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Dear Esteemed Readers, Authors, and Colleagues,

I hope this letter finds you in good health and high spirits. It is my distinct pleasure to address you as the Editor-in-Chief of Integrative Omics and Applied Biotechnology (IIOAB) Journal, a multidisciplinary scientific journal that has always placed a profound emphasis on nurturing the involvement of young scientists and championing the significance of an interdisciplinary approach.

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I would like to extend my gratitude to our authors, reviewers, editorial board members, and readers for their unwavering support. Your dedication is what makes IIOAB Journal the thriving scientific community it is today. Together, we will continue to explore the frontiers of knowledge and pioneer new approaches to solving the world's most complex problems.

Thank you for being a part of our journey, and for your commitment to advancing science through the pages of IIOAB Journal.

Yours sincerely,

Vasco Azevedo

***Vasco Azevedo**, Editor-in-Chief*
Integrative Omics and Applied Biotechnology
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ARTICLE

HORMONAL REACTIONS IN CHILDREN DURING DYNAMIC PHYSICAL LOAD

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ABSTRACT

One of the key functions of the catecholaminergic hormonal system or sympathetic-adrenal system (SAS) is the mobilization of the body's energy resources during muscle activity. The mechanisms of adaptation of children to dynamic physical activity differ in many ways from those in adults. Adaptation occurs mainly due to vegetative reactions, while the mobilization readiness of the SAS is insufficient. Physical activity is an integral part of the life of children and adolescents, however, at present, modern schoolchildren are dominated by static posture, and motor activity is reduced. The article describes the results of a study of the SAS reaction of children aged 7-15 to dosed physical activity subject to the age, gender, and the initial autonomic tone (IAT). Fluorometry was used to measure the levels of adrenaline (A), norepinephrine (NA), DOPA, and dopamine (DA) in the urine portion before and after exercise. The initial autonomic tone (IAT) was measured by the histogram obtained by cardiointervalography on an automated REACARD device. The conclusion about IAT was carried out according to the parameters of amplitude mode (AMo), variational range (ΔX) and regulatory mechanism stress index (SI). As a functional test, we used a 1.5 W bicycle stress test, calculated per 1 kg of the subject's body weight. An analysis of the level of excretion of A, NE, DA, and DOPA at a state of relative rest and after a bicycle stress test revealed that the nature of urgent adaptation of SAS in schoolchildren varies with age, and depends on the gender and autonomic tone of children. Differences between children with sympathetic and vagotonic initial autonomic tones were revealed. Regardless of age, the reaction of sympathotonic children is more adequate, indicating an emergency mobilization of the body's energy resources. Vagotonic children at the age of 9.10 and 14.15 years showed a sharp decrease in the level of excretion of NE, DA, and DOPA, despite the low preload values. It is shown that the period of the most stable physical performance of children is the age of 9.10 years for boys and 7.12 years for girls, which allows us to consider it as the most favorable for the beginning of an intensive training process. It is shown that moderate and balanced SAS reactions are a prerequisite for sustainable physical performance of school-age children.

KEY WORDS
sympathetic-adrenal system, children's physical activity, initial vegetative tone

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INTRODUCTION

The adaptation mechanisms of children to physical activity are very different from those in adults [1,2]. An exceptional role in the nervous and humoral regulation of adaptation processes is played by SAS, one of the main functions of which is the mobilization of energy resources during muscular activity. Adaptation-trophic effects of the sympathetic nerves are transmitted to the skeletal muscles due to the mediator of norepinephrine (NE) adrenergic plexuses of blood vessels [3,4]. A short-term dosed physical activity causes activation of the hormonal link and an increase in adrenaline (A) as an "anxiety hormone", and long-term and moderate exercise cause an increase in NE as a "homeostasis hormone" [5]. Of great importance for assessing the reserve capabilities of SAS is the analysis of the shift of catecholamine precursors (CA). According to existing ideas, an increase in the excretion of A and NE against the increase in the level of dopamine (DA) and DOPA may indicate the mobilization of SAS reserves [6]. An adverse reaction is when an increase in CA is not accompanied by a corresponding increase in DA and DOPA. SAS reactivity can be widely used to assess the functional capabilities of this system in children at different ages and at different periods of education [4,5]. There is no doubt that the tone of the autonomic nervous system (ANS) affects the activity of the catecholaminergic system [7]. A functional test sample in the form of a dosed physical load allows us to judge the reserve capabilities of the regulatory system. The response of the body to the effect of a gradual load is regarded as reactivity [6], that is, a temporary characteristic of functional shifts, the direction of which depends on the degree of fitness for a given external stimulus. Physical activity causes the activation of SAS. However, quantitative and qualitative shifts in the excretion of spacecraft depend on the age of the children, the degree of fitness, the severity of psycho emotional stress, and the characteristics of the nervous system of the subjects [7].

The study showed that the proportion of metabolic reactions associated with muscle activity in children is relatively lower. Adaptation of an organism to physical activity occurs mainly due to vegetative reactions [8]. Moreover, the mobilization readiness of the SAS at the prelaunch stage is insufficient.

Against the background of a large number of scientific studies, the issues of age-gender characteristics of SAS reactions to physical dynamic loads, which are an integral part of the life of children and adolescents, have been little studied. Moreover, the assessment of the nature of the urgent adaptation of the SAS of the child's body is carried out, as a rule, without taking into account the initial state of the central and peripheral parts of the ANS. It is also known that vegetative tone is one of the most important parameters that reflect the direction of adaptive rearrangements during muscular activity [9,10].

The objective of this study was to study the tonic effects of the ANS on the adaptation of SAS to gradual physical activity in schoolchildren.

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MATERIALS AND METHODS

The experiment involved 130 children of 7-15 years old of both sexes, of the main health group. The level of A, NE, DOPA, and DA was fluorometrically [11] recorded in a portion of urine before and after exercise. The initial autonomic tone (IAT) was determined using the histogram obtained by the method of cardiointervalography on the automated REACARD complex. The conclusion about IAT was carried out according to the parameters of amplitude mode (AMo), variational range (ΔX) and regulatory mechanism stress index (SI) [10,12]. As a functional test, we used a 1.5 W bicycle stress test, calculated per 1 kg of the subject's body weight. Descriptive statistics and t-test were used. Written consent from the subjects or parents was taken and the study was approved by the Kazan University ethical committee.

RESULTS

It was found that autonomic tone affects the hormonal reactions of the body, the nature of shifts in gradual physical activity depends on the age of the children. In 7-year-old schoolchildren with a predominance of sympathetic influences, the level of A and NE increases from 25.30% to 33.00%, and DOPA and DA - from 19.13% to 4.93%. In vagotonic boys, on the contrary, the release of DA decreases against the background of stable values of A and NE (Tab. 1). In the normotonic state, the most significant shift is noted in relation to A, amounting to 6.50 ng/min ($p < 0.05$). An increase is also observed in the excretion of NE from 15.33±1.11 ng/min to 20.16±2.01 ng/min ($p < 0.05$). This is accompanied by an adequate increase in dopamine levels by 33.81 ng/min ($p < 0.05$). That is, the normotonic variant of IAT is the most balanced variant of autonomic regulation that characterizes favorable changes in SAS. The 7-year-old vagotonic boys show no significant shifts in CA excretion with a decrease in the DA level by 17.20 ng/min. The asthenization syndrome of the child's body and the lack of formation of adaptation mechanisms to dynamic loads in 7-year-old boys are likely to manifest.

With age, the SAS reaction changes. In vagotonic children aged 8 years, it is more balanced, with an increase in excretion of A and NE ($p < 0.05$) and an increase in DA (11.25%).

Table 1: The content of catecholamines and DOPA in the urine of 7-year-old boys and girls under the influence of a bicycle stress test with a different initial vegetative tone (M±m)

No.		IVT	Indicators: Dopamine, ng / min		DOFA, ng / min		Adrenalin, ng / min		Norepinephrine, ng / min	
			before	after	before	after	before	after	before	after
boys	1	S	139.94±5.84	165.88±8.01	14.84±1.69	16.00±1.94	8.11±0.56	10.71±0.92	18.55±1.16	23.26±2.24
			∑						∑	
	2	No.	183.81±8.68	216.47±10.12	19.10±1.85	20.35±1.94	8.33±0.21	14.83±0.98	15.33±1.11	20.16±2.01
			∑				α»		∑	
	3	V	165.30±7.37	148.10±4.65	15.45±1.34	15.28±1.47	7.96±0.59	7.92±0.64	15.94±1.02	15.09±0.96
girls	1	S	119.42±4.37	168.59±6.62	12.50±1.12	12.59±1.19	7.66±0.16	11.05±0.96	16.81±1.83	19.77±1.91
			∑				α»			
	2	No.	140.20±60.01	203.35±12.97	13.67±1.62	14.31±1.65	7.34±0.23	12.62±0.88	13.72±1.40	20.79±2.00
			α»				α»		α»	
	3	V	154.37±7.34	176.87±9.02	20.72±1.88	23.94±2.01	7.16±0.49	11.51±0.84	14.81±1.12	20.66±1.12
			∑				∑		∑	

Note: the differences are significant in comparison with the state at rest: «●» $p<0.05$; «●●» $p<0.01$

Table 2: The content of catecholamines and DOPA in the urine of 9-year-old boys and girls under the influence of a bicycle stress test with a different initial vegetative tone (M±m)

No.		IVT	Indicators: Dopamine, ng / min		DOFA, ng / min		Adrenalin, ng / min		Norepinephrine, ng / min	
			before	after	before	after	before	after	before	after
boys	1	S	127.30±6.96	123.10±10.97	11.76±1.00	11.04±1.22	6.26±0.42	7.47±0.59	15.31±1.61	18.83±1.82
	2	No.	213.99±11.34	214.02±12.05	15.64±1.36	16.02±1.48	7.98±0.64	10.72±0.90	16.62±1.63	20.40±2.02
							∑			
	3	V	193.27±10.38	254.13±14.35	13.32±1.27	14.87±1.40	7.33±0.40	11.74±0.86	15.50±1.76	28.83±2.00
			α»				∑		α»	
girls	1	S	161.80±7.83	132.86±5.25	11.64±1.01	11.96±1.17	10.02±0.92	10.84±0.81	21.80±1.94	22.02±1.66
			α»							
	2	No.	163.75±6.98	193.87±9.62	14.62±1.32	15.04±1.48	7.24±0.53	8.16±0.67	14.40±1.15	20.17±1.86
			∑						∑	
	3	V	124.05±3.69	120.65±3.60	13.81±1.22	13.04±1.19	7.44±0.62	5.76±0.34	19.21±1.61	16.55±1.24
							∑			

Note: the differences are significant in comparison with the state at rest: «●» $p<0.05$; «●●» $p<0.01$

A high level of physical performance was found in boys aged 9 and 10 years, which is most pronounced in the group of vagotonics: the level of excretion of NE increases by 53.00% and 71.84%, and A - by 62.01% and 85.94% (p <0.05) with an increase in DA (33.64%). So, in 9-year-old boys, the SAS reaction to dosed physical activity is more balanced (Tab. 2), which is especially pronounced in the normotonic and vagotonic state. Normotonic patients have a moderate increase in A and NE by 2.74 ng/min and 3.78 ng/min (p <0.05) against the background of stable indices of predecessors. Even more effective is the reaction of vagotonic boys, with a significant increase in A and NE excretion by 53.00% and 62.01% (p <0.01) and (p <0.05) accompanied by an increase in DA excretion by more than 35% (p <0.05).

An increase in the adaptive capabilities of SAS is observed in boys aged 12 and 13 years and is expressed more significantly in the normotonic and vagotonic state, when there is an increase in the excretion of A and NE in response to physical activity in the range from 35.20% to 59.65% (p <0.05). However, in sympathotonic boys, the shift in NE does not exceed 16.25%.

The puberty neuro-endocrine transformations typical of adolescents aged 14 and 15 [13,14] change the nature of adaptive reactions (Tab.3). Thus, sympathotonics aged 14 years showed a sharp jump in NE excretion by 10.96 ng/min (p <0.05) in the absence of a significant shift in DA excretion and a tendency toward a decrease in DOPA. Vagotonics, on the contrary, have a decrease in NE excretion by 10.25 ng/min (p <0.01), while the excretion of DA decreases from 189.99±9.96 ng/min to 162.37±8.26 ng/min. That is, the depletion of SAS reserves explains the absence of a shift in CA excretion. Only in boys in a state of eutonia the reaction of urgent adaptation of SAS is considered balanced - an increase in the excretion of NE (p <0.05), a moderate shift of A against the background of a tendency toward an increase in predecessors. A sharp decrease in the reserve of SAS is observed under sympathicotonia - NE excretion at the age of 15 years increases to 80.30%, and the DOPA level decreases (p <0.05). In vagotonics, signs of body asthenization are observed - a decrease in NE by 5.01 ng/min (p <0.05) with a decrease in DA (p <0.05).

In girls, unlike boys, at the age of 7 years, the reaction of the adrenal glands is more adequate. Regardless of IAT, there is an increase in A and NE in the range from 45.25% to 72.34%, which is accompanied by an increase in DA by 45.04%. Thus, in sympathotonic girls, the bicycle stress test causes an increase in A excretion by 3.94 ng/min (p <0.01), while the DA level increases from 119.42±4.37 ng/min to 168.59±6.62 ng/min. In normotonic girls, the reaction is balanced with respect to all parts of the CA biosynthesis. The jump in the excretion of A and NE by 5.28 ng/min and 7.07 ng/min (p <0.05) is combined with an equally significant increase in DA - from 140.20±60.01 ng/min to 203.35±12.97 ng/min (p <0.01). In vagotonics, the SAS reaction is smoother but equally favorable - an increase in A and NE in the range from 3.24 ng/min to 6.25 ng/min (p <0.05) is accompanied by a significant increase in DA (p <0.01) against a moderate positive shift in DOPA levels.

A decrease in compensatory reactions is observed at the age of 8 years when the sympathetic and normotonic group has no positive shift in excretion of A and NE, and the release of DA decreases by 9.35%. Positive dynamics in the excretion of catecholamines is observed only in schoolgirls with a vagotonic IAT. The normotonic 9-year-old girls show sufficient functional reserves of SAS - the DA level increases by 30.21 ng/min (p <0.05) with increased excretion of NE (p <0.01) and stabilization of A and DOPA levels, which is not the case for the sympathonic and vagotonic girls. In the first group, the shift of catecholamines is absent, and the DA content significantly decreases - by 28.94 ng/min (p <0.01), that is, the low level of reserve capabilities of SAS explains the absence of shifts in the CA excretion as the reaction to standard physical activity. The vagotonic 9-year-old girls clearly show signs of a decrease in the adaptive capacity of the studied neurohumoral regulatory system: there is a decrease in A excretion (p <0.05), a tendency toward a decrease in NE, and a lack of shift in the content of precursors.

Table 3: The content of catecholamines and DOPA in the urine of 14-year-old boys and girls under the influence of a bicycle stress test with a different initial vegetative tone (M±m)

No.		IVT	Indicators							
			Dopamine, ng / min		DOFA, ng / min		Adrenalin, ng / min		Norepinephrine, ng / min	
			before	after	before	after	before	after	before	after
boys	1	S	160.70±8.14	177.32±8.98	23.66±1.22	22.92±1.02	8.26±0.44	10.32±0.66	24.01±1.83	34.96±2.12
									∑	
	2	No.	180.63±10.23	203.92±12.34	24.40±1.28	25.66±1.34	8.63±0.42	9.60±0.74	19.66±1.77	29.94±1.92
									∑	
	3	V	189.99±9.96	162.37±8.72	20.37±1.00	20.00±1.12	8.96±0.40	11.91±0.72	23.88±1.86	13.34±1.28
			∑				∑		α>>	
girls	1	S	169.93±7.42	172.28±8.01	20.25±1.18	21.32±1.20	6.96±0.21	10.34±0.70	20.90±1.69	30.66±1.92
							∑		α>>	
	2	No.	±	±	±	±	±	±	±	±
	3	V	190.04±10.32	157.16±5.12	23.60±1.46	23.04±1.30	8.84±0.62	7.66±0.78	17.00±1.00	17.63±1.14

Note: the differences are significant in comparison with the state at rest: «●» p<0.05; «●●» p<0.01

Normotonic 12-year-old girls are a group of children with the most favorable SAS reaction. After the dynamic load, a moderate but significant increase in A and NE excretion occurs - from 35.90% to 50.65%.

At the age of 13-15 years, the adaptive reactions of the nervous and endocrine systems of girls decrease again, which may be due to the functional tension of the hypothalamic-pituitary system in adolescence [15]. Thus, in sympathotonic girls, despite the relative increase in indices at rest, the shift in NE during the load is greatest, and there is no positive dynamics of the predecessors. A decrease in the reserve capacity of SAS is also observed in vagotonics - against the background of a low preload level, negative shifts are observed in the excretion of NE (14 years) and DA (a decrease of 18.00%). That is, physical activity is stressful for girls aged 13-15 years.

CONCLUSION

The obtained results allow us to conclude that favorable SAS reactions to gradual physical activity are observed in boys of 9 and 10 years old, and in girls of 7 and 12 years old - an increase in excretion of A and NE is accompanied by an increase in DA and DOPA. The study showed that moderate and balanced SAS reactions are a prerequisite for the sustainable physical performance of school-age children. The most favorable period for the beginning of an intensive training process for boys is the age of 9 and 10 years, and for girls - 7 and 12 years.

CONFLICT OF INTEREST

There is no conflict of interest.

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REFERENCES

[1] Drzhevetskaia IA. [1994] The function of the adrenal cortex in 6-year-old children living in a chemically-contaminated region, Drzhevetskaia IA, Gubareva LI, Solgalov GD. Human physiology, 20(4):106-109.
[2] Erik M, Omer M, Anthony C, et al. [2016] Stress reactivity and personality in extreme sports athletes: The psychobiology of BASE jumpers. Physiology and Behavior, 167, 289-297.
[3] Orbeli LA. [1962] Selected works. Orbeli LAM L, 2:67-123.
[4] Krylova AV, Sitdikov FG, Anikina TA, Zverev AA. [2018] Adaptive reactions of the sympathetic-adrenal system of adolescent boys to physical activity. Proceedings of the XIV International Conference Adaptation of Developing Organism. Kazan, 72.
[5] Chinkin AS. [2015] Excretion of catecholamines with urine in skiers at rest and under competitive loads of different durations, Russian Physiological Journal, 11:1324-1330.
[6] Lebenthal Y, Gat-Yablonski G, Shtaif B. [2006] Effect of sex hormone administration on circulating ghrelin levels in peripubertal children J Clinic. Endocrinol. Metabolism, 90(1):328-331.
[7] Shaikhelislamova MV, Sitdikov FG, Sitdikova AA, Dikopolskaya NB, Kayumova GG. [2012] The reaction of the adrenal cortex to dosed physical activity in children with different initial autonomic tone, Bulletin of experimental biology and medicine, 154(12):677-680.
[8] Dudnikova EV, Nesterova EV. [2011] The role of the sympathetic-adrenal system in the pathogenesis of acid-dependent diseases in children and adolescents, Bulletin of physiology and respiratory pathology. 1:26-30.
[9] Fomin NA. [1991] Physical foundations of motor activity. Physical education and sport, 174-188.
[10] Baevskii RM. [2003] Physiological norm and the concept of health, Russian Physiological Journal, 89(4):473-489.
[11] Matlina ESh, Menshikov VV. [1967] Clinical biochemistry of catecholamines. Medicina Publ., Moscow
[12] Kmit GV. [2005] The duration of the individual phases and periods of the cardiac cycle based on the type of autonomic regulation of heart rate in children aged 7-8 years, New investigations. Almanac. 1:78-83.
[13] Ostrander MM, Ulrich-Lai YM., Choi DC. [2006] Hypoactivity of the hypothalamic pituitary adrenocortical axis during recovery from chronic variable stress. Endocrinology, 147(4):2008–2017
[14] Lozano BG, Matute LÁ, González AA, Vicente RG, Casajús JA. [2018] Soccer helps build strong bones during growth: a systematic review and meta-analysis European Journal of Pediatrics, 177(3):295-310.
[15] Drain JR, Groeller H, Burley SD, Nindl BC. [2017] Hormonal response patterns are differentially influenced by physical conditioning programs during basic military. J Sci Med Sport. 20 (Suppl 4):S98-S103.=

ARTICLE

METHODOLOGICAL ASPECTS OF NONCANCER GENESIS RISKS FORMATION

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ABSTRACT

The objective of this work was to qualitatively and quantitatively assess the concentrations of hazardous trace elements in the water used and the inhaled atmospheric air. The object of study was a residential area located 1990 meters from a pollution source - a petrochemical plant. During its operation cycle, the industrial enterprise releases into the atmosphere the processing products of petroleum raw materials, which include non-carcinogenic substances such as ethylene, ammonia, zinc, aluminum, copper, and C1-C5 carbons. The study involved a sociological survey of the main population of the studied residential area. The results of the survey revealed that the majority of the respondents noted deterioration in the taste of drinking water, stinking odor in the inhaled air, and deterioration in their health due to the products of the petrochemical enterprise. The result of the study was the identification of the main risks, their assessment was made, and hazard coefficients and indices were calculated. The most vulnerable human body systems were determined, and particular substances were identified, which the accumulation leads to the onset of pathological processes in the body.

KEY WORDS
environmental pollution, non-carcinogenic risk, risk assessment, technogenesis, petrochemical enterprise

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INTRODUCTION

The intensive development of various industrial enterprises leads to a steady increase in the number of patients whose pathologies directly depend on the activities of plants [1]. Based on the above, the objective of our work was to determine the specifics of the development of non-cancer risks in the study area located 1990 meters from the source of pollution. The residential area is under the influence of petrochemical techno-genesis. During the operation of the plant, the products of its vital activity inevitably enter the atmosphere, for example, the petrochemical enterprise we are studying releases about 14313 tons of polluting microelements into the environment. Such an impact adversely affects the population of a nearby residential area and provokes many negative factors. Non-carcinogenic risks are the risks that arise due to the effect of toxic microelements on the human body, cause many chronic diseases but do not lead to the development of oncological abnormalities. To identify a particular risk, a number of manipulations are necessary, the results of which will make it possible to predict the occurrence of various occupational diseases. In other words, these studies are an assessment of the risk that workers have due to the specifics of their work, as well as due to the influence of toxic substances. Non-carcinogens, like other substances, enter the human body orally, through the water used in food, through the inhaled air, and also percutaneously, i.e. upon contact of the toxic substance with the skin [3].

Summarizing the foregoing, we can conclude that the inhabitants of the studied settlement are daily affected by various toxic microelements that tend to accumulate in the human body, an excess of which leads to the development of chronic diseases, and even to death if the contact is too prolonged [4].

MATERIALS AND METHODS

The research method is to determine the hazard coefficient and hazard index. The result will be a pollutant exposure risk assessment [5]. Hazard coefficient (HQ) is the ratio of the level of an external toxic macro element (dose and concentration of a substance) to its safe, i.e. acceptable level. Hazard index (HI) is the sum of the hazard factors of various pollutants. Risk assessment is carried out gradually as follows: identification of priority pollutants; identification; assessment of the dose-response system; risk profile [6].

At the first stage, sampling is performed. This is necessary to identify the degree of risk and assess the qualitative and quantitative analysis of toxic macro elements (exposure assessment) in work areas by the level and time of exposure of substances to humans, as well as to determine the ratio of the data obtained with their maximum permissible values.

In the subsequent stages, depending on the obtained results of the samples, either a dose-response estimate is identified, or thresholds, concentrations and uncertainty factors are determined.

The potential hazard coefficient is the ratio of the actual concentration of a toxic element in the environment (C) to the maximum permissible concentrations of the same element (MPC). The coefficient of potential hazard is determined by the formula:

$R = C/MPC$,

This formula is valid only when exposed to one pollutant. The population of the residential area is influenced by many factors, therefore, all hazard factors from various elements will be summarized.

When exposed to a set of substances, the following condition applies: the potential danger from trace elements should not be higher than when exposed to a single element. For this, the sum of the potential hazard coefficients from each element should not exceed a unit:

$C1/MPC1 + C2/MPC2 + \ldots + Cn/MPCn \leq 1$.

Children aged from 1 to 7 years were surveyed in preschool educational institutions through interviewing their parents. Respondents aged from 7 to 17 years were polled personally, in the territory of secondary educational institutions. For questioning in preschool institutions and schools, permission was received from their directors on the basis of an information letter from the Chief Physician of the Center for Hygiene and Epidemiology of the Republic of Tatarstan. The adult population was interviewed at the place of residence. The age of respondents was from 18 to 80 years. Written consent from the subjects was taken and the study was approved by the Kazan University ethical committee.

RESULTS

The results of the analysis of the potential danger of pollutants emitted into the environment by a petrochemical plant to the health status of residents of a residential area located 1990 m from a pollution source found that the most toxic trace elements are ethylene, ammonia, zinc, aluminum, copper, and C1-C5 carbons.

It was found that pollutants enter the body in two ways: through inhaled atmospheric air and water, both orally and when in contact with skin.

Risk calculations determined that the main toxic components in the air are ethylene and C1-C5 carbons. Both substances are non-carcinogenic and cause great harm to the health of the population of the study area. The accumulation of ethylene in the cells of the body adversely affects the functioning of the cardiovascular system (hazard index (HI) is 0.55). C1-C5 carbons, in turn, impair the functioning of the respiratory system (HI = 0.44).

An assessment of the risks associated with the cutaneous intake of non-carcinogenic substances revealed that aluminum is the most dangerous element and its hazard coefficient is 2.57*10-5.

The main harmful element entering orally with water is ammonia; its risk value is 0.007.

Thus, the studies performed revealed four main toxic non-carcinogenic elements, which enter the body in various ways. An assessment of their risks showed that they all lie in the range of acceptable values of chronic non-carcinogenic risk.

The results of the survey revealed that the vast majority (70%) of respondents were concerned about the quality of drinking water. The main causes of anxiety when using tap water were statistically reliably established: smell ($p < 0.05$), taste ($p < 0.05$). 56% of respondents complain about the smell of water, and 50% complain about the taste. The study also revealed that 32.51% of respondents use tap water, the rest drink either bottled (29%) or additionally treated water (42%).

The main reasons for the contamination of drinking water are still excessive use of water supply networks, as 42% of water structures need updating, and disinfection of drinking water by chlorination, which also poses a threat to the health of the population of the residential area [10].

The analysis of the survey data found that respondents feel a decrease in the intensity of unpleasant odors in the air only in the daytime. It was statistically reliable that the main causes of complaints are the smell of gas ($p < 0.001$) and chemicals ($p < 0.001$). In percentage terms, 25.2% of respondents report the presence of a gas odor, 15.2% - the smell of chemicals.

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DISCUSSION

It was revealed that the population of residential areas located in close proximity to large petrochemical facilities is under the huge negative impact of emissions of toxic trace elements from enterprises. This means that a high level of heavy metals and gases in the environment contribute to the development of favorable conditions for the onset of pathological processes [8].

Ethylene, ammonia, zinc, aluminum, copper, and C1-C5 carbons have the greatest impact on the study area. The following are descriptions of each pollutant.

Ammonia is classified as a second hazard class. This gas is highly soluble in water, has a sharp, specific smell. The presence of ammonia in water has a detrimental effect on all living organisms. The use of drinking water with a high content of this microelement leads to an increase in blood pressure, leaching of calcium from the body, also causes a decrease in sensitivity to insulin and impaired glucose metabolism.

Copper is a representative of the third hazard class, which has an unpleasant astringent taste, the water in which the trace element is present has a bluish tint. A high concentration of copper in the body causes intoxication, which leads to disruption of the nervous system, kidneys, liver, as well as to perforation of the nasal septum [8].

Aluminum also belongs to the third hazard class. The use of water with an increased concentration of this metal causes a deterioration in the state of the nervous system, the accumulation of aluminum leads to Alzheimer's disease, Parkinson's disease and a number of other neurodegenerative disorders, which means that the element has the ability to accelerate the aging process.

Zinc belongs to the third hazard class. Drinking water with a high concentration of zinc causes after 12-13 hours signs of intoxication, namely fever, bouts of vomiting and pain in the stomach. Chronic effects include erosion of the walls of the stomach, and also an increase in blood cholesterol fractions.

Ethylene belongs to hazard group III. This toxin enters the body through inhaled air. Ethylene has a detrimental irritating effect on the mucous membranes of the body, which over time causes inhibition of the activity of the heart and a decrease in vascular tone. Chronic effects include psycho-emotional and thermoregulation disorders.

A sociological survey revealed the attitude of residents of the study area to the consequences of the operation of the petrochemical enterprise. It was found that a large part of the population is dissatisfied with the deterioration in the quality of not only air and drinking water but also the state of their health in general, and they believe that this is due to the proximity of the plant to the residential area.

SUMMARY

1) The impact of chemicals on the human body is an integral factor if there is a settlement near the petrochemical enterprise. The main pollutants in the study area were ethylene, ammonia, zinc, aluminum, copper, and C1-C5 carbons.
2) The results of the survey showed that the main complaint of the respondents was the presence of unpleasant odors in the air almost around the clock, as well as a specific taste of drinking water.
3) The analysis of the data obtained found that aluminum concentrations are greatest when toxic substances enter the body during skin contact. Its risk value is 2.57*10-5.
4) The most dangerous substances entering the human body through inhaled atmospheric air are ethylene and C1-C5 carbons. Hazard indices were calculated, which made it possible to determine that ethylene is the most dangerous element for the cardiovascular system (HI = 0.55), and C1-C5 carbons negatively affect the respiratory system (HI = 0.44).
5) The calculations of the hazard coefficient revealed that when toxic elements enter the body with water, namely through the skin and drinking water, the level of risk lies in the range of acceptable values (HQ≤1).
6) The calculations of the hazard coefficient revealed that when toxic elements enter the body with inhaled air, the level of risk lies in the range of acceptable values (HQ≤1).

CONCLUSION

The conducted study showed that the population of the considered residential area is daily exposed to various negative impacts from the nearby petrochemical enterprise. An assessment of the impact of such negative factors made it possible to determine that such exposure to many toxic substances leads to the development of various chronic diseases, and the chronic exposure to such harmful substances can make a person disabled.

CONFLICT OF INTEREST

There is no conflict of interest.

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None.

REFERENCES

[1] Avaliani SL. [2005] Chemical pollutants of the environment and assessment of the health risk of the population, Sanitary doctor, 5:71-73.
[2] Sitdikova ID, Ivanova MK, Meshkov AV. [2013] Hygienic assessment and management of risk factors of carcinogenic and mutagenic hazard in modern technogenesis, Public Health and Habitat. 4(241):11-12.
[3] Principles for the assessment of risks to human health from exposure to chemicals, [1999] World Health Organization, Genevam, 495.
[4] Halperin WE. [1996] Medical screening in the workplace proposed principles, jornal of occup. 28(8):547-552.
[5] Sitdikova ID, Amirov NKh. [2003] The risks in occupational medicine (assessment, management, prognosis), Kazan: Publishing House, RU
[6] Izmerov NF, Denisov EI. [2003] Occupational health risk for workers (guidance). Trovant, 448.
[7] Tsunina NM. [2002] Hygienic assessment of the state of the environment of the territorial-industrial complex. Hygiene and Sanitation, 1:15-17.
[8] Koosha K, et al. [2019] Assessment of groundwater quality and remediation in karst aquifers A review. Groundwater for Sustainable Development, 8 (2019): 104–121.
[9] Bigorgne G. [2003] Air quality and chemical pollutants, Allerg Immunol (Paris), 35(5):164-165.
[10] Fadeeva SA, Sitdikova ID, Mingazova EN, Lopushov DV, Berezin KA. [2018] Risk assessment as a criterion of environmental stress, Indo American journal of Pharmaceutical sciences, 05(09):9323-9327.

COMMUNICATION

INFLUENCE OF STYLBENOIDS ON AGROBACTERIUM TUMEFACIENS

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ABSTRACT

A strain of Agrobacterium tumefaciens, isolated from the trunk of infected V. vinifera L. cv. Rkatsiteli was studied microscopically and its pathogenesis was established. The goal of the research was to study the role of stilbenoids on the bacterial growth. The bacterium strain was inoculated in two ways: a) the surface of the growth medium was covered by a watery suspension of stilbenoids; b) Stilbenoids was added to the growth medium before sterilization. In both experimental protocols the concentrations of the stilbenoids were: 1 mg/100 ml, 2 mg/100 ml, 3 mg/100 ml, 4 mg/100 ml, 5mg/100ml, 10 mg /100 ml, 15mg/100ml, 20 mg /100 ml and 30 mg /100 ml. The control version was the same medium without stilbenoids. The incubation period was 14-15 days at 270C and all the treatments completely (100%) inhibited Agrobacterium tumefaciens growth over the control. A second experiment was therefore set up in order to study the bacterial growth inhibition under stilbenoid concentrations lower than 1 mg/100 ml (ranging from 0.1 mg/100 ml to 0.9 mg/100 ml): the bacterial growth inhibition increased from 0.0 % to 88.0% by increasing the stilbenoid concentrations.

KEY WORDS
Vine, crown gall, stilbenoids

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INTRODUCTION

Vine and grape stilbenoids are one of the groups of a wide class of phenol compounds, which incorporates cis- and trans-isomers of resveratrol and their derivatives, as dimers, trimers, tetramers and glycosides [1-9]. Stilbenoids have diversified high biological activity and these compounds are very important for plants as phytoalexins. Stilbenoids act against different vine diseases caused by biotic factors. The following stilbenoids were identified in the extract of vine (*Vitis vinifera* L.) trunk, roots and canes: Ampelopsin A, (E)-piceatannol, Pallidol, E-resveratrol, hopeaphenol, isohopeaphenol, (E)-ε-viniferin, (E)-miyabenol C, (E) –w-viniferin, r- and r2-viniferin. It was established that the extract inhibits the growth of sporulation of fungus *Plasmopara viticola* by 50%, while the most active inhibitor of it turned out to be r2-viniferin [10]. Biotransformation of resveratrol, pterostilbene and a mixture of both occurred by the protein secretome of Botrytis cinerea; 21 analogous were obtained [11]. The reaction with pterostilbene afforded 5 new compounds while the reaction with a mixture of pterostilbene and resveratrol afforded 7 unusual stilbene dimers. The anti-fungal effect of these stilbenoids was evaluated against *Plasmopara viticola* [11]. At three stages of fruit development of *Vitis vinifera* L. cv. Huxelrebe and the hybrid Castor, the berries were in vitro infected by *Botrytis cinerea*, resulting in the synthesis of pterostilbene, (E)-ε-viniferin and trans-resveratrol, being (E)-ε-viniferin the most produced stilbenoid [12]. Berries of *Vitis vinifera* L. cv. Barbera were in vitro infected with conidial suspension of *Aspergillus japonicus*, *A. ochraceus, A. fumigatus* and *A. carbonarius* and the levels of ochratoxin A and stilbenoids were detected. All fungi except for *A. fumigatus* significantly increased the concentration of trans-resveratrol and at the same time trans-piceid was unaffected; only *A. ochraceus* was able to significantly increase the piceatannol concentration. Stilbenoids showed antifungal activity against *A. carbonarius* since trans-resveratrol (300 μg/g) and piceatannol (20 μg/g) totally inhibited the fungal growth [13]. Besides the above-mentioned biological activity stilbenoids have many other functional roles and they are affected by many viticultural factors [14-26]. The vine varieties of Georgia are rich in biologically active stilbenoids; trans-resveratrol, trans- ε-viniferin, 2 tetrameric stilbenes, including hopeaphenol, were isolated and identified from shoots of Rkatsiteli variety. These stilbenoids were identified in the Georgian red-grape wine varieties and their wines [26-29]. The study of stilbenoids in Georgian wine varieties in terms of qualitative and quantitative analyses, and their impact on bacterial and fungal disease is an urgent need. As a consequence, the goal of the paper is to test the role of stilbenoids on the activity of the crown gall agent Agrobacterium tumefaciens.

METHODS

Agrobacterium tumefaciens was isolated from infected trunks of 16-year-old vines of *V. vinifera* L., cv Rkatsiteli grafted on Kober 5BB, grown at a density of 2,850 vines/ha; the vineyard was located in Kakheti (Gurjaani) region of Eastern Georgia, at 600 m asl elevation, on alluvial soil. The pathogenic strain of *Agrobacterium tumefaciens* was first isolated in February 2018 and then modified in July 2018 and January 2019. Last modified pathogenic strain of Agrobacterium tumefaciens was applied to the experiment described in this article. The isolation was done by taking a little piece of the crown gall which was cleaned from the other microorganisms by ethyl alcohol. A suspension was then prepared and sowed in the culture media in petri dishes and the multiplication of bacteria colonies occurred, under standard conditions (24 hours at 27°C) in petri dishes.

The pathogenesis of bacterial strain was determined by the development on a carrot plant disc. The morphological characteristics of the strain were determined by gramm method on the base of microscopic analysis (Electronic microscope XSP-14).

The stilbenoids were extracted by acetone from air-dried vine pruning material, after grinding. The extract was concentrated in vacuo at 40 °C and then the stilbenoid containing fraction was isolated by column chromatography: a Sephadex G-25 gel filtration media was used, eluting with MeOH:H2O (60:40) and a concentration in vacuo occurred. The composition of the stilbenoid extract was detected by the method of high-performance liquid chromatography (HPLC/MS). A Varian chromatograph was utilized, equipped with a Supelcosil PM LC18 Column, 250 x 4,6 mm; eluents: A. 0,025% trifluoroacetic acid; B. Acetonitrile: A80/20. Gradient mode: 0-35 min, 20-50% B, 48-53min, 200% B. Flow rate of the eluent- 1 ml/min; wavelength-306 and 285nm. Isolated stilbenoid-containing fractions were filtered using a membrane filter (0,45μ) before the chromatographic procedure. The chromato-mass-spectral investigations were carried out under the above-mentioned conditions; mass-spectra were detected by obtaining positive ions.

The effect of stilbenoids on the activity of the bacterial strain was tested by two experimental approaches: A). A water suspension of the stilbenoids was used at different concentrations, as follows: 1.0-5.0 mg /100 ml, 10 mg /100 ml, 20 mg / 100 ml and 30 mg /100 ml; POTATO DEXTROZE AGAR was used to multiply the bacterial strain: 20 ml of steril PDA medium were placed in Petri dishes. Their surface was covered by the water suspension of the stilbenoids and then the bacterial strain was incubated. The incubation period was 14-15 days at 270C. Water without stilbenoids was used in some petri dishes, as a control. B). The stilbenoids were directly added into the medium (PDA) at different concentrations, as follows: 1.0-5.0 mg /100 ml, 10 mg /100 ml, 20 mg /100 ml and 30 mg /100 ml. PDA without stilbenoids was used as control. The incubation conditions were the same as in approach A.

After the analysis of the results a second experiment was set up, in order to test the role of lower stilbenoids concentrations (0.1 to 0.9 mg/100 ml) on the bacterial growth inhibition.

RESULTS

Based on morphological study, the Agrobacterium tumefaciens strain resulted gram-negative with a Stiff form. It multiplied both as units and groups and had a flagellum giving it the ability to move [Fig. 1].

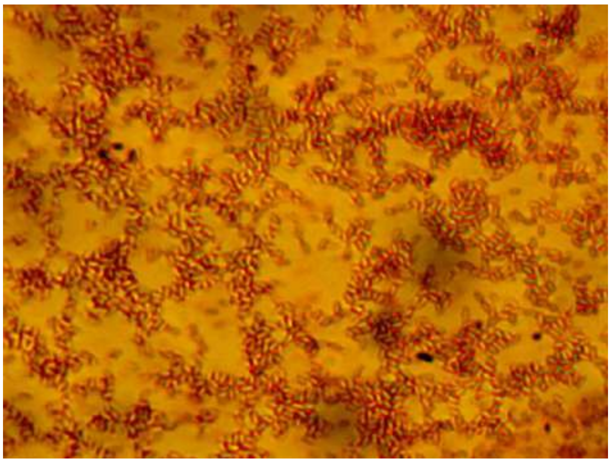

Fig. 1: Microscopic photograph of the *Agrobacterium tumefaciens* strain

The composition of the vine stilbenoids was represented by trans-resveratrol and its derivatives, as follows: trans-resveratrol 80.1%; trans- ε –viniferin 7.1%; dimers, trimers and tetramers 12.8%. The growth of the Agrobacterium tumefaciens strain was completely (100%) inhibited by the stilbenoids at concentration higher than 1 mg /100 ml. According to the Table the bacterial growth inhibition increased by increasing the stilbenoid concentrations from 0 to 0.9 mg/100 ml. Inhibition occurred at 0.2 mg/100ml, being 8%, and increased up to 1.0 mg/100 ml, being 100%.

Table 1: *Agrobacterium tumefaciens* growth inhibition and multiplication rate depending on the stilbenoid concentration

N	Stilbenoids concentration mg/100ml	Bacterial growth inhibition %	Bacterial multiplication %
1	0.0	0	100
2	0.1	0	100
3	0.2	8	92
4	0.3	20	80
5	0.4	30	70
6	0.5	40	60
7	0.6	52	48
8	0.7	60	40
9	0.8	75	25
10	0.9	88	12
11	1.0	100	0

CONCLUSION

Stilbenoids from the vine trunk were effective in reducing the development of a pathogenic strain of Agrobacterium tume faciens, at a concentration above 1 mg/100 ml. The research result is very important for Georgian vine grape varieties for further researches on the role of stilbenoid phytoalexins on vine disease resistance.

CONFLICT OF INTEREST
There is no conflict of interest.

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FINANCIAL DISCLOSURE
None.

REFERENCES

[1] Adrian M, Jeandet TP, et al. [2000] Stilbene content of mature Vitis vinifera berries in response to UV-C elicitation, J Agric Food Chem, 48:6103-6105.
[2] Bavaresco L. [2003] Role of viticultural factors on stilbene concentrations of grapes and wine. Drugs Exp Clin Res, 29:181-187.
[3] Bavaresco L, Fregoni C. [2001] Physiological role and molecular aspects of grapevine stilbenic compounds, Molecular biology & biotechnology of the grapevine. Kluwer Academic Publishers, The Netherlands, 500:153-182.
[4] Bavaresco L, Fregoni M, et al. [2002] The occurrence of the stilbene piceatannol in grapes. Vitis 41:133-136.
[5] Bavaresco L, Petegolli D, Cantu E, Fregoni M, Chiusa G, Trevisan M. [1997] Elicitation and accumulation of stilbene phytoalexins in grapevine berries infected by Botrytis cinerea. Vitis, 36: 77-83.
[6] Bavaresco L, Pezzutto S, Fornaroli A, Ferrari F. [2003] Grapevine iron-chlorosis occurrence and stilbene root concentration as affected by the rootstock and arbuscular mycorrhizal infection L Acta Hortic, 603:401-410.
[7] Bavaresco L, Pezzutto S, Gatti M, Mattivi F. [2007] Role of the variety and some environmental factors on grape stilbenes. Vitis, 46:57-61.
[8] Bavaresco L, Vezzulli S, et al. [2003] Effect of Ochratoxin A-Producing Aspergilli on Stilbenic Phytoalexin Synthesis in Grapes. J Agric Food Chem, 51:6151-6157.
[9] Bezhuashvili M. [1994] Development of theoretical basics for vine and oak timber lignin and identification of the ways to use the gained products. Doctoral thesis, Tbilisi, Georgia.
[10] Bezhuashvili M, Shubladze L, Okruashvili D. [2013] Trans-Piceid Stilbenoid in the Juice and Skin of the red Grape (Vitis vinifera L.) Varieties growing in Georgia, Bull Georg Nati Acad Sci, 7:74-79.
[11] Bezhuashvili M, Surguladze M. [2016] The Derivatives of Resveratrol-Viniferins from Grape Saperavi(Vitis vinifera L.). 3rd Scientific Conference on Natural and Synthetic Biological Activity Substances, Tbilisi,Georgia, 112-113.
[12] Gabastoni J, Khawand E, et al. [2018] Stilbenes from grapevine root: a promising natural insecticide against Leptinotarsa decemlineata. Journal of Pest Science, 91:897–906.
[13] Gindro K, Schnee S, et al. [2017] Generation of Antifungal Stilbenes Using the Enzymatic Secretome of Botrytis cinerea. Journal of Natural products, 80:887-898.
[14] Guebalia HA, Chira K, Richard T, Mabrouk T, Furiga A. [2006] Hopeaphenol: the first resveratrol tetramer in wines from North Africa. J Agric Food Chem, 54:9559-9564.
[15] Gabaston J, Cantos VE, et al. [2017] Stilbenes from Vitis vinifera L. Waste: A Sustainable Tool for Controlling Plasmopara Viticola. Agric Food Chem, 65:2711–2718.
[16] Jeandet P, Bessis R, Douillet BA, Adrian M. [2002] Phytoalexins from the Vitaceae: Biosynthesis, Phytoalexin Gene Expression in Transgenic Plants, Antifungal Activity, and Metabolism. Literature Review in Journal of Agricultural and Food Chemistry, 50:2731-41.
[17] Langcake P, Cornford CA, Pruse RJ. [1979] Identification of pterostilbene as a phytoalexin from vitis vinifera leaves, Phytochemistry, 18:1025–1027.
[18] Langcake P, Pryce RJ. [1976] The production of resveratrol by vitis vinifera and other members of the vitaceae as a response to infection or injury. Physiol. Plant Pathol, 9:77–86.
[19] Langcake P. [1981] Disease resistance of Vitis spp. and the production of the stress metabolites resveratrol, epsilon-viniferin, alpha-viniferin and pterostilbene, Physiol. Plant Pathol, 18:213–226.

[20] Mattivi F, Vrhovsek U, et al. [2011] Profiling of Resveratrol Oligomers, Important Stress Metabolites, Accumulating in the Leaves of Hybrid Vitis vinifera (Merzling × Teroldego) Genotypes Infected with Plasmopara viticola, J Agric Food Chem, 59:5364–5375.
[21] Pawlus D, Waffo TP, Shaver J, Merillon JM. [2012] Stilbenoid Chemistry from Wine and the Genus Vitis Int Sci Vigne Vin, 46:57-111.
[22] Reniero F, Angioni A, Rudolph M, Mattivi F. [1996] Identification of two stilbenoids from Vitis roots. Vitis Geilweilerhof, 35:125-127.
[23] Riviere C, Pawlus A, Merillon JM. [2012] Natural stilbenoids: distribution in the plant kingdom and chemotaxonomic interest in Vitaceae. Natural Product Reports, 29:1317-33. Niesen DB, Hessler C, Navindra SP. [2013] Beyond resveratrol: A review of natural stilbenoids identified from 2009–2013. Journal of Berry Research, 3:181-196.
[24] Larronde F, Richard T, et al. [2005] New stilbenoid glucosides isolated from vitis vinifera cell suspension cultures (cv. Cabernet sauvignon). Planta Medica, 71:888–890.
[25] Saeza V, Pasteneb E, Vergara C, et al. [2018] Oligostilbenoids in Vitis vinifera L. Pinot Noir grape cane extract: Isolation, characterization, in vitro antioxidant capacity and anti-proliferative effect on cancer cells panel. Food Chemistry, 265:101-110.
[26] Surguladze M, Bezhuashvili M. [2017] New stilbenoids - Miyabenols from Saperavi grapes (Vitis vinifera L.) to wine. 8 th international conference on polyphenols and health, Quebec, Canada, 52.
[27] Surguladze M, Bezhuashvili M. [2018] Biological activity of some stilbenoids from grape saperavi (Vitis vinifera L.) ICP+TC 2018 XXIX International Conference on Polyphenols 9 th Tannin Conference, Madison, USA. Gverdebi.
[28] Vergera C, Von BD, Mardones C, et al. [2012] Stilbene Levels in Grape Cane of Different Cultivars in Southern Chile: Determination by HPLC-DAD-MS/MS Method. Agric Food Chem, 60:929–933.
[29] Waffo TP, Fauconneau B, et al. [1998] Isolation, identification, and antioxidant activity of three stilbene glucosides newly extracted from vitis vinifera cell cultures, J Nat Prod. 61:655–657.

COMMUNICATION

PROCESS PARAMETERS OF GRAIN QUALITY AND BREAD-MAKING PROPERTIES OF WINTER RYE FLOUR

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ABSTRACT

Research has been conducted in the conditions of the Middle Urals to study the effect of sowing dates on the process and bread-making properties of winter rye grain in 2014-2016 on the basis of the educational and scientific experimental field of the FSBEI HE Perm SATU. The field experiment was conducted on the predecessor of annual grasses for green fodder. For sowing, we used the winter rye variety - Falenskayia 4. Sowing was carried out on seven different days: August 15, 18, 21, 24, 27, 30, and September 2. Process analyzes of grain quality were carried out in the testing laboratory of PermAgroService LLC. In the course of research, it was found that in different years according to meteorological conditions, rye forms grain of the 3-4 quality class and bread of satisfactory quality regardless of the sowing period.

KEY WORDS
winter rye, sowing period, grain quality, bread-making properties.

INTRODUCTION

Currently, there is a problem of grain production for high-quality baking flour [5, 6, 16]. Rye bread is not only inferior to wheat bread but even surpasses it in nutritional properties and a positive effect on health [8, 12]. However, sown areas of winter rye are reduced both in our country and in world production [1, 2, 11, 15]. There are many reasons. One of them is untimely sowing and, as a result, the death of plants during overwintering. The influence of sowing dates on the yield and quality of grain of winter crops has been studied by many scientists of our country and abroad [3, 4, 7, 9, 10, 13, 14]. According to these studies, we can conclude that high grain quality is formed at optimal periods but in the specific conditions of the region they are different, and their correct determination is an important challenge.

MATERIALS AND METHODS

Field studies were carried out at the educational-scientific experimental field of the FSBEI HE Perm SATU in 2014-2016. The soil of the experimental plot is soddy, fine podzolic, heavy loamy, moderately cultivated. The predecessor of annual grasses on green fodder. The object of study is winter rye - Falenskaia 4. The predecessor is annual grasses. Soil tillage included disking, plowing, and tandem disk harrowing. Mineral fertilizers (ammonium nitrate, diammonium phosphate) were introduced before pre-sowing cultivation, at the rate of N45P45K45 and together with spring fertilization at a dose of 45 kg/ha of ammonium nitrate. Sowing was carried out on seven different days [Table 1]. Grain harvesting was carried out at the end of wax - the beginning of solid ripeness in a single-phase method.

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Table 1: Winter rye sowing dates

Sowing term No.	Planned sowing date	Actual sowing date	
		2014	2015
1 (k)	August 15	August 15	August 14
2	August 18	August 18	August 21*
3	August 21	August 21	August 24*
4	August 24	August 24	August 29*
5	August 27	August 28*	September 4*
6	August 30	September 2*	September 10*
7	September 2	September 8*	September 12*

*Changes in the planned sowing days occurred due to heavy precipitation.

The process parameters of grain were determined in the testing laboratory of PermAgroService LLC. The bread-making properties of the flour were evaluated at the Krasnoufimsk breeding center of FSBSI Ural Scientific Research Institute of Agriculture. For these analyzes, samples of winter rye grain of 2015 and 2016 were used.

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Weather conditions during the filling and ripening period of winter rye grains during the research period varied significantly. In 2015, this period was characterized by lower temperatures and high humidity (HTC= 1.98), which led to lodging of plants and affected the quality of grain. The summer period of 2016 was arid (HTC= 0.23), which contributed to the formation of high-quality grain and its early ripening.

RESULTS

The winter rye grain, which is used for food purposes, is regulated by the national standard of the Russian Federation - GOST R 5349 - 2008 "Rye. Technical specifications". According to this standard, rye is divided into 4 classes, depending on the quality of the grain. Quality indicators include: color, odor, and condition of the grain, number of drops, nature, mass fraction of moisture, weed admixture, Fusarium grains, grain admixture and pest infestation.

Grain nature is one of the important indicators of the process parameters of grain. In 2015, which was unfavorable due to weather conditions for ripening and harvesting grain, its nature varied between 635 - 656 g/l (Table 2). During the first (August 15) and seventh (September 8) sowing dates, the grain nature corresponded to class 4, as it was less than 640 g/l. From the second (August 18) to the sixth (September 2) sowing dates, it corresponded to class 3. In 2016, favorable for the ripening of grain, its nature was higher and was in the range of 685 - 728 g/l. From the first (September 14) to the fifth (September 4) sowing term, it amounted to 706-728 g/l, which corresponds to class 1. Sowing at a later date (September 10 and 12) lead to a decrease to class 2 and amounted to 685 - 686 g/l. On average, over two years, the nature of winter rye grain varied from 660 to 688 g/l and corresponded to GOST classes 2 and 3. Grain of a higher class is formed during medium sowing dates.

Lodging of winter rye is the main indicator of the bread-making properties of grain. In 2015, the indicator was 61 s [Table 2], which corresponds to class 4. In 2016, from the first (August 14) to the fifth (September 4) sowing term, grain developed as class 3 with a lodging value of 81 - 89 s. At late sowing terms, it corresponded to class 4 (68 s).

According to other indicators of the standard (color, odor, pest infestation, weed and grain admixture), the grain corresponded to class 1.

Table 2: Grain process parameters

Sowing term	Nature, g/l			Lodging value, s		
	2015	2016	mean	2015	2016	mean
1 (k)	639	719	679	61	89	75
2	647	728	687	61	84	73
3	654	722	688	61	81	72
4	655	715	685	61	83	72
5	656	706	681	61	77	69
6	641	686	664	61	68	65
7	635	685	660	61	68	65
Mean	647	709	678	61	79	70

The yield of flour does not depend on the sowing date and year of harvest and is 63%.

In appearance, the bread samples differ in the shape of their crust and crumb [Fig. 1,2]. The samples of 2015 have the crust shape closer to flat, the crumb of brown bread with dense undeveloped porosity (2.5 points). In 2016, the crust shape is semi-oval, the crumb has a brown color and good porosity (4 points). The volume of test bread of the studied samples changed slightly over the years [Table 3]. Samples grown at the first sowing term (September 14-15) in both years of research were more than 300 ml in volume.

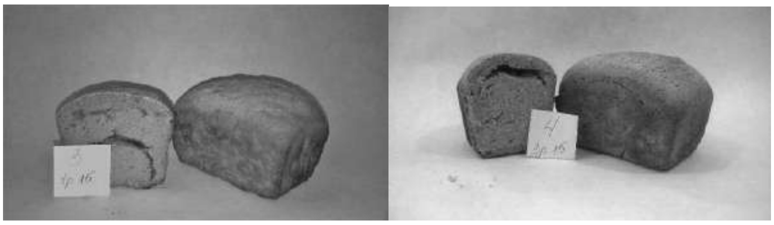

Fig. 1: Laboratory bread made of the 1st and 3rd term grain of 2015.

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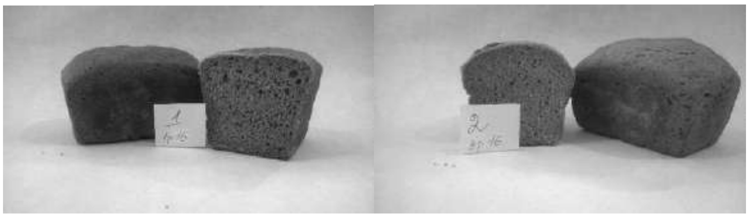

Fig. 2: Laboratory bread made of the 1st and 3rd term grain of 2016.

The bread-making score in 2016 was 3.7 points, that is, the bread had satisfactory qualities. And in the conditions of 2015, it decreased to 2.5 points. The sowing period did not affect this indicator.

Table 3: Flour bread-making properties

Sample			2015		2016		Mean	
			August 15	August 21	August 14	August 24	August 14-15	August 21-24
Flour yield, %			63	63	63	63	63	63
Baking assessment	Volume, ml		315	290	324	295	320	293
	score		3	2.5	3	2.5	3	2.5
	Appearance	Surface, score	3.7	3.7	3.7	3.7	3.7	3.7
		Shape, score	4	4	4	4	4	4
		Crust color, score	3.8	3.8	4	4	3.9	3.9
	Crumb	Porosity, score	2.5	2.5	4	4	3.3	3.3
		Crumb structure, score	3.8	3.8	3.9	3.9	3.85	3.85
		Crumb color, score	4	4	4	4	4	4
	Appearance, score		3.8	3.8	3.9	3.9	3.85	3.85
	Total score, points		2.5	2.5	3.7	3.7	3.1	3.1

CONCLUSION

Thus, the process parameters of Falenskaia 4 winter rye grain in the Middle Urals are more dependent on weather conditions. During years with favorable meteorological conditions, in the phase of grain maturation, grain of classes 3-4 is formed with the following process parameters: grain nature of 685-728 g/l, lodging value 61-89 s. The top-quality grain by its nature is formed during sowing from August 18 to September 4. The milling quality of rye grain does not depend on weather conditions and the sowing period. The bread-making properties of Falenskaia 4 winter rye flour depend only on weather conditions. The total bread-making assessment of flour indicators in a favorable year is 3.7 points.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

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FINANCIAL DISCLOSURE

None.

REFERENCES

[1] ROSSTAT. [2014]Regions of Russia. Socio-economic Indicators. Russian Federal Service of State Statistics, Moscow, Russia. Available from: 〈http://www.gks.ru〉 (in Russian).

[2] Schierhorn F et al. [2013] Post-Soviet cropland abandonment and carbon sequestration in European Russia, Ukraine, and Belarus. Glob Biogeochem Cycles, 27 (2013): 1175-1185.

[3] Sato H, Uchimura Y, Matsue Y. [2003] Flour characteristics of wheat influenced by sowing time. Japanese Journal of Crop Science 72(1):43-49.

[4] Gribovskaia EV, Pinchuk LG. [2016] Grain quality of winter wheat with different terms and sowing rates in the southeast of Western Siberia. Bulletin of Filippov Buryat State Agricultural Academy, 3(44):8-15.

[5] Ismagilov RR et al. [2001] Quality and production technology of food grain of winter rye, AgriPress, 224.

[6] Ismagilov RR. [2010] Bread-making properties of winter rye and methods of their improvement, Agrarian Bulletin of the Urals. 3:54-55.

[7] Krokhova MM. [2014] Productivity and quality of winter wheat grain grown in the Southern Steppe of Ukraine, Scientific and practical journal, 4(25):82-86.

[8] Kuznetsova LI, Siniavskaia ND. [2003] Functional bakery products based on rye flour, Bakery of Russia, 6:10.

[9] Lazarev VI, Kotelnikov MN. [2015] Influence of sowing terms on the yield and grain quality of winter wheat in the conditions of Kursk region. Bulletin of Kursk Agricultural Academy. 5:52-55.
[10] Lapteva NK, Mitkin LV. [2016] Technological indicators of grain quality of winter rye for baking, depending on varietal characteristics. Agrarian Bulletin of the Upper Volga, 2:20-23.
[11] Ponomareva ML et al. [2014] Analysis of the state of production and the role of selection in increasing the competitiveness of winter rye. South-East Agrarian Bulletin, 1(2):30-33.
[12] Sysuev VA. [2012] Rye grain is the basis of human health. Achievements of science and technology of the agro-industrial complex, 6(3):5.
[13] Tikhonova OS, Fatykhov Ish. [2013] Influence of sowing terms of winter grain crops on grain quality in the Middle Urals. Bulletin of Izhevsk State Agricultural Academy, 1(34):51-53.
[14] Torikov VE, Ptitsyna NV. [2017] Quality of winter wheat grain depending on the time of sowing and the level of mineral nutrition. Bulletin of the Altai State Agrarian University, 3(149):11-15.
[15] Urban EP. [2016] Relevant issues of increasing the baking and feed qualities of winter rye by methods of selection. Agriculture and selection in Belarus, 52:251-257.
[16] Chubenko NT. [2013] Who is responsible for the quality of the bread? Bakery of Russia, 1:4-6.

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COMMUNICATION

AFTERRIPENING PERIOD OF GRAIN SEEDS IN THE CONDITIONS OF THE MIDDLE PRE-URALS

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ABSTRACT

By the time when the phase of full (technical) ripeness is reached, the grain of many crops removed from the field usually has reduced seed and technological advantages. The physiological maturity of the grain, at which the seed (high germination) and technological properties become pronounced, occurs only after some time. This period of time is called the after ripening period. The paper presents data on the after ripening period of spring crops under conditions which are typical for Middle Pre-Urals, namely high humidity and reduced temperature during formation and maturation of grains. As a result of three years of research, it was revealed that spring sown cereals form seeds with laboratory germination on sod-podzol medium developed soil that meet the requirements of the sowing standard (92% and higher). The after ripening period duration is more dependent on the weather conditions of a year and the crop.

KEY WORDS
Spring wheat, spring barley, oats, viability and laboratory germination of seeds, afterripening period

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INTRODUCTION

At first glance, the issue of assessing the seed and grain quality has been resolved yet: grain is dried, sorted and submitted for analysis. However, in regions with high humidity, immediately after harvest seeds are characterized by low germination ability and germinate energy. The period that coincides with the time interval between the onset of physical (harvesting) ripeness in grains and until they reach physiological ripeness is called the after ripening period. At this point, after harvesting crops, a complex of physiological and biochemical processes continues in the grain, laboratory germination and germination energy of seeds in this period of time are at the level of 20 - 70%, and after completion of the after ripening period they increase to sowing conditions (92 - 100%). Also, the quality of gluten improves in commercial wheat grains during ripening. This leads to an increase in the yield of flour during grinding and improvement of baking properties. In oilseeds, oil yield increased during their processing. In the production of malt, high germination of grain is also very important. This complex of processes occurring in grain can be characterized as the conversion of simple substances which are unstable during storage (sugar, amino acids) into complex and more stable storage substances (starch, proteins). In practical work, it is necessary to take into account the duration of the after ripening period in order to correctly evaluate the seed and technological advantages. A long after-ripening period is undesirable from the point of view of storage and processing of grain, but in some cases it plays a positive role. For example, a crop and variety having a long after ripening period are of economic value in areas with wet autumn, as this eliminates the germination of grain standing in ears in rainy weather. Studies show that weather conditions do affect the sowing quality of seeds of spring cereal crops [4, 6], but the value of their laboratory germination ability can be regulated by agro technical methods: mineral nutrition [1, 3, 7], sowing and care methods [2], terms and methods of harvesting and post-harvest processing [5]. The issue on determining the after ripening period duration for modern varieties of cereal crops remains relevant for regions with high humidity during formation and ripening of grain.

MATERIALS AND METHODS

The studies were carried out in the conditions of the Middle Pre-Urals, on sod fine-podzole and heavy loamy medium-cultivated soil of the experimental field belonging to the Perm State Agricultural Academy in 2008 – 2010, where the field experiment was laid according to the following scheme: spring wheat (varieties of *Irgina* and *Krasnoufimskaya* 100), barley (varieties of *Ecolog* and *Fakir*), oats (varieties of *Dens* and *Fakir*). The distribution of options was systematic, using the split plots method, the plot area was 40 m2, and the replication is fourfold. Laboratory studies to determine the sowing qualities of viability and laboratory germination ability were carried out in the Plant Production Department laboratory. The tetrazolium-topographic method was used to determine the seed viability. Laboratory germination was determined from the phase of firm ripe stage (grain moisture of 21% and below), and then with an interval of 4 days in four multiple repetitions.

Agrotechnics in the experiment was generally accepted for early spring cereal crops in the Perm Territory. The preceding crop was a bean-barley mixture for grain. Soil cultivation included: 1) under-winter ploughing in autumn to the depth of the arable layer (20 - 22 cm), preverval harrowing at spring and pre-sowing cultivation with harrowing in two tracks to a depth of 8 - 10 cm with the onset of physical ripeness of the soil. Fertilizers were applied under pre-sowing cultivation at a dose (NPK)30, the form of fertilizers was diammofoska at (NPK 10:26:26) and ammonium nitrate (N 34). Sowing was carried out during the day after pre-sowing cultivation to a depth of 3-4 cm in an ordinary way with the SSNP-16 seeder. For sowing, varieties differing in early maturity were used: early ripening - *Irgina, Dens*, mid-ripening - *Krasnoufimskaya 100*, *Ecolog*, *Gonar*, and *Fakir*. The seeding rates were optimal for the Perm Territory: spring wheat - 7, barley - 5, oats - 6 million viable seeds per hectare. Crop tending consisted of one treatment with agritox herbicide (2 kg / ha) in the tillering phase. Cleaning was single-phased and carried out in the phase of firm ripe stage.

RESULTS

Meteorological conditions in the years of research were different. The year of 2008 was favorable as to temperature and humidification conditions for the growth and development of spring crops (hydrothermal humidity factor value = 1.5). 2009 was characterized by dry and hot weather in May - June and cool and humid until mid-July (hydrothermal humidity factor value = 1.1). From May to mid-June 2010, favorable conditions were observed for the growth and development of plants (hydrothermal humidity factor value = 1.4), and the period from mid-June to the end of August was characterized by increased air temperature and dry weather (hydrothermal humidity factor value = 0.5), which led to reduction of the forming and ripening phases of grain and reduction of the after ripening period.

As a result of three years of research, it was found that in the conditions of the Middle Pre-Urals, seeds of the spring cereals are formed with a high viability of 93 - 99 % [Table 1]. Also, starting from the firm ripe stage phase, laboratory germination was determined in order to establish the duration of the after ripening period.

Table 1: Viability and laboratory germination ability of seeds of spring crops before and after the after ripening period, %, 2008 – 2010

Crop	Variety	Seed viability, %			Laboratory germination ability, %					
					2008		2009		2010	
		2008	2009	2010	before ripening	after ripening	before ripening	after ripening	before ripening	after ripening
Wheat	*Irgina*	99	97	99	32	98	60	91	46	93
	Kr. 100	99	93	99	37	99	64	87	71	97
Barley	*Ecolog*	97	97	99	10	96	48	90	76	97
	Fakir	99	96	99	12	89	45	95	81	93
Oats	*Dens*	94	94	99	20	87	21	93	52	93
	Fakir	95	95	98	13	89	23	91	58	96

During the years of research, laboratory seed germination ability was different with breakdown by crops. Immediately after harvesting (harvesting was carried out at a firm ripe stage, two out of three wheat seeds had laboratory germination ability higher by 10 - 11% in 2008 and by 12 - 41% in 2009 than barley and oats. In 2010, barley seeds immediately after harvest had the highest laboratory germination (76 - 81%).

After the release of the seeds of cereal crops from a dormant state, all of them had high laboratory germination ability (87 - 99%).

[Table 2] shows data on the duration of the after ripening period for three years of research, which was calculated from the onset of firm ripe stage of the seeds until they reach a laboratory germination ability of not less than 92%. According to the requirements of the state standard, seeds intended for sowing must have a laboratory germination ability of at least 92 % (GOST R 52325-2005). In our studies, the achievement at the laboratory germination ability level of 92% was taken as a criterion that the seeds underwent after ripening and reached full ripeness.

Table 2: The after ripening period, %, 2008 – 2010

Crop	Grade	The after ripening period duration					
		2008		2009		2010	
		date of ripening	days	date of ripening	days	date of ripening	days
Wheat	*Irgina*	15.08-09.09	25	08.29-21.09	23	06.08-27.08	21
	Kr. 100	17.08-09.09	23	09.09-30.09	22	08.08-20.08	12
Wheat average					22		
Barley	*Ecolog*	18.08-19.09	34	04.09-26.09	22	09.08-16.08	7
	Fakir	17.08-19.09	35	09.09-30.09	28	07.08-16.08	9
Barley Average					25		
Oats	*Dens*	11.08 -05.12	117	03.09-14.10	40	04.08-23.08	19
	Fakir	15.08–05.12	113	05.09-14.10	38	06.08-23.08	17
Oats average			115		39		18

The after ripening period duration was counted from the onset of the firm ripe stage of seeds (grain moisture below 21%) to achieve laboratory germination ability that meets the requirements of standard GOST R 52325-2005. As a result of the studies, it was revealed that after ripening depends on the conditions of a year and on the hereditary pattern of the crop. A close inverse correlation was revealed for wheat and barley (r = -0.86 and -0.81, respectively) between the average daily air temperature during grain formation and the duration of the after ripening period; for oats, the relationship between these indicators had medium indicator value (r = -0, 48). A direct and close relationship was noted between the length of the ripening period and the amount of precipitation for oats and barley (r = 0.98), the medium indicator value was obtained for wheat (r = 0.36).

The ripening of seeds was the longest for oats, while it varied from year to year for wheat and barley. In a more humid year of 2008 (hydrothermal humidity factor value for the period of grain formation was 1.5), the after ripening period for membranous crops (barley, oats) was longer than for wheat. For wheat, it averaged 2–4 days, for barley - 34 days, and for oats it was more than three months. In the drier years of 2009 and 2010, this period for barley was reduced to 8 - 25 days, and for oats it was to 18 - 39 days, i.e. was comparable to the after ripening period of wheat. Therefore, the adage that "barley begins to grow when streams flow" can be considered obsolete for modern varieties. Thus, a large variation in the duration of the after ripening period in the years of research was observed for oats and barley, the coefficient of variation (V) was 56 and 53%, and it was less changed for wheat (V = 48%). Probably, this may be due to the heterogeneity of seed quality in these crops.

When comparing the after ripening period by varieties, it was revealed that for earlier ripe varieties (Irgina, Fakir, Dens), the firm ripe stage occurs 2-6 days earlier than in mid-ripening varieties, but the after ripening period is longer. However, when seeds ripen in dry and hot weather, the after ripening period is reduced, especially for membranous crops (barley, oats).

CONCLUSION

Thus, the after ripening period duration depends on the conditions of the year and the hereditary nature of the crop. It was established that the after ripening period of spring wheat seeds is by years of research more consistent and amounted to about 20 days. The conditions of a year affect the after ripening duration for barley and oat seeds; in hot and dry weather (2010), this period was reduced. Knowing the duration of this period, we can say that it is impractical to assess grain quality immediately after harvesting, especially in regions with a lack of sunny warm days, and with high humidity. For example, in the conditions of the Middle Pre-Urals, it is advisable to determine the sowing qualities of spring wheat and barley from November, oats in dry years also from November, and in cold wet years it is better to perform in spring, after preliminary air-thermal heating.

CONFLICT OF INTEREST
There is no conflict of interest.

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FINANCIAL DISCLOSURE
None.

REFERENCES

[1] Voitovich NV, Fokanov AM, Marchenkova LA. [2006] Features of the formation of properties and sowing qualities of grain seeds depending on the conditions of mineral nutrition, Bulletin of the Russian Academy of Agricultural Sciences, 1:38 - 41.

[2] Ivanov VM, Chernukha SL. [2010] Influence of seeding rate and physiologically active substances on productivity, quality of grain and seeds of spring wheat in the Trans-Volga region near to Volgograd city, Agrarian Bulletin of the Urals, 4:74–76.

[3] Kryuchkov A, Shatalov A. [1973] Effect of fertilizers on seed quality. Ural fields, 11:19.

[4] Pospelova LD. [2009] Yield and sowing qualities of barley seeds of the Veresk variety under different weather conditions, Agrarian Bulletin of the Urals, 4:60–61.

[5] Romanov P, Romanova Z. [1973] Dates and methods of harvesting wheat for seeds, Ural fields, 7:25.

[6] Trubnikova LI. [2009] Sowing qualities of seedings of spring soft wheat grown in different climatic zones of the Tyumen region, Agrarian Bulletin of the Urals, 7:66 - 67.

[7] Eliseev SL, Yarkova NN. [2010] Yields and the after ripening period of spring wheat in the Urals, Scientific support for the innovative development of the agro-industrial complex: Collection of scientific articles of the International scientific and practical conference dedicated to the 80th anniversary of the Perm State Agricultural Academy / FSEI HPE Perm State Agricultural Academy, Perm, 271-274.

ARTICLE

ORGANIZATION AND APPLICATION OF INFORMATION AND ANALYTICAL SUPPORT FOR GEOLOGICAL MONITORING OF WATER USE

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ABSTRACT

The article presents an approach to organizing geoecological monitoring of water by the creation and application of an information-analytical system that uses both and local operational observations, as well as modern GIS technologies. For the formation of a basic platform for the organization of a single information and analytical space, the processing of geoecological monitoring data at a local and regional level is considered. The structure of information and analytical support for the collection and processing of geoecological monitoring data has been developed. An algorithm has been developed for assessing the geoecological state of decentralized water supply. The algorithm is built on the basis of the interpolation model of the time series of the annual cycle, built on the basis of regime observations based on GIS data. A digital relief model of the investigated territory of the Navashino district is built. The paper presents the results of experimental studies. The site of the local observations was the territory of the Chud village (Nizhny Novgorod region). At the selected site, preliminary hydrogeological work was carried out with the determination of the conditions for the movement of karst waters and the zones of location of the main sources of decentralized water supply were determined.

KEY WORDS
information and analytical systems, GIS data, information processing services, assessment algorithm, digital model, water use.

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INTRODUCTION

Currently, water supply in an area remote from large settlements is based on the use of hydrological resources through decentralized water supply systems (springs, wells). The use of decentralized water supply in remote settlements is in many cases the only possible [1-5]. Based on the studies and a comprehensive analysis of the features of water use in such territories, it was found that the main problems of the water management complex are as follows:

- poor condition of objects of economic and drinking water supply;
- poor management of irrigated farming systems, usually used in areas of decentralized water supply;
- wasteful water use and negative anthropogenic impact on water bodies and consequently unsatisfactory water quality in water bodies;
- increasing vulnerability of water use systems from the harmful effects of natural and technogenic nature, especially in areas of active agro-industrial development of the territory. A high degree of impact on water bodies is exerted by dispersed (diffuse) runoff from agricultural and residential territories occupied by industrial waste;
- imperfection of legislative, regulatory, technological and information support [6,7].

On the territory of the Russian Federation, geo ecological monitoring systems of various levels have been developed and are functioning, within the framework of which regular monitoring of water supply to the population is carried out. However, the drawbacks of the monitoring systems currently used are that systematic monitoring of water use and water quality is carried out only with centralized water supply [8]. Monitoring of decentralized water supply, unscheduled inspections aimed at preventing harmful effects on the health of the population of poor-quality drinking water, reveal only a part of violations and inconsistencies. Extremely few published data on the quality of water used for drinking needs extracted from private wells and boreholes located in local areas. They, as a rule, are not included in monitoring programs, and the control functions at the moment are actually assigned to users.

Solving the indicated problems requires more effective approaches to organizing geo ecological monitoring of water use through the creation and application of modern information and analytical systems using both locative and local operational observation data and modern GIS technologies.

The structure of the information-analytical support of the geo ecological monitoring

The use of information-analytical systems should be aimed at providing the following basic principles of the water management for achieve the purpose and solve of tasks [9]:

- the principle of the management of the water use, that aimed at the preserving and the restoring of the functional and the structural integrity of catchment areas, landscapes and aquatic ecosystems;

- the principle of the compliance of the environmental priority of the protection of water bodies, as well as water management activities must meet environmental requirements and restrictions and water management activities must not have the negative influence on the environment;
- the principle of the priority of the use of water bodies for purposes of the drinking and household-domestic water supply over other purposes of their use. It is subject to the compliance of the balance of the use, of the reproduction and of the protection of waters from pollution and depletion.
- The basis for the construction of systems of the geo-ecological monitoring is technical and information means, which are combined on the basis of the systematic approach to solve the following tasks:
- the organization of regular observations for the condition of the hydrogeological environment based on quantitative and qualitative indicators;
- the organization of the collection, of the processing and of the analysis of data of the water use, that obtained as the result of observations at locative and local levels;
- assessment and forecasting of changes in the state of researched water bodies, the development of management actions based on the obtained information of locative and local levels and GIS data [10].

Monitoring levels are distinguished by the scale of observations. The initial level is the locative level of the geo-ecological monitoring. It covers territories of small villages, towns, individual enterprises, factories, economic complexes, etc. Locative levels are integrated into the larger network (within the limits of district or city). This integrate forms the system of the local level of the geo-ecological monitoring. Systems of the local level are combined into larger ones - regional monitoring systems, which cover territory of the region or the limits of several regions. The regional geological monitoring is designed to assess changes in the geological environment in territories of the complex anthropogenic influence. Such monitoring solves tasks of the estimate of the influence on the geological environment at the project stage and it does not provide for the creation of a new special network of regime observations [11].

The information processing of data is built on the locative and local levels in the system of geo-ecological monitoring. The locative and local monitoring is determined by the specific conditions of the execution of the geo-ecological monitoring and by features of specific objects of the hydrogeological environment [12, 13]. Upper horizons of the lithosphere and main objects of water use are as the object of the research in the geo ecological monitoring of the decentralized water use. Upper horizons of the lithosphere research in limits of the hydrogeological environment [14]. The [Fig. 1] shows the generalized scheme of the information processing of geo ecological monitoring data.

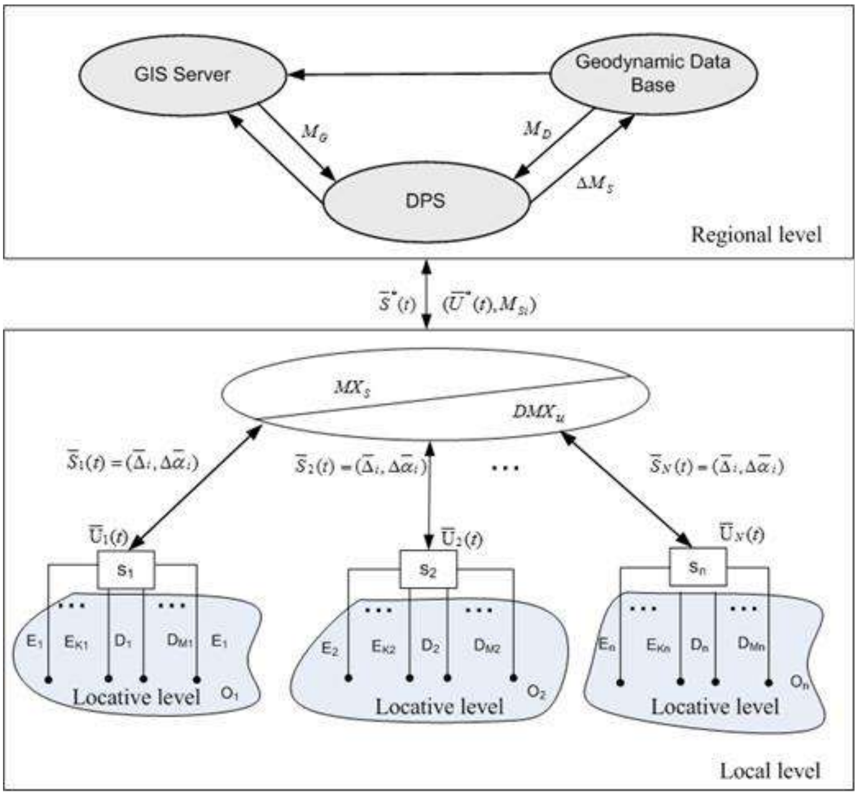

Fig. 1: The generalized scheme of the information processing of geo ecological monitoring data.

In the presented figure, hierarchical levels of data processing of the geo ecological monitoring of the decentralized water use are highlighted. At the same time, the level of locative observations was highlighted, which provides the initial operational information for the analysis, and which combined at the local level of hydrogeological monitoring. The next level execute the collection and management of the geo-ecological monitoring system at the level of the interaction with the regional geographic information system (GIS) with the allocation of the hydro-geodynamic vector of model data mismatch with real observation data.

The data server of the local level is used for combine of the data of the information-measuring complexes of locative levels and it is used for formation of the base platform for the organization of the single information - analytical space. This server is designed to collect observation data from information-measuring systems, which located in the area of its service. The size of the service area is selected in accordance with the number of information-measuring complexes and systems up to 100 square km., parameters of communication channels between measuring complexes and the regional server, the number of user queries to existing databases. All parameters (metrological characteristics of measuring complexes, parameters at which measurements were taken, spatial coordinates of the object under research, characteristics of the surrounding area) are transmitted by measuring complexes and systems to the central server along with primary digital data. It is for systematize primary data and into account parameters of the collection of data [15]. Reducing of the fragmentation of existing measuring complexes should be achieved through the software of the local data server. In particular it is by providing specialized services of the processing information.

In accordance with the considered principles of the information processing, the structure of the information-analytical support of the collection and of the processing of the geo-ecological monitoring data can be represented in the generalized modular form [Fig. 2].

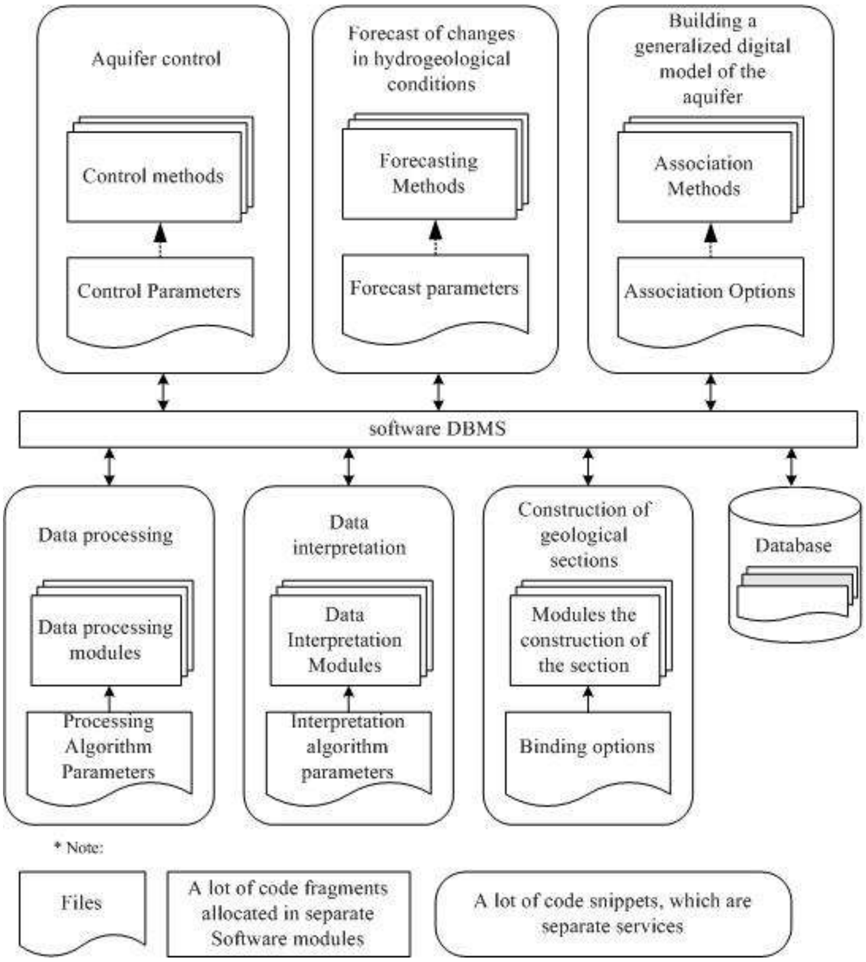

Fig. 2: The generalized modular form of the information-analytical support.

[Fig. 2] shows, that the local data server provides services of data processing and of the interpretation of data. In addition, the processing algorithms of each service are divided into separate modules. It is very convenient when adding new ones, as well as correcting old processing methods and algorithms. The presence of a large amount of source and of processed data and the ability of adding of new methods of the processing and of the interpreting data, provide the user the simple way of the compare and of the analyze these methods and algorithms, and it is give the flexible and fast mechanism for testing new methods [16].

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MATERIALS AND METHODS

Algorithms of assessing of the geo-ecological state of the decentralized water supply

The assessment of the local level of the geo-ecological state of the decentralized water supply can be carried out on the basis of the joint spatio-temporal processing of observation data of the locative level and the initial information from GIS databases. In this case, the geodynamic parameter is the parameter of the control. This parameter is the depth of locate of the aquifer for the decentralized water supply in the i of control zone. Second parameter is the integral parameter of water quality - water salinity are taken. It is taken after temperature correction as the result of the preliminary processing of geo-electric data of the locative control.

The processing algorithm is built on the basis of the interpolation model of time series of the year cycle, which is built on the basis of operational observations by GIS data. For each locative observation zone, model forecast series of aquifer parameters are formed by upcoming year cycles:

$$h_i = a_{0i} + a_{1i} \cdot t + a_{2i} \cdot t^2 + \ldots + a_{ni} \cdot t^n$$
$$m_i = b_{0i} + b_{1i} \cdot t + b_{2i} \cdot t^2 + \ldots + b_{ki} \cdot t^k \ , \qquad (1)$$

where и - coefficients of the forecasting model; and - the level of the model.
Abnormal changes of the recorded data are determined at locative levels according to the following boundary conditions

$$\frac{\partial^{[n+1]} h_i}{\partial t^{[n+1]}} \geq \varepsilon_{hi} \text{ or } \frac{\partial^{[k+1]} m_i}{\partial t^{[k+1]}} \geq \varepsilon_{mi} \ , \qquad (2)$$

where ε_{hi} , ε_{mi} - forecast thresholds of the assessing of the limit of aquifer parameters at locative levels
The generalized model of the geo-ecological state of decentralized water supply of the local level is formed on the basis of the following relationships:

$$\mathrm{E}_h = \int_S \gamma_{hi} \left| \frac{\partial^{[n+1]} h_i}{\partial t^{[n+1]}} \right| \partial S \leq \max\{\mathrm{E}_h\}$$
$$\mathrm{E}_m = \int_S \gamma_{mi} \left| \frac{\partial^{[k+1]} h_i}{\partial t^{[k+1]}} \right| \partial S \leq \max\{\mathrm{E}_m\} \ , \qquad (3)$$

where γ_{mi} , γ_{hi} - weighting factors, which taking into account the rating of information at locative observation points; - the zone of the local monitoring of the geo-ecological state of the decentralized water supply; $\max\{\mathrm{E}_h\}$, $\max\{\mathrm{E}_m\}$ - maximum deviation thresholds of generalized estimates.

Weighting coefficients are determined in accordance with the rating information coefficients k_i of locative observation points, which are formed on the basis of hydrogeological data of GIS.

$$\gamma_{hi} = \frac{k_i \dfrac{\max\{\Delta h_i\}}{a_{0i}}}{\sum_{i=1}^{N} k_i \dfrac{\max\{\Delta h_i\}}{a_{0i}}} \ ,$$
$$\gamma_{mi} = \frac{k_i \dfrac{\max\{\Delta m_i\}}{b_{0i}}}{\sum_{i=1}^{N} k_i \dfrac{\max\{\Delta m_i\}}{b_{0i}}} \ , \qquad (4)$$

where - the total number of locative control points in the system of the automated monitoring of the geo-ecological state of the decentralized water supply at the local level, $\max\{\Delta h_i\}$, $\max\{\Delta m_i\}$ - maximum forecast deviations of aquifer parameters at locative observation points.

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Description of the study area

The territory on which geo ecological studies were carried out is located in the north-eastern part of the Navashinsky district and includes 19 settlements. The total area of the settlement is 267.13 square kilometers. A significant part of the territory of the settlement is subject to karst formations, this is confirmed by the presence of craters, basins and lakes of karst origin. The territory belongs to the western part of the Volga Upland and is a hilly-plain relief between the rivers Oka and Tesha. Geologically, the settlement area belongs to the upper part of the Perm system, the lower sub-tier of the Kazan tier. Deposits are represented by dolomites, limestones, marls and clays. In the southwestern part of the Settlement, rivers flow along weakly cut flat-bottom valleys and have wide floodplains. The relief is mostly flat, areas with a slope of less than 1 degree make up about 90% of the settlement. The hydrographic network of the territory in question is represented by the Oka River, the Teshey River, small sections of the Led and Bolshaya Kutra rivers, as well as numerous lakes and streams. By the nature of the water regime, the rivers belong to the East European type with distinct spring floods, stable summer low water, interrupted by small rain floods and a stable low winter low water. The main role in their nutrition is played by precipitation, groundwater provides a steady low-water flow. Spring level rise begins in late March - early April, even during freezing and lasts 15-20 days. During the flood period, the water level regime of the Tesha and Bolshaya Kutra rivers is dependent on the Oka River. The decline in spring flood levels is slow and lasts about a month. The winter regime begins at the end of November, when the rivers are covered with ice. Water consumption during this period is sharply reduced, and on small streams stops altogether.

The Tesha River, the right inflow of the Oka River, originates on the Volga Upland, has a length of 311 km, a basin area of 7800 square kilometers. The river has 9 large inflow. In the territory under consideration, the river flows in its lower course, partly along the floodplain of the Oka River. The largest old lake in the settlement are located in the floodplain of the river. Oka: Stary Klyuch -1 03.4 hectares, Kharitonovo - 61.1 hectares, Glubokoe - 13.0 hectares, Ivanovo - 11.6 hectares, Mordovo - 8.7 hectares, Sitnoye - 5.6 hectares, Dolgovsky - 4.8 hectares, Dalnee - 3,3 hectares. Lakes of karst origin, which are natural monuments - Big Svyatoye Dedovo, Small Svyatoye. Big Svyatoye Dedovo Lake has an area of 128.1 hectares, a depth of up to 20m. In the territories of settlements and in their vicinity there are a large number of ponds organized on watercourses.

For observation, a site was selected on the second floodplain terrace of the Teshi River, which flows 3.5 km south of Lake Svyato. Water samples from different aquifers were taken on the coastal territory of the lake and in the vicinity westward towards the Oka River, a chemical analysis of the main water indicators determining the presence and development of karst processes was carried out. In hydrogeological terms, the area is characterized by the presence of two aquifers. The first horizon refers to the Quaternary and alluvial sands, the second to the fractured and destroyed rocks of the Kazan and Sakmara tiers. The Quaternary alluvial deposits of the second floodplain terrace of the Teshi River pass on the research site. In the upper part of the layer, the sands are fine-grained, with depth turn into different-grained [17,18]. Figure 3 presents a digital elevation model of the study area of the Navashinsky district. The model was built using the Arc GIS package (Arc Map10.4.1) using satellite imagery from the Landsat 8 satellite with an accuracy of 10-15 meters in the WGS - 84 coordinate system.

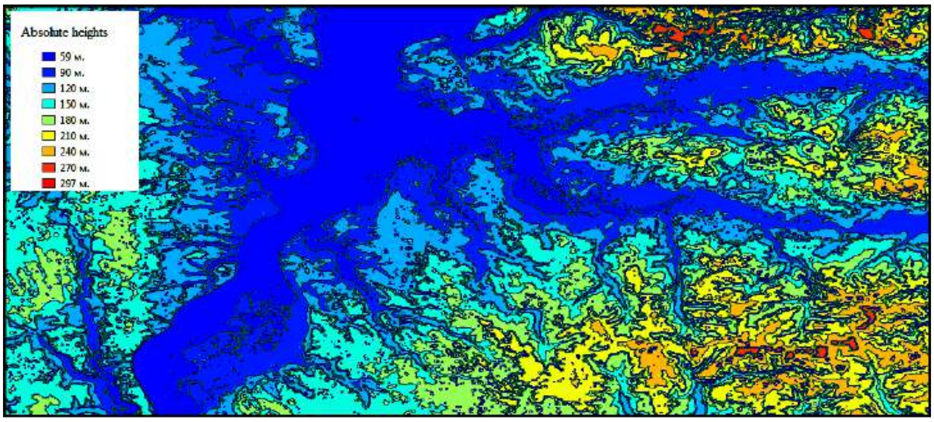

Fig. 3: Digital elevation model of the study area.

The relief of the territory as a whole is flat with alternating low-lying plains and hills with fluctuations in absolute elevations of 100-300 meters

RESULTS & CONCLUSION

The site of the local observations was the territory of the village of Chud, Nizhny Novgorod region. The purpose of the experimental work and the organization of regime observations on the territory of decentralized water supply is to test the developed system of dynamic hydrogeological control with information and analytical support. Hydrogeological control is based on the allocation of key geodynamic zones and the use of geoelectric methods [19,20]. At the selected site, preliminary hydrogeological work was carried out with the determination of the conditions for the movement of karst waters and the zones of location of the main sources of decentralized water supply were determined. Based on the preliminary work, the key points of hydrogeological control of the territory were identified. The karst massif is divided into the region of infiltration and inflation of atmospheric precipitation and surface water, the region of underground runoff, and the area of discharge or discharge of karst waters beyond the boundaries of karst rocks. Regime observations were carried out from February to September 2017 at eight points of local control using a bipolar equipotential unit. [Fig. 4] shows the data of mineralization registration at the hydrogeological control point.

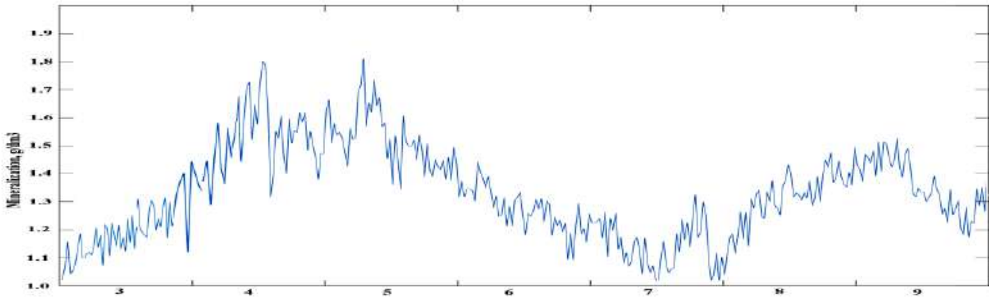

Fig. 4: Mineralization data of water used for drinking water supply in the village of Chud.

Based on the studies, it was noted that with the development of karst-suffusion processes, the intensity of hydrogeological variations of local sections of the geological environment in the study area has a pronounced dynamically unstable character. In accordance with the data obtained, zones of safe drinking water use are identified, as well as a zone with a disturbed hydrogeological regime and undesirable use of water for drinking water supply. Based on the studies, it can be concluded that in settlements in such a territory it is necessary to carry out work using the developed hydro geodynamic control system with a period of at least 5 years (the recommended period of astrological monitoring), and in the case of activation of surface manifestations of karst processes in the territory more often.

CONFLICT OF INTEREST

There is no conflict of interest.

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REFERENCES

[1] Belousova AP, Gavich IK, Lisenkov AB, Popov EV. [2006] Environmental hydrogeology: Textbook for universities. IKC Akademkniga, 397.

[2] Stepanov NA, Zavodova EI. [2015] Characterization of the impact of the qualitative composition of drinking water on human health. Occupational medicine and human ecology, 3:200-205.

[3] Alekseev LS. [2004] Water quality control. 3rd ed, Revised and add, INFRA M, 154.

[4] Burdakova NE, Petrova EV. [2015] The effect of drinking water quality on human health. Actual problems of ecology in the XXI century Vladimir, 130-135.

[5] Elipasheva EV, Maksimova TV, Kulikov PN, Sergeev GM. [2011] Ionochromatographic determination of certain toxic anions in the water of centralized drinking water supply systems and natural waters. Water: chemistry and ecology, 1(31):61-65.

[6] Lukashevich OD. [2007] Ecological and technological aspects of assessing the quality of natural waters for industrial and domestic use. Water and ecology: problems and solutions, 1(30):3-16.

[7] Klimchuk AB, Tokarev SV. [2014] Recommendations for the protection of underground drinking water sources in karst regions, Speleology and karstology, 12:5-16.

[8] Androsov MV, Bazhaikin AL, Bortnik IYu. [2014] Commentary on the Federal Law of January 10, 2002 N 7-Ф3, in On Environmental Protection, Edt Dubovik OL O, Publisher: Norma, INFRA.

[9] Romanov RV, Dorofeev NV, Kuzichkin OR, Podmaster'yev KV. [2015] Spatial - temporal processing of geoelectric data of geodynamic control. Fundamental and applied problems of engineering and technology, 6(314):110-117.

[10] Dorofeev NV, Kuzichkin OR, Eremenko VT, Romanov RV, Grecheneva AV. [2017] Geoecological monitoring of decentralized water supply based on the construction of specialized information and analytical systems: monograph, 161. ISBN 978-5-9929-2577-9, Oryol State University, RU.

[11] Dorofeev NV, Kuzichkin OR, Romanov RV, Koskin AV. [2017] Spatio-temporal data processing of automated geodynamic monitoring system. Proceedings of the 2017 IEEE 9th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS, 231-237.

[12] Grecheneva AV, Kuzichkin OR, Mikhaleva ES, Romanov RV. [2017] The results of joint processing of geotechnical and geodynamic monitoring data of Karst processes. Journal of Engineering and Applied Sciences, 12(23):6628-6634.

[13] Dorofeev NV, Romanov RV, Kuzichkin OR. [2016] The determination of hazard factors according of regime observations for the aquifer in karst areas. 16th

International Multidisciplinary Scientific GeoConference SGEM 2016, 2(1):867-874.

[14] Romanov RV, Kuzichkin OR, Tsaplev AV. [2015] Geoecological Control of the Aquifer in the Decentralized Water Supply Systems of the Local Level. The 8th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems, 42–46.

[15] Grecheneva AV, Kuzichkin OR, Bykov AA, Dorofeev NV, Romanov RV. [2017] Information and analytical support for the processing of heterogeneous data of geotechnical monitoring. International Multidisciplinary Scientific Geo Conference Surveying Geology and Mining Ecology Management, SGEM, 17(52):681-688.

[16] Dorofeev NV, Orekhov AA, Romanov RV. [2012] Organization of regional data collection in the geographic information-analytical system of geo ecological monitoring. Engineering and life safety, 2(12):30-32.

[17] Report of Institute for Engineering Surveys. [2009] Zoning of the territory of the Nizhny Novgorod region on the development of especially dangerous natural and technogenic processes. 36–81.

[18] Shilnov AA. [2002] The influence of karst on the formation of natural landscapes of the Tesha-Seryozhinsk natural area. Ecology and conservation, 5:96–99.

[19] Romanov RV, Kuzichkin OR, Using AV. [2014] geoelectric sounding methods for geoecological water control in non-centralized water supply systems at the local level Engineering and life safety, 3 (21): 35-39.

[20] Kuzichkin O, Grecheneva A, Bykov A, Dorofeev N, Romanov R. [2017] Optimization of an equipotential method of electro investigation for a research of karst processes, SGEM, 17(52):681-688.

ARTICLE

EVALUATION OF THE ACCURACY OF THE PHASE METRIC METHOD OF GONIOMETRIC CONTROL IN GEOTECHNICAL MONITORING

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ABSTRACT

The relevance of the study is due to the increasing requirements for observing the measuring accuracy and sensitivity of the control of angular parameters (goniometry) in the process of angular moving of the geotechnical monitoring objects. It is shown that the use of accelerometers is a promising approach in the field of dynamic goniometry. However, the stringent requirements for observing operating conditions and the low noise immunity of accelerometers do not provide the possibility of large-scale implementation of these sensors. In this regard, this article is aimed at studying the accuracy of the new method of automated measurement of the angle based on accelerometers, which will compensate for the existing errors of the accelerometer sensors. As a method of processing the signals of the accelerometers, it is proposed to use the phase metric method, the essence of which is to convert the signals of the accelerometers into a harmonic function of time and calculate the phase shift proportional to the angle of rotation of the accelerometer. The article substantiates the use of the phase metric method in measuring accelerometric systems, presents the results of experimental studies evaluating the accuracy of the developed method, as well as the results of testing the sensor on real monitoring objects. The materials of the article are of practical value for specialists in the field of measurement automation, geotechnical monitoring, as well as specialists in the development of tools and methods for optimizing the metrological support of inertial sensor systems.

KEY WORDS
Geo technical monitoring, goniometric control, phase metric method, accelerometers

INTRODUCTION

Registration and control of the angular motion parameters of construction objects and their components is an urgent metrological task of geotechnical monitoring. The development of tools and methods for monitoring the angular parameters of objects is becoming increasingly important with increasing requirements for compliance with measuring accuracy and sensitivity. For example, during geotechnical monitoring, to monitor the spatial characteristics of buildings are monitoring tools (tilt meters) that allow you to track changes in the spatial state and geometric parameters of the structure. They are equipped with various types of sensors: solid-state accelerometer, compensated servo-accelerometer, electric DTE converter, etc. [1]. Depending on the type of specific tasks and the typology of geotechnical control objects (hazardous facilities, industrial facilities and residential buildings), tolerances for vertical deviations of buildings and structures vary in the range from 0.3° to 5(7) °. In this case, the geometrical systems of geotechnical monitoring must meet the requirements of high sensitivity (<0.3°) and noise immunity (> 0.1°) of measurements.

An example of equipment used to monitor building vibrations is the Guralp CMG3ESPC [2] and the Guralp CMG-5T accelerometer [3]. The use of accelerometers as an informative measurement method is characterized by low temperature stability, has severe restrictions on the scale of the observational network, and requires additional adjustment of measurements taking into account exogenous loads. The basis for calculating the slope angle when processing information in systems of this class is the standard trigonometric transformation of the projections of the gravitational acceleration vector on the corresponding sensitivity axes of the sensor. In special cases, numerical integration and wavelet transform of the recorded signals are also used. In this case, the main drawback is that the data on changes in spatial and geometric characteristics show only the final result of the structural deformation, but do not reflect the real process of the development of these deformations.

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When using accelerometers in goniometric control, there are a number of metrological problems. It is known that the largest numerical component of the total error of the accelerometers is the zero error and the sensitivity error - 10% and 6% each, as well as the lateral sensitivity error (2 ... 5%) and non-linearity of the accelerometer (0.5 ... 2.5%). Also significant disadvantages of these inertial sensors are the relatively low accuracy and noise level of the output signal, zero drift [4]. In this case, the total error determined from the mean square criterion reaches 12-15% [5]. This error value is very large; therefore, to increase the accuracy of measurements, it is necessary to apply methods for compensating for accelerometer errors.

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The multiplicative errors of the accelerometer transducers should be distinguished as a separate class of errors that have a major effect on the stability of the measuring branches of the transducer. In the theory of errors, the multiplicative error is defined as a deterministic systematic deviation of the readings of the measuring device with a long period [6, 7]. The causes of the multiplicative error are mainly the peculiarities of the operating environment (temperature instability, instability of the supply voltage source, etc.) [8-11]. Moreover, the multiplicative component of the measurement error depends both on the projection of the apparent acceleration on the nominal axis of the sensitivity of the accelerometer (the error of the scale factor), and on the projection of the apparent acceleration on the plane orthogonal to the nominal axis of the sensitivity of the accelerometer (the error of the mismatch of the axes).

As a solution to the problem of increasing the stability of measurements to the influence of multiplicative errors, compensation methods are widely used, the essence of which is the use of an alternating current source in devices for generating the output signal of the accelerometer with subsequent amplification of the rectified output signals in differential-type amplifiers. In this case, accuracy is improved and instability is eliminated by incorporating into the measuring circuit a variable compensation resistor, one of the contacts of which is connected to the input of one of the rectifiers, the other with an additional input of a differential amplifier [12].

There is a known fact about the direct dependence of the maximum mismatch of the branches of the accelerometer transducer at the maximum value of the multiplicative error. In this case, the multiplicative error cannot be fully compensated, and it can be partially eliminated by compensating for the asymmetry of the differential measuring transducer [13].

Currently, on the basis of improving the technological base and taking into account the foregoing, we can conclude that there are prospects for the widespread use of accelerometric converters. Analysis of the operational properties of accelerometric converters (Analog devices, Motorolla, Seika, STM microelectronics, Honeywell, etc.) [14-17] shows that the manifestation of dominant errors has low consistency, a lack of algorithmic support (lack of data processing requirements, unreliability of compensation mechanisms) and design features (misalignment of the sensitivity axes to the converter housing). Therefore, the development and use of data processing methods for accelerometers require not only the need for development, but also the development of algorithms.

The aim of the study is to assess the accuracy of the phase metric method of goniometric control based on the use of accelerometers, which allows you to compensate for the existing errors of the accelerometer sensors and improve the metrological characteristics of the accelerometer systems for monitoring the angular displacements of objects.

METHODS

Phase metric method of accelerometric measurements

The proposed phase metric method of accelerometric measurements assumes the presence of at least a pair of accelerometers mounted coaxially in the area of the control object that performs angular motion. [Fig. 1a] show variations of the layout schemes for attaching accelerometric sensors to the test object using the phase metric method. [Fig. 1b] illustrates the determination of the rotation angle of two accelerometers based on the projections of the acceleration vector of gravity onto each of the axes of the accelerometers in a rectangular coordinate system in two-dimensional space.

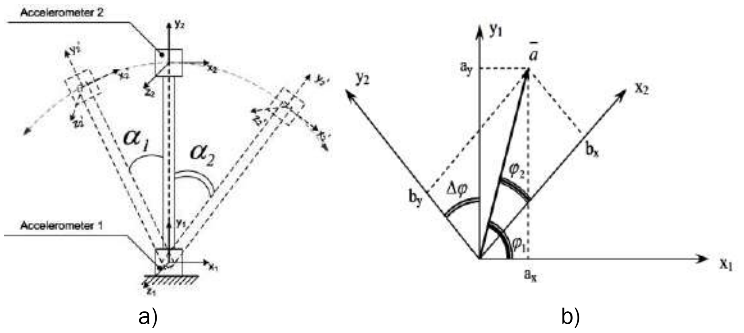

Fig. 1: Phase metric method of accelerometric measurements.

To implement the accelerometric measurements of the angle using the phase measuring method, it is necessary to convert the signals from three-component accelerometers to the phase of the sinusoidal oscillation, multiplying them by and. The most detailed implementation of the phase metric method of accelerometer measurements of the angle is presented in [Fig. 2].

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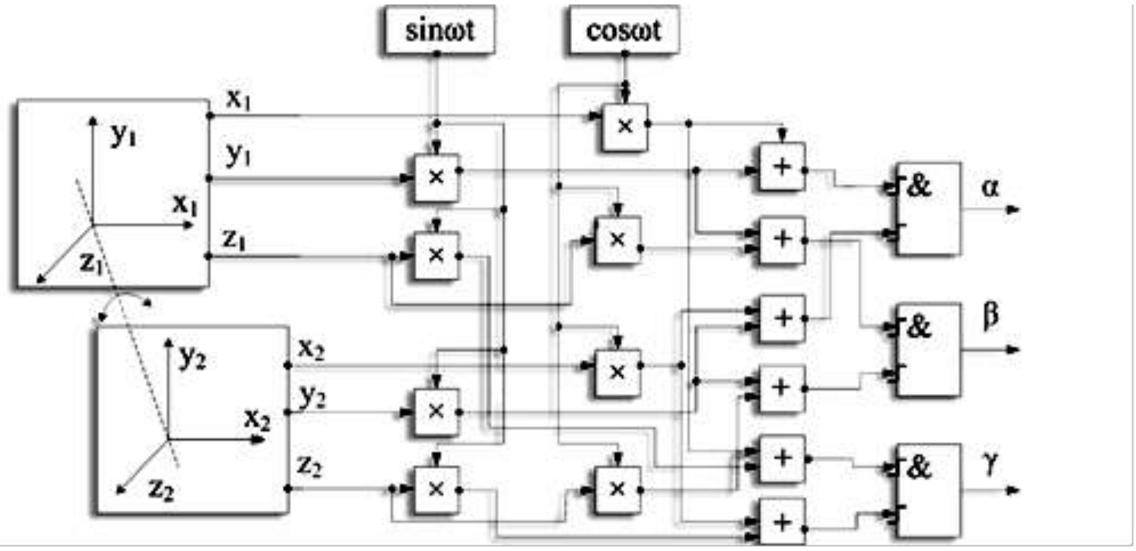

Fig. 2: Block diagram of the phase-measuring method of accelerometer measurements of the angle.

As a result of the multiplication operation, the signals of the accelerometers will take the form:

$$x_1 = k_{x1} a \cos(\Delta\alpha);\quad y_1 = k_{y1} a \sin(\Delta\beta);\quad z_1 = k_{z1} a \cos(\Delta\gamma);$$
$$x_2 = k_{x2} a \cos(\Delta\alpha);\quad y_2 = k_{y2} a \sin(\Delta\beta);\quad z_2 = k_{z2} a \cos(\Delta\gamma); \qquad (1)$$

where are the angles between the direction of the acceleration vector $\vec{a}$ of the common point O located on the axis of rotation and measuring accelerometric systems ($(\vec{x}_1, \vec{y}_1, \vec{z}_1)$ and $(\vec{x}_2, \vec{y}_2, \vec{z}_2)$); k_{x1}, k_{y1}, k_{z1} k_{x2}, k_{y2}, k_{z2}, , , , are the sensitivity coefficients of the corresponding accelerometers.

The formula for the product of the total signal for the components x and y of the accelerometer 1 and accelerometer 2 is:

$$S = \sum U_1 \cdot \sum U_2 = \frac{1}{2}(\cos\alpha - \cos(2\omega t + \varphi)) \cdot U^2 \cdot \sqrt{{x_1}^2 + {y_1}^2} \cdot \sqrt{{x_2}^2 + {y_2}^2} \qquad (2)$$

where φ is the phase shift.

Since double the frequency is observed in the signal as a result of transformations according to formula (2), further signal conversion involves the use of a low-pass filter (LPF) and separation of the phase angle that is practically equal to the angle of goniometric control. When implementing the algorithm for calculating the phase angle by converting it to a time interval, the error of the method can be estimated.

Assuming frequency multiplicity, the ratio of the generator frequency and the sampling frequency:

$$\frac{F}{f_d} = m \qquad (3)$$

The error of determining the angle in this case, for the real value of the phases based on direct calculations:

$$\alpha = arctg\left[\frac{U^0{}_i \sin(2\pi \cdot m)}{U^0{}_{i+1} - U^0{}_i \cos(2\pi \cdot m)}\right] - arctg\left[\frac{U_i \sin(2\pi \cdot m)}{U_{i+1} - U_i \cos(2\pi \cdot m)}\right] \qquad (4)$$

In this case, the analytical expression for estimating the angle measurement error by means of the accelerometric method is as follows:

$$max(\Delta\alpha/\alpha) = \frac{\sqrt{2\pi \cdot m - 1} - arctg(\sqrt{2\pi \cdot m - 1})}{\pi \cdot m} \qquad (5)$$

As can be seen from expression (5), there are no multiplicative components in the error structure, and the systematic error in determining the angle can be reduced by increasing the sampling frequency with respect to the generator frequency.

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RESULTS AND DISCUSSION

Application of the phase metric method in geotechnical monitoring

In the field of geotechnical monitoring, accelerometers were used to record the angle of deviation from the vertical of the supporting structures of the building and horizontal subsidence of the foundation [18 - 20]. The principle of operation of the sensor in the field of geotechnical monitoring is based on determining the rotation of load-bearing structures and subsidence of the foundation of buildings and structures from the vertical in various planes and determining the angle of axial deviation relative to the base coordinate system associated with the Earth [21]. In this case, it is advisable to carry out joint monitoring of the hydrogeological regime [22, 23] and deep geodynamic processes [24] using approaches to select key geodynamic objects [25].

The object of research using the developed method was the design of a separate two-story three-section building of a residential brick house. The relief of the building plot is calm, the layout is approaching horizontal. The building is two-story, rectangular in plan, with a basement and an attic. Basement floor height (from floor to ceiling) - 1,500m. The height of the first and second floors (from floor to ceiling) is 2,700m. The general dimensions of the building are 46,900 x 12,000m. The maximum height of the building from the planning level is 9,700m. According to the structural system, the building of this residential building belongs to wall buildings. The structural design of the building is frameless longitudinal wall. Vertical load-bearing structures - brick walls (from mark-0.800 to mark + 6.300); horizontal supporting structures - prefabricated reinforced concrete floor slabs (overlapping basement, first and second floors).

As a result of the initial visual inspection, it was revealed that the wall of the building has a drawdown of up to 103 mm. In addition, visually detectable deformation fractures of the building located in the middle of the building were discovered. Vertical, horizontal and inclined through cracks in the outer brick walls of the building with an opening width of up to 18mm. Deformations and subsidence of building foundations as a result of the formation of voids (up to 250 mm deep) in a soil base under precast reinforced concrete slabs of a strip foundation. Vertical and inclined through cracks in the internal brick walls of the building with an opening width of up to 16 mm.

The layout of the accelerometers (LIS331DLH, STMicroelectronics) for geotechnical monitoring of the deformation processes of the foundation and load-bearing walls of a residential building is shown in [Fig. 3] [26].

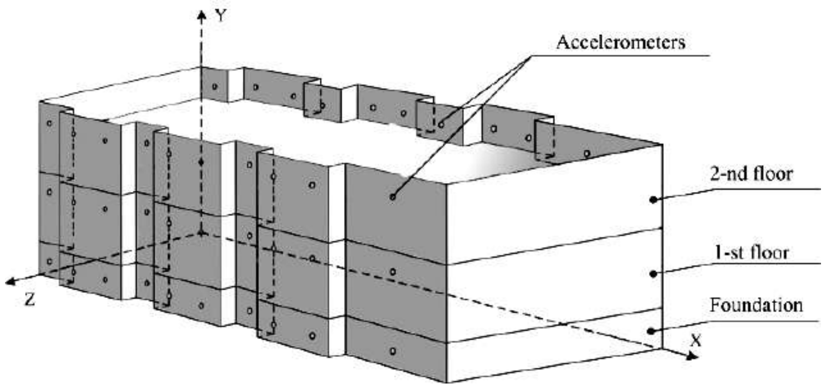

Fig. 3: Layout of accelerometer sensors.

An experimental assessment of the accuracy of the phase metric method during geotechnical monitoring

The changes in the foundation settlement were recorded simultaneously with the changes in the angle of inclination of the foundation parts at the control points. Before the onset of operational observations, a metrological assessment of the accuracy of the phase metric system of goniometric control was carried out using a Leica NA532 optical level meter. This model is equipped with a compensator and air damper system and has high sensitivity. Automatic alignment of the device to the working position occurs in the compensator's operating range of 15´ with an accuracy of ± 0.5 ". [Table 1] shows the results of an experimental assessment of the accuracy of the phase-measuring method compared to the applied goniometric control method.

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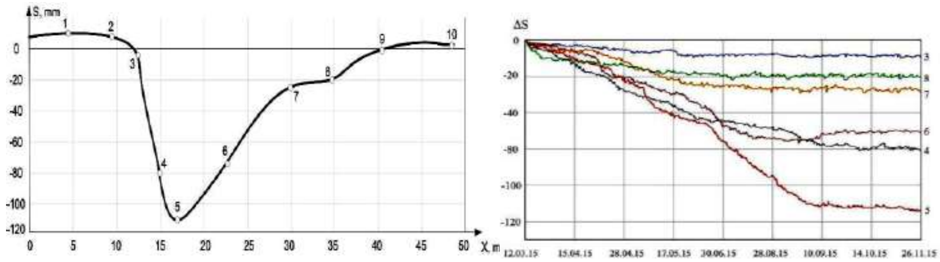
Table 4: Results of an experimental assessment of the accuracy of the developed method

The angle of rotation of the shaft according to the readings of the LeicaNA532, °	The average value of the angle of rotation obtained by the traditional method,°	The average value of the rotation angle obtained on the basis of the developed method, °
1±0,00012	1,0256	1,0021
2±0,00012	2,0183	2,0054
5±0,00012	5,0197	5,0012
8±0,00012	8,0249	8,0063
10±0,00012	10,0317	10,0023
12±0,00012	12,0299	12,0088
15±0,00012	15,0317	15,0097

[Fig. 4] shows the distribution of sediment values along the perimeter of the foundation at the time of the beginning of monitoring and the results of data on the control points of observations in the period from 12.03.2015 to 11.26.2015.



a)

b)

Fig. 4: a) The initial distribution of sediments along the perimeter of the foundation, b) a graph of changes in precipitation in the places where the sensors are installed.

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CONCLUSION

The results of an experimental evaluation of the accuracy of the method show that, on average, the deviation of the measured values of the angle from the value of the angle of rotation when processing the data by the developed method of goniometric control is 0.0053°. When processing data using the traditional trigonometric transformation using the arc tangent function of 0.0260°. The results of testing the sensor based on the developed method for geotechnical monitoring made it possible to estimate the error with respect to theodolite measurements. The error amounted to (± 0.01 deg), the accuracy of registration of the foundation settlement (± 0.1 mm).

As a result of the research, an analysis was carried out and methods for reducing the errors of accelerometric transducers in solving problems of measuring angles were proposed. According to the results of the analysis, it was proposed:

- reduce the total value of the error by software tools to compensate for errors.
- the errors of zero offset and temperature drift are compensated by the method of removing the systematic component from the acceleration signal;
- the error of nonlinearity and the error of the bias of the sensitivity coefficient of the accelerometer are compensated by the calibration method of the accelerometer in the reduced range of measured accelerations;
- to eliminate multiplicative errors due to the application of the developed phase-measuring method for measuring the angle of rotation.

As a result of research, a new method for automated measurement of the angle based on accelerometers was developed and tested. It has been established that in the case of applying the phase metric method, the measuring error of the accelerometer transducers can be significantly reduced and amount to degrees with the sensitivity coefficient of the accelerometer. This will improve the metrological characteristics of accelerometer measuring systems.

CONFLICT OF INTEREST

There is no conflict of interest.

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None.

FINANCIAL DISCLOSURE

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REFERENCES

[1] Kuckartza J, Collier P, Hutchinson G. [2011] The Design of an Integrated Structural Monitoring System for a High-Rise Building Based on Tiltmeters and GNSS. Joint International Symposium on Deformation Monitoring. http://dma.lsgi.polyu.edu.hk/JISDM-Proceeding/Proceeding/Full%20paper/164.pdf.

[2] Guralp Systems CMG-3ESPC User Manual http://www.manualsdir.com/manuals/770943/guralp-systems-cmg-3espc.html?download

[3] Guralp Systems CMG-5T User Manual http://www.guralp.com/documents/DAS-050-0001.pdf.

[4] van Hees VT, Fang Z, Langford J. et al. [2014] Auto-calibration of accelerometer data for free-living physical activity assessment using local gravity and temperature: an evaluation on four continents, J Appl Physiol (1985). 2014 Oct 1;117(7):738-744.

[5] Doscher J. [1998] Accelerometer Design and Applications J Doscher. Analog Devices. https://elpuig.xeill.net/Members/vcarceler/articulos/jugando-con-el-wiimote-y-gnu-linux/sensor971.pdf/at_download/file

[6] Haiying H. [2004] Modeling Inertial Sensors Errors Using Allan Variance H Haiying. University of Calgary URL: https://www.ucalgary.ca/engo_webdocs/NES/04.20201.HaiyingHou.pdf

[7] Yuskel Y. [2008] Notes on Stohastic Errors of Low Cost MEMS Inertial Units. https://pdfs.semanticscholar.org/8099/741b10ce60ff9d370fd7e285899713fcdde6.pdf

[8] Dorofeev NV, Kuzichkin OR. [2010] Problems of multiplicative instability of differential measuring transducers of an electromagnetic field. Questions of Radio Electronics, 1(1):117-122.

[9] Pavlov DV, Petrov MN, Lukin KG. [2013] Development of a dynamic model of a fiber-optic gyroscope. Bulletin of NovSU, 75.

[10] Dyumin AF. [2006] An optimal linear filter in the problem of calibrating errors of inertial angular velocity meters. Fiz.-mat. Sciences, 42.

[11] Bogdanov MB, Saveliev VV. [2012] A method for determining the multiplicative errors of measuring channels of a strap down inertial navigation system containing angular velocity sensors. Technical science, 11-2.

[12] Nikolaevich CI, Ivanovich ND. [2015] Correction of temperature error, approximation of calibration characteristics of sensitive elements of transducer equipment with intrasensory electronics, Measurement, Monitoring Control. The control, 4(14): 1-15.

[13] Tsaplev AV. [2014] The signal conditioning device of the accelerometer sensor of the angle of rotation of the radar antenna devices, AV Tsaplev, NV Dorofeev, OR Kuzichkin.- Radio engineering and telecommunication systems, 4:13-19.

[14] Kuzichkin OR et al. [2008] Methods and devices for transmitting and processing information. Radio engineering, 10: 79-82.

[15] Motorola Electronic Components Datasheet URL: https://datasheetspdf.com/pdf-file/1198249/Motorola/MMA2201D/1

[16] STM microelectronics URL: https://www.st.com/en/mems-and-sensors.html

[17] Accelerometer LIS331DLH. STMicroelectronics. Datasheet. URL: https://www.st.com/resource/en/datasheet/lis331dlh.pdf

[18] Grecheneva AV et al. [2016] Organization of geodynamic monitoring on the basis of the geoelectric method. 4th International Conference: From East Siberia to the Pacific - Geology, Exploration and Development ISBN: 978-946282197-2.

[19] Grecheneva AV et al. [2017] Application of a phase-measuring method in the inclinometric systems of geotechnical monitoring. Proceedings of the 2017 IEEE 9th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS 2017, 1(3):168-171.

[20] Kuzichkin O, Mikhaleva R, Nikolay V. [2017] Dorofeev Carrying out geodeformation monitoring in karst areas based on accelerometric goniometers. Journal of Fundamental and Applied Sciences, 9(1):1871-1884.

[21] Grecheneva AV et al. [2016] Organization of geodynamic monitoring on the basis of the geoelectric method. 4th International Conference: From East Siberia to the Pacific - Geology, Exploration and Development ISBN: 978-946282197-2.

[22] Kuzichkin O et al. [2017] Regression algorithms eliminate interference with the endogenous character geoecological monitoring of water resources. SGEM, 17(52):749-754, DOI: 10.5593/sgem2017/52/S20.096.

[23] Kuzichkin OR et al. [2017] Design and use of highly sensitive induction sensors for geodynamic monitoring. Journal of Engineering and Applied Sciences. 12(14):3644-3648.

[24] Grecheneva A et al. [2017] The method of selection of the key geodynamic objects. CEUR Workshop Proceedings, 1839:74-83, MIT 2016 Vrnjacka Banja Serbia, 28.08.2016.

[25] Grecheneva A et al. [2017] Positioning of the Goniometric Monitoring System based on the Phase Measuring Principle. International conference on industrial engineering, applications and manufacturing (ICIEAM). Saint Petersburg, ussia, May 16-19, 2017, New York.

ARTICLE

ASSESSMENT OF THE GEODYNAMIC SENSITIVITY OF THE METHOD OF EXPRESS CONTROL OF GROUNDWATER QUALITY

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ABSTRACT

The article assesses the sensitivity of the geoelectric express control method for a bipolar geoelectric installation. With an increase of the sensitivity of geoelectric measuring systems, the influence of temperature in the geological environment on measurements increases significantly and is the most significant interference-generating factor. In this regard, the article discusses the use of temperature correction algorithms. The geodynamic sensitivity of the geoelectric method for express control of the aquifer parameters was estimated based on analytical relations for the signal-to-noise ratio. The article also presents the structure of the measuring complex for geoecological monitoring. A generalized calculated geoelectric scheme based on the principle of imaginary sources, explaining the principle of the geoelectric method of express control of the aquifer, is given. To assess the sensitivity of the geoelectric method, measuring observations were conducted by the measuring complex for geoecological monitoring in the coastal zone of Lake Svyato (Nizhny Novgorod Region, Russian Federation). The data obtained show a rather high sensitivity of the geoelectric express control method to hydrogeodynamic variations in the parameters of the upper aquifer.

KEY WORDS
sensitivity, express control, groundwater monitoring, electrical conductivity

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INTRODUCTION

At present, monitoring systems for controlling zones of decentralized water supply are used. The purpose of automated control systems for decentralized water supply at the local level is to constantly monitor the level regime and quality of the waters of the upper aquifer, as well as the development of measures to eliminate the causes of pollution. The basis of its construction is the geoelectric methods of express analysis of the upper aquifer by a generalized parameter - electrical conductivity [1, 2]. The choice of the electrical conductivity of water as a generalized parameter of water quality is determined by its information content and the high adaptability of geoelectric methods for monitoring this parameter in real time. In addition, this makes it possible to use distributed geoelectric measurements for hydrogeological assessment of the development of exogenous and endogenous geological processes in the study area [3, 4].

When geoecological monitoring of groundwater using geoelectric methods of express control, spatiotemporal variations of the aquifer level and groundwater conductivity are used as unified hydrogeological indicators [5]. The indicators obtained during geological monitoring make it possible to formulate an assessment of the development of negative hydrogeological processes in the territories of decentralized water supply. Modern systems of geological monitoring, built on the basis of geoelectric sounding methods, are highly sensitive to geodynamic changes in the geological environment, which leads to their high efficiency of use when monitoring the aquifer [6]. However, with increasing sensitivity of geoelectric measuring systems, the effect of temperature on measurements in the geological environment increases significantly. In this case, temperature changes in the geological environment are the most significant interference-generating factor. The temperature effect distorts the time series of the recorded data, and require mandatory temperature correction of the results of geoecological monitoring of the aquifer [7].

The aim of the work is to assess the sensitivity of the geoelectric express control method for the bipolar implementation option, taking into account the use of temperature correction algorithms.

METHODS

Principles of express control of aquifer parameters based on geoelectric methods

For the organization of geoecological monitoring of water resources, an effective approach is the use of various methods of geoelectric control [8-11]. At the same time, the measuring complex of geoecological monitoring includes an electro-locating unit, which serves to collect and process primary control data [12]. As a result of the interpretation of the sounding data, the structure depth and geoelectric parameters of the aquifer are determined. The electrolocation complex consists of a control unit for processing and analyzing data, radiating electrodes AB, sensors for measuring the electromagnetic field MN, temperature gradient sensors T1 T2 and wires.

The structure of the measuring complex for geoecological monitoring of the aquifer is shown in [Fig. 1].

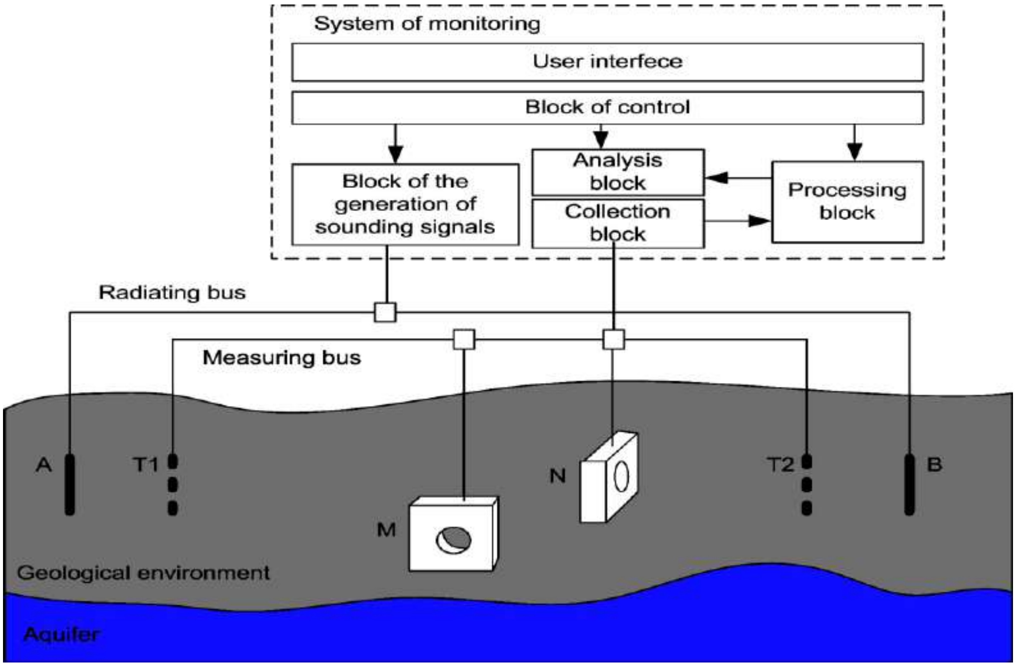

Fig. 1: The structure of the measuring complex for geoecological monitoring of the aquifer.

The parameters of the probing signal reflect the electromagnetic properties of the hydrogeological environment. Further, from the sensors M and N at the measurement points after pre-processing, an analysis of the parameters of the hydrogeological environment. To eliminate the influence of temperature interference, a gradient temperature measurement is carried out along the depth and area with temperature sensors T1,T2 [7,13]. When monitoring the geological environment, it is most rational to use non-contact transformer sensors (NTS) of the electric field [14]. They do not have galvanic contact with the medium and eliminate all kinds of excessive electrochemical noise.

[Fig. 2] shows a generalized calculated geoelectric scheme explaining the principle of the geoelectric method of express control of the aquifer, built on the principle of imaginary sources [15].

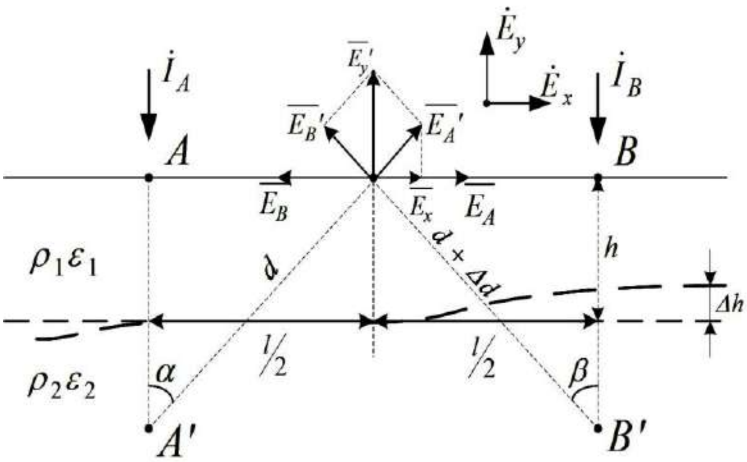

Fig. 2: Estimated geoelectric scheme.

In this case, the total recorded signal at the observation point $O(x, y)$ is determined by the superposition of normal signals generated by the sources of the probing signal A and B in the surface layer with parameters σ_1, ε_1, and signals from imaginary sources A' and B'.

Signals of imaginary sources determine the level of occurrence h, and geoelectric parameters of the aquifer σ_2, ε_2.

In accordance with the calculation scheme, the basic relations for the geoelectric field at the observation point are as follows:

$$E_y = E_A - E_B + E'_A \sin\alpha - E'_B \sin\beta, \; E_x = E'_A \cos\alpha + E'_B \cos\beta,$$
$$\alpha = arctg(l/2h), \; \beta = arctg(l/2(h-\Delta h)), \; d = sqrt(4h^2 + l^2/4). \quad (1)$$

Passing to the geodynamic parametric transfer functions of the hydrogeological section for a bipolar sounding installation [16], we obtain:

$$\dot{H}_x = \frac{K(j\omega)l}{2\pi(\sigma_1 + j\omega\varepsilon_1)d^3}(1+(1-\frac{3\Delta d}{d})\frac{\dot{I}_B}{\dot{I}_A}), \quad (2)$$
$$\dot{H}_y = (\frac{4}{\pi(\sigma_1 + j\omega\varepsilon_1)l^2} + \frac{K(j\omega)h}{2\pi(\sigma_1 + j\omega\varepsilon_1)d^3})(1-\frac{\dot{I}_B}{\dot{I}_A}) + \frac{K(j\omega)\Delta d(3d^2 - 12h^2)}{2\pi(\sigma_1 + j\omega\varepsilon_1)d^4 h}\frac{\dot{I}_B}{\dot{I}_A}$$

where $K(j\omega)$ - contrast ratio.

For low-frequency methods of geoelectric control, when measuring sensors are located on the day surface of a geoelectric section, the hydrogeodynamic trend can be determined in accordance with the following relation:

$$H(\Delta d, \sigma_2) = \frac{3l\Delta dK}{2\pi\sigma_1 d^4} \quad (3)$$

Compensation of the influence of temperature interference on the parameters of the geoelectric model

When using the geoelectric method of express control of the aquifer, the geodynamic variations of individual selected layers are well described when expression (2) expressing by the transfer function of the form [17]:

$$H(j\omega, \overline{\sigma}, \overline{\varepsilon}, T) = \sum_{i=1}^{m} A_i(\overline{\sigma}, \overline{\varepsilon}, T)/(B_i(\overline{\sigma}, \overline{\varepsilon}, T) + j\omega), \quad (4)$$

where the coefficients A_i and B_i are the functional dependences on the electromagnetic and spatial parameters of the media that make up the geoelectric section, is the temperature on the surface of the medium.

The electromagnetic properties of geological media (specific conductivity and permittivity) are determined primarily by the water content in the rocks that make up the geological environment. The active component of the electrical conductivity of rocks is formed due to the conductivity of the main porous structure and pore filler σ_R. In this case, the effect of temperature on the active component of the conductivity of the medium can then be described by the following linear equation:

$$\sigma = \sigma_C + \sigma_R - (\alpha_C + \alpha_R)T, \quad (5)$$

where α_C and и α_R are the parametric temperature coefficients.

When applying low-frequency electrical prospecting methods in geodynamic control systems, the imaginary component of the geoelectric field, which is determined by the dielectric of the water saturating the rock, should be taken into account. Moreover, the dielectric constant of water in the low frequency region is an order of magnitude higher than that of most minerals = 80 (at 20 degrees C). Numerous researches have shown that the temperature dependence of the dielectric constant of aqueous solutions is well described by a linear equation [18]:

$$\varepsilon_R = \varepsilon - \beta_R T \quad (6)$$

Mineralization determines the parametric nature of the effect of temperature on the electromagnetic characteristics of the researched geological environment, what should be taken into account when constructing processing algorithms in automated systems for express monitoring of groundwater quality.

In accordance with the accepted horizontally layered model of the geoelectric section in accordance with (5.6), the temperature effect can be taken into account through the generalized linear dependence of the complex conductivity of the upper layer of the geoelectric section [19].

$$H(j\omega,\overline{\sigma},\overline{\varepsilon},T) = H_1(j\omega,\sigma_1,\varepsilon_1,T_0)\alpha_T\Delta T + \sum_{i=1}^{m} A_i(\overline{\sigma},\overline{\varepsilon},T_0)/(B_i(\overline{\sigma},\overline{\varepsilon},T_0)+j\omega) \quad (7)$$

Based on (5,6), we have a linear regression relation uniting the time intervals and allowing to distinguish the hydrogeodynamic trend of the aquifer, which can be given to the following form:

$$H(j\omega,\overline{\sigma},\overline{\varepsilon},T) = H(j\omega,\overline{\sigma},\overline{\varepsilon},T_0) + H_1(j\omega,\sigma_1,\varepsilon_1,T_0)\alpha_T\Delta T + \Delta H_i(j\omega,\overline{\sigma},\overline{\varepsilon},T_0) \quad (8)$$

where i is the number of measurement intervals, is the generalized temperature coefficient, is the average generalized temperature, is the temperature deviation from the average.

Based on the regression relations, assuming that the hydrogeodynamic trend is stationary within the measurement interval, for each time interval, the transfer function variations are determined by temperature waves in the surface layer of the geoelectric section. Upon receipt as a result of regime observations, N is the number of intervals for monitoring the hydrogeodynamic process; M is the number of measurement points in the control interval, the temperature correction algorithm can be built on the basis of regression analysis of the data [20].

As a result, the generalized temperature coefficient is defined as:

$$\alpha_T = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} H_{ij}\left(T_{ij} - \frac{1}{M}\sum_{j=1}^{M} T_{ij}\right)}{\sum_{i=1}^{N}\sum_{j=1}^{M} T_{ij}\left(T_{ij} - \frac{1}{M}\sum_{j=1}^{M} T_{ij}\right)}. \quad (9)$$

Where do we get the calculated value of the geodynamic variations of the transmission coefficient Δi:

$$\Delta_i = \frac{1}{M}\sum_{j=1}^{M} H_{ij} - \frac{1}{M}\sum_{j=1}^{M} T_{ij} \cdot \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} H_{ij}\left(T_{ij} - \frac{1}{M}\sum_{j=1}^{M} T_{ij}\right)}{\sum_{i=1}^{N}\sum_{j=1}^{M} T_{ij}\left(T_{ij} - \frac{1}{M}\sum_{j=1}^{M} T_{ij}\right)} \quad (10)$$

Denote by, $\overline{H_M} = \frac{1}{M}\sum_{j=1}^{M} H_{ij}$ and $\overline{T_M} = \frac{1}{M}\sum_{j=1}^{M} T_{ij}$, then the geodynamic trend taking into account the temperature correction can be determined by the following relation:

$$\Delta_i = \overline{H_M} - \overline{T_M} \cdot \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} H_{ij}\left(T_{ij} - \overline{T_M}\right)}{\sum_{i=1}^{N}\sum_{j=1}^{M} T_{ij}\left(T_{ij} - \overline{T_M}\right)}. \quad (11)$$

The above relations (7-10) are of a general nature, allowing one to formalize the preliminary stage of processing geoelectric data at local control levels, taking into account temperature variations in the geological section. In this case, when assessing the sensitivity of the applied control method, it should be taken into account that the regression temperature correction algorithms reduce the temperature noise to the level of white noise with intensity

$$\Delta H_T = H_1(j\omega,\sigma_1,\varepsilon_1,T_0)\alpha_T \int_M \Delta T^2 \partial t(1 - \mathrm{mod}\, R_T) \quad (12)$$

where is the correlation coefficient of the regression analysis of the temperature dependence.

Assessment of geodynamic sensitivity

Assessment of the geodynamic sensitivity of the geoelectric method of express control of the parameters of the aquifer can be carried out on the basis of analytical relations for the signal to noise ratio. Assuming that after temperature correction the interference $\xi(t)$ is stationary and has an average value of zero. In this case, the deviations of the measured parameters $\Delta\delta_k = \{\Delta h, \Delta d, \Delta\sigma\}$ are also equal to zero on average. Suppose that the largest allowable parameter changes during measurements are equal $\Delta\delta_{km}$. Then the signal-to-noise ratio can be written as

$$D_k = (\Delta\delta_{km})^2 / D[\Delta\delta_k] \quad (13)$$

where $D[\delta_k]$ is the dispersion of noise in hydrogeodynamic parameters, determined by the noise.

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Under the assumption that the observation interval is determined by the assumed width of the spectrum of hydrogeodynamic processes. In this case, the noise dispersion is determined in accordance with equation (12), and for low-frequency methods of express control it has the following form:

$$D[\xi] = \int_{t=0}^{\tau} (H_1(\sigma_1, T_0)\alpha_T \int_{t=0} \Delta T^2 \partial t(1 - \operatorname{mod} R_T) - \overline{H}_1(\sigma_1, T_0))^2 \partial t \quad (14)$$

RESULTS AND DISCUSSION

Results of experimental studies and conclusions

Hydrogeological monitoring was carried out in the coastal zone of Lake Svyato. This is a large karst lake in the study area of the Nizhny Novgorod region up to 20 m deep. It was formed as a result of the merger of several karst sinkholes. Steep coasts 2-3 meters high are strongly indented by many capes and bays. There are several large islands on the lake. The lake is flowing, the bottom is sandy with a thick layer of silt, with water transparency up to 3 meters. The observations were carried out from May 1, 2017 to October 25, 2017 in the area of the location of the well of the water supply of the tourist camp. The first horizon of the study area refers to Quaternary and alluvial sands, the second to fractured and destroyed rocks of the Kazan and Sakmara tiers. Quaternary alluvial deposits of the second floodplain of the Teshi River pass on the research site. In the upper part of the stratum, the sands are fine-grained, with a depth turn into different-grained. The water at the source of lake Svyato and in the lake itself is characterized by very low mineralization. According to the analysis, its mineralization is 0.01 g/liter. The chemical composition of the water is sulfate-calcium-magnesium. In the samples of water from the well (depth 18 m) on the territory of the Svyato Lake, the water is fresh, aggressive towards sulfates and carbonates. According to the chemical analysis of water horizon sulfate-calcium-sodium. The mineralization of the aqueous solution is 0.07 - 0.26 g/liter. According to these calculations, in the coastal zone of the lake, groundwater is aggressive towards carbonate and not aggressive towards sulfate rocks.

As can be seen from the data presented during the entire observation period, the piezometric level of karst waters is very close to the level of ground above-karst waters (figure 3). Moreover, in the observed period, there is an excess of the levels of above-ground karst water over the piezometric pressure of karst water, together with a rise in the general level of the first aquifer. This difference according to observations ranged from 0.7 to 1.6 meters.

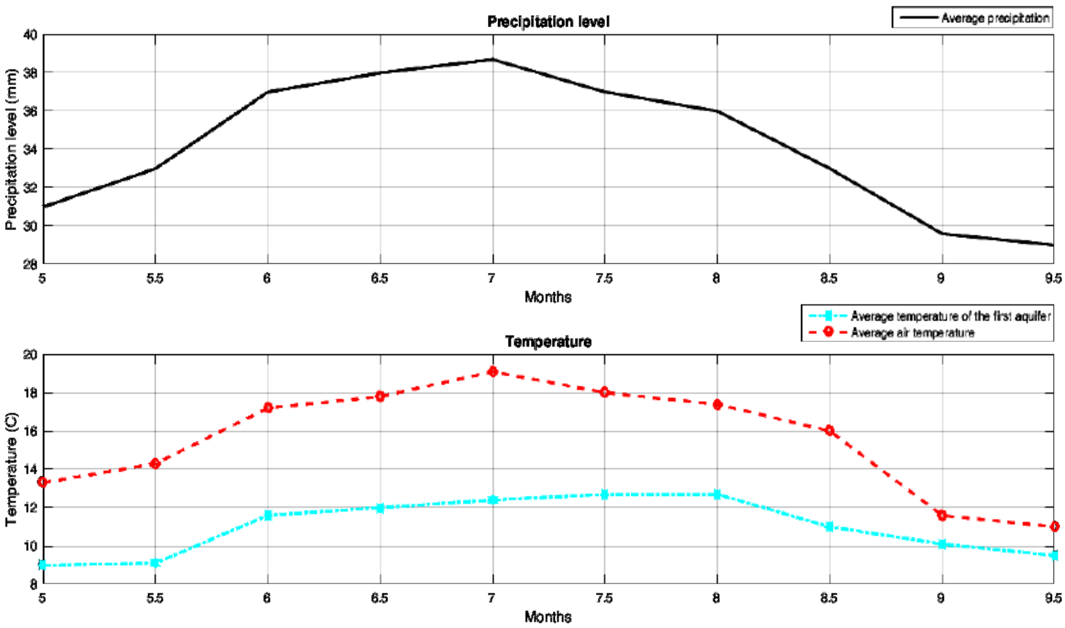

Fig. 3: Data from hydrogeological observations and average temperature.

Data on average temperature are obtained on the basis of regression processing of geoelectric signals, on the basis of the above algorithms obtained using a two-pole electrical complex of express control. The measuring geoelectric system was placed as follows. Radiating electrode A was removed from the lake by a distance l1 = 5meters; the first and second blocks of the proximity transformer sensor (NTS1 and NTS2) are located at a distance of l3 and l4 from the radiating electrode (provided that l3 = l4 = 30metres); electrode B is installed at the greatest possible distance l2 = 250 meters from the radiating electrode A. 16 daily intervals were treated [Fig. 4].

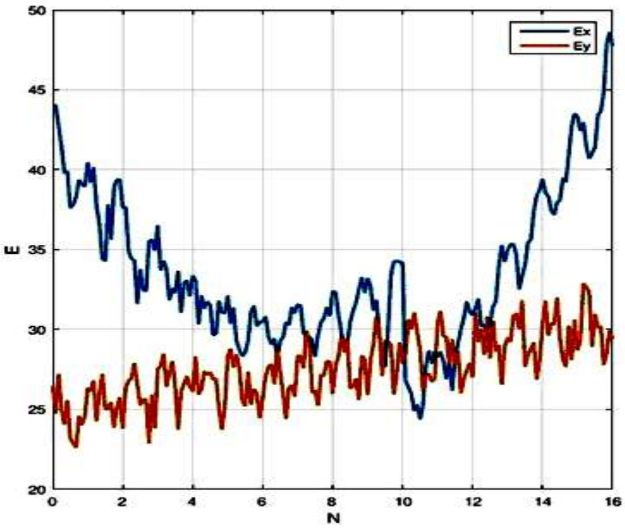

Fig. 4: Data of operational observations of a bipolar geoelectric complex of express control.

[Table 1] shows the data on the assessment of sensitivity at 16 measurement intervals.

Table 1: Data for determining the sensitivity of the geoelectric express control method

№	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
D_σ dB	32	33,5	33,6	34,2	35	34,6	33,9	34,7	35,3	36,7	37	37,8	38,3	39,1	40	41,2
D dB	37	36,4	36,3	35	33	33	33,3	34,3	34,8	37,1	37	38,2	38,4	39,1	39	39,4

CONCLUSION

The data obtained show a rather high sensitivity of the geoelectric express control method to hydrogeodynamic variations in the parameters of the upper aquifer. At the same time, the average sensitivity of a bipolar geoelectric express control system is 0.32% in conductivity, and 0.45% in terms of probability of correct detection of 0.95. It should be noted that an increase in the sensing poles makes it possible to obtain more accurate information about the hydrogeological variations of the studied hydrogeological zone.

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE

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REFERENCES

[1] Belyustin AA. [2015] Potentiometry: physicochemical fundamentals and applications. St. Petersburg: Publishing House, 336, RU.

[2] Budnikov GK, et al. [2003] Fundamentals of modern electrochemical analysis. World Binom LZ, 592.

[3] Sharapov RV, Kuzichkin OR. [2014] Geodynamic monitoring in area of nuclear power plant. Applied Mechanics and Materials, 492:556–560.

[4] Dorofeev NV, et al. [2017] Spatio-temporal data processing of automated geodynamic monitoring system. Proceedings of the 2017 IEEE 9th International Conference on Intelligent

Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS, 1:231–237.

[5] Romanov RV, Kuzichkin OR, Tsaplev AV. [2015] Geoecological Control of the Aquifer in the Decentralized Water Supply Systems of the Local Level. 8th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems, 42–46.

[6] Yakubovsky YuV, Renard IV. [1991] Electrical Intelligence. 3rd Edition. Moscow, RU, 358.

[7] Kuzichkin OR, Tsaplev AV. [2007] Temperature correction of the results of geomonitoring studies based on parametric models of media. Design and technology of electronic means. 2:39–43.

[8] Zhdanov MS. [1986] Electrical Intelligence: Textbook for universities. Moscow, RU

[9] Zhdanov MS. [2007] The theory of inverse problems and regularization in geophysics. Scientific world, RU.

[10] Khmelevskoy VK. [1984] Electrical intelligence. Publishing House of Moscow State University, 422.

[11] Gavrilov VA, et al. [2006] Experience of integrated well geophysical observations in order to monitor the state of the geomedium. Earth Science Series, 2(8):43-53.

[12] Grecheneva AV, Kuzichkin OR, Romanov RV, Bykov AA. [2017] Analysis of influence of endogenous factors on results of geoecological express-control of water resources. Journal of Engineering and Applied Sciences, 12(24):6852-6857

[13] Kuzichkin OR, et al. [2017] Geodynamic monitoring of development of a karst on the basis of georadar sounding. Proceedings of the 2017 IEEE 9th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS 2017, 1:227-230

[14] Orekhov AA, Dorofeev NV, Romanov RV. [2013] Technical diagnostics in blocks transformer sensors geodynamic control systems. Mechanical engineering and life safety, 2(16): 29-32.

[15] Tsaplev AV, Romanov RV, Kuzichkin OR. [2015] Estimation of bias currents in the electrolocation monitoring system of the upper aquifer. 15th International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM Albena; Bulgaria, 18(24):213-220.

[16] Bykov AA, Kuzichkin OR. [2014] Regression prediction algoritm of suffusion processes development during geoelectric monitoring. Advances in Environmental Biology, 8:1404-1410.

[17] Kuzichkin OR. [2009] Approximation of equivalent transfer functions of a geoelectric section in geodynamic control. Methods and devices for transmitting and processing information, 11:172-177.

[18] Recommendation of the International Telecommunication Union. [2018], Electrical characteristics of the earth's surface. P series Radio wave propagation Geneva. https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.527-4-201706-I!!PDF-R.pdf

[19] Kuzichkin O, Chaykovskay N. [2011] Spectral processing of the spatial data at geoelectric monitoring. International Conference on Multimedia Technology, IEEE ICMT, Hangzhou, China, 765-768.

[20] Tsaplev AV, Kuzichkin OR. [2012] The use of regression processing to compensate for temperature interference in geoelectric control systems. Radio industry, 2:147-153.