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Comparative hygienic assessment of hard water impact before and after its stabilization treatment on the functional state of the central nervous system and kidneys of rats (on the example of the Olkhovska water treatment plant, Ukraine)

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Abstract. According to WHO data, the population health level on 80% is bonded with drinking water quality and water supply characteristics. Quality of drinking water is worsening during its transportation through distribution pipelines due to their internal corrosion, what leads also to negative economic effects. According to available literature data, the most effective simultaneous corrosion and scale control can be provided by chemical Sea-Quest, empirical formula $Na_{35}H_5P_{26}O_{85}$, manufacturing by Aqua Smart, Inc., USA. Studying of drinking water stabilizing treatment by chemical Sea-Quest influence on functional state of laboratory animals' organs and systems were conducted by us. Bibliographical analysis of scientific information, chemical, physical, physic-chemical, electrochemical, gravimetric, physiological, statistical research methods were used.

Key words: composition and properties of drinking water, internal corrosion, deposits, chemical Sea-Quest, Wistar line rats.

1. Introduction

Losses from corrosion in industrialized countries account to 3-4% of gross national income. Ukraine is one of the most metal saturated countries in Eastern Europe, but its metal fund's corrosion protection level, durability and reliability is significantly less than level, which has already been reached by most industrialized countries. Metal constructions are mainly concentrated on the objects of basic industries, municipal and housing economy. In the Ukraine, about 20% (17 thousands of kilometers) of water supply and 10% (5.3 thousands of kilometers) of sewage networks are in poor condition. The problem of water distribution pipelines' internal corrosion is complemented by their tuberculosis that cause reduction of tubes' lumens and as a result – increasing in water transporting cost and pressure, sometimes substantial, leading to permanent increase in the number of accidents on city municipal objects (Pokhmurs'kyy, 2011).

According to available literature data, the most effective simultaneous corrosion and scale control can be provided by chemical Sea-Quest, empirical formula $Na_{35}H_5P_{26}O_{85}$, manufacturing by Aqua Smart, Inc., USA (hereinafter Sea-Quest) (Zagorodniuk et. al., 2015a, b).

Sea-Quest has chelating properties, which are manifested in prevention of polyvalent cations' insoluble compounds formation, inducing peptization of already formed sediment composed of polyvalent cations and forms monomolecular film on the inner surface of the pipes, stopping or significantly slowing corrosion (Aqua Smart, Inc., 2003).

Chemical has international certificates of NSF (USA) and DWI (UK), hygienic certificates of approval for manufacture, delivery, sale and use in Ukraine, Russia, Poland, England, Italy, Israel, USA, Germany and many other countries (Zagorodniuk et. al., 2015a, b; Prote, 2019).

Typically, corrosion rate is inversely proportional to the water saturation by minerals, and level of water saturation by minerals in its turn determines water ability to form deposits. Thus, the greatest interest is to study influence of slightly minerals gluted water treatment by Sea-Quest. Ability to form scaling depends upon hardness of water as well as it is known that increased hardness mainly affects water organoleptic properties deterioration and therefore has an indirect effect on central nervous system and plays role in occurrence and development of nephrolithiasis.

2. Study area

The objective of our research work was comparative hygienic assessment of impact from Olkhovka filtration plant water course load on the functional state of rats' central nervous system and kidneys before and after its treatment by chemical Sea-Quest.

To achieve this objective we have formulated the following tasks:

1) To find out macrocomponent composition of Olkhovka filtration plant water;
2) To calculate on the base of chemical composition of Olkhovka filtration plant water dose of Sea-Quest for water treatment;
3) To determine stability and corrosivity of Olkhovka filtration plant water before and after its treatment by Sea-Quest;
4) To find out values of basic organoleptic and sanitary-toxicological parameters of Olkhovka filtration plant water safety and quality;
5) To conduct comparative hygienic assessment of treated and untreated by Sea-Quest Olkhovka filtration plant water impact on functional state of rats' central nervous system and kidneys.

3. Materials and methods

Researches were conducted in the laboratories of State Institution – Ukrainian Research Institute of Medical Rehabilitation Therapy of Ministry of Health of Ukraine, Institute of Hygiene and Ecology, and O.O. Bogomolets National Medical University Department of Hygiene and Ecology # 1.

Drinking water of II ascent from Olkhovka filtration station (purified water supplied to the water distribution network, hereinafter Olkhovka filtration plant drinking water) before and after stabilizing treatment as well as its impact on functional state of rats' CNS and kidneys were studied. We have used the following methods: bibliographical analysis of scientific information, chemical, physical, chemical, electrochemical, gravimetric, physiological, statistical research methods (i.e. Trakhenberg et al., 1978; Trakhenberg, 1991).

Studying of water composition and properties before and after its stabilizing treatment were conducted in accordance with generally accepted methods (Voda pitievaia. Metody analisa [Drinking water. Methods of analysis], 1974; Gigienichni vymohy do vody pytnoi, pryznatchenoi do spozhzhyvannia ludunoyu: DSanPin 2.2.4 – 171 – 10 [Hygienic requirements to drinking water intended for human consumption: State Sanitary Rules and Norms 2.2.4. – 171 – 10], 2010; HACH USEPA methods, 2008).

Determinations and assessment of values for Langelie-saturation index and Ryznar stability index were conducted in accordance with aggregated standards of water consumption and sewerage for various industries (Ukrupnennyye normy vodopotrebleniya i vodootvedeniya dlya razlichnykh otrasley promyshlennosti, 1982), and values of water stability index were determined experimentally according to the requirements of state standard (Metody technologitcheskogo analisa. Opredelenie stabilnosti vody. Voda choziayistvenno-pitievogo i promyshlennogo vodosnabzhenia. GOST 3313-46, 1946).

Determination of corrosive aggressiveness of water was conducted by electrochemical method of integrated corrosion rate of metal assessment through periodical measurements of instantaneous corrosion rate using P5126 during 14 days in accordance with general requirements and methods of control (SOU HME 42.00 – 35077234.010:2008 (Ukrainian National standard), 2008).

For water treatment liquid form of chemical Sea-Quest – Sea-Quest liquid – was used. Dose of chemical Sea-Quest liquid was calculated as follows:

$$C_{SQ} = (C_{CaCO3}/200 + C_{Fe} + C_{Mn} + \sum C_{Me2+} + 0{,}15) / \rho, \qquad (1)$$

Where C_{SQ} – dose of chemical Sea-Quest liquid in cm^3/m^3, which is needed for stabilizing treatment of water

C_{CaCO3} – total hardenss of water stabilizing treatment of which by Sea-Quest is conducted, expressed in ppm $CaCO_3$

C_{Fe} – concentration of total iron in water stabilizing treatment of which by Sea-Quest is conducted, expressed in ppm

C_{Mn} – concentration of manganese in water stabilizing treatment of which by Sea-Quest is conducted, expressed in ppm

$\sum C_{Me2+}$ – sum of all other divalent metals (excluding ferrous iron and managanese), which are in water, stabilizing treatment of which by Sea-Quest is conducted, expressed in ppm

If $\sum C_{Me2+}$, expressed in ppm, does not exceed 10% of calculated C_{SQ}, then within ±5% of calculated, C_{SQ} could be adjusted for convenience of practical application.

ρ – density of certain lot of Sea-Quest liquid (according to manufacturer's data deviations from 1.3 to 1.35 g/cm^3 are accaptable).

Physiological studies were conducted on Wistar line white rats weighting 180.0 – 200.0 g without regard to their gender. During the experiment, the animals were under constant food and drinking regime.

All bioethical aspects were taken into consideration while planning and conducting research. The studies were conducted taking into account the requirements of European Commission (Directive 2010/63/EU "On the protection of animals used for scientific purposes", Official Journal of the European Communities, 2010), Ministry of Education and Science of the Ukraine (Command dated 01.03.2012 # 249 «About approval by scientific institutions of studies, experiments on animals» registered by the Ministry of Justice of Ukraine on March 16, 2012 by # 416/20729) and Ministry of Public Health of the Ukraine (Command dated 28.09.2009 # 692 «About approval of methodical recommendations and research methods of natural medicinal resources and preformed remedies biological effects dated 28.09.2009).

Studied water was carried into stomach of rats using soft probe with olive once a day fractionally – 6th equal volume portions, all of which were administered, taking into account circadian biorhythm of rats in the evening (about 17.00), total dose of 1% of experimental animal body weight.

Comprehensive survey of rats was carried out after 16-18 hours after last carrying in of water. Received data were compared with those of intact rats.

Scope of research was to determine functional state of central nervous system and kidneys of rats after course of animals' load by Olkhovka filtration plant drinking water before and after stabilizing treatment by chemical Sea-Quest.

Published methodological approaches and methods were used for conduction of described above researches (Zamoshchina et al., 1997; Aleksyeyenko et. al., 2002).

In case of biological activity and safety determination statistical analysis of data in series of experiments was conducted using indirect differences (Kaminskiy, 1964). In case of animals' course loads by Olkhovka drinking water filtration plant before and after treatment by chemical Sea-Quest data were processed using method of direct regressive dependence (Venchikov A.I. & Venchikova V.A., 1974).

4. Results and discussion

Results of macrocomponent composition research of Olkhovka filtration plant water are in Table 1.

Chemical composition of Olkhovka filtration plant drinking water can be expressed by formula:

$$\mathbf{M\ 1.97\ \frac{SO_4\ 60\ (HCO_3{+}CO_3)\ 29\ Cl\ 12}{(Na+K)\ 74\ Mg\ 16\ Ca\ 10}}$$

Water by content of major ions is sodium bicarbonate-sulfate.

For calculation of Sea-Quest dose for stabilizing treatment company-manufacturer recommends to determine total hardness in ppm $CaCO_3$, and not in other units (eg in $mmol/dm^3$ or $mgEq/dm^3$, as it is common for CIS countries) with subsequent recalculation of received values in ppm $CaCO_3$. Methodology for determination of bivalent metals amount in water, which is used in country of chemical Sea-Quest origin – the USA and CIS countries is based on different approach. Taking this into consideration, we have decided to determine total hardness and metal content: iron (total and ferrous) and manganese using GOST techniques that found wide spreading in CIS countries and HACH USEPA methods, which are used in the USA.

Results of measurements are provided in Table 2.

It should be noted that total hardness determined according to the requirements of GOST 4151, after conversion into ppm $CaCO_3$ differ from results obtained by determining total hardness in accordance with procedure HACH Method 8213 «Hardness, total» in ppm $CaCO_3$: 7.15 mgEq/dm^3 x 50.05 ≈ 358 ppm $CaCO_3$ versus 485 ppm $CaCO_3$ in case of parameter's value determination using direct method without further units' convertion.

Calculated according formula (1) dose of chemical Sea-Quest, which is necessary for Olkhovka filtration plant drinking water treatment is 2.6 mg of dry substance per

1 dm^3, what is eaquel to 6 µl of chemical solution with density 1.35 g/cm^3 per 1 dm^3 of treating water.

For research conducting water, this was storing before and after treatment under constant temperature conditions, which were created and maintained in laboratory premises using air conditioners, was used. Temperature of water was 18±2°C.

Parameters' values for water before and after stabilizing treatment, which are used for calculation of the Langelier index and Ryznar stability Index, calculated values of these indices are provided in the Table 3.

Despite the fact that due to stabilizing treatment using chemical Sea-Quest Langelier index decreased from 1.06 to 1.0, while Ryznar stability index increased from 6.09 to 6.14, their assessment remains the same radically different. Thus, taking into consideration Langelier index values both before and after stabilizing treatment serious scaling should be expected, and taking into consideration Ryznar stability index mild corrosion should be expected.

During experimental determination of water stability its pH and alkalinity before and after shaking with excess of chemically pure calcium carbonate were measured.

Values of instantaneous and integrated corrosion rates determined using polarization method as well as water stability, determained according to the main method (by alkalinity) and additional (by pH) are provided in Table 4.

Results of conducted researches indicate that treatment of Olkhovka filtration plant drinking water by chemical Sea-Quest there are radical changes its stability, determined in accordance with GOST 3313 (treatead water dissolves better chemically pure calcium carbonate) and decreasing of its corrsoivety, determined by electrochemical method of polarization resistance in accordance with SOU HME 42.00 – 35077234.010:2008.

Table 1. Macrocomponent composition of Olkhovka filtration plant drinking water

Names of the parameters	**Units of mesurements**	**Amounts**			
		Olkhovka filtration plant drinking water	**WHO requirements, Guidelines for Drinking-water quality, Fourth Edition**	**Requirements of SSRaN 2.2.4-171-10**	
				Sanitary-chemical parameters of drinking water safety and quality	**Parameters of physiological usefulness of drinking water mineral composition**
Sodium and Potassium	mg/dm^3	477.3	is not standardized * (200-300)	Na ≤ 200, K – is not determined**	Na: 2-20; K: 2-20.
Calcium	mg/dm^3	54.0	is not determining	is not determining	25-75
Magnesium	mg/dm^3	54.1	is not determining	is not determining	10-50
Chlorides	mg/dm^3	117.2	Not more than 250	Not more than 250 (350)	is not determined
Sulfates	mg/dm^3	797.7	Not more than 500	Not more than 250 (500)	is not determined
Carbonates	mg/dm^3	21.0	is not determining	is not determining	Total alkalinity: 0,5-6,5 $mmol/dm^3$
Hydrogen carbonates	mg/dm^3	445.3	is not determining	is not determining	Total alkalinity: 0,5-6,5 $mmol/dm^3$
TDS	mg/dm^3	1966.6	Not more than 1000	Not more than 1000 (1500)	200-500

* WHO experts believe that at concentrations that can significantly affect human health the substance is not found in drinking water. However, it is noted that exceeding of values provided in brackets may cause denial to use such water due to the deterioration of its organoleptic properties.

** Determination of parameters' values is not obligatory for making conclusion about safety and quality of drinking water or physiological usefulness of its mineral composition.

Table 2. Total hardness of Olkhovka filtration plant drinking water and content of metals, which are determining dose of chemical Sea-Quest for stabilizing treatment

Names of the parameters	Units of measurements	Contents				Methods of measurements
		Olkhovka filtration plant drinking water	WHO requirements, Guidelines for drinking-water quality, Fourth Edition (2011)	Requirements of SSRaN 2.2.4-171-10		
				Sanitary-chemical parameters of drinking water safety and quality	Parameters of physiological usefulness of drinking water mineral composition	
Total hardness	mg-Eq/dm^3	7.15	are absent*	not more than 7.0 (10.0)[1]	1.5 – 7.0	GOST 4151
Total iron	mg/dm^3	< 0.05	≤ 0,3 (are absent)[2]	≤ 0.2 (1.0) [1]	is not determining **	GOST 4011
Manganese	mg/dm^3	0.005	≤ 0.1 (0.4)[2]	≤ 0.05 (0.5)[2]	is not determining **	GOST 4974
Copper	mg/dm^3	0.0012	≤ 2.0	≤ 1.0	is not determining **	GOST 4388
Zinc	mg/dm^3	0.0021	≤ 3 (are absent)[2]	≤ 1.0	is not determining **	GOST 18293
Hardness, total	ppm $CaCO_3$	485	are absent*	not more than 7.0 (10.0)[1]	1.5 – 7.0	HACH Method 8213 “Hardness, total”
Iron, total	ppm	0.02	≤ 0.3 (are absent)[2]	≤ 0.2	is not determining **	HACH Method 8008 “Iron, Total. FerroVer Method”
Iron, ferrous	ppm	< 0.02	≤ 0.3 (are absent)[2]	≤ 0.2	is not determining**	HACH Method 8146 “Iron, Ferrous. 1,10-Phenanthroline Method”
Manganese	ppm	< 0.1	≤ 0.1 (0.4)[2]	≤ 0.05 (0.5)[2]	is not determining	HACH Method 8034 “Manganese. Periodate Oxidation Method”

1 – Values provided in brackets could be used by water treating enterprise up to 1 January of 2020 in some cases associated with specific natural conditions and technology of drinking water processing, which does not allow to get drinking water quality to stricter regulation, what must be indicated in technical specifications or other documents describing drinking water production process.
2 – Values provided in brackets are substantiated from position of direct impact on human health.
* WHO experts believe that available data does not allow to establish substantiated from the position of effects on human health neither minimum nor maximum values of drinking water total hardness, total iron, zinc content. Drinking water total hardness standardizing as well as total iron, zinc content in different countires of the world is based on consumer, economic and operational positions.
** Determination of parameters’ values is not obligatory for making conclusion about safety and quality of drinking water or physiological usefulness of its mineral composition.

Table 3. Parameters' values for water before and after stabilizing treatment, which are used for calculation of Langelier Index and Ryznar Stability Index, calculated values

Names of the parameters	**Units of mesurements**	**Olkhovka filtration plant drinking water**		**Methods of measurement**
		before treatment	**after treatment**	
pH	units of pH	8.20	8.15	ISO 10523:1994, MOD
Temperature	^0C	18.0	18.0	-
TDS	ppm	1960	1961	-
Hardness, total	ppm $CaCO_3$	485	482	HACH Method 8213 "Hardness, total"
Bicarbonate alkalinity	ppm $CaCO_3$	446	442	HACH Method 8203 "Alkalinity. Phenolphthalein and Total Method"
Saturation pH (calculation)	units of pH	7.14	7.15	Aggregated standards of water consumption and sewerage for various industries
Langelier Index	-	1.06	1.0	Aggregated standards of water consumption and sewerage for various industries
Ryznar Stability Index	-	6.09	6.14	Aggregated standards of water consumption and sewerage for various industries

Table 4. Values of corrosion rates and water stability before and after its stabilizing treatement, determined by experimental pathway

Names of the parameters	**Units of mesurements**	**Olkhovka filtration plant drinking water before treatment**	**Parameter assesmant**	**Olkhovka filtration plant drinking water after treatment**	**Parameter assesmant**
Instantaneous corrosion rate (Ip)	mm/year	0.261	alert	0.049	moderate
Integrated corrosion rate	mm/year	0.210	alert	0.047	moderate
Index of water stability by pH	-	0.935	baseness	0.869	baseness
Index of water stability by alkalinity	-	1.0	stable solution	0.801	baseness

Table 5. Impact of Olkhovka filtration station drinking water on the duration of falling sleep and sleep duration ("opiate test")

Parameters* Steps of research	**Duration of falling sleep, min**		**Sleep duration, min**	
	(M_1±m_1)	**n**	**(M_2±m_2)**	**n**
Control group	3.30 ± 0.15	5	26.90±1.26	5
Study group	3.37±0.40	5	36.87±8.10	5
D	+0.07	5	+9.97	5
p	>0.5	5	>0.2	5

*Notation conventions hereinafter: M – arithmetic mean; m – the arithmetic mean error; D – difference; p – degree of probability; n- number of rats.

Values of all main organoleptic and sanitary-chemical parameters of safety and quality of Olkhovka filtration plant drinking water meet the requirements of State Sanitary Rules and Norms 2.2.4-171-10 as well as WHO requirements, except mercuri content, which is above established by State Sanitary Rules and Norms 2.2.4-171-10 numbers, but within values recommended by WHO experts. Adding of chemical Sea-Quest does not change mercuri content in treating water.

By the main parameters of radiation safety (total activity of uranium isotopes' natural mixture, total volume activity of Radium-226 and Radium-228, etc.) Olkhovka filtration plant drinking water completely meet requirements both of State Sanitary Rules and Norms 2.2.4-171-10 and WHO (Guidelines for drinking-water quality, 2011).

Taking into consideration that at the moment of research conducting it was not possible to determine choloro-fom content – main byproduct of chlorination in drinking water, which is affecting the duration of falling sleep and sleep duration, we run opiate test for Olkhovka filtration plant drinking water. The research results of Olkhovka filtration plant drinking water impact on duration of falling sleep and sleep duration are given in Table 5.

Statistically processed above mentioned data demonstrate no significant alteration of falling sleep duration as well as duration of narcotic sleep ($p > 0.5$ and $p > 0.2$, respectively) in case of animals' load by Olkhovka filtration plant drinking water, indicating the absence of influence on the functional state of the CNS from such load and indirectly not exceeding of chloroform MAC in tested water.

Course load of rats by Olkhovka filtration plant drinking water after its treatment using chemical Sea-Quest doesn't influence on amount of animals' exits to the Center in comparison with control group ($p > 0.5$), but number of crossed squares is significantly higher than in control group ($p < 0.001$), and lower than in control group are values for number of vertical stands ($p < 0.001$) and number of submerging in burrows ($p < 0.05$) – see listed in Table 6 data.

The influence of water on CNS before and after its treatment by chemical Sea-Quest is in direct relation to the duration of water load course, indicating on the presence of slight cumulative effect.

Summarizing received data, it can be argued that treatment of Olkhovka filtration plant drinking water by chemical Sea-Quest in general has a positive effect on the functional state of rats' central nervous system.

Data regarding influence of Olkhovka filtration plant drinking water before and after its treatment by chemical Sea-Quest on functional state of rats' kidneys are provided

Table 6. Influence on CNS functional state by the «open field» parameters of rats' course loads by Olkhovka filtration station drinking water after its treatment by chemical Sea-Quest

Parameters	Control group		Study group				D	P
			Average value of parameter per course		Regression analysis			
	$(M_1 \pm m_1)$	n	$M_2(y_{14}/y_{av.}) \pm m_2$	n	$(y = a \pm k \bullet x_n)$	pk		
Number of exists to the center, n	1.33±0.37	5	1.24±0.10	10	$y = 1.40 - 0.036 \bullet x_n$	>0,2	–0,09	>0,5
Number of crossed squares, n	56.80±1.90	5	68.04±1.13	10	$y = 70.64 - 0.65 \bullet x_n$	>0,05	+11,24	<0,001
Number of vertical stands, n	19.40±1.20	5	11.86±0.35	10	$y = 9.99 + 0.27 \bullet x_n$	<0,02	–7,52	<0,001
Number of submerging in burrows, n	15.80±1.90	5	11.19±0.20	10	$y = 11.10 + 0.02 \bullet x_n$	>0,5	–4,61	<0,05
Grumings, s	25.20±4.16	5	19.48±1.62	10	$y = 27.18 - 1.10 \bullet x_n$	<0,01	–5,72	<0,001
Grumings, n	3.00±0.25	5	2.83±0.20	10	$y = 3.81 - 0.14 \bullet x_n$	<0,05	–0,17	>0,5
Fadings, s	4.20±1.15	5	4.20±1.15	10	-	-	-	-
Fadings, n	1.00±0.0001	5	1.00±0.0001	10	-	-	-	-
Boluses, n	1.40±0.30	5	2.44±0.14	10	$y = 3.21 - 0.11 \bullet x_n$	<0,01	+1,04	>0,2

Notation conventions hereinafter:

$(y=a \pm k \cdot x_n)$ – regression equations, where y – parameter; a– calculated value; ±k – regression coefficient; x_n – day of course load;

$M_2 y_{av.}$ – average value of the parameter per course in case of reliable dynamics absence;

$M_2 y_{14}$ – average value of the parameter per course in case of reliable dynamics presence;

D – difference of parameter's value with control group; P – degree of "D" probability.

Table 7. Influence of Olkhovka filtration station drinking water before and after treatment by chemical Sea-Quest on fumctional state of rats' kidneys

Parameters, Units of mesurements	**Control group, n = 7, ($M_1 \pm m_1$)**	**Water before treatment, n = 11**			**$D_{1,2}$**	**$P_{1,2}$**	**Water after treatment, n = 11**			**$D_{1,3}$**	**$P_{1,3}$**
		($M_2 \pm m_2$)	**Regression analysis**	**P_k**			**($M_3 \pm m_3$)**	**Regression analysis**	**P_k**		
Daily dieresis, ml/cm² of body surface	1.03±0.12	2.07±0.09	$y=1.99+0.02\ x_6$	>0.2	+1.04	<0.001	1.77±0,14	$y=1.49+0.07\ x_6$	>0.05	+0.74	<0.001
Glomerular Filtration Rate, ml/(cm²·min)	0.06±0.01	0.15±0.005	$y=0.15+0.005\ x_6$	>0.5	+0.09	<0.001	0.14±0,01	$y=0.08+0.008\ x_6$	<0.001	+0.08	<0.001
Tubular reabsorption, %	98.46±0.27	99.09±0.02	$y=99.10-0.004\ x_6$	>0.5	+0.63	<0.05	98.93±0,06	$y=98.58+0.05\ x_6$	<0.01	+0.47	>0.1
Excretion of creatinine, mmol	0.006±0.001	0.016±0.0005	$y=0.015+0.0001\ x_6$	>0.5	+0.010	<0.001	0.015±0,001	$y=0.008+0.001\ x_6$	<0.001	+0.009	<0.001
Excretion of urea, mmol	0.56±0.05	0.94±0.06	$y=0.86+0.02\ x_6$	>0.2	+0.38	<0.001	0.91±0,05	$y=0.85+0.015\ x_6$	>0.2	+0.35	<0.001
pH of urine, units of pH	6.00±0.001	6.64±0.08	$y=6.60+0.009\ x_6$	>0.5	+0.64	<0.001	6.37±0,04	$y=6.28+0.024\ x_6$	>0.05	+0.37	<0.001

in Table 7. These data indicate that drinking water before treatment by chemical Sea-Quest, which was introduced to the rats' stomachs during week course, has no cumulative capacity of its effects, basing on absence of regression tests changes depending on the duration of load course by water.

The increase in daily diuresis through glomerular filtration increasing, stimulation of creatinine and urea daily excretion, as well as shift of acid-base reactions of daily urine to alkaline side, are appearing at the beginning of introduction to the rats' stomachs water and are held until the end of the course. Effects of treated water on renal function parameters are similar to untreated water, except tubular reabsorption, which has no differences with control group, but in general it is positive.

Course of Olkhovka filtration plant drinking water introduction to the rats' stomachs at daily dose of 1% from body weight compared to control group stimulates diuresis, accompanied by stable daily excretion of creatinine and urea from the body of animals.

Course of Olkhovka filtration plant drinking water after treatment by chemical Sea-Quest introduction to the rats' stomachs at daily dose of 1% from body weight compared to control group stimulates diuresis, accompanied by stable daily excretion of potassium and sodium from the body of experimental animals, and increase excretion of creatinine, urea and chlorides from the body of animals and compared to the same introduction course of initial Olkhovka filtration station drinking water, which did not pass treatment by chemical Sea-Quest:

– improves emotional state of animals and their orienteering-research activity;
– does not change diuresis, and at this stable daily excretion of creatinine and urea from the body of the animals also does not change;
– does not cause damage to target organs (stomach, liver, myocardium, kidneys).

5. Conclusions

1. Drinking water of II ascent from Olkhovka filtration station by content of major ions is sodium bicarbonate-sulfate.
2. Dose of chemical Sea-Quest, empirical formula $Na_{35}H_5P_{26}O_{85}$, which is needed for stabilizing treatment of Olkhovka filtration station drinking water is 2.6 mg dry per 1 dm^3.
3. Langelier Index and Ryznar Stability Index calculation for water treatment by chemical Sea-Quest efficiency assessment is uninformative.
4. Determination of water stability using experimental method in accordance with GOST 3313 and corrosion rates determined using electrochemical method of polarization resistance in accordance with SOU HME 42.00 – 35077234.010:2008 are informative and quite adequate in assessing both the ability of drinking water to form deposits or strength internal corrosion in household-drinking water supply systems and efficiency of water treatment by chemical Sea-Quest.
5. TDS and content of sulfates in Olkhovka filtration plant drinking water exceed established by WHO and State Sanitary Rules and Norms 2.2.4-171-10 MACs. Total hardness and content of mercury in Olkhovka filtration plant drinking water exceed established by State Sanitary Rules and Norms 2.2.4-171-10 MACs, but within normative values recommended by WHO. Integrated corrosion rate caused by Olkhovka filtration plant drinking water is 0.210 mm / year and in accordance with SOU HME 42.00 – 35077234.010:2008 this is alert. These features of composition and properties of Olkhovka filtration plant drinking water are manifested by presence of effects that are appearing at the beginning of introduction to the rats' stomachs water and are held until the end of the course: increase in daily diuresis through glomerular filtration increasing, stimulation of creatinine and urea daily excretion, as well as shift of acid-base reactions of daily urine to alkaline side. Olkhovka filtration plant drinking water before its stabilizing treatment, which was introduced to the rats' stomachs during week course, has no cumulative capacity of its effects, basing on absence of regression tests changes depending on the duration of load course by water.
6. Drinking of Olkhovka filtration plant drinking water, which was treated by chemical Sea-Quest, empirical formula $Na_{35}H_5P_{26}O_{85}$, positively affects on function of central nervous system and kidney of Wistar line rats, including grading of micromercurialism negative effects.
7. Stabilization treatment of drinking water by chemical Sea-Quest can be recommended as one of the measures for improving quality of tap drinking water supplied to end consumers.

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References

Aleksyeyenko N.O., Pavlova O.S., Nasibulin B.A. & Ruchkyna A.S., 2002, Posibnyk z metodiv doslidzhen' pyrodnykh ta preformovanykh zasobiv: mineral'ni pyrodni likuval'no-stolovi ta likuval'ni vody; peloyidy, rozsoly, hlyny, vosky ta preparaty na yikhniy osnovi [Guide to research methods of natural and preformed products: mineral natural healing-table and healing waters; peloids, brines, clays, waxes and thereon based preparations], Part III. Experimental and preclinical studies. SOCIO, Kyiv, 120 pp. (in Ukrainian).

Aqua Smart, Inc., SeaQuest® Corrosion Control, 2003, (http://www.aquasmartinc.com/).

Command of Ministry of Education and Science of the Ukraine # 249 dated 01.03.2012, About approval by scientific institutions of studies, experiments on animals. (https://zakon.rada.gov.ua/laws/show/z0416-12).

Command of Ministry of Public Health of the Ukraine # 692 dated 28.09.2009, About approval of methodical recommendations and research methods of natural medicinal resources and preformed remedies biological effects. (https://zakon.rada.gov.ua/rada/show/v0692282-09/card6).

Council Directive 2010/63/EU, 2010, On the protection of animals used for scientific purposes [Assessed on 22 September 2010]. Official Journal of the European Communities. L 276: 33 – 79.

Guidelines for drinking-water quality, 4th ed., 2011, WHO Press, Geneva, Switzerland, 541 pp.

Gigienichni vymohy do vody pytnoi, pryznatchenoi do spozhzhyvannia ludunoyu. DSanPin 2.2.4 – 171 – 10. [Hygienic requirements to drinking water intended for human consumption. State Sanitary Rules and Norms 2.2.4. – 171 – 10], 2010, Kyiv, 31 pp. (in Ukrainian).

HACH USEPA methods, 24 ed., 2008, Loveland, Colorado, 295 pp.

Kaminskiy L.S., 1964, Statisticheskaya obrabotka laboratornykh i klinicheskikh dannykh. Primeneniye statistiki v nauchnoy i prakticheskoy rabote vracha [Laboratory and clinical data statistical analysis. The use of statistics in scientific and practical work of doctor], 2nd ed. Medicine, Saint Peterburg, 250 pp. (in Russian).

Metody technologitcheskogo analisa. Opredelenie stabilnosti vody. Voda choziayistvenno-pitievogo i promyshlennogo vodosnabzhenia. GOST 3313-46 [Methods of technological analysis. Determination of water stability. Water of household-drinking and industrial water supply]. State standard 3313-46, 1946, Moscow, (in Russian).

Pokhmurs'kyy V.I., 2011, Pro stan zakhystu metalofondu Ukrayiny vid koroziyi [About level of protection against corrosion for Ukrainian metal fund]. Scientific Papers' Collection of V.M. Shymanovs'kyy Ukrainian Institute of Steel Structures, Ukraine: 64-69 (in Ukrainian).

Prote, 2019, Sea-Quest. (https://www.yelp.com/biz/prote-bioremediacja-ropopochodnych-prote-technologie-dla-pozna%C5%84).

Systemy tsentralizovanogo gospodarsko-pytnogo vodopostachchannia ta comunalnogo teplopostachchiannia. Zahyst protukoroziyniy. Zagalni vymogy ta metody controluvannia. SOU ZhKCh 42.00 – 35077234.010:2008 [Systems of centralized household-drinking water supply and municipal heating. General requirements and methods of control. SOU HME 42.00 – 35077234.010:2008 (Ukrainian National standard)], 2008, Kyiv, 14 pp. (in Ukrainian).

Trakhtenberg I.M., 1991, Problema normy v toksikologii (sovremennyye predstavleniya i metodicheskiye podkhody. osnovnyye parametry i konstanty) [The problem of norm in toxicology (Modern vision and Methodological approaches, Basic Parameters and Constants)], 2nd ed., revised and enlarged. Medicine, Moscow, 243 pp. (in Russian).

Trakhtenberg I.M. et. al., 1978, Pokazateli normy u laboratornykh zhivotnykh v toksikologicheskom eksperimente. [Indicators of norm for laboratory animals in toxicological experiment]. Medicine, Moscow, 176 pp. (in Russian).

Ukrupnennyye normy vodopotrebleniya i vodootvedeniya dlya razlichnykh otrasley promyshlennosti [Aggregated standards of water consumption and sewerage for various industries], Council of Economic Mutual aid, All Soviet Unioin Scientific-Research Instiiute for Water Supply, Sewerage, Hydrotechnics, Construction and Engineering Hydrogeology, 2nd ed., 1982, Construction Publishing, Moscow, 528 pp. (in Russian).

Venchikov A.I. & Venchikova V.A., 1974, Osnovnyye priyemy statisticheskoy obrabotki rezultatov nablyudeniy v oblasti fiziologii [Basic techniques for statistical processing of observations' results in the area of physiology]. Medicine, Moscow, 154 pp. (in Russian).

Voda pitievaia. Metody analisa [Drinking water. Methods of analysis], 1974, Official Standards' Publish House, Moscow, 195 pp. (in Russian).

Zagorodniuk K., Bardov V., Omelchuk S., Zagorodnyuk Yu. & Pelo I., 2015a, Hygiene of water and water supply: science, practice, enlightenment work and teaching activity in the Ukraine at the modern stage of its development. Materials of International scientific-practical congress of pedagogues, psychologists and medics “Driven to discover”, the 5 th of June, Geneva (Switzerland): 189-99.

Zagorodniuk K., Bardov V., Omelchuk S., Zagorodnyuk Yu. & Pelo I., 2015b, Ukraine’s population water supply: nowadays realities and ecologically-hygienic assessment of possible ways of branch’s development. International scientific periodical journal “The Unity of Science”, Vena (Austria): 193 – 202.

Zamoshchina T.A., Grebennikova E.V. & Lopukhova V.V., 1997, Vliyaniye povrezhdeniya golubogo pyatna ili yader shva na tsirkadnyye ritmy krys. testirovannykh v otkrytom pole [Impact of coeruleus or raphe nuclei damage on rats’ circadian rhythms tested in open field]. Journal of Higher Nervous Activity 47(3): 577-583 (in Russian).