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## Section 1. Architecture

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### MEANS OF SIMULATING NATURAL LIGHT AND VIEW OUT IN PUBLIC AND RESIDENTIAL PREMISES

**Abstract.** Recent trends in the field of lighting indicate that natural light should be a prototype when designing high-quality artificial lighting. Basing on this tendency, the article outlines the main means of natural light and view out simulation in public and residential premises. In general, three main groups of simulation means were identified, namely: view out simulation means; natural lighting simulation means; means of simultaneous simulation of natural light and view out.

**Keywords:** simulation means, natural light, view out.

**Problem formulation.** By evolutionary development the human body is genetically predisposed to natural light (sunlight and light of the sky) [2, 889], so natural light should be a prototype when designing high-quality artificial lighting. The time from the end of the twentieth century to the beginning of the twenty-first century was characterized by the active development of new light sources (LED – light emitting diodes) and lighting materials. This tendency has led to the appearance of a number of means of simulating natural lighting in the interior design. These tools greatly enhance the qualitative characteristics of artificial lighting systems, so their detailed study is a topical task. The conclusions obtained in this study can be useful in designing light environment of modern residential and public interiors.

**Analysis of recent research and publications.** In relation to the modern stage of light architecture development, G. Kazakov notes that the current characteristic architectural theme is the interpenetration and sometimes even blurring of the

distinctions between internal and external space [6, 42]. The psychological connection with the outer space or the possibility of looking at the distance for visual comfort and prevention of fatigue is recognized as one of the most important requirements for high-quality lighting [1, 11]. Given the fact that natural light is traditionally considered to be the most favorable for a person's comfort, the number of artificial lighting installations simulating the properties of natural light is increasing. In the course of the study, the lighting equipment and systems of the following six manufacturers from different countries were analyzed: Sky Factory [7] and Artificial Sky [3] (USA), product Sunlight LED Window (USA, Australia) [8], Ewinlight (China) [5], CoeLux (Italy) [4]. During the study the author used illustrative, video and text information from sources of free access, in particular from official sites of companies, as well as technical specifications of products, which are provided by manufacturers under the subscription.

**The purpose of the article.** The main purpose of this work is to identify the main means of natural light and view out simulation in public and residential premises.

**Results.** In general, in the context of this study, three main groups of simulation means can be distinguished, namely: view out simulation means; natural lighting simulation means; means of simultaneous simulation of natural light and view out.

*The first, technologically simplest and most common means of view out simulation* consists in the inner illumination of a light-penetrated surface with high-quality color printing – a realistic image of the sky and clouds or plants – applied on it. This simulation may be exemplified by the light panels and LED light ceilings produced by Sky Factory [7]. These light panels consist of an aluminum case, high resolution photographic image printed on a semi-transparent sheet, light scattering acrylic surface, which is superimposed on this photo, LEDs as light sources that provide uniform illumination of the image at a small depth of the entire design. LED ceilings are manufactured using the same technology, but in this case polycarbonate is used as a material for the light-scattering surface. Artificial sky by the company Artificial Sky also belongs to the first simulation method [3]. It has the form of a suspended light ceiling and consists of separate light panels with LED illumination of a light-scattering surface with a photographic image.

*The second type of view out simulation* is the use of high-resolution screens built into the architectural context which play a video captured by a fixed video camera reproducing a view from a window in natural dynamics. This simulation may be exemplified by the virtual window and lighting system produced by the Sky Factory [7]. The virtual window provides an illusion of natural landscape. Its visual image, motion and sound are played back by means of a wall LED LCD that is embedded in a standard size window frame. The light system on the ceiling also contains a horizontal screen, which is embedded in a special frame.

The main *means of simulating natural lighting* is the use of artificial lighting, whose color temperature is adjusted to the color temperature of natural light. Sunlight LED Window [8], created by enthusiasts Craig Proudley and Regina Putyrae may be considered as an example of using this simulation means. This lighting system has a range of color temperature from 2200 K to 4000 K and comprises two components. The first component is an LED illuminating device in the form of a light panel that produces scattered light. The second component is a device for real-time tracking of color temperature and daylight intensity that is attached to a window and sends information received through a wireless radio frequency transmitter to the light panel, providing automatic control of color temperature and intensity of light radiation.

*The first means of simultaneous simulation of natural light and view out* is to use a virtual light ceiling with pre-programmed LED lighting, which simulates the natural dynamics of cloud motion through the playback of a corresponding video. An example of this simulation may be a product called Virtual Sky by the Artificial Sky [3], which uses white LEDs and RGB color type SMDs (surface mounting devices) to create dynamic lighting.

*The second means of simultaneous simulation of natural light and view out* comes closest to the reproduction of the natural lighting properties. It is based on the use of complex optical systems for the visual distancing of artificial sky and the illusion of the parallel character of light beams cast. The product Ewindow by the Ewinlight [5] may serve as an example of using this simulation. It visually reproduces daylight through the window spaces due to the use of a complex optical system in conjunction with LED lighting. The product looks like a light panel that simulates the clear or slightly clouded blue sky and its structure resembles a window frame and is mounted in the recesses in enclosing structures. With the light on, the panel becomes transparent, forming an illusion of three dimensions and visually distancing the blue sky.

The second example of this simulation, which is even closer to the reproduction of the illusion of natural light, is the lighting systems manufactured by CoeLux [4]. Designed for installation in suspended ceilings, these systems realistically reproduce the distribution of natural light and contain two components: cold scattered light perceived as a blue sky, and warm direct light that simulates sunshine. This effect is ensured by the use of light-diffusing panels made of special nanostructured plastic, which being only a few centimeters thick, reproduce the natural phenomenon of Rayleigh scattering (this phenomenon is the cause of the blue color of the sky in the nature). Either an LED projector (in systems that imitate both the appearance of the sun in the cloudless sky and the corresponding lighting) or LED elements (in systems simulating only sunlight in the cloudless sky) are used as light sources. Using a complex optical system, such as a light well, provides a sense of depth of the sky and an illusion of the distance between a person and the sun which is inherent in natural light. However, in existing models the artificial sun has an unchanging position and the same angle of incidence of parallel rays.

**Conclusions.** In the course of the research the means of simulation of natural light and view out in public and residential premises were determined. Consequently, the means of view out simulation include:

- inner illumination of permeable surface with the application of a realistic image of the sky and clouds or plants produced by means of high-quality color printing;
- high-resolution screens embedded in the architectural context which play a video captured by a fixed video camera, reproducing a view from a window in its natural dynamics.

The means of natural light simulation include:

- artificial lighting, the color temperature of which is adjusted to the color temperature of natural light.

The means of simultaneous simulation of natural light and view out include:

- a virtual light ceiling with pre-programmed LED lighting, which simulates the natural dynamics of clouds motion through the playback of a corresponding video;
- complex optical systems for visual separation of artificial skies and illusion of the parallel character of incident light beams.

**Prospects for further research.** In the future, it is advisable to explore each of the identified means of simulating natural light and view out in the context of harmonizing their light properties with the properties of natural light while simultaneously using them within combined lighting systems.

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## Section 2. Materials science

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### **DETERMINATION OF CR, CU, NI, ZN, MN CONTRENTATION LEVELS IN SEA WATERS BY ICP-OES**

**Abstract.** In this work we evaluated the concentration levels of heavy metals such as Cr, Cu, Ni, Zn, Mn, in the sea waters of the Vlora (Albania). The used technique was ICP-OES. The assesment of heavy metals in Vlora bay indicates the presence of slight pollution by Cr, Cu, Ni, and Mn, while the concentrations of Zn values were below the detection limit.

**Keywords:** Maritime pollution, heavy metals, water samples, Inductively Coupled Plasma Optical Emission Spectrometry.

#### **1. Introduction**

The coastline of the Vlora is increasingly attacked today by various forms of nuisance due to industrial activity and massive urbanization, resulting in an increasing extent of pollution not only from domestic sources but also from industrial ones. The coastal fringe is increasing wastewater discharge without any treatment, causing biological and physicochemical contamination of marine waters [1, 1–10].

From the hydrodynamical point of view, these waters as a part of mediterraeen sea have a flow as it shown in figure1 (Pano N. et al, 2014). Small and

medium size rivers such as Vjosa river discharge water in the Vlora bay. In short, all those specifics are expected to directly or indirectly affect the levels of concentration of metals and metalloids in the waters [2, 163–167].

In this framework, traces of the metals Cr, Cu, Ni, Zn, Mn, are considered. Metals such as Cu and Zn are components of household garbage. Based on material-flow studies, a contribution of 50–80% of these metals may come from urban sewage [3, 77–87].

It would be worthy as routine environmental study, comparative analysis regarding to other coun-

try's places measurement. The study of the maritime pollution and contamination for the Albanian Adriatic coasts is attracting the interests of many actors and agencies. Partial analysis have been undertaken in this framework as in [4, 81–89], but up now there has not been established a large-scale process of measurement, data elaboration and mapping the metals and metalloid presence in the water. Bearing in mind that the tourism is very important part of the country's economy, many researchers have been involved independently recently in the study of pollution from industrial activities as Hg for example [5, 1–5]. and the presence of metalloids in the rivers, atmosphere and in the sea water. The main objective of this study is to evaluate the presence and average

concentration total of heavy metals in the water of Vlora Bay, investigating the possible natural sources and influences of anthropogenic activities on the water quality.

## 2. Materials and Methods of Analysis

In our study, we carried out seven sampling stations at the places where we considered more affected by antropogenic sources. The measurements were realized in a calm water, during springtime. The stations were located at distance 50 m from the coastline and samplers ware taken in three vertical points along the water column: at surface and close under-surface straits at 10 cm, 60 cm largeness, and in a intermediate depth of 120 cm quote, with a horizontal Van Dorn water sampler (see figure 1).

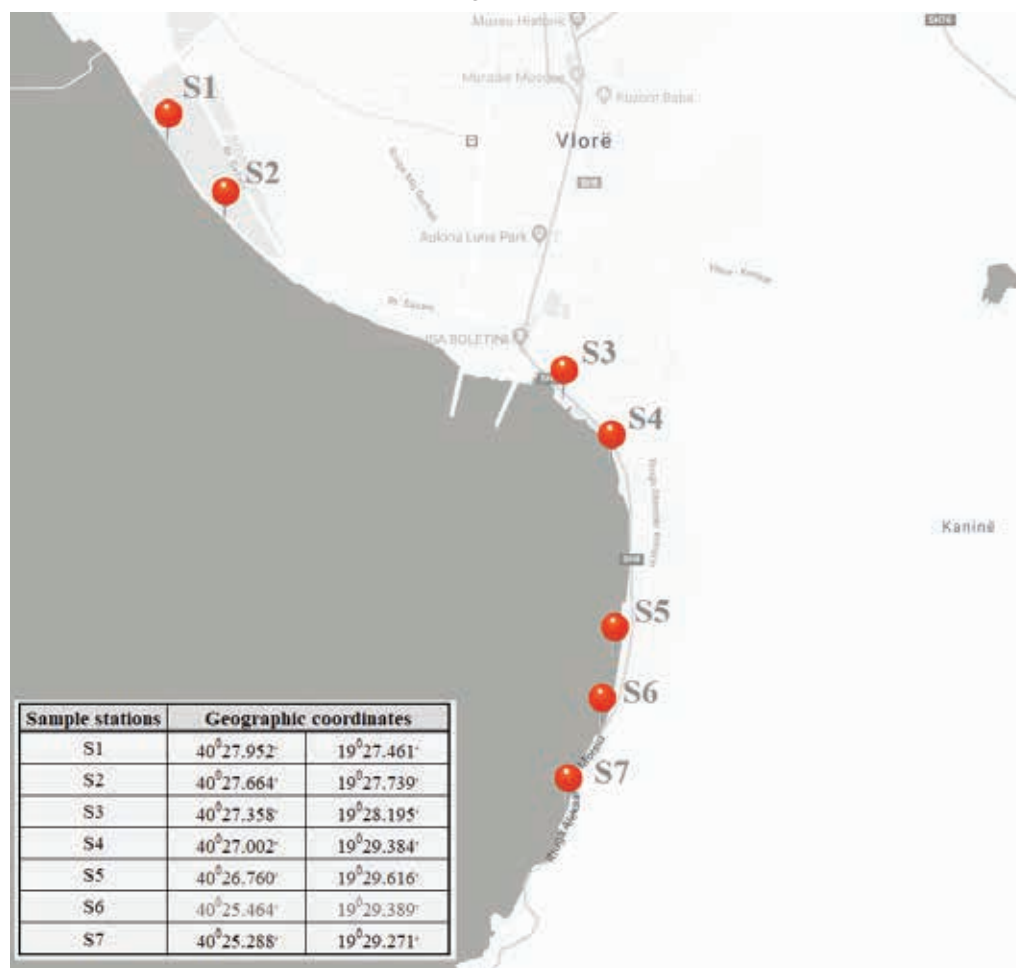


Figure 1. Positions of sampling Stations

After, we used a glass bottle, to keep it sterilized and to avoid any kind of sample contamination.

Their capacities ranging from 500 ml, previously washed with distilled water and transported at low

temperatures 4 °C in portable coolers. The conservation of the water samples was done according to the guide for the preservation and handling of samples according to ISO 5667/3 [6, 1–6]. The determination of the traces of metals is carried out by atomic emission spectroscopy with plasma coupled by induction according to standard NF EN ISO 11885. The analytical method used is described by [7, 1–9]. The analyses were performed in triplicate, the standard deviation (SD) found in the analyzes of traces in triplicate ele-

ments. The main objective of these measurements was to evaluate the way and the quantity values in which both the atmospheric pollutions and waste discharges, due to water flows, would contribute in distributions of heavy metals along the water column.

### 3. Results and Discussions

By direct analysis using ICP-OES the level of concentration of the metals Cr, Cu, Ni, Zn, Mn have been identified. Each of them shows specifics that we are referring shortly herein.

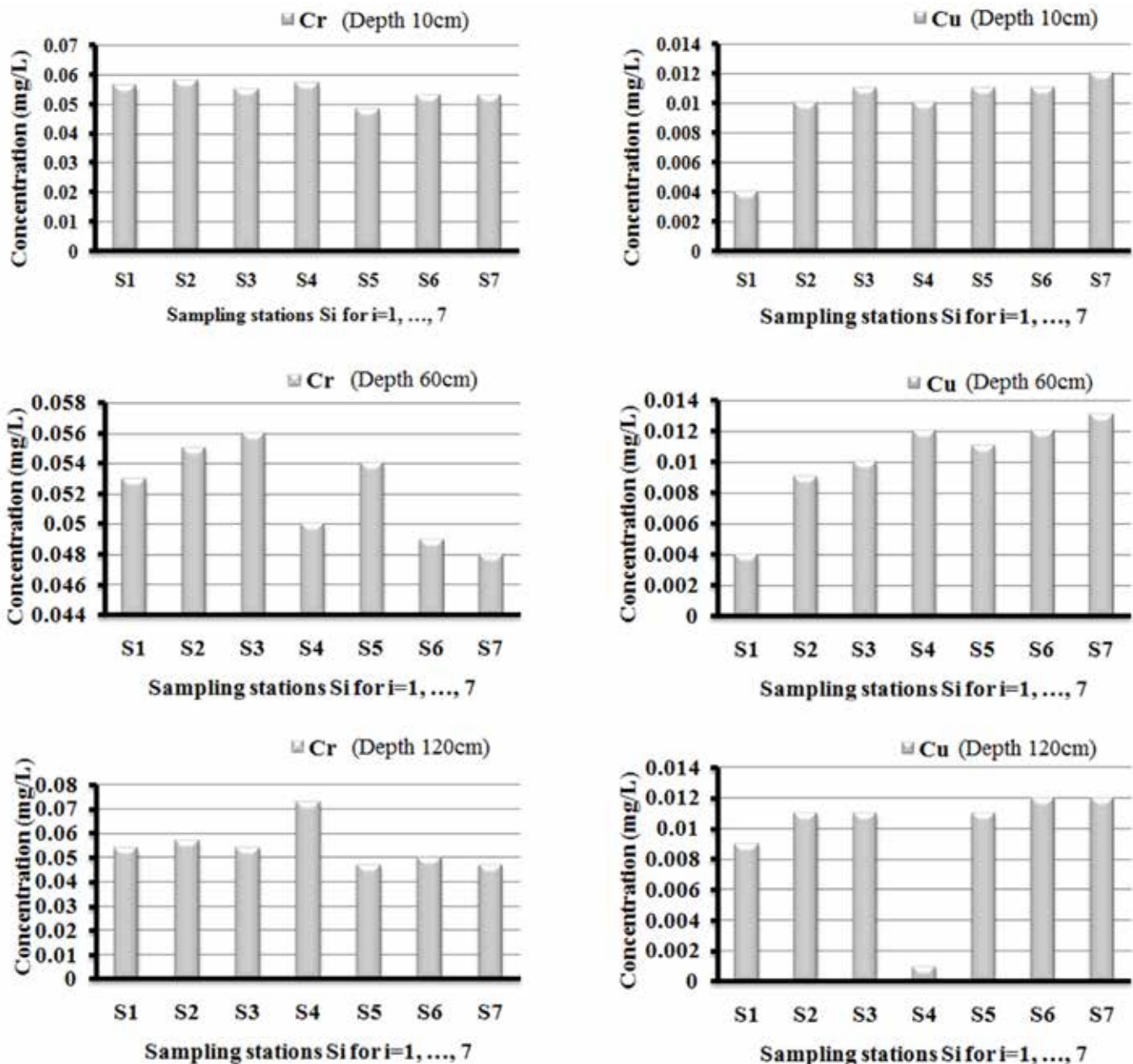


Figure 1. Cr and Cu concentrations (mg/l) in seawater column



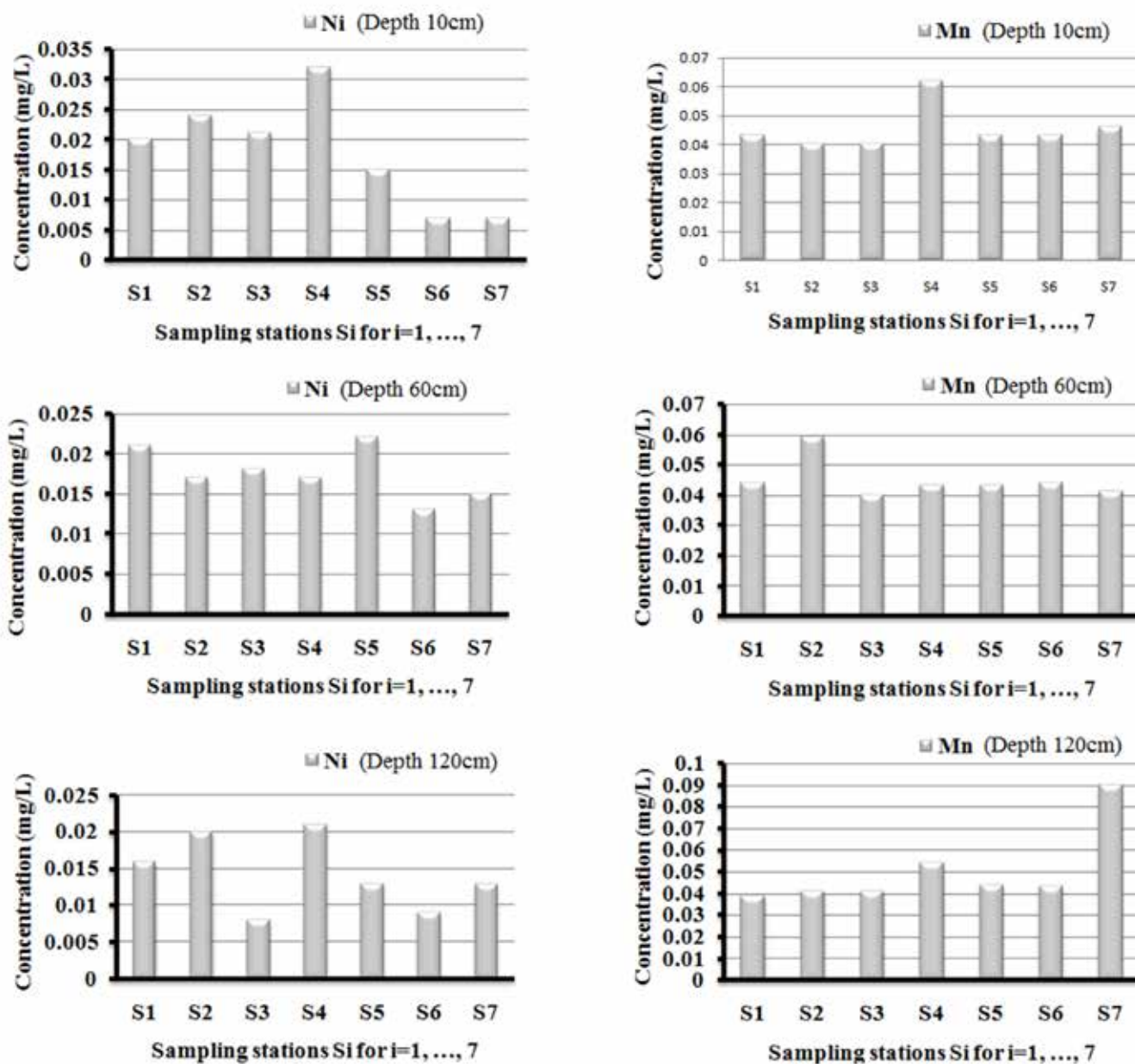


Figure 2. Ni and Mn concentrations (mg/l) in seawater column

Table 1.– Descriptive statistical data for Cr, Cu, Ni, Mn. (Depth- 10 cm)

Variable	Mean	StDev	Coef Var	Min	Q1	Median	Q3	Max	Skewness	Kurtosis
Cr	0.05429	0.00335	6.18	0.048	0.053	0.055	0.057	0.058	-1.09	1.33
Cu	0.00986	0.00267	27.11	0.004	0.01	0.011	0.011	0.012	-2.28	5.6
Ni	0.018	0.00909	50.51	0.007	0.007	0.02	0.024	0.032	0.09	-0.68
Mn	0.04529	0.00765	16.9	0.04	0.04	0.043	0.046	0.062	2.26	5.44
Zn	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>

<sup>1</sup>NDL = Non Dedection Limits

Based on descriptive analysis on table 1 (depth 10 cm) it is shown that the mean concentration value of Cu is higher than allowed limit (0.008 mg/l) [8, 1–4], where it is noticed that 75% of samples are with concentrations over 0.01 mg/l (Q1). Mean-

while the mean concentration values of Zn, Ni, Mn and Cr are below the allowed limit (Zn: 0.01mg/l, Mn: 0.05mg/l, Ni: 0.050mg/l and Cr: 0.1 mg/l) [9, 101–120]. We noticed a high value for Ni variation coefficient of 50.51%.

Table 2.– Descriptive statistical data for Cr, Cu, Ni, Mn. (Depth-60 cm)

Variable	Mean	StDev	CoefVar	Min	Q1	Median	Q3	Max	Skewness	Kurtosis
Cr	0.05214	0.00313	6.01	0.048	0.049	0.053	0.055	0.056	-0.18	-1.94
Cu	0.01014	0.00302	29.81	0.004	0.009	0.011	0.012	0.013	-1.66	3.07
Ni	0.01757	0.00315	17.95	0.013	0.015	0.017	0.021	0.022	0.11	-0.67
Mn	0.04486	0.00641	14.3	0.04	0.041	0.043	0.044	0.059	2.34	5.85
Zn	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>

<sup>1</sup>NDL = Non Dedection Limits

Based on descriptive analysis on table 2 (depth 60cm) it is shown that the mean concentration value of Cu is higher than allowed limit (0.008 mg/l) [8, 1–4], where it is noticed that 75% of samples are with concentrations over 0.009 mg/l (Q1). Meanwhile the mean concentration values of Zn, Ni, Mn

and Cr are below the allowed limit (Zn: 0.01mg/l, Ni: 0.050mg/l, Cr: 0.001 and Mn :0.050mg/l–except for S2 station with a value 0.059 mg/l) [9, 101–120]. We noticed a high value for Cu variation coefficient of 29.81% which shows a high level of heterogeneity which shows a high level of heterogeneity.

Table 3.– Descriptive statistical data for Cr, Cu, Ni, Mn. (Depth-120 cm)

Variable	Mean	StDev	CoefVar	Min	Q1	Median	Q3	Max	Skewness	Kurtosis
Cr	0.05457	0.00896	16.42	0.047	0.047	0.054	0.057	0.073	1.72	3.46
Cu	0.00957	0.00391	40.85	0.001	0.009	0.011	0.012	0.012	-2.31	5.54
Ni	0.01429	0.00502	35.17	0.008	0.009	0.013	0.02	0.021	0.17	-1.4
Mn	0.05029	0.01818	36.16	0.039	0.041	0.043	0.054	0.09	2.29	5.38
Zn	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>	NDL <sup>1</sup>

<sup>1</sup>NDL = Non Dedection Limits

The zinc: The mean values of zinc found in samples of seawater are under the detection limit of < 0.2ppb. So our results are still below the norm [10, 1–2].

Based on descriptive analysis on table 3 (depth 120 cm) it is shown that again the mean concentration value of Cu is higher than allowed limit (0.008 mg/l) [8, 1–4], where it is noticed that 75% of samples are with concentrations over 0.009 mg/l (Q1). Meanwhile the mean concentration values of Zn, Ni and Cr are below the allowed limit (Zn: 0.01mg/l, Ni: 0.050mg/l and Cr: 0.001)

[9, 101–120]. 25% of the concentrations of analyzed samples for Mn are below the allowed limit (Q3 = 0.054 mg/l). We noticed a high value for Cu variation coefficient of 40,85% which shows again a high level of heterogeneity which shows a high level of heterogeneity.

#### 4. Conclusion

Marine pollution is a serious problem, especially in countries in the process of industrialization like Albania. With the absence of stations and sewage treatment systems in these countries, wastewater is

discharged into the sea without any prior treatment, leading to degradation of the sanitary quality of coastal waters and disruption of marine ecosystems.

The assessment of heavy metals in Vlora bay indicates the presence of slight pollution by Cr, Cu, Ni, and Mn, while the concentrations of Zn values were below the detection limit. According to water column we noticed a heterogenic distri-

bution. These levels of concentrations may derive from atmosphere pollution as well as anthropogenic sources. Despite the low levels at the study period, longterm exposure will increase the total metal content over the allows limit and will alter aquatic life. An immediate improvement could be a prior treatment of urban waste, mainly wastewater according to the standards.

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## Section 3. Medical science

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### INVESTIGATION OF THE GENOTOXICITY OF NEW DRUG “BAKAGIN” FROM THE PAROTID SECRETES CENTRAL ASIAN GREEN TOAD *BUFO VIRIDIS LAUR*

**Abstract.** The effect of the new pharmacological preparate of “Bakagin”, isolated from the Central Asian green toad *Bufo viridis Laur* parotid, to induction of chromosomal aberrations in mammalian cells was studied in the following tests: *In vivo* cytogenetic test for chromosomal aberrations in the mice bone marrow cells; *In vivo* cytogenetic test for micronuclei in polychromatophilic erythrocytes of mouse bone marrow, and *in vitro* cytogenetic test for chromosomal aberrations in human peripheral blood lymphocytes.

It is shown that preparate “Bakagin” at concentrations of 0.093; 1.4 and 2.8 mg/ml *in vivo* tests has not genotoxicity to induction of chromosomal aberrations in bone marrow cells. Also, preparate *in vitro* tests at concentrations of 0.8–3.2 mg/ml has not genotoxicity to the MN (micronucleus) in the PCE (polychromatophilic erythrocytes) of bone marrow and in the test for the induction of chromosomal aberrations in human peripheral lymphocyte culture.

**Keywords:** Bufadienolides, bakagin, genotoxicity, mutagenicity, carcinogenicity, chromosomes, cytogenetic test, aberration, micronuclei, polychromatophilic, lymphocytes, cytostatics, translocation, polyploidy, karyotype, hypotonization.

It is known that drugs along with their basic properties may have genotoxic potency, namely, mutagenic and carcinogenic activities. Identification of such a negative effect of drugs has become necessary part of a pre-clinical study for safety of drug use in the world and is recommended by the internationally agreed Harmonized trilateral guidelines for testing genotoxicity (European Union, Japan and the USA) [1; 2].

In this work it is investigating the pharmacological drug of Bakagin, consisted sum of bufadienolides isolated from the Central Asian green toad *Bufo viridis Laur* venom. The preparate is recommended for the treatment of acute and chronic cardiovascular diseases of II and III degree, caused by rheumatic heart disease, atherosclerotic cardiosclerosis, hypertension and other conditions, requiring use the cardiac glycosides.



According to international recommendations [1; 2], the main method for assessing the genotoxicity of pharmacological preparations is cytogenetic *in vivo* analysis of mammalian bone marrow cells. The study of the genotoxicity of chemical compounds in chromosomal aberrations in the bone marrow of small rodents is generally accepted, reliable, more informative and most accessible method, since it allow to explore the full range of structural and quantitative damage of chromosomes [3].

The main aim of this work is to identify in the pharmacological drug "Bakagin" ability to induce chromosomal abnormalities in mammalian cells by the following tests:

- Cytogenetic *in vivo* test for chromosomal aberrations in the mice bone marrow cells;
- Cytogenetic *in vivo* test for micronucleus in the mice bone marrow polychromatophilic erythrocytes;
- Cytogenetic *in vitro* test for chromosomal aberrations in human peripheral blood lymphocytes.

### Experimental

#### Chromosomal aberration induction *in vivo* test in mouse bone marrow cells

The study of the genotoxicity of "Bakagin" preparation was carried out in male mice with mass of  $18 \pm 2.0$ g, 6 animals per group. Mice were kept in the vivarium of the Institute of Bioorganic Chemistry, Academy of Sciences Republic of Uzbekistan with 12-hour light mode, free access to food and water. The basic rules of maintenance and care were according to the standards given in the manual [4] and by Good Laboratory Practice. The drug is injected intra-peritoneal according to general accepted methods at doses of 0.093 mg/kg; 1.4 mg/kg and 2.8 mg/kg for 5 days. For control mice were injected physiological solution. As a positive control cytostatic Cyclophosphamide once in a dose of 20 mg/kg intra-peritoneal is injected. Mice were sacrificed 26 hours after injection of Cyclophosphamide [5; 6].

Last day of the experiment, 2 hours before slaughter, mice of all groups were intra-peritoneal injected with 0.2 ml of a 0.025% Colchicine. The bone marrow was removed from the tibia bones by washing it with RPMI-1640 nutrient medium and fetal calf serum, and to maintain cell viability placed to thermostat for 37°C. After centrifuge the cell suspension was removed and remaining cells were hypotonized with a potassium chloride solution. Cells were fixed using a mixture of methanol and glacial acetic acid. Further, preparations were prepared from cell suspension and in the Motic BA210 microscope (at  $100 \times 10$  magnifications) chromosome damage on metaphase cells were analysed. For each drug dose the number of studied metaphases was not less than 600.

As cytogenetic indices were distinguished and counted:

1. Chromosomal aberrations: paired fragments, paired micro fragments, symmetrical and asymmetrical translocations;
2. Chromatid aberrations: single fragments, single micro fragments, symmetrical and asymmetrical translocations;
3. Changes in the number of chromosomes: aneuploidy, polyploidy.

Taking into account the possibility of artefacts, associated with the drug preparation specifics, cells with aneuploidy were not taken into account, from the nature of chromosome damage analysis genes (achromatic gaps) were excluded.

Statistical processing of obtained data was performed with the calculation of  $\chi^2$  with the Yates J., correction for small numbers and p values. Results were considered statistically significant at  $p < 0.05$  [5].

#### Micronucleus *in vivo* test for mice bone marrow polychromatophilic erythrocytes

The study of micronucleus (MN) in polychromatophilic erythrocytes (PCE) is a convenient model, since firstly, these cells do not contain their own nucleus and MN are well-visualized structures of the cytoplasm; secondly, the maturation time of PCE is



about 24 hours and the influence of genotoxic drugs can be clearly differentiated from previous violations: the discover of micronucleus in NHE are formed before the start of the experiment, they are not taken into account, whereas the micronucleus in PCE are formed under influence of studied drugs (Fig. 1).

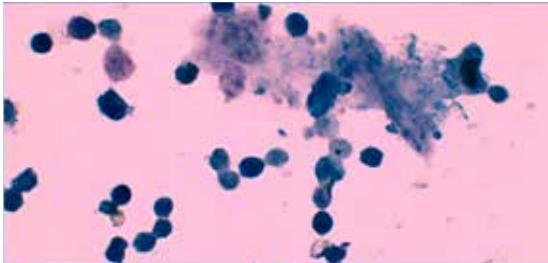


Figure 1. Micrograph of a micronucleus in a polychromatophilic erythrocyte

Studies have been carried out on male white outbred mice aged 8–9 weeks. Bakagin was intra-peritoneal injected into mice at doses of 0.093 mg/kg; 1.4 mg/kg and 2.8 mg/kg, daily for 5 days, 6 mice were taken in each group. A physiological solution is used as a negative control, the volume of injected solution was 0.2–0.3 ml depending on the body mass of mice, and the solution was injected for 5 days. As an inducer of genotoxic effect (positive control), cytostatic Cyclophosphamide at a dose of 20 mg/kg is used, immediately injected once intra-peritoneal after dilution by water for injection. The slaughter of mice was carried out 28 hours after injection of Cyclophosphamide. After the slaughter in all experimental and control variants, bone marrow was isolated from 2 femoral bones from each mouse and placed in 0.5 ml of Fetal calf serum. After that suspension is centrifuged for 10 min at 1000 rpm, supernatant removed, precipitate is re-dissolved and applied to glass slides. The smears were left to dry for overnight. The glasses were fixed in 96% ethanol for 5 minutes. The staining of glasses was performed with 5% Gimsa. Further, for differentiate PCE from NHE, glass was clarified with 0.001% citric acid. Microscopic analysis of glasses were done at a magnification of  $10 \times 100$  using a Motic light microscope with an integrated video camera (EU).

For each experimental variant, the ratio of PCE / (PCE + NHE) was determined and compared with the indicator in the control [7]. In the absence of statistically significant differences in the amount of PCE and NCE from control (at  $p > 0.05$ ), more than 1000 PCE were calculated for each animal and the number of MN was determined, with further calculation of the mean value (M) and standard deviation (s) in the group. Statistical data processing was performed by Student's t-test at a significance level of  $p < 0.05$ .

#### ***In vitro* test for inducing chromosomal aberrations in human peripheral blood lymphocytes**

**Cultivation of lymphocytes:** Human lymphocytes as a model object have a number of advantages: the availability of obtaining material; mass cell population; the natural initial synchrony of the lymphocyte population, since they are in the peripheral blood in the  $G_0$  – phase; possibility of stimulation of lymphocytes with phytohemagglutinin; human karyotype knowledge ( $2n = 46$ ). (Fig. 2)



Figure 2. Normal karyotype of human peripheral blood lymphocytes,  $2n = 46$

These features of lymphocyte culture cells give the reason to use them as a model object in the study of pharmacological drugs [8; 9].

The peripheral blood lymphocytes of healthy donors were cultured according to the Hungerford method [10]. After thorough treatment of donor skin with 70% ethanol, blood from the cubital vein was taken, then placed in a tube containing heparin (20 U/ml blood). Cultivation was performed in a sterile box. Samples of heparinized whole blood under sterile conditions were poured over 0.8 ml into culture

medium vials. The composition of culture medium: RPMI 1640 medium with Glutamine (Russia); fetal calf serum (Russia); Gentamicin, Phitoheмоagglutinin (Russia). In to the blood medium concentration of 0.8; 1.6; 3.2;  $\mu\text{g}/\text{ml}$  was added Bakagin and as a control physiological solution is used. The vials were placed in to thermostat at  $37^\circ\text{C}$  for incubation of cells before fixation, for 54, 60, 66, 72 hours, while the cells were exposed to the drug at all phases of the first mitosis cell cycle, then the culture medium with Bakagin was replaced with fresh medium without Bakagin. Into culture medium 1.5 hours before fixation was injected Colchicine ( $0.4 \mu\text{g}/\text{ml}$ ), which destroy the microtubules of spindle division and prevents to diverging of chromosomes, and therefore, the cells stop at the stage of mitosis metaphase.

**Hypotonization of cells:** After the end of cultivation, the cell culture centrifuged at 1000 rpm for 7 minutes, supernatant was removed using water pump, preheated at  $37^\circ\text{C}$  a hypotonic solution of potassium chloride ( $0.75 \text{ M}$ ) was added and obtained precipitate re-suspended. Further, the cell culture tubes were kept in a water bath at ( $37^\circ\text{C}$  for 15 min. At the end of hypotonization, the tubes again centrifuged under the same conditions and supernatant is removed.

**Cell fixation:** Cells were fixed at 4 time points: 54, 60, 66, 72 hours after the start of cultivation. For cell fixation, the precipitate was re-suspended in 1–1.5 ml of freshly prepared fixative (mixture of methanol and glacial acetic acid in a ratio 3:1) and its volume was adjusted to 10 ml, then the tubes were kept for 20 min at  $4^\circ\text{C}$ . The change of the clamp with subsequent centrifugation was performed three times.

### Preparation of chromosome preparations:

The preparations were prepared immediately after fixing. The cell suspension was excavated onto pre-cooled slides moistened with distilled water. After drying, the preparations were stained according to Romanovsky-Giemsa. For each drug concentration of Bakagin analysed at least 600 metaphases.

Cytogenetic analysis of metaphase plates was performed on a Motic BA210 light microscope, under immersion with an increase of  $100 \times 10$ . The selection of metaphase plates for cytogenetic analysis, classification and counting of chromosomal aberrations was carried out according to the generally accepted method.

Statistical processing of obtained data was performed with the calculation of  $\chi^2$  with the Yeats correction for small numbers and p values. Results were considered statistically significant at  $p < 0.05$  [5].

### Results and discussion

#### Results of chromosomal aberration induction *in vivo* test in mouse bone marrow cells

The results of mutagenic activity of Bakagin in various doses showed that with the studied doses drug did not induce a statistically significant dose-dependent increase of the number of aberrations, i.e., the number of microscopically detected chromosomal aberrations in the experimental variants remain at the level of the control. The aberrations detected in the control and in all doses of drug were in the nature of single and pair chromosome breaks in bone marrow cells. In the control and experiments, no aberrations of exchange were found, as well as a deviation number of chromosomes against to norm.

Table 1. – The frequency of chromosome aberrations in the mice bone marrow cells by *in vivo* action of Bakagin

Indicators	Physiolo-gi-cal solution	Dose of Bakagin (mg/kg)			Cyclophos phamide, (20 mg/kg)
		0.093	1.4	2.8	
1	2	3	4	5	6
Number of studied meta-phase	600	600	600	600	600

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	
The number of metaphases with rearrangements	4	3 ( $\chi^2 = 0.000$ . p = 1.000)	5 ( $\chi^2 = 0.000$ . p = 1.000)	4 ( $\chi^2 = 0.126$ . p = 0.723)	74 ( $\chi^2 = 65.282$ . p < 0.001)	
Share meta-phases with restructuring, %	Total	0.6%	0.5%	0.8%	0.6%	12.3% (n = 74)
	Single fragments	0.5%	0.2%	0.5%	0.3%	3.6% (n = 22) ( $\chi^2 = 13.236$ . p < 0.001)
	Double fragments	0.1%	0.3%	0.3%	0.3%	1.3% (n = 8) ( $\chi^2 = 4.030$ . p < 0.045)
Exchange aberrations, %	–	–	–	–	7.3% (n = 44) ( $\chi^2 = 43.622$ . p < 0.001)	
Chromosome number change, %	–	–	–	–	–	

A number of microscopically detected chromosomal aberrations in all concentrations (between 0.093–2.8 mg/kg) remain in the level of control, without statistically significant differences (p > 0.05) (see Table 1).

Cyclophosphamide in a dose of 20 mg/kg, used as a positive control, induced a statistically significant increase the number of chromosomal aberrations in the mice bone marrow cells relative to the negative control (P < 0.001).

Thus, it can be concluded that “Bakagin” drug in the used concentrations (0.093 mg/kg; 1.4 mg/kg; and 2.8 mg/ml) and within the sensitivity of the meth-

od for the induction of chromosomal aberrations in bone marrow cells *in vivo* has not genotoxicity.

#### Results of micronucleus *in vivo* test for mice bone marrow polychromatophilic erythrocytes

Polychromatophilic erythrocytes are defined on the glass as small rounded, nucleus-free cells of a bluish-gray colour with a delicate net in the cytoplasm. In contrast, normochromatophilic erythrocytes have a gently pink colour due to discoloration with citric acid, which removes the dye from DNA and RNA-free cells. Micronucleus in PCE and NHE are defined as clear rounded purple formations inside of cytoplasm.

Table 2. – The frequency of micronucleus in PCE of mice bone marrow under action of “Bakagin”

<b>Group</b>	<b>Number of mature red blood cells. M ± s</b>	<b>Number of PCE. M ± s</b>	<b>Number of PCE with MN. M ± s</b>	<b>Number of PCE with MN1000 PCE. M ± s</b>	<b>Proportion of PCE to all erythrocytes. % M ± s</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
Negative control	1480.8 ± 12.08	1149.8 ± 8.03	5.3 ± 0.6	4.6 ± 0.6	43.71 ± 1.28
Bakagin, 0.093 mg/kg	1551.3 ± 12.42	1174.2 ± 10.57	5.8 ± 0.5	4.9 ± 0.5 (p = 0.972)	43.08 ± 1.25 (p > 0.05)
Bakagin, 1.4 mg/kg	1633.3 ± 12.30	1291.0 ± 11.52	6.0 ± 0.6	4.6 ± 0.5 (p = 0.847)	44.10 ± 1.22 (p > 0.05)

1	2	3	4	5	6
Bakagin, 2.8 mg/kg	1636.0 ± 13.81	1246.3 ± 10.3	5.6 ± 0.5	4.5 ± 0.5 (p = 0.893)	43.23 ± 1.22 (p > 0.05)
Cyclophos- pha-mide, 20 mg/kg	1628.0 ± 11.12	1222.5 ± 11.8	50.3 ± 1.4	41.1 ± 1.4 (p < 0.001)	42.88 ± 1.23 (p > 0.05)

The study was carried out in doses of Bakagin 0.093 mg/kg; 1.4 mg/kg and 2.8 mg/kg. In the doses used, the appearance of micronucleus in polychromatophilic erythrocytes was observed in insignificant amounts. A number of microscopically detected micronucleus in all investigated concentrations of "Bakagin" (between 0.093–2.8 mg/kg) remains at the control level, without statistically significant differences (see Table 2).

Cytostatic antitumor drug Cyclophosphamide was used as a positive control. In a dose of 20 mg/kg, it led to appear statistically significantly large number of MN in PCE of mice bone marrow against to control (P < 0.001).

Thus, "Bakagin" in studied doses in vivo conditions polychromatophil erythrocytes of mice bone marrow did not lead to increase the yield of micronucleus. Preparate did not show genotoxicity in the test for MN in PCE of the bone marrow within the sensitivity of method.

#### Results for *in vitro* test to inducing chromosomal aberrations in human peripheral blood lymphocytes

To establish mutagenic activity of the "Bakagin", the peripheral blood lymphocytes of healthy donors *in vitro* were used (see Table 3).

Table 3.– The frequency of structural mutations of chromosomes in human peripheral blood lymphocytes by influence of Bakagin

Indicators	Control	Dose of Bakagin. µg/ml per 1 culture			Cyclophos-phamide µg/ml per 1 culture	
		0.8	1.6	3.2	20 µg/ml	
1	2	3	4	5	6	
Number of studied meta- phases	525	536	521	531	529	
Number of metaphases with rearrangements	2	3 ( $\chi^2 = 0.23$ ; P = 0.630)	2 ( $\chi^2 = 0.24$ ; P = 0.623)	2 ( $\chi^2 = 0.24$ ; P = 0.625)	17 (3.21%) ( $\chi^2 = 10.397$ ; P = 0.002)	
Number of rearrange- ments	2	3	2	2	22	
Share rear- range-ments	Total	0.38	0.56	0.38	0.37	22 (4.15%) ( $\chi^2 = 15.245$ ; P < 0.002)
	Single frag- ments	0.19	0.37	0.38	0.18	4 (0.75%) ( $\chi^2 = 0.789$ ; P = 0.375)
	Double fragments	0.19	0.18	–	0.18	11 (2.08%) ( $\chi^2 = 6.759$ ; P = 0.010)



<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
Exchange aberration	–	–	–	–	7(1.32%) ( $\chi^2 = 5.32$ ; P = 0.024)
Chromosome number change	–	–	–	–	–

The results of mutagenic activity evaluation for Bakagin by the tests for induction of chromosomal aberrations in a culture of human peripheral blood lymphocytes in several concentrations showed that the drug did not induce a statistically significant dose-dependent increase in the number of chromosome aberrations. The number of microscopically detected chromosomal aberrations in the experimental variants remains at the control level. Microscopically detected aberrations, both in the control and experiments, were characterized as single and pair breaks. Both in the control and experiments, no aberrations for exchange nature were found, as well as deviation of the number of chromosomes from the norm, which indicates the absence of genomic mutations.

The number of microscopically detected chromosomal aberrations in all doses of drug (between 0.8–3.2  $\mu\text{g}/\text{ml}$ ) without statistically significant differences ( $p > 0.05$ ) remain at the control level.

Cyclophosphamide, used as a positive control, relative to the negative control ( $p = 0.002$ ) induced a statistically significant increase in the number of chromosomal aberrations in human peripheral blood lymphocytes.

Thus, Bakagin *in vitro* tests in concentrations (between 0.8–3.2  $\mu\text{g}/\text{ml}$ ) and within the sensitivity of the method used did not show genotoxicity for the induction of chromosomal aberrations in human peripheral blood lymphocyte culture.

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## **ARTERIOGENIC ERECTILE DYSFUNCTION AND INFRA-RED RADIATION**

**Abstract.** The article provides survey of bibliography related of diagnosis of erectile dysfunction. In particular, interaction of interagency range infra-red radiation with biological objects of various complexity has been considered. That effects of terahertz range infra red waves in biological systems is possible on molecular, cell and system level of regulation.

**Keywords:** erectile dysfunction, diagnosis, endothelial dysfunction, terahertz range infra-red radiation.

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## **АРТЕРИОГЕННАЯ ЭРЕКТИЛЬНАЯ ДИСФУНКЦИЯ И ИНФРАКРАСНОЕ ИЗЛУЧЕНИЕ**

**Аннотация.** В данной статье изложены современные данные литературы, касающиеся диагностики артериогенной эректильной дисфункции. Затронуты вопросы взаимодействия инфракрасного излучения терагерцового диапазона с биообъектами различной сложности реализации. Реализация эффекта инфракрасных волн терагерцового диапазона в биосистемах возможна на молекулярном, клеточном и системном уровнях регуляции.

**Ключевые слова:** эректильная дисфункция, диагностика, эндотелиальная дисфункция, инфракрасное излучение терагерцового диапазона.

Артериогенная эректильная дисфункция (ЭД) развивается вследствие нарушения притока артериальной крови к кавернозным артериям и кавернозным телам [1]. Имеются многочисленные аргументированные данные о том, что в основе артериогенной ЭД лежит не органическое, а функционально обратимое поражение артерий – эндо-

телиальная дисфункция (ЭнД). В настоящее время ЭнД рассматривают в качестве функциональной стадии развития атеросклероза [2–4].

Впервые состояние ЭнД коронарных артерий исследовал Ludmer P. L. и соавт. (1986) до и после интракоронарного введения ацетилхолина. Данная методика ограничивается инвазивностью,

технической сложностью и высокой стоимостью. В 1992 г. Celermajer D. S. и соавт. впервые описали метод неинвазивной оценки эндотелиальной функции плечевой и бедренной артерий.

Необходимо отметить, что Энд не ограничивается коронарными артериями, а является системным нарушением, которая поражает все сосудистые русла [7]. Состояние системной эндотелиальной функции у пациентов с ЭД впервые изучил Kaiser D. R. и соавт. (2004). Авторы сделали вывод, что артериогенную ЭД можно рассматривать в качестве клинического маркера, указывающего на присутствие системного сосудистого поражения.

Virag R. (2002), впервые использовал методу посткомпрессионных изменений диаметра кавернозных артерий с целью оценки эндотелиальной функции. Virag и соавт. (2004) пришли к заключению, что в патогенезе органической ЭД важное значение имеет нарушение функции эндотелия кавернозных артерий.

Основным методом диагностики артериогенной ЭД на современном этапе является доплерография кавернозных артерий полового члена после интракавернозного введения вазоактивных препаратов – фармакодуплерография (ФДГ) [11]. Этот метод имеет ряд недостатков – боль и страх больного перед инъекцией в половой член, что может снизить диагностическую ценность получаемых результатов. Часть перечисленных недостатков лишена методика доплерографии сосудов полового члена после приема ингибиторов 5-фосфодиэстеразы [12; 13]. Однако результаты данного исследования в большей степени зависят от степени сексуального возбуждения пациента. Необходимо отметить и высокую стоимость подобного исследования [14], и длительность (по времени) обследования.

Технически трудновыполнимым порой является и посткомпрессионный метод оценки Энд кавернозных артерий [15].

Таким образом, используемые методы диагностики артериогенной ЭД (компрессия, стимуляция

лекарственными препаратами – per os, интракавернозная инъекция, артериография, ФДГ) не физиологичны по своей сути, инвазивны и технически сложны по исполнению. Комбинация методик с применением аудиовизуальной сексуальной стимуляцией повышает диагностическую ценность [16] в определении эндотелиальной функции кавернозных артерий, однако в целом точность результатов остается неудовлетворительной.

Иное дело – инфракрасное (ИК) излучение, а именно его дальний диапазон.

ИК – излучение, лежащее в спектральном диапазоне излучения от 3,5 мкм до 56 мкм играет важнейшую роль в жизнедеятельности и развитии человеческих клеток.

Установлено, что рассматриваемый диапазон электромагнитных волн используется живыми организмами для связи и управления, при этом сами живые организмы излучают колебания миллиметрового диапазона [17; 18]. Волны, возбуждаемые в организме при воздействии на него ИК излучения дальнего диапазона, в известной мере имитируют сигналы внутренней связи и управления (информационные связи) биологических объектов. В результате восстанавливается нормальное по спектру и мощности излучение, свойственное здоровому организму [17; 19]. Таким образом, представленный диапазон частот качественно не изменяет организм, но может отрегулировать, нормализовать его функциональное состояние в пределах, присущих данному биологическому виду [20; 21].

Каждая живая клетка является одновременно и излучателем, и приёмником электромагнитных волн определённой частоты. Система управления в организме зависит от того, каким образом живые клетки обмениваются этими волновыми сигналами. На клеточном уровне сигнал от любой здоровой клетки всегда один и тот же по частоте.

Больные клетки органов такие сигналы продуцируют разными показателями по амплитуде, фазе и частоте и, которые, по своим физическим характеристикам, зависят от множества факторов.

Терагерцовый ИК диапазон частот электромагнитных волн располагается в шкале электромагнитных волн между микроволнами и оптическим инфракрасным диапазонами (рис. 1) и интересен, прежде всего, тем, что именно

в нем находятся молекулярные спектры излучения и поглощения (МСИП) различных клеточных метаболитов (NO – оксид азота, CO – оксид углерода, активные формы кислорода и др.) [22–26].



Рисунок 1. Спектр электромагнитного излучения

Совершенно закономерно наибольший интерес вызывает электромагнитное излучение на частотах молекулярного спектра NO, который является не только универсальным регулятором физиологических и метаболических процессов в отдельной клетке и в организме в целом, но и осуществляет межклеточные взаимодействия, функционируя как сигнальная молекула практически во всех органах и тканях человека и животных [27–34].

NO является нейромедиатором, вазодилататором, мощным фактором гемостаза и антиагрегантом [29,30,32–34].

Как было отмечено ранее, спектральный диапазон ИК-излучения

(длина волн 3,5–56 мкм) играет важнейшую роль в жизнедеятельности и развитии клеток, поэтому особенно важно изучение механизмов влияния ИК-излучения на процессы энергетического обмена в клетках, которые основаны на биохимических реакциях катаболизма и анаболизма.

Было обнаружено, что облучение организма ИК-излучением энергией  $0,02 \div 0,3$  эВ приводит к активации анаболических процессов и процессов транспорта в клетке. В частности, усиливают-

ся синтез белка, захват кислорода на ион железа в гемоглобине и миоглобине, перенос ионов металлов через клеточные мембраны [35].

ИК-излучение в терагерцевом диапазоне вызывают повышение продукции оксида азота эндотелием сосудов, что сопровождается нормализацией сниженной базальной и индуцированной вазодилатирующей его активности у животных в состоянии острого иммобилизационного стресса [36]. Курс облучения терагерцевыми волнами у животных при длительном стрессе вызывает повышение концентрации нитритов – стабильных метаболитов NO [37] и [38] снижение концентрации эндотелина I в сыворотке крови, способствуя нормализации баланса продукции вазоконстрикторных и вазодилататорных веществ эндотелием, то есть препятствует развитию эндотелиальной дисфункции.

По мнению ряда современных авторов, при облучении ИК-излучения терагерцового диапазона может не только возрастать синтез эндогенного NO и повышаться его реакционная способность, но и увеличиваться продолжительность существования NO в клетках [39].

Таким образом, ИК-излучение дальнего диапазона, соответствующее собственному излучению человека (рис. 2), оказывает естественное влияние на клетки и ткани организма, что не противоречит физиологии клеток и тканей, следовательно процессы анаболизма и катаболизма протекают согласно установленным законам, баланс энергообмена в клетках не нарушен.

При однократном воздействии узкоспектрального дальнего ИК-излучения на клетки или ткань,

восстановить нарушенный энергообмен невозможно, что будет регистрироваться определенными параметрами. При отсутствии нарушений в энергообмене, регистрируемые параметры будут соответствовать показателям нормы.

Вышеуказанные аргументированные данные, позволяют утверждать, что ИК-излучение дальнего диапазона может быть использовано для диагностики и лечения эндотелиальной дисфункции кавернозных артерий.

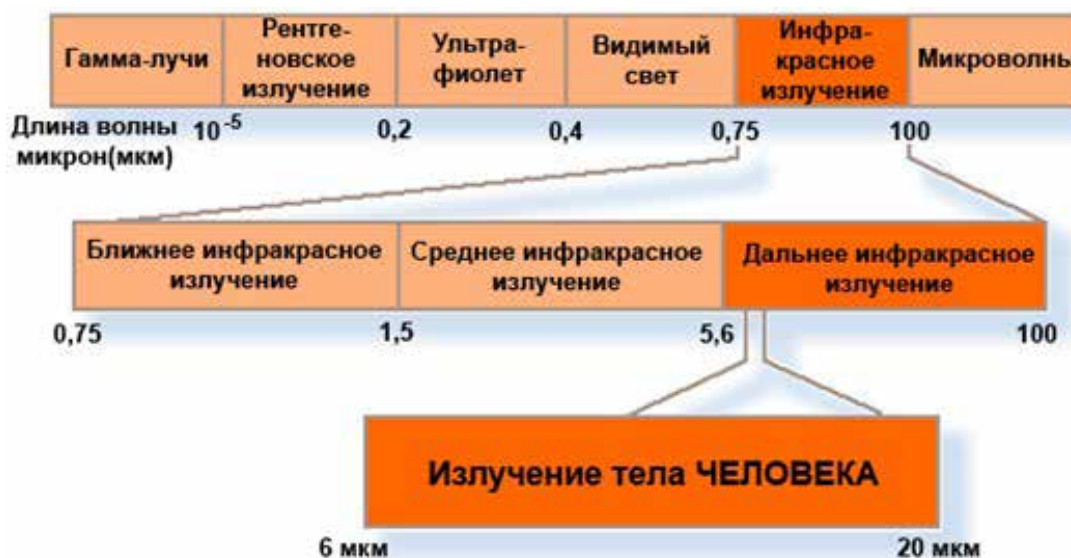


Рисунок 2. Диапазон излучения тела человека

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## Section 4. Agricultural sciences

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### CURRENT STATE AND GEOGRAPHIC DISTRIBUTION OF WATER SOURCES KARIZ

**Abstract.** The article systematizes the materials on the geography of distribution, history and current state of the ancient sources of water kyariz. It is established that the kyarizes were first built 3,000 years ago and they have spread to more than 40 countries. Ancient kyarizes were first built in Iran and Azerbaijan, and then spread throughout the world. Kyarizes are unique underground structures and historical monuments, and therefore in 2007 kyarizes are included in the UNESCO world heritage List. However, due to a number of reasons, in particular due to careless attitude to them, the use of modern water intakes, etc. the number of operating kyarizes decreases from year to year. At the beginning of the last century, there were more than 1.500 kyarizes in Azerbaijan, but now their number is about 382. Performance kariz compared with 1938 decreased more than 11 times. Therefore there is an urgent need for the restoration of the ancient irrigation tunnels and construction of new ones.

**Keyword:** the kiariz, the geographical spread, the history of the construction and current state.

**Introduction.** In modern and ancient literature, historical documents and archives there is no systematic and comprehensive information about the world's sources of water kyarizes. In selected monographs, manuscripts, articles, questionnaires, online, Wikipedia and other sources provide accurate information about kyariz [14; 16; 17; 18; 19; 20]. There is no accurate information on the number and status of these sources.

Various issues related to archeology and Ethnography, as well as other arguments about kyarizes were examined by researchers in many countries, including Azerbaijan [2; 4; 5; 10; 13; 21; 24; 25; 26; 27; 28; 29; 30; 31; 32]. In general, information on geographical distribution, kyarizes, history of creation,

its current state, its design features and other indicators are distributed.

**The purpose of the study** is to systematize information about the geography of distribution, kyarizes, history of creation and its current state.

**Research methodology.** Information about kyarizes in the world and in our country has been collected, studied, analyzed and systematized. During the research we used archives, funds, Internet, review books and works of some scientists, as well as the results of our research in 2014–2019.

**Geography and origin of geographical distribution of kyarizes.** Kyariz are mainly distributed in the middle East, Central Asia and the Upper Caucasus. According to the studied sources, the search

engines can be found in Iran, Afghanistan, China, Pakistan, Azerbaijan, Syria, Jordan, Saudi Arabia, Tunisia, United Arab Emirates, Morocco, the Team, Turkmenistan, Tajikistan, Uzbekistan, Kyrgyzstan, Kazakhstan, Ukraine, Spain, Turkey, Algeria, Mexico. Peru, great Britain, Belgium and other countries, and currently most of these kyarizes operate in most of these countries.

Kariz in Iran, Afghanistan, China, Pakistan, Turkmenistan, Tajikistan, Uzbekistan, Crimea, Turkey and several countries and are called kariz In Peru, they are called pakis or fugues, drainage in the UK, falkin in Saudi Arabia, Tunisia tagara in Mexico Mambo or alcasar, Jordan and Syria ganat Romani, cetara in Morocco, Gallery or posesia in Spain, in the United Arab Emirates and Oman Falaj, Belgium Kahn, in Ukraine (Crimea) called catacomb.

Since there were no records and statistics of kyriz, it was impossible to obtain accurate information about their number. However, according to some reports, a large number of kyarizes are located in Azerbaijan and Iran. At the beginning of the last century there were more than 1500 in Azerbaijan and about 2000 in Iran [2; 4]. According to the data collected, more than 1.000 kyarizes were registered in Azerbaijan in 1938.

According to researchers, studying the irrigation tunnels in Iran was previously 22.000 kariz [5]. The total length of the plots was 314.84 thousand km, and their total productivity (consumption) was 93.5 m<sup>3</sup>/s. the Researchers compared the consumption of the Iranian kyarizes with the Euphrates river, which was approximately 75% of the expenses of the Euphrates. With kariz was watered 1280 hectares of dry land.

In Yazd province in Iran, the length of the current kiariz is 40 km, and the length Kunabadha well – 20 km depth of the main well Kunabadha well kiariz is 300 metres away. In Yazd province in Iran, the length of the current kiariz is 40 km, and the length Munabadha well – 20 km depth of the main well Munabadha well kiariz is 300 metres away. Researchers are surprised to find that this well was excavated

by hand. The exact date excavated well Kunabadha of kiariz unknown and but it does not prevent its stable operation. In general, in the East kyarizes are considered the most unique underground hydraulic structures in the world due to its architectural structure, durability and smooth operation. In Turkmenistan in 1951 there were about 700 kyarizes. In other countries, except Central Asia and the Middle East, the number of kyarizes was small. According to some reports, kyarizes are widespread in Afghanistan. Here almost every village has its own kyariz [16].

**History of kyarizes.** In many sources you can read about the history and author of the first kyarizes [10; 15; 20]. The first kyariz according to sources was built 3000 years ago in Iran, about three hundred years before the war between the Greeks and the Iranians [15]. Currently, he is in Kunabadi, Iran. In 2007, this water source was included in the UNESCO World Heritage List. The method of digging kyarizes was later adopted and used by other peoples and countries. For example, Morocco, Algeria, Lebanon, Afghanistan and other countries used the Iranian experience.

This source also noted that the kyarizes were created by the Uighurs 2000 years ago and were used as an irrigation system [15; 20]. However, it is assumed that the idea and technology of creating kyarizes were brought here along the silk road from the Iranians. That is, the Uyghur kyariz built by Iranian technology. Unique services of scientists and specialists who study the history, Ethnography, archeology and irrigation agriculture in our country, it should be emphasized their invaluable contribution in the study in Azerbaijan. The works created by Azerbaijani scientists in this field today are important sources of evidence that the kyarizes are ancient, advanced engineers and strategic installations [1; 2; 3; 4; 10; 23; 25].

According to studies, Azerbaijan archeology and Ethnography, kyariz in our country was established in the first century BC [29; 71; 74]. This proves that the history of irrigation agriculture in Azerbaijan dates



back to ancient times [73]. Thus, irrigated agriculture in Azerbaijan was formed about 8.000 years ago.

According to Yu. Safarov's research, the settlement of people in the territory of Azerbaijan coincides with the period of 2 million years ago. Therefore, its agricultural culture has a more ancient history. So, in the course of archaeological excavations was discovered 150 the earliest examples of agricultural material and cultures of the era of the anolyte, and more than 70 p.c. of these samples were found on the territory of Azerbaijan, including in the basin of the river Kur, in the plain of mil-Karabakh, Mugan and Araz. Comparative analysis showed that Kur-Araz intensively developed in the form of early agriculture in the VI–III Millennium BC, before the era of enolithic culture in Azerbaijan [8]. The history of kyarizes were studied in a variety of ways:

- ceramics, burnt bricks and other remains found in archaeological excavations;
- according to the age of the tools and vehicles used in the construction of kyariz, as well as construction equipment;
- preliminary comparison of the old materials found as a result of agrochemical studies;
- technology and tools ispolzuemye in ramesane kariz.

The study leads to the conclusion that the kyarizes were created simultaneously both in Iran and in Azerbaijan. Therefore, Iran and Azerbaijan are considered to be the homeland of the kyarizes.

The only one built in Europe, in the city of Evpatoria in the Crimea kyariz, attracted attention with its uniqueness. Originally built in the XVI century, the well was 9 meters from the surface of the earth. The entrance to kyariz was carried out through vertical passages. The dug well, every 50 m, was covered with a stone resembling a door. The base of the well was made of brown stones rather smooth.

Water-pressure ceramic pipes are made of red clay connected to each other with a special composition of the mixture installed on the bottom of the well. Pipes are connected with rings. Running water

from the pipeline is collected in the water purifier and reservoir, and then was transferred to the Khan mosque and Khan Hamam. In the late 40s Evpatoria was a military base of the Soviet Union on the black sea coast. So they could not use kyarizes sappers filled most of the vertical wells of the cellar with concrete. Currently, the remains of this kyariz remain on the territory of private houses.

On the map of Evpatoria 1811 specified the place of kiariz "as the ancient reservoir". Currently, this place is located between Golden Army street and Banny lane. Archaeologist L. M. Moiseev involved in Leningrad in 1935 at the Congress of specialists in architecture and art of Iran, likened the kariz system – a water system with Iran's kariz and showed that they were similar. It should be noted that Iranian and Azerbaijani kyarizes were built in the same architectural style. Kyarizes were also widespread in Turkmenistan, mainly in Kopetdag, and they were much larger.

They were dug on the slopes of the cliff, had a depth of 100 m and a length of over 10 km, Width of wastewater kariz whose age was more than 2500 years with up to 2 meters in width and 4 meters in height. By 1925, in Turkmenistan there were more than 35 major kaprizov. In the Bahar district more than 20, 17 in Ashgabat, 4 in Ashgabat and 10 in the village of Bahir. on the slopes of the Kopetdag mountains in places Actype and Bikrova found the remains of 38 archaeological and wells kariz.

According to Gulshad Gundogdyev, the employee of Institute of archeology and Ethnography of the Academy of Sciences of Turkmenistan, a large part of the irrigation tunnels dug in the mountain and foothill areas of the Kopetdag mountains, had already been reached before the construction of the channel Garakum. But the work and memory of the creators of these kyarizes were engraved in history as an eternal monument [14; 20].

In China, kyarizes were distributed in the Turfan massif, mainly in areas inhabited by Uighurs, they used this source of water for irrigation and water supply. Two thousand years ago, the Uighurs adopted



ideas and technologies from the ancient Iranians. The Iranians brought this technology to China along the ancient silk road [16].

Turpan was turned into a blooming oasis when the kyarizes were an ideal irrigation system. Today, the kyariz irrigation system is considered to be the main source of water in Turpan, as it was many years ago. The total length of kyarizes is more than 2500 km. Vertical wells with a diameter of 1.0–1.5 m and a depth of 100 m are dug 30–50 m and have drainage. It is no coincidence that experts compare the kyarizes of Turpan with the Great Wall of China. Currently the Museum of Turpan kariz. The number of tourists visiting this Museum is increasing every year, and tourists watching them have the opportunity to learn more about these unique sources of water.

Since the era of Alexander the Great kyarizes in Afghanistan are still being built. In this hot and sandy country you can live only because of groundwater. In these places, the villagers are engaged in digging kyariz. Vertical wells up to 50 m deep are dug and interconnected with underground drainage, where the accumulated water flows to the surface from a distance of hundreds of meters. According to A. Bakina, almost every village in Afghanistan has an extensive network of kyariz [86].

A terrible misfortune befell the Afghan people, turned the kariz in the clandestine war. The parties fighting each other use the kyarizes as a “shelter” and “guerrilla warfare”. Explosives are destroyed. As a result, these historical monuments are destroyed.

**The current state of kyarizes.** In Azerbaijan, kyarizes were very little studied as an engineering asset. According to information received at the be-

ginning of the last century, more than 1.500 kyarizes operated in Azerbaijan. According to other data, since 1950 there have been more than 900 kyarizes in Azerbaijan [22]. Their total consumption was 25 m<sup>3</sup>/s and about 50.000 hectares were irrigated with drinking water.

According to the materials stored in the archives of the Azerbaijan state Institute of water projects (“Azdovsutlaslayiha” Institute), in 1938 there were 1023 kyarizes in Azerbaijan (table 1). The total water consumption was 23645 m<sup>3</sup>/s, and the length was more than 731 km. More than 27850 vertical wells were fixed on the wells. The famous traveler and geographer-scientist G. R. Grum-Gryzhimaylo, who was in Azerbaijan in the early twentieth century, after getting acquainted with the kyarizes in Azerbaijan, he expressed his impressions: “The more difficult and difficult this device is to build, the more it requires courage and talent. Sometimes the water from a depth of 60 meters and more sometimes she rises to the surface. Are we wrong to say that we can conquer nature and admire and respect the farmers who are changing it?” [4].

According to the unanimous opinion of the researchers, the kyarizes built in Azerbaijan and Iran differ in the national architectural style built in other countries. Here you can feel the traditions and crafts inherent only to the Eastern peoples. Near the vertical wells there are architectural monuments (Fig. 1, 2).

A magnificent view of one such monument, called “Girhpille”, fascinates with its beauty. They were built using stone and burnt bricks. Breed were used not only for water, but and as seats for refreshment and storage food.

Table 1. – Information about functioning kyarizes in 1938 on the territory of Azerbaijan

Number No.	Region	Numeral	Expence l/sec	Long. km	Numeral of well. piecec
1	2	3	4	5	6
1.	Ganja	103	3500	166.829	7062
2.	Gazah	8	397	17.710	530
3.	Tovuz	5	297	12.719	361
4.	Shamkir	29	1042	14.926	734

1	2	3	4	5	6
5.	Goranboy	20	561	21.644	693
6.	Barda	45	2428	40.051	2024
7.	Yevlakh	4	150	3.759	222
8.	Tartar	2	54	1.143	49
9.	Aghdam	105	3040	112.424	3908
10.	Aghchabedi	68	2118	124.278	4630
11.	Fuzuli	71	603	37.830	1491
12.	Jabrayil	111	2099	59.311	2234
13.	Nakhchivan	136	2365	31.714	1058
14.	Sharur	129	1203	21.974	903
15.	Shahbuz	9	300	1.042	29
16.	Julfa	28	900	11.533	143
17.	Ordubad	99	928	31.940	992
18.	Mountainous Karabakh	52	734	20.181	887
Total:		1023	23645	731.008	27950

According to the researchers [4; 6], the monument “Girhpille” built over kiariz in the city of Yazd in Iran, is also a product of the monument “Girhpille” and the skill created in the city of Ordubad in Azerbaijan (Fig. 1, 2). The outer part of ancient kyariz also created according to ancient arnamentom. From the outer part of the kyarizes created pools and channels for water drainage (Fig. 3, 4).



Figure 1. The entrance of “Girhpille” made of for descent into the well kyariz at Yazd, Iran [4]



Figure 2. The entrance of “Girhpille” made of for descent into the well at Ordubad Azerbaijan [4]

Despite the fact that kyarizes are monuments of ancient heritage, most of them are subject to wear and tear or have been spoiled by waste and dried up. In 1938, 1023 kyarizes were registered in Azerbaijan (this is the official figure. Their number was much higher). In 1955, there were 931, 763 in 1972 and 382 in 2004. The total capacity was 23645 l/s, 13720 l/s in 1955, 6961 l/s in 1972 and 2230 l/s in 2004 (tab. 1, 2). Over the years, the number of kyarizes, in particular the number of active kyarizes, decreased by about 2.7 times compared to 1938 and productivity decreased by 11 times.



Figure 3. The pool and drenagge chanel at exit kyariz in Ordubad [4]



Figure 4. The exit part of the ancient kyariz in Shamkir

The decrease in the productivity of kyarizes is associated with their timely repair and the inability to recover.

Table 2. – Dynamics of quantity and consumption of kyarizes in Azerbaijan

Num-ber No.	Bölgələr və rayonlar	1955		1972		2004	
		Numeral of kyariz, pieces	Total consumption, l/sec	Numeral of kyariz, pieces	Total consumption, l/sec	Numeral of kyariz, pieces	Total consumption, l/sec
1.	Nakhchivan AR	377	2698	334	1063	320	1033
2.	Ganja-Gazakh region	165	3997	108	968	40	790
3.	Mountin Karabakh	52	134	51	125	–	–
4.	Barda	45	1428	35	1150	8	162
5.	Yevlakh	4	150	2	35	–	–
6.	Tartar	2	54	–	–	–	–
7.	Aghdam	105	2040	100	1210	–	–
8.	Aghhcabede	68	1518	58	1112	10	220
9.	Fuzuli	71	604	70	316	4	25
10.	Chabrayıl	111	1099	101	982	–	–
Total:		931	13720	763	6961	382	2230

**Conclusion.** Kyarizes is an ancient and underground hydraulic device that delivers water to the consumer without any mechanical means and energy and works flawlessly for thousands of years. But

due to neglect, their number gradually decreases. Therefore, there is a serious need for major repairs and restoration of ancient kyarizes, as well as the creation of new ones.

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## Section 5. Technical sciences

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### STUDY OF THE EFFECT OF THE CHEMICAL COMPOSITION OF MALLEABLE CAST IRON ON THE PROPERTIES OF PERMANENT CASTINGS

**Abstract.** In this article the study and analysis of the relationship between the main elements of the chemical composition of malleable cast iron (carbon and silicon) used in manufacturing of the permanent castings, are performed. The main properties of malleable cast iron: ultimate tensile strength, elongation at tensile strength, temporary tensile strength.

**Keywords:** permanent mold casting, malleable cast iron, main chemical elements of malleable cast iron, chemical composition elements correlation, correlation coefficient.

The spreading of the permanent mold casting method is due to a number of advantages over sand casting [1; 2]. The advantages are in the homogeneity of the material properties over the section of the part, the practical absence of stresses in the castings, high mechanical properties, machinability. Malleable iron castings are widely used for standard parts in the automotive, tractor and agricultural engineering, car-building, shipbuilding, the electrical industry, machine-tool construction, sanitary engineering and construction equipment, and heavy engineering. The quality malleable cast iron permanent mold casting depends on many factors: 1. The main elements of the chemical composition of malleable cast iron (carbon and silicon), their interaction in forming the structure of the permanent mold casting, 2. On the

thermal state of the permanent molds before they are filled with molten metal, 3. On the temperature of the molten metal in a permanent mold, 4. On the initial temperature of the permanent molds, 5. On the quality of the permanent coatings, 6. On annealing modes, etc. The purpose of the study is to establish correlations between the main elements of the chemical composition malleable cast iron: carbon and silicon. Table 1 shows the statistical data on the chemical composition (carbon and silicon), ensuring the production of high-quality permanent castings from malleable cast iron. The table has two variables:  $X$  is the carbon content in percent,  $Y$  is the silicon content in percent, the frequency of occurrence of a pair of numbers  $X_i Y_{j,i}$  at the intersection of the rows and columns.

Table 1.

	$X_1 = 2.5$	$X_2 = 2.6$	$X_3 = 2.7$	$X_4 = 2.8$	$X_5 = 2.9$
$Y_1 = 1.0$	2	3	4	5	6
	0	8	6	1	6



<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
$Y_2 = 1.2$	8	3	4	7	8
$Y_3 = 1.4$	5	6	1	3	0
$Y_4 = 1.6$	4	2	1	2	0

The sample size is 75. Let's make an unconditional distribution law for each of the elements of the chemical composition of malleable cast iron: carbon and silicon: (table 2 and table 3), respectively.

Table 2

$X_i$	$X_1 = 2.5$	$X_2 = 2.6$	$X_3 = 2.7$	$X_4 = 2.8$	$X_5 = 2.9$
$n_i$	17	19	12	13	2.9
$p_i$	17/75	19/75	12/75	13/75	14/75

Where  $p_i$  is the probability of  $X_i$  occurrence.

Table 3.

$Y_j$	$Y_1 = 1.0$	$Y_2 = 1.2$	$Y_3 = 1.4$	$Y_4 = 1.6$
$n_j$	21	30	15	9
$q_j$	21/75	30/75	15/75	9/75

Where  $q_j$  is the probability of  $Y_j$  occurrence.

Using the data of (table 2 and table 3) to assess the closeness of the relationship between the main elements of the chemical composition of malleable cast iron, we find the mathematical expectation  $M(X)$ , the variance  $D(X)$  and the standard deviation of the  $X_i$  and  $Y_j$  respectively [3].  $M(X) = 2.684$ ,  $D(X) = 0.02$ .

$$M(X) = \sum X_i p_i, D(X) = M(X_i^2) - M^2(X), \\ \sigma(X) = \sqrt{D(X)}$$

By using the similar procedure we calculate  $M(Y)$ ,  $D(Y)$ .  $M(Y) = 1.205$ ,  $D(Y) = 0.3$ , the values of the quadratic deviations are given below:

$$\sigma(X) = 0.14, \sigma(Y) = 0.5477.$$

To establish the density of the relationship between the elements of the chemical composition of malleable cast iron (carbon and silicon), we calculate the correlation moment

$$\mu(X_i Y_j) = \sum X_i Y_j p_{ij} - M(X) \times M(Y), \\ \mu(XY) = 0.06391. r_{xy}$$

Then the correlation coefficient is found from the relationship

$$r_{xy} = \frac{\mu(xy)}{\sigma(x)\sigma(y)}, r_{xy} = 0.79$$

The percentage of silicon does not depend on the percentage of carbon, but there is a relationship between them. The value of the correlation coefficient indicates a strong relationship between the elements of the chemical composition of malleable cast iron: carbon and silicon. The values of the percentage of carbon and silicon in the technological process of production are random, but for high-quality permanent castings their total value should be in the range of 3.6–4.2.

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## THE GAS METHOD FOR ENHANCED OIL RECOVERY

**Abstract.** This article considered classification of the method for increasing oil recovery using of water-gas injection technology, reservoir properties.

**Keywords:** Water-alternating gas injection, oil recovery factor, well production, associated petroleum gas, reservoir pressure maintenance.

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## ГАЗОВЫЙ МЕТОД ДЛЯ УВЕЛИЧЕНИЯ НЕФТЕОТДАЧИ ПЛАСТОВ

**Аннотация.** В данной статье рассматривается один из газовых методов для повышения нефтеотдачи пластов это метод водогазового воздействия и процесс вытеснения нефти водогазовой смесью. Предлагается использование насосно-эжекторную технологию для реализации данного метода.

**Ключевые слова:** Водогазовое воздействие (ВГВ), коэффициент извлечения нефти (КИН), скважинная добыча, попутный нефтяной газ (ПНГ), поддержание пластового давления (ППД).

В настоящее время в связи с увеличением объемов трудноизвлекаемых запасов нефти и газа, появляется необходимость использования методов воздействия на пласты. Один из современных газовых методов для увлечения нефтеотдачи пластов является водогазовое воздействие.

Учитывая физические условия содержания углеводородов в пустотном пространстве коллекторов (их физико-химических свойств, определяющих поверхностные взаимодействия флюидов и породы, капиллярных и др.) технологические и технические возможности (достигаемой степени полноты охвата объема пласта процессом вытеснения при реализуемой системе разработки), экономическое ограничения на плотность сетки скважин, величины предельного дебита, обводнённости продукции и другие факторы, можно ясно сказать, что из про-

дуктивных пластов на поверхность извлекается только некоторая часть запасов углеводородов. При этом отдельные компоненты получаемого из скважин продукта можно использовать для повышения эффективности извлечения нефти.

Количественно доля запасов, которая может быть извлечена (при применении наиболее эффективных в данных геолого-физических условиях технологий и технологических средств с выполнением оптимальных экономических показателей и соблюдением требований охраны недр и окружающей среды), определяется коэффициентом извлечения нефти [1].

В общем виде коэффициент извлечения нефти может быть выражен как отношение количества нефти, извлеченной на поверхность ( $Q_{\text{извл.}}$ ), к балансовым запасам нефти залежи ( $Q_{\text{бал.}}$ ):

$$КИН = \frac{Q_{извл}}{Q_{бал}} \quad (1)$$

Конечный КИН обычно выражается в виде произведения трех коэффициентов – вытеснения ( $K_{выт}$ ), охвата процессом вытеснения ( $K_{охв.}$ ) и заводнения ( $K_{зав.}$ ):

$$КИН = K_{выт} * K_{охв.} * K_{зав.} \quad (1.1)$$

Таким образом, мероприятия по воздействию на пласт должны быть направлены в первую очередь на увеличение коэффициентов вытеснения и охвата, чтобы в конечном счете, увеличить коэффициент извлечения нефти [2].

Для использования данного метода в промышленности, предлагаю применять насосно-эжекторную технологию закачки водогазовой смеси.

Насосно-эжекторная технология использует только промышленно выпускаемое оборудование, не имеющее дорогостоящих или надежных элементов. В частности, струйные аппараты (эжекторные устройства) характеризуются простотой конструкции, низкими капитальными вложениями на их изготовление. В устройстве

СА отсутствуют какие-либо движущиеся детали, что положительно влияет на общую надежность системы. Эта технология может применяться как на отдельных скважинах, кустах скважин, так и целых месторождениях.

Интересным вариантом насосно-эжекторной технологии ВГВ является насосно-компрессорная технология закачки водогазовой смеси (ВГС). Ее суть заключается в том, что давление газа, поступающего в приемную камеру эжектора, повышается за счет использования так называемого “струйного компрессора”, состоящего из струйного аппарата (эжектора), подпорного насоса, емкости высокого давления. Такой вариант насосно-эжекторной системы более функционален, дает возможность подобрать эжектор с меньшим значением коэффициента инжекции, который обладает более высоким безразмерным перепадом давления, и при постоянном рабочем давлении перед соплом эжектора позволит получить более высокое давление ВГС на выходе из системы. Вариант реализации данной технологий показан на (рис. 1).

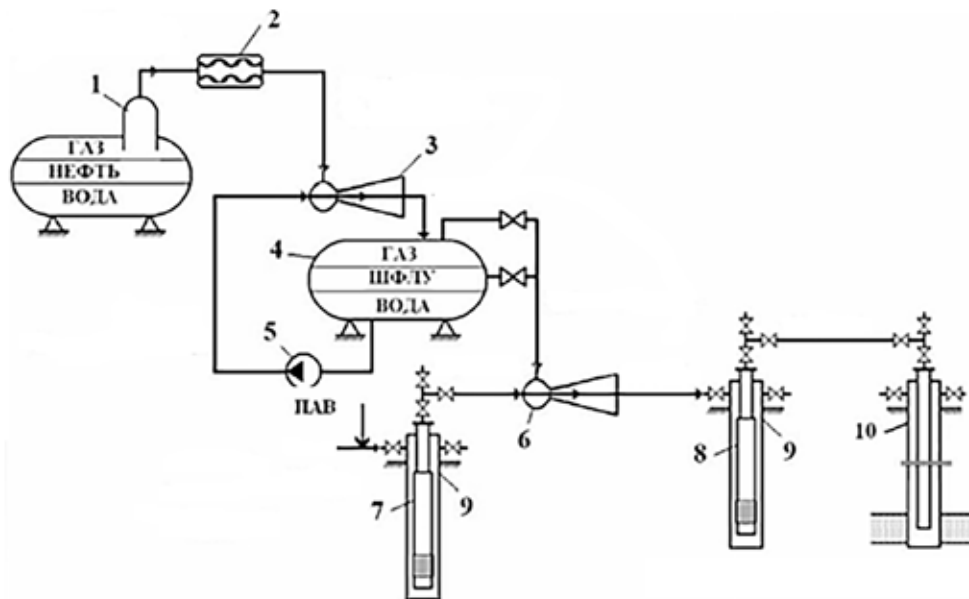


Рисунок 1. Одна из схем реализации насосно-эжекторной технологии водогазового воздействия на пласт: 1 – трехфазный сепаратор; 2 – винтовой компрессор;

3, 6 – эжектор первой, второй ступени; 4 – емкость высокого давления (5 МПа);

5 – подпорный насос первой ступени ВНН8-2000; 7 – подпорный насос второй ступени ЭЦН7А-340; 8 – дожимной насос ЭЦНП7-470; 9 – шуфр; 10 – нагнетательная скважина

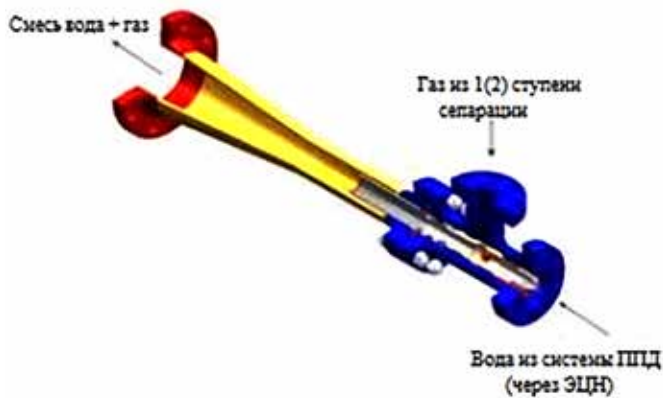


Рисунок 2. Водогазовый эжектор

При реализации метода водогазового воздействия на нефтяной пласт предлагаем использовать на устье фонтанной арматуры – водогазовый эжектор (рис. 2). Установка предназначена для подачи водогазовой смеси в нефтяной пласт с целью повышения коэффициента извлечения нефти. Повышение давления водогазовой смеси происходит в три ступени, давление смеси на выходе из установки – от 12,0 до 18,0 МПа, газ-водяной фактор, приведенный к стандартным условиям –  $43,5 \text{ м}^3/\text{м}^3$ .

Попутные нефтяные газы при нагнетании их в нефтегазовый коллектор ввиду наличия эффекта частичной или полной взаимной смешиваемости с пластовой нефтью обладают лучшими отмывающими и вытесняющими способностями, чем применяемая в системе поддержания пластового давления (ППД) вода.

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При закачивании газа в нагнетательные скважины на первом этапе способа, в первую очередь им будут заполняться наиболее проницаемые, а в случае внедрения способа на объектах эксплуатации с уже действующей системой ППД – наиболее промытые пропластки и системы трещин. Будут происходить вытеснение нефти (остаточной в случае реализации способа на истощенных объектах) к забоям добывающих скважин, причем достигаемый коэффициент вытеснения будет выше, чем при вытеснении водой за счет растворения газа в нефти, снижения вязкости последней и реализации режима ограниченной смешиваемости. Достигаемый на этом этапе коэффициент охвата вытеснением будет невысок.

Таким образом, предложенные технологии реализации водогазового воздействия на пласт насосно-эжекторная и насосно-компрессорная система позволяют преодолеть недостатки, свойственные другим технологиям [3].

**Заключение:** В настоящее время процесс применения водогазового-воздействия на нефтегазовых месторождениях низкая. Данный метод предотвращает прорывы газа в добывающие скважины и увеличивает количество извлекаемой нефти.

Предлагаемый метод, не смотря на положительные результаты, полученные при исследовании, нуждается в дополнительных исследованиях и изучений.



## Section 6. Transport

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### OPTIMAL ROUTE DEVELOPMENT FOR TRANSPORTATION OF FUEL AND LUBRICANTS

**Abstract.** The article considers the method of compiling optimal routes for the transportation of industrial goods by road.

**Keywords:** optimal route, reduced table, minimal element, link selection, algorithm for the task solving method.

Organization of material and finished products transportation is an important national economic task. The cost of transportation is an integral part of the base cost of the final product, so it is important to reduce the cost of transportation of products. In this study, the task under consideration is the optimal routing for transportation of fuel and lubricants between the major industrial centers of Ukraine: Kiev, Kharkiv, Dnipro, Zaporizhia, Lviv. The optimal route is the route

of shortest length. The task is formulated as follows: to visit all the cities, enter and leave each city once, and return to the initial city of the route. We solve the problem by the branch and bounds algorithm [1; 2].

The mathematical model of the task is presented in the table demonstrating the distances between cities (Table 1) in kilometers. In Table 1, the numbers 1, 2, 3, 4, 5 indicate the cities of Kiev, Kharkiv, Dnipro, Zaporizhia, Lviv, respectively.

Table 1.

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1.	–	487	496	544	487
2.	500	–	222	303	1042
3.	510	250	–	90	948
4.	570	300	89	–	1014
5.	550	1050	950	1020	–

The algorithm for compiling the optimal transportation route consists of the following steps:  
1) reduce Table 1 to rows. It is done by finding mini-

mal element  $h_i$  for each row of Table 1. This is the smallest value in each row. Table 2 shows the minimal elements of rows.

Table 2.

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b><math>h_i</math></b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
1.	–	487	496	568	544	<b><math>h_1 = 487</math></b>

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
2.	500	–	222	303	1042	<b><math>h_2 = 222</math></b>
3.	510	250	–	90	948	<b><math>h_3 = 90</math></b>
4.	570	300	89	–	1014	<b><math>h_4 = 89</math></b>
5.	550	1050	950	1020	–	<b><math>h_5 = 550</math></b>

From each element of the row we subtract the minimal element of this line – we get (Table 3) given in lines.

Table 3.

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1.	–	0	9	81	57
2.	278	–	0	81	820
3.	420	160	–	0	858
4.	481	211	0	–	925
5.	0	500	400	470	–
					<b><math>q_5 = 57</math></b>

2) reduce (Table 3) by columns. To do this, we find in the columns of (Table 3), where there are no zeros, the minimal elements  $q_j$  in the columns as the

smallest value of the corresponding column and subtract its minimal element from each element of the column. Table 4 is the result of the reduction.

Table 4.

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1.	–	$0^{160}$	9	81	$0^{763}$
2.	278	–	$0^{81}$	81	763
3.	420	160	–	$0^{241}$	801
4.	481	211	$0^{211}$	–	868
5.	$0^{678}$	500	400	470	–

3) let us estimate the number of zeros in (Table 4). We find an estimate of the zeros as the sum of the smallest element of the row and the smallest element of the column, at the intersection of which is the estimated zero. We select the first link in the chain of the optimal route of cities according to the highest estimate of zero, in our case it is 1–5. 4) cross out in table 4 the row and column at the intersection of which there is zero with the highest rating. We return to point 1) of the algo-

rithm for finding the optimal route for city bypass. We work following the steps of the algorithm until a  $2 \times 2$  table remains. From a  $2 \times 2$  table, pairs of cities are automatically found. From the links of cities an optimal transportation route is built. In our case, this route has the form: 1–5–4–3–2–1. Its length is 2903 km. This is the shortest route length. It is possible to make sure that the shortest route length is possible if one of the links of the route is prevented from use in the calculation [3].

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