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ИЗВЕСТИЯ ВЫСОКИХ ТЕХНОЛОГИЙ
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Տեղեկագիրը հրատարակվում է Ակադեմիկոս Ի.Վ.Եղիազարովի ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտի, Հիդրավլիկական հետազոտությունների հայկական ազգային ասոցիացիայի, Երևանի կապի միջոցների գիտահետազոտական ինստիտուտի եւ Շուշիի տեխնոլոգիական համալսարանի կողմից: Հիմնադրվել է 2016թ.: Լույս է տեսնում տարեկան 2 անգամ:

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ON MOVEMENT OF SUSPENDED PARTICLES IN TURBULENT FLOW

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The analysis of mud structures operating experience enabled to represent their positive sides and reveal design deficiencies. To develop mathematical models of the mudflows movement is of great importance and drawing up design diagrams of structures requires bringing out distinctive features of the movement of suspended particles by turbulent water. On the basis of experimental investigations carried out to define carrying capacity of the flow has been ascertained that the ratio of coefficients of resistance with saturated suspended particles and clean fluid with high concentrations always greater than a unit, when in many known research works it is believed that this ratio is less than a unit. The obtained experimental results are rigorously substantiated theoretically. The course of the change of the ratio of mixture resistance coefficient and clear water runs in the following way: at first increase of coefficient C leads to decrease of $f_{pw} / f_w < 1$ *to a minimum value, then it starts increasing till a unit and more than unit.*

Key words: *turbulence, diffusion, fluid, coefficient of resistance, pulsating energy.*

Introduction

Scientists of many countries worked at issues of the movement of suspended particles in a turbulent stream. The principle difficulty here lies in the fact that different models of turbulence are not sufficiently perfect and up to now are subjects of theoretical and experimental study. As far back as in the middle of the last century academician A.N. Kolmogorov carried out study of the issue, the main ideas on locally isotropic turbulence of the stream being underlay in a so-cold $k-\varepsilon$ model of turbulence [1]. Later his hypotheses were used for closure of equations describing the movement of temperature heterogeneous streams [2] and suspended particles in turbulent stream [3,4]. In his fundamental works F.I.Frankl formulated equations of momentum and energy of turbulent pulsation fluid and hard components of flow, taking into account interaction between hard particles and fluid [5,6].Issues concerning the force of interaction between hard particles and fluid in their pulsating movement were also considered by J.O.Hinze [7,8]. Mud streams are formed as a result of interaction of a number of natural factors: hydrometeorological, climatic, geomorphologic, hydrological.

Formation of mud torrents in basins of mountain rivers in the main is conditioned by heavy falls of rain, hence, defining the regime of precipitations and establishing design characteristics of downpours has a certain importance for determining basic parameters of mudflows. However, the analysis of meteorological conditions, corresponding to heavy mud streams occurring in the Republic of Armenia and Nagorno-Karabakh Republic has shown that mud streams formation not always is in close agreement with heavy precipitations. This is explained by the fact that for formation of mudflows it is necessary that the basin was sufficiently wetted by earlier rains and that on slopes there were sufficiently much amount of easily sliding down the slope material. Heavy precipitations preceding a mudflow are typical of almost all mud streams occurring in basins of mountain rivers [23]. A mud stream is composed of a mixture of water and loose conglomerate – sediment. These flows are characterized by suddenness of formation, a short-run action and a great collapsing force. Moving mud streams in their way destroy settlements, buildings, various structures and facilities, roads, flooded gardens and fell trees, vineyards, and other agricultural areas. Running down through a channel the stream entails more and more particles of different nature and the force of gravity moves them along

the sloping surface they are resting as deposited large particles and eventually the stream is transformed in a fast-moving and full of energy turbulent mud-and-stone stream containing a great amount of sediment.

Mud streams in mountainous regions are triggered by brief and heavy fall of rains, heavy snowmelt, as well as break of obstructions, etc. At that it is quite natural that in the given basin shaped like centres or on water catchment hill slopes must be enough material containing tiny clay particles, sand, gravel, stones, and even boulders. Mud streams are characterized by strongly pronounced upper section (slope i=0,4-0,2), transition zone (i=0,2-0,5), and the lower or deposition section (i=0,05-0,01) [3,18,20].

Conflict settings

Development of the theory of turbulence of homogeneous and heterogeneous flows is now underway based on closure of equations completion procedure, by using various models of $k-\varepsilon$ and $k-\overline{u_i' u_j'}-\varepsilon$ type and preparation of numerical methods for solution of the equations. A specific point at that is determination of the ratio of resistance coefficients with maximum suspension of particles and clear water of various concentrations.

Research results

Experimental unit is composed of a rectangular metallic tray of 20m length, 0.37m width, and 0,24m height. By special devices the tray can be installed at different slope angles. At the top of the tray are mounted feed tank designed for feeding fluid flow, equipped with triangular measuring weir gauge and metering hopper for feeding of hared particles (sand) in desired quantity.

Sediment carrying stream passing through the operating section of the tray gets into a collecting tank. At the end of each experiment sand arriving into the tank is removed, dried out, and weighed. Then weight flow of hard particles is determined, which enables, in its turn, also to control operation of the metering hopper.

In the course of experimental study sand of six grain-size composition and weighted average diameter d=0,9mm, 1,10 mm; 2,64 mm; 7,85 mm; 8,5 mm, and 14,0 mm was used. The experimental tray was installed at the following slopes: i=0,01; 0,02; 0,03; 0,05; 0,08, and 0,15.

Water discharge changed within the range Q_w =10 l/s – 52 l/s. Hard particles consumption changed within Q_p= 0,059 kg/s – 10,5 kg/s. By variation of fluid and hard discharges such state of the flow was reached, when quantity of transported by them hard material met carrying capacity of the flow. It means that a nonessential addition of sand will cause their deposition. Such procedure has been repeated for all inclined positions of the experimental tray for different fluid and hard discharge and silt grain-size compositions. Then for identical conditions the tray was fed by clear water of discharge equal to fluid component of double-component flow. Thus , 90 experimental points have been obtained. On the basis of these data the following Chezy coefficients of mixture C_{wp}, clear water C_w of ratios $C_{wp}=\frac{u_{wp}}{\sqrt{R_{wp}i}}$, $C_w=\frac{u_w}{\sqrt{R_w i}}$ and their relationship $\frac{C_{wp}}{C_w}=\frac{u_{wp}}{u_w}\sqrt{\frac{R_w}{R_{wp}}}$, therefore, and $\frac{f_{wp}}{f_w}$.

To obtain energy of sediment suspension, i.e. energy that the stream consumes to support hard particles in suspended state in the flow recommendations of F.I. Frankle and I.O. Hinze [5-8] can be used. To complete equations derived by these authors connections between pulsing characteristics have been used and corresponding averaged hydraulic parameters of the flow not only of gradient type (in the form of Bussenesck) applicable for small-scale turbulence, but also of convection type, which would hold for the large-scale turbulence. On such an approach can be found in [8,9], where it is pointed out that in general energy balance of turbulent pulsations the sediment suspension energy

takes a place between small-scale and large scale turbulence. As a result for the suspension energy relevant to mass unit of the mixture (G) of homogeneous slow-changing flow we get

$$G = -(1+\beta C) g W_C C(1-C) + K_1 W_C C\,, \tag{1}$$

$$\beta = \frac{\rho_p - \rho_w}{\rho_w}\,. \tag{2}$$

where ρ_w and ρ_p are fluid density and hard particles, respectively, C is concentration (volumetric), g is acceleration of gravity, W_C is hydraulic size of hard particles in tight fall, K_1 is experimental constant equal to unit by order.

In case of slight water turbidity and absence of the second member Eq. (1) can be written as

$$G = -\beta g W_C C\,, \tag{3}$$

For a one-dimensional smoothly changing motion toward X, for equation of energy balance of turbulent pulsing we have

$$\frac{\partial}{\partial y}(\nu + \frac{\nu_t}{\sigma k}\frac{\partial k}{\partial y}) + P_r + G - \varepsilon = 0\,, \tag{4}$$

where

$$P_r = \nu_t (\frac{du}{dy})^2\,. \tag{5}$$

Between pulsation kinetic energy (k) and energy dissipation (ε) exist the Kolmogorov-Prandtl ratio

$$\nu_t = C\mu \frac{k^2}{\varepsilon}\,. \tag{6}$$

As it has been shown in [2, 3, 4, 8] in a number of applied problems, including the one under discussion, the first member in Eq.(4) presenting molecular and turbulent diffusion of pulsations kinetic energy, is smaller than in comparison with other members and to the first approximation can be neglected. It should be noted that the presence of this member in no way change the conclusion we will arrive without it. Hence, after the first member has been neglected and substitution of G and P_r according to Eq.(3) and (5), Eq.(4) will have the following form:

$$\beta W_C C g - \nu_t (\frac{du}{dy})^2 + \varepsilon = 0\,, \tag{7}$$

or making use of the mass conservation equation

$$W_C C + \frac{\nu_t}{\sigma_C}\frac{dC^2}{dy} = 0\,, \tag{8}$$

we get

$$-\beta g \frac{\nu_t}{\sigma_C}\frac{dC}{dy} - \nu_t (\frac{du}{dy})^2 + \varepsilon = 0\,, \tag{9}$$

Equation of momentum for the problem under study will have the following form

$$\nu_t \frac{du}{dy} = u_*^2 (1 - \frac{y}{H}), \tag{10}$$

where H s the depth of the flow, u_*^2 is the friction velocity.
Joint resolution of Eqs. (9) and (10) gives

$$\varepsilon = \frac{u_*^4}{\nu_t}(1 - \frac{y}{H})^2 (1 + \frac{\frac{\beta g}{\sigma c}\frac{dc}{dy}}{(\frac{du}{dy})^2}). \tag{11}$$

Hence, making use of Eq.(6). we have

$$k = \frac{u_*^2}{C_\mu^{1/2}}(1 - \frac{y}{H})\left[1 + \frac{\beta g}{\sigma C}\frac{dC}{dy} / (\frac{du}{dy})^2\right]^{1/2}. \tag{12}$$

From Eq.(12) follows that pulsing energy of the flow inhomogeneous fluid decreases in comparison with existing flow of clear water since $\frac{dC}{dy} < 0$.

Energy dissipation equation for the present problem can be written in the following form

$$C_{1\varepsilon}\frac{\varepsilon}{k}\left[\nu_t (\frac{du}{dy})^2 + (1 - C_{3\varepsilon})\beta g \frac{\nu_t}{\sigma C}\frac{dC}{dy}\right] - C_{2\varepsilon}\varepsilon = 0. \tag{13}$$

or

$$\varepsilon = \frac{C_{1\varepsilon}}{C_{2\varepsilon}}\nu_t \left[(\frac{du}{dy})^2 + (1 - C_{3\varepsilon})\beta g \frac{1}{\sigma C}\frac{dC}{dy}\right]. \tag{14}$$

From this it follows that energy dissipation of the flow also decreases in comparison with that of the clear water. In accordance with the forgoing we arrive at conclusions that the resistance coefficients of the flow with suspended particles are smaller than corresponding flow of clear water. This conclusion is borne out by experimental and theoretical researches [15,16]. However, it is necessary to take into consideration that in all experiments both fineness of hard particles and their concentration were small (C=0,0017-0,004, d=0,105).

Therefore dependence expressed in Eq.(11) is satisfied for that flows. When the coefficient of sediment is great energy of the flow is spent on suspension of hard particles and is determined by Eq.(10). Inasmuch as increase of concentration leads to gradual decrease of the first member of Eq.(1), and second one increases, then to determine the value of C, G assumes zero value (when $f_{pw} = f_w$), after which G takes positive value and then increases. Then the summand at the unit in parentheses of Eq. (11) becomes positive, which will cause increase of turbulent pulsations energy, therefore dissipation energy. As a result the ratio f_{pw} / f_w being greater than unit firstly slowly increased with C till C=0,3, then begins abrupt increase. The fact that the above mentioned ratio is greater than unit and increases with concentration is also evidenced by available research works in the field of hydraulic transport through pipes and pneumatic tube transport [17].

Conclusion

The foregoing enables to arrive at a conclusion that the course of change of the ratio of coefficients of resistance f_{pw} / f_w takes place in the following way – when C=0 then $f_{pw} / f_w = 1$. Further increase of C leads to decrease $f_{pw} / f_w < 1$ till some minimum value, then it starts increasing till to unit and larger than unit.

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Հ.Վ. Թոքմաջյան
Շուշիի տեխնոլոգիական համալսարան

Հեղեղատար կառուցվածքների շահագործման փորձի ուսումնասիրությունները թույլ տվեցին պատկերացում կազմել դրանց դրական կողմերի վերաբերյալ և հայտնաբերել կոնստրուկտիվ թերությունները: Հեղեղային հոսքերի շարժման գործընթացի մաթեմատիկական մոդելների ստեղծման և կոնստրուկցիաների հաշվային սխեմաների կազմման համար կարևոր նշանակություն ունի տուրբուլենտ հոսանքում կախյալ մասնիկների շարժման յուրահատկությունների բացահայտումը: Փորձնական հետազոտությունների արդյունքում, որոնք իրականացվել են հոսանքի տեղափոխման հատկության ունակության բացահայտման նպատակով, պարզվել է, որ մեծ կոնցենտրացիաների դեպքում դիմադրության գործակցի հարաբերակցությունը կախյալ մասնիկներով հագեցած հեղուկի և մաքուր հեղուկի գործակցի հետ միշտ մեծ է մեկից, և դա այն դեպքում, երբ բազմաթից հայտնի հետազոտություններում պնդվում է, որ այն փոքր է մեկից: Ստացված փորձնական հետազոտությունների արդյունքները հիմնավորվում են տեսականորեն: Մաքուր ջրի խառնուրդի դիմադրության գործակիցների հարաբերության փոփոխման ընթացքը իրականանում է հետևյալ ձևով. սկզբում C գործակցի մեծացումը հանգեցնում է $f_{pw} / f_w < 1$ փոքրացմանը՝ մինչև որոշակի նվազագույն արժեքի: Այնուհետև այն սկսում է մեծանալ՝ մինչև մեկ և ավելին:

Բանալի բառեր. Տուրբուլենտություն, դիֆուզիա, հեղուկ, դիմադրության գործակից, պուլսացիոն էներգիա:

О ДВИЖЕНИИ ВЗВЕШАННЫХ ЧАСТИЦ В ТУРБУЛЕНТНОМ ПОТОКЕ

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Анализ опыта эксплуатации селезащитных сооружений позволили представить их положительные стороны и выявить конструктивные недостатки. Важное значение для разработки математических моделей процесса движения селевых потоков и составления расчетных схем конструкций имеет выявления особенности движения взвешенных частиц в турбулентном потоке. На основании экспериментальных исследований, проведенных с целью определения транспортирующей способности потока, установлено, что отношение коэффициентов сопротивления с предельно

насыщенными взвешенными частицами и чистой жидкости при больших концентрациях всегда больше единицы, в то время, когда во многих известных исследованиях утверждается, что оно меньше единицы. Полученные экспериментальные результаты обосновывается теоретически. Ход изменения отношения коэффициентов сопротивления смесей чистой воды происходит следующим образом: сначала увеличение коэффициента С приводит к уменьшению $f_{pw} / f_w < 1$ до некоторого минимального значения. Далее оно начинает возрастать до единицы и больше

Ключевые слова: турбулентность, диффузия, жидкость, коэффициент сопротивления, пульсационная энергия.

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DEVELOPMENT OF OVERALL PREDICTION THEORY FOR RIVER CANALS TRANSFORMATIONS IN WATERCOURSES AND ITS PARTICULAR APPLICATIONS

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Steady soil progradation in channels of rivers and their tributaries, and sediment accumulations transported by water cause natural transformation of channels. These fluvial processes change the view of riverbeds in plan and especially vertical views.

The analysis of the present state of the problem in question has revealed a number of considerable shortcomings and errors. They are consequences of erroneous assessment of water flow discharge characteristics, as well as use of connections having inadequate substantiation in fundamental equations.

Statements, provisions, and equations generalizing stabilized states of different channel forming phenomena have been assumed in the work, their application boundaries being substantiated. In consequence of carried out investigations for stabilizing channel formation a universal mathematical model was developed applicable for the following cases:

- *channel formations of natural and man-made origin,*
- *different sediment regimes of flow (from under saturated flows to turbulent mudflows,*
- *various cross-sections of channels (rectangular, trapezoidal etc.).*

Key words: *water, river, channel, flood, turbulence, reservoir, anti-mudflow.*

Introduction

Figure 1. The gorge formed by flood

Canal transformation of water streams (deformations of river canals) aside from natural reasons also occurs engineering structures are build on rivers. During the last 50 years various large land-reclamation in submountain regions was accompanied by construction of many river structures. As a result the specific portion of man-made transformations of river canals have been essentially growth.

Figure 2. Sediment accumulations at downstream

For example, the portion of supports failure caused by floods in all damages of bridge and other river passages designed for various pipelines and communication lines is averaged ¾ (Fig.3).

Figure 3. Failure of bridge supports caused by flood

Figure 4. High-water dam

Many reservoir dams, flood and mudflow barriers (Fig. 4) currently are in operation and are being built. In each one of such structures accumulated sediment at the upper bowl produces bottom changes of river canals.

Current state of issues related to river canals transformation. First of all it is important to note that the majority of researchers usually is specialized in a hypotheses specific problem related to river

beds. Theoretical and experimental researches are mainly carried out to solve a specific problem. In our opinion this is the reason that no attempt was made to investigate and define the general basic provisions enabling to cover all kinds of river bed transformations. To ground such a statement let us briefly return to the current state of questions under discussion.

Development of economy is conditioned by creation of wide communication networks. For this reason from the beginning of the last century among represented problems first research works were devoted to bridge hydraulics which studies hydrodynamics and canal deformations of bridge passages. A number of Soviet and foreign researchers made an important contribution [1, 2]. They on the basis of several accepted hypotheses obtained first simple regularities on determining depth of river canals flooding. Later on this problem especially for lowland large and middle size rivers arrived to quite well and reliably solutions, including machine ones. For mountain and submountain rivers where there are more various and rapidly changing factors conditioning this phenomenon we have not thorough solutions [4]. In each of these cases at the top bowl accumulations of silt cause transformations of the river bed.

Current state of bed transformations related problems. First of all it should be noted that the majority of authors are specialized in a specific bed phenomena or research of the problem. Theoretical and experimental researches are curried out to solve individual aspects of problems. For that reason these issues and problems have never been investigated in width and depth and no attempt was made to set up such fundamental link between all kinds of bed transformations. To ground the above situation let us briefly represent the current state of problems under discussion.

It has always assumed that a high quality transport infrastructure is an essential prerequisite for economic growth. Therefore from the beginning of the 20th century the first scientific works were devoted to hydrodynamics of highway stream crossings and defining of river canals deformations (bridge hydraulics). A number of Soviet and foreign scientists [1,2] made important contributions trying to answer a number of complex questions. They through accepting several hypotheses obtained first simple regularities of canal flooding depth. In following decades for lowland large and middle size rivers this problem has come to a quite fundamental and reliable solution, including machine solution [3]. In case of mountain and submountain rivers, where there are more heterogeneous and dynamically varying factors conditioning the present phenomena, solutions still are not final [4]. Still there are not reliable and complete models describing process of silt accumulation in reservoirs. Still far from reality approaches are used in designs [5]. If large reservoirs can not be affected by erroneous decision of this problem, then in case of small and middle-size reservoirs that error often leads to serious consequences. And such reservoirs account for a large share in all existing reservoirs.

At upstream reach of high-water dams and anti-mudflow dams especially in spring and autumn begins silt accumulation process [6]. A current and especially stabilized, final surface, being shaped in a river canal is an important prerequisite on the basis of which calculation of accumulated sediment volume and dimensions of the structure is made. In the late forties of the last century many natural and laboratory investigations were carried out in the former Soviet Republics (Russia, Kazakhstan, Georgia, Armenia) to predict coordinates of such surfaces. The suggested formulae are quite simple and do not express running hydrodynamic multifactor physical phenomena. There also are a number of suggestions on theoretical approach for solution of these problems (USA, Japan, Denmark Institute of Hydraulics), where some arguable provisions were used [7, 8, 9].

The above given objective account of the problem enables to set the objective of the present paper and important problems to achieve the purpose in view.

Conflict settings

The goal of the work is to develop a generalized theory on hydrodynamic phenomena attending canal transformation and for particular cases to suggest prediction techniques for stabilizing canal transformations.

With this end in view the following problems should be solved:

- setup and substantiate those peculiarities of the canal and flow which generalize all transformations of the cannel,
- clearly define conditions which present the problem statement, define the framework of equations applicability and prove reliability of provisions describing the problem,
- develop a system describing stabilizing canal transformations and following them phenomena and on its basis for a particular case suggest methods for determining coordinates of the canal's stabilized shape.

Research results

Quantitative and qualitative analyses of obtained solutions for riverbed formation variety problems have been carried out. It enabled to assess the validity of the main provisions and approaches accepted by these suggestions. For most general and strict statement of the problem the phenomena under study are non-steady. It means that riverbed transformations and flow parameters causing them are changed over a long period of time (months, years) also with time.

Thorough analysis of existing methods has revealed a number of shortcomings and mistakes. They, in the main, result from not correct assessment of real values of water flow output characteristics, as well as making use of links having partial application and weak substantiation in fundamental equations. In particular:

- In determining parameters of the river canal transformed section, in the developed model as output values of parameters describing water flow are accepted confirmed values laying just above that section. It turned out that in different sections while predicting transformations different output characterizing values are referred to the same river, which results in unreliable solutions. Such an approach is a result of insufficient notion about silt transport regime:
- To determine Q_T flow of silt used in balance (3) equation each authors uses his preferable formula. In a number of works it has been shown that Q_T flow calculated by different formulae for the same condition strictly differ from each other (up to 50%) [5, 10]. It means that disadvantages of this or that formula having narrow range of application or many inaccuracies automatically take place in further developments.
- The next serious mistake is made in (1) equation when presenting energy losses for bi-phase fluid flow; to calculate the losses clean water regularities are used. In the last two decades a number of carried out experimental investigations have shown that the presence of silt is essentially raises energy consumption [11].
- The disadvantage is of methodic nature and concerns prediction of the most important final result for the riverbed transformation through non-linear differential equations of non-steady flow, a number of linearization and arguable assumptions being made during solution of the system. Instead of the above approaches a more simple and reliable mathematical model describing phenomena under study is suggested below.

To correct main shortcomings and mistakes existing in the proposed models designed for predicting various canal transformations the authors of the paper a number of researches and developments have been carried out and the main results are given below.

Statement of the problem

Let us assume that in any section of a riverbed transformations of an arbitrary shape development begins due to a natural or man-made cause. Before the beginning of the phenomenon hydrological, geometrical, and hydraulic actual, output parameters of the riverbed are:

- flows of stream and sediments, carrying capacity of the stream - Q, Q_T, S
- slope of the riverbed and the coordinate of the bottom – i_r, z_r,
- depth and width of the stream, cross-section area of the stream, wetted perimeter and average velocity of the cross-section - h_r, b_r, A_r, X_r, V_r, values of these parameters are determined by field investigations.

The above parameters in stabilized regime of the water (except the first three ones) are changed along the river.

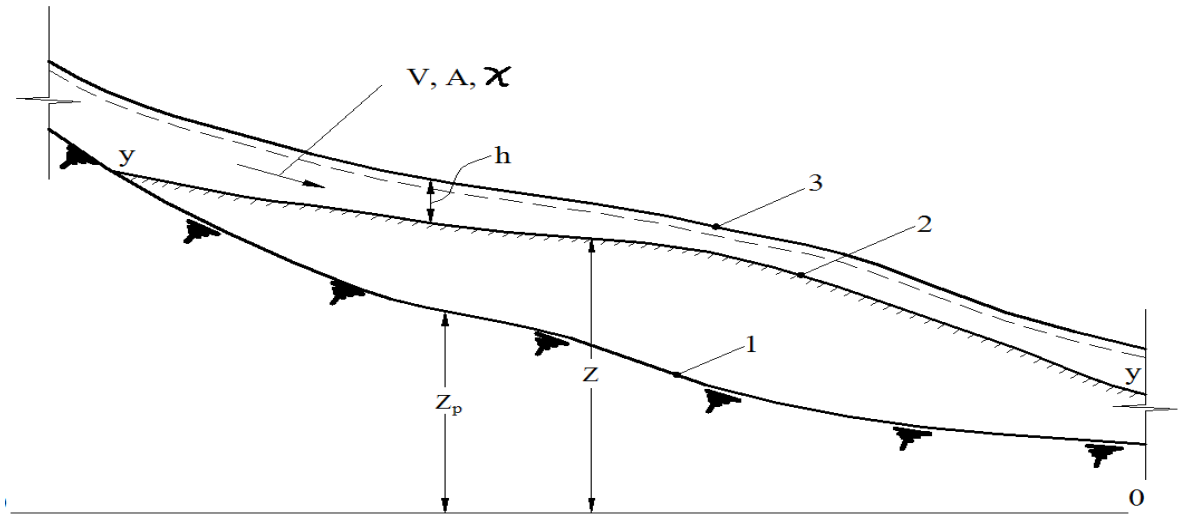

Figure 5. Longitudinal profile of the stabilized riverbed

Irrespective of causing reasons (natural or man-made) and running form (flooding or accumulation of silt) after dying of riverbed changes in the given section a new practically stabilized riverbed is formed (in Fig. 5 its bed is marked by a surface).

Assumed problems and approaches

Before proceeding to the solution of the problem let us present those important principles of which assumption enables to correct the above mentioned disadvantages and inaccuracies.

Values of parameters describing the riverbed and flow along water flow are strictly changed. Therefore, it is most important to make clear and substantiate those values which lead to stabilizing state of riverbed transformations. To this end a number of natural observations and silt regime clarifying researches have been carried out. On the basis of the obtained results analysis has been proved that most complete and accurate description of the river bed and water flow moving through it is provided by values taken in sections where sediment carrying capacity gets its maximum. Thus, according to the flow direction in adopted classification of separate sections an addition is made.

In particular, between sediment transition and sections of accumulation for the given water flow a “boundary section” concept is assumed [10].

The mathematical model of stabilizing riverbed transformations

Real and complete explanation of hydrodynamic phenomena following riverbed transformations enables to suggest a very simple physical model for the problem solution. It is assumed that stabilization of riverbed transformations has already been reached.

An objective is set to define values corresponding to a stabilized phenomenon. Such an approach provides prerequisites to avoid a model describing non-steady phenomena. Instead, the following simple system is suggested

$$\frac{dz}{dx} + \frac{dh}{dx} + \frac{d}{dx}\left(\frac{V^2}{2g}\right) = \frac{dh_f}{dx}, \tag{1}$$

$$A \cdot V = const, \tag{2}$$

$$Q_T = const, \tag{3}$$

(Here the direction of x is opposite to that of flow).

Before proceeding problem elaboration it is also important to specify and set a applicability framework for the system of equations, the point which is missing in existing methods. Balance Eqs.1,2, and 3 of energy, fluid, and sediment rate derived for single-phase real fluid indeed have a strict validation. However, it also is necessary to make clear the conditions where they can be applied for double-phase fluid. To this end in view V.G. Sanoyan's standard equation was used. By a number of transformations making it applicable for engineering solutions was shown that in a wide range (0 to 0.8) of hard and fluid parts ratio Eqs.1,2, and 3 of single-phase fluid flow are also applicable for double-phase fluid unidimensional motion [12].

In transforming the above equations a number of known hydrodynamic regularities have been used. Simultaneously expressions [10, 11] derived by the authors for conditions of energy losses and sediment balance have been taken into account. As a final result to describe phenomena running in stabilizing transformations the following differential linear equation [13] has been obtained by joint solution of Eqs.1, 2, and 3.

$$\frac{d\bar{z}}{d\bar{x}} + \frac{d\bar{h}}{d\bar{x}} - \frac{Fr_0}{\beta_0 \bar{A}^3}\frac{d\bar{A}}{d\bar{x}} = i_0 \bar{d}_{OT}^{1/3} \bar{A}^{(4a-10)/3}. \tag{4}$$

The above equation generalizes fundamental balance equations of energy, fluid and hard components of the flow, as well as links and regularities representing silt regime and channel conditions.

In addition due to this equation a relation between coordinates $\bar{z}$ of the new bed, depth $\bar{h}$ of the flow moving through that channel and water cross-section $\bar{A}$ is established. Other members of this equation are either output or determined making use of these values through classic methods. In particular, the developed mathematical model has been applied to predict channel bottom transformations in the Rion river (in Georgia) mouths and flow parameters in new conditions [14].

Conclusion

The mathematical model developed for stabilized state of a channel formation phenomenon is applicable for the following cases:

- channel transformations of natural and antropogenic origins,
- various sediment regimes of the flow (from low saturated flows to turbulent mud flows),
- various shapes of channels cross-sections (rectangular, trapezoidal),

The result of performed developments enables:

- to clear up conditions necessary for delta formation and silt propagation possible shapes in adjacent to river mouths areas depending on changes of the “erosion base”,
- to predict the bottom flooding measure in bridge passages,
- to receive coordinates of the upper surface of sediments accumulated against mud flow dams.

The work has been performed within the framework of 11-30/15T theme.

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ՋՐԱՀՈՍՔԵՐՈՒՄ ՀՈՒՆԱՅԻՆ ՁԵՎԱՓՈԽՈՒԹՅՈՒՆՆԵՐԻ ԿԱՆԽԱՏԵՍՄԱՆ ՀԱՄԸՆԴՀԱՆՈՒՐ ՏԵՍՈՒԹՅԱՆ ՄՇԱԿՈՒՄԸ ԵՎ ՄԱՍՆԱՎՈՐ ԿԻՐԱՌՈՒՄՆԵՐԸ

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Գետերի ու դրանց վտակների հուներում մշտապես ընթացող գրունտների ողողումները և հոսանքով եկող ջրաբերուկների կուտակումները պատճառ են հանդիսանում հունային բնական ձևափոխությունների՝ փոխվում են հուների հատակագծային և հատկապես ուղղաձիգ տեսքերը:

Նշված հիմնահարցի առկա վիճակի վերլուծությունը ի հայտ է բերել մի շարք էական թերություններ և սխալներ: Դրանք հետևանք են ջրահոսքի ելքային բնութագրերի ոչ ճիշտ գնահատման, ինչպես նաև հիմնարար հավասարումներում ոչ բավարար հիմնավորում ունեցող կապերի օգտագործման:

Աշխատանքում ընդունվել են տարբեր հունակազմական երևույթների կայունացած վիճակներն ընդհանրացնող սահմանումներ, դրույթներ և հավասարումների: Հիմնավորվել են դրանց կիրառման սահմանները: Կատարված մշակումների արդյունքում առաջարկվում է կայունացող հունակազմության համար ստացված մաթեմատիկական համակիրառելի մոդել, որը կիրառելի է.

- բնական և արհեստական ծագման հունաձևափոխությունների,
- հոսանքի տարբեր ջրաբերուկային ռեժիմների (ցածր հագեցված հոսանքներից մինչև տուրբուլենտ սելավներ),
- հուների տարատեսակ ընդլայնական հատույթների (ուղղանկյունաձև, սեղանաձև և այլն) պայմանների համար:

Բանալի բառեր. ջուր, գետ, ջրանցք, հոսանք, տուրբուլենտություն, ջրամբար, հակասելավային կառուցվածք:

РАЗВИТИЕ ОБЩЕЙ ТЕОРИИ ПРОГНОЗА ИЗМЕНЕНИЯ РУСЕЛ В ВОДНЫХ ПОТОКАХ И ИХ ЧАСТНЫЕ ПРИМЕНЕНИЯ

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Размыв грунтов русел рек и их притоков, а также скопление наносов приводят к изменению характеристик параметров русел. Анализ современного состояния проблемы, выявил некоторые значимые ошибки и упущения, которые связаны как с ошибочной оценкой выходных параметров потока, так и с применением необоснованных зависимостей в основных уравнениях.

Ключевые слова: вода, река, канал, поток, турбулентность, водохранилище, противоселевое сооружение.

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PROBLEMS OF EXPERIMENTAL STUDY OF ACCUMULATED AIR RELEASE

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The paper studies accumulated in a pipeline air emission into the atmosphere. The analysis of the differential equation of a fluid column motion has shown that flow rate at the outlet section tends to infinity.

Since the blowout rate is finite then it is commonly accepted that blowout of air-mixed mass occurs not at the outlet section but at the section located at some Xx distance from the outlet section. This assumption is proven by the experiment carried out at the damaged force pipeline of the Saralanj pump station.

A formula has been derived to determine the blowout rate. To evaluate the Xx distance a laboratory experimental studies have been carried out. The measured magnitude of range obtained by the experiments enables to quantify the Xx value.

An analytic calculation method for energy loss in a straight hydraulically smooth pipe of uniform cross-section through which a viscous fluid flows in steady-state conditions has been suggested. This method enables to determine hydraulic friction losses based on a unified approach, i.e. without binding it to the fluid flow regime. Satisfactory convergence of calculated and known in literature values of friction resistance coefficients has been shown.

Key words: *fluid, viscosity, velocity, energy, loss, pressure.*

Introduction

Complex and effective use of water resources requires combination of environmental, socio-economic and technical issues. In irrigation and drinking water systems of the Republic of Armenia hundreds of pump stations, gravity water pipelines are in operation of which the total length of the water main measures three thousand km. [3]. Physiographic characteristics, rough landscapes of mountainous countries cause serious difficulties for implementation and effective operation of engineering infrastructures and especially water supply systems.

In highlands pressure lines of irrigation, drinking water gravity cannels and pump stations have many siphon sections in the vertical plane where air accumulations occur which sometimes are called air cushions [1, 2, 7, 8, 10]. The main reason of air accumulations development in high locations of gravity pipelines is an aerated water entry developed in head works. rising and descending branches of high location pipelines in many cases are of large inclination due to which air accumulations developed in the siphon sections in conditions of operation hydraulic mode are not entrained by the fluid flow. As a consequence of all this the value of discharge flow through the pipeline is diminished. Not frequently, particularly, in small diameter siphon pipes the bubbles can occupy the entire section of the siphon pipes and make the siphon flow stop [4, 9, 12].

Many research workers carried our theoretical and experimental study of air accumulation development reasons in siphon sections of a pipeline and impact of the accumulations on the hydraulic mode. Release from the pipe end of the accumulated air entrained by fluid flow is less studied and

known as “Air Shot”. This phenomenon occurs almost in all pipelines functioning in pressure mode mainly when hydraulic mode undergoes a drastic change [5].

At the moment you open your kitchen water tap after a long interruption of the water supply service when the pipeline became full of air a sudden release of water mixed with accumulated air will occurs with a specific noise reminding that of sneezing. This stream of the water and air mixture strongly hits the washbasin. This phenomenon is far more dangerous in gravity water lines, pressure pipelines of pump stations. There it causes destruction and rupture of the pipe in head works (Mkfchian pump station first step, Saralanj pump station, Hermon-Elpin gravity canal [4]).

Waterlines of turbine installations of small hydropower stations built in the last decade in Armenia are located higher than the head works of the gravity waterline. It makes operation of the station complications [7, 11].In case the small hydropower stations taken out of service in the head works of the waterline due to water discharge abrupt decrease a difference occurs between the given and demanded discharges and as a consequence on some part of the waterline adjacent to the head works non-pressure flow is developed.

When on derivation length at the river section the discharge is recovered, in the head works the water level rise takes place, but the waterline no longer can receive additional discharge, till the entrapped in the pipeline air is not removed by an air release valves.

Currently a number of gravity waterlines are under design and construction in the country. Most of problems we are after is related to the design, effective operation, raising of safety, and maintenance.

Release of accumulated air was also observed in non-pressure tunnel of Tatev hydropower stations. As a result of a discharge more than water discharge, the tunnel cross-section was locked and when the entrapped air was released from the entrance section, the metal structures of the tunnel portal were destroyed.

Conflict settings

The problem of theoretical analysis of the water and air mixture stream release from the pipe end is reduced to determination of two physical magnitudes: ***release velocity*** and ***a force that stream hits on the motionless obstacle***.

Theoretically, determination of these two physical magnitudes, particularly, impact of the released mass on an motionless obstacle, is impossible, because releasing aerated two-phase mass concentration is unknown. For this reason investigation of this phenomenon should be carried out experimentally.

Researchresults. We planned to design, build, and install an experimental setup (Fig.1) in the hydraulic research laboratory of the Institute of Water Problems and Hydro-engineering after Academician Yeghiazarov.

The experimental setup consists of a D=25mm diameter glass tube (1), plug valve (2), check valve (3), valve of discharging unit (4), air release valve (5), flexible unit of connection (6), slope changing device (7). The experimental setup is fed from a large basin, which is installed at H=7m height from the entrance valve.

Sequence of experiments performance and obtained results

The experiment is performed in the following way: the glass tube is installed at $i_0 = \sin\alpha$ angle and by full opening the entrance valve the discharge Q and long-term L_0 are measured (Fig.1).

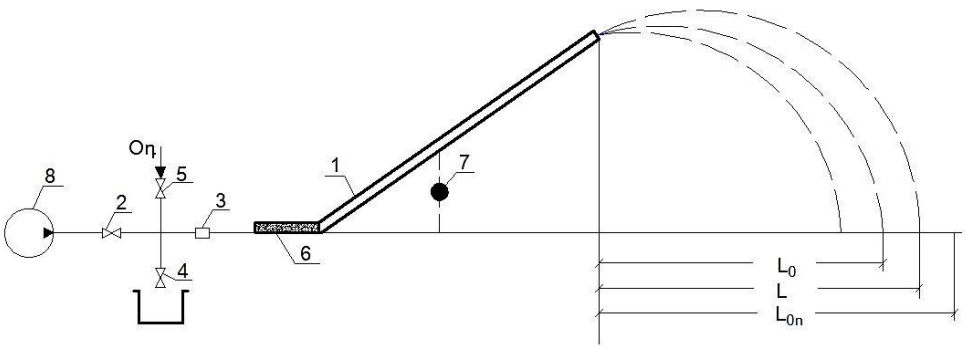

Figure 1. Experimental setup for release phenomenon observation

Trajectory equation of the stream's central particle can be expressed as

$$y = \frac{g\,x^2}{2V^2\cos^2\alpha} - x\,tg\alpha \tag{1}$$

Taking into account that when $y = h,\ x = L$, we have

$$L = \frac{V}{g}\cos\alpha\left(V\sin\alpha + \sqrt{V^2\sin^2\alpha + 2gh}\right): \tag{2}$$

It is evident that $L_0 / L = k$ quantity will characterize atmospheric air influence on the range of the stream.

A.Ya.Margaryan [5, 7] differential equation of the fluid column situated in front of air accumulation (in the line of flow) presents as

$$\frac{dV}{dt} = \frac{g\,i_0}{A}\,\frac{p_0\,W_0}{x\left[p_0 + \rho\,g\,x\left(i_0 + \frac{Q^2}{K^2}\right)\right]}, \tag{3}$$

where p_0 and W_0 are initial absolute pressure and volume of air accumulation, respectively, K is pipeline transmission capacity, x is the length of the fluid column between the outlet cross-section and air accumulation.

From Eq.(3) it follows that when $x \to 0,\ \ dV/dt \to \infty$ hence $V \to \infty$, that is from the pipe's end air accumulation is released by infinite high velocity.

The below table shows relative release ranges

Table 1

Relative release ranges

α_0	h cm	Q cm³/s	V cm/s	L_{0d} cm	L_0 cm	L cm	L_{od}/L_0 -	$k = L_0/L$ -

Actually the release velocity is final. This means that air mixed fluid flight starts from a section located at some x_* distance from the pipe end (Fig. 2).

Let us determine $V(x)$function in the [x_0, x_*] interval. As far as $dx = -Vdt$, then Eq.(3) takes the following expression of a differential equation with detachable variables

$$VdV = -\frac{b}{c}\frac{dx}{\left(x+\frac{p_0}{2c}\right)^2 - \left(\frac{p_0}{2c}\right)^2}, \tag{4}$$

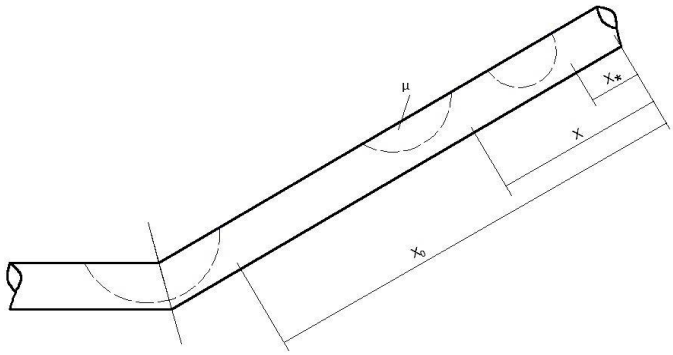

Figure 2. Time-dependent positions of air accumulation

where $b = p_0 W_0 \frac{i_0 g}{A}$, $c = \rho g\left(i_0 + \frac{Q^2}{K^2}\right)$: (5)

Substituting the variable, we have

$x + \frac{p_0}{2c} = u$ and denoting $\frac{p_0}{2c} = a$: (6)

Eq.(4) takes the following expression

$$VdV = -\frac{b}{c}\frac{du}{u^2 - a^2}: \tag{7}$$

Integrating Eq.(8) for boundary conditions

$$u = u_0,\ V = 0, \tag{8}$$

we get

$$V^2 = \frac{b}{ca}\ln\left|\frac{(u_0 - a)(u + a)}{(u_0 + a)(u - a)}\right|: \tag{9}$$

Substituting constants of Eqs.(5) and (6), we have

$$V=\sqrt{\frac{2g\,i_0W_0}{A}}\sqrt{\ln\frac{x_0\left(x+\dfrac{p_0}{\rho\,g\left(i_0+Q^2/K^2\right)}\right)}{x\left(x_0+\dfrac{p_0}{\rho\,g\left(i_0+Q^2/K^2\right)}\right)}}: \tag{10}$$

First root of Eq.(10) has a dimension of velocity

$$\sqrt{\frac{2g\,i_0W_0}{A}}=V_0\ : \tag{11}$$

Hence

$$V=V_0\sqrt{\ln\frac{x_0\left(x+m\right)}{x\left(x_0+m\right)}}, \tag{12}$$

$$\left(m=\frac{p_0}{\rho\,g\left(i_0+Q^2/K^2\right)}\right) \tag{13}$$

According to the above assumption and substituting $x=x_*$ in Eq.(12), we get the release velocity

$$V_*=V_0\sqrt{\ln\frac{x_0\left(x_*+m\right)}{x_*\left(x_0+m\right)}}: \tag{14}$$

Conlusion

Experimental studies will enable to clear up a number of problems which play a decisive role in design and operation processes, including the following:

1. findings obtained by experimental study on air accumulations displacement nature in gravity waterlines,
2. analysis of results obtained by theoretical and experimental study on critical velocity value of air accumulation entrainment by fluid flow,
3. theoretical and experimental study on air accumulation development reasons in the pressure pipeline and impact mechanism of water and air mixture stream released from the end outlet of the pipeline.

The work has been performed within the framework of 15T-2K263 theme.

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ԽՈՂՈՎԱԿԱՇԱՐԻՑ ՕԴԱՅԻՆ ԿՈՒՏԱԿՄԱՆ ԱՐՏԱՆԵՏՄԱՆ ՓՈՐՁԱՐԱՐԱԿԱՆ ՀԵՏԱԶՈՏՈՒԹՅՈՒՆՆԵՐԻ ԽՆԴԻՐՆԵՐԸ

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[2]Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան
[3]Շուշիի տեխնոլոգիական համալսարան

Քննարկվում է խողովակում առկա օդային կուտակման՝ մթնոլորտ արտանետման երևույթը: Օդային կուտակման առջևում գտնվող հեղուկի սյան շարժման դիֆերենցիալ հավասարման վերլուծությամբ պարզվել է, որ ելքի կտրվածքում հոսանքի արագությունը ձգտում է անվերջության:

Քանի որ արտանետման արագությունը պետք է լինի վերջավոր, ապա ընդունված է, որ օդախառը զանգվածի արտանետումը կատարվում է ոչ թե խողովակի ելքի կտրվածքից, այլ դրա ծայրից որոշ Xx հեռավորության վրա գտնվող կտրվածքից:

Այս պնդումը հաստատվել է Սարալանջի պոմպակայանի վթարված մղման խողովակաշարի վրա կատարված փորձերով:

Ստացվել է արտանետման արագության որոշման բանաձև: Որպեսզի գնահատվի Xx-ի մեծությունը, կատարվել են լաբորատոր փորձնական հետազոտություններ: Դրանց արդյունքում որոշված հեռահարության չափված մեծության միջոցով գնահատվել է Xx- ի մեծությունը:

Բանալի բառեր. հեղուկ, մածուցիկություն, արագություն, էներգիա, կորուստ, ճնշում:

ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПРОБЛЕМЫ ВЫБРОСА СКОПИВШЕГОСЯ ВОЗДУХА

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В статье рассматривается проблема выброса воздуха в атмосферу,скопившегося в трубопроводе.Анализ дифференциациального уравнения движения жидкости в трубе показывает,что скорость потока на выходе из секции,как правило,бесконечна.

Поскольку дебет фонтанирующей скважины ограничен,то обычно считается,что дебет смешанных воздушных масс происходит не на выходе выпускной секции,а на участке,рассположенном в некотором Хх расстоянии от секционной розетки.Это предположение подтверждается экспериментом,проведеннм трубопроводом насосной станциии Сараландж.

Ключевые слова: жидкость, вязкость, скорость, энергия, потеря, давление.

$$u = \left(\frac{2a}{\upsilon^2}\right)^{1/2} \upsilon l_0^{1/2} f' = U_0 f'$$

The local shear stress is determined by the below equation

$$\tau_0(z) = \mu \frac{\partial u}{\partial r}\bigg|_{r=0} = \frac{1}{\sqrt{2}} f_0'' U_0 \mu \left(\frac{2a}{\upsilon^2}\right)^{1/4} \frac{1}{z^{1/4}}$$

The average value of shearing stresses is determined by the below formula

$$\tau_w = \frac{4}{3\sqrt{2}} f_0'' U_0 \mu \left(\frac{2a}{\upsilon^2}\right)^{1/4} \frac{1}{l^{1/4}}$$

Pressure loss in the l long section of under consideration will be

$$\Delta p_2 = \frac{16}{3\sqrt{2}} f_0'' U_0 \mu \left(\frac{2a}{\upsilon^2}\right)^{1/4} \frac{l^{1/4}}{d}$$

Making some simple transformations of the above equation, we have

$$\Delta p_2 = 45.5 \cdot \frac{1}{\mathrm{Re}^{3/4}} \cdot \left(\frac{l}{d}\right)^{3/4} \cdot \frac{\rho \langle u \rangle^2}{2}$$

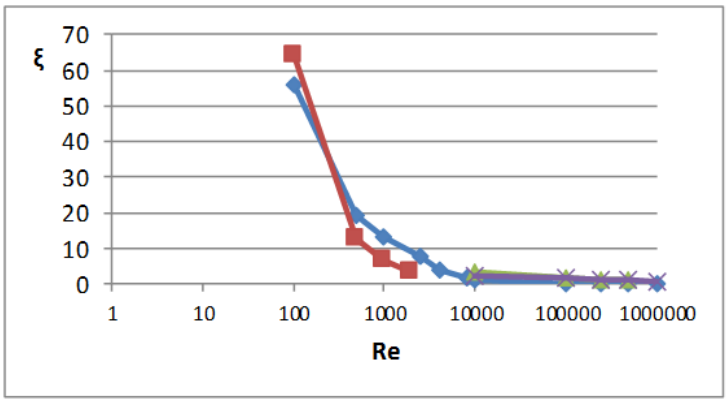

Figure 1. Comparison of friction resistance coefficients for $l/d = 100$

1- theoretical curve plotted by Eq. (20) $\zeta = \left[\frac{45.5}{\mathrm{Re}^{3/4}} \cdot \left(\frac{l}{d}\right)^{3/4} + 2.42\right]$, 2- plotted by $\zeta = \frac{64}{\mathrm{Re}} \cdot \frac{l}{d}$ [1],

3- plotted by $\zeta = \frac{0.316}{\mathrm{Re}^{0.25}} \cdot \frac{l}{d}$ [1], 4- plotted by $\zeta = \left(0.0032 + \frac{0.221}{\mathrm{Re}^{0.237}}\right) \cdot \frac{l}{d}$ [4] .

Pressure general loss in the pipe is summed up from losses at the initial section where velocity profile is stabilized and in the section of stabilized flow

$$\Delta p = \Delta p_2 + \Delta p_0 = \left[45.5 \cdot \frac{1}{\mathrm{Re}^{3/4}} \cdot \left(\frac{l}{d}\right)^{3/4} + 2.42\right] \frac{\rho \langle u \rangle^2}{2} \tag{20}$$

Comparison of calculated values of the friction resistance coefficient with experimental data available in the literature (see the Figure)

Discrepancy between the two Averaged 8 per cent.

UDC 626:627.81

RISKS ASSESSMENT OF KHACHEN RESERVOIR USEFUL CAPACITY INCREASE

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Khachen reservoir as brought into service in 1954. The annual average flow of the Khachen river is 116x106m3and the useful capacity of the reservoir is 20x106m3. The culvert aqueduct of the reservoir is calculated for a hydrograph of one per cent probability. It is planned to increase useful storage capacity of the reservoirby 3.8x106m3at the expense of transformation volume. To this end it is foreseen to install valves of automated regulation on the shaft spillway and keep elevation of water on high retaining level (HRL)The capacity of the dam to withstand internal erosion and stability of slopes for different levels of the water have been checked and hydraulic calculations have been performed for spillway structures and storm water flows.

***Key words**: reservoir, water balance, stability, dam, storm water sewer, spillway, shaft spillway.*

Introduction

The Khachen reservoir of seasonal regulation was commissioned in 1964 designed for 1000 ha agriculture land irrigation.The reservoir is located in submountain steppe landscape zone, where lukewarm climate conditions are characterized by dry winters and humid summers.The annual average flow is 116,4x10^6m^3. Full storage capacity of the reservoir is 23x10^6m^3, of which 20x10^6m^3 is useful one. The plan of the reservoir is shown in Fig.1.

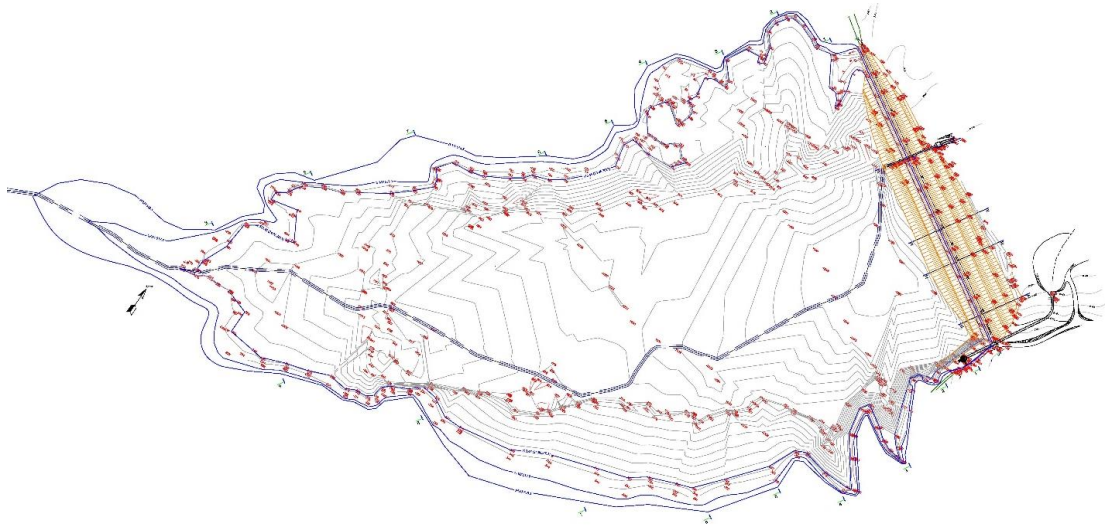


Figure 1. The plan of the dam and bowl of Khachen reservoir

Table 1 shows water balance of the Khachen reservoir. Results of field and laboratory investigations were used in calculations [1, 2].

Khachen reservoir, as all reservoirs, except annual flow regulation for irrigation purpose also regulates storm water maximum flow. To regulate storm rainfall flow on the reservoir surface a shaft spillway was constructed for 168m^3/s capacity. D.Kocherin simplified formula [1,2] was used to evaluate spillway structure capacity

$$q_{\max} = Q_{\max}\left(1 - {V_\phi}/{W_n}\right) \quad (1)$$

where $q_{\max}$ is the spillway flow, $Q_{\max}$ is the maximum flow of water pouring the reservoir, V_{ϕ} is the 3,8x10^{6}m^3 volume of accelerated spillway is obtained from $V = f(H)$ curve, W_n is the volume of storm water flow. calculations are performed for one per cent probability flow

$$q_{1\%} = 204 \times \left(1 - {}^{3.8}\!/_{21.7}\right) = 168.3\,\text{m}^3/\text{s}$$

Table 1

Khachen reservoir annual water balance (m^3) of 50 and 75 percent probability

Probability, P	Entry end			Outlet portion						Remnant in the reservoir	Downstream of the spillway
	River flow	Atmospheric precipitates on reservoir surface	Total	1200 ha new agricultural land water demand	water demand of existing 1000 ha agricultural land	Seepage losses	Evaporation	Environmental flow	Total		
50%	113.54	0.86	114.4	5.69	23.0	0.69	1.01	6.94	37.33	3.0	74.07
75%	87.36	0.86	88.22	7.4	29.9	0.90	1.31	9.02	48.53	3.0	36.69

Thus, performed calculations show that the storm water sewer provides free passage of the estimated flow of one per cent probability to downstream portion. Fig.2 shows flood hydrograph of one per cent probability, which shows that storm water flows passage to the downstream through the existing shaft spillway practically is impossible.

Thus, performed calculations show that the storm water sewer provides free passage of the estimated flow of one per cent probability to downstream portion. Fig.2 shows flood hydrograph of one per cent probability, which shows that storm water flows passage to the downstream through the existing shaft spillway practically is impossible.

Regardless of the fact that maximum flows of the Khachen river are formed also in snowmelt period, however they for the most part are formed by torrential rains. The largest of flow rates 121m^3/s was reported at water inspection station located below the Khachen-Kolatak river mouth, and at Khachen-Vank water inspection point it was 91,5m^3/s.

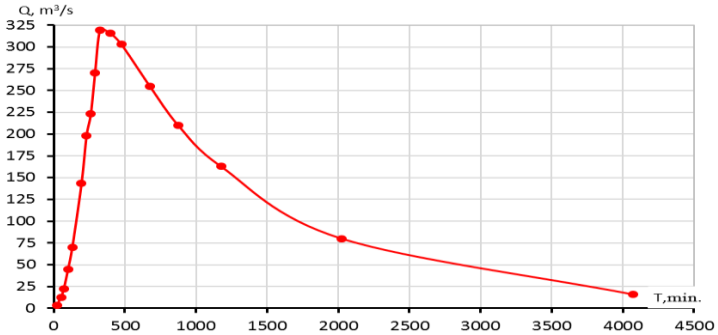


Figure 2. Hydrograph of rainwater flood of one per cent probability of the reach of river of Khachen reservoir dam

Over five decades of Khachen reservoir operation the volume of accumulated sediment amounts to 1,5x10^{6}m^3. At that this volume is located along the entire length of the reservoir and in its different parts the thickness of deposited sediment layers is different: at the dam toe it is 9-10 m, in the middle part of the reservoir – 6-7m, and at the tail it is about 1-2m. Thus it should be noted that today the total capacity of Khachen reservoir reduced from the design capacity not more than seven per cent, and useful capacity only 3-4 per cent, that is half of the dead storage.

Table 2

Maximum flows of different probability

River reach	Maximum flows (m^3/s) according to probability P%					
	0.1	0.5	1	3	5	10
Khachen reservoir	319	235	204	152	126	92

As a result of field measurements and laboratory developments morphologic actual curves have been plotted (Fig.3) and silts' actual volumes shown on them.

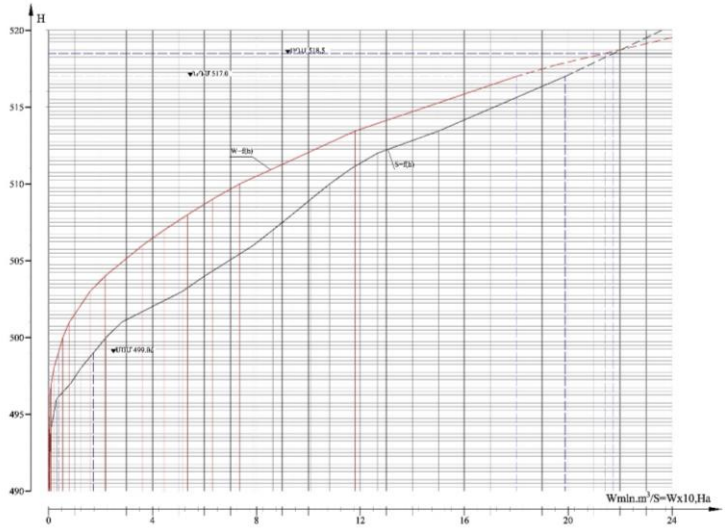


Figure 3. Dependence of volume and area of Khachen reservoir and its water level

Conflict setting

This study is aimed to increase the useful volume of the Khachen dam reservoir using $3{,}8x10^6m^3$ transformation volume between low retaining level (LRL) and HRL setting up valves of automatic regulation on the shaft spillway. In such case, quite natural that both the values of porous pressure and mode of deformation are changed. As it was pointed out above the transformation volume and the flow of the shaft spillway make removal of flood flow to downstream. For this reason total capacity of spillway should be added to $272m^3/s$ or the transformation volume should be added to 11,8x106m^3, which will lead to lowering LRL by 3,4m and the useful volume will become $12x10^6m^3$ [1,2]. According to international norms the spillway capacity should be increased, or NRL decreased. Actually, in recent years the other way about has been done. If in the past capacity of irrigation spillway was around $35m^3/s$, then today after its rehabilitation its capacity plus the capacity of the siphon system does not exceed $7m^3/s$. During rehabilitation of the regulation tower in the irrigation tunnel gallery a pipe of 820mm diameter was installed having 5m3/s capacity (Figs. 4 and 5).

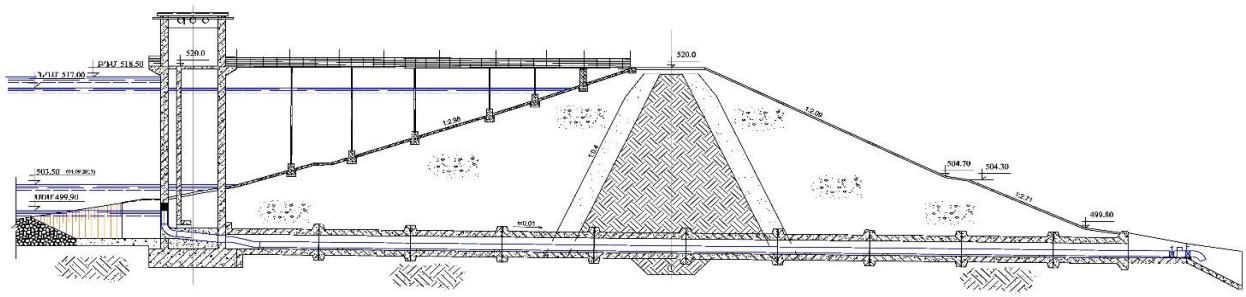


Figure 4. Khachen reservoir irrigation spillway after rehabilitation

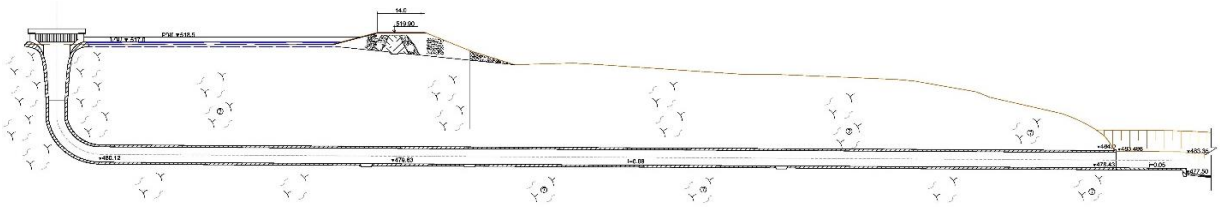
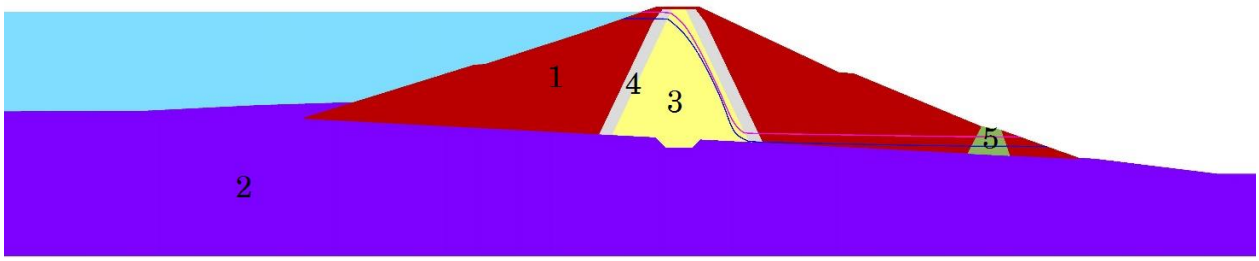


Figure 5. Khachen reservoir emergency shaft spillway

Research results

Strength and stability test carried out for Khachen reservoir in case of water LRL and HRL various calculation methods and techniques have been used. As a calculation section the most dangerous plane section was considered (Fig. 6) on which depression levels are placed (Fig. 7).

Design parameters of static calculation have been defined as a result of laboratory investigations analysis, and design parameters of dynamic calculation were taken from reference books [3]. To determine shear module of soil and Poisson coefficient empirical formulas based on velocities of propagation of dynamic waves have been used



1.Pebble-gravel formation with up to 10% sand filler (dam body)
2.Pebble-gravel deposits with up to 20% sand filler (base)
3.clay loams mixtures up to 5% (dam body)
4. Sand grains of different size (transition prism)
5. Stone banket

Figure 6. Calculation section selected for strength and stability calculations

$$G = \rho \times V_s^2 \tag{2}$$

$$\mu = \frac{0.5 - \gamma_v^2}{1 - \gamma_v^2}, \quad \gamma_v = \frac{V_s}{V_p} \tag{3}$$

where if $\sigma_z > 0.2$ MPa, then $V_s$and V_p, of which zero values are listed in table 1, are determined by the below formula

$$V_{p,s} = 1.3 \times V_{p_0, s_0} \times \left(\frac{\sigma_z}{\sigma_{z_0}} \right)^{1/6} \tag{4}$$

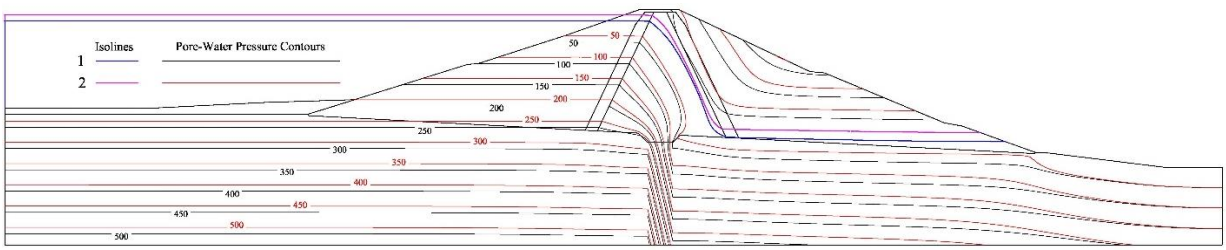


Figure 7. Porous pressure contours and depression curves

Except for the principal loading, as a design case another two loading cases have been considered:

seismic loading and quick lowering of the water level from LRL to MM. In case of seismic loading the problem is solved by two different methods.

In case of seismic loading the normative value of horizontal acceleration was accepted A=0.3g. Taking into account normative documents on seismic construction of the Republic of Armenia and the Republic of Nagorno-Karabagh [4] the design values of the horizontal acceleration were calculated K_0=1.0, K_1=0.3, K_2=1.0, $A_{hw2.}$=0.09g. Then according to Building Code for earth dams design [3, 4, 5] coefficients of the dam stability have been calculated in cases of principal and special loadings.

Thus, for principal loading

$$Ks = \frac{\gamma_n \times \gamma_{fs}}{\gamma_c} = \frac{1.2 \times 1.0}{1.0} = 1.2$$

and special loading

$$Ks = \frac{\gamma_n \times \gamma_{fs}}{\gamma_c} = \frac{1.2 \times 0.9}{1.0} = 1.08 \qquad (5)$$

Khachen dam slopes comparison stability testing for principal and special loading cases were carried out applying the circular cylindrical method. To determine the slope's stable angle of inclination the slopes stability assessment circular cylindrical method was used. The following Ordainar, Bishop, Janbui, and Morgenstein-Price four techniques were used. This method enables to consider stability of a mass of arbitrary surface and satisfy three equations of static equilibrium. Boundary values of shear stresses are defined by Cauchy law and the function of internal forces dependence is considers by $X = E\lambda f(x)$ law where λ is a scale factor and is determined during iteration, and $f(x)$ arbitrary function characterizes X stresses propagation regularity on separate layers is preselected by the user.

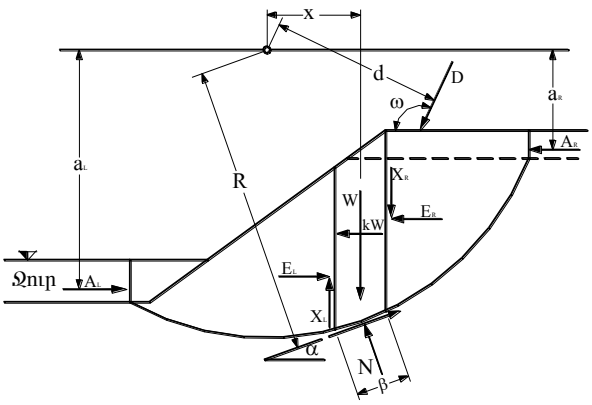


Figure 8. Cylindrical surface of shear

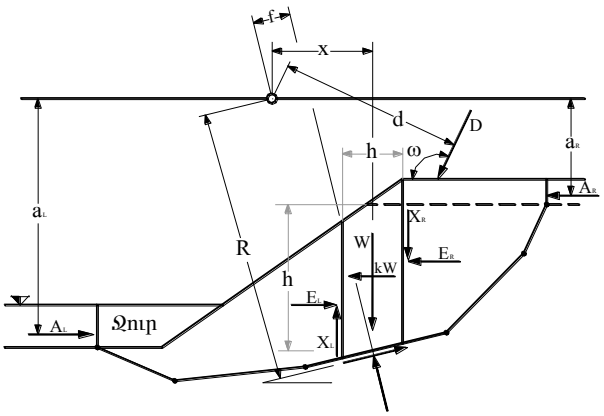


Figure 9. Arbitrary polygonal surface of shear

The above figures show a sliding down mass and forces acting on it where W is the total weight, x and e are horizontal and vertical distances between the centre of mass and centre of rotation, N is the normal reaction and f is its arm, S_m is the tangential reaction and R is its arm, α is the slope angle, E and X are normal and tangential reactions on the layer internal surface, D is the pin load and d is its arm and ω is the slope angle, A is the hydrostatic load and a is its arm, kW is the horizontal seismic load.

On each layer's internal surface a sliders training resistance is developed which is determined by the following formula

$$S_m = \frac{\tau \times \beta}{K} = \frac{\beta \times (c' + (\sigma_n - u) \times tg\varphi')}{K}, \qquad (6)$$

Where $\sigma_n = \frac{N}{\beta}$ is the normal stress on the layer bed, K is the safety factor, β is the length of the layer base.

Table 3

Stability testing of Khachen dam slopes in case of primary and special loading and for different water levels in the reservoir

	Loading	Reservoir water level	Stability factor values (K) calculated by different methods			
			Ordinary	Bishop	Janbu	Morgenstern-Pruse
Upper slope of the dam	principal (under the action of static forces)	is empty	2.452	2.487	2.449	2.488
	principal (under the action of static forces)	N=517.0 m	2.104	2.417	2.292	2.452
		MFL=518.5 m	2.156	2.545	2.425	2.422
	special (under the action of seismic forces)	is empty	1.91	1.941	1.894	1.951
	special (under the action of seismic forces)	NFL=517.0 m	1.438	1.586	1.543	1.591
		MFL=518.5 m	1.456	1.603	1.571	1.605
	principal loading	water horizon instantaneous lowering	1.262	1.317	1.287	1.322
Lower slope of the dam	principal (under the action of static forces)	is empty	1.817	1.846	1.79	1.858
	principal (under the action of static forces)	NFL=517.0 m	1.795	1.898	1.781	1.901
		MFL=518.5 m	1.795	1.898	1.781	1.901
	special (under the action of seismic forces)	is empty	1.441	1.479	1.425	1.49
	special (under the action of seismic forces)	MFL=517.0 m	1.465	1.511	1.473	1.519
		MFL=518.5 m	1.465	1.511	1.473	1.519

Comparison testing of Khachen dam slopes stability under seismic loading in case of the damped forced oscillations problem solution for an earth body dynamic equilibrium is expressed in a matrix form

$$[M]\{\ddot{a}\}+[D]\{\dot{a}\}+[K]\{a\}=\{F\}, \tag{7}$$

where $[M]=\int_s \rho\{N\}^T\{N\}dS$ is the matrix of the mass, ρ is the specific weight, $[D]=\alpha[M]+\beta[K]$ is the matrix of damping characterizing resistive capacity of the material (damping forces), $[K]=\int_s [B]^T[C][B]dS$ is the matrix of stiffness, $\{F\}=\{F_b\}+\{F_L\}+\{F_n\}+\{F_g\}$ is the nodal force vector, $\{F_g\}$ is the gravity force vector, $\{\ddot{a}\}$ is the nodal acceleration vector, $\{\dot{a}\}$ is the nodal velocity vector, $\{a\}$ is the nodal displacement matrix [6].

Since real earth materials have nonlinear properties constructive matrix is calculated for each loading phase.This change is conditioned by the change of mechanical properties of the materia. As show experimental investigations carried out on a spatial experimental facilityhyperbolic dependence

exists between the soil's deviation stress and strains.

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta, \tag{8}$$

$$\tau_m = \tau_{xy}\cos 2\theta - \frac{\sigma_x - \sigma_y}{2}\sin 2\theta, \tag{9}$$

$$S_r = \tau\beta = c' + (\sigma_n - u)tg\varphi', \; S_m = \beta\tau_m, \tag{10}$$

Applying final elements method [9] stability factors of slopes are determined by the following formula

$$K_{FEM} = \frac{\sum S_r}{\sum S_m} \; : \tag{11}$$

To evaluate the mode of deformation of the dam and stability of the slopes under seismic impact in the dam calculation section forced oscillations equation has been solved on the basis of the finite methode. [10]. As a model oscillogram was used the oscillogramme of San-Fernando quake of 9 February, 1971 according to Richter magnitude 6,6 earthquake[11].

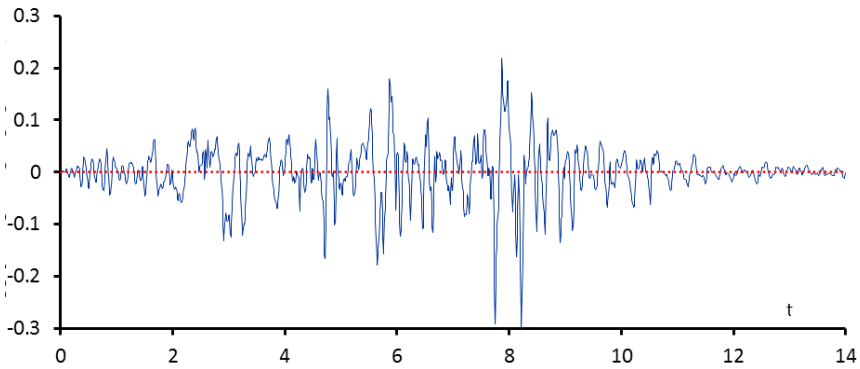


Figure 10. Oscillogram of San-Fernando 9 February 1971 earthquake

Computations have been made for design normal andhigh water retaining levels. For these cases also depression surfaces have been calculated.

For the dam crest and the base for the reservoir water two levels horizontal time-dependence displacements were calculated during the earthquake (Fig.11). Then in case of LRL and HRL for the upper (Fig.12) and lower (Fig.13) slopes stability factor dependence on time.

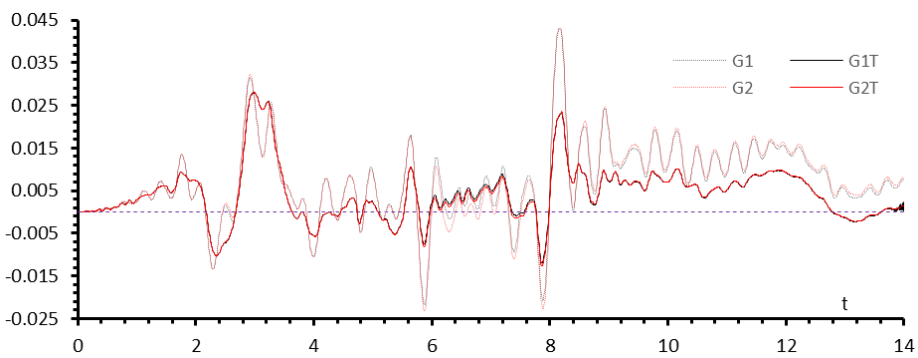


Figure 11. Horizontal displacements of the reservoir dam design section base and the dam crest in the water LRL and HRL levels in the reservoir (LRL-G1T-base, G1—crest || HRL- G2T-base, G2- crest)

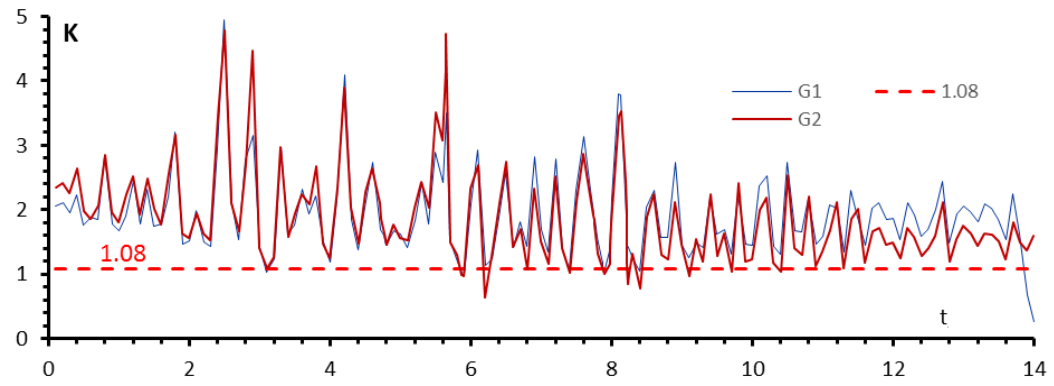


Figure 12. Upper slope stability factor dependence on time (LRL-G1 || HRL-G2)

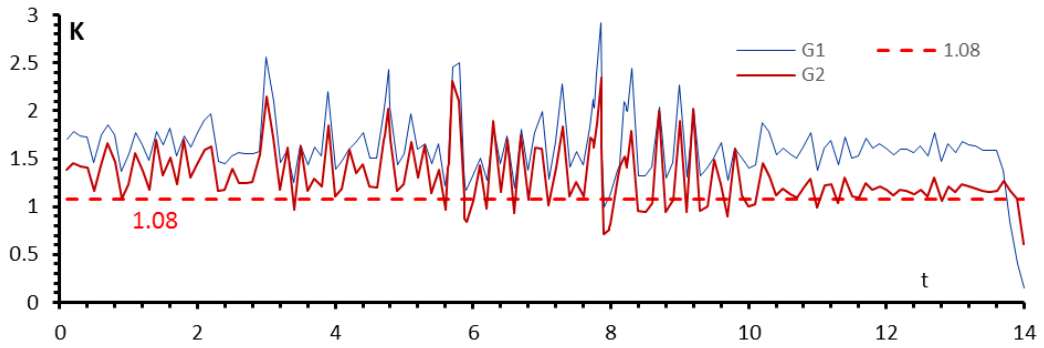


Figure 13. Lower slope stability factor dependence on time (LRL-G1 || HRL-G2)

Determination of the dam failure wave and area subject to inundation.

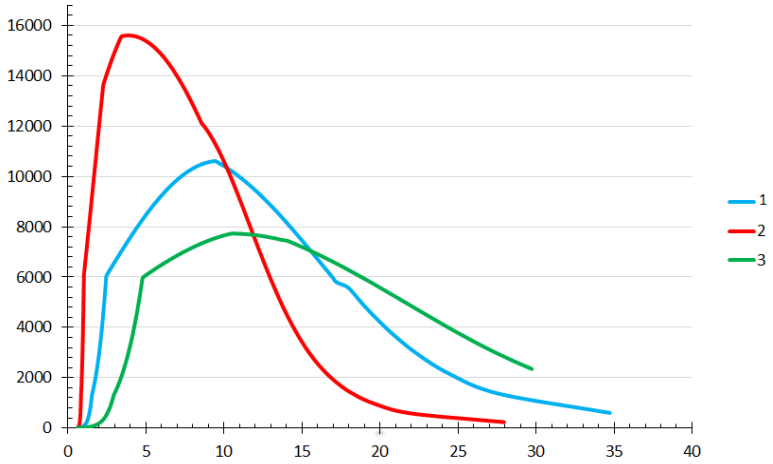


Figure 14. Characteristic curves for the water outflowing through the washed out opening

1- $Q_{ж} = 2Q_T$ **, 2-** $Q_{ж} = 0.5Q_T$ **, 3-** $Q_{ж} = 5Q_T$

The main reason of dams failure is impermissible amount of filtration through the dam body or water flow over the dam which in time washes out ground particles causing increase of filtration flows. The fluid running over the top of the dam washes out the soil gradually widening the opening in the dam body. This process deepens into the dam body and gradually widens the slit. The transversal

growth of the opening is conditioned by the penetration depth $\Delta b_i = \Delta y_i \dfrac{y_i}{y_i + \Delta y_i}$ where Δb_i is the transverse growth of the opening when the depth growth is Δy_i.

Using the above plotted flows and taking into account morphologic structure of the river bed areas subject to inundation and the obtained results have been mapped in Fig.15.

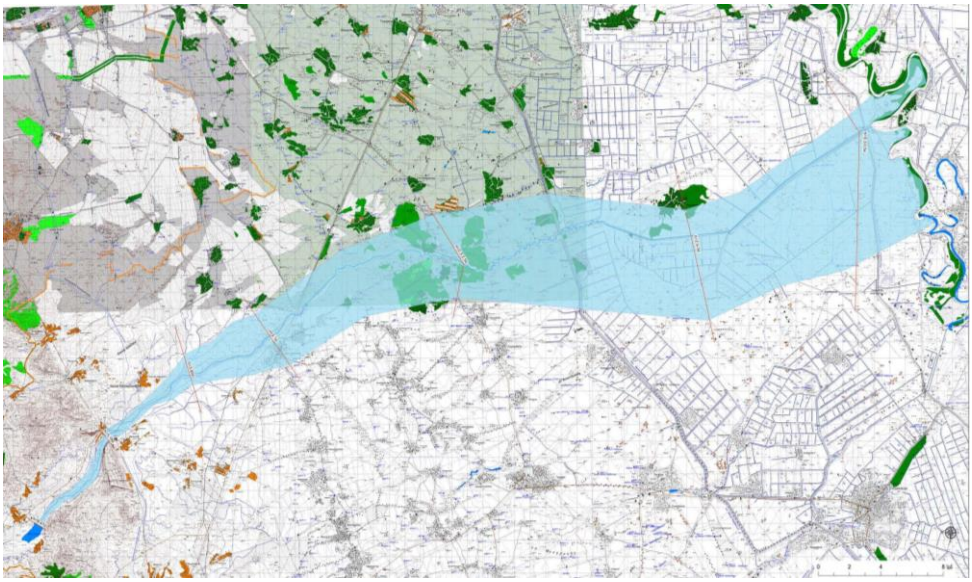


Figure 15. Areas subject to flooding on 1:50000 topographic map

Conclusion

Increase of effective capacity of the Khachen reservoir due to transformation volume does not essentially increase risk of the reservoir operation for the reservoir operation presently is equally dangerous. Later on it is necessary to add capacity of emergency spillway by construction of a riverside emergency spillways.

Increase of water level does not influence on sand boil and stability of the dam both for the main and special loading cases. In case of dynamic loading computations performed using circular cylindrical method unambiguously prove stability of the dam. According to solution of the plane problem of forced damping oscillations values of stability factors are ambiguous which is conditioned by roughness of initial calculation parameters and high horizontal acceleration.

Increase of the useful capacity of the reservoir by the above technique will raise effectiveness of the dam, irrigated land will be expanded by another 2000ha. However, in future the useful capacity of the reservoir can be doubled by adding the height of the dam and planning a new riverside emergency spillway.

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ԽԱՉԵՆԻ ՋՐԱՄԲԱՐԻ ՕԳՏԱԿԱՐ ԾԱՎԱԼԻ ԱՎԵԼԱՑՄԱՆ ՌԻՍԿԵՐԻ ԳՆԱՀԱՏՈՒՄ

Գ.Գ. Վերանյան
Շուշիի տեխնոլոգիական համալսարան

Խաչենի ջրամբարը շահագործման է հանձնվել 1964թ.: Խաչեն գետի տարեկան միջին հոսքը կազմում է 116.0մլն մ^3, իսկ ջրամբարի օգտակար ծավալը՝ 20մլն մ^3: Ջրամբարի հեղեղային ջրթողը հաշվարկված է 1% ապահովվածությամբ հիդրոգրաֆի համար: Նախատեսվում է ավելացնել ջրամբարի օգտակար ծավալը 3.8մլն. մ^3 – ով տրանսֆորմացիայի ծավալի հաշվին: Այս նպատակով նախատեսվում է հորանային ջրթողի վրա տեղադրել ավտոմատ կարգավորման փականներ և ջրամբարում ջրի նիշը պահել

ԲԴՄ-ի վրա: Ստուգվել է պատվարի սուֆոզիոն ամրությունը և շեպերի կայունությունը ջրի տարբեր մակարդակների դեպում, իրականացվել է ջրթող կառուցվածքների և վարարային ելքերի հիդրավլիկական հաշվարկ:

Բանալի բառեր. ջրամբար, ջրային հաշվեկշիռ, կայունություն, պատվար, վարարային ելք, հեղեղատար ջրթափ, հորանային ջրթող:

ОЦЕНКА РИСКОВ УВЕЛИЧЕНИЯ ПОЛЕЗНОГО ОБЪЕМА ХАЧЕНСКОГО ВОДОХРАНИЛИЩА

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Хаченское водохранилище сдано в эксплуатацию в 1964 году. Средний сток р.Хачен составляет 116 млн. м^3, а полезный объем – 20 млн м^3. Катастрофический водосброс рассчитан для гидрографа 1% обеспеченности. За счет объема трансформации намечается увеличить полезный объем водохранилища на 3,8 млн. м^3. С этой целью на гребне шахтного водосброса намечается установить автоматические затворы и уровень воды в водохранилище сохранить на уровне НПУ.

Проверены суффозионная прочность плотины и устойчивость откосов при разных уровнях воды в верхнем бьефе, проведены гидравлические исследования водосбросных сооружений.

Ключевые слова: водохранилище, водный баланс, устойчивость, плотина, паводковый расход, водослив, шахтный водосброс.

UDC 551.491:631.432

SHIRAK PLATEAU SOIL HYDROGEOLOGICAL CONDITIONS AND IMPROVEMENT PROBLEMS

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Armenia is a water-short country having insufficient arable land and where intermountain valleys occupy only 10 per cent of the area. Comparatively large dales are Ararat Valley, Shirak Plateau, Masrik Plain and the middle flow valley of the Pambak River. 39 per cent of irrigated land of Armenia is located in these regions and just here are concentrated problems related to high levels of ground water and overdampness of the aeration zone.
For Shirak Plateau, as well as other irrigated land of the province carrying out continues research on both the ground water deepness in specific locations and actual state of mineralization is a primary task and necessity. To find answers to correct solutions of a number of problems related to soil-reclamation state – to raise and maintain fertility is a matter of primary importance.

Keywords: *plateau, deep-water, subsurface water, ground water, salinity, land fertility, soil-reclamation condition.*

Introduction

Shirak Plateau is located in Shirak Province in the north-west of the Republic of Armenia covering over 2700 square kilometers of mountainous area of which 938 square kilometers are not-used for farming, and 28,8 ha is irrigated [1].

Located in the province Shirak and Ashotsk large hollows enclosed by massifs condition of formation of special soil and climatic conditions for agricultural development. Shirak plateau is located 1400 to 1600 meters above sea level, Ashotsk Plateau is 1900 to 2100 meters above sea level, and mountain picks rise 3100 to 4090 meters (at mountain Aragats) above sea level.
In the province the climate in summer is dry, and the winter is long and very cold -the air temperature can go as low as -46C. For Shirak province it is typical abundance of solar radiation, low relative humidity of air and Low annual precipitation (500 to 550mm) [1]. Formation of cultivated plants crop is directly conditioned not only by geography (position of arable land)and land treatment but also soil-and-hydrogeological conditions, precipitation regime, application of advanced technology etc. It is extremely important correct explanation and analysis of natural soil and water conditions, finding regularities of their annual and of many years quantitative changes in accordance with saltiness and deepness of ground water location.

Exceeding of permissible norms of salts in the active basic layer of soil is followed by the plant natural growth and development disorder. The following can cause salt accumulation in soil:

- Small deepness (0 to 3m) of ground water location,
- Supernormal mineralization (0.5 to 0.8g/l) of ground water
- Large content of salt in the mother rock
- Heavy mechanical structure of soil (heavy and average clay sands and clays).

Land of Shirak province in terms of agriculture is evaluated as the best. Black earth forms 69,4 per cent of the province territory, which is a best base especially for technical cultural plants.

Mountain and meadow soils cover 12.1 per cent of the province territory, and chestnut soil – 1.6 per cent [1].

The objective of the work is to analyze and find reasons of the above mentioned phenomena taking place in Shiral plateau and give positive solutions of problems.

Problem statement

There are around 10 soil types and 20 subtypes which causes thermal and water regime upward zoning [1]. These types are located at three elevations, so called soil belts.

- Low mountain (typical are black soils with almost all subtypes, chestnut soils, here and there stony)
- Middle mountain (meadow and steppe soils)
- High mountain (mountain and meadow soils).

Mountainsides of low steepness have benn distructed by erosion both the natural and antropogenic erosion of soils are typical to Shirak and Ashotsk plateaus as to the whole province. Natural erosion is a result of winds and water flows (precipitations, floods). To fight against these phenomena forest and field shelter belts are used. Due to erosion impoverishment of soil occurs and humus so important for a plant to grow decreases, necessary structure of the soil destructed and becomes unsatisfactory in terms of land reclamation.

High content of carbonate, mineralization of organisms and vegetation, high lime content, poor vegetation, small humus content (2-3%) [1] are typical for brown soils of Shirak plateau at elevation range from 1400 to 1500m. For Shirak field carbonate black earth as soil generating rocks are alluvial-prolluvial deposits. Due to carbonate black earth tillage and irrigation their large part are used for cultivation of crop plants and sugar-beet, for quantity of carbonates drastically decreases at upper elevations. Irrigated agricultural land is not salted, at the same time it cannot be said that the land is in good state. It is known that impermissible amount (less than 0.2%) of salt in soil causes deterioration of land reclamation condition and as a consequence occurs cultural plant yield decrease, disturbance of natural growth. These circumstances enforce to develop an effective and stable form of soil fertility management enabling to raise the soil productivity using different measures, optimal usage of fertilizers, management of water regime, agrarian amelioration measures etc. State of agricultural land reclamation is also directly conditioned by effective use of water resources.

Natural waters are complex, multi-component systems of which composition is in constant change due to running therein physical, biochemical, biological processes, running ion-exchange reactions with deposition layers, colloid and disperse mixtures sedimentation.

Ground waters are formed as a consequence of natural process and may content over 60 chemical elements, as well as microbodies. Total quantity of substances solved in water, except the gases, determine its mineralization. Mineralization of ground waters and formation of chemical composition depends on to basic factors: conditions of their origin, interaction with mineral rocks, through which water passes and water exchange conditions. In a number of cases washout of solvable minerals and enrichment of ground waters occur by more widespread anions
HCO^-, SO_4^2, CI^- and cations Ca^{2+}, Mg^{2+}, Na^+. By their ratio ground waters basic properties are determined – alkalinity, degree of minaralization, hardness.

Precipitations and especially springtime snowmelt runoff serve as the plateau ground waters source. In that period of year occurs drastic rise of ground waters and over humidification of the aeration belt. one of ground waters significant sources is filtration water of irrigation network in vegetation period.

Monitoring of ground water realization level and hydrochemical regime has shown that land amelioration and good condition of environment depend on location of ground waters yearly and of many years levels, and first of all in vegitation period when not correct irrigation drastically raises ground waters level, and chemical fertilizing raises waters mineralization.

Mineralization of ground waters and their level regime influence on salt water solution in the land, and the latter in its turn influence on agricultural cultures yield.

Reclamation condition of landscape including Shirak plateau is directly conditioned by the above mentioned processes which characterize soil and hydrogeological conditions (land and ground water physical and chemical conditions, possibilities of usage) of the given region.

From this it necessitates investigation of the land salinity, mineralization of ground water and irrigation water which will enable to draw up balance of saltwater system "irrigation water, aeration zone water, ground water, drainage water" and determine its nonclosure degree. In other words it will be possible to avoid secondary salination, implement improvement reclamation condition of the plateau irrigated land, rise of cultural plants yield [2, 3].

To evaluate reclamation condition of Shirak plateau land and in case of necessity to implement improvement carrying out the following investigations:

- To study mineralization portions of the plateau ground water according to typical regions and deepness, found out their expansion boundaries and yearly oscillation dynamics,
- To evaluate ground and irrigation waters applicability under international standards,
- To calculate irrigated land saltwater balance of system "irrigation water, aeration zone water, ground water, drainage water",
- To characterize components of saltwater balance according to the significance and their fluctuation boundaries for soil and hydrogeological various typical conditions of the plateau.
- To determine the saltwater nonclosure degree according to typical regions,
- To evaluate risks of soils secondary salination due to ground and irrigation water mineralization,
- To find out reasons of of cultural plants yield decrease and portions,
- To develop a possible version of a mathematical model for solving irrigated land soils and hydrogeological conditions improvement problem.

Water resources are formed by surface runoff and subsurface water which is replenished by precipitation and meltwater.

Overland flow is far weak due to high porosity of the area, and river network density is small oppositely to southwest. The Akhurian River flows trough Shirak land and finally empties into the Araks River.

Shirak plateau as well as the entire area is quite rich by subsurface water which are formed at the expense of infiltrated in volcanic mountain shield water. Shirak (Giumry) artesian basin is mostly known [1]. For irrigation purposes Akhurian artesian basin (1400 to 1500m) which is fed by infiltrated into subsoil water of Aragats volcanic mountain shield plays an important role.

Akhurian river basin ground water is characterized by 1g/l general mineralization, 10 to 12^{0}C temperature and 7 mgeqv/l gwnwral hardness. For Giumry narrow gully lake-river complex east part typical are 0.6 to 0.85g/l mineralization (hydrocarbonate or sulfite), 9.8 to 10.5^{0}C temperature, 7.6 to 7.8pH value. High qualitative indices of mineralization are characterized Verin Akhurian narrow gallies pressure fresh water of water-bearing horizons – 0.08 to 0.24 g/l general mineralization, and that of ground water – 0.36 to 0.42g/l. From Zuigaghbiur and Vardaghbiur depressions 240 to 250m depths eastern water spouts over 8m height. Mineral water spouts from 3 to 12m from the earth surface. In Akhurian River basin subsurface fresh water (0.08 to 0.30g/l) of different mineralization is widespread.

In western parts of Gyumri city mineralization of subsurface water varies around 1 and more g/l limits:

- 1.5 to 2.0g/l (sulfite ion prevails up to 0.9g/l)
- 2.0 to 3.0g/l sulfite and chloride ions prevail)
- 3.0g/l and more (sulfite and aluminum prevail).

To thee south and south-west from Gyumri city quantity of fluorine in ground water ranges from 1.5 to 1.9g/l/

The regime of subsurface waters are classified into three types [1]:

- Natural (changes of the level, temperature and chemical composition of ground waters are interrelated with natural factors)
- Man-made affected ((is typical for Giumry and Ashotsk narrow gallies when irrigation season starts water temperature and chemical composition are changed)
- Natural affected (is typical for west part of Giumry narrow gallies , especially in the region where mineral watersare waidely spread.

Surface and subsurface waters are in indirect in hydraulic interconnection, and discharge occurs in the Akhurian river and its tributaries, in certain areas in the form of springs and marshes.

Hydrogeological subdivisions estimate subsurface water protectability degree by a sum of numbers taking into account three basic indices [1]:

- Depth of ground water location
- Mechanical composition of aeration zone soils
- Thickness of weak permeable rocks of the aeration zone (50 to over 250m according to boreholes data)

For agricultural irrigated land hydroeconomic balance plays an important role, which encompasses three important points:

- Evaluation of natural water resources
- revelation of usable and demanded water volumes
- estimation of flow regulation and water resources transfer from place to place.

It follows fro the above mentioned that for improvement of the Shirak plateau and why not other irrigated land of the province the following problems need to be solved:

- regulation of ground water location according to cultural plants different groups in terms of their roots length
- measures designed to lessen ground water mineralization
- regulation of salt accumulation process in active layers of soil
- prevention of natural and man-made erosions
- correct and in-time carrying out agglomeration and land treatment
- measures designed to fight against natural water contamination.

To successfully solve the above problems overhumid landscapes data [2-6] of many years investigations (1960 to 2010) can lead to positive results for lands similar to Shirak province in the process of their reclamation.

Conclusions

To improve Shirak plateau soils reclamation condition first of all it is necessary to study both the location depth and borders of ground waters mineralization fluctuations, to reveal processes occurring in the soil active layer of the region.

To organize agricultural production it is necessary to study altimetry, steepness of surfaces, mountainsides positions, horizontal and vertical ruggedness.

The work has been performed within the framework of 15T-2K136 theme.

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ՇԻՐԱԿԻ ՍԱՐԱՀԱՐԹԻ ՀՈՂԱՋՐԱԵՐԿՐԱԲԱՆԱԿԱՆ ՊԱՅՄԱՆՆԵՐԸ ԵՎ ԲԱՐԵԼԱՎՄԱՆ ԽՆԴԻՐՆԵՐԸ

Ս.Ն. Երոյան, Գ.Շ. Հովսեփյան, Ս.Շ. Նուրիջանյան, Ս.Մ. Մկրտչյան

Ակադեմիկոս Ի.Վ. Եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ

Հայաստանը լեռնային սակավահող և սակավաջուր երկիր է, ուր միջլեռնային հովիտները զբաղեցնում են տարածքի ընդամենը 10%-ը: Համեմատաբար մեծ լեռնային հովիտներ են հանդիսանում Արարատյան հարթավայրը, Շիրակի սարահարթը, Մասրիկի հարթավայրը և Փամբակ գետի միջին հոսանքի

հովիտը: Այս տարածքներում են գտնվում հանրապետության ոռոգելի հողերի 39%-ը և այստեղ էլ առկա են գրունտային ջրերի բարձր մակարդակների,աերացիայի գոտու գերխոնավացման խնդիրները:

Շիրակի սարահարթի, ինչպես նաև մարզի մյուս ոռոգելի հողատարածքների համար առաջնահերթ անհրաժեշտություն է գրունտային ջրերի թե տեղադիրքերի խորության, և թե հանքայնացման փաստացի վիճակի վերաբերյալ մշտական հետազոտությունների իրականացումը: Խիստ կարևոր է նաև հողերի մելիորատիվ վիճակի, բերրիության բարձրացման և պահպանման նպատակով մի շարք խնդիրների ճիշտ լուծումների պատասխանները:

Բանալի բառեր. սարահարթ, արտեզյան, ստորգետնյա, գրունտային ջրեր, աղակալվածություն, հողերի բերրիություն, մելիորատիվ վիճակ

ПОЧВЕННОГИДРОГЕОЛОГИЧЕСКИЕ УСЛОВИЯ И ЗАДАЧИ УЛУЧШЕНИЯ ШИРАКСКОГО ПЛАТО

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Армения – горная малоземельная и маловодная страна, где среднегорные долины занимают всего 10% от общей территории. Сравнительно большие горные долины – Араратская равнина, Ширакское плато, Масрикская равнина и долина среднетечении реки Памбак. На этих территориях находятся 39% орошаемых земель республики и здесь же высокий уровень грунтовых вод, задачи переувляженности зоны аэрации.

Для Ширакского плато, как и остальных орошаемых земель области, первоочередная необходомость осуществление постоянных исследований по состоянию глубины залегания грунтовых вод и их фактических минерализаций. Крайне важно решения ряда задач с целью повышения мелиоративного состояния земель, улучшения и сохранения их плодородия.

Ключевые слова: плато, артезианские, подземные, грунтовые воды, засоленность, плодородные земли, мелиоративное состояние.

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DEVELOPMENT OF RATIONAL METHODOLOGY FOR INVESTIGATION GROUNDWATER IN VOLCANIC AREAS

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In many volcanic regions of the world their ancient tydrographic networks, especially river valleys with powerful groundwater flows, were covered by lava. The central volcanic plateau in Armenia is one of the regions of recent volcanism. Investigation carried out in scveral volcanic areas in Aragats, Gegham, Vardenis, Suniq mountains, Ararat, Shirac in termountain areas, etc. has led to combination of hydrogeological and paleo-geomorphologycal investigations, interpretation of air-photographs and space images, applying and using of hydrogeophysical methods and the final stage of the mathematical modeling. The paper focuses on the features and possibilities of use electrical sounding for prospecting of groundwater. Consider example of such using methods of mathematical modeling for Ararat intermountain volcanic area. Data of the ways of the groundwater movement and places of their deposition of the drill wells with the aim of the water carring horozons revealing are received.

Key words: *volcanic areas, groundwater, mathodology, paleorelief, hydrogeophysical methods, mathematical modeling.*

INTRODUCTION

Water plays paramount role in the development of the economics of all the countries in the world. It becomes more important because of the quick increase in population and the further development of industry and agriculture. In the history of the Earth geological development the repeated outbursts of volcanism, accompanied by the huge lava ejections different by composition had occurred. As a result the vast areas were covered with the products of volcanic activity. The effusive rock covers and beds had masked the geological structure of many regions, their ancient relief, and, specifically, river valleys with the powerful ground-water flows being timed for them.

The problems of formation of underground freshwater resources of volcanic areas and establishment of their distribution regularities are of great theoretical and practical significance. The volcanic formations are characterized by an extremely varied physic-geographical conditions and by a geological tectonic structure determining an unequal distribution of natural resources of underground water, the variety of their composition and mineralization, significant differences of the regime in different regions of volcanism.

In the area of active water cycle the supply of underground water is mainly carried out by the infiltration of atmosphere sediments, the condensation of moisture from the air, the absorption of surface flow, the inflow of water from the side of internal regions of supply.

Decision of scientific and practical objectives in volcanic areas is extended in connection with the research-prospecting works on water with the purpose of water supply and irrigation. Rising of efficiency of survey works and reliability of their results in such specific regions requires improvement of approaches and methods of getting initial data relating to both immediacy of conduction of investigation and rise their informative level. Decision of these objectives in volcanic

areas as compared with other geological districts becomes complicated by the fact, that here, on many cases, ancient (marking) measures are latent under strong coverlet of clinker and coulee. Under carrying out hydrogeology works this fact requires to apply complex methods of investigation.

PURPOSES OF INVESTIGATIONS

It is known, in many cases, the rock forming processes was accompanied by intensive volcanism in Apennines, Asia Minor, south of Balkan Peninsula, as well as Caucasus. In the northern hemisphere the strongest volcanic processes during Cainozoe was associated with Aleutsk, Okhotsk-Chukotsk, Kuril-Kamchatka volcanic zones (Russia), as well as volcanic districts situated along the west part of North America and volcanic structures making up Central and South America. Strong outbreaks of volcanism of Cainozoe became apparent on the bounds of East Pont (Turkey), Iran, Afghanistan and features the Armenian highland.

The central volcanic plateau in Armenia is one of the regions of recent volcanism. The typical feature of andesites and basalt that stipulates their high permeability is the existence of variety of joint types [1]. These are joints caused by rook cooling, lava tunnels, intersecting cells as well as joints caused by bulking of solidified lava voids remaining between lava beds being consequent in time and so on. The effusive complex is water bearing one owing to the jointing and other structure-texture lava features. Almost all the existing lava joints are interconnected and occur all over their depth. The intensive infiltration is also promoted by the existence of the enormous stone placers on the lava surface and the considerable declivity of large morphological units (mountain massifs and some ridges). In whole the deeply penetrating atmospheric and condensation waters forming considerably watered interlava zones and powerful sublava streams more over the gradient of the ancient relief represented by sedimentary and volcanogenious-sedimentary deposits (clay, sandstone, tuff a breccia, tuff sandstone). The paleorelief under discussion is considered to be the relief of the regional water heat and the main distributor of the depth runoff in volcanic areas. Sometimes this water flows come to the day surface in the form of springs or solid discharge zones.

This highland is considered as one of the most interesting volcanic areas all over the world. Its regional structure is included into the uplift of Caucasus Minor and consists of few newest structures. As a result of intensive volcanism were formed the highlands Aragats, Vardenis, Gegham, Suniq and Karabakh, as well as Akhalcalac's (Javakhq) lava highland [2] and invermountain volcanic areas Ararat, Shirak, etc.

The following consecution (stages) of combining methods is the overall:

- hydrogeological condition area;
- interpretation of air-photographs and space images;
- paleo-geomorphologycal investigations;
- applying and using results of hydrogeophysical investigations;
- mathematical modeling for solution hydrogeological (water-balanced) objectives.

Combining of these methods is based on various physical and geological pronciples and allows to get reliable and impartial solution of the present objectives.

BESIC STAGES OG SOLVIG PROBLEMS

Hydrogeological investigations

The composed geology-hydrogeological profile of volcanic structures, including the areas of creating, draining and unloading of groundwater, is to be presented mainly by three complexes of rocks, being different discriminated by petrophysical and water-physical characteristics. Lower sublava complex: to this complex relate all of sublava measures of mainly of paleogenic and neogenic ages, which roof serves as an area aquifer for the ground water (Fig. 1).

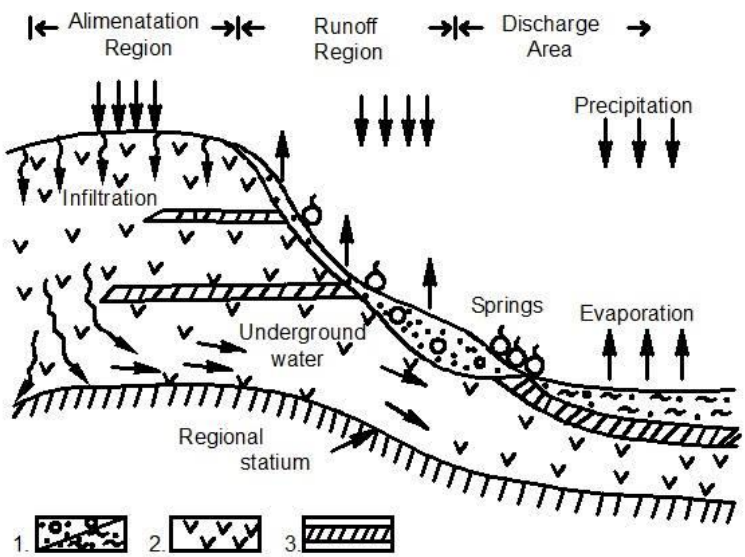

Figure 1. The scheme of volcanic structure
1 - top recent complex, 2 - middle volcanic complex, 3 - lower sublava complex

These are sedimentary and volcanogenic formings (argil, sand, tufa sand, tufa breccia and so on). Middle complex: the rocks are represented as volcanic formings, mainly, of the paleogenic-neogenic and quaternary age. This complex is the dominant water-bearing complex of volcanic constructions. At last, top complex: this is the recent lacustrine-riverside, eluvial-delluvial and other fiable-fragmental and semi-combined forming (variously granuled sands, pebble stones, clay loam and so on). There in mountainous islands of external provinces of supply, in many cases, is surveyed bleakness of lava forming, and the top complex of rocks is nearly absent here in the section, and precipitations are infiltrated into the deep of the volcanic structure through crumbling and honeycomb differentials of lava. The infiltration has a place either before regional sublava aqueous, or before local aqueous rocks, represented as inter-lava rocks by relatively aqueous layers or by relatively compact less honeycomb differentials of lava. In the transit area (middle mountain island) and, in particular, in dump and accumulation (flat island) of groundwater have a place all of three complexes of rocks.

Paleogeomorphological investigations

The study of volcanic relief requires the knowledge of morphology fundament on which laid volcanic and denudation processes. The morphostructure of lava layers of plateau flow reflects the preliminary form and structure of surface of sublava relief as well as the following volcano- tectonic and neo- tectonic processes of platform regions.

However, not always the modern and buried reliefs duplicate each other. The knowledge of this problem is especially important while the balance hydrological calculations of underground flow. The displacement of buried watershed with respect to the modern one may be established in particular by the results of field geophysical investigations. The establishment of correlational connection between the modern and buried reliefs allows to prognose the character of paleoreliefs of the volcanic regions.

Interpretation of air-photographs and space images

At present time great experience has been gained on using the materials of aerospace photos while the search of underground water in platform regions.

The underground waters are not directly reflected on the material of air-photographs and space images. Their existence is proved by the exposure, recognition and coordination of water control factors and characteristic of concrete physic-geological and hydrogeological conditions. The interpretation of aerospace photos of Central Armenian volcanic upland will enable to create a report on indication and interpretation characteristics aiming at recognition of tectonovolcanic and volcanogenic-accumulative paleovalleys as the basic hydrogeological elements of volcanic regions. Coming from the general geological-hydrogeological structure of many volcanic regions the given characteristics may be used in the search of underground water in similar regions.

While the interpreting the aerospace photos one shouldn't forget that the interpretation results are of probabilistic statistic character. That's why the data of aerospace photos mainly under the difficult condition of fold mountain regions need a review and detailed specification by other methods mainly by geophysical ones.

Hydrogeophysical investigations

Methodological aspects of the study will consider the relatively detailed, as when they search for groundwater considered the most effective. The geophysical methods are successfully used for:[3]

- Investigation of the conditions of occurrence, and, particularly, the depth of occurrence of sublava water-resisting rocks;
- Prospecting for interlava streams; in mapping and estimating the thickness of river-lake deposits which fill the local depressions (volcanic cups) among the effusive formations, being of interest as reservoirs for the ground-water accumulation;
- Investigation of the well sections, especially to discover and to characterize the water-bearing collectors.

When solving the indicated hydrogeological problems the averaged lithological section in volcanic areas should be represented by the three rock complexes which sharply differ in the geologo-hydrogeological and physical (specifically electrical) properties.

The typical geoelectrical sections containing water-bearing horizons, are specified according to the data of electrical sounding (fig. 2):

a) Type KHK ($\rho_1 < \rho_2 > \rho_3 < \rho_4 > \rho_5$): water-bearing lavas in the middle part of the ES curve (horizon ρ_3).

   When the water-bearing horizon is absent, i.e. if it 'falls out', the ES curve is shifted to the K ($\rho_1 < \rho_2 > \rho_3$) type section.

b) Type KQ ($\rho_1 < \rho_2 > \rho_3 > \rho_4$): water-bearing volcanic rocks are indicated on the falling right branch (horizon ρ_3). In that case, the largest resistivity value (horizon ρ_2) usually characterize relatively 'dry' lava rocks.

c) Type AK ($\rho_1 < \rho_2 < \rho_3 > \rho_4$): water-bearing horizon is indicated on the initial left branch of the curve (horizon ρ_2). Relatively 'dry' and massive varieties of lavas (horizon ρ_3) serve as a water-bearing base.

d) Type K ($\rho_1 < \rho_2 > \rho_3$): water-bearing lavas are indicated in the middle part of the curve (horizon ρ_2) with resistivities between 200 ohmm and 400 ohmm typical of water-bearing lavas.

Geoelectrical sections of type 'a' and 'b' are characteristic of areas with interlava-water flows, whereas the 'c' and 'd' type sections occur in regions with sublava-buried valleys.

It is known that between the specific rock resistance and the water mineralization exists a linear dependence, namely, the value ρ decreases as the water mineralization degree (C) increases at any salt

composition. The value ‘C’, in its turn, depends on the climatic factors and the relief. At the same time the feeding area is a high mountain part of the highland. Owing to the tigh amount of precipitation (600-700mm/year) and the small evaporation causing an intensive ground water runoff the water mineralization is rather small and amounts 50-70 mg/l of the day residue. With lowering of the decrease of the amount of precipitation (600-500 and 500-400 mm/year) and the increase of the degree of evaporation are observed. The phenomenon could explain the relatively low value of the ground water runoff. If results in increasing the water mineralization up to 100-1500 mg/l in the middle parts and up to 200-300 mg/l in the foothill areas.

Consequently, the regularity observed in the change of ground qater mineralization (70-150-300 mg/l) is a main cause which determines the zone variations of the effusive rock specific resistance.

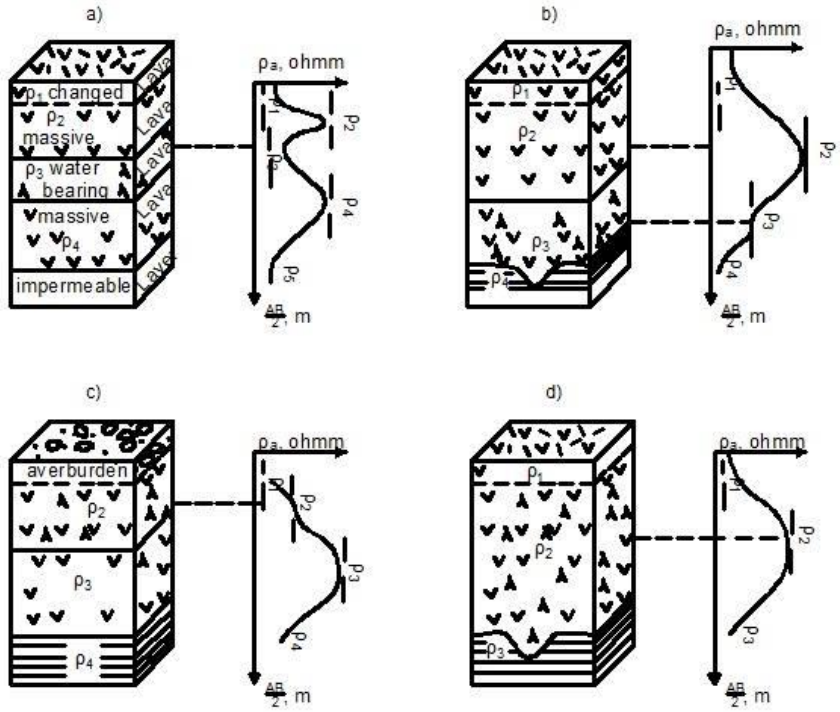

Figure 2. Main types of geoelectrical sections, containing water-bearing lava horizons a,b,c,d-types sections block diagrams and resistivity curves

So, for instance, in the Gegham highland lava rock distribution the zonality is pronounced with the resistivity of 5500, 2700 and 1350 ohm, respectively. These zone involve the ground-water feeding, transit and discharge areas.

As it was mentioned above the numerous powerful ground water streams in the volcanic areas are timed to thepaleo-relief depression forms. In that case the solution of the problem will come to the determination of the volcanic rock thicknesses and to the platting of the sublava relief map as a main distributor of the sublava surface runoff. Fig. 3 presents the geoelectrical section crossing the Aragats volcanic highland west to the east. The comparison of the recent- and paleo-reliefs has shown that the recent and the ancient watersheds do not coincide. The latter has a shift to the east. It means that the waters infiltrating through the regional watershed relied move chiefly in the western direction. This phenomenon was taken into account in prospecting for ground waters and in estimating the ridge water balance.

The Fig. 4 presents the paleorelief map of the ancient hydrographical system for Aragats massif. According to the map there is a number of the buried valleys; in the northern and southern parts the local drainage basins are noted. The relief complexity of the volcanic high-mountain ridge areas will not always allow to carry out the field works by the electrical sounding method. In that case the useful information may be provided by searching for the correlation relationship between the recent and the buried reliefs. The search for that relationship is usually carried out in the volcanic areas having been explored in the geologo-geophysical respect wint the purpose of extending the found relationship to the high-mountain areas.

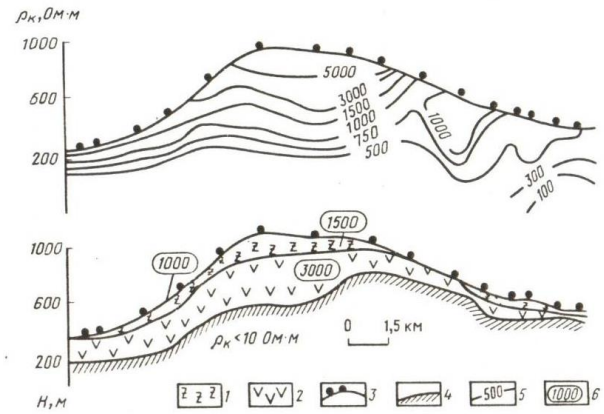

Figure 3. Geoelectric sections through the Aragats volcanic highland west to the east; 1. andesite-basalt; 2. basalt; 3.points of resistivity sounding; 4. configuration of buried relief; 5. isoohmic lines; 6. resistivity of volcanic rock, according to the geoelectric measurements (ohmm)

Mathematical modeling

The mathematical model of the investigated territory will be created at the final stage of the work. With the help of computer programs the filtration task on rational location of the boreholes intended for water search will be solved and also determined the admissible sampling of underground water for water supply purposes [4]. As an example of such a region may serve Ararat intermountain area in Armenia.

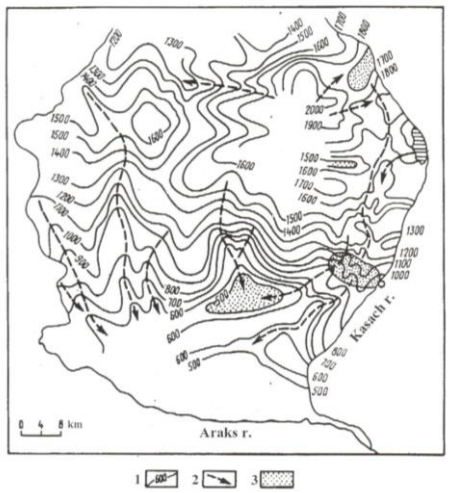

Fig 4. Paleorelief map of Aragats volcanic highland. 1 – isolines of paleorelief, m; 2 – main direction of subsurface water movement; 3 – buried subsurface water basins

The Ararat Artesian Basin (AAB) is located in the middle stream of the Araks River within the Ararat Depression Valley and extends in a NW-SE direction for about 120.0 km with a width of 10.0-30.0 km.) and occupies an area of about 1,300 km^2.

AAB has a complex tectonic and geological-hydrogeological structure, represented by three depressions - Hoktemberyan, Artashat and Arazdayanand two uplifts - Sovetashen and Khor Virap.

Groundwater resources of AAB are developed from precipitation, condensation and discharge of deep artesian inflows within the Araks catchment basin on an area of 31,500 km^2, including 14,900 km^2 of Armenian territory and 16,600 km^2 of Turkish territory.

Two groundwater complexes have been identified in the subsurface of AAB: an unconfined aquifer and confined (artesian) water bearing complex which is conditionally divided into two aquifers. Artesian aquifers are connected with successive complexes of folded systems made of permeable and weakly permeable rocks, specified by extreme instability of geological-lithological and hydrogeological parameters, in particular spreading and thickness, variety of water bearing rocks and their hydraulic conductivity, transmissivity properties, water temperature and mineralization.

The operational groundwater resources of AAB were assessed by various authors within 1966-1984.

In 1984 the State Commission of Reserves (SCR) approved a safe annual average yield of groundwater resources in the amount of 56.6 m^3/s, of which safe abstraction by wells is 34,7 m^3/s and by springs is 21,9 m^3/s. If groundwater abstraction will not exceed the approved safe yield, natural hydrodynamic and hydrochemical balance of interconnected subsurface system will not be distorted.

Analysis of groundwater consumption in 1978-1983 in ABB led to the identification of 2,003 wells as of 1983, of which 1,593 were operational [5]. Out of 1,593 wells, 878 were flowing artesian wells and the remaining 715 were operated by pumps. The abstraction made up 12.9 m^3/s, or 406.8 Mm^3/year from flowing wells and 21.7 m^3/s, or 685.7 Mm^3/year from the pump operated wells. These volumes did not exceed the safe yield approved by the SCR in 1984.

According to groundwater source inventory data conducted during 2006-2007 in AAB, 1,986 wells were used in 2007 with an average abstraction of 36.5 m^3/s, or 1,151.1 Mm^3/year. Thus average total abstraction from the wells already in 2006-2007 had exceeded the permitted annual abstraction (34,7 m^3/s) by 1.8 m^3/s.

Due to intensive development of fish farms in the last 7-8 years, abstraction of groundwater solely for fishery purposes increased up to 35.5 m^3/s, or 1,119.4 Mm^3/year and total abstraction in the AAB (including drinking, agricultural and industrial water supply) increased to 55,6 m^3/s.

This situation caused the development of groundwater level drawdowns and depletion of the capacities of artesian wells in AAB, including reduction of discharge of the Sevjur-Aknalich Springs.

Due to the inadequate technical design of numerous wells drilled in AAB in the past 6-7 years and non-compliance with the established 400-1,000 m distance between wells, natural hydraulic connections between layers were distorted. Due to the overly-dense network of newly-drilled wells, the number of hydrogeological “windows” between various aquifers has increased causing depletion of the piezometric level, mixing of water from various aquifers, and changes in chemical content of groundwater (increasing mineralization of waters to up to 0.3 g/l, see table 10). The outflow component of aquifers by regions was also distorted. The discharges of natural springs and yield of wells have reduced sharply under the conditions of increased abstraction by wells [6, 7].

Solution of the problem is generally connected with management and prediction of regime of underground waters of valley; it is solved by method of mathematical modeling using data of hydrogeologic and geophysical investigations.

Consideration of hydrogeological, drilling and geophysical data allows to increase the accuracy of creating of geofiltration scheme of investigated area [8]. It is represented by three water carrying

horizons – ground, low pressure and pressure – and by two separate aquitard. The problem of non-stationary filtration underground water in layered stratum is analyzed (Fig. 5).

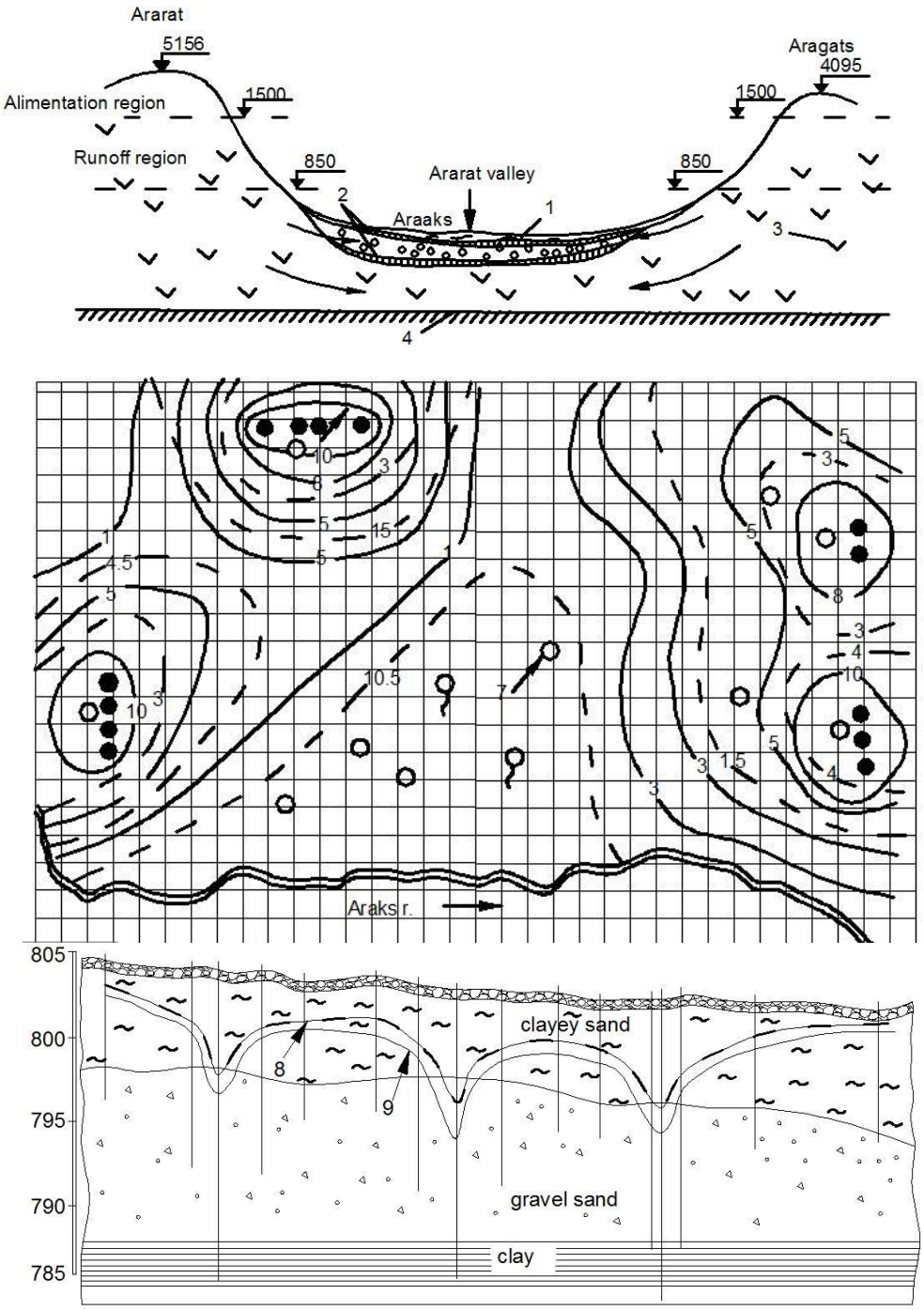

Figure 5. a) Schematic section of profile Aragats mountain-Ararat valley-Ararat mountain. b) Fragment of maps hydroisohypse. c) Hydrogeological cross-section for horizon of groundwaters 1-verburden; 2-lake-river deposots; 3-volcanic rocks; 4- regional stratum; 5-observation well; 6-exploitation well (design); 7-springs; 8,9-groundwater level (m) data of well and data of modeling

From the point of view of rational use of natural resources of the Ararat plain the central place for hydrogeological and soil processes takes permanently acting hydrogeological model (PAHM),

which is a complex consisting of mathematical model and information base with its control systems and technical means. The main problems for the PAHM are control and information output for substantiation of the change of hydrogeological processes from different tecnogenic influences, estimation of permissible quantities of underground water extraction choice of water intake wells rational operation regime, regulating of ground water regime for well-timed carrying out of engineering – land reclamation works and ground waters level stabilization on the predetermined (optimal) depths.

The results of carried investigations are used for making Master Plan of rational usage and protection of underground waters of Ararat valley, and also for design of water intake structures and drilling some exploitation wells for civil and irrigation needs.

Conclusion

Development of rational methodology for prospecting and using of groundwater in volcanic areas can solve the following problems:

- the stage of field works projections – generalized physico–hydrogeologocal models (GPHM), especially the ones of expected palep valleys, are composed on the basis of gathering and analysis of present petrophysical and water-physical characteristins of the studied region and results of works similar areas; if space images and air photographs are available their preliminary deciphering is carried out and control sites for field works are chosen;
- the stage of field investigations – using a complex of methods-geophysical, paleomorphological-for stidy of sublava water resisting layers condition, extraction and characterizing of water carrying collectors;
- the stage of processing and interpreting of fild investigation data-correlative dependencies between structural-hydrogeological, paleomorophological and geophysical properties are established; maps and sections of hydrographic network are composed and the best sites for subsurface water extraction established. During the investigations of buried hydrographic network of volcanic regions, and particularly for composing their total GPHM;
- practical application oh the results, obtained during the investigation, is aimed at solving important hydrogeological problems, connected with formation of resources groundwater's for Central Volcanic highland Armenia by use a mathematical modeling. Creation of summary map for regional aquifuge with indication the places for selected water;
- an establishment of opportunities of the developed methodology for searching of groundwaters in analogical regions.

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ՀՐԱԲԽԱՅԻՆ ՏԱՐԱԾԱՇՐՋԱՆՆԵՐԻ ՍՏՈՐԵՐԿՐՅԱ ՋՐԵՐԻ ՈՒՍՈՒՄՆԱՍԻՐՈՒԹՅԱՆ ՄԵԹՈԴԱԲԱՆՈՒԹՅԱՆ ՄՇԱԿՈՒՄ

Ռ.Ս. Մինասյան, Գ.Մ. Մխիթարյան, Գ.Ս. Թորոսյան
Ակադեմիկոս Ի.Վ. Եգիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ

Աշխարհի տարբեր հրաբխային շրջաններում լավային ապարները ծածկել են դրանց հնահիդրոգրաֆիկ ցանցը, որոնցից շատերում առկա են հզոր ստորեկրյա ջրահոսքեր: Որպես բնորոշ տարածք կարելի է նշել Հայկական կենտրոնական հրաբխային լեռնաշղթան: Այստեղ առանձին տեղամասերում իրականացված համալիր ուսումնասիրությունները՝ Արագածի, Գեղամա, Վարդենիսի, Սյունիքի բարձրավանդակներում, Արարատի, Շիրակի միջլեռնային գոգավորություններում ցույց են տալիս, որ ստորերկրյա ջրերի ուսումնասիրությունների համար արդյունավետ մեթոդոլոգիա համարվում է ջրաերկրաբանական, հնաերկրաձևաբանական մեթոդների, օդատիեզերական նկարահանումների վերծանման և ջրաերկրաֆիզիկական մեթոդների համալիր, իսկ եզրափակիչ փուլում՝ մաթեմատիկական (ջրաերկրաբանական) մոդելավորումը:

Աշխատանքում հատուկ ուշադրություն է դարձված ջրաերկրաֆիզիկական մեթոդի՝ ուղղաձիգ էլեկտրազոնդավորման տարատեսակի կիրառման առանձնահատկությունների և հնարավորությունների վրա:

Բերված են նաև Արարատյան միջլեռնային գոգավորությունում մաթեմատիկական մոդելավորմանն կիրառման որոշ արդյունքներ ջրաերկրաբանական խնդիրների լուծման նպատակով: Այստեղ որոշված են ստորերկրյա ջրերի կենտրոնացված շարժման ուղիները, դրանց բեռնաթափման տեղամասերը և հորատանցքերով ջրառների տեղերը ջրամատակարարման նպատակներով:

Բանալի բառեր՝ հրաբխային շրջաններ, ստորերկրյա ջրեր, մեթոդաբանություն, հնառելիեֆ, ռաերկրաֆիզիկական մեթոդներ, մաթեմատիկական մոդելավորում:

РАЗРАБОТКА РАЦИОНАЛЬНОЙ МЕТОДОЛОГИИ ДЛЯ ИССЛЕДОВАНИЯ ПОДЗЕМНЫХ ВОД ВУЛКАНИЧЕСКИХ РЕГИОНОВ

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Во многих вулканических регионах мира лавовые породы покрыли их древную гидрографическую сеть с приуроченным к ней мощными потоками подземных вод. Типичным примером вулканических регионов является Центральное вулканическое нагорье Армении. Комплексные исследования выполненные в вулканичских областях-Арагацский, Гегамский, Варденисский, Сюникский нагорий, в пределах Араратской, Ширакской межгорных впадин показали, что наиболее рациональной методикой изучения подземных вод считается комплексирование гидрогеофизических, гидрогеологических, палеогеоморфологических методов и дешифрирование аэрокосмофотоснимков, а на завершающей стадии выполнение математического (гидрогеологического) моделирования. В работе особое внимание уделено использования гидрогеофизическогоо метода в модификации вертикального электрозндирования. Приведены также результаты использования математического моделирования при решении гидрогеологических задач в пределах Араратской межгорной впадины. Здесь установлены основные пути сосредоточенного движения подземных вод, места их разгрузки и их отбора буровыми скважинами в целях водоснабжения.

Ключевые слова: вулканические регионы, подземные воды, методология, палеорельеф, водно-геофизические методы, математическое моделирование.

UDC 633.11:631.4

THE DIFFERENT CULTIVATION METHODS EFFECT ON THE SOIL AGRO-PHYSICAL PROPERTIES AND WATER PROVIDING DURING AUTUMN SOWING

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The main aim of the research is to increase the autumn sowing crop, enrich the agro-physical properties of soil, improve water providing and decrease the cost price of producing goods in NKR foothills with light brown loamy and carbon soil of average strength by means of machining cultivation reduction. The use of stepped cultivation in topsoil (0-20cm) decreased soil thickness compared with plowing on about 6,7 % . This method of cultivation improved also the soil porosity and water-permeability. If in the arable land during the tillage (0-20cm) porosity is about 41,35%, water-permeability is 3,28mm/min, in under topsoil(20-30cm)is 38,7%and 2,25mm/min, in stepped topsoil cultivation conditions the same indices are 54,7%, 4,17mm/min and 51,2%, 3,45mm/min accordingly.The reducing of intensity of topsoil cultivation use and keeping soil surface leftover stubble are favorable not only for topsoil but also for low topsoil vegetation in all the stages and assist to increase the storage of moisture on average about 2,74%. On this case the crop yield of winter wheat comparable with usual plowing increased on 2,9 c/ha, and the production cost price decreased on 21,2%

***Key words**: soil cultivation, agro-physical properties, water providing, crop yield, expenses reduction*.

Introduction

In order to get high and stable crop with low cost in complicated ecological conditions it is necessary to invest newest sorts to as new agro means for keeping land productivity, growth one of which the machine cultivation is. By changing physical, chemical and biological processing course the machine cultivat.ion becomes more influential for land productivity than all the other technological processes. In the technological structure of crop cultivation 50% of outlay is for cultivation operations. Most researchers agree that depending on land cultivation decrease the restoration conditions are improved. Besides the energy costs are reduced and it not only makes cheaper the technologies but also increases the stability of soil and environment [1-3].

The level of land cultivation is zero technology, the use of which despite improving the productivity of certain lands, needs to be equipped with high technical provision and intensive chemicalisation.

This circumstance limits the wide use of direct sowing. Besides there are other obstacle factors, land and climate conditions, the lack of field research and so on [4].

In many works there are data about the advantages of complex and minimal cultivation structure, especially in the lands with lack of moisture and in the lands which need landfall such us in the wheat sowing areas of NKR, where the annual average downfalls are 250-420mm and the most part of arable land is on the different slopes. In above mentioned areas during the vegetative growth there are 30-35% of downfall (from annual amount of downfall). With such distribution of atmosphere downfall the crop yield generally depends on autumn and winter moisture supplies in soil. It is necessary to solve the problem of landfall with the problem of water supply and drought in complex, by use of minimal soil protection technology and special equipment.

During the researches it has been estimated that the most productive lands are the lands which have been cultivated gradually, consisted of upper wholly mold surface layer and bottom line deeply mold level. Creating such profile doesn`t demand much expense, the ledged bottom of cultivated

topsoil prevents the flow of ingrained water into the soil, mold lines provide good water-permeability in deeply rooted layers and the productive prevention of moisture vaporization is reached by means of mulching of cultivated plots of land. The mulch layer protects also from downfall and from washing, raindrops and sun radiation, promotes the snow accumulation and decreases of the top soil freezing [5].

That`s why the creation and maintenance of the best topsoil structure by means of different cultivation systems is the urgent issue of modern intensive farming. But the dynamics earth processing and their effect on its productivity during cultivation demand of the regular research of the changes in agro-physical indexes [6] and this work is dedicated to it.

Conflict settings

The aim of the research is to find out the effect of different methods of cultivation in NKR Askeran district light brown loamy soil with carbon average strength (pH=7.5), with humus ingredient` 2.5-3.0%, on such agro physical properties of soil, from which the water supply and preventing of landfall depend on. In short rotation of clean fallow-winter crop-winter barley (2012-2015) there were conducted some field and laboratory researches, and compared the data of storey topsail cultivation due to traditional methods.

Yearly tillage was done in 20-22cm depth, using PLN-4-35 plough, and the storey top soil cultivation with grape PRVM-3 kind of moldering machine, which had two recovered moldering toes, which could mold the soil with 7-12sm depth, and before it the distance between the cutting particles as 100cm, the width-10cm and the depth-25-35cm. There were studied the agro physic properties of winter crop, its water supply and grain crop. The examples of soil were taken during two periods: in the beginning and in the end of plant growth according to topsoil (0-10, 10-20, 20-30cm) twice.

During field and laboratory researches there were used the fallowing methods and methodology: the volume-mass method, water supply by Khachinsky method, soil moisture by weight method, the crop yield by widely spread method of B.A. Dospekhov [7, 8].

Research results

It has been established during field experiments that the different methods (in fallow grain sowing circulation) as in topsoil (0-20sm) so in low topsoil provide not the same soil structure. Stepped topsoil cultivation provides more volume, porosity, water–permeability compare with traditional plowing. In this case the change in topsoil, 1.21g/cm³ in low topsoil, and in case of tillage-accordingly 1.19 and 1.25g/cm³ (Table 1).

It can be supposed that by storey topsoil cultivation the decrease of thickness in topsoil upper layer is gained due to down fall water in deep mold holes, temperature changes, which make soil shorten and widen [5].

As you can see from the data in the same chart the porosity has the best data as in storey topsoil, so in traditional tillage, but it was higher in case of storey topsoil cultivation as in upper (0-10cm) topsoil, so in low (20-30cm) topsoil and it was more in 132 times. It can be explained also by changing the use of plough and creating due to its tools, pores in soil and using of plow sole, which effects on soil fauna, especially on the speed of migration of worms to food sources.

The good water-permeability of soil is favorable for its normal air conditioning and biological activity.

Soil water-permeability and wetness can be affected by agro-machines with use of physical properties long-lasting improving method .During our experiment the data f soil water-permeability indicate that stepped plowing cultivation compared with tillage, in case of winter crop sowing led to increasing of water-permeability as in arable and topsoil, so in under topsoil.

Table 1

The different cultivation methods effect on the soil agro physical properties during autumn sowing vegetation (2012-2015 on average)

Cultivation method	Layer Cm	Thickness g/cm³	Porosity %	Water permeability Mm/min
Moldboard Plowing 20-22cm	0-10	1.17	42.1	3.91
	10-20	1.21	40.6	2.65
	20-30	1.5	38.7	2.25
	0-30	1.21	40.5	2.95
LID_{05} 0-30cm		0.08	1.03	2.15
Stepped cultivation	0-10	1.08	55.8	4.26
	10-20	1.15	53.6	4.09
	20-30	1.21	51.2	3.45
	0-30	1.15	53.5	3.93
LID_{05} 0-30cm		0.07	1.05	2.12

In topsoil it excelled in 0,92m/min or 28.2% compared with plowing in under topsoil it excelled in 1.22mm/min or 53.3% first it is conditioned by penetration of water deep in the soil through loosened clefts and due to its abnormal property making soil self loosened and on the other hand by activation of zoo fauna, especially of earth worms, which not only favor the low topsoil biological loosening improving its structure, but also by creating numerous passes provide the soil profile transparency in 1m depth.

During the autumn sowing vegetation the least stock in its different layers was observed after traditional plowing and composed 19.25-9.56%, and the most in case of stepped plowing composed 22.97-12.11% (Table 2).

Table 2

Soil moisture reserve during vegetation depended on cultivation methods (2012-2015 on average)

Cultivation method	Layer Cm	Soil moisture according to layer, %		
		In the beginning of vegetation	During spike forming	Before harvest
Moldboard Plowing 20-22cm	0-10	15.12	14.45	8.25
	10-20	19.48	18.32	9.12
	20-30	23.14	21.63	11.30
	0-30	19.25	18.13	9.56
LID_{05} 0-30 cm		1.03	1.12	1.08
Stepped Cultivation	0-10	19.18	18.13	10.82
	10-20	24.46	20.61	12.40
	20-30	25.28	21.43	13.11
	0-30	22.97	20.06	12.11
LID_{05} 0-30cm		1.14	1.11	1.04

In case of stepped cultivation in spring the high content of moisture dampness was kept during the whole vegetation period and before harvest excelled plowing in 2.55%. It is explained by the fact that in case of stepped cultivation the leftover stubble of soil surface holds the soil crusting surface, and due to it water-permeability and ventilation improve, moisture improves and makes soil loose and in soil upper layer the quantity of organic substances increases. In soil which was mold without moldboard plowing the plough sole disappears. These factors favor the soil thickness decrease fertility and crop yield increase.

The crop yield of autumn sowing grain in our experiment (for 4 years average data) in case of stepped cultivation composed 18.8c/ha, which excelled the traditional plowing in 18.2% (Table 3).

Table 3

Wheat grain crop yield according to experiment varieties (2012-2015)

Variant	Harvest c/ha					Deviation from spotter	
	2012	2013	2014	2015		c/ha	%
Moldboard plowing 20-22cm	26.8	23.4	24.7	28.6	25.9	-	-
Stepped cultivation	28.2	27.6	27.9	31.3	28.8	2.9	18.2
AET $_{05}$ 0-30cm	1.2	0.6	1.1	0.8	1.4	-	-

Conclusion

So comparison of the uninterrupted moldboard plowing cultivation in depth of 20-22cm and stepped cultivation in light brown loamy and carbon soil for autumn sowing (as its main cultivation) showed that the wingless cultivation with preserving surface plant leftover favors the improving of as topsoil (0-20cm) so of low topsoil (20-30cm) agro physical properties, water supply and crop yield increasing and expenses reduction in 21.2%.

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ՄՇԱԿՄԱՆ ՏԱՐԲԵՐ ՁԵՎԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ՀՈՂԻ ԱԳՐՈՖԻԶԻԿԱԿԱՆ ՀԱՏԿՈՒԹՅՈՒՆՆԵՐԻ ԵՎ ՋՐԱՊԱՀՈՎՎԱԾՈՒԹՅԱՆ ՎՐԱ՝ ԱՇՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ՑԱՆՔԵՐՈՒՄ

Ս.Բ. Գալստյան
Շուշիի տեխնոլոգիական համալսարան

Հետազոտության նպատակն է ԼՂՀ նախալեռնային գոտու բաց շագանակագույն կավավազային, կարբոնատային միջակ հզորությամբ հողային պայմաններում՝ մեխանիկական մշակման նվազեցման ճանապարհով հասնել հողի ագրոֆիզիկական հատկությունների, ջրապահովվածության օպտիմալացման, աշնանացան ցորենի բերքատվության բարձրացման և արտադրվող արտադրանքի ինքնարժեքի իջեցման: Հարկաշերտավոր մշակման կիրառումը վարելաշերտում (0-20սմ) հողի խտությունը առի շրջմամբ վարի համեմատությամբ նվազեցրել է 6,7%, ենթավարելաշերտում՝ (20-30սմ) 4,9%: Հարկաշերտավոր մշակումը բարելավել է նաև հողի ծակոտկենությունն ու ջրաթափանցությունը: Եթե առի շրջմամբ վարի դեպքում վարելաշերտում ծակոտկենությունը միջին հաշվով կազմել է 41,35%, ջրաթափանցությունը՝ 3,28մմ/րոպ, ենթավարելաշերտում՝ 38,7% և 2,25մմ/րոպ, ապա հարկաշերտավոր մշակման դեպքում այդ նույն ցուցանիշները համապատասխանաբար կազմել են՝ 54,7%; 4,17 մմ/րոպ և 51,2%; 3,45 մմ/րոպ:

Բանալի բառեր: հողի մշակում, ագրոֆիզիկական հատկություններ, ջրապահովվածություն, բերքատվություն, ծախսերի կրճատում:

ВЛИЯНИЕ РАЗЛИЧНЫХ ФОРМ ОБРАБОТКИ ПОЧВЫ НА АГРОФИЗИЧЕСКИЕ ПРИЗНАКИ И ВОДООБЕСПЕЧЕННОСТЬ В ПОСЕВАХ ОЗИМОЙ ПШЕНИЦЫ

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Цель исследования -достижение оптимизации агрофизических признаков и водообеспечение почвы, повышения урожайности озимой пшеницы и снижения себестоимости производимой продукции путем сокращения ее механической обработки в условиях средней мощности светло-коричневой, суглинистой и карбонатной почвы в предгорных зонах НКР. Применение ступенчато- слойной обработки по сравнению с отвальной вспашкой сократило плотность почвы в пахотном слое на 6.7%, а в подпочвенном-на 4.9%. Ступенчато-слойная обработка улучшила так же пористость почвы и ее водопроницаемость. Если при отвальной вспашке пористость пахотного слоя, в среднем составляет 41.35%, водопроницаемость 3.28мм/мин, а пористость подпочвенного слоя 38.7% с водопроницаемость - 2.25мм/мин, то при ступенчатой обработке те же показатели, соответственно составляют 54.7%, 4.17мм/мин и 51.2%, 3.45мм/мин.

Применение ступенчато-слойной обработки и сокращение ее интенсивности, а так же сохранение стерневых отходов поверхности почвы привели как в пахотном, так и в подпочвенном слое к

увеличению запасов влажности, в среднем до 2.74% на всех этапах вегетации. Этот метод обработки увеличивает урожайность озимой пшеницы по сравнению с обыкновенной вспашкой на 2.8 ц/га, и снижает себестоимость продукции на 21.2%.

Ключевые слова: обработка почвы, агрофизические признаки, водообеспеченность, продуктивность, сокращение затратов.

UDC 631:537.8:58.03

15 EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDSTREATED WATER INCREASE THE EFFICIENCY THE USAGE OF SOLONETZ-SOLONCHAK SOIL AND CROP YIELD

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There are large areas of the world that exist under sodic soils and need attention for efficient, inexpensive and environmentally feasible amelioration. Records nearly a century old reveal the use of water, crop, chemical amendment, electric current, and tillage as amelioration tools for such soils. Owing to gradual increases in amendment cost in some parts of the world during the last two decades, this amelioration strategy has become cost-intensive, particularly for the subsistence farmers in developing countries. The aim of the current work is to increase the usage efficiency of the sodic soil and crop yield. For this proposes chemical amelioration method was used: hydrochloric acid was used as ameliorant after which the soil was washed with 15 Hz extremely low frequency electromagnetic field (0.4 mT) treated water. The amelioration presses and the crop yield were more effective in case of irrigation with magnetized water than with non-treated water, suggesting the higher efficiency of the proposed method to increase the crop yield in the solonetz-solonchak lands.

***Key words**: amelioration, extremely low frequency electromagnetic field, magnetized water, sodic soil, solonetz-solonchak lands.*

Introduction

Sodic soils are characterized by the occurrence of excess sodium (Na+) to levels that can adversely affect soil structure and availability of some nutrients. Deterioration in these soils occurs through changes in the proportions of soil solution and exchangeable ions, soil pH as well as osmotic and specific ion effects (Oster et al., 1999). Structural problems in sodic soils created by certain physical processes (slaking, swelling and dispersion of clay minerals) and specific conditions (surface crusting and hardsetting) may affect water and air movement, plant available water-holding capacity, root penetration, seedling emergence, runoff, erosion and tillage and sowing operations (Shainberg and Letey, 1984; Gupta and Abrol, 1990; Sumner, 1993; Oster et al., 1999). In addition, serious imbalances in cation nutrition usually occur in such soils, which may range from deficiencies of several nutrients to high levels of Na+ (Naidu and Rengasamy, 1993). Such physical and chemical changes have a bearing on the activity of plant roots and soil microbes and ultimately on crop growth and yield (Naidu and Rengasamy, 1993).

Sodic soils exist mostly under arid and semiarid climates. Sodic soil amelioration needs replacement of excess exchangeable Na+ by more favourable calcium (Ca2+). The replaced Na+ is leached from the root zone through excessive irrigations. Thus, in addition to a source of Ca2+, adequate water movement into and through sodic soils is another key factor involved during the amelioration process.

Records nearly a century old of sodic soil amelioration research and practice reveal that several site-specific methods have been used to ameliorate a variety of sodic soils (de Sigmond, 1924; Kelley and Brown, 1934; Oster et al., 1999). These methods include (1) leaching without amendment application, generally applicable to ameliorate gypsiferous soils, (2) application of high electrolyte water containing divalent cations, high-salt-water dilution, (3) use of chemical amendments, both inorganic and organic, (4) soil profile modification through tillage, (5) horizontal flushing after amendment application to ameliorate low-permeability sodic soils where vertical leaching is not efficient, (6) electromelioration consisting of passing electrical current through the soils and (7) phytoremediation dealing with cultivation of certain plant species, tolerant to ambient soil salinity and

sodicity levels, without the application of an amendment. These methods or their suitable combinations have been used under specific conditions.

Armenia has 30,000 km2 area. Mountains make about 70% of the country's territory. The average altitude is 1,800 meters above sea level. About 90% of the territory is located above 1,000 meters. In general Armenia has 14 types of soils, including 27 subtypes, multiple families, varieties and species of soils. Saline-alkaline hydromorphic and solonetz-solonchaks soil type comprises about 31.000 ha (approx. 1.2 % of total area).

On the other hand it was shown that by non-ionizing radiation treated water have modulation effect on plant seed germination potential (Amyan and Ayrapetyan, 2004). It was shown also that extremely low frequency electromagnetic field (ELF EMF) and mechanical vibration at infrasound frequency (MV at IS frequency) had frequency-dependent character on plants seed's germination. In case of ELF EMF effect on germination potential of barley seeds the more effective frequency windows were 15 Hz (Amyan and Ayrapetyan, 2004). Our previous study has shown that a frequency-window effect of ELF-EMF on physicochemical properties of water depends on the chemical and physical compositions of the environment such as background radiation, light intensity, temperature, and gas composition (Baghdasaryan et al., 2013).

In our work, based in above mentioned phenomena, we focused on the same frequency window (15 Hz, 0.4 mT) where most positive effect on seed germination was shown. Therefore, the purpose of the present work is to increase the efficiency of the chemical amelioration method and crop yeald production in sodic soils. For this proposes as ameliorate the soil with hydrochloric acid HCl (30 %) and then washed it 15Hz EMF treated water.

Conflict settings

Five-hundred-gram soil samples were randomly collected from the upper 0-25 cm soil layer from Ararat valley (Armenia), placed in individual plastic bags, and stored in a cool, insulated box during transportation to the laboratory. The processing of abiotic analyses of the soil samples were done after two days of storage at 4°C.

The controlled generator and low-noise amplifier on a coil (manufactured by the Institute of Radiophysics and Electronics of National Academy of Sciences, Armenia) generated the ELF EMF. The Helmholtz coil had a cylindrical form with a dimension of 154 mm in diameter and 106 mm in height. Rings of Helmholtz were formed by two equal ring coils located coaxially and parallel. The distance between the coils was equal to their radius (77 mm). The magnetic field created by these rings had high homogeneity. Based on our previous finding that in case of ELF EMF the most effective frequency window was at 15 Hz (0.4 mT) for effective changes in physicochemical properties of DW for seed germination (Amyan and Ayrapetyan, 2004) we selected this frequency for ELF-EMF treatment in our current experiments.

A glass test tube (1) by 7 cm in diameter and 50 ml volume was placed in the coil (2) as ELF EMF source (Fig. 1). EMF was generated by the controlled generator (4) (GZ-118, Russia) and low-noise amplifier on the coil ((3), IRPhEA NAS, Armenia). Helmholtz coils generate a homogeneous magnetic field (0.4 mT) and are formed by two equal ring coils located coaxially and parallels. The harmonic voltage generated by generator (4) after being amplified by low-noise amplifier (3) passes to the Helmholz coils (2).

Water treatment and experimental setups. Distilled water (DW) was exposed to ELF EMF (15 Hz; 0.4 mT) for 30 minutes, whereas untreated DW that was placed in a non-activated coil for 30 minutes was used as control. Three experimental setups were done: (1) control, where no ameliorant was used and washed with regular or non EMF treated water. Due to the saturation of soil with water, only 20% of water amount calculated in field experiment was used (Papinyan et al., 2009). (2) Soil ameliorated with HCl (30%) and washed with non-treatedwater. (3) Soil ameliorated with HCl (30%) and washed with 15 Hz (0.4 mT) ELF EMF treated water. To check the efficiency of amelioration

vegetative experiments were performed. Half a kg solonetz-solonchak soil is placed in polyethylene tubes and fifteen seeds of winter wheat were germinated in each polyethylene tubes.

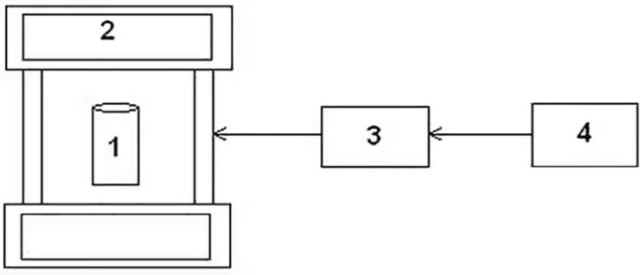

Figure 1. The schematic diagram of a device for EMF treatments. (1) glass test tube with diameter 7 cm and volume 50 ml, (2) Helmholtz coils, (3) the low-noise amplifier, (4) the generator of a harmonic field

Chemical analysis. Soil pH was determined with a pH electrode in the filtered supernatant after an overnight incubation period at room temperature of a mixture containing 20 g soil and 40 ml distilled water (DW) (1:2 soil:water ratio), followed by shaking for 10 min (160 rpm) and incubation overnight at room temperature.

The elemental analyses of Ca, Na, K, Mg by done in the filtered supernatant by flame photometry. The filtered supernatant was prepared in this structure soil:double-distilled water, 1:10, followed by shaking for 30 min (160 rpm) and overnight incubation at room temperature.

The rest of chemical analysis was done by standard laboratory methods of soil analysis (Alban and Kellogg, 1959).

Statistical analysis. Statistical analyses were conducted using SPSS software (release 17). The means of measures in two groups were compared by independent T test. Data were expressed as means. All experiments were repeated at least three times.

Research results. The efficiency of chemiacal amelioration of solonetz-solonchak soilwas investigated using 15 Hz ELF EMF treated water after using HCl (30 %)amalorant. Chemical composition of soil in water solution and indicators of exchangeable Na^+ and $K^+$are shown in Table 1.

Papinyan et al. (2009) in the field experiment have calculated that the required amounts of ameliorant and irrigation water for 1 ha soil is 240 tons of 30% HCl and 56.8 thousand m^3 irrigation water, respectively. In ourlab experimentsonly half of required ameliorant was used, total 10 ml of 30% HCl and 2.1 l of water for 0.5 kg of soil amelioration.

During the three experimental setups filtrates periodicaly were taken and chemical analysis were performed. It has been shown the use ofelectromagnetically treated water has advantages: in the filtrate the concentration of Na is higher 4,2% than in non-treated water used experiments (Table 2).

The efficiency Na^+ removal from soil is aboout 5 % with treated water used. It has been shown that using the EMF treated water both the amount of amelorant and washing water can be decreased by 20-25 %. For ameloration of 1 ha instead of estimated 240 tons of HCl (Papinyan et al., 2009) only 190 tons is required if using EMF treated water, saving 50 tons of HCl per ha of soil ameliorated. With the cost of 1 tons of 30 % HCl of 50 $ (USA), it is possible to save 250 $ in this method by decreasing amount of amelorant: at the same time the decraese of amount of water can also be advantageous: 10,000 m^3 x 0.03 $ (USA) = 300 $, thus using this method overall we can save 280 $.

Table 1

The chemical composition of investigated soil water solution and the indicators of exchangeable Na^+ and + K^+.

Soil laye, cm	pH	Σ of salt, %	mg-ekv/100gsoil									
			Total CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	Na^+	exchangeable Na^+, K^+	
0-25	9,8	1.57	3.59	5.00	7.05	10.47	0.50	0.08	21.94	21.8	18.3	1.8

Table 2

Chemical composition of the washed filtrate. Twenty percent of the amount of washing water (from 2.1 l) was used.

N	Exp. setups	pH	Σ of salts g/l	mg-ekv/l							Water (l)	Filtrate (l)	Total removed Na %
				CO_3^{2-}	Total HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$			
1	Control		No filtrate observed		-	-	-	-	-	-	0,4	No	-
2	HCl + non-treated water	6.8	11.7	No	10,0	129,6	50,8	50,0	12,8	127,6	0,4	0,3	15,8
3	HCl + treated water	7.0	12.8	No	10,0	144,4	68,4	48,0	12,8	162,0	0,4	0,3	20,0

Table 3

The chemical analysis of the investogated soils water solution and exchangeable $Na^+$and K^+.

N	The experimental setups	pH	Salts %	mg-ekv/l									
				CO_3^{2-}	Total HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	Na^+	Exchang. Na^+	K^+
1	Control	9.8	1.6	3.6	5.00	7.1	10.5	0.55	0.1	21.9	21.8	18.3	1.8
2	HCl + non-treated water	9.0	0.1	0.07	1,25	0.3	0.07	0.10	0.04	1.43	1.38	4.50	1.8
3	HCl + EMF treated water	8.8	0.1	0.05	1.16	0.3	0.12	0.15	0.16	1.32	1.27	3.80	1.7

The soils chemical analysis of the hypothetical case where the entire calculated amount of washing water (2,1 l per 0.5 kg soil) was used is presented in Table 3.

The current study showed that even with a use of only 50 % of the amelorant the salt concentration in the soil decreased from 1.6 % (control) to 0.1 % in the second and third experimental setup.

Table 4

The seeds growth in the ameliorated soils

Experimental setups	The numbers of growing seeds after 7th day	The numbers of growing seeds after 12th day
HCl (30%)+ non-treated water	0	0
HCl (30%)+ treated water	1	4

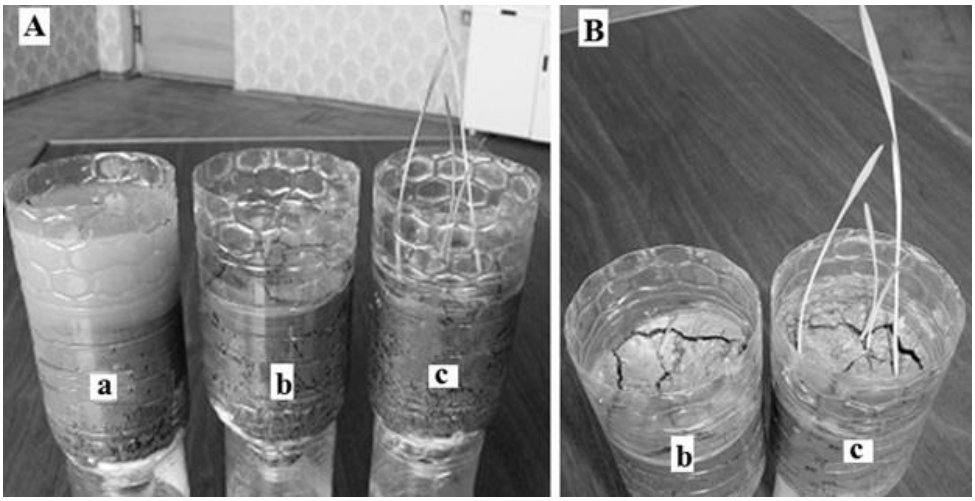

Figure 2. The growth of winter wheat in the following setups: a) control-no ameloration, b) in amelorated soil, c) after ameloratin 15 Hz (0,4 mT) EMF treated water was used. A- view from front and B- view from above

To investigate the usage of ameliorated solonetz-solonchak soil and the in the lab in each experimental setup 15winter wheat seeds were grown in polyethylene tubes. After 7 and 12 days the number of grown seeds were calculated (Table 4, Fig. 2).

After 12 days of growth significant changes($p<0.05$) in the setup where 15 Hz ELF EMF treated water was used were observed (Fig. 2).

Conclusion

Salinity is one of the major factors responsible for soil degradation. Approximately one third of the world's land surface is arid or semiarid (4.8 x 10^9 ha), half of which is estimated to be affected by salinity (Croughan and Rains, 1982). Salinity is a major abiotic stress at present (Rueda-Puente et al., 2007), and is one of the most severe environmental problems affecting crop growth (Lopez et al., 2002) and in concert with drought seems to be one of the world's most serious problems in agriculture.

The global population is about 6.3 billion, increasing day by day at an alarming rate. According to an estimate, it will be 9.0 billion by 2050 (Lal, 2007). Thus, there is a dire need to increase crop productivity either through increase in yield per unit area or by increasing area under cultivation.

EMF treated distilled water has been shown to have an activation effect on germination potential of barley seeds (Amyan and Ayrapetyan, 2004), more pronounced at 15Hz frequencies. It is also known that different plants during vegetation if irrgeted byELF EMFtreated water have elevated seedgermination, reduced root development period, increased resistance to thermal and osmotic stress (Amyan and Ayrapetyan, 2004). On the other hand it is well documented that EMF can change the physicochemical properties of water (Baghdasaryan et al., 2013).

During amelioration of solonetz-solonchak soil high amount of ameliorant (H_2S0_4-100 tonn/ha, HCl-240 tonn/ha) and 45.000-50.000 m^3/ha of irrigation water were used washing salt washout from soil (Papinyan et al., 2009). Soil becomes useable for agriculture. In the first year the yield of wheat is 40-50 c/ha, and during 3 years in that soil can be grow 100-120 c/ha of lucerne hay (Papinyan et al., 1988; 2009). Papinyan et al., (2009) shown that solonetz-solonchak soil of Ararat valley can be amelorated by «Nairit»'s surplus production of 30% hydrochloric acid solution.After amelioratation the soil was washed with non-treated irrigation water(Papinyan et al., 2009). Currently proposed amelioration method has several advantages to the conventional methods (Papinyan et al., 2009), such as increase the efficiency of the usage the soil amelioration and at the same time the crop yield.

Thus, the proposed goals to increase the useage of solonetz-solonchak soil, reduce the cost of ameliorantion processes and amount of water for irregation, to induce the germination of seeds and increase the yield of cultivated crops, have been approved with our methods.

It can been concluted that using ELF-EMF treated water it is possible to decrease of used amount of amelorant and washing water, to increase the germinetion of the seeds, to induce the futher growth, to encrease the yield production of agricaltural cultivatred plants and to gain ecologicaly clean products.

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15 ՀՑ ՀԱՃԱԽԱԿԱՆՈՒԹՅԱՄԲ ՄՇԱԿՎԱԾ ՋՈՒՐԸ ԲԱՐՁՐԱՑՆՈՒՄ Է ԱՂԱԿԱԼԱԾ ՀՈՂԻ ԵՎ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ՕԳՏԱԳՈՐԾՄԱՆ ԱՐԴՅՈՒՆԱՎԵՏՈՒԹՅՈՒՆԸ

Գ.Ա. Սաֆարովա
Շուշիի տեխնոլոգիական համալսարան

Երկրագնդի վրա կան շատ տարածքներ, որոնք գտնվում են աղակալած հողերի տակ և արդյունավետ, մատչելի և էկոլոգիապես պիտանի հողաբարելավման համար ուշադրության կարիք ունեն: Գրեթե մեկ հարյուրյամյակի արձանագրությունները բացահայտում են ջրի, բերքի, քիմիական բարելավման, էլեկտրական հոսանքի և վարելահողի օգտագործումը որպես հողաբարելավման գործիքներ այսպիսի հողերի համար: Վերջին երկու տասնամյակում երկրագնդի որոշ մասերում բարելավման արժեքի մեջ աստիճանական աճի շնորհիվ, այս հողաբարելավման ռազմավարությունը դարձել է ինտենսիվ արժեք, մասնավորապես՝ կենցաղային ֆերմերների համար՝ զարգացող երկրներում: Ընթացիկ աշխատանքի նպատակն է մեծացնել աղակալած հողերի և բերքի արտադրողականության օգտագործման արդյունավետությունը: Այս նպատակով կիրառվեց քիմիական ուղղման (հողաբարելավման) մեթոդը. օգտագործվեց հիդրոքլորիդ թթու՝ որպես հողաբարելավման նյութ, ինչից հետո հողը ջրվեց 15հցչափազանց ցածր հաճախականություն ունեցող էլեկտրամագնիսական (0.4մլ) ջրով:Հողաբարելավման գործընթացը ճնշվում է, և բերքը մագնիսացված ջրով ոռոգման դեպքում դառնում է ավելի արդյունավետ, քան ոչ մագնիսացված ջրով ջրելիս՝ առաջարկելով ներկայացված մեթոդի ավելի մեծ արդյունավետություն աղակալած հողերում բերքատվությունը բարձրացնելու համար:

Բանալի բառեր. բարելավում, խիստ ցածր հաճախականությամբ էլեկտրամագնիսական դաշտ,մագնետիկ ջուր,նատրիումական հող, աղակալած հողեր:

15 ГЦ УЛЬТРАНИЗКОЙ ЧАСТОТЫ ЭЛЕКТРОМАГНИТНЫХ ПОЛЕЙ С ОЧИЩЕННОЙ ВОДОЙ ПОВЫШАЮЩЕЙ ЭФФЕКТИВНОСТЬ ИСПОЛЬЗОВАНИЯ СОЛОНЦЕ-СОЛОНЧАКОВЫХ ПОЧВЫ И УРОЖАЙНОСТИ КУЛЬТУР

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Есть большие районы мира, которые существуют в рамках натриевых почв и требуют внимания для эффективного, недорогого и экологически возможной мелиорации. Записи почти столетие старые раскрывают использование воды, урожая, химической поправки, электрического тока, а также обработки

почвы в качестве мелиоративных инструментов для таких почв. Вследствие постепенного роста стоимости поправки в некоторых частях мира в течение последних двух десятилетий, эта стратегия мелиорация стала затратным, особенно для фермеров в развивающихся странах. Целью настоящей работы является повышение эффективности использования в натриевый почвы и урожайности сельскохозяйственных культур. Для этого предлагается был использован химический метод мелиорация: соляная кислота использовалась в качестве мелиорантов, после чего почву промывали 15 Гц крайне низкой частоты электромагнитного поля (0,4 мТл) обработанной воды. Мелиорация прессы и урожайность были более эффективными в случае орошения с намагниченной водой, чем с необработанного водой, что указывает на более высокую эффективность предлагаемого метода для повышения урожайности в солонцов-солончаковых земель.

Ключевые слова: мелиорация, крайне низкой частоты электромагнитное поле, магничная вода, натриевые почвы, земли солонцы-солончаки.

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ARCHITECTURAL MEMORIAL OBJECTS IN THE STRUCTURE OF THE OBJECTIVE-SPATIAL ENVIRONMENT

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The object of the present paper is to develop the systems concepts of objective-spatial environment formation of the architectural memorial complexes. The subject of the research is viewed in the format of the two main equipollent components: physical objects creating the architectural space and informative sphere for actualization of memory and moral integrity of the visitors to the memorial.

Key words: *cultural heritage site, architectural memorial complex, objective-spatial environment, systems analysis, actualization of memory.*

Introduction

By now there are known different real definitions which may characterize social, cultural and economic phenomenon of the city.

In a sense, it can be assumed that an urban settlement (in the format of a city) is some alternative to the rural settlement and in this kind of civilized competition there is a constant search for the optimal balance conditions between the tendency to progress gained by the mankind (simultaneously with the knowledge) and a nested genetic code, based on the internal harmony and the understanding of traditional values, concern for the environment, the physical condition and spiritual order of the neighbors.

The development of a significant number of civilization processes (planetary, continental, regional) is largely connected with the phenomenon of urbanization of settlements and residential areas — the historical process associated with the formation of new cities, growth and structural change of their architectural space, accompanied by the concentration of political, economic, cultural and social processes.

Currently, the consequences of the phenomenon of urbanization are characterized by the intensification of the process of the world population growth (in large modern metropolitan areas), followed by a sharp decrease in the amount and area of land suitable for their living.

The historical period corresponding to the end of the twentieth century (or rather 1990) marked the transition of the industrial society (urbanized cities) to the post-industrial format of functioning.

Theory and practice of urban planning, building, and development (in the framework of the academic discipline of "city planning" or "urban studies") is focused on the analysis of complex problem-solving methods related with cultural, social, functional, sanitary and hygienic, technical and economic, architectural and compositional factors.

Development of the existing urban realm or city or creation of the new one (as a separate structural unit and the centre of the corresponding agglomeration) is the most challenging task of architectural design. The city is viewed as an object of complex development (dynamic system), in which the conditions and opportunities for development of its economic (production) and social subsystems are equally taken into account.

The modern city is a combination of structural elements (subsystems), which are interrelated in complex, and often tenuous ways: production and non-production processes, businesses, external factors that create conditions for the city functioning (as an interaction system) and form a certain entity.

Turning to the issue of memorial complexes, it should be pointed out that the cultural and historical heritage sites fulfill functions of the social transmission of the cultural state of each nation in particular and the world community on the whole. The value of the universal human and national memory consists in actualization and/or preservation of the possibility to determine and develop directions for mental and cultural identification and integration of personalities, ethnicities, and communities.

By now memorials (as physical cultural resources) are identified according to their historical (memorial, from Latin “memorialis” meaning “commemorative”, [1]), architectural, artistic, and technological value. The artistic image of the heritage site is formed through various art forms and externalized in a particular memorial ensemble or complex.

Description of the subject of research

The value of the monuments (of culture, art, and architecture) is determined not so much by economic characteristics of development and/or maintenance, as by the cultural and historical importance they have for the life of the modern civil society.

Contemporaries preserve monuments of the past for the future generations to tell about historical and social relations, establish direct contact between the past and the present, creating conditions for a better awareness of the past events and phenomena in the brightest and most memorable forms.

The major function of the memorials is to create necessary conditions for maintaining succession in the cultural development of nations (all segments of population) on all possible levels: a single household, a separate nation (country), and the whole world community.

The classification of monuments (cultural heritage sites) includes the following types (of monuments) in the corresponding formats of elements of the objective-spatial environment while maintaining (or modifying) their functional purpose:

- historical monuments (Figure 1):
- monuments of labour or industrial activity;
- monuments related to the state system of the society (nation);
- monuments related to the class struggle and revolutionary movement;
- monuments connected with the struggle for independence;
- monuments connected with the development of science, education, and art.

Figure 1. The monument to Minin (standing) and Pozharsky (sitting) on the background of St. Basil's Cathedral, Moscow

Figure 2. Archaeological Museum-preserve "Tanais" - is Located about 30 km West of Rostov-on-don, on the outskirts of the farm of Nedvigovka

- the archeological monuments (Figure 2):
- fortresses;
- cities;
- remains of ancient settlements, burial grounds and ritual structures;
- rock engravings and cave paintingss and inscriptions;
- places of archeological finds of tangible or intangible value (characteristic);
- objects and items located at the bottom of reservoirs.
- monuments of urban planning and architecture (Figure 3):
- monuments of urban planning art;
- monuments of residential architecture;
- monuments of civil (public) architecture;
- monuments of religious architecture;
- monuments of military−defensive architecture;
- monuments of industrial heritage;
- monuments of landscape architecture;
- architectural monuments.
- monuments of the environmental art (Figure 4):
- monumental sculpture;
- monumental painting;
- monumental decorative art.

The value of the universal human and national memory consists in actualization and/or preservation of the possibility to determine and develop directions for mental and cultural identification and integration of personalities, ethnicities, and communities.

Every monument (social or cultural heritage site) is characterized by a particular cultural and historic value dependent on the structure of their tangible and intangible characteristics.

An architectural memorial complex is a cultural and historical heritage site representing a conformed combination of the elements of the architectural space intended for materialization of memory and honour of the society to important historical events [2].

Figure 3. Russia's only urban planning and life museum, housed in the building, created by the renowned Fedor Schechtel. This house - the pearl of Art Nouveau, which has no equal in the whole South of Russia. Taganrog city

Figure 4. The monument "The Worker and the Collective Farm Woman" in Moscow, Russia

The effectiveness of the “memorial” function of the present subject of research is evaluated by the interaction of the following structural components:

– the passive component – connected with the material format of creating the artistic image and expressed through object composition of the architectural space elements of the memorial complex;
– the active component – connected with the visual and emotional format of the communicative environment, intended for actualization of the ways of transmitting traditions, immersiveness in the historical events taken place on the territory of the memorial complex.

The essential and sufficient criterion for estimating efficiency of the “memorial” function of the memorial complex is the co-existence of the “funds” of primary and secondary spheres of activity and quantitative representation of visitors (consumers of primary funds). It is due to the immediate contact of visitors with the architectural space of the memorial complex that occurs evident or latent actualization of memory and knowledge about a corresponding historical event and a proper emotional background is created to enhance the feeling of immersiveness [3].

The memorial complexes erected in the Soviet Union period (in the second part of the 20th century) which are commemorated to the great and tragic events of the Great Patriotic War are the example of moral integrity and honour to the heroism of the united nation [4] (Figure 5, 6).

The modern concept of the memorial complex is guided by its new role – the qualitative and quantitative transformation: from a certain historical “phenomenon” to a meaningful “process” targeted to solve actual and challenging problems of the civil society. It is in this process that the passive and active components of the “memorial” function become equipollent for creating the informative potential of the cultural heritage site.

Figure 5. Memorial headstone structures (complexes) of modern structural components focused on implementation of the memorial function to commemorate the perished in the Great Patriotic War (1941-1945)

Figure 6. The monument "The Worker and the Collective Farm Woman" in Moscow, Russia

The multifunctional format of the modern memorial complex provides ample opportunities for the organization of some communicative and social space. The structural integrity of this kind of space (architectural space) provides vivid emotions, psychologically comfortable conditions for human interaction, education and formation of the society’s unity of opinions on the memorable and historic events.

The systems analysis of the objective-spatial environment

The proposed here approach to the evaluation of the memorial complex operation is focused on the application of the socio-environmental concept and principles of the general system theory: integrity, space efficiency, invariability, hierarchal pattern of the structure as well as the determining factor principle and its relative share [5].

Architectural memorial complexes are characterized as objects of modern multi-purpose architecture, in which architectural forms and objective-spatial environment rather form some

meaningful, materialized idea, function, or conception about the subject, than a particular type of building or structure.

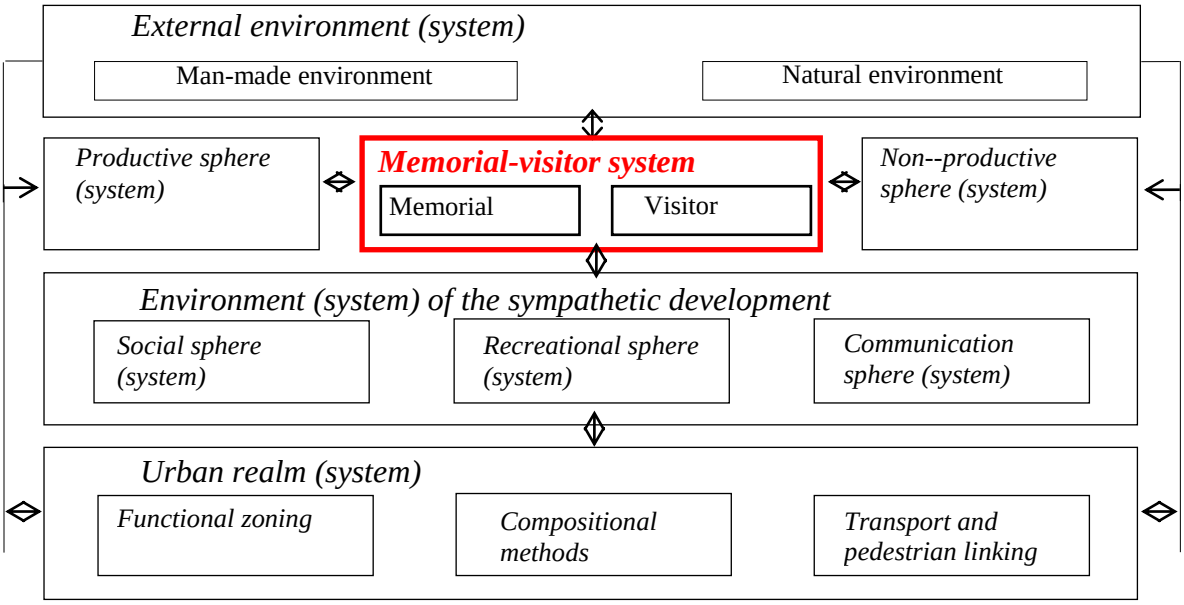

Figure 7. The structure of the objective-spatial environment (system)

The architectural space of the memorial complex presents itself as a multifunctional spatial socio-environmental system in which civil society living on a certain territory (conventional urban realm) is considered in the format of a particular interrelated “dialectical” unity and integrity with the corresponding environment (man-made or natural).

Figure 7 illustrates the structure of this kind of objective-spatial environment (or the system for the corresponding structural connection analysis).

Among the given structural elements (systems, spheres) of the objective-spatial environment the system “memorial complex-visitor” is of paramount importance.

The developed concept of the memorial complex, a number of relevant compositional methods for its implementation, the level of architectural and artistic presentation determine visual and emotional perception of information by the visitor (consumer) of the heritage site.

The integration of the memorial complex into the existing (or designed) structure of the objective-spatial environment predetermines the qualitative and quantitative changes of the corresponding city-planning condition.

The systems approach to studying and solving problems connected with the creation and development of the memorial complex, as "the centre of social memory", is used in the widest range: from the analysis of the system in a holistic view (architectural space) to the study of its individual subsystems (spheres of production, non-productive, recreational, social, communication activities) and simple structural components.

Establishing conditions for creation and/or evolutionary development of the architectural space of memorial complexes is inextricably linked with the appropriate state (level of development) of socio–economic, urban, technological, transport and communication, environmental indicators of the urban environment and modern civil society.

Findings and recommendations

1. The necessity to provide scientific and methodological reason for designing new memorial complexes as well as preservation and reconstruction of the erected ones is a relevant issue.

2. The systematic approach allows to conduct the effectiveness analysis of the main functional load of the subject of research on the whole as well as of its separate structural elements.

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ՃԱՐՏԱՐԱՊԵՏԱՀՈՒՇԱՐՁԱՆԱՅԻՆ ԿՈԹՈՂՆԵՐԸ ՄԻՋԱՎԱՅՐԻ ԱՌԱՐԿԱՅԱՏԱՐԱԾԱԿԱՆ ԿԱՌՈՒՑՎԱԾՔՈՒՄ

Ա.Ն. Սոկոլովա

Շինարարության և ճարտարապետության ակադեմիա, Դոնի Ռոստով

Աշխատանքի նպատակն է՝ մշակել ճարտարապետահուշարձանային օբյեկտների համալիրների առարկայատարածական ձևավորման համակարգերի սկզբունքային գաղափարներ: Հետազոտության առարկան դիտարկվում է երկու համազոր բաղադրիչների ձևաչափով. ճարտարապետական միջավայր ձևավորող նյութական առարկաներ և հիշողության արդիականացման ու հուշարձանի այցելուների հոգևոր միավորմանը նպաստող տեղեկատվական ոլորտ:

Բանալի բառեր. մշակութային ժառանգության օբյեկտներ, ճարտարապետական հուշահամալիր, առարկայատարածական միջավայրի համակարգեր:

АРХИТЕКТУРНО-МЕМОРИАЛЬНЫЙ КОМПЛЕКС В СТРУКТУРЕ ПРЕДМЕТНО-ПРОСТРАНСТВЕННОЙ СРЕДЫ

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Целью работы является разработка системных принципов формирования предметно-пространственной среды архитектурно-мемориальных комплексов. Объект исследований представляется в формате двух основных равнозначных компонентов: материальных предметов, формирующих архитектурную среду и информационной сферы для актуализации памяти и духовного единения посетителей мемориала.

Ключевые слова: объект культурного наследия, архитектурно-мемориальный комплекс, предметно−пространственная среда, системный анализ, актуализация памяти.

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EFFECT OF HYDROSTATIC PRESSURE ON DIAMAGNETIC SUSCEPTIBILITY OF A HYDROGENIC DONOR IMPURITY IN CORE/SHELL/SHELL SPHERICAL QUANTUM DOT WITH KRATZER CONFINING POTENTIAL

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Effect of hydrostatic pressure on diamagnetic susceptibility of on-center hydrogenic donor impurity in a $Ga_{1-x_1}Al_{x_1}As/GaAs/Ga_{1-x_2}Al_{x_2}As$ *core/shell/shell structure with Kratzer confining potential have been theoretically investigated in the framework of the effective mass approximation. The diamagnetic susceptibility have been calculated as a function of the characteristic parameters of Kratzer confining potential. With the increase of the hydrostatic pressure, the diamagnetic susceptibility increases. The same dependence from the depth of the Kratzer potential with additional effect: the value of the diamagnetic susceptibility become saturated. The results show that as the potential minimum point increases the diamagnetic susceptibility increases until some critical value, after which it decreases.*

Key words: *Spherical quantum dot, Kratzer potential, diamagnetic susceptibility.*

Introduction

Investigation of Coulomb systems in quantum dots (QD) constitute a subject of essential interest of specialists, due to the changings of geometrical shapes and sizes of QD it's possible to control physical properties, particularly imputiy and exiton states in zero-dimensional structures [1, 2]. With decreasing of the sizes of semiconductor the binding energy hydrogen-like system is increasing. Impurity states in QDs was investigated in many papers [3, 4].

At last years special fixedly attention given to spherical symmetric core/shell/shell systems [5, 6]. Essential prosperity of these systems is possibility of controlling of energetic spectrum of charge carriers through the changing of inner radius as well as outer. Wherein theoretical result obtaining for core/shell/shell system has generelized character, because by corresponding limit transition it can be realized spherical quantum dot as well as quantum well.

At the same time in number of papers [7, 8] are studied diamagnetic properties of impurity atoms in QD. Thereby it presents interest investigation of diamagnetic properties of impurity localized in center of spherical core/shell/shell system in that case, when confienment potential of structure described within model of Kratzer molecular potential [5]. The Kratzer potential have the following form

$$V_{conf}(r) = \frac{\alpha}{r^2} - \frac{\beta}{r} + U_0, \tag{1}$$

where α, β, U_0 – are parameters of potential. This parameters are related with the height of confinement potential and the potential minimum point r_0 of $U(r)$ potential according to the relation: $\alpha = U_0 r_0^2$, $\beta = 2U_0 r_0$. Said at first caused by fact, that problem of impurity state with this

potential is analytically exactly solvable and that's why it's possible to get a whole line of analitical reults and that let us present detailed picture diamagnetic characteristics of impurity atom.

Diamagnetic susceptibility

For diamagnetic susceptibility, χ_{dia} we can write [7]:

$$\chi_{dia} = -\frac{e^2}{6\mu c^2}\int_0^\infty \left\{ f_{n_r,\ell'_0}^{(0)}(r)\right\}^2 r^4 dr\,. \tag{2}$$

The integral in equation (2) was calculated in [5], and based on this we can write

$$\chi_{dia} = -\frac{e^2}{6\mu c^2} I_{n_r,\ell'_0}\,, \tag{3}$$

where

$$I_{n_r,\ell'_0} = \frac{1}{(2\gamma)^2}\frac{\Gamma(2\ell'_0+5)}{\Gamma(2\ell'_0+3)}\frac{\left\{\left(\frac{d^{n_r}}{dh^{n_r}}\right)\left[\frac{F\left\{\ell'_0+5/2,\ell'_0+3,2\ell'_0+2,A^2/D^2\right\}}{(1-h)^{2\ell'_0+2}D^{2\ell'_0+5}}\right]\right\}_{h=0}}{\left\{\left(\frac{d^{n_r}}{dh^{n_r}}\right)\left[\frac{F\left\{\ell'_0+3/2,\ell'_0+2,2\ell'_0+2,A^2/D^2\right\}}{(1-h)^{2\ell'_0+2}D^{2\ell'_0+3}}\right]\right\}_{h=0}}\,,$$

where are made next designations: $A^2 = 4h/(1-h)^2$, $D = (1+h/(1-h))$. From this expression, it can be written analytical expression for diamagnetic susceptibility for $1s$ and $2s$ states. So for 1s state

$$\chi_{dia}^{0,0} = -\frac{e^2}{3\mu c^2}\frac{\ell'_0(2\ell'_0+1)}{(2\gamma_0)^2}\,, \tag{4}$$

and for 2s state

$$\chi_{dia}^{1,0} = -\frac{e^2}{3\mu c^2}\frac{\ell'_0(2\ell'_0+1)\left(\ell'^2_0+7\ell'_0+9\right)}{(2\gamma_1)^2(\ell'_0+2)(\ell'_0+3/2)}\,. \tag{5}$$

Now let's consider the behavior of diamagnetic susceptibility in dependence on hydrostatic pressure and parameters of the QD. In all results, the units of length and energy are presented in Bohr radius $a_B^* = 104$ m and effective Rydberg constant $E_R^* = 5.275$ meV respectively. As for diamagnetic susceptibility, it is presented in $\left(a_B^{*2}\cdot r_e\right) = 4.362$ m^3, where $r_e = 4.194\times10^{-4}$ m is the classical radius of electron. Also it's necessary to notice, that in all calculations should be considered the dependence of the μ, ε and r_0 on hydrostatic pressure P [9,10]. The effective mass changes with P as

$$\mu(P) = \mu(0)e^{0.078P}\,, \tag{6}$$

where $\mu(0) = 0,067*\mu_0$ (μ_0 is free electron mass). The variation of dielectric constant with pressure is given as:

$$\varepsilon = 13.13 - 0.088P\,. \tag{7}$$

In all expressions P is in GPa. The dependence of R_{out} (outer radius of QD) on P given as:

$$R_{out}\left(P\right)=R_0\left(1-1.5082\cdot 10^{-3}P\right). \tag{8}$$

Note that the parameter r_0 correlated with outer radius of QD R_{out}. This correlation will be assumed as linear and the coefficient of proportionality $\lambda_{\exp}$ should be chosen from the experimental data. So dependence of r_0 on P could be written as:

$$r_0\left(P\right)=\lambda_{\exp}R_0\left(1-1.5082\cdot 10^{-3}P\right). \tag{9}$$

It is obvious that the dependence of the geometrical parameter r_0 on pressure leads to the changes the profile form of the Kratzer potential. Fig. 1 *a)* shows the dependence of diamagnetic susceptibility of the electron on minimum point of Kratzer potential r_0. With increasing of r_0 curves monotonically fall wherein there is observed increasing of absolute value of diamagnetic susceptibility. The curve highest located curve corresponds to biggest value of pressure, because module of average value of r has the smallest value in this case. In addition, it should be noted, that with increasing of r_0 curves diverges from each other.

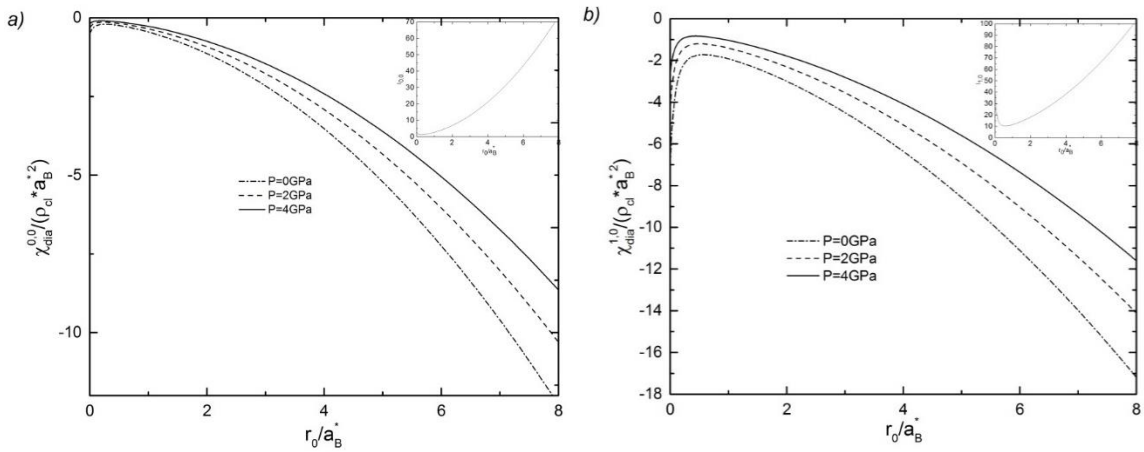

Figure 1. Dependencies of diamagnetic susceptibility χ_{dia} on parameter r_0 for different values of hydrostatic pressure for a) $1s$ and b) $2s$ states

On Fig. 2 *a), b)* are shown dependencies of diamagnetic susceptibility on depth of Kratzer confinement potential. As follows from this figures with increasing of U_0 absolute value of diamagnetic susceptibility decrease because of decreasing of localization area of electron. As in previous case for $2s$ state absolute value of diamagnetic susceptibility has bigger values than for $1s$ state.

All these reasonings are valid as well for $2s$ state (Fig. 1 *b)*). As it can be seen by absolute value $\chi_{dia}^{1,0}$ is bigger than $\chi_{dia}^{0,0}$ for every value of r_0, because in $2s$ state area of localization of electron is bigger than in case of $1s$ state as it can be seen from graphics for I_{0,ℓ'_0} and I_{1,ℓ'_0} in top right angles of

both figures. In both cases, when increasing r_0 starting from some value of r_0 absolute value of diamagnetic susceptibility starting sharply increase. This fact caused by quantum emission of electron from QD, whereupon area of localization of electron becomes more larger, than QD sizes.

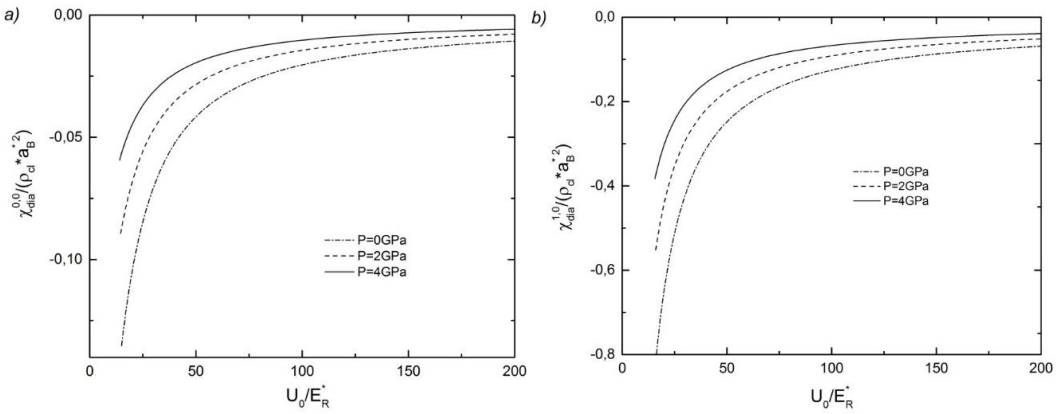

Figure 2. **Dependencies of diamagnetic susceptibility** χ_{dia} **on parameter** U_0 **for different values of hydrostatic pressure for a)** $1s$ **and b)** $2s$ **states**

On Fig. 3 *a), b)* are shown dependencies of diamagnetic susceptibility on hydrostatic pressure for different values of r_0. With increasing of P all three curves approach to each other (module of diamagnetic susceptibility decrease).

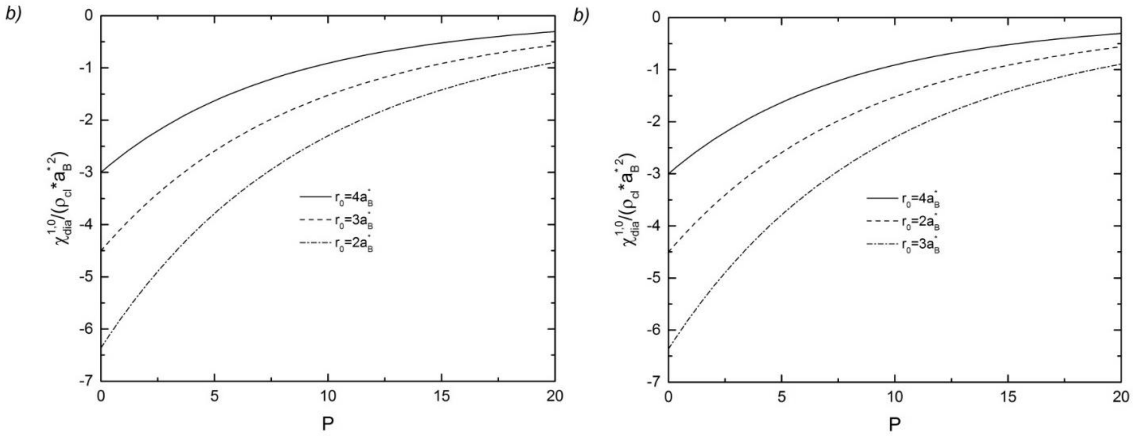

Figure 3. **Dependencies of diamagnetic susceptibility** χ_{dia} **on hydrostatic pressure** P **for different values of** r_0 **for a)** $1s$ **and b)** $2s$ **states**

Curve which corresponds to biggest value of r_0 ($r_0 = 4a_B^*$) located lower of all others, because in this case electron is localized on greatest distance from impurity. Null value of pressure corresponds to those value of diamagnetic susceptibility of impurity electron, when minimum of Kratzer potential has values $r_0 = 2a_B^*$, $r_0 = 3a_B^*$ and $r_0 = 4a_B^*$.

Conclusion

In this article the dependence of diamagnetic susceptibility values of the electron in $Ga_{1-x_1}Al_{x_1}As/GaAs/Ga_{1-x_2}Al_{x_2}As$ core/shell/shell structure with Kratzer potential and on-center hydrogenic impurity on hydrostatic pressure are considered. The same dependencies also obtained on the parameters r_0 and U_0 for different values of hydrostatic pressure. Due to the quantum emission of

electron from core/shell/shell structure, starting from some value of r_0 the behavior of the value of diamagnetic susceptibility is changing sharply.

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ՀԻԴՐՈՍՏԱՏԻԿ ՃՆՇՄԱՆ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԿՐԱՏՑԵՐԻ ՍԱՀՄԱՆԱՓԱԿՈՂ ՊՈՏԵՆՑԻԱԼՈՎ ՄԻՋՈՒԿ/ՇԵՐՏ/ՇԵՐՏ ԳՆԴԱՁԵՎ ՔՎԱՆՏԱՅԻՆ ԿԵՏՈՒՄ ՋՐԱԾՆԱՆՄԱՆ ԴՈՆՈՐԱՅԻՆ ԽԱՌՆՈՒԿԻ ԴԻԱՄԱԳՆԻՍԱԿԱՆ ԸՆԿԱԼՈՒՆԱԿՈՒԹՅԱՆ ՎՐԱ

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Արդյունարար զանգվածի մոտավորության շրջանակներում տեսականորեն հետազոտվել է հիդրոստատիկ ճնշման ազդեցությունը Կրատցերի սահմանափակող պոտենցիալով $Ga_{1-x_1}Al_{x_1}As / GaAs / Ga_{1-x_2}Al_{x_2}As$ միջուկ/շերտ/շերտ գնդաձև քվանտային կետում ջրածնանման դոնորային խառնուկի դիամագնիսական ընկալունակության վրա: Դիամագնիսական ընկալունակությունը հաշվարկվել է

որպես ֆունկցիա Կրատցերի պոտենցիալի բնութագրական մեծություններից: Հիդրոստատիկ ճնշման մեծանալուն զուգահեռ դիամագնիսական ընկալունակությունը աճում է: Նմանատիպ կախվածություն է նաև Կրատցերի պոտենցիալի խորությունից հավելյալ երևույթով՝ դիամագնիսկական ընկալունակության արժեքը հագենում է: Արդյունքները ցույց են տալիս, որ պոտենցիալի մինիմումի կետի աճին զուգընթաց դիամագնիսական ընկալունակությունը աճում է մինչև որոշակի արժեք, որից հետո նվազում է:

Բանալի բառեր՝ գնդաձև քվանտային կետ, Կրատցերի պոտենցիալ, դիամագնիսական ընկալունակություն:

ЭФФЕКТ ГИДРОСТАТИЧЕСКОГО ДАВЛЕНИЯ НА ДИАМАГНИТНУЮ ВОСПРИИМЧИВОСТЬ ВОДОРОДОПОДОБНОЙ ДОНОРНОЙ ПРИМЕСИ В СФЕРИЧЕСКОЙ КВАНТОВОЙ ТОЧКЕ ЯДРО/СЛОЙ/СЛОЙ С ОГРАНИЧИВАЮЩИМ ПОТЕНЦИАЛОМ КРАТЦЕРА

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В рамках теории эффективной массы теоретически исследован эффект гидростатического давления на диамагнитную восприимчивость водородоподобной донорной примеси в сферической квантовой точке $Ga_{1-x_1}Al_{x_1}As/GaAs/Ga_{1-x_2}Al_{x_2}As$ ядро/слой/слой с ограничивающим потенциалом Кратцера. Диамагнитная восприимчивость вычислена как функция характеристических параметров потенциала Кратцера. С увеличением гидростатического давления диамагнитная восприимчивость увеличивается. Такая же зависимость от глубины потенциала Кратцера с добавочным эффектом: величина диамагнитной восприимчивости становится насыщенной. Результаты показывают, что с увеличением точки минимума потенциала диамагнитная восприимчивость увеличивается до некоторого значения, после которого уменьшается.

Ключевые слова: сферическая квантовая точка, потенциал Кратцера, диамагнитная восприимчивость.

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The article copyright Submission Format Requirements

Articles can be submitted in Armenian, English or Russian up to 14 p.
(titled "Economic" up to 24 p).
Sheet format A4, margins up , down, left , right 18 mm.
The fonts: Armenian – Unicode /GHEA Grapalat/, Russian, English – Times New Roman.
The space between the lines – 1,15

1. The title of the article is given in the article's submitted language , in capital letters, in Armenian 11, Russian and English 12 bold font size at the right bottom of the page.
2. Universal Decimal Classification consisting of 6 symbols at least is given in the left corner of the next page.
3. A line down , in the middle , the article's submitted language , the title, capital letters, in Armenian 12, Russian and English 14 bold font size.
4. Two lines down, from the left, in the article's submitted language, the review of the author's name and surname, initial affiliation, in Armenian 11, Russian and English 12 bold font size
5. Aline , from the left, in the article's submitted language, (Italic) is given the name of the organization , in Armenian 9, Russian and English 10 font size.
6. Disabling text in horizontal solid line, from the left corner of the page are given the Key Words (up to 5-8 words), in Armenian 10, Russian and English 11 font size
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8. Two lines down is given the main text of the article, in Armenian 10, Russian and English 11 font size.The paragraphs begin from new line, 10 mm from the depths. The expound of the theme are guaranteed of the following scheme: "Introduction", "conflict settings", "Research results", "Conclusion". In case of need can also be other section with corresponding titles.
9. The formulas are presented in separated lines, in the middle and are numbered on the right, in brackets. The formula , as well as math's symbols and expressions are given in the text in Microsoft Equation, Italic 10 font size.
10. There can be found pictures, diagrams , graphs and tables in texts. The pictures and diagrams are numbered by transit numbering by sign "Figure". The description of pictures, diagrams , the names of pictures , diagrams graphs and the signs of description are given below. They can be placed vertical or horizontal in Armenian 9,Russian and English 10 bold font. Tables are numbered by "Table" transit numbering. The names of tables , sign description are given above. They could be placed vertical or horizontal. If the table can't be placed on a single page, it must be transferred to the other page and mentioned as condonation. In table column must not be left free lines, there must be put dash or write " not" ("determined").
11. Pictures , diagrams graphs in electronic version are colored as a rule.
12. At the end of the article , two lines down, from 10 mm left corner is typed "literature" Armenian 11, Russian and English 12 bold font. A line down is presented the list of literature numbered by link sequence . In list the sources must be marked […] and include the authors last name and the first letter of name , full names of theme , publishing dates , (place publishing, town, year, tom and pages). Official information as well as a-mail computer programs, reports, commands, copyrights patents, in case of patents are given the whole details. The sources are given in original languages. At the same time Armenian and Russian sources are given in Latin fonts.
13. On separate pages is given the translation of the article headquarter sand summary.(besides article presented language), Armenian , Russian (resume) and English (summary).
14. The Articles should be sent to the info@bulletin.am.
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16. On a separate sheet of paper are given the information about the authors (surname, name, affiliation (the whole), picture, academic degree, address, telephone, organization, position, e-mail.

Հոդվածների հեղինակային օրինակների ձևակերպման համար ներկայացվող պահանջներ

Հոդվածները կարելի է ներկայացնել հայերենով, ռուսերենով և անգլերենով՝ մինչև 14 էջի ("Էկոնոմիկա" խորագրով՝ մինչև 24 էջի) սահմաններում.
Էջի ֆորմատը՝ A4, լուսանցքները՝ վերևից, ներքևից, աջից և ձախից՝ 18 մմ.
Տառատեսակը հայերեն՝ Unicode /GHEA Grapalat/, ռուսերեն և անգլերեն՝ Times New Roman.
Միջտողային հեռավորությունը՝ 1,15:

1. Էջի վերին աջ անկյունում, հոդվածի ներկայացման լեզվով, գլխատառերով՝, հայերեն՝ 11, ռուսերեն և անգլերեն՝ 12 **bold** տառաչափով տրվում է հոդվածի խորագիրը:
2. Հաջորդ տողի էջի ձախ անկյունում տրվում է ՀՏԴ-ն՝ առնվազն վեցանիշ թվով:
3. Դրանից մեկ տող ներքև, մեջտեղում, հոդվածի ներկայացման լեզվով գլխատառերով դրվում է վերնագիրը՝ հայերեն՝ 12 **bold**, ռուսերեն և անգլերեն՝ 14 **bold** տառաչափով:
4. Երկու տող ներքև, ձախից, հոդվածի ներկայացման լեզվով, հեղինակի (հեղինակների, որոնց թիվը, որպես կանոն, չի կարող գերազանցել 4-ը) Անվան, Հայրանվան սկզբնատառերը և Ազգանունը՝ հայերեն՝ 11, ռուսերեն և անգլերեն՝ 12 **bold** տառաչափով:
5. Մեկ տող ներքև, ձախից, հոդվածի ներկայացման լեզվով, շեղատառերով (*Italic*) տրվում է կազմակերպության (կազմակերպությունների) անվանումը՝ հայերեն՝ 9, ռուսերեն և անգլերեն՝ 10 տառաչափով:
6. Անջատելով տեքստը հորիզոնական հոծ գծով՝ էջի ձախ անկյունից, հոդվածի ներկայացման լեզվով, տրվում են Բանալի բառերը (5-8 բառ)՝ հայերեն՝ 10, ռուսերեն և անգլերեն՝ 11 տառաչափով:
7. Երկու տող ներքև, հոդվածի ներկայացման լեզվով, մեջտեղում, շեղատառերով (*Italic*), գրվում է հոդվածի համառոտագիրը՝ 10-20 տող՝ հայերեն՝ 9, ռուսերեն և անգլերեն՝ 10 տառաչափով:
8. Երկու տող ներքև ներկայացվում է հոդվածի հիմնական տեքստը՝ հայերեն՝ 10, ռուսերեն և անգլերեն՝ 11 տառաչափով: Պարբերությունները սկսվում են նոր տողից՝ 10 մմ խորքից: Երաշխավորվում է նյութի շարադրման հետևյալ սխեման. «***Ներածություն***», «***Խնդրի դրվածքը***», «***Հետազոտության արդյունքները***», «***Եզրակացություն***»: Անհրաժեշտության դեպքում կարող են լինել նաև այլ բաժիններ՝ համապատասխան վերնագրերով:
9. Բանաձևերը ներկայացվում են առանձին տողով, մեջտեղում և համարակալվում են աջ մասում, փակագծերի մեջ: Բանաձևերը, ինչպես նաև տեքստում տեղադրվող մաթեմատիկական սիմվոլներն ու արտահայտությունները տրվում են Microsoft Equation-ով, Italic՝ 10 տառաչափով:
10. Տեքստում կարող են լինել նկարներ, գծապատկերներ, գծագրեր և աղյուսակներ: Նկարները և գծապատկերները համարակալվում են միջանցիկ համարակալմամբ՝ «**Նկ.**» նմուշառմամբ: Նկարների, գծապատկերների, գծագրերի անվանումները, նշանակումների բացատրությունները տրվում են ներքևում: Դրանք կարելի է տեղադրել ուղղաձիգ կամ հորիզոնական դիրքով՝ հայերեն՝ 9, ռուսերեն և անգլերեն՝ 10 **bold** տառաչափով: Աղյուսակները համարակալվում են միջանցիկ համարակալմամբ՝ «**Աղ.**» նմուշառմամբ: Աղյուսակների անվանումները, նշանակումների բացատրությունները տրվում են վերևում: Դրանք կարելի է տեղադրել ուղղաձիգ կամ հորիզոնական դիրքով: Եթե մեկ թերթի վրա աղյուսակը չի տեղավորվում, պետք է շարունակել մյուս թերթի վրա՝ նշելով, որ շարունակությունն է: Աղյուսակի սյունյակներում ազատ տեղեր չպետք է մնան. պետք է դնել գծիկ կամ գրել «չկա» («չի որոշված»):
11. Նկարները, գծապատկերները, գծագրերը էլեկտրոնային տարբերակով, որպես օրենք, տրվում են գունավոր տարբերակով:
12. Հոդվածի վերջում, երկու տող ներքև, ձախից՝ 10 մմ խորքից տպագրվում է «**Գրականություն**»՝ հայերեն՝ 11, ռուսերեն և անգլերեն՝ 12 **bold** տառաչափով: Մեկ տող ներքև ներկայացվում է գրականության ցանկը՝ համարակալված ըստ հղումների հերթականության: Ցանկում աղբյուրները պետք է նշվեն [...] տեսքով և ընդգրկեն՝ հեղինակի/ների/ ազգանունը և անվան /Հայրանունի/ առաջին տառը /երը/, նյութերի լրիվ անվանումը, հրատարակության տվյալները /տեղը, հրատարակչությունը, քաղաքը, տարեթիվը, հատորը, էջերը/: Տեղեկատվական պաշտոնական, այդ թվում՝ էլեկտրոնային աղբյուրների, համակարգչային ծրագրերի, հաշվետվությունների, հրահանգների, հեղինակային իրավունքի արտոնագրերի, պատենտների դեպքում ներկայացվում են լրիվ տվյալները: Աղբյուրները բերվում են բնօրինակի լեզվով: Միևնույն ժամանակ, հայերեն և ռուսերեն աղբյուրները ներկայացվում են նաև լատինատառ շարվածքով:
13. Առանձին էջերի վրա տրվում է հոդվածի գլխամասի և համառոտագրի թարգմանությունը (բացի հոդվածի ներկայացման լեզվի)՝ հայերեն, ռուսերեն (Резюме) և անգլերեն լեզուներով (Summary):
14. Հոդվածները պետք է ուղարկել info@bulletin.am էլ. հասցեով:
15. Տեքստի խմբագրված և սրբագրված տարբերակը համաձայնեցվում է հեղինակ(ներ)ի հետ:
16. Առանձին թղթի վրա տրվում է հեղինակների մասին տվյալները (Ազգանուն, Անուն, Հայրանուն (ամբողջական), լուսանկարը, գիտական աստիճանը, գիտական կոչումը, հասցեն, հեռախոսը, կազմակերպությունը, զբաղեցրած պաշտոնը, էլեկտրոնային հասցեն):

Требования, предъявляемые к оформлению авторских образцов статей

Статьи можно представить на армянском, русском и английском языках объемом до 14 страниц (статьи под рубрикой "Экономика" до 24 страниц)
Формат страницы: А4, поля сверху, снизу, справа и слева по 18 мм
Шрифт армянский - Unicode/GHEAGrapalat/, русский и английский - TimesNewRoman.
Междустрочное расстояние - 1,15

1. В верхнем правом углу страницы заглавными буквами (на языке статьи) записывается название рубруки по шрифту: армянский – 11 **bold**, русский и английский - 12 **bold**.
2. На следующей строке в верхнем левом углу страницы записывается УДК (минимум шестизначное число).
3. На следующей строке набирается заголовок статьи заглавными буквами по центру по шрифту: армянский – 12 **bold**, русский и английский - 14 **bold**.
4. Две строки ниже, слева, на языке статьи набирается фамилия и инициалы автора (соавторов, как правило, не более 4 человек) по шрифту: армянский – 11 **bold**, русский и английский - 12 **bold**.
5. На следующей строке, слева, на языке статьи курсивом (*Italic*) дается название организации (организаций) по шрифту: армянский - 9, русский и английский - 10.
6. Отделив текст горизонтальной выделенной линией, слева даются ключевые слова (5-8 слов) по шрифту: армянский - 10, русский и английский - 11.
7. Две строки ниже, на языке статьи, по центру курсивом (*Italic*) дается аннотация (10-20 строк) по шрифту: армянский - 9, русский и английский - 10.
8. Две строки ниже, дается основной текст статьи по шрифту: армянский - 10, русский и английский - 11. Абзацы начинаются с новой строки с отступом 10 мм. Рекомендуется следующая схема изложения материала: "Введение", "Постановка задачи", "Результаты исследования", "Заключение". В случае необходимости могут быть также другие разделы с соответствующими названиями.
9. Формулы располагаются отдельной строкой по центру и нумеруются в правой части в скобках. Формулы, а также математические символы и выражения приводятся по “MicrosoftEquation”, курсивом (*Italic*) по шрифту - 10.
10. В тексте могут быть рисунки, графики, чертежи и таблицы. Рисунки и графики нумеруются по порядку - "Рис.". Названия рисунков, графиков, чертежей, объяснения обозначений приводятся снизу. Их можно расположить в вертикальном или горизонтальном положении по шрифту: армянский - 9 **bold**, русский и английский - 10 **bold**. Таблицы нумеруются по порядку - "Таб.". Названия таблиц, объяснения обозначений приводятся сверху. Их можно расположить в вертикальном или горизонтальном положении. Если таблица не помещается на одной странице, нужно продолжить ее на следующей странице, отметив, что это продолжение данной таблицы. В таблице не должно быть свободных столбцов, в этом случае нужно поставить черточку или написать "нет" ("не определено").
11. Рисунки, графики и чертежи в электронной версии, как правило, приводятся в цветном варианте.
12. В конце статьи, через две строки, с отступом слева 10 мм печатается "Литература" по шрифту: армянский - 11 **bold**, русский и английский - 12 **bold**. На следующей строке приводится список использованной литературы, пронумерованный по последовательности ссылок. В списке источники должны указываться в виде [...] и включать фамилию и инициалы автора (авторов), полное название статьи (материала), данные публикации (место, издательство, город, год, том, страницы). В случае официальной информации, в том числе электронных источников, компьютерных программ, отчетов, инструкций, сертификатов об авторских правах, патентов, приводятся полные данные. Источники приводятся на языке оригинала. В то же время армянские и русские источники печатаются также латинскими буквами.
13. На отдельных листках дается перевод названия статьи, фамилии и инициалов автора (авторов), названия организации (организаций), ключевых слов и аннотации (кроме языка статьи) на армянский язык (Ամփոփում), русский язык (Резюме) и английский язык (Summary).
14. Статьи нужно отправить на почту info@bulletin.am.
15. Отредактированная версия текста согласовывается с автором (авторами).
16. На отдельном листе приводятся сведения об авторах (Фамилия, Имя, Отчество (полностью), фотография, ученая степень, ученое звание, адрес, номер телефона, организация, занимаемая должность, адрес электронной почты).

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