hour duration	3 day duration without taking into account biochemical properties variability	18–24 hour duration; precise differentiation of colonies
	Results not authentic due to subjective selection of colonies		No subjective assessments

Table 10

Documents regulating safety of drinking mineral waters that require adjustments

No.	Title of a document	Parameters under control	Required adjustments
1	State Standard 13273-88 "Mineral drinking therapeutic waters and mineral drinking therapeutic and table waters. Technical conditions"	>70 parameters, contents of 8 biogenic elements are regulated. Safety parameters are not regulated.	1. The term "drinking" is not substantiated for simultaneous introduction together with the term "mineral" for therapeutic and therapeutic and table waters
2	SER 2.3.2.1078-01. "Food raw materials and food products". item 1.8.2. "Waters; drinking ones, mineral natural table ones, therapeutic and table ones, therapeutic ones"	9 safety parameters, 3 out of them higher than MPC: Pb – 0.1 mg/dm^3 (10 times higher) Cd – 0.01 mg/dm^3 (5 times) Hg – 0.005 mg/dm0^3 (10 times)	1. - « - « - « - « - « 2. Introduction of the term "table" is not substantiated (water is "therapeutic and table" in its essence) 3. Introduction of mineral therapeutic waters and mineral therapeutic and table waters into this SER is not substantiated
3	The Customs Union Technical regulations CU TR 021/2011 "On food products safety". Appendix 3. "Hygienic requirements to food products safety", item 8 "Beverages"	3 safety parameters higher thamnMPC: Pb – 0.1 mg/dm^3 (10 times higher) Cd – 0.01 mg/dm^3 (5 times) Hg – 0.005 mg/dm0^3 (10 times)	1. The term "table" water is introduced again. 2. Mineral natural waters are unreasonably assigned into "beverages" category. 3. There is no list of biogenic elements (water is controlled only as per 3 safety parameters).

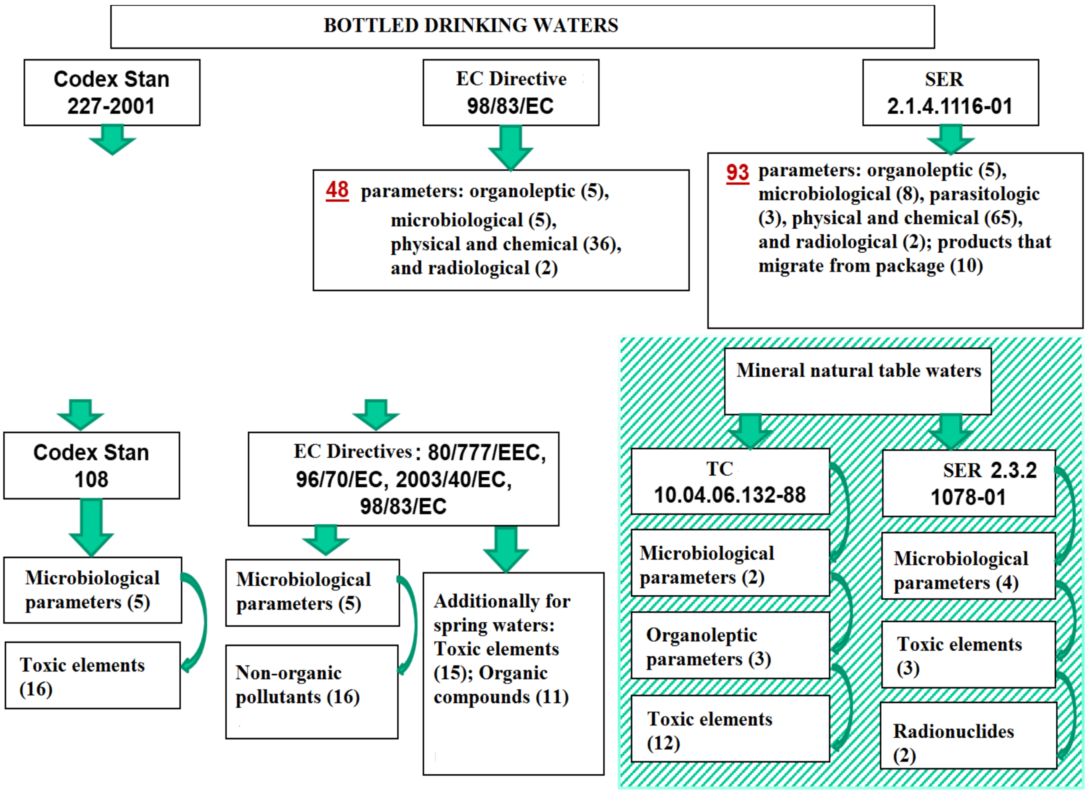

Figure 2. Regulatory documents for control over safety of different bottled waters

Regulatory and legal base should be updated in such a way that could provide support to manufacture of high quality bottled waters including those aimed for children nutrition. When such waters were introduced into daily rations at schools and pre-school children facilities in Moscow, Barnaul, Samara, and Smolensk, their considerable health-improving effects were proven [24, 25].

Therefore, development of drinking water market as a segment of the overall food consumer market requires the following:

– updated regulatory and methodical base for control over quality and safety of distributed waters;

– improved systems for monitoring over epidemiologic safety based on up-to-date research techniques and tools;

– wider implementation of methodology for assessing health risks related to consumption of water with different quantitative and qualitative structure.

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