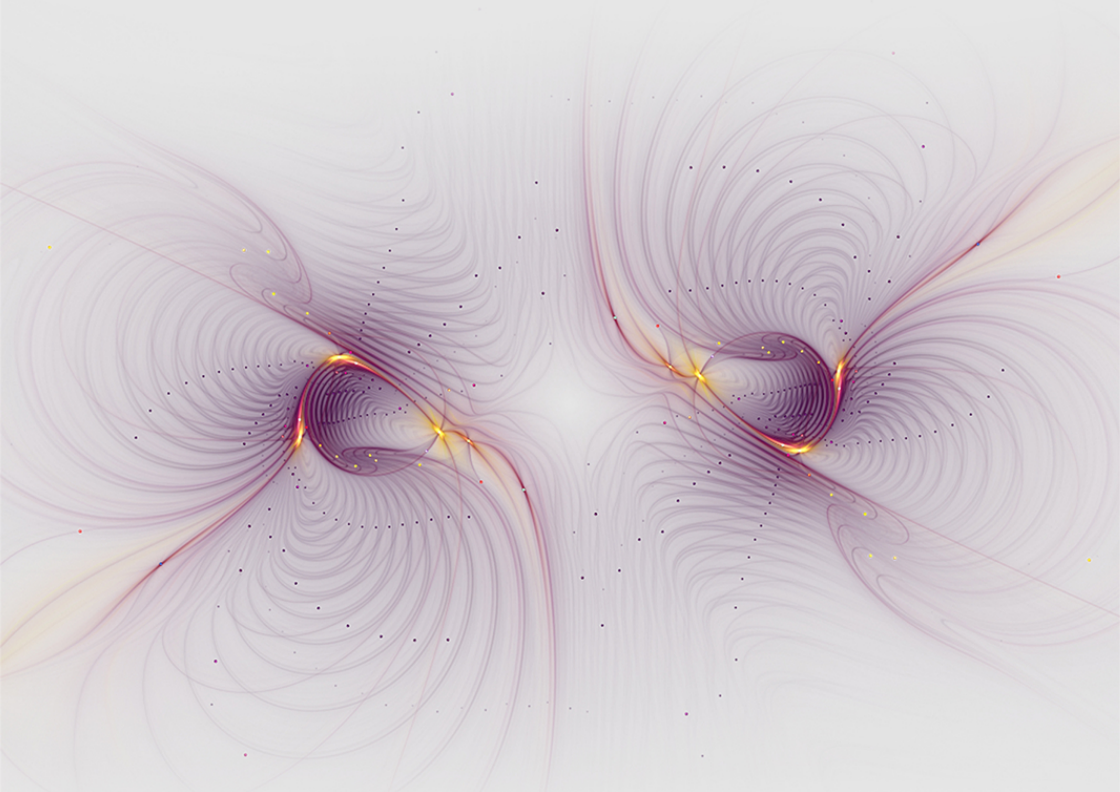
2nd International Scientific and Practical Conference

INNOVATIVE RESEARCH: TECHNOLOGY AND NATURAL SCIENCES

Prague March 10, 2023



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PREMIER Publishing

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INNOVATIVE RESEARCH: TECHNOLOGY AND NATURAL SCIENCES
Proceedings of the 2nd International Scientific and Practical Conference (March 10, 2023).
Premier Publishing s.r.o. Prague. 2023. 32 p.

ISBN 978-80-88612-11-7

The recommended citation for this publication is:
Konograi Olga A., Intermodal and Multimodal Container Services // INNOVATIVE RESEARCH: TECHNOLOGY AND NATURAL SCIENCES. The 2nd International Scientific and Practical Conference (March 10, 2023), Premier Publishing s.r.o. Prague. 2023. Pp. 25–31.

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Praha 8 – Karlín, Lyčkovo nám. 508/7, PSČ 18600

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Offset Paper. Garinitura Arno. Conv. Pec. liter. 14.
Typeset in Premier Publishing s.r.o. Prague, Czech Republic.
Printed by Premier Publishing s.r.o.

Section 1. Information technology

DOI: 10.5281/zenodo.7809712

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ARTIFICIAL INTELLIGENCE FOR DECISION MAKING IN THE SUPPLY CHAIN

Abstract. Artificial Intelligence (AI) is a technology that has the potential to significantly impact organizational decision-making. In Supply Chain (SCM), data analysis and organizational decision-making plays a crucial role in providing insights into various aspects of the supply chain such as, relevant goods, inventory levels, order processing times, delivery times, and transportation costs. By analyzing data, companies can identify inefficiencies in their supply chain and take corrective actions to improve performance. The SC system is a customer-oriented and integrated system that determines planning, administration, and management processes for internal/external material and related flows, formulating the optimal factor of added value. In this study, we aim to identify hazardous products by analyzing product identification information at customs checkpoints and locations where vendible items are delivered to customers. We have identified several commodity groups and substances that are potentially harmful and dangerous to human health.

Keywords. AI, SC, algorithm, Weka.

Introduction. Supply Chain is a complex and diverse system that dynamically changes with respect to various factors such as investment policy, scientific and technical development, supplier and customer concentration, geographical location of system users, demand and dynamics for products/services, competitive environment, and warehousing and transportation service costs. Due to the complexity of obtaining and processing information, managers cannot always achieve high levels of supply chain optimization and rationalization. The SC system is a completely integrated and customer-oriented system that determines planning, administration, and management processes for internal/external material and related flows, formulating the optimal factor of added value.

Main Part. Technological progress has brought new challenges to people regarding the healthiness of the products we consume daily because the amount of hazardous products has already reached its peak.

The economic potential of many little countries depends almost entirely on exports, and movement of material resources and reservation are related to significant resours labor inputs, which increases the cost of goods [1]. In some countries, local entrepreneurs and exporters add hazardous substances to the content of products, reducing operating expenses tied to the production of goods, making them cheaper, but significantly damaging human health and causing various diseases. Such products mainly include foodstuffs, building materials, clothing, toys, etc. In this study, we analyzed product identification information at customs checkpoints and locations where vendible items are delivered to customers to identify hazardous products. We highlighted several commodity groups and substances that are potentially harmful and dangerous to human health, and the table below shows three groups with subgroups of toxic elements and their admissible indicators.

Table 1.

Commodity group	Toxic elements		Admissible indicator	An indicator higher than allowed%	Customer age
Meat and meat products	Lead	A	0.1	28%	Adolescent and adult
	Arsenic	B	0.05	10%	
	Cadmium	C	0.3	28%	
	Grisin	D	Inadmissible	3–5%	
Milk and dairy products	Lead	A	0.05	26%	Adolescent and adult
	Arsenic	B	0.05	8%	
	Cadmium	C	0.02	11%	
	Pesticides	D	0.01	15%	
Toys	Antimony	A	0.75	29%	Adults
	Arsenic	B	0.4	14%	
	Cadmium	C	0.1	17%	
	Mercury	D	0.18	36%	

The accumulation of vast amounts of data on various household products enables us to leverage machine learning techniques to identify relevant data and take appropriate actions. After identifying and recording a product that is prepared for sale, a pre-designed algorithm is used to analyze the information. An operator at the Information Management Center analyzes the contents of the received message, identifies the main issue – the type of incident – and selects the category of toxic elements for which the permissible limit is pre-determined by the algorithm.

The recorded information is then transmitted to all active operators for a thorough analysis of the relevant data for each product. The operators' primary task is to identify the product that contains the most harmful concentrations. To achieve this, the data is preprocessed and analyzed, and appropriate Machine Learning algorithms are developed. However, during the primary data collection stage, we often have minimal control over the process, leading to the occurrence of anomalous data such as external spectrum values, unidentifiable data, incomplete data, and data inappropriate for learning.

Failure to filter out these anomalous cases while analyzing the data can result in erroneous conclusions. To process and analyze the data, we use the Python programming language, which has a vast ecosystem of third-party libraries, including NumPy, Pandas, and Scikit-learn, that provide advanced data processing and analysis features. Scikit-learn is a library for machine learning that provides tools for data modeling and predictive analysis.

We have broken down the data parameters into the following classifications, The following are examples of anomalous data that may occur during the primary data collection stage:

– External spectrum values, which include adverse effects that may arise during product transportation or violation of packaging requirements;

– Unidentifiable data;

– Incomplete data;

– Data that is not suitable for learning, such as information that is not related to product suitability.

If anomalous cases are not filtered out during data analysis, it can lead to inaccurate conclusions. To carry out data processing and analysis, we utilize the Python programming language due to its vast ecosystem of third-party libraries such as NumPy, Pandas, and Scikit-learn that offer advanced data processing and analysis features. Scikit-learn is a machine learning library that provides tools for data modeling and predictive analysis. In order to streamline the analysis process, we begin by eliminating "triage" actions which involve multiple operators processing information simultaneously.

We have categorized expiration date of the product under One Hot Encoding method, while we have selected the following transitional periods as categories: 1–5–14–30 days old;

We utilized the Python programming language in conjunction with a collection of machine learning algorithms that is known also as Weka for data analysis and visualization. Weka contains a diverse range of machine learning algorithms and tools that can be utilized for tasks such as data pre-processing, classification, clustering, association rules, and visualization. We utilized Weka's visualization tools to generate a graphical representation of the correlation coefficient for the data. The following visualization fragments provide an approximate model for the interdependence of the data.

Figure 1 illustrates the relationship between the concentration indicator and unacceptable quantities of permissible substances. Each point on the graph represents a separate case. The content of the substances not allowed in the product is filled with orange color, while those that are identified and marked with an admissible quantitative indicator are depicted in blue color.

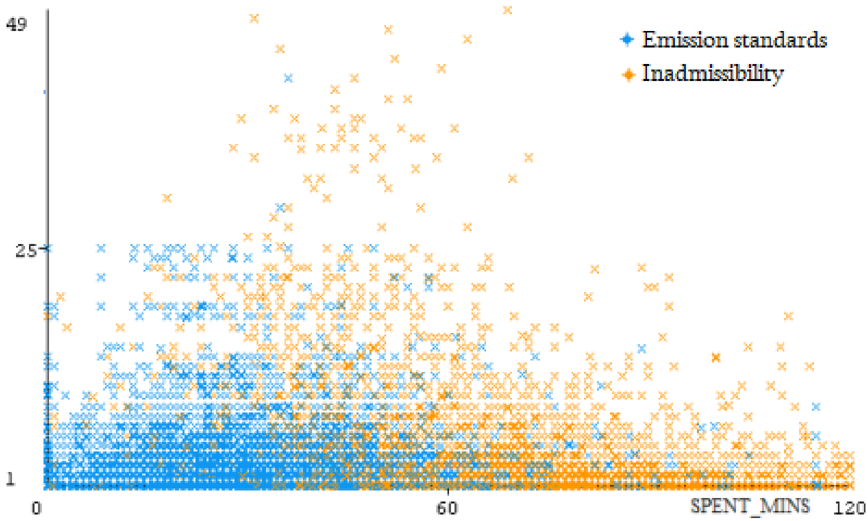

Figure 1.

The graph below (Figure 2) gives the result of the analysis carried out by different operators to identify one harmful substance.

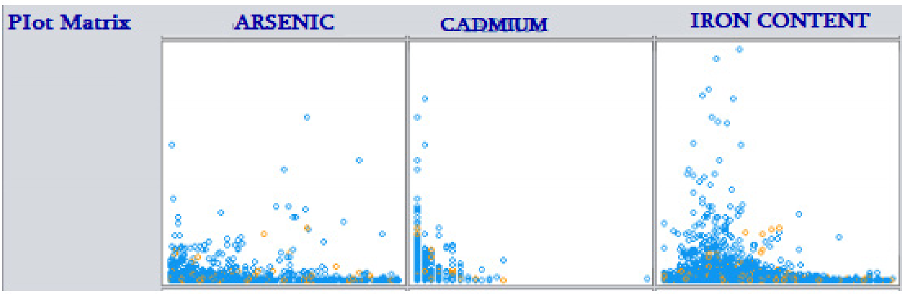

Figure 2.

The Weka tools enable us to analyze the product based on various parameters and visualize the results. However, one potential solution to address this issue is by using a smart contract in the transportation process. The contract can specify the requirement for a product that is safe for human consumption, and this condition can be verified using an artificial intelligence algorithm. The authenticity of the suppliers and carriers can be stored in a blockchain, and the terms of the mutual agreement can be determined using the smart contract. Before the final confirmation of the contract and the transfer of the service amount, the fulfillment of the conditions specified in the contract between the parties can be verified using a logically designed mathematical algorithm and program code [2].

Conclusion: Artificial intelligence (AI) is a highly recommended one of the most important technology for managing supply chains, as it is a powerful tool for monitoring and controlling the delivery of safe products. In this study, we employed the Python programming language to carry out extract, transform, and load (ETL) operations, and preprocess the data to obtain a structured dataset suitable for machine learning. By utilizing the Python programming language and Weka tools, we conducted an analysis of the dataset of a product exported. During the analysis, we identified, removed, and corrected anomalous cases that could potentially impact the accuracy of the machine learning results. Consequently, we obtained results that enhance the protection of consumers from hazardous products.

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Section 2. Pedagogy

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APPLİCABLE POSSİBİLİTİES OF PROJECT-BASED LEARNİNG İN BİOLOGY TEACHİNG

Abstract. The article emphasizes the general features and application of the project method in biology teaching and its rich values when used in education. It explains project-based learning opportunities that allow students to develop the ability in performing practical activities.

Keywords: project-based learning, student-oriented, problem-oriented, biology, project types, project characteristics.

One of the most important aims of education is to raise individuals who "learn to learn". Today, science and technology develop very rapidly and as a result, radical changes are experienced in education within the world globalization process.

Project-based learning approaches become more relevant over the years. Project means imagination, design, development, planning. Project-based learning may be defined as a learning way, a learning strategy, and a way of mastering the curriculum. Project-based learning is based on constructivismc [2, 47]. According to constructivist learning, the student is an active learner. Project-based learning also reflects Vygotsky's ideas. It proposes that concepts develop and understanding occurs when individuals engage in discussion and meaningful interaction with more skilled peers or teachers. These individuals can model problem solving, find solutions, and evaluate success [1, 66]. Project-based learning is an approach based on the idea of recognizing the problems encountered in life, understanding the importance of these problems and their causes, solving problems, and eliminating potential problems in advance which serves to think that learning should be comprehensive and competency-based. It has many features that distinguish it from traditional training. This responsibility consists of the stages of identifying the problems given, finding solutions, managing research, analyzing data, selecting data, integrating the data selected, and connecting old information with new information. Features of project-based learning include:

- Projects are student-oriented. Students have the autonomy to make decisions about all aspects of the project;
- Projects are problem-oriented. The problem plays a leading role in the organization of concepts and principles, then guides and directs activities;
- Expected results are cognitive and practical;
- Students interact with the real world through projects;
- Projects are carried out within the framework of cooperation. Projects require collaboration to achieve a goal;
- Projects usually involve multiple disciplines;
- Projects require a lot of time.

Project-based learning owes its origin to American philosophers who belonged to the pragmatic school of philosophy. The main supporter of this method was U. Kilpatrick [3, 161]. H. Kilpatrick's projects are divided into two parts, collective and individual. Collective projects are projects in which students work in groups. Individual projects are projects that students work on individually. Projects are divided into four groups: game projects, story projects, excursion projects, and business projects. Researchers distinguish a number of project types and classify them in different ways. The time limit in class doesn't always allow for a more in-depth and detailed study of the subject, therefore, research projects are conducted both in the classroom and in extracurricular activities. Perspectively, the projects used in biology teaching can be divided into three groups: course projects, extracurricular projects, and research projects. Projects in the class are carried out within 1–2 academic hours. In the project called "Proper nutrition", the most interesting of them, using food and its energy value – calorie and energy expenditure tables, students prepare an optimal individual menu, taking into account their needs and energy costs. Extracurricular projects are small research projects and the material can be used practically in the classroom. Research projects on "Energy drinks and their effects on the human body", and "Benefits and harms of food supplements" are quite interesting. Research projects are not only theoretical research on the topic of the study, it also includes a practical experimental part, sociological surveys, analysis, and students' independent results. The best research studies and projects are submitted to city and republic competitions, also posted on the subject website.

Different types of projects can be used in biology classes. Students are particularly interested in research projects aimed at studying the functioning and regulation mechanisms of organs and organ systems, for example, "Taste Hallucinations", "Health Formula", etc. The research project "Plants and animals – bioindicators of the environment" can be linked to the solution of environmental protection and regional ecological problems.

Topics related to genetics make it possible to create interesting and innovative projects. For example, in the project "My Genealogy (Pedigree Chart)", the aim is to familiarize with the method of genealogical research and to compile one's own family tree. Students first collect information about three generations from both sides of their parents, conduct an analysis of the characteristics of the signs, and hereditary character (recessive, dominant, autosomal). They determine the genotypes and phenotypes of the offspring. Students independently get knowledge from multiple sources of information while working on a project and as a result, communication skills are formed when applying knowledge in practice.

Designing creative projects requires maximum independence and a creative approach. However, the creative project has its own algorithm. Firstly, it is necessary to formulate ideas to define needs, put forward requirements for the design object, analyze them, and start planning and preparing the object. "Flower varnish", and "Creating crafts from waste materials" are examples of such projects.

In a role-playing project, problems and goals are definitely mentioned. In such projects, the result can't always be described at the beginning, it can only be determined at the end of the project. For example, the project "Acquaintance with the human body – organ system" is a role-playing game by its nature and content. Each student plays the role of a certain organ, talks about its functions and importance in the body, simulates different situations and their solutions.

Information projects are initially aimed at gathering information about any object and event, familiarizing the project participants with this information, analyzing it, and summarizing the facts. The structure of such a project can be shown as follows: the purpose of the project, sources of information, processing of information, result, and presentation. As an example of such projects carried out in biology classes, the creation of the film "Movement of single-celled animals (unicellular organism)" etc. may be shown. Such projects, and scientific-research projects, require a well-thought-out structure, the ability to make systematic adjustments during the course of the project. Such projects are often integrated into research projects and become their organic part, module.

Practical projects are aimed at the participants' own social interests. Such a project requires a well-thought-out structure, even defining the scenario of all the activities of its participants, the function of each, and the precise results of joint activity. Practical projects carried out in biology classes and extracurricular activities are "Cultivation, use and preservation of tubers (fungus)", "cultivation of plant seedlings", etc. The topics of biology projects may cover a wide variety of problems and issues, up to global problems facing humanity. The evaluation criteria of biology projects may be attributed to the following:

- accuracy of the set goal and task;
- thematic relevance and volume of the literature used;
- justification of selected methods for conducting research;
- analysis of the data obtained;
- the presence of conclusions or practical recommendations in the study;
- quality of work arrangement.

Consequently, note that Project-Based Learning helps students to better master the learning material, increases interest in the subject, helps to develop habits of working independently, creative approach to problem-solving, then working habits are formed with various additional information sources, methodical resources are created to be used both when learning new topics and repeating, also for individual correction of knowledge.

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Section 3. Technical sciences

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MEASURES TO PREVENT AND COMBAT COMPLICATIONS DURING FOUNTAIN AND GAS LIFT OPERATION OF WELLS AT GAS CONDENSATE FIELDS

Abstract. the article presents measure to prevent and a combat complication during fountain and gas lift operation of wells at the Altyguyi field, and also provides recommendations on dewaxing the elevator for the normal operation of fountain and gas lift wells. In addition, optimization of operated gas lift wells according to existing methods is presented.

These measures can serve as instructions for the prevention and control of complications during fountain and gas lift operation of wells at gas condensate fields.

Keywords: puncher, paraffin, plug, gas injection line, fountain, contour water, fitting, pollution, catastrophe, filter shank.

At the Altyguyi field, when choosing the gushing mode (the diameter of the fitting), it is necessary that the well has an optimal flow rate with a small gas factor, gives less water and sand, gushes calmly, without large pulsations. Only when these conditions are met, it is possible to ensure the most rational use of reservoir energy and long-term, uninterrupted gushing of the well.

When choosing the mode of operation of a fountain well, reservoir conditions are also taken into account – the proximity of contour water, the possibility of a plug in the well, the mode of the field itself, etc.

The main reasons for the disruption of the normal operation of fountain wells are the waxing of fountain pipes, the formation of a sand plug, corroding of the fitting, clogging of the fitting or ejection of paraffin complications, etc. [1].

Measures to restore the operation mode of wells are carried out depending on the reason that caused its violation.

When a sand plug is formed in the fountain pipes, which caused the buffer pressure to drop to zero and the supply is stopped, a liquid (oil) pump is flushed into the annular space to restore circulation and eliminate the plug.

A significant decrease in pressure in the annular space indicates the formation of a plug at the bottom and the appearance of water, the latter is detected by taking a sample from the jet. When water appears, it is necessary to increase the pressure on the face by reducing the diameter of the fitting. To eliminate the downhole plug, the well is allowed to work without a fitting or oil is pumped into the annular space.

The pressure drop on the buffer while increasing the flow rate of the well indicates that the nozzle is corroded by sand, in this case it is necessary to transfer the fountain jet to another outlet and immediately change the nozzle.

If the specified method fails to eliminate sand jams in the lifting pipes or at the bottom, then the well is stopped for repair work, after which it is put into normal operation.

Dewaxing of the elevator is the main way to ensure the normal operation of fountain wells. The largest amount of paraffin is deposited in the upper part of the lifting pipes, at a length of 400–1000 m from the wellhead and in the field oil collection system, in which paraffin deposition increases during the cold season. Several methods are used against waxing of lifting pipes. First of all, these are regime measures: reduction of pulsation and frequency of gushing, regulation of the gas factor in order to reduce it as much as possible.

If these measures do not give results, it is necessary to clean the lifting pipes from paraffin.

There are 3 types of cleaning from paraffin: mechanical, thermal, and chemical [2; 3].

Mechanical cleaning of pipes from paraffin is carried out during the operation of wells without stopping them with scrapers of various designs.

When exposed to heat, the lifting pipes are heated with steam, hot oil pumped into the annulus of the well without stopping it. The melted paraffin is carried out by a jet of oil to the surface, while the paraffin melts in the switch line. The thermal method does not prevent the deposition of paraffin in pipes, it is used sporadically, under favorable conditions and when for some reason it is not possible to use other more effective methods.

As a solvent of paraffin, it is envisaged to use condensate (gasoline), which is extracted at the Altyguyi deposit in sufficient quantities.

The most characteristic complications in gas lift mining are the appearance of sand and cork formation, the deposition of paraffin in lifting pipes and discharge lines.

Measures against sand entering the well are of a regime nature and are reduced to limiting depression, i.e. limiting oil extraction. The amount of liquid extraction from gas lift wells is regulated by changing the amount of injected working agent, the depth of immersion of lifting pipes or their diameter. To prevent the settling of sand during the periods of its greatest inflow from the reservoir, without interrupting operation, oil is pumped into the annulus in small portions by a mobile pump.

Sometimes the pressure of the gas injected into the well increases sharply when the liquid supply is stopped at the same time. This may occur due to the formation of a so-called cartridge sand plug in the lifting pipes, which blocks the section of the lifting pipes, preventing the mixture of oil and injected gas from reaching the surface. To destroy such a plug, gas is pumped not into the annular space, but into lifting pipes. If in this way it is not possible to push the plug from the pipes to the bottom of the well, then it is necessary to remove the pipes [4].

When wells are equipped with a single-row lift, it is finished with a shank of a smaller diameter than the main tubing string. The descent of the lifting pipes with a shank to the filter facilitates the conditions for the removal of sand by the liquid to the surface and prevents the formation of sand jams.

Measures to prevent paraffin deposits in lifting pipes during gas lift operation of wells, and methods for cleaning pipes from paraffin are similar to those used in fountain operation.

With the drop in reservoir pressures and the flooding of reservoirs at some stages of development in the gas condensate fields of the western part of Turkmenistan, it is planned to improve the gas lift. It is proposed to install a column of lifting pipes equipped with borehole chambers with gas lift valves (starting and working) located in them in the production column on the packer. This eliminates the influence of the injected gas on the flow of liquid into the well. It is planned to conduct research on optimizing the operating modes of gas lift wells according to known methods to determine the optimal flow rate.

It is also necessary to equip the gas lift gas distribution system with regulating and measuring equipment.

All the measures mentioned above are aimed at increasing and stabilizing gas lift production and reducing the volume of injected gas.

At the Altyguyi gas condensate field under development, the number of gas lift wells will increase with the expiration of the operating time, since with the cessation of well gushing, it becomes necessary to transfer them to a mechanized method [5].

Under the existing modes of gas lift lifts, the depth of the input of the working agent (gas) is in the range of 1400–3000 m, the gas input into the lift is carried out through holes (punchers) temporarily replacing the working valves.

Gas supply to gas lift wells is carried out from the gas pipeline via separate gas injection lines at operating pressures of 6.2–11 MPa.

Operated gas lift wells need to be optimized according to existing methods. According to calculations, in gas lift wells with a gas inlet point of 2300–2500, we accept a working pressure of P_{work} = 6.4; 7.4; 8.4 MPa, and in wells with a gas inlet depth of 3000–3500 m – 10–12 MPa. At the Altyguyi gas condensate field, it is necessary to implement a closed-cycle compressor gas lift with high-quality gas preparation for the needs of the gas lift and further gas supply to the export gas pipeline.

The issues of ecology and nature protection include restrictions on the external impact on the environment, preventing the loss of hydrocarbon resources during the extraction, carrying out technical and control measures.

Oil and gas enterprises occupy one of the first places among other sectors of the national economy in terms of the degree of environmental impact. Exploration and development of oil fields includes such technologies as exploration drilling, oil production, collection and preparation of hydrocarbons, transportation and processing.

The enterprises of the oil and gas industry have a harmful effect on all objects of nature, the atmosphere, the hydrosphere and underground and surface waters, the geological environment, drilled wells at all depths, on the land where they are located.

The cycle of oil and gas works consists of two main groups:

1. New construction sites (search and exploration, drilling, installation of equipment)
2. Working processes of the enterprise (collection, processing, shipment and processing of oil and gas)

When carrying out construction work, a report is made on technogenic pollution of the earth and the environment for technical reasons.

A report on the measures taken to protect the environment should be prepared by oil and gas producing organizations.

It should be noted that the time spent on exploration, drilling and preparation of oil and gas fields, the production time of the enterprise, pollution is caused for technical reasons.

The performance of these works causes high harm to the environment. Ecological catastrophes that occur are physical and mechanical impacts on soil, land, flora, fauna, soil, lowering of hydrogeological conditions, strengthening of soil erosion conditions, deterioration of living conditions of fauna and flora and local residents, and others.

Currently, geological studies have been completed at the Altyguyi gas condensate field and a field test plan has been prepared based on the data obtained.

When drilling wells in the fields, the environment is polluted mainly by some chemical elements used in the preparation of drilling fluids.

Currently, normal limit values, chemical elements indicating aggressiveness used in the preparation of drilling fluids have not been established.

During drilling operations, the source of atmospheric air pollution is diesel-fueled equipment that emits 2 tons of hydrocarbons and soot, 30 tons of nitrogen oxides, 8 tons of carbon monoxide and 5 tons of sulfur anhydrite into the atmosphere during the year. When drilling wells, drilling mud is mixed with soil layers, surface and groundwater, forming 30 m^3/day of water used.

During the development of wells, hydrocarbon mainly causes pollution. In most cases, oil-based circulating solutions with serious environmental consequences produce used wastewater, suspension and colloidal solution.

When preparing environmental protection measures during installation work in wells, it is necessary to avoid work that negatively affects natural objects. Since the sources of pollution are closely related to the technology used by the enterprise, it is necessary to establish the technology that has the least impact on the environment. When geochemical breakdown of the soil, it is necessary to perform the following:

- When preparing plots, it is necessary to prevent contamination of the topsoil from the products obtained;
- To collect sedimentary rocks of drilled rocks on slurry barns;
- It is necessary to cover the slurry barn;
- Restore the soil area of the extracted products;
- Road construction.

As a result of drilling operations, there is a negative impact on the hydrogeological change in the soils of the earth, and as a result, drilling fluids penetrate into aquifers, which lead to the formation of a complex of waters.

The waters used in drilling fluids are divided into three groups:

1. Water formed during the production of works;
2. Water for household work;
3. Atmospheric, rainwater.

Circulating waters are used to carry drilled rocks to the surface. In world practice, 95% of clay elements are mixed into the composition of circulating waters for the preparation of drilling fluids.

The quality of the flushing solutions used helps the speed of drilling operations, the prevention of complications with colmatation and water occurrence.

During the operation of producing wells and oil and gas collection facilities, the integrated safety and environmental protection system includes:

– monitoring of the condition of borehole fittings;

– selection of equipment and pipelines that meet the specified operating conditions, taking into account current regulations;

– periodic testing of equipment for strength (crimping);

– corrosion protection;

– prevention of technological complications that create emergency situations (gas communications flooding, deposition of paraffin and salts in wells and collection systems), with the use of special inhibitor substances.

When collecting and storing oil, the requirement of safety and reduction of hydrocarbon emissions into the environment are ensured at the stage of arming assembly points in compliance with building codes and regulations, with the necessary equipment of tanks with floating roofs or breathing valves, with mandatory collapse of tank farms to localize emergency oil spills.

When implementing the gas lift method of oil production, with a high manifestation of gas injected into the well to ensure safety and environmental protection, it is envisaged (in addition to the design and construction of the main facilities in full compliance with the required technological parameters of operation according to the current building codes and regulations) the construction and proper operation of additional technological equipment that provides a hydrate-free operation of gas distribution systems (furnaces for heating gas and inhibition unit). In the case of the construction of furnaces for heating hydrocarbons, make a preliminary calculation of atmospheric pollution by combustion products and assess the need to determine the MPC.

Storage and use of chemicals is planned to be carried out in accordance with their individual characteristics and in accordance with Safety Regulations (SR) in the oil industry, including providing employees with personal protective equipment (PPE), carrying out instructions and monitoring the condition of equipment used for the use of chemicals (surfactants, methanol, etc.).

The operation of electrical installations and heating equipment is provided in accordance with the current rules of SR and fire safety rules.

According to estimates, in oil fields with a similar technology of oil extraction and collection, the maximum concentrations of the above harmful substances at the border of the sanitary zone (within a radius of 1000 m from the source of emission) do not exceed the maximum permissible (MPC), which are set for each harmful substance individually according to the methodology of the State Committee for Hydrometeorology (OND-86).

In this regard, emissions of harmful substances into the atmosphere, subject to regular (accident-free) technological modes of operation of oil and gas field equipment, can be considered approximately corresponding to the maximum permissible emissions (MPI).

A detailed assessment of emissions for all fishing facilities is taken into account when compiling an environmental passport.

The environmental passport is being developed in accordance with GOST 17.0.0.04–90 "System of standards in the field of nature protection and improvement of the use of natural resources", which already gives the full technological cycle of this production from the supply of raw products to the finished product. At the same time, the presence of emissions, discharges and solid waste is carefully checked and calculated at each production facility and their impact on the environment is analyzed. All this material is described and calculated in the relevant chapters of the environmental passport. It also concludes that it is necessary to calculate the norms of MPD, the results of which are issued in the form of a second volume, but in the future, in the event of an increase in oil production due to Miocene-Paleogene and Mesozoic underlying red-colored sediments, it will be necessary to adjust all calculations on emissions.

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Section 4. Chemistry

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PRODUCTS OF VAPOR OXIDATIVE AMMONOLYSIS OF 4-CHLORO-o-XYLENE AND THEIR CHROMATOGRAPHIC ANALYSIS

Functionally substituted aromatic nitriles, including 4-chlorophthalonitrile, are perspective raw materials for the production of dyes, heat-resistant polyimide polymers and other important products [1]. Gas-phase catalytic oxidative ammonolysis is a single-stage efficient method for the synthesis of imides and aromatic nitriles [2]. Previously, the vapor-phase oxidative ammonolysis of o-xylene on a V-Sb-Bi-Cr/γ-Al_2O_3-oxide catalyst was studied to obtain phthalimide [3], as well as 4-bromo-o-xylene [4] and 4-phenyl-o-xylene [5] on the V-Sb-Bi-Zr/γ-Al_2O_3-oxide contact to obtain the corresponding phthalonitrile. It is important to add that, based on kinetic data, a mechanism for the formation of products of oxidative ammonolysis of both 4-bromo-o-xylene [6] and 4-phenyl-o-xylene [7] was proposed at this contact.

We [8] indicated the impossibility of comparing the transformations of 4-phenyl-, 4-bromo- and o-xylene during oxidative ammonolysis within the same reaction series. Therefore, a comparison under the same conditions of the reactivity of 4-phenyl-, 4-bromo- and o-xylene in vapor-phase oxidative ammonolysis was studied. To assess the reactivity, the conversion values of the starting materials were used and it was determined that these aromatic compounds are located in the following order in terms of reactivity: o-xylene> 4-phenyl-o-xylene> 4-bromo-o-xylene. An explanation is given that due to the prevailing role of the steric factor of the bulky phenyl radical in the adsorption stage and the electronic factor of the bromine atom in the kinetic region, it is impossible to compare the transformations of 4-phenyl-o-xylene and 4-bromo-o-xylene within the same reaction series, which determined the heterogeneity of the limiting stage and polar effects in these complex processes. For both substituted o-xylene in the process of oxidative ammonolysis, the kinetic control is not of the same type and, therefore, the applicability of the free energy linearity principle (FEL), i.e. the eligibility of using ρ-σ analysis or the proportionality (additivity) of the action of the electronic effects of substituents within the same reaction series is not fulfilled. However, when comparing under the same conditions the reactivity of o-xylene, 4-chloro- and 4-bromo-o-xylene in heterogeneous catalytic oxidative ammonolysis on a V-Sb-Bi-Zr/γ-Al_2O_3-oxide catalyst, the kinetic control is of the same type and, therefore, the actions of the electronic effects of substituents within the framework of one reaction series are performed [9]. In [10], the reactions of the vapor-phase oxidative ammonolysis of 4-chloro-o-xylene on oxide catalysts were studied and it was shown that, on all samples of catalysts, the chromatographic method identified as reaction products 4-chlorobenzonitrile, 4-chloro-o-tolunitrile, 4-chlorophthalonitrile, 4-chlorophthalimide and carbon dioxide. Compared with other oxides of metals of variable valence, upon modification of the base V-Sb-Bi/γ-Al_2O_3 oxide catalyst ZrO_2, the parameters of the process of oxidative ammonolysis of 4-chloro-o-xylene to obtain 4-chlorophthalonitrile turned out to be higher. Indeed, in the oxidative ammonolysis of 4-chloro-o-xylene on a V-Sb-Bi-Zr/γ-Al_2O_3 oxide catalyst, 4-chlorophthalonitrile is obtained with a selectivity of 86.42% at a 97.6% conversion of the starting 4-chloro-o-xylene (co-xy), i.e. the yield of the target dinitrile is 84.35% at T= 673K, contact time 1.87 s, = 1.24 kPa, = 7.80 kPa and = 61.91 kPa. In this case, 4-chlorophthalimide is formed with a yield of 2.88%, which is considered the second main product along with 4-chlorophthalonitrile. Since ortho-substituents create a steric tension that favors intramolecular cyclization, due to which an imide is formed from the substrate and dinitrile and under the influence of the polar effect, isolated transformations of xylenes occur with the formation of dinitriles [11]. The yields of the main products, being highly dependent on the process conditions and the catalyst used, are determined by the structure of the initial and intermediate substances [12]. Kinetic measurements were carried out on a setup with a 20 cm^3 non-gradient flow reactor made of 12Kh18N10T steel with a vibrofluidized catalyst bed. To prevent condensation of high-boiling products, a part of the installation was thermostated at 520–540 K. Oxygen and nitrogen were purified from traces of organic compounds and dried before use. Ammonia was passed through an oil filter. We used 4-chloro-o-xylene of chemically pure grade. 4-chlorophthalonitrile, 4-chlorophthalimide, 4-chloro-o-tolunitrile, and 4-chlorobenzonitrile were isolated from the products of oxidative ammonolysis of 4-chloro-o-xylene and purified by distillation [13].

In the reaction products, 4-chlorophthalonitrile, 4-chloro-o-tolunitrile, 4-chlorophthalimide, 4-chlorobenzonitrile, CO_2 and unreacted 4-chloro-o-xylene, oxygen, and diluent gas nitrogen were identified by chromatography. Chromatographic analysis was carried out according to the following scheme. The reaction gases were passed successively through 1, 4-dioxane traps to absorb nitriles, 4-chlorophthalimide, and 4-chloro-o-xylene and sulfuric acid to absorb ammonia. Analysis of carbon dioxide was carried out on an LKhM-8MD chromatograph. TEGNM on INZ-600 was used as a stationary phase. The separation of O_2 and N_2 was carried out on the same chromatograph on a parallel column with Na X. The ammonia concentration at the outlet of the reactor was determined from the results of titration of unreacted sulfuric acid in the second trap. Analysis of the products absorbed by 1, 4-dioxane was carried out on a Khrom-5 chromatograph with a flame ionization detector. As a stationary phase, which was filled in a column 1200 mm long and 4 mm in diameter, a mixture of Apiezon L (21%) and PEG-40000 (0.5%) was used on N–AW chromaton (0.2–0.25 mm) or polysorb-1 alone (0.25–0.5 mm). The flow rate of the carrier gas (nitrogen) is 80 ml/min. Sample inlet temperature 353 K, programmed temperature rise rate 20 deg/min. Chromatograms were calculated using the internal standard method (label-tetradecane).

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