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Development of the coagulant obtaining technology from substandard bauxite of Kazakhstan for wastewater treatment

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Abstract. One of the important environmental problems of Kazakhstan is the insufficient quality of natural and wastewater treatment, the reason for which is the lack of the main, mandatory reagent in water purification technology – coagulant. Aluminum-containing natural and man-made raw materials can be comprehensively processed in order to obtain modified mixed reagents-coagulants. One of the promising types of raw materials on the territory of Kazakhstan for the production of coagulants are substandard bauxites of the Krasnooktyabrsky deposit. This article presents a fundamentally new approach to the development of a technology for producing an effective coagulant with high coagulating properties in a wide pH range – a mixed sulfate aluminum-iron-silica coagulant (MSAISC) – when decomposing Red October bauxite with sulfuric acid with maximum extraction of aluminum, iron and silicon into a paste-like phase. Such a composition of the coagulant, called by us MSAISC (mixed sulfate aluminum-iron-silica coagulant) allows you to expand the range of action both in temperature and pH of the medium. In this sense, silicon coagulant, as well as modern aluminum polyoxychlorides, can be used without flocculant. The simultaneous presence of aluminum, iron and silicon salts in the composition of the coagulant makes it possible to combine the properties of «three in one».

Keywords: *bauxite, technology, coagulant, flocculant, water treatment, particle size distribution*.

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1. Introduction

The basis for sustainable development of the Republic of Kazakhstan is to ensure and realization of the right of the Republic of Kazakhstan to protect national interests in matters of development, use of its natural resources, as well as to reduce the impact on the environment, which can be achieved by solving socio-economic and environmental problems. One of the modern tasks of our time is the protection of water resources, which consists in the creation of drainless water supply systems, effective wastewater treatment, etc [1].

Among the methods of wastewater treatment, special attention should be paid to physical and chemical methods using coagulants. They are used to remove fine colloidal particles, petroleum products, radioactive substances, metal cations, and the disposal of valuable components. Natural compounds of aluminum and iron, their oxides or hydroxides, as well as waste from a number of industries containing salts of these metals are used as raw materials for the production of coagulants. Along with the public utilities, the main consumers of coagulants are the production of pigments, synthetic fibers, the pulp and paper, leather, textile, oil-producing industries and other industries [2-9].

Currently, the production of coagulants in Kazakhstan is practically absent, in the nearest neighboring states it is limited, and the deficit is replenished by importing Russian coagulants of an insufficiently wide range [10].

New types of coagulants obtained by Russian and Ukrainian scientists are known, which are difficult to introduce into production as a result of departmental barriers: mixed coagulant AWR (Al_2O_3 – 3.5%; Fe_2O_3 – 0.3%); ALG – aluminum sulfate without iron; aluminum oxychloride; aluminum polyoxychloride (POXA); «SIZOL» (OJSC «Aurat», Moscow; Institute of Bioorganic Chemistry and Petrochemistry of the National Academy of Sciences of Ukraine: coagulant-flocculant SIZOL-1 – for domestic wastewater and disinfection of sediments and industrial waters; SIZOL-2500 – for drinking water treatment; aluminum sulfate JSC «Aluminum of Kazakhstan» is supplied to Russia, displacing Ukraine, Finland, Sweden and China [11].

The main consumers of coagulants are: public utilities; pulp and paper industry; production of synthetic fibers; production of pigments; leather, textile, oil producing, mechanical engineering, energy, metallurgy and other industries [1-6].

The coagulant traditionally used to purify colored and turbid waters with a pH of 5-7.5. Aluminum sulfate is quite expensive and ineffective at a water temperature of +11ºC and during floods. In addition, there is another negative factor in the use of aluminum sulfate a change in the salt composition of the treated water, as a result of which the alkalini-

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ty and hydrogen index decrease and the sulfate content increases. This increases the corrosive activity of water, which reduces the service life of networks and water pipes and reduces their throughput. One of the main disadvantages of the coagulant – aluminum sulfate is significant amounts of residual aluminum in purified water [12].

Known methods of using mechanical mixtures of aluminum and iron salts as coagulants, many technologies have been developed for obtaining standard aluminum sulfate from various types of natural raw materials and production waste, but all technologies include limits for cleaning aluminum coagulant from iron impurities, the properties and behavior of mixed aluminum-iron coagulants in (AIC) have been poorly studied [11].

Currently, the production of coagulants in Kazakhstan is practically non-existent, and their deficit is covered by importing Russian coagulants of a poor assortment. The need is satisfied only by 50-60% by aluminum sulfate of the enterprise JSC «Aluminum of Kazakhstan», obtained from pure aluminum hydrate [12].

The development of technologies for obtaining and using new coagulants for treatment of natural and wastewater from substandard natural and man-made raw materials will allow obtaining the necessary products for all regions of Kazakhstan. It will effectively treat wastewater from natural and industrial complexes to the required standards and obtain high-quality drinking water, since the issues of effective treatment of drinking and wastewater in Kazakhstan are particularly acute and concern all its regions.

The methods for obtaining coagulants – purified and unrefined aluminum sulfates – include all methods of processing aluminum-containing raw materials using sulfuric acid.

Aluminum sulfate are the most important sorbents for purifying drinking water and fixatives in dyeing fabrics. The most common method for obtaining aluminum sulfate is the decomposition of pure chemical compounds with sulfuric acid, for example, aluminum hydrate – a semi-finished product of alumina production. Such aluminum sulfate complies with state standards, but the cost of it is high.

When obtaining a coagulant from natural raw materials, stages of purification of the aluminum sulfate solution from iron were required, which increased the cost of the production technology [12].

Currently, many methods for obtaining coagulants have been developed - mixed, unrefined from iron. In this case, the main raw material for obtaining coagulants can be any aluminum-containing raw material: bauxites, nepheline syenites, clay, kaolin; alumina-containing materials: thermal power plant ash and overburden clay rocks [1-11].

In terms of obtaining alumina acid methods are economically feasible for processing high-silicon aluminum-containing raw materials, allowing the removal of silica from the technological process at the head of the process flow chart [12]. If we consider these methods for obtaining a coagulant, then the process flow chart would be simplified by ignoring all subsequent stages of obtaining alumina after acid decomposition.

2. Materials and methods

Currently, Kazakhstan has a large reserve of aluminum-containing ores, including [13-14]:

– bauxites (kaolinite-gibbsite deposits);
– nepheline syenites (Kubasadyr and Ishim deposits);
– clays (Kostanay region);
– kaolin (Kostanay region);
– alumina-containing materials: thermal power plant ash and overburden clay rocks.

One of the promising types of raw materials for the production of coagulants is substandard bauxite, unsuitable for the production of alumina, having a high content of iron in the form of siderite and silicon.

Bauxite is a rock consisting mainly of aluminum and iron hydroxides with an admixture of aluminosilicates, titanium and calcium minerals and other impurities (magnesium, chromium, vanadium, etc.) in small quantities [14].

To obtain modified mixed coagulant-reagents, complex processing of natural, technogenic raw materials containing aluminum is possible. In Kazakhstan, there are large reserves of raw materials in the form of bauxite, the quality of which is determined by the silica content (bauxite with a silica content of 5-10% is low-quality) – Torgai, Krasnooktyabrskoye, Belinskoye deposits, Amangeldy group, Altai and others. One of the promising types of raw materials for the production of coagulants is substandard bauxite from the Krasnooktyabrsk Ore Mining Administration [15].

The main minerals of the Krasnooktyabrskoye bauxites are gibbsite, hydro hematite, hematite, kaolinite, recurrent siderite, calcite, and in small quantities magnetite, rhodochrosite, anatase, rutile, hydro goethite, hematogel, quartz, limonite, lepidocrocite, gypsum, zircon, ankerite, ferrous chromite, corundum, boehmite, leucoxene, magnesite, arsenopyrite, pyrite, and marcasite [15]. They differ from the widely known Torgay bauxites in their physical properties, structure, chemical, and material composition and are stony, loose, and clayey. The content of aluminum oxide (Al_2O_3) fluctuates from 39.5 to 55.3%, silicon dioxide (SiO_2) – from 3.2 to 13.6%, siderite iron (Fe_2O_3) – from 5.6 to 24.6%. The modulus of siliceous bauxite varies from 2.99 to 15.1% [16]. Such impurities complicate the processing of bauxite into alumina using the traditional alkaline method.

Bauxites are processed at the Pavlodar Aluminum Plant using a sequential Bayer-sintering scheme. Production is based on the processing of low-grade, high-siliceous Krasnooktyabrskoye bauxites (97%) with a relatively low content of harmful impurities, the reserves of which are gradually depleted [16]. Deterioration of the quality of bauxites leads to an increase in the cost of raw materials, auxiliary materials, energy resources, their transportation, as well as to the formation of a large amount of waste - sludge and emissions into the atmosphere. One of the problems in solving this problem, as well as the rational use of natural resources and waste reduction, is the development of a technology for the production and use of coagulants for the purification of natural and wastewater from natural and man-made raw materials.

The most applicable is aluminum sulfate out of the traditionally used coagulants.

Kazakhstan has large reserves of high-silica and high-iron bauxites, the use of which by the aluminum industry is very difficult due to the high content of harmful impurities [13]. In this regard, the possibility of using them to obtain coagulants for treatment of waste and drinking water is of particular interest. The average chemical composition of bauxites in northern Kazakhstan is as follows, %: Al_2O_3 – 42-44; Fe_2O_3 – 5-7; SiO_2 – 20-25; CaO – 1.5-2.5; MgO – 0.5-1.0.

The new technology for obtaining mixed coagulants is developed: sulfate aluminum-iron, sulfate-chloride aluminum-iron, sulfate coagulant-flocculant from bauxite, etc., which have a number of advantages traditionally used in industry: a wide pH range, high treatment efficiency, low cost of the coagulant, additional flocculant properties of the coagulant. These properties of coagulants arise due to the diversity and physicochemical properties of the hydrolysis products. The effect of water treatment with a mixed coagulant at 20ºC is close to the effect of coagulation with iron sulfate at 50°C and aluminum sulfate at 80°C.

In laboratory research and testing, bauxite and sulfuric acid were utilized. The chemical composition of bauxite, %: Al_2O_3: – 40.8; Fe_2O_3 – 3-27.0; SiO_2 – 8.7; CaO – 0.75; Na_2O + K_2O – 0.5; loss on ignition (LOI) – 0.7. The sulfuric acid used was technical-grade contact acid of the 1st or 2nd grade, conforming to state standard, and is produced at several enterprises in Kazakhstan.

Figure 1 illustrates a laboratory setup for sulfuric acid leaching of bauxite. This setup consists of specialized vessels made of thermo- and chemically resistant glass, interconnected with a thermostat, and equipped with reflux condensers and stirrers.

Figure 1. Laboratory Setup for Acid Decomposition of Krasnooktyabr Bauxite

Technology for producing the coagulant includes the following process steps: 1 – raw material preparation; 2 – leaching with sulfuric acid; 3 – crystallization (Figure 2).

Bauxites up to 300 mm in size are crushed to 25 mm and grounded to 0.15 mm. The crushed ore is fed to a ball crusher with a water ratio of S:L=1:1. The pulp in the vessel (2) with a S:L ratio of 1:1 is pumped for decomposition into the reactor (4) through the discharge tank (2) (Figure 2).

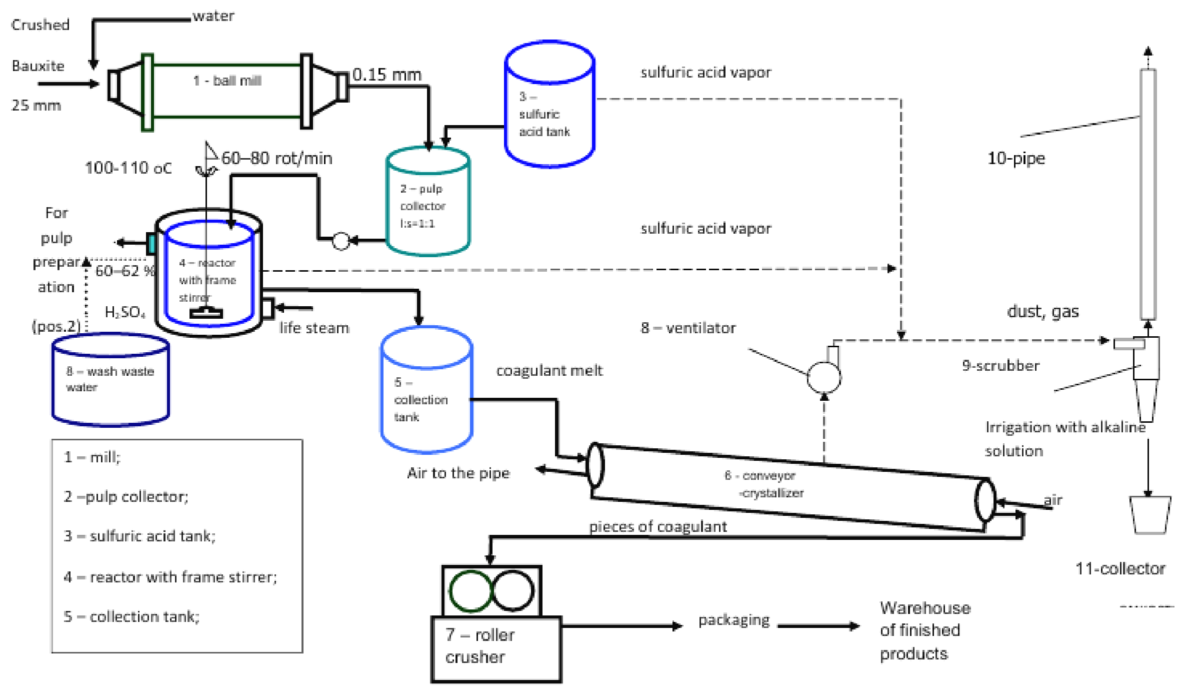

Figure 2. Basic technological scheme of obtaining the MSAISC

Concentrated (92%) sulfuric acid is fed into the same reactor from the pressure vessel (3) to achieve an acid concentration in the reaction mass of 60-62%. The decomposition of sulfuric acid is carried out at a temperature of 100-110°C for 40-60 minutes. Heating occurs by feeding the heat of reaction and blind steam into the reactor body. After leaching is complete, the melt is fed to the belt crystallizer (6). The thickness of the through layer of the belt is 10-20 mm. The surface of the melt is cooled by blown air at a rate of 800–1200 m³ per ton of finished product. The crystallizer belt is equipped with a casing. The process of curing and removing the product is improved by wetting the tape with water. The melt solidifies on the belt in the form of plates with a thickness of 12-18 mm and linear dimensions up to 150 mm.

Air is supplied to the crystallizer body by a fan and sucked in by an air blower in order to accelerate the process of hardening the finished coagulant. The speed of movement is 1.5-2 m/min, the time of passage through the belt is 30 min.

Wastewater from washing the decomposition reactor and condensate is collected in a tank (8), where it enters the container (2) of the decomposition reactor for preparation of the initial pulp. Filling the reactor with the decomposed mass is carried out to 1/2 of the volume associated with foaming. To suppress foaming, the mixing speed of frame mixers should be 60-80 rpm. The list of main process equipment is presented in Table 1.

Table 1. List of main process equipment

Name of equipment	Process parameters			Materials	Characteristics of the product
	Temperature	Duration	Pressure		
Fresh water pressure tank	20-25	Periodical	-	Steel 63	Technical water
Belt conveyor	90-100	Continous	-	Thermostatic tape type P	bauxite
Wet grinding rod or ball mill	25-40	Continous	-	Steel 3	bauxite, water
Screw feeder	20-25	Continous	-	Steel 3	pulp
Pulp tank	70-80	Continous	-	Steel	pulp
Reactor	100-110ºC	Continous	-	Steel 06XH28MDT frame, stirrer	melt
Dosing pump	20-25	Periodical	-	Chromium cast iron	acid 90%
Acid collection tank	20-25	Periodical	atm.	Steel 3	oil of vitriol 90% H_2SO_4
Pressure water tank	-	-	-	Steel 3	technical water
Acid pressure tank	-	-	-	Steel 08X22H28MDT	acid
Centrifugal pump	95-100	-	-	Steel 06XH28MDT	
Belt conveyor crystallizer				Rubberized fabric tape, type P, heat-resistant	melt
- Melt for crystallization	100-110	Continous	atm.		
- Air for cooling	20 ±10	Continous	0.08		
Ventilator	40-60	Continous	-	Carbon steel	air

To avoid the emission of sulfuric acid vapors into the atmosphere, the vapors and gases leaving the decomposition reactor, as well as the entire volume of air sucked from the crystallizer body, from the sulfuric acid pressure tank are sent to gas cleaning (9, 10). In this case, sulfuric acid vapors are absorbed by a weakly alkaline solution of pH 8-8.5.

When the solution is saturated with sulfuric acid till pH value of 7.5, it is being sent to prepare a pulp for the decomposition of sulfuric acid and a new portion of the alkaline solution is prepared for gas treatment.

The finished coagulant MSAISC is delivered to a cold closed rail warehouse or directly to the wagon. If necessary, the coagulant can be crushed into pieces of the required size and placed in paper bags or other containers permitted by technical specifications.

3. Results and discussion

It should be noted that most of the work on this topic is aimed at obtaining purified aluminum sulfate, which increases the cost of the resulting product. The use of methods for obtaining mixed coagulants simplifies the process, since there is no need to carry out operations such as separation of liquid and solid phases, degreasing, evaporation and etc (Figure 3).

The obtained coagulant was analyzed for the content of aluminum, iron, free acid and insoluble residue. Evaluating the test results, the most optimal parameters for obtaining modified MSAISC were selected: H_2SO_4 concentration – 60%, stoichiometric dosage; the amount of sulfuric acid is 90–98% of the stoichiometrically required; temperature – 110°C; process duration – 90 minutes; Al_2O_3 production – 94%; Fe_2O_3 production – 93%. Chemical composition of the solid coagulant, %: Al_2O_3 – 11.18; Fe_2O_3 – 4.66; sulfates – 42.0; hydrated water – 32.3; free acid – none.

The technology for obtaining a coagulant includes the following process operations: raw material preparation (grinding), sulfuric acid leaching, crystallization, and crushing of finished products. The basic hardware diagram includes a mill, a pulp collector, a sulfuric acid tank, a reactor with a frame mixer, a conveyor-crystallizer, and a roller crusher.

Using this method for obtaining a mixed coagulant simplifies the process of processing bauxites since it eliminates the precipitation of sulfuric pulp, the operation of evaporation and dehydration of sulfuric acid solutions and crushing of the product, which is a weakness of the acid technology.

(a)

(b)

Figure 3. Coagulant from substandard bauxite: (a) – substandard bauxite; (b) – coagulant SSAZhKK

Obtaining a coagulant in granular form facilitates its loading and transportation. The main disadvantages include an increased content of insoluble impurities. Since the method did not include an operation for separating liquid and solid phases, bauxites with a low content of silica and aluminum silicates were processed in accordance with the proposed technology to reduce the amount of insoluble sediment in the product. In the case of recycling bauxite with a large amount of these impurities and if necessary, after separation with sulfuric acid to obtain purified coagulant. Additional operations should be carried out to dilute the pulp, separate the liquid and solid phases and wash the latter, which would significantly increase the cost of the process.

The proposed technologies for obtaining combined aluminum iron coagulants of various modifications allow processing aluminum raw materials with a high iron content and with a high silicon content.

To produce 1 ton of the coagulant MSAISC containing 11% Al_2O_3, the following materials and energy costs are required: Krasnooktyabrsky bauxite – 0.33 tons (based on processing ore of the following composition, %: Al_2O_3 – 42.76; Fe_2O_3 (total) – 19.05; SiO_2 – 14.77; CaO – 3.5; CO_2 – 2.89), industrial water – 0.24 m^3, the amount of 92% sulfuric acid – 0.43 tons, electricity – 19.8 kW/h, air for cooling – 1.15 thousand m^3, thermal energy to maintain the reaction – 0.1 Gcal.

An environmental assessment was conducted for the MSAISC coagulant production technology, focusing on the following aspects:

1). Presence of toxic ompurities. Evaluation of toxicological impurities generated during production, as well as by-products formed during usage, their transformation, decomposition, or interaction with the environment.

2). Distribution and spread conditions. Assessment of how toxic impurities and by-products disperse and persist in application regions, considering factors like mobility, migration, stability, and lifespan.

3). Transformation and decomposition. Analysis of the conditions under which by-products transform or decompose in the natural environment and the duration of these processes.

4). Monitoring and detection. Evaluation of current methods and proposed measures for controlling and detecting toxic impurities in the product and its by-products.

5). Environmental impact. Assessment of negative ecological consequences resulting from the release of toxic impurities and by-products into the environment, including their effects on food, housing, and industrial premises.

The acid decomposition process of substandard bauxite in this technology results in:

1). Emissions of pollutants. Sulfuric acid decomposition of bauxite emits pollutants such as sulfuric acid vapors (1–3 mg/nm^3), necessitating purification before atmospheric release, and inorganic dust. Emissions from raw material preparation and acid reactors are neutralized using aspiration systems. Vapors and gases extracted from decomposition reactors, crystallizer casings, and pressure tanks are directed to gas purification systems for neutralization. Acid vapors are absorbed using a mildly alkaline solution (pH 8-8.5), ensuring that pollutant emissions remain below permissible limits, thereby preventing air pollution.

2). Wastewater. The technological scheme produces two types of wastewaters:

3). Conditionally clean (warm) wastewater. This is cooled and reused for reactor cooling.

4). Industrial wastewater. Generated from floor washing, equipment cleaning, etc. at the stage of condensation of water vapor in the dust and gas emissions treatment system Combined wastewater is used to dilute bauxite suspension after wet grinding.

5). Production waste. The insoluble residue (sludge) amounts to 1174.7 kg (with 30% moisture) per 1000 kg of mixed aluminum-iron-silicate coagulant. Depending on consumer preference, this residue can be separated on-site, becoming a by-product, or sent in solid form without separation, effectively used in treating industrial and low-turbidity wastewater. Alternatively, it can be stored for future processing into cement or extraction of valuable components. Thus, the insoluble residue is better regarded as a valuable technogenic raw material.

No toxic impurities were detected during coagulant production. In regions where the coagulant is produced and used for natural water purification, no toxic by-products are formed. Negative environmental impacts from by-products entering the environment, food, housing, or industrial premises are not anticipated, as residual concentrations of pollutants and introduced impurities (aluminum, iron, silicon oxides) during water purification with the coagulant comply with various permissible limits depending on water use categories.

4. Conclusions

Therefore, based on the conducted studies it was established that the mixed sulfate alumina-iron coagulant MSAIC in its coagulation properties and efficiency is close to commercial aluminum sulfate.

The technology for obtaining the coagulant includes the following process operations: raw material preparation (grinding); sulfuric acid leaching; crystallization; crushing of final products.

The main equipment and process flow chart for obtaining the coagulant includes a mill, a pulp collector, a sulfuric acid tank, a reactor with a frame mixer, a conveyor-crystallizer and a roller crusher.

The optimal process parameters were established: pulp L:S ratio = 1:1.5; sulfuric acid concentration 60% ration = 2:1, process temperature 110-130°C, exposure time 30-50 min; extraction of Al_2O_3 – 97%; Fe_2O_3 – 93%., SiO_2 = 83%. Chemical composition of MSAISC, %: Al_2O_3 – 11.18; Fe_2O_3 (total) – 6.66; SiO_2 – 7.7; sulfuric acid – 0.8; insoluble residue – 6.5.

During the coagulant production process, the following wastes are generated:

– wastewater from washing the decomposition reactor and condensate, which are returned to the bauxite decomposition process and to the preparation of the initial pulp;

– sulfuric acid vapors leaving the decomposition reactor and the crystallizer casing and sulfuric acid pressure tank, which will be sent for gas treatment by absorption with a weak alkaline solution and sent to the preparation of pulp for sulfuric acid decomposition;

– solid production waste – insoluble residue (sludge).

The main disadvantage of mixed unrefined coagulants is the increased content of insoluble residue, but when treating slightly turbid waters, this disadvantage becomes an advantage since insoluble impurities act as opacifiers, improving the coagulation process.

In order to reduce the number of insoluble residues in the product it is recommended to process bauxites with a low content of silica and aluminum silicates. The operation of separating the liquid and solid phases is necessary to separate the insoluble residue. When processing bauxites with a high content of these impurities if it is necessary to obtain a purified coagulant, then it is required to introduce additional operations to dilute the pulp after separation with sulfuric acid, separate the liquid and solid phases and wash the latter.

The new generation MSAISC coagulant has coagulation capacity, works in clarification of wastewater, significantly accelerates the treatment process and is not inferior in quality of purification to commercial coagulants (aluminum sulfate, iron chloride). The coagulant is able to soften water, reduce carbonate hardness, sodium-potassium salinity, chemically purify water from heavy and harmful elements.

Obtaining the proposed coagulant and its application not only increases the effect of natural and wastewater treatment but also improves the ecological state of the bauxite mining area, reduces the area of placement and storage of substandard raw materials on the territory of the natural-industrial complex, as well as its deficit. In addition, it allows preventing damage to the environment during treatment as a result of coagulation of natural and wastewater containing suspended substances, heavy metal cations, oil products, radioactive substances, as well as for the disposal of precious alloyed metals.

The use of this method for obtaining a mixed coagulant simplifies the process of bauxite processing since it eliminates the operation of settling sulfuric pulps, evaporation and dehydration of sulfuric solutions, as well as crushing the product, which are the disadvantages of acid technologies. Obtaining a coagulant in a granular form facilitates its loading and transportation. The main disadvantages include an increased content of insoluble impurities. Since the method does not include an operation for separating the liquid and solid phases, in order to reduce the content of insoluble sediment in the product it is recommended that bauxites with a low content of silica and aluminosilicates be processed using the proposed technology. In the case of processing bauxites with an increased content of these impurities and if it is necessary to obtain a purified coagulant, additional operations should be introduced to dilute the pulp after sulfuric acid opening, separate the liquid and solid phases and wash the latter, which significantly increases the cost of the process.

The proposed technologies for obtaining mixed alumina-iron coagulants of various modifications will allow processing both high-iron and high-silicon aluminum types of raw materials.

Author contributions

Conceptualization: U.N., L.K., B.T.; Data curation: L.K., B.T.; Formal analysis: U.N., L.K., B.T.; Funding acquisition: U.N.; Investigation: U.N., L.K., B.T., G.B.; Methodology: U.N., L.K., B.T.; Project administration: U.N., L.K., B.T.; Resources: L.K., B.T., G.B., S.S.; Software: G.B., S.S.; Supervision: U.N., L.K.; Validation: U.N., L.K., B.T.; Visualization: G.B., S.S.; Writing – original draft: U.N., L.K., B.T.; Writing – review & editing: L.K., B.T. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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Қазақстанның кондициялық емес бокситінен ағынды суларды тазарту үшін коагулянт алу технологиясы

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Аңдатпа. Қазақстанның маңызды экологиялық проблемаларының бірі – табиғи және сарқынды сулардың дұрыс сапалы түрде тазаланбауы. Себебі суды тазарту технологиясындағы негізгі, міндетті коагулянт реагентінің тапшылығы болып табылады. Құрамында алюминий бар табиғи және техногендік шикізатты модификацияланған аралас реагенттер-коагулянттар алу мақсатында кешенді өңдеуге болады. Қазақстан аумағында коагулянттар өндірісі үшін болашағы бар шикізат түрлерінің бірі – Краснооктябрь кен орнының кондициялық емес бокситтері болып табылады. Бұл мақалада pH кең диапазонында жоғары коагуляциялық қасиеттері бар тиімді коагулянтты – аралас сульфатты алюминий-темір – кремний коагулянтын (АСАТКК) – Краснооктябрь бокситін күкірт қышқылымен ыдырату арқылы, алюминий, темір және кремнийді паста фазасына барынша шығара отырып, коагулянт алу технологиясын әзірлеу бойынша түбегейлі жаңа тәсіл ұсынылған. Біз АСАТКК (аралас сульфатты алюминий-темір-кремний коагулянты) деп аталған коагулянттың мұндай құрамы қоршаған ортаның температурасы мен pH бойынша әсер ету ауқымын кеңейтуге мүмкіндік береді. Бұл тұрғыда кремний коагулянты қазіргі алюминий полиоксихлоридтері сияқты флокулянтсыз қолдануға болады. Коагулянттың құрамында алюминий, темір және кремний тұздарының бір мезгілде болуы «үшеуі бір» қасиеттерін біріктіруге мүмкіндік береді.

Негізгі сөздер: *боксит, технология, коагулянт, флокулянт, су тазарту, дисперстік құрамы*.

Технология получения коагулянта из некондиционных бокситов Казахстана для очистки сточных вод

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Аннотация. Одна из важных экологических проблем Казахстана – недостаточно качественная очистка природных и сточных вод, причиной, которой является дефицит основного, обязательного реагента в технологии очистки воды – коагулянта. Алюминий содержащее природное и техногенное сырье можно комплексно перерабатывать в целях получения модифицированных смешанных реагентов-коагулянтов. Одним из перспективных видов сырья на территории Казахстана для производства коагулянтов являются некондиционные бокситы Краснооктябрьского месторождения. В настоящей статье представлены принципиально новый подход по разработке технологии получения эффективного коагулянта, обладающего высокими коагулирующими свойствами в широком диапазоне pH, – сульфатного смешанного алюможелезисто-кремниевого коагулянта (ССАЖКК) – при разложении краснооктябрьского боксита серной кислотой с максимальным извлечением алюминия, железа и кремния в пастообразную фазу. Такой состав коагулянта, названного нами ССАЖКК (смешанный сульфатный алюмо-железо-кремниевый коагулянт) позволяет расширить диапазон действия как по температуре, так и по pH среды. В этом смысле кремниевый коагулянт так же, как и современные полиоксихлориды алюминия можно применять без флокулянта. Одновременное присутствие в составе коагулянта солей алюминия, железа и кремния позволяет объединить свойства «три в одном».

Ключевые слова: *боксит, технология, коагулянт, флокулянт, очистка воды, дисперсный состав*.

Publisher's note