Hindawi Publishing Corporation
Journal of Chemistry
Volume 2013, Article ID 321609, 7 pages
http://dx.doi.org/10.1155/2013/321609

Research Article

The New Standard for Drinking Water

V. Goncharuk

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

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

Received 3 July 2013; Accepted 13 September 2013

Academic Editor: Oleksandr A. Loboda

The main positions of the new standard on drinking water are provided. The inconsistency of existing approaches to the assessment including methodology of drinking water quality was substantiated. The main advantage of the new standard is the inclusion of integral methods of water quality, universal for all kinds and types of toxic compounds, irrespective of their origin and nature of the action.

1. Introduction

Drinking water, that is, the water whose organoleptic, physicochemical, and biological properties meet human biological needs and has neither color nor smell, should have a taste determined by the presence of physiologically necessary salts of calcium, magnesium, sodium, and potassium in corresponding concentrations without which metabolism in the human organism is impossible.

What optimal parameters should the water possess to be completely safe from the biological and physiological points of view?

For the first time in the world in 1853, in Brussels, at the International Congress of Hygienists, an attempt was made to set a standard for drinking water, which would include only nine controllable components. Among them there were vitally important substances such as magnesium, calcium, total mineralization (determined mainly by the presence of salts of sodium and potassium), and the content of oxygen in the water, sulfates, chlorides, nitrates, and ammonium. However, the age of industrialization, a fast development of the agroindustrial complex and the emergence of megapolises with compact settlement of people, whose number dramatically increased, started on the planet. A further development of civilization became impossible without the creation of civilized systems of water supply and a complex of water disposal facilities. 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. As a result of a low quality of drinking water real threats to the sanitary-epidemiological situation in various regions of the planet cropped out. And only early in the 20th century the first standard for drinking water appear in the USA. After almost a century after adoption in Brussels of the first recommendation for drinking water quality a document of the World Health Organization (WHO) was published, which today, at the beginning of the 21st century, proposes to bring under regulation 95 indices of which 26 are toxic substances, whose presence in drinking water is undesirable. The US standard regulates 102 indexes in drinking water, where complete absence is required for as many as 35 toxic indexes.

A high level of technogenic load on water bodies, the use of imperfect technologies of water conditioning, 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, posing real threat to human health. In the situation that has taken shape there is in principle no possibility to provide the population of any country or continent with quality and safe for human health drinking water [1–4].

An increase of the quality of the water being controlled by a national standard in various countries of the world does not solve the issue of obtaining safe drinking water at the centralized water conditioning stations either. All this calls

Table 1: Microbiological indicators of drinking water quality.

Indicator	Measurement units	Norm, not more than: Water of systems of centralized drinking water supply	Norm, not more than: Water of uncentralized drinking water supply additionally purified (unbottled, bottled)
Number of bacteria in 1 cm^3 of water under study (TMN) at 37°C	CFU/cm^3	100[1*]	20[1*]
Number of bacteria in 1 cm^3 of water under study (TMN) at 22°C	CFU/cm^3	100[1*]	20[1*]
Number of bacteria of the colibacillus group (coliform microorganisms) in 1 dm^3 of water under study (BCG index)	CFU/dm^3	3[2*]	Absence[2*]
Number of thermostable colibacillus (fecal coliform—FC index) in 100 cm^3 of water under study	CFU/100 cm^3	Absence[3*]	Absence[3*]
Number of pathogenic microorganisms in 1 dm^3 of water under study	CFU/dm^3	Ditto[3*]	Ditto[3*]
Number of coliphages in 1 dm^3 of water under study	PFU/dm^3	“ ”	“ ”
Spores of sulfate-reducing clostridia	Presence (amount)/20 cm^3	Absence[4*]	Absence[4*]
Blue pus bacillus *(Pseudomonas aeruginosa)*	CFU/dm^3	Not determined	Absence

[1*] An excess of the norm shall not be allowed for 95% of water sample in the water supply network that is under investigation during the year.
[2*] An excess of the norm shall not be allowed for 98% of water samples in the water supply network that is under investigation during the year. In the event the BCG index is exceeded at the stage of colony identification investigations shall be carried out for the presence of fecal coliforms.
[3*] In the event of the presence of coliform bacteria or coliphages in a water sample their amount shall be immediately determined in repeatedly taken water samples. If in these samples generally coliform bacteria are found in the amount of >2/100^3 and (or) thermostable coliform bacteria and (or) coliphages, pathogenic bacteria of the colibacillus group and (or) enteroviruses shall be determined. The investigation of drinking water for the presence of pathogenic bacteria of the colibacillus group and enteroviruses shall also be carried out following the decision of the organs of sanitary supervision in the event of the emergence of the epidemic situation.
[4*] The control shall be exercised at the outlet from the drinking water conditioning station in the case of using surface sources of water supply or underground ones, which have the hydraulic connection with the surface water body; during the transition period annually the index of the spores of sulfate-reducing clostridia with the norm “absence/20 cm^3” shall be controlled.

Table 2: Mycological indicators of drinking water quality.

Indicator	Measurement units	Norm: Water of systems of centralized drinking water supply	Norm: Water of uncentralized drinking water supply additionally purified (unbottled, bottled)
Micromycetes	CFU/100 cm^3	Absence	Absence*

* *Aspergillus fumigatus*, *Aspergillus niger*, and *Penicillium expansum* must not be present at all.

for the ever more expensive equipment and complication of technological processes.

Against the background of such catastrophic changes in the quality of the environment the monitoring of several tens of substances in drinking water causes, to say the least, a surprise. A surprise is also caused by a lack of understanding of the fact that in pursuit of “technical progress,” even increasing the amount of controllable components in drinking water several times as much, one cannot give any guarantees that it is in fact drinking water and safe for human health. Even the use of underground water at present does not always guarantee the quality of the drinking water obtained, especially if one takes into account the fact that an absolute majority of organic matter in the environment under the effect of various physicochemical and ecological factors undergoes biotransformation into unknown and, most often, into unpredictable compounds. According to the aforementioned synergism the effects of two or more compounds of toxic nature of each individually taken substance increase in that case if this substance initially is not toxic. Hence the senselessness of using classic approaches to the assessment of drinking waters follows. The notion itself of “normalizing maximum allowable concentrations in drinking water of different toxicants” purportedly safe for human health is, as a matter of fact, immoral.

The proposed new standard include fundamentally new, very effective integrated methods of monitoring water quality, which are designed for revealing acute toxicity at the level of organism and finding chronic toxicity at the cellular level using cytogenetic methods on biological objects for this purpose. These methods are universal for all types and kinds of toxic compounds irrespective of their origin and the nature of their effect.

The new Standard for Drinking Water includes three different regulatory documents [5]:

Table 3: Toxicity level of drinking water.

Indicator	Measurement units	Norm: Water of systems of centralized drinking water supply	Norm: Water of uncentralized drinking water supply additionally purified (unbottled, bottled)
Chronic toxicity on *Ceriodaphnia affinis*	Number of dead individuals and (or) a decrease of the number of newly born individuals in an experiment compared with the reference during 7 ± 1 days	Not determined	Absence of chronic toxicity
Genotoxicity on *Drosophila melanogaster* Mg	Rate of occurrence of dominant lethal mutations in an experiment compared with the reference during 72 h	Ditto	Genotoxicity absent
Toxicity on *Tetrahymena pyriformis*	A reduction of the increment coefficient of the number of infusorians in an experiment compared with the reference during the time set—24 hours (a short-term biotesting) or 96% (a long-term biotesting)	" "	Toxicity absent
Toxicity on *Vibrio fischeri*	Reduction of the level of luminescence of bacteria in an experiment compared with the reference over 30 min	" "	Toxicity absent
Genotoxicity on *Salmonella typhimurium*	A deviation of the total mutagenic activity of umuC-gene of bacteria *Salmonella typhimurium* in an experiment compared with a reference over 4 hours	" "	Genotoxicity absent

Table 4: Organoleptic indicators of drinking water quality.

Indicator	Measurement units	Norm, not more than: Water of systems of centralized drinking water supply	Norm, not more than: Water of uncentralized drinking water supply additionally purified (unbottled, bottled)
Organoleptic indicators of quality			
Smell at 20°C	Point	2	0
Smell during heating to 60°C	Point	2	1
Smell and taste	Point	2	0
Color	Deg	20	5
Turbidity	NUT	2.5	0.5

(i) GOST (state all-union standard) for tap water (conditionally drinking);

(ii) GOST for drinking water of increased quality (the water absolutely safe for human health);

(iii) GOST for bottled water.

A new concept of providing the population with quality drinking water along with the general provisions and regulation requirements of the quality of drinking water accepted in the European Union, the WHO, and the Codex Alimentarius [6–10] has been taken into account in the development of the standard [11–15].

Such a concept provides for the following. Water safety in terms of toxicological and microbiological indices is prepared at waterworks. This water is suitable for household or domestic use and is fed to the distribution networks. In this case it is obtained mainly from the water of surface sources.

High-quality drinking water in the amount sufficient for satisfying human physiological needs is prepared at the consumption site in the plant of water pump rooms. It is then not fed to the distribution network but is supplied to the consumer by other methods (by gravitation flow or bottling). Such drinking water is obtained mainly from underground water protected against anthropogenic influence or from tap water.

The fundamental feature of the new standard is the regulatory justification of a new conceptual approach to water supply of population with quality drinking water. It provides economic water supply by utilizing the differentiating consumption of drinking water depending on physiological, sanitary-hygienic, and economic needs of human over one 24-hour period in a specific populated area. The necessity of such an approach is determined by the following objective reasons: unjustified use of quality drinking water for sanitary-hygienic needs; unsatisfactory state of transportation and

Table 5: Chemical indicators of quality, which affect the organoleptic properties of drinking water.

Indicator	Measurement units	Norm, not more than: Water of systems of centralized drinking water supply	Norm, not more than: Water of uncentralized drinking water supply additionally purified (unbottled, bottled)
Inorganic components			
Hydrogen index (pH)	pH unit	6.5–8.5	6.5–8.5
Dry residue (total mineralization) optimal content	mg/dm^3	1000 (1500)*	1000 100–400
Total hardness, optimal value	$mmol/dm^3$	7 (10)*	7 1.5–4.0
Total alkalinity, optimal value	$mmol/dm^3$	6.5	6.5 0.5–5.0
Sulfates	mg/dm^3	250 (500)*	150
Chlorides	mg/dm^3	250 (350)*	150
Total iron (Fe)	mg/dm^3	0.2	Absence
Manganese (Mn)	mg/dm^3	0.05	Ditto
Copper (Cu)	mg/dm^3	1.0	“ ”
Zinc (Zn)	mg/dm^3	5.0	“ ”
Calcium (Ca), optimal value	mg/dm^3	100	100 20–60
Magnesium (Mg), optimal value	mg/dm^3	30	30 6.0–15
Sodium (Na), optimal value	mg/dm^3	200	200 20
Potassium (K), optimal value	mg/dm^3	20	20 2.0–20
Organic components			
Methyl-*tert*-butyl ether	mg/dm^3	0.015	Absence
Oil products	mg/dm^3	0.05	Ditto
Chlorophenols	mg/dm^3	0.0003	“ ”

*The value in the brackets may be established following the ruling by the Chief State Sanitary Physician in the corresponding area for the specific system of the drinking water supply based on the evaluation of the sanitary-epidemiological state in a town and the technology of drinking water treatment used in a case, when other sources of drinking water supply are inaccessible.

distribution networks of the system of centralized drinking water supply; discrepancy of the technology of drinking water treatment in centralized systems of drinking water supply to the water quality in a water source; unjustified high economic costs for reconstruction and modernization of the systems of centralized drinking water supply for the preparation of high-quality drinking water in a volume substantially exceeding physiological and sanitary-hygienic human needs.

The second fundamental distinction of the new standard is the fact that the main accent was made on new approaches to the assessment of the quality of drinking water in terms of integral indexes of water toxicity, which is set by the methods of biotesting according to standardized techniques. This makes it possible to obtain objective information on the quality of drinking water before the conduction of a detailed analysis by all indices. Such an analysis is expedient in the case of finding toxicity and the necessity of establishing cause of its emergence.

The third fundamental distinction of the new standard is the requirement of complete absence of all toxic chemical and biological pollutants in drinking water designed for human consumption.

The employment of the methods of assessment of the drinking water quality by the integral indexes makes it possible within short terms and at the lowest economic costs to assess the suitability of drinking water for human consumption.

Unlike the methods of chemical analysis adopted today in the world (more than 100 indexes of water quality), the employment of the integrated methods of biotesting makes it possible to substantially (~ by 3-4 times) reduce the amount of controlled indexes.

It is a well-known fact that in the modern period in all countries of the world units, devices of various powers, and miniplants for add-on treatment of drinking water from various sources of water supply were used on a wide scale including from drinking water of centralized water supply and the center of realization or the pouring of tertiary treated drinking water to the containers of the consumers. An indispensable condition of achieving all regulatory indexes of

Table 6: Toxicological indicators of the harmlessness of drinking water chemical composition[1*].

Indicator	Measurement units	Norm, not more than: Water of systems of centralized drinking water supply	Norm, not more than: Water of uncentralized drinking water additionally purified (unbottled, bottled)
Inorganic components			
Aluminum (Al)	mg/dm^3	0.2 (0.5)[2*]	Absence
Ammonia (by NH_4^+)	mg/dm^3	0.5 (1.5)[2*]	Ditto
Barium (Ba)	mg/dm^3	0.1	0.1
Beryllium (Be)	mg/dm^3	0.0002	Absence
Boron (B)	mg/dm^3	0.5	Ditto
Cadmium (Cd)	mg/dm^3	0.001	« »
Arsenic (As)	mg/dm^3	0.01	« »
Nickel (Ni)	mg/dm^3	0.1	« »
Nitrates (by NO_3^-)	mg/dm^3	45	5
Nitrites (by NO_2^-)	mg/dm^3	0.1	0.02
Perchlorates (ClO_4^-)	mg/dm^3	0.01	Absence
Mercury (Hg)	mg/dm^3	0.0005	Ditto
Leas (Pb)	mg/dm^3	0.01	« »
Selenium (Se)	mg/dm^3	0.01	« »
Strontium (Sr)	mg/dm^3	7	2
Stibium (Sb)	mg/dm^3	0.005	Absence
Thallium (T1)	mg/dm^3	0.0001	Ditto
Fluorides (F^-) for climatic region:	mg/dm^3		
II		1.5	1.5
III		1.2	1.2
IV		0.7	0.7
Total chromium (CCr)	mg/dm^3	0.05	Absence
Cyanides (CN^-), in particular cyanogen chloride	mg/dm^3	0.05	Ditto
Organic components			
Benz(a)pyrene	mg/dm^3	0.00001	Absence
Benzol	mg/dm^3	0.001	Ditto
Pesticides (sum)[3*]	mg/dm^3	0.0005	« »
Synthetic anionoactive surface-active substances (ASAS)	mg/dm^3	0.1	« »
Trichloroethylene and tetrachloroethylene (sum)	mg/dm^3	0.01	« »
Tetrachloride carbon	mg/dm^3	0.002	« »
Integral indicators			
Permanganate oxidizability	mg O/dm^3	2	0.75
Total organic carbon	mg C/dm^3	4	1.5

[1*] When in drinking water several chemical substances are detected, which refer to the 1st and 2nd classes of safety, and have sanitary-toxicological indicators of hazard, the sum of relationships of concentrations of every one of them determined in water to the standard should not exceed 1.
[2*] The value in brackets may be set only by the ruling of the Chief State Sanitary Physician in the corresponding area for the specific system of drinking water supply based on the evaluation of the sanitary-epidemiological state in a town and the technology of drinking water treatment used with the account of the specific situation.
[3*] Pesticides (sum): organic insecticides, herbicides, fungicides, nematicides, acaricides, algicides, bactericides, virucides, rodenticides, slimicides, bound products (in particular growth regulators), and then metabolites and degradation products. The program of control involves only these pesticides, which, most likely, may be contained in this water.

Table 7: Substances formed and getting into drinking water during water conditioning.

Indicator[1*]	Measurement units	Norm, not more than: Water of systems of centralized drinking water supply	Norm, not more than: Water of uncentralized drinking water supply additionally purified (unbottled, bottled)
Acrylamide[2*]	mg/dm^3	0.001	Absence
Bromates	mg/dm^3	0.1	Ditto
Residual chlorine dioxide	mg/dm^3	0.2–0.8	“ ”
Residual ozone, within	mg/dm^3	0.1–0.3	“ ”
Residual polyphosphates (PO_4^{3-})	mg/dm^3	3.5	“ ”
Trihalogenmethanes: chloroform, bromoform, dibromochloromethane, bromodichloromethane (total)	mg/dm^3	0.1	“ ”
Formaldehyde	mg/dm^3	0.05	“ ”
Residual free chlorine, within	mg/dm^3	0.3–0.5	“ ”
Residual bound chlorine, within	mg/dm^3	0.8–1.2	“ ”
Chlorate ion	mg/dm^3	0.7	“ ”
Chlorite ion	mg/dm^3	0.7	“ ”
Chloroform	mg/dm^3	0.06	“ ”
Dibromochloromethane	mg/dm^3	0.03	“ ”

[1*] The program of control involves specific indicators with the account of the technology of water conditioning from the cited list.
[2*] The program of control involves specific indicators of using respective reagents and calculating them based on the analysis of the content of the monomer in the commodity flocculant. The reagent doses and the level of the monomer should correspond to the following requirements: at the polyacrylamide dose 1 mg/dm^3 the content of acrylamide in it should not exceed 0.05%.

Table 8: Reagents permitted as preservatives for drinking water.

Preservatives	Measurement units	Permitted mass fraction of a preservative in water, not more than
Silver (Ag)	mg/dm^3	0.025 (0.05)[1*]
Carbon dioxide (CO_2)	%	0.2–0.6

[1*] For waters containing chloride ions >50 mg/dm^3.

drinking water safety is the setting of certain requirements of drinking water of both centralized and uncentralized systems of water supply.

By microbiological indexes drinking water should conform to the requirements given in Table 1.

By mycological indexes (micromycetes) drinking water should be in line with the norm given in Table 2.

Toxicity of drinking water of uncentralized water supply is an integral (express) quality index of drinking water in the case of suspicion of contamination of a water source or a distribution network with toxic compounds. The list of indices, test objects, and norms for determination of toxicity obtained from the results of biotesting are given in Table 3.

Radiation safety of drinking water shall be determined by the next acceptable levels: total volumetric activity of α-radiators ($\Sigma\alpha$-activity) not exceeding 0.1 Bq/dm^3 and total volumetric activity of β-radiators ($\Sigma\beta$-activity)—1.0 Bq/dm^3.

By organoleptic and chemical quality indexes, which affect organoleptic properties, drinking water should correspond to norms given in Tables 4 and 5.

According to toxicological indices of harmlessness of the chemical composition drinking water should be in line with norms given in Table 6 and the EC directives [6].

For the water supply system, which uses reagent water treatment methods prior to its delivery to the distribution network, during pouring out, transportation, and storage for a set time of suitability and in conducting research the indexes given in Table 7 are additionally taken into account. The content of substances that are formed and enter the drinking water during its treatment should not exceed the norms given in Table 7.

Reagents, introduced as preservatives for drinking water, shall be in accordance with Table 8. Other substances and methods for preservation of add-on purified bottled water from a noncentralized drinking water supply avoid the introduction of carbon dioxide and silver ions.

Thus, the approval and introduction of the new standard will allow us:

(i) to substantially reduce capital and operational costs for obtaining high-quality drinking water in amounts sufficient for meeting physiological needs of the population;

(ii) to reduce costs for exercising control over the quality of drinking water intended for human consumption as a result of using integral methods of assessing water quality without reequipment of chemical-analytical laboratories with expensive equipment;

(iii) to improve the state legislative database for providing the population with good-quality drinking water, safe for human health.

Designations and Abbreviations

BCG: Groupofcolibacillusbacteria
Bq: Becquerel
PFU: Plaque-formingunits
GMN: Generalmicrobialnumber—numberofsapro-phytemicroorganisms
CFU: Colony-formingunits
NUT: Nephelometricunitsofturbidity
ASAS: Anionoactivesurface-activesubstances
SSAS: Syntheticsurface-activesubstances
TCB: Thermostablecolibacillusbacteria.

References

[1] M. F. Falcone-Dias, I. Vaz-Moreira, and C. M. Manaia, "Bottled mineral water as a potential source of antibiotic resistant bacteria," *Water Research*, vol. 46, no. 11, pp. 3612–3622, 2012.

[2] M. José Figueras and J. J. Borrego, "New perspectives in monitoring drinking water microbial quality," *International Journal of Environmental Research and Public Health*, vol. 7, no. 12, pp. 4179–4202, 2010.

[3] M. A. Shannon, P. W. Bohn, M. Elimelech et al., "Science and technology for water purification in the coming decades," *Nature*, vol. 19, pp. 295–2301, 2008.

[4] A. Bosch, S. Guix, D. Sano, and R. M. Pinto, "New tools for the study and direct surveillance of viral pathogens in water," *Current Opinion in Biotechnology*, vol. 452, pp. 301–310, 2008.

[5] V. V. Goncharuk, "SOS: drinking water," *Journal of Water Chemistry and Technology*, vol. 32, no. 5, pp. 255–283, 2010.

[6] "The Directive of the European Union Council 98/82/EU concerning water quality designed for human consumption," *The Official Journal of the European Communities*, pp. 2–5, 1998.

[7] *Guidelines for Drinking—Water Quality*, vol. 1 of *Recommendations*, World Health Organization, Geneva, Switzerland, 3rd edition, 2004.

[8] CODEX STAN 227-2991, General Standard for Drinking Waters Bottled/Packed (different of mineral waters).

[9] U.S. Environmental Protection Agency, "National primary drinking water regulations, disinfectants and disinfection byproducts, final rule," *Federal Register*, vol. 63, no. 241, Article ID 69389, 1998.

[10] Directive of the EU 98/83/EU of November 3, 1998, Drinking Water. Regulatory Documents. Reference Book [in Ukrainian].—L'viv, Leonorm, Part 2.—323 P., 2001.

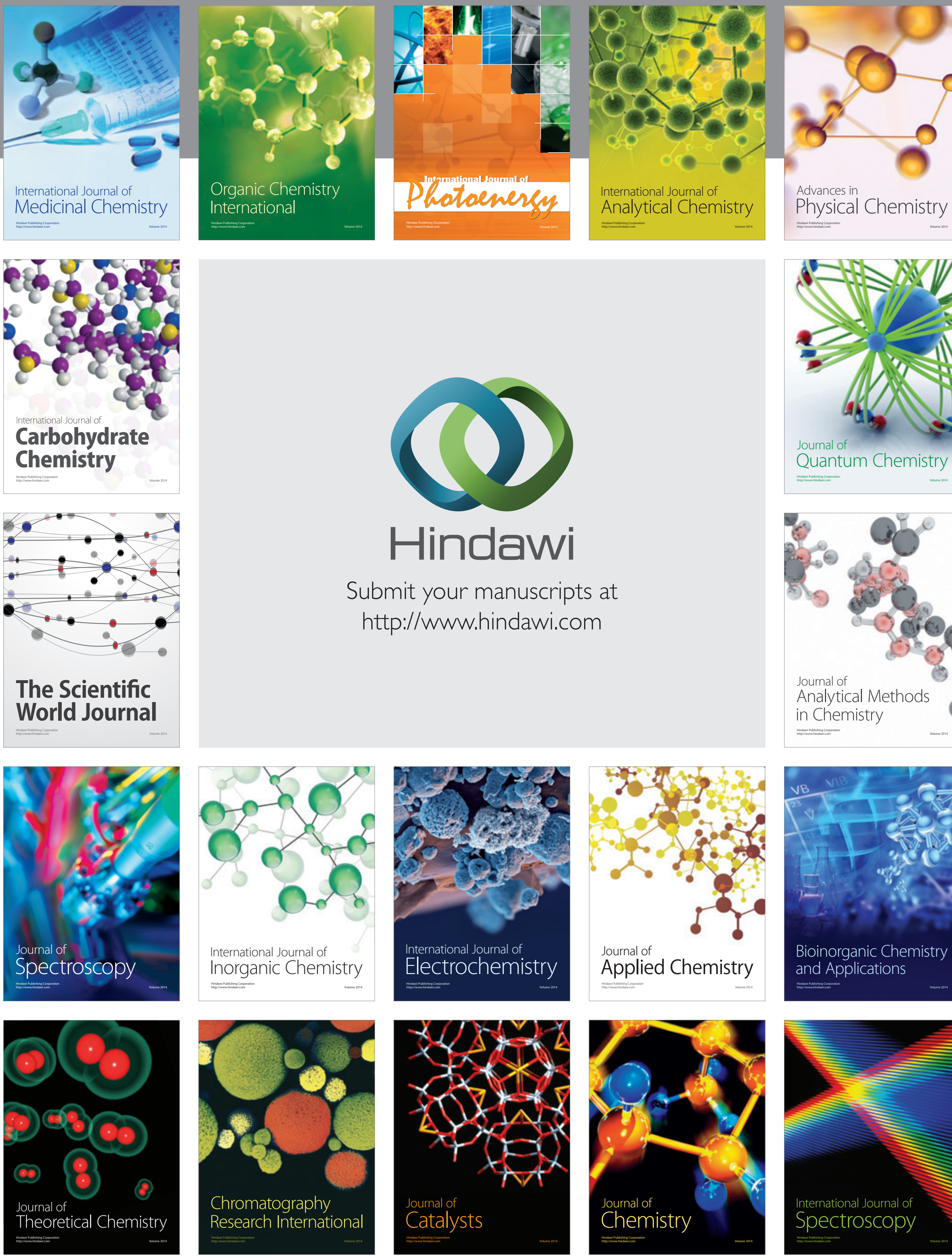
[11] V. V. Goncharuk, "A new concept of supplying the population with a quality drinking water," *Journal of Water Chemistry and Technology*, vol. 30, no. 3, pp. 129–136, 2008.

[12] O. P. Oksiyuk and V. M. Zhukiskii, "Environmental water quality standards for the Ros' River," *Hydrobiological Journal*, vol. 35, no. 6, pp. 16–21, 1999.

[13] V. V. Goncharuk, A. V. Rudenko, E. Z. Koval et al., "The problem of water infection with pathogens of mycoses and prospects of resolving this problem," *Journal of Water Chemistry and Technology*, vol. 26, no. 2, pp. 1–18, 2004.

[14] M. Fielding and M. Farrimond, *Disinfection by-Products in Drinking Water: Current Issues*, Royal Society of Chemistry, Cambridge, UK, 1999.

[15] V. V. Goncharuk, N. A. Klimenko, L. A. Savchina, T. L. Vrubel, and I. P. Kozyatnik, "Water treatment and demineralization technology: current issues in the technology of drinking water conditioning," *Journal of Water Chemistry and Technology*, vol. 28, no. 1, pp. 2–49, 2006.


International Journal of Medicinal Chemistry
Organic Chemistry International
International Journal of Photoenergy
International Journal of Analytical Chemistry
Advances in Physical Chemistry
International Journal of Carbohydrate Chemistry
Hindawi
Submit your manuscripts at
http://www.hindawi.com
Journal of Quantum Chemistry
The Scientific World Journal
Journal of Analytical Methods in Chemistry
Journal of Spectroscopy
International Journal of Inorganic Chemistry
International Journal of Electrochemistry
Journal of Applied Chemistry
Bioinorganic Chemistry and Applications
Journal of Theoretical Chemistry
Chromatography Research International
Journal of Catalysts
Journal of Chemistry
International Journal of Spectroscopy