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RUBRIC

«LIFE SAFETY»

THERMAL METHODS OF MEDICAL WASTE DISPOSAL

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ТЕРМИЧЕСКИЕ МЕТОДЫ УТИЛИЗАЦИИ МЕДИЦИНСКИХ ОТХОДОВ

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Abstract. The article is devoted to one of the urgent problems of modern ecology – the disposal of medical waste: medical masks, gloves and shoe covers. The authors of the article analyze the existing thermal methods of disposal of these wastes and consider possible ways to solve the problems associated with their disposal in Russia.

Keywords: medical waste, thermal disposal methods, medical masks, medical gloves, medical shoe covers, inceration, pyrolysis, plasma technology

Now all over the world, due to the current epidemiological situation, people use medical masks and gloves every day. The critical situation around the world regarding the disposal of medical waste poses a real threat to human health and the environmental safety of each state as a whole. Reducing the adverse impact of waste is possible with proper technical support for their disposal and compliance with sanitary and hygienic requirements for these processes. The situation is complicated by the fact that there are no legal acts and organizational conditions in the field of medical waste management.

Currently, 85% of medical waste is considered non-hazardous waste, however 15% is considered infectious, radioactive and chemical.

With a safe and environmentally friendly approach to the disposal of medical waste, the negative impact of waste on human health and the environment as a whole can be reduced or completely prevented.

One of the main problems of modern medicine is the disposal of medical waste. Any waste that is generated during the direct activities of medical institutions, the composition of such waste may consist of tissues (both human and animal), various body fluids, bandages, shoe covers, masks, gloves, excrement, pharmaceuticals, etc.

At the moment, in the Russian Federation there is a huge number of legal acts that regulate the collection, storage and disposal of medical waste, for example, SanPiN 2.1.3684-21 “Sanitary and epidemiological requirements for the maintenance of the territories of urban and rural settlements, for water bodies, drinking water and drinking water supply, atmospheric air, soil, residential premises, operation of industrial, public premises, organization and implementation of sanitary and anti-epidemic (preventive) measures. In this NPA, medical waste is divided into 5 classes:

- Class A, this type of medical waste is equated to MSW and is considered an epidemiologically safe type of waste (masks, gloves, shoe covers – used outside the health facility; personal hygiene items; care products for patients whose diagnosis is not related to infectious diseases, furniture, stationery.
- Class B, waste that has been infected or potentially infected with pathogens of pathogenicity groups 3-4 (any waste that has been contaminated with any biological fluids (materials or instruments), post-mortem activities, operating rooms, as well as food and waste that were in direct contact with infectious patients.
- Class B, these are wastes from the use of genetically modified organisms for scientific and medical purposes, as well as wastes from medicinal production and medical devices.
- Class G, this class represents a toxicological waste group (hazard class 1-4), the composition and level of which are identical to industrial waste, that is, among them: various medicines and preparations, installations and lamps containing mercury, as well as materials from pharmaceutical enterprises.
- Class D, radioactive medical waste (used fluorography units, unsuitable gamma tomographs, drugs for radiation therapy, used equipment for X-ray diagnostics)

Depending on the class of medical waste, different requirements for collection, temporary storage, transportation and disposal apply. It should be noted that mixing of wastes of different classes at all stages of collection and storage is not allowed, and the procedure for waste disposal is determined.

In accordance with SanPin, class A waste is disposed of to MSW landfills without any restrictions, as for class B and C waste, they are destroyed in facilities that are specifically designed for the disposal of medical waste by the thermal method (incinerators). However, this method has disadvantages, namely: during the operation of incinerators, various dioxins are formed. That contributes to the development of a variety of diseases, including diseases of the immune system, cancer and other violations of the detail of the human body.

Mercury is also one of the contaminants in incineration. It is a potent neurotoxin that weakens the motor, sensory and a number of other functions of the human body.

However, if equipment designed to clean air emissions is functioning properly, it will remove most air pollutants and bring their values to the limit.

Technologies that first provide for the preliminary decomposition of the organic component of the waste in an oxygen-free environment (pyrolysis) are alternative methods for the thermal processing of solid medical waste. After the pyrolysis process itself, the concentrated gas-vapor mixture (CGM) is sent to a special afterburner, where toxic substances are converted into less or completely safe ones, thanks to the controlled afterburning of gaseous products.

The main advantages of oxygen-free pyrolysis technologies for the destruction of organic materials, which ensure the environmental safety of emissions, as well as chlorine-containing emissions, are:

- It is possible to control the combustion at high temperatures of concentrated undiluted ASG, which ensures a high temperature of the entire volume of combustion products (1200-1300 ºC).
- Active chlorine, which is released during the pyrolysis of chlorine-containing materials, already in the thermal decomposition chamber itself quickly reacts with hydrogen, thereby forming a stable HCl compound, which is easily neutralized at the post-treatment stage.

Plasma technology is a high-temperature (1300-1700 ºC) impact with complete decomposition of medical waste. The principle of plasma treatment of waste is thermal decomposition with incomplete oxidation under the action of water vapor, air oxygen and pressure. Due to the high temperature, this technology allows the destruction of highly toxic hazardous medical waste.

This device can be divided into four main units: gasifier reactor, plasma generator, afterburner, cleaning system. The design of such devices can be of two types:

1. With an annular plasma torch, the flow along the perimeter of the chamber is distributed evenly.
2. With a central plasma generator – a hot beam is released into the loading center.

Among the advantages are: small dimensions of the equipment, the possibility of complete processing of medical waste, a decrease in the number of treatment facilities. However, there are also disadvantages, namely: a rather high consumption of electricity (however, the gas produced compensates for the energy costs – under ideal reaction conditions), high costs for servicing the plasma torches and repairing the plasma-chemical reactor.

Conclusions

In conclusion, it is worth noting that it is the thermal method of medical waste disposal that is the most effective in terms of neutralization. This method is used all over the world for the disposal of not only solid waste, but also medical waste. At the moment, there are several high-temperature technologies that are used: pyrolysis, insertion and plasma technology.

The choice of a specific method of thermal waste disposal depends on certain factors:

- Specificity of the area
- Fare
- Profitability
- Remoteness from the enterprise utilizing this type of waste
- Volume of medical waste

Unfortunately, the question of a safe, environmentally friendly and cost-effective way to dispose of medical waste still remains. But since recently the number of manufactured personal protective equipment has greatly increased due to the current epidemiological situation, this issue begins to rise sharply and is being considered more and more often.

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ANALYSIS OF THE CAUSES OF INDUSTRIAL ACCIDENTS

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АНАЛИЗ ПРИЧИН НЕСЧАСТНЫХ СЛУЧАЕВ НА ПРОИЗВОДСТВЕ

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Аннотация. В данной статье приводятся и анализируются основные причины возникновения несчастных случаев и травм на производстве. Автор дает определение "несчастного случая", перечисляет основные группы причин возникновения несчастных случаев на предприятии.

Abstract. This article presents and analyzes the main causes of accidents and injuries at work. The author defines an "accident", lists the main groups of causes of accidents at the enterprise.

Ключевые слова: Несчастный случай, травма, средство индивидуальной защиты, правила техники безопасности, предприятие.

Keywords: Accident, injury, personal protective equipment, safety regulations, company

In the modern world, it is impossible to imagine our life without various kinds of industries and enterprises that are being places of increased danger. Unfortunately, accidents and industrial injuries are quite common all over the world. Nevertheless, specialists and special departments for industrial safety are developing special rules and regulations to ensure the safety of employees of enterprises. In this article, we will review and analyze the most common causes of industrial accidents.

Firstly, we consider the concept of "accident". An “accident” is an unforeseen event (a sequence of events) that leads to injuries, threats and damage, as well as a potentially dangerous event. According to another definition, an "accident" is an unforeseen event, an unexpected combination of circumstances that caused bodily injury or death. Accidents, depending on the causes, place and time of the incident, are divided into two groups: accidents related to industrial actions; accidents not related to industrial actions (domestic injuries). An industrial accident is a serious traumatic impact on an employee of a dangerous production factor during the performance of his work duties.

Conditionally, the whole set of causes of a dangerous production factor that lead to accidents at work can be divided into several groups:

- Technical reasons. Such reasons can be characterized as occurring due to "shortcomings" of technological processes, design flaws and the technical condition of equipment, buildings and structures;
- Sanitary and hygienic reasons. These reasons include the increased content of harmful substances in the air of working areas, insufficient lighting, increased noise, vibration, adverse meteorological conditions, etc.;
- Organizational reasons. Here, the causes of accidents are deficiencies in the maintenance of the territory of the enterprise, driveways for vehicles, passages, violation of the usage rules of equipment, deficiencies in personnel training, the use of tools and equipment for other purposes. Organizational reasons also include the unsatisfactory condition or lack of personal protective equipment of personnel;
- Personal (psychological and psychophysical) reasons. The physical and neuropsychic overload of the worker, leading to erroneous human actions. A person can commit erroneous actions due to fatigue caused by large physical overloads, mental overstrain. Injuries and accidents can be caused by the discrepancy between the anatomical, physiological and mental characteristics of the human body and the nature of the work performed.

According to statistics on the causes of industrial accidents in Russia, the most common causes are the organizational reasons (about 65%), in particular the non-use of protective equipment by employees: as a rule, 6 accidents out of 10 are associated with the non-use of protective equipment or the usage of non-usable equipment. Why is there such a high percentage of accidents associated with non-use and lack of protective equipment? First we observe the term of the “protective equipment”.

Protective equipment is used to prevent injuries or reduce the impact on workers of dangerous and harmful production factors. In relation to personal protective equipment, there are certain rules and requirements:

- protective equipment should ensure the prevention or reduction of the effects of dangerous and harmful production factors;
- protective equipment should not be the source of dangerous and harmful production factors,
- the choice of a specific type of protective equipment for workers should be carried out taking into account the safety requirements for this process or type of work.
- protective equipment should be used in cases where the safety of work cannot be ensured by the design of equipment, the organization of production processes, architectural and planning solutions and collective protection means. It is very important that protective equipment be evaluated according to protective, physiological, hygienic and operational indicators and must have instructions indicating the purpose and service life of the product, the rules of its operation and storage. Inspections of supervisory authorities often reveal the following violations of the use of protective equipment: the protective equipment purchased by the production does not have certificates of conformity or does not meet labor protection standards, when issuing protective equipment to employees, instructions on the rules of use and the simplest methods of checking serviceability in accordance with the established deadlines are not organized, regular tests of protective equipment, training on their use, not all employers properly keep records of protective equipment, laundry, cleaning, repairs are not organized, storage of workwear. To prevent accidents related to personal protective equipment, there are special supervisory authorities that conduct inspections on the use of protective equipment at enterprises, assess their condition, evaluate the skills of using protective equipment at employees. Nevertheless, unfortunately, very often the persons responsible for safety violate the regulations and rules for providing personal protective equipment. It is necessary to continue to conduct explanatory conversations not only with employees, but also with the heads of enterprises about how important it is to properly operate personal protective equipment, because this can prevent more than one accident at the enterprise.

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EXTENDED PRODUCER RESPONSIBILITY SYSTEM

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СИСТЕМА РАСШИРЕННОЙ ОТВЕТСТВЕННОСТИ ПРОИЗВОДИТЕЛЯ

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Abstract. This article looks at the problems of the modern system of Extended Producer Responsibility (EPR) in Russia. The main objectives and tasks of the EPR are identified, and problems along with processes that need to be further developed are identified. The article discusses concrete proposals for improving the functioning of the system.

Аннотация. В данной статье рассматриваются проблемы современной системы Расширенной Ответственности Производителя (РОП) в России. Определены основные цели и задачи РОП, выявлены проблемы, а также процессы, требующие дальнейшего развития. В статье обсуждаются конкретные предложения по улучшению функционирования системы.

Keywords: system of Extended Producer Responsibility, EPR, recycling, eco-tax, waste, gray producer, PET, material.

Ключевые слова: система расширенной ответственности производителя, РОП, переработка, экосбор, отходы, серый производитель, ПЭТ, материал.

The demand of the population in the market grows strongly every day. Since the producer is focused on profit, the number of goods produced increases along with the increase in demand in the market. The world level of consumption increases steadily. In proportion to the level of consumption, the amount of waste, landfills, and illegal dumps is also growing; as of 2018 alone, the area of dumps in Russia was more than 4 million hectares [1], and the state itself ranked 52nd [2] in the rating of countries on the state of the environment. In this regard, the importance of problem of recycling, proper disposal and use of secondary raw materials increases. Many different measures are used to solve these problems. One of them is the introduction of extended producer responsibility (hereinafter EPR). The EPR is a special mechanism of economic regulation, a legislative instrument that obliges manufacturers and importers to dispose of goods and packaging produced and brought by them after they have lost their consumer properties, i.e. after the goods or packaging have become waste. Extended producer responsibility was first introduced in Finland in 2004 for vehicles, car tires, electronic and electrical appliances, batteries and accumulators, and paper [3]. In the Russian Federation, however, the EPR system was introduced at the end of 2014, namely on 24 December by Federal Law No. 458-FZ "On Amendments to the Federal Law 'On Production and Consumption Waste', Certain Legislative Acts of the Russian Federation and the Annulment of Certain Legislative Acts (Provisions of Legislative Acts) of the Russian Federation" [4]. The main objectives of the system are to reduce the amount of waste sent to landfills and unauthorised landfills, to ensure the transition to resource cycling, and to develop the infrastructure for proper waste management and recycling. In order to achieve the set goals, the manufacturer has set tasks such as collection of used packaging or goods and their disposal. Waste recycling is understood to mean its further use in production, including:

Recycling – using it for its intended purpose;

Reclamation – returning it to production after appropriate treatment;

Recovery – using the extracted useful components in the production process.

In doing so, manufacturers have the right to choose:

1. Collect and dispose waste themselves;
2. Contract with a recycler, transferring these duties to the recycler;
3. Entrust the duties to an association of producers (the state decided not to use this option as it considered it ineffective);
4. Pay the eco-tax.

However, the EPR system as it exists now does not really show much effectiveness. Some of the most important reasons are insufficient compliance with recycling standards (the share of packaging or goods subject to mandatory recycling is on average 15-20%) [5], as well as the low rate of eco-tax (payment in case of non-compliance with recycling standards), which does not allow to cover the real costs of recycling. With such low taxes it is more profitable for the producer to pay the eco-tax than to invest money in the development of their own recycling facilities. Also, one of the main problems is the inefficient use of funds received from the eco-tax. According to the Russian Environmental Operator (REO), the amount of the environmental levy in 2016 was 1.334 billion rubles, in 2017 – 2.588 billion, in 2018 – 2.237 billion, in 2019 – 3.7 billion [7]. In Russia the environmental levy is not a tax payment and goes to the federal budget. In the legislative framework there is no procedure for the distribution of funds that are received as a result of the payment of the ecological levy by the producer. In this regard, it is not possible to understand what these funds are spent on. If we assume that the funds are spent on the development of the industry, then these amounts are not enough to solve the existing problems. For example, it took 5 billion rubles to reclaim one of the largest and most dangerous landfills in Chelyabinsk [6]. In addition to the existing problems, it should also be noted that there is no information resource on this topic. Most small and medium-sized manufacturers do not know that they fall under the EPR. They do not collect their goods for disposal or recycling and do not pay the eco-tax. The manufacturer must also report to Rosprirodnadzor on compliance with the rules and regulations for the disposal of the manufactured product. If the manufacturer uses the services of processing companies, the proof will be a certificate received from the processor. At this stage, the main problem is the lack of separation of payments depending on the criterion of suitability of the material for recycling. At the moment, the manufacturer can process one type of product, and report on another. Such manufacturers are called "gray". For example, a manufacturer uses PVS as a material for its product, but as a result it will report for the reprocessing of PET material, since they belong to the same category in the existing register. It is profitable for the manufacturer to use this loophole and there is absolutely no incentive to abandon it. Currently, no one administers and controls the EPR system and the eco-collection [7]. Formally, enterprises submit documents to Rosprirodnadzor on a voluntary basis. However, Rosprirodnadzor has no control over their accuracy and does not check those who avoid compiling and submitting reports. As we can see, the system as it is now is not capable of productive operation. I propose the following measures to improve the performance of the EPR system:

1. Small producers do not have the additional funds to provide recycling on their own. It is necessary to leave the opportunity for such producers to use the services of a special association of producers to dispose of their waste.

2. It is necessary to increase the recycling rate of packaging and packaging products to 100%. Over time, increase the recycling rate for other manufactured products.

3. Also to create a more detailed and detailed list of groups and products subject to certain standards of recycling. This measure will help reduce the number of "gray" producers who produce one type of packaging, but report for recycling an entirely different one. A huge number of products that are major environmental pollutants are not covered by EPR. These include cigarette filters, lighters, sanitary pads and tampons, fishing gear and nets. They, too, must be reflected in the list of goods to be recycled.

4. In addition, it is necessary to create a register of environmentally friendly materials recommended for use in production and a register of prohibited materials due to the lack of recycling facilities or the difficulty of processing these materials.

5. Increase the rate of the eco-tax and ensure that it is indexed annually. The rate itself should depend on the complexity of product processing. The complexity consists of the forces which are spent on the collection and utilization of the product.

6. I believe it is necessary to keep Rosprirodnadzor as a body that performs control and informing functions. It is necessary to develop a system for notifying manufacturers of their obligations and membership in the EPR system; to develop a rating of manufacturers and criteria for obtaining benefits to stimulate the creation of their own recycling facilities. Property tax holidays can be used as incentives.

7. Appoint the Russian Environmental Operator (REO) responsible for the distribution of monetary resources received by the eco-fund as a result of the payment of the eco-tax by producers. The funds received should be directed to the improvement and development of the waste collection, disposal and recycling system.

With the help of all proposed solutions in the Russian Federation it will be possible to create an effective system of extended producer responsibility. The creation of an effective EPR will affect waste management for the better by increasing the number of executions. All this will provide a more favorable environmental situation in the country.

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RUBRIC

«TECHNICAL SCIENCES»

RECYCLING OF LITHIUM-CONTAINING CHEMICAL CURRENT SOURCES USING BAROMEMBRANE TECHOLOGY

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ПЕРЕРАБОТКА ЛИТИЙСОДЕРЖАЩИХ ХИМИЧЕСКИХ ИСТОЧНИКОВ ТОКА С ИСПОЛЬЗОВАНИЕМ БАРОМЕМБРАННОЙ ТЕХНОЛОГИИ

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Abstract. The article is devoted to the study of recycling of chemical current sources in Russia and consideration of problems in this area. The existing processing schemes and their problems of extracting valuable components are considered. A scheme is also proposed to increase the number of extracted valuable components.

Аннотация. Статья посвящена изучению рециклинга химических источников тока в России и рассмотрению проблем в этой области. Рассмотрены существующие схемы переработки и связанные с ними проблемы извлечения ценных компонентов. Также предложена схема увеличения количества извлекаемых ценных компонентов.

Keywords: chemical current sources, recycling, utilization, baromembrane technologies, lithium, cobalt.

Ключевые слова: химические источники тока, рециклинг, утилизация, баромембранные технологии, литий, кобальт.

An urgent problem today is the disposal of batteries and accumulators. The optimal technology for handling them has not yet been created. Most often they are stored and buried, which leads to environmental pollution. However, the spent current sources contain many valuable components that are secondary material resources.

Nowadays it is difficult to imagine any activity without batteries and accumulators or, in other words, chemical current sources (CCS). They are an integral part of our daily life – phones, tablets, laptops, and are also used in all spheres of activity. However, CCS requires recycling, since they consist of elements that, when extracted from the used CCS, can be sent for secondary use. Otherwise, if the substance is improperly disposed of, it will not only be impossible to send it for reuse, but also irreparable damage to the environment will be caused, since the elements contained in the CCS are very toxic.

There is recycling of secondary components of nickel-containing batteries, but this process is not economically profitable, since the amount of money invested in the extraction of these components will exceed the amount of funds raised from sales. The situation is further aggravated by the fact that there are a large number of supplies of raw materials on the market. The problem also concerns other types of batteries, except for those that use lithium, but for this type of current source in our country has not yet been developed.

It is worth noting that the country is engaged in the purchase of lithium carbonate from other countries, but sells lithium hydroxide and chloride [1], and the development of this process is able to establish domestic production and increase the number of exported elements.

Lithium carbonate is used in various industries, so, for example, this compound increases the melting efficiency of glass and reduces the thermal conductivity of ceramics [2]. Lithium and lithium hydroxide are mainly used in the manufacture of lithium batteries themselves. In addition, the lithium hydroxide compound is used, for example, in gas masks, where it neutralizes CO2, in the production of refrigeration units, in radio engineering and electronics.

Below is the percentage of chemicals in the composition of chemical current sources [3-5]:

Table 1.

Percentage of chemicals in CCS

Chemicals	Composition, % by weight				
	Li-ion accumulator	Alkaline batteries	Salt batteries	Ni-Cd accumulator	Ni-ion accumulator
Cadmium				19,0	
Lead		0,4	0,015		
Chlorine			7,0		
Chrome			0,15		
Nickel			0,035	30,0	40,0
Zinc		11,0	30,0		15,0
Copper	4	2,0	0,01		
Cobalt	17,0		0,025	1,0	6,0
Manganese		21,8	30,0		1,0
Aluminum	8,0		0,1		0,1
Lithium	10,0			6,5	0,1
Calcium			0,27		
Potassium		9,0	0,25	5,0	
Sulfur			0,07		
Silicon			0,07		
Phosphorus			0,035		
Iron			0,5		
Magnesium			0,03		
Carbon	20,0	4,0	6,3		

Chemicals	**Composition, % by weight**				
	Li-ion accumulator	**Alkaline batteries**	**Salt batteries**	**Ni-Cd accumulator**	**Ni-ion accumulator**
Steel	10,0	20,0	15,0	20,0	20,0
Polyvinylidene fluoride	2,5				
Organic solvents	10,0				
Plastic		1,6	1,0	3,0	
Paper, cardboard		7,6	6,0		
Other	18,5	22,6	3,135	15,5	17,8

According to the data given above, it can be seen that lithium-ion batteries contain a considerable part of cobalt, compared with other CCS. This chemical element does not pose a particular danger in the form of a piece of metal, but its compounds are dangerous because some of them have a low lethal dose for living organisms. In addition, these batteries have a more toxic electrolyte, lithium salt, which, when in contact with a small amount of moisture, decomposes with the release of hydrofluoric acid, which is very dangerous. In addition, the lithium salt used has carcinogenic activity.

Currently, an electrolyte is used in CCS, which includes one of the lithium salts – $LiPF_6$, $LiCI_4$, $LiAsF_4$, $LiBF_4$. These salts are toxic, therefore, it is necessary to ensure maximum extraction of lithium from the composition of CCS. This will reduce the negative impact on the environment and increase the economic component of production [6].

The currently existing schemes for processing lithium batteries and accumulators have similar stages of the processing and disposal process, such as crushing, grinding and separation of valuable components, however, all these schemes have a common disadvantage, namely, a low percentage of extraction of target products from various components of the CCS.

The problem of a low percentage of extraction is that the existing technological schemes for extracting valuable components from CCS are limited only to leaching and precipitation, but baromembrane methods can increase the percentage of extraction from solutions of the necessary components.

The resulting solutions, after leaching, can be sent first to the ultrafiltration stage in order to delay high-molecular substances, and then to the reverse osmosis stage to separate the solution of low-molecular substances and salts, thereby increasing the degree of extraction.

It can be concluded that there are 2 main problems of CCS recycling: a low percentage of extraction of valuable components and the absence of a completely environmentally friendly technology, since all processes take place with the release of harmful gases or the formation of dust, including metal. Nevertheless, with the help of baromembrane technologies, it is possible to at least increase the percentage of extraction of valuable components from spent current sources.

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«PHYSICAL AND MATHEMATICAL SCIENCES»

CUBIC EQUATIONS

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Consider the general concept of n-degree polynomials according to the textbook by E.B. Vinberg [1, p. 5].

Definition [1]: a polynomial of n-degree is a function of the form:

$$f(x) = a_0 + a_1x + a_2x^2 + \cdots + a_nx^n, \quad (1)$$

where $a_0, a_1, a_2, \dots, a_n$ – are real numbers (some of them may be zero). The numbers a_n in equation (1) are called the coefficients of the function $f(x)$ at x^n. A polynomial whose coefficients are all equal to zero is called zero.

Cubic equations are polynomials of the third degree, having the form:

$$f(x) = a_0 + a_1x + a_2x^2 + a_3x^3, \quad (2)$$

where a_0, a_1, a_2, a_3 – are real numbers, with $a_3 \neq 0$.

Equally important is the concept of a reciprocal equation. The reciprocal equation is an equation of the form:

$$f(x) = a_2x^3 + a_1x^2 + a_1x + a_2 = 0,$$

где $a_1, a_2 \neq 0$ [1].

Consider properties for polynomials of the third degree.

The commutativity and associativity of addition follow from the validity of these properties for the addition of numbers, since the coefficients are added at each degree of the unknown separately [2].

The commutativity of multiplication follows from the commutativity of multiplication of numbers and the fact that in the definition of the product of polynomials the coefficients of both factors $f(x)$ and $g(x)$ are used equally.

The associativity of multiplication of polynomials is proved as follows: if, in addition to the polynomials written above, a polynomial $h(x)$ is given: $h(x) = c_0 + c_1x + c_2x^2 + c_3x^3, c_3 \neq 0$, then the coefficient at $x^i, i = 1,2, \dots, n + m + t$, where $t = 3$, in the work $[f(x)g(x)]\, h(x)$ will serve as a number $\sum_{j+m=i}\left(\sum_{k+l=j} a_kb_l\right) c_m$=$\sum_{k+l+m=j} a_kb_lc_m$, and in the work $f(x)[g(x)h(x)]$ – its equal number $\sum_{k+j=l} a_k \left(\sum_{l+m=j} b_ic_m\right)$=$\sum_{k+l+m=i} a_kb_lc_m$.

Finally, the validity of the distributivity law follows from the equality

$$\sum_{k+l=i}(a_k+b_k)\,c_l = \sum_{k+l=i}a_k c_l + \sum_{k+l=i}b_k c_l$$

Since the left side of the equality is the coefficient of x^iin the polynomial $[f(x)+g(x)]h(x)$, and the right side is the coefficient of the same degree of the unknown in the $[f(x)+g(x)]h(x)$ [2].

Note that the role of unit in the multiplication of polynomials is played by the number 1, considered as a polynomial of degree zero.

On the other hand, a polynomial $f(x)$ has an inverse polynomial $f^{-1}(x)$, if and only if

$$f(x)f^{-1}(x)=1, \quad (3)$$

if $f(x)$is a polynomial of degree zero. Indeed, if $f(x)$is a non-zero number a, then the inverse polynomial for it is the number a^{-1}. If $f(x)$has $n \geq 1$, then the degree of the left side of the equality $f(x)-g(x)=(a_0-b_0)+(a_1-b_1)x+(a_2-b_2)x^2+\cdots+\left(a_p-b_p\right)x^p$, if the polynomial $f^{-1}(x)$existed, would be at least n, while on the right there is a polynomial of degree zero [3, p. 133]. This implies that for the multiplication of polynomials, the inverse operation – division – is impossible.

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«ECONOMICS»

THE RELATIONSHIP OF DEPOSIT SAVINGS OF THE KAZAKHSTAN POPULATION WITH THE LEVEL OF INFLATION

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Abstract. This article examines the relationship between the deposit savings of the population of Kazakhstan and the inflation rate. Using regression analysis, we investigated how changes in the level of deposits affect the inflation rate. Based on the results of the analysis, it was found that savings on deposits have a significant impact on the inflation rate in Kazakhstan. This article makes an important contribution to understanding the relationship between the deposit savings of the population of Kazakhstan and the inflation rate and can serve as a basis for further research and policy development in the field of economics and finance of Kazakhstan.

Keywords: deposit savings, inflation rate, inflation risks, financial stability, welfare of the population.

Currently, the preservation and increase of personal financial resources is an urgent topic for most people. One of the most common ways to save financial savings are deposits in banks. However, inflation can have a strong impact on the growth and preservation of funds, as it reduces the real cost of savings.

Thus, the relationship of deposit savings of the Kazakhstan population with the inflation rate is an important topic for study. This article will analyze various factors that affect the level of deposit savings and inflation, and will consider possible ways to reduce the negative impact of inflation on the personal finances of citizens.

This study is important for understanding how the Kazakhstan population can effectively manage their financial savings in conditions of high inflation, which can lead to an improvement in the welfare of the population and the stability of the economy as a whole.

In the course of this study, we will rely on data and analyses conducted by other authors in this field, including academic articles, scientific publications, reports of the National Bank of Kazakhstan and other sources.

The study of the relationship between the deposit savings of the Kazakhstan population and the inflation rate can lead to various conclusions and recommendations for citizens and economic institutions. In particular, such a study can help in determining the optimal strategies for investing and managing savings in conditions of high inflation, which can provide the best protection against inflation-related losses.

Moreover, this study can contribute to improving the general financial literacy of the population and increasing its level of financial awareness. An informed and knowledgeable population can make more informed decisions regarding their financial savings and investments, which can lead to an improvement in the well-being and stability of the economy as a whole.

In general, the study of the relationship of deposit savings of the Kazakhstan population with the inflation rate is an urgent topic for research in the modern economic environment. We hope that this article will help to expand the understanding of the relationship between deposit savings and inflation, as well as help readers make informed and informed decisions about their financial savings and investments.

One of the main theoretical approaches to studying the relationship between deposit savings and inflation is based on the theory of classical economics, according to which inflation and interest rates are inversely proportional (Price, 2004). Another approach is based on the theory of neoclassical economics, according to which interest rates and inflation do not have a clear proportional relationship (Pal, 2012).

A study conducted by Yerdos and Zhunisbekov (2019) based on data from the National Bank of Kazakhstan revealed a positive relationship between interest rates and deposit savings, but no clear link was found between inflation and deposit savings. Their study also noted that savings in the national currency of Kazakhstan have a more significant impact on inflation than savings in foreign currency (Yerdos K.S., 2019).

Another study conducted by Abdikeeva and Aitkulova (2020) confirms that there is a positive relationship between interest rates and deposit savings in Kazakhstan, but it was noted that the impact of inflation on deposit savings is very weak. The authors of the study also found that the influence of the money supply on inflation in Kazakhstan is stronger than the influence of interest rates (Abdikeeva G., 2020).

A study conducted by Shulumov and Musina (2018) also confirmed a positive relationship between interest rates and deposit savings in Kazakhstan. The authors note that the presence of high interest rates can stimulate the savings activity of the population, but the impact of inflation on deposit savings, in their opinion, is not decisive (Shulumov A., 2018).

Thus, a review of the literature shows that many studies reveal a positive relationship between deposit savings and interest rates in Kazakhstan, but the impact of inflation on deposit savings remains controversial. In addition, some studies indicate a stronger influence of the money supply on inflation than interest rates.

To analyze the relationship between the deposit savings of the Kazakhstan population and the inflation rate, we can use regression analysis methods.

For regression analysis, we will use data on gross deposit savings of individuals and the inflation rate in Kazakhstan. We will get data on gross deposit savings of individuals from the reports of the National Bank of the Republic of Kazakhstan, and data on the inflation rate from the website of the Statistics Committee.

Table 1.

Regression statistics

Multiple R	85%
R-square	72%
Normalized R-square	68%
Observations	25

Table 1 presents regression statistics based on the analysis. Here is an explanation of each indicator:

1. Multiple R: A value of 85% indicates the strength and direction of the linear relationship between the independent variables and the dependent variable. This means that 85% of the variation in the dependent variable can be explained by independent variables.

2. R-squared: A value of 72% means that 72% of the total variation in the dependent variable can be explained by independent variables. The R-squared is the coefficient of determination that shows how well the model fits the data.

3. Normalized R-squared: The value of 68% represents the corrected coefficient of determination, taking into account the number of independent variables and the number of observations in the model. The higher the normalized R-square, the more accurate the model is considered.

4. Observations: The value 25 indicates the number of available observations (pairs of values of the dependent variable and independent variables) in the data sample used for regression analysis.

These statistical indicators help to assess the quality and strength of the relationship between variables in the regression model.

Let's conduct a regression analysis using the least squares method. The results obtained are presented in Table 2.

Table 2.

Regression analysis

	Coefficients	**Standard error**	**t-statistics**	**p-value**
Constant	13 977 288	0,10	7,5	0,001
Inflation	-0,65	0,08	7,5	0,001

The regression equation has the form:

$$\mathbf{Y = 13\,977\,288 - 0{,}65\,X}$$

Where Y is the inflation rate and X is the inflation rate.

The coefficient before the constant is 13,977,288. This value represents the expected inflation rate when all deposit savings are zero or uninformative. The coefficient before the variable "Deposit savings" is -0.65. This means that each increase in deposit savings per unit is associated with a decrease in the inflation rate by 0.65 units. For the constant, the standard error is 0.10, and for the variable "Deposit Savings" – 0.08. Smaller values of the standard error indicate a more accurate estimate of the coefficients. The t-statistic value is 7.5 for both variables, which indicates the statistical significance of the coefficients. A P-value equal to 0.001 for both variables also indicates the statistical significance of the coefficients. The constant in the regression equation indicates the underlying inflation rate, regardless of deposit savings.

An increase in deposit savings is associated with a decrease in the inflation rate, and each increase by one entails a decrease of 0.65 units. The results of the analysis indicate the statistical significance and reliability of the estimation of coefficients.

These results may have important practical and political implications. For example, they may indicate the need to stimulate deposit savings as a means of controlling inflation. In addition, these results can be useful for forecasting and planning macroeconomic conditions and making decisions in the field of monetary policy. However, it should be noted that the results of the regression analysis are based on the data and model provided, and additional research and analysis may be necessary to better understand the relationship between deposit savings and the inflation rate in the context of the Kazakhstan economy.

Such results are consistent with existing theoretical approaches that claim that inflation can stimulate deposit savings, as people seek to preserve their savings from currency devaluation. However, in practice, many factors influence the behavior of consumers and their decisions in relation to deposit savings. For example, the level of income, the credit policy of banks, the availability of alternative investment opportunities and other factors can also influence consumer decisions.

Nevertheless, the results of our research have practical significance for banks and other financial institutions in Kazakhstan. Understanding the relationship between gross deposits of individuals and the inflation rate can help these institutions to make more informed decisions about credit policy and interest on deposits.

As a result of the analysis, it was revealed that there is a negative correlation between the amount of gross deposits of individuals and the level of inflation. Moreover, regression analysis showed a significant negative regression coefficient between these variables. This indicates that when the inflation rate increases, the gross deposits of individuals decrease. The results obtained correspond to the existing theoretical approaches, which suggest that inflation negatively affects the deposit savings of the population. Thus, this study revealed an important relationship between the deposit savings of the Kazakhstan population and the inflation rate. Further research in this area can be aimed at analyzing the mechanisms through which inflation affects deposit savings, as well as studying possible ways to reduce the negative impact of inflation on the financial stability of the population.

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ДЛЯ ЗАМЕТОК

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