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ARCHITECTURAL TECHNIQUE FOR SMOG ELIMINATION IN ALMATY

Abstract. The weather of Almaty is calm for more than 200 days a year, which results in a steady smog in an urban environment. This phenomenon is associated with the terrain of Almaty. The increase in development density and temperature inversion over the city, which prevents both horizontal and vertical air displacement. For this situation of stagnant smog in valley the authors of the article propose architectural and town-planning techniques for forced aeration of the city territory. The article discusses their authorial projects using contrast zones, as well as water properties to reduce the harmful effects of polluted air in Almaty and other cities.

Keywords: architecture, smog, aeration, atmospheric physics.

The problem of smog has been known for a long time. Millions of people on the planet get poisoned from pollution every day! Millions of people die of smog every year. However, toxic substances in the atmosphere continue to increase. Environmental pollution has penetrated the soil and water resources [1]. The existing biodiversity and of forest ecosystems has been diminished [2]. Scientists have been raising alarm for the pending environmental disaster for several decades in a row.

Smog is the product of urban civilization; it covers many cities, including Almaty. According data of the World Health Organization (WHO), almost 92% of the population on Earth lives in places with polluted air [3]. It is associated with about 3 million deaths per year. The level of air pollution due to the development of industry and vehicles has increased dozens of times from year to year. Referring to these facts, Kazakhstan scientists come to the conclusion that European countries before the others began to apply various environmental standards [4]. The high level of environmental pollution in Almaty was noted compared with the world leaders in pollution [5].

The active growth of the city leads to an increase in development density, an increase in the number of private cars and bus routes, and growth of private housing and high-rise residential compounds. According to studies, 80% of Almaty's air pollution comes from motor vehicles. There are 800 thousand cars in the city, which annually emit about 260 thousand tons of harmful substances into the air. The studies also show CHP-2 and CHP-1, located within the city boundaries and burning coal and fuel oil are the major reason for the formation of smog. In 2014, CHP-2 feed 32 880 tons of hazardous chemicals into the atmosphere. The private sector, often heated by coal, makes an enormous contribution to air pollution [6]. In February, a snapshot of a black curtain over Almaty was published in the article "One Day in the Life of a Suffocating Planet" in The Guardian. In the article, journalist Chris Michael made a selection of photographs of the dirtiest cities in the world [7]. "Today, our daily MPC is exceeded by eight times. All day long, we are absorbing air that is hazardous when you are breathing it for more than half an hour", - says Pavel Alexandrov, the author of the airkaz.org website [8].

It seems like the mountain-valley circulation and the west-eastward flowing wind directions flushes toxic air out of the city. But in real the situation is quite different. The following key reasons result in such a situation: firstly, the terrain of Almaty, which is located in the piedmont basin, delays the ventilation;

secondly, the increase in the development density associated with the active growth of the city has worsens the aeration of residential area; thirdly, the temperature inversion over the city, which not only prevents the vertical displacement of air masses, but in addition it acts like a screen and throws the entire torch of hazardous substances back to the ground, increasing their concentration on the surface of the atmosphere multiple times. Thus, we can assume that residents of Almaty live in a tightly closed container filled with toxic gas.

Inadequate registration of the aeration mode is one of the problems of today's urban planning. Employees of the newly established «AlmatyGenPlan» Research Institute deem it necessary to address this problem. The results of the theoretical studies and researches conducted by Institute are reflected in the reports and articles [9-12]. Institute is trying to find out the options for financial opportunities for the further scientific research for the improvement of the air environment in Almaty, the implementation of experimental design and subsequent practical application of the results in urban design and development.

It is known that urban development makes significant changes in the wind pattern. Hence it appears that aeration is a controlled process. Consequently, the task is to conduct an in-depth study of the dependence of the velocity and direction of movement of air currents in the territory of the projected development on the relative position of buildings and their location in relation to the winds. The geographical position of Almaty and its development forms more than 200 days a year of calm weather, which results in smog stagnation. Thus, in order to disperse this stagnant air, it is first necessary to create conditions for the wind generation, which in turn will provide the city with forced aeration.

Consider town planning methods of wind flows generation. The simplest ones are the creation of contrasting zones in the building, such as "water-land", "sun-shadow", "cold-heat", "black-white", "oasis-desert", "open-closed spaces", "low - high pressure zones". In this, formation of various "transitional", "connecting" spaces between them in the form of through openings, arches, terraces, courtyard, and supported buildings, is important. This will ensure the flow of air masses, and transformation of negative environmental factors, such as intense insulation, high wind velocity, into positive ones. In some cases, they can be enhanced, while in other situations they can be reduced, depending on the goal.

Contrast zones ensure non-uniform heating of the underlying surface, which creates an uneven distribution of atmospheric pressure, due to which air masses are displaced. The air masses movement occurs in the direction from high to low pressure. The greater the pressure difference, the faster the air moves, the stronger the wind. It should be noted that there is also feedback - the long-term air movement, which transports some air from some districts to another, affects the difference in atmospheric pressures in these districts.

Today, many demand to eliminate high-rise buildings in Almaty for the aeration of the city. But does a high-rise building always prevent the city from airing? The authors of this article believe that it all depends on their design. High-rise buildings not always hinder aeration, but if designed properly also can initiate the movement of the air flow and can also act as filter (figure 1a, 1b). This can be achieved by creating an atrium inside a building, in accordance with Bernoulli's law - this will draw air currents from the surrounding territory pushing them up, and turning carbon dioxide into oxygen using a specially developed technology that has already been tested and licensed [13].

Figure 1a – Design of "Tau Samal" multifunctional residential complex at the intersection of Zhandosov and Navoi Streets. Changes in the aeration of the central building, depending on the upper floor structure of the atrium

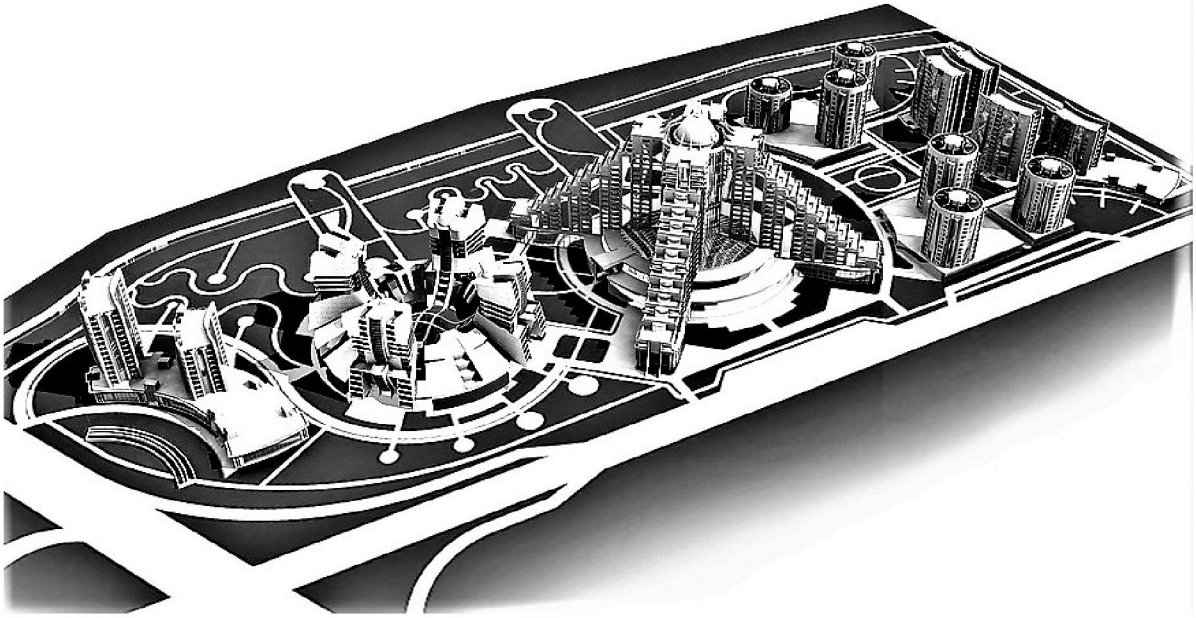

Figure 1b – Design of "Tau Samal" multifunctional residential complex at the intersection of Zhandosov and Navoi Streets. 3D image of a residential building

This technique that was proposed in Tau-Samal pilot project at the intersection of Navoi and Zhandosov streets, created under the authorship of the candidate of architecture, L. Rakhimzhanova (figure 1a, 1b). Preliminary studies have shown that this method will work even with zero wind levels at ground level. However, to determine more accurate atrium proportions, a special calculation of atmospheric physicists is needed in order to avoid uncomfortable human stay when air flows through the building and its surrounding territory.

Virtually any through atrium creates an updraft. But our project, as noted above, transforms the air quality: in the process of pushing it up, it purifies it using specially developed technology, turns carbon dioxide into oxygen, and also generates additional energy.

The Tau Samal project has also used water properties to improve air quality. An artificial channel created would be filled from Big Almatinka River and flowed by gravity through the center of the residential complex, sometimes even flowing it into the interiors of buildings. In addition for comfortable conditions the water was intended to create a variety of visual and psychological effects. The channel would play a public and social role, being the core of various social and youth activities.

The role of water in the elimination of smog in urban environments is enormous. It cleans the air pool, improving air quality [14]. Moreover, it performs two fundamental functions, namely: 1) a modifier of the external environment able to transform negative factors into positive ones; 2) a source of comfort and (figure 2).

Depending on the relief of the underlying surface, water changes the speed and direction of the wind. Its abilities to absorb, refract, disperse environmental factors (sun, wind) depending on its thickness, texture, position in space, allowing to regulate low and high pressure zones, which in turn contributes to the wind strength for aeration of the territory. Water properties of being still, falling, splashing, cascading, allow for its use as screens and barriers in improving microclimate. At the same time, its properties vary depending on the position of water surfaces in space: to be vertical, inclined, to serve as the upper screen or middle screen inside streets, centers and complexes. The authors refer to water screens as “shielded systems”.

Ability of water to improve air environment of the most polluted district of Tastak were proposed for the entertainment and business center on Lake Sairan (figure 5, 6). This is another project with an atrium, but of a spherical shape, inscribed in a conical one. Here, the use of water has been fully developed. First of all, for the most part it bases directly on the water; it has an underwater part with a museum and a surface part with various water effects.

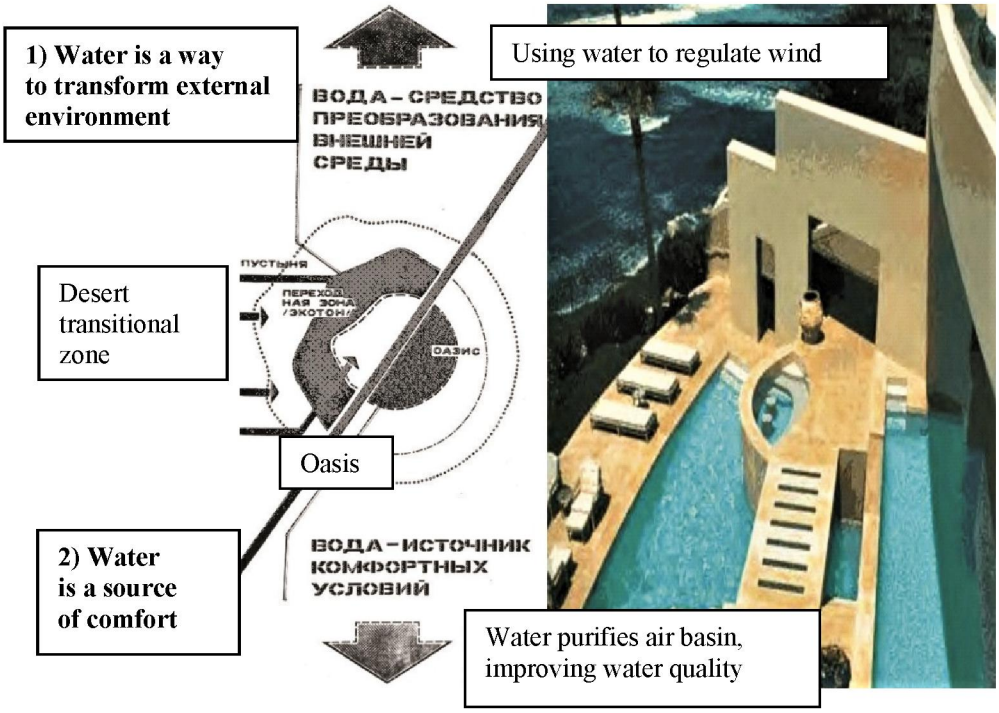

Figure 2 – Two functions of water: to be a source of comfort and a modifier of the external environment

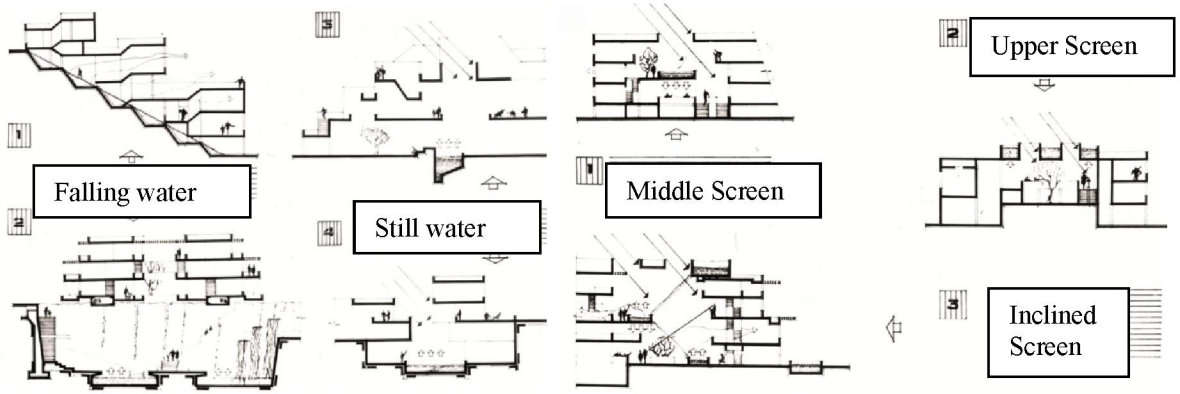

Figure 4 – Demonstration of various water properties to improve microclimate in its various positions

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Figure 5, 6 – Entertainment and Business Center on Lake Sairan

Noteworthy is the fact that the projected center had various fog and cloud-forming installations (figure 7), which were already proposed to be used in the urban environment in the dissertation of Rakhimzhanova L.Sh. back in the 80's, where various nozzles and water curtains were carefully studied in industrial workshops [14]. Today, the use of some nozzles can already be seen in street restaurants of Almaty to provide a cool microclimate on hot days.

Figure 7 – Examples of the use of fog for the elimination of smog in the urban environment

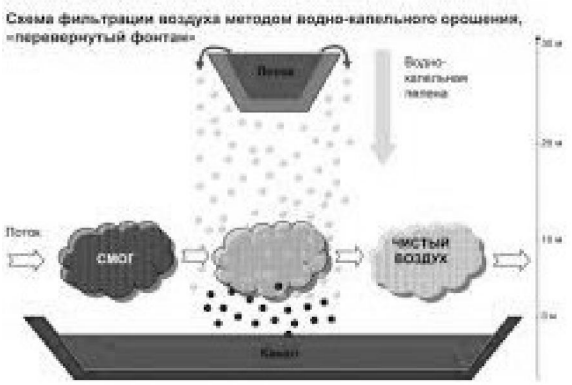

Figure 8 –
Water-drip curtain project of Serik Burkutbvayev

There are other suggestions for Almaty in using water to eliminate smog, for example, the Almasagyn water cascades project (*Alma* is Almaty, *as* is pouring, and *agun* is water) by Serik Burkutbvayev, Doctor of Physics and Mathematics (figure 8). This is something like a Roman aqueduct, from where a water droplet curtain forms, drops (asagyn) are dripping and water is naturally sprayed in the air [15].

It should be mentioned that today China began to use fog guns to purify its cities from smog [16]. These mechanisms are installed on machines that are commonly used to combat dust in factories and construction sites (figure 9). As is well known, China took up a serious fight against smog and intends to spend $277 billion to do it. Sprinklers are going to be installed on high buildings in Chinese cities, which are able to suppress smog and bring the level of hazardous elements in the atmosphere to the recommended level in just a few hours (figure 10).

Figure 9 – Fog Guns

Figure 10 – High-Rise Sprinklers

The authors of this article from AlmatyGenPlan are aware of projects to purify the air basin of Almaty and of other authors of the world, in connection with which they intend to unite uncoordinated scientific forces and make air in Almaty other cities clean. The strong established mechanism of the country in the field of engineering will be useful to combine with the developed concepts such as air ozonation [17], air purification and disinfection systems of tenre-aerolife LLP [13], as well as artificial creation of clouds and fogs.

The results of the research presented in the article can be used in the development of the master plan, the development of detailed plans, as well as in the development of regulatory and technical documents in the field of urban planning, architecture and construction of Almaty.

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АЛМАТЫНЫҢ ТҮТІНТҰМАНЫН СӘУЛЕТТІК ЖОЮ АМАЛДАРЫ

Аннотация. Алматыда жылына 200 тәуліктен артық уақыт бойына желсіз тымық ауа-райы орнап, қалалық ортада тұрақты түтінтұманды қалыптастырады. Бұл құбылыс Алматы қаласының жер бедеріне, құрылыс салу тығыздығының артуы және қаланың үстіндегі температура инверсиясының ұлғаюымен тығыз байланысты болып табылады, бұл жайлар ауа массасының көлденең және тік қозғалысына кедергі келтіреді. Туындаған жағдайға байланысты, мақаланың авторлары қаланың аумағын мәжбүрлеп желдендіру үшін сәулеттік- қала құрылыстық амалдарды ұсынады. Мақалада контрасттық аймақтарды, сондай-ақ Алматы қаласында газданған ауаның зиянды әсерлерін жою үшін судың қасиеттерін пайдаланатын олардың авторлық жобалары қарастырылады.

Түйін сөздер: сәулет, түтінтұман, аэрация, атмосфера физикасы..

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АРХИТЕКТУРНЫЕ ПРИЁМЫ ЭЛИМИНАЦИИ АЛМАТИНСКОГО СМОГА

Аннотация. В Алматы более 200 дней в году безветренная погода, что формирует устойчивый смог в городской среде. Это явление связано с рельефом местности Алматы, увеличением плотности застройки и температурной инверсией над городом, что препятствует как горизонтальному, так и вертикальному перемещению воздушных масс. В связи с создавшейся ситуацией авторы статьи предлагают архитектурно-градостроительные приёмы принудительного проветривания территории города. В статье рассматриваются их авторские проекты, использующие контрастные зоны, а также свойства воды для погашения вредного воздействия загазованного воздуха в Алматы и других городах.

Ключевые слова: архитектура, смог, аэрация, физика атмосферы.

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REFERENCES

[1] Mukhamedzhanov M.A., Sagin Jay, Kazanbaeva L.M., Nurgazieva A.A. Challenging issues of fresh water within the territory of East Kazakhstan and adjacent areas of Central Kazakhstan // News of the Academy of sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. Vol. 2, N 434 (**2019**). P. 15-20. ISSN 2518-170X (Online), ISSN 2224-5278 (Print). https://doi.org/10.32014/2019.2518-170X.33

[2] Ismaylov M.J., Zeynalova S.M., Ismaylova L.A. Dynamics of the relic forest landscape in Azerbaijan and ways to solve environmental problems // News of the Academy of sciences of the Republic of Kazakhstan Series of Geology and Technical Sciences. Vol. 2, N 434 (**2019**). PP.48-54. ISSN 2518-170X (Online), ISSN 2224-5278 (Print). https://doi.org/10.32014/2019.2518-170X.37.

[3] http://www.cleanairpower.com/emissions.html (in Eng.).

[4] Sassykova L.R., Sendilvelan S., Bhaskar K., Zhumakanova A.S., Aubakirov Y.A., Abildin T.S., Kubekova Sh.N., Mataeva Z.T., Zhakupova A.A. Norms of emissions of harmful substances generated from vehicles in the different countries of the world // News of the Academy of sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences, Vol. 2, N 434 (**2019**). P. 181-190. ISSN 2518-170X (Online), ISSN 2224-5278 (Print). https://doi.org/10.32014/2019.2518-170X.53

[5] Abilkayir. N.A. Population health as a major factor of quality of life // News of the Academy of Sciences of the Republic of Kazakhstan. Series of biology and medicine. Vol. 2, N 332 (**2019**). P. 20-27. ISSN 2518-1629 (Online), ISSN 2224-5308 (Print). https://doi.org/10.32014/2019.2519-1629.16.

[6] Smog over the city – special opinion. https://realkz.com/page.php?page_id=295&article_id=282

[7] AUA group. Almaty Smog is in The Guardian», 15.02.2017
http://auagroup.kz/world-air/smog-almaty-popal-the-guardian.html.

[8] Attention - Disaster: What is happennig to the air in Almaty? 12.12.17.
https://www.the-village.kz/village/city/situation/827-zagryaznenie-vozduha.

[9] Uranchaev N.T., Shachnovitch A.Iu., Zhanbyrshy A.M., Toktybaev D.Zh. Analysis of the Effect of the width of the buildings (southernprospect of Al-Farabi) of Changing the wind mode in the construction of Almaty // Research report. Almaty, August 2018 (in Rus.).

[10] Rakhimzhanova L.Sh. Smart Geometry creates smog free city // XXV International Conference ISUF-2018. The form of the city and the social context: from tradition to the needs of the time. Krasnoyarsk, 2018 (in Eng).

[11] Vaidya S., Rakhimzhanova L. Eco-friendly Antismog Architecture // 13th National Convention. Kathmandu, Nepal, April 28-30, 2013 (in Eng.).

[12] Rakhimzhanova L.Sh., Vaidya S. // International recognition of Art Nouveau and its subconscious creative communications. Art Scientific Journal, World Art International Conference on Art and Humanities Vienna, Austria, August 24-25, 2013 (in Eng.).

[13] Tenre Airlife. http://www.tenre-airlife.kz/ru/about/.

[14] Rakhimzhanova L.Sh. The role of Water areas in shaping the spatial environment in the conditions of the arid zone // Thesis, MARCHI, Moscow, 1984.

[15] Every good project begins to have its own life at some point. 09.09.16.
https://kursiv.kz/news/otraslevye-temy/2016-09/lyuboy-khoroshiy-proekt-v-kakoy-moment- nachinaet-zhit-svoey-zhiznyu.

[16] Know-how in China - Fog guns for air purification.
https://billionnews.ru/3518-nou-hau-v-kitae-tumannye-pushki-dlya-ochistki-vozduha .

[17] Bahtaev Sh., Toigozhinova A.Zh., Zhirnova O.V., Wojcik W.T., Suleimenov B.A., Koshimbayev Sh.K. Modeling of processes in the zone of corona discharge ionization // News of the Academy of sciences of the Republic of Kazakhstan. Series of geology and technical sciences. Series of Geology and Technical Sciences. ISSN 2224-5278. Vol. 1, N 421 (**2017**). P. 197-204. ISSN 2518-170X (Online), ISSN 2224-5278 (Print).

[18] Kenzhaliyev B.K., Surkova T.Yu., Yessimova D.M. Concentration of rare-earth elements by sorption from sulphate solutions // Complex Use of Mineral Resources. 2019. N 3. P. 5-9. https://doi.org/10.31643/2019/6445.22

[19] Mochamad B. Triyono, LilisTrianingsih, Didik Nurhadi. Students' employability skills for construction drawing engineering in Indonesia // World Transactions on Engineering andTechnology Education. 2018. Vol. 16, Issue 1. P. 29-35.

[20] Kenzhaliyev B.K., Berkinbayeva A.N., Sharipov R.H. (2015). Research of the Interacting Process of Copper-Base Alloys with Leaching Solutions under the Action of Different Physicochemical Factors // American Journal of Applied Sciences. 12(12), 982-992. https://doi.org/10.3844/ajassp.2015.982.992

[21] Kenzhaliyev B.K., Dosymbaeva Z.D., Iskhakova R.R., Suleimenov E.N. (2015). Investigation into the Use of Electrochemical Extraction to Draw Gold from Refractory Ores // American Journal of Applied Sciences. 12(11), 857-864. https://doi.org/10.3844/ajassp.2015.857.864

[22] Lavrinenko S.V., Arpentieva M.R., Kassymova G.K. (2019). Motivation of technical university students and its impact on the effectiveness of the educational process // International youth scientific conference "Heat and mass transfer in the thermal control system of technical and technological energy equipment" (HMTTSC 2019). https://doi.org/10.1063/1.5120670

[23] Kenzhaliyev B.K., Iskhakova R.R., Dosymbayeva Z.D. (2015).Sorption Extraction of Noble and Non-Ferrous Metals from Process Leaching Solutions // American Journal of Applied Sciences. 12(11), 875-884. https://doi.org/10.3844/ajassp.2015.875.884

[24] Almagambetova A., Tileubay S., Taimuratova L., Seitmuratov A., Kanibaikyzy K. Problem on the distribution of the harmonic type Relay wave// News of the National academy of sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences 2019. 1(433): 242-247 (in Eng.). ISSN 2518-170X (Online), ISSN 2224-5278 (Print). https://doi.org/10.32014/2019.2518-170X.29